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Appendix 1 - Watercourse and Biodiversity Assessment

WATERCOURSE AND BIODIVERSITY ASSESSMENT

PROPOSED TIARA MINE, LOCATED

NEAR PHALABORWA IN THE LIMPOPO PROVINCE

OCTOBER 2020

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Disclaimer:

I, **Jacob Schrijvershof,** declare that -

- I act as the independent specialist in this matter;
- I do not have and will not have any vested interest (either business, financial, personal or other) in the undertaking of the proposed activity, other than remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist assessment relevant to this application, including knowledge of the National Environmental Management Act (Act 107 of 1998) (NEMA) and the National Water Act (Act 36 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; all the particulars furnished by me in this report are true and correct;
- I am aware that a person is guilty of an offence in terms of Regulation 48 (1) of the EIA Regulations, 2014, if that person provides incorrect or misleading information. A person who is convicted of an offence in terms of sub-regulation 48(1) (a)-(e) is liable to the penalties as contemplated in section 49B (1) of the National Environmental Management Act, 1998 (Act 107 of 1998); and
- I understand that any false information published in this document is an offence in terms of regulation 71 and is punishable in terms of section 24F of the Act.

Joppie Schrijvershof

Executive summary

Oasis Environmental Specialists (Pty) Ltd in collaboration with Eco Elementum (Pty) Ltd was appointed to conduct an aquatic, and terrestrial ecological assessment report for the proposed for the proposed tiara Granville Emerald and Quartz mining operation in respect of the Farm BVV Ranch 776 LT, Josephine 749 LT, Buffalo Ranch 834 LT, Danie 789 LT, Granville 767 LT, Farrel, 781 LT, and Willie 787 LT, all located within the magisterial district of Phalaborwa, Limpopo Province. The field assessment was conducted on the 15th of October 2020 in order to assess the current watercourse and ecological conditions and to expand baseline data for future reference.

The aim of this study is to ensure compliance with the general legislative requirements as part of the for the Water Use Authorisation process prescribed by the National Water Act (NWA) (Act No 36 of 1998) and National Environmental Management Act (NEMA) (Act No 107 of 1998).

The scope of work entailed determining the Present Ecological Status (PES) for the watercourses associated with the proposed Tiara Mine. In order to make this determination, the following components were assessed:

- *In situ* water quality in accordance with guidelines of the Target Water Quality Ranges (TWQRs) for aquatic ecosystems of South Africa;
- Habitat Assessment (via the Intermediate Habitat Integrity Assessment (IHIA));
- The riparian vegetation was determined with the use of Riparian Vegetation Response Assessment Index (VEGRAI);
- Macroinvertebrates were assessed using the South African Scoring System Version 5 (SASS5) and Invertebrate Habitat Assessment System (IHAS);
- Identify and delineate any wetland, channel areas and/or watercourses associated within the study boundary according to the Department of Water Affairs' "Practical field procedure for the identification and delineation of wetlands and riparian areas";
- Determine the Ecological Services, Importance and Sensitivity (EIS) of identified watercourses using the latest applicable approach as supported by the DWS (formally DWA);
- Determine and assess the significance of the impacts caused by the proposed Tiara Mine on any associated watercourses;
- Identifying, describing and rating potential impacts/risks to the wetlands/rivers/streams/channel and rivers and recommend mitigation measures for the identified impacts to minimise the negative impacts; enhance any positive impacts; and
- Indicate the minimum buffer required to protect any watercourses identified within the study boundary.

The scope of work entailed to the biodiversity study following:

- An examination of onsite, SANBI GIS databases on Endemic and Red Data faunal and floral species in the study area;
- A literature search on Red Data Book species predicted to occur in the study area;
- Identify potential negative impacts on any biodiversity from the proposed mine establishment and operations and assess the significance of these impacts;
- Provide recommended mitigation measures for the identified impacts in order to avert or lower the significance of the negative impacts; and
- Identify any sensitive areas present on site.

The overall results of the aquatic and channel and river assessment based on the various methodologies concluded that:

- According to the ecological classification for the quaternary catchments B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment); the Mulati is classified in its present state as a **Category C (Moderately Modified)** Upstream and as a **Category B (Largely Natural)** downstream.
- The Selati is classified in its present state as a **Category B (Largely Natural)** River.
- The default ecological management class for the relevant quaternary catchments is considered to be a **highly sensitive** system for the Selati River and **moderate** for the Mulati in terms of ecological importance with both being a **highly ecological sensitive**.
- The Selati River was dry at the time of the assessment, where the downstream site and the Mulati River has pockets of water at the time of the assessment, although receiving 100 mm a few days before the assessment. This suggest that these systems could be classified as ephemeral streams.
- No wetland areas were identified during the site survey.
- From the *in situ* water quality dissolved oxygen (DO) levels were below guideline levels.
- The IHIA results recorded the sites assessed within a **largely modified state (Category D)**.
- The predominant cause for concern was damming, current mining, erosion, grazing, deforestation and alien invasive plants.
- Hydrophytic riparian vegetation consisted of mainly of *Cyperus spp*. *Juncus spp*, *Crinum macowanii* and *Typha capensis.*
- The findings for the vegetation assessment revealed that riparian habitat of the area was **largely modified (Category D)**.with deforestation within the non-marginal zone and alien invasive vegetation within the marginal zone.

- This SASS5 scores for both downstream sites indicate that the stream is **seriously modified (Category E/F)**. The majority of highly pollution tolerant organisms indicates the pressure from lack of suitable flow at the time of the assessment and these results should be interpreted with low confidence.
- The habitat reaches which were assessed for the Mulati DS site, found to be **inadequate**, where biotopes with limited habitat structures were present.
- Although no fish species were sample, the SQR fish data available for that specific reach had 12 species of fish expected to occur within that stretch of river according to DWS (2013).
- The channel delineation revealed numerous non perennial 'A' Section channels and only two ephemeral 'B' Section channels, namely the Mulati River and Selati River.
- The majority of drainage channels were identified as 'A' Section channels without any riparian plant species identified
- Both the 'A' Section and 'B' Section channels overlaps with the propose mining blocks, which could impact the functionality of these system, especially during rain events, ultimately leading to the Olifants River being impacted further by the mining activities within the Kruger National Park downstream.

The overall results for the biodiversity (faunal and floral) assessment concluded:

- According to the biodiversity datasets provided by SANBI (2020), the majority of the application area falls within Ecological Support Areas (ESA) and Critical Biodiversity Areas (CBA).
- Information on plant species recorded in that area was extracted from the POSA list, indicate that 292 plant species have been recorded in the area queried of which 288 are endemic species are known to occur within the area queried.
- Nine possible red data protected trees listed in Mucina and Rutherford (2006) and SANBI species lists (2020)
- *Combretum imberbe, Boscia albitrunca, Adansonia digitata, Balanites maughamii subsp. maughamii, Catha edulis, Pterocarpus angolensis, Elaeodendron transvaalense* and *Sclerocarya birrea subsp. Caffra*. must attain permit applications for the cutting or trimming of trees should they be encountered
- The IUCN critically endangered (*Encephalartos dyerianus*) is know to be found within the Phalaborwa area's open grasslands and shrublands on the slopes of low granite hills, but was not observed during the site visit.
- Observed trees in the area include *Breonadia salicina, Sclerocarya birrea, Lannea schweinfurthii, Senegalia caffra, S. nigrescens, Vachellia sieberiana, V. karroo, Dichrostachys sericea, Ziziphus mucronata,Diospyros mespiliformis, Ficus sur, F. sycomorus, Philenoptera violacea, Combretum imberbe, C. apiculatum, C. collinum* and *Philenoptera violacea*.

- African Baobab trees (*Adansonia digitata*) were identified within the present landscape. Although they are not yet classified by the IUCN's Red List criteria, but they are a part of the "Catalogue of Life." The baobab is a protected tree in South Africa. The effects of drought, desertification, deforestation and over-use of the fruit have been cited as causes for concern for these slow growing species (Osman, 2014).
- No other protected species were observed during the survey.
- River lily species (*Crinum macowanii*) with the roots and leaves having some medicinal uses as a pain killer and having emetic and laxative properties were found closer to watercourse areas.
- The dominant plant species identified were alien invasive Castor oil plant (*Ricinus communis*) (category 2) and Spanish reed (*Arundo donax*) (category 1b) within the riparian zones.
- Some spoor and droppings of *Sylvicapra grimmia, Aepyceros melampus, Tragelaphus strepsiceros, Hystrix africaeaustralis* and some smaller rodents were seen.
- Between game farms and private reserves the diversity of the animals increased In the cattle areas, more *Sylvicapra grimmia, Aepycerosmelampus, Tragelaphus strepsiceros* and *Raphicerus campestris* activity were noted (higher protection and better habitat). Larger species and rare game are present and include *Loxodonta africana, Syncerus caffer, Panthera pardus, Panthera leo, Crocuta, Equus quagga, Connochaetes taurinus, Giraffa camelopardalis, Hippotragus niger, Hippotragus equinus* and *Damaliscus lunatus*.
- Limited faunal species were observed and the majority were sites near game farms and private reserves and included: Communal spider nests, sociable weaver (*Philetairus socius*), Southern red-billed hornbill (*Tockus erythrorhynchus*), Girrafe liseted as vulnerabe (*Giraffa camelopardalis*), Chacma baboon (*Papio ursinus*) and Bluetailed sandveld lizard (*Nucras caesicaudata*).
- The proposed mining operations fall within close proximity to Important Bird Areas (IBAs), where the proposed mining area falls close to the Kruger National Park.

All bushveld areas and watercourses still intact can be considered highly sensitive areas serves as a breeding and foraging habitat for a number of faunal species. These areas can be regarded as ecologically irreplaceble and covers the majority of the area. It will be nearly impossible to imitate these areas after mining has been completed with a rehabilitation programme. Historical transformed Grasslands with cultivation which have been considered as moderately sensitive as they have been disturbed by surrounding anthropogenic activities, but some vegetation has started establishing again. Current transformed land by mining operation and agriculture can be considered low sensitive and covers the majority of the area.

All expected faunal species are listed in **Appendix A** for QDS 2330DC and 2330DD and all floral species are listed in A**ppendix B** for the Phalaborwa and Gravelotte area.

The risk assessment on the channel and river areas for the current mining operations were rated as a **moderate impact without and without mitigation for construction and establishment** and as a **high impact with and without mitigation**, although there is a significant lowering in the impact scores when mitigation is being implemented. Identified impacts to watercourses pertaining to erosion, sedimentation, water quality and quantity alterations and the continued spread of alien invasive species were assessed. The proposed Tiara Mine already lies within pristine bushveld landscape and should mining commence, that mitigation measures must being implemented appropriately as it could reduce impacts immensely for the operational phase as these systems drain into the receiving Olifants System eventually.

A number of potential ecological impacts relating to proliferation of alien invasive species, loss of species of conservation concern, loss of indigenous vegetation, floral and faunal habitat and ecological structure of water resources and soil, loss of floral diversity and ecological integrity. The significance of potential impacts on biodiversity within the area was rated as a **very high significance with and without mitigation** as the proposed areas lies in a pristine bushveld area owned by private game reserves and with the implementation of a suitable rehabilitation programme, could not reach the historical ecological importance and status.

During construction it will be important to liaise with the landowners off the game farms and private reserves. Where dangerous animals are present, it will be important to ensure that game is moved to other camps where possible. A ranger from the farm must be present during construction to ensure the safety of man and animals.

Provided mitigation measures are to be implemented within an environmental management programme (EMPr) and the significance of any negative impacts reduced should the mining commence. Potential impacts associated with the construction and operational phase include:

- Increased sedimentation and water quality impairment due to runoff from waste dumps;
- Water quality contamination due to runoff or seepage from any tailings storage facility;
- Alteration of natural flow regime due to discharge of pit water;
- Increased utilisation of aquatic resources by local population; and
- Habitat loss associated with the stream diversion.

Should mining commence the following mitigation measures, aimed at minimising the afore-mentioned impacts, include (but are not limited to):

- Design and implementation of a suitable stormwater system;
- Rehabilitation of the disturbed areas;
- Limiting instream sedimentation;
- Minimising pollutants entering the watercourse;
- Implement a programme for the clearing/eradication of alien species including long term control of such species;
- A 100 m buffer was implemented for the channel and river systems;
- Ongoing water quality monitoring must take place; and
- Biomonitoring where/if flow conditions allow for effective sampling analysis must take place annually to determine any trends in ecology and hydrology.

The proposed mining activities are planned for an ecologically pristine site of high sensitivity, which can never be fully rehabilitated and ecologically restored to its pre-mining condition. The proposed mine is expected to have a serious long term negative impact on the project area and the surrounding environment.

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LIST OF ABBREVIATIONS AND ACCRONYMS

BGIS: Biodiversity Geographic Information System

CBA: Critical Biodiversity Areas

DEM: Digital Elevation Model

DWAF: Department of Water Affairs and Forestry

DWS: Department of Water Affairs and Sanitation

EA: Environmental Authorisation

EC: Ecological Category

EIS: Ecological Importance and Sensitivity

EMPr: Environmental Management Program

ESA: Ecological Support Areas

FRAI: Fish Response Assessment Index

GIS: Geographic Information System

IBA: Important Bird Areas

IHAS: Invertebrate Habitat Assessment System

IHIA: Intermediate Habitat Integrity Assessment

NFEPA: National Freshwater Priority Area

NWA: National Water Act (Act no 36 of 1998)

PES: Present Ecological Status

QDS: Quarter Degree Square

REMP: River Eco-Status Monitoring Program

RHP: River Health Programme

SANBI: South African National Biodiversity Institute

SASS5: South African Scoring System

TWQRs Target Water Quality Ranges

VEGRAI: Riparian Vegetation Assessment Index

WMA: Water Management Areas

WUL: Water Use Licence

1 INTRODUCTION

1.1 Background

Oasis Environmental Specialists (Pty) Ltd in colaberation with Eco Elementum (Pty) Ltd was appointed to conduct a watercourse and terrestrial ecological assessment report for the proposed for the proposed tiara Granville Emerald and Quartz mining operation in respect of the Farm BVV Ranch 776 LT, Josephine 749 LT, Buffalo Ranch 834 LT, Danie 789 LT, Granville 767 LT, Farrel, 781 LT, and Willie 787 LT, all located within the magisterial district of Phalaborwa, Limpopo Province (**Figure 1**). The field assessment was conducted on the 15th of October 2020 in order to assess the current watercourse and ecological conditions and to expand baseline data for future reference.

The proposed project is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. The project falls within Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. The northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA.

The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)) using truck and shovel opencast mining method.

The extent of the area applied for covers approximately 16987.9548 hectares. The life of mine (LoM) is estimated at 30 (thirty) years with Run of Mine (RoM) of 35 700 tonnes per month (tpa). The construction phase is expected to commence in the first quarter (Q1) of 2021, with first sealable product delivered in Q2 of 2020. Process water supply will be sourced from Mulati River as well as developing new groundwater abstraction boreholes on site).

1.2 Legal framework

1.2.1 National Environmental Management Act (Act No. 107 of 1998)

The EIA Regulations, promulgated under NEMA, focus primarily on creating a framework for co-operative environmental governance. NEMA provides for co-operative environmental governance by establishing principles for decision-making on matters affecting the environment, institutions that will promote co-operative governance and procedures for co-ordinating environmental functions exercised by State Departments and to provide for matters connected therewith.

1.2.2 **National Waste Act, 2008 (Act No. 59 of 2008)**

The NEMWA aims at promoting sustainable waste management practices through the implementation of “Integrated Waste Management Planning”, where “Integrated Waste Management Planning is viewed as a holistic approach of managing waste, aimed at optimising waste management practises to ensure that the implementation thereof yields practical solutions that are environmentally, economically and socially sustainable and acceptable to the public and all relevant spheres of government”.

1.2.3 **National Water Act, 1998 (Act No. 36 of 1998)**

The National Water Act, 1998 (Act No. 36 of 1998) (NWA) aims to provide management of the national water resources to achieve sustainable use of water for the benefit of all water users. This requires that the quality of water resources is protected as well as integrated management of water resources with the delegation of powers to institutions at the regional or catchment level. The purpose of the Act is to ensure that the nation’s water resources are protected, used, developed, conserved, managed and controlled in responsible ways. Of specific importance to this application is Section 19 of the NWA, which states that an owner of land, a person in control of land or a person who occupies or uses the land which thereby causes, has caused or is likely to cause pollution of a water resource must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring and must therefore comply with any prescribed waste standard or management practices.

Regulations GN 704 dated June 1999 under the NWA, 1998 (Act 36 of 1998) stipulates that no development activities may take place within the 1:100 year floodline of a watercourse, or within 100 m of the watercourse, whichever is the furthest.

Regulations GN 509 dated August 2016 under the Section 21 c and i water uses of the NWA, 1998 (Act No 36 of 1998) stipulates the:

"Extent of a watercourse" as:

(a) The outer edge of the 1 in 100 year flood line and/or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam.

"Regulated area of a watercourse" for section 21(c) or (i) of the Act water uses in terms of this Notice means:

(a) The outer edge of the 1 in 100 year flood line and /or delineated riparian habitat, whichever is the greatest distance, measured from the middle of the watercourse of a river, spring, natural channel, lake or dam;

(b) In the absence of a determined 1 in 100 year flood line or riparian area the area within **100 m from the edge of a watercourse** where the edge of the watercourse is the first identifiable annual bank fill flood bench (subject to compliance to section 144 of the Act); or

(c) A 500 m radius from the delineated boundary (extent) of any watercourse.

1.2.4 National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)

The purpose of the Biodiversity Act is to provide for the management and conservation of South Africa's biodiversity within the framework of the NEMA and the protection of species and ecosystems that warrant national protection. As part of its implementation strategy, the National Spatial Biodiversity Assessment was developed.

This Act is applicable to this application for environmental authorisation, in the sense that it requires the project applicant to consider the protection and management of local biodiversity. This report serves as an ecological assessment being undertaken to assess the flora and fauna for the proposed mining area.

In terms of the Biodiversity Act, the "developer" has a responsibility for:

- The conservation of endangered ecosystems and restriction of activities according to the categorisation of the area (not solely by listed activities as specified in the EIA regulations).
- Promote the application of appropriate environmental management tools in order to ensure integrated environmental management of activities; thereby ensuring that all development within the area is in line with ecological sustainable development and protection of biodiversity.
- Limit further loss of biodiversity and conserve endangered ecosystems.
- A person may not carry out a restricted activity involving a specimen of a listed threatened or protected species without a permit issued in terms of Chapter 7 of NEM: BA (Act No. 10 of 2004).

- Such activities include any that are “of a nature that may negatively impact on the survival of a listed threatened or protected species”.

1.3 Scope of work

1.3.1 Watercourse Assessment

The scope of work entailed to the Watercourse Assessment following:

- Identify and delineate any wetland, channel areas and/or watercourses associated within the study boundary according to the Department of Water Affairs’ “Practical field procedure for the identification and delineation of wetlands and riparian areas”;
- Determine the Present Ecological Status (PES) and Functional Integrity of identified wetlands and streams within a 500 m buffer around the proposed Tiara mine and infrastructure using Department Water and Sanitatation guidlines;
- Provide recommended mitigation measures for the construction and operational phase impacts of the proposed mine in order to avert or lower the significance of the negative impacts on the delineated watercourses; and
- Indicate the minimum buffer required to protect any wetland/ channels and streams identified within the study boundary.

1.3.2 Ecological Assessment

The scope of work entailed to the Biodiversity Assessment following:

- An examination of onsite and SANBI GIS databases on Endemic and Red Data faunal and floral species in the study area;
- A literature search on Red Data Book species predicted to occur in the study area;
- Identify potential negative impacts on any biodiversity from the mining areas and assess the significance of these impacts;
- Provide recommended mitigation measures for the identified impacts in order to avert or lower the significance of the negative impacts; and
- Identify any sensitive areas.

1.4 Assumptions and Limitations

It is difficult to apply pure scientific methods within a natural environment without limitations, and consequential assumptions need to be made. The following constraints may have affected this assessment:

- A hand-held Garmin eTrex 30 were used to delineate the watercourses had an accuracy of 3 m to 6 m
- The findings, results, observations, conclusions and recommendations provided in this report are based on the author's best scientific and professional knowledge as well as available information regarding the perceived impacts on the watercourses and biodiversity; and
- The assessment in determining the present ecological state (PES) of the identified system was based on a single site visit. Site visits should ideally be conducted over differing seasons in order to better understand the vegetation, hydrological and geomorphologic processes driving the characteristics of the watercourse. In order to obtain a comprehensive understanding of the dynamics of the aquatic ecosystem in an area, ecological assessments should always consider investigations at different time scales (across seasons/years) and through replication, as river systems are in constant change; and
- The watercourse management and rehabilitation plan will need to be updated as more information about the dynamics of the system and its response to the implemented management measures are observed over time.
- **It is important to note that although this report describes the regional vegetation, vegetation previously recorded for the area (POSA) and the conservation status of the project area, where majority of the areas are private land, therefore limiting access to them.**

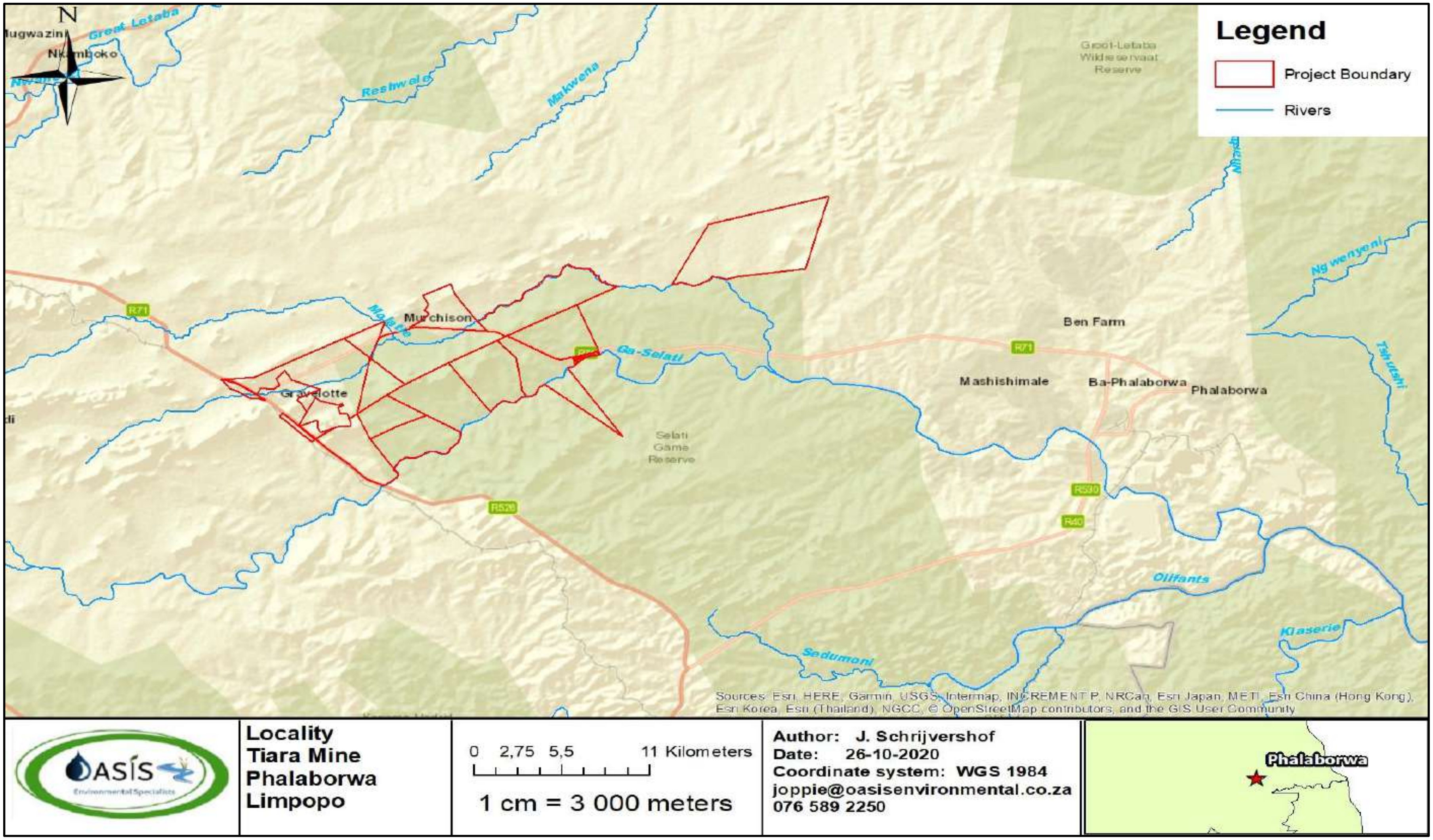

Figure 1: Locality of proposed Tiara Mine near Phalaborwa in the Limpopo Province.

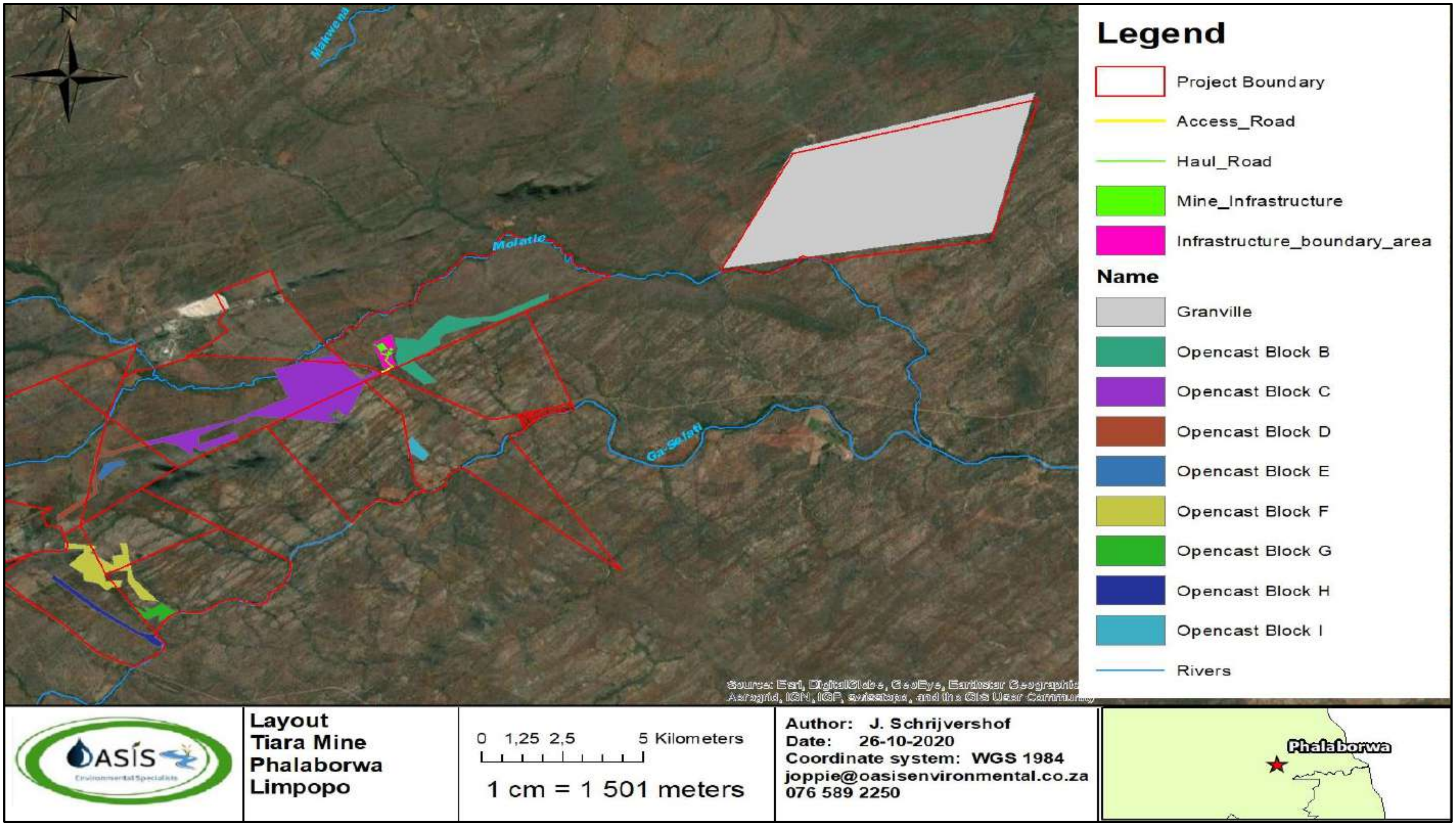

Figure 2: Layout of the proposed Tiara Mine

2 METHODOLOGY

This section details the different techniques and methods utilised to obtain the data for this report in order to finally assess the watercourse conditions of the site based on the various inputs explained below.

2.1 Aquatic Assessment

2.1.1 ***In situ* Water Quality**

The physical and chemical properties of water that determine its suitability for a variety of uses and for the protection of the health and integrity of aquatic ecosystems refers to the quality of water (DWAF, 1996). The various water quality parameters were all taken *in situ*. These parameters include pH, temperature (°C), electrical conductivity (µS/cm), and dissolved oxygen (DO % and mg/L) using calibrated water quality meters. These values were measured using an Aquameter (model no AM-200) and Aquaprobe (model no AM-800). These parameters were compared to guidelines of the Target Water Quality Ranges (TWQRs) for aquatic ecosystems of South Africa.

2.1.2 **Intermediate Habitat Integrity Assessment (IHIA)**

Habitat was assessed and characterised according to section D of the "Procedure for Rapid Determination of Resource Directed Measures for River Ecosystems, (Kemper, 1999)".

The Intermediate Habitat Integrity Assessment (IHIA) model was used to assess the integrity of the habitats from a riparian and in-stream perspective. The habitat integrity of a river refers to the maintenance of a balanced composition of physico-chemical and habitat characteristics on a temporal and spatial scale that are comparable to the characteristics of natural habitats of the region (Kleynhans 1996). The criteria used in the assessment of habitat integrity for the current study are presented in the table below (**Table 1**).

Table 1: Criteria used in the assessment of habitat integrity (Kleynhans, 1996).

Criterion	Relevance
Water abstraction	Direct impact on habitat type, abundance and size. Implicated in flow, bed, channel and water quality characteristics. Riparian vegetation may be influenced by a decrease in the supply of water.
Flow modification	Consequence of abstraction or regulation by impoundments. Changes in temporal and spatial characteristics of flow have an impact on habitat attributes such as an increase in duration of low flow season, resulting in low availability of certain habitat types or water at the start of the breeding, flowering or growing season.
Bed modification	Regarded as the result of increased sediment from the catchment or a decrease in the ability of the river to transport sediment (Gordon *et al*., 1993). Indirect indications of sedimentation are stream bank and catchment erosion. Purposeful alteration of the stream bed, e.g. the removal of rapids for navigation (Hilden & Rapport, 1993) is also included.
Channel modification	May be the result of a change in flow, which can alter channel characteristics causing a change in marginal instream and riparian habitat. Purposeful channel modification to improve drainage is also included.
Water quality modification	Originates from point and diffuse point sources. Measured directly or derived based on agricultural activities, human settlements and industrial activities may indicate the likelihood of modification. Aggravated by a decrease in the volume of water during low or no flow conditions.
Inundation	Destruction of riffle, rapid and riparian zone habitat. Obstruction to the movement of aquatic fauna and influences water quality and the movement of sediments (Gordon *et al*., 1992).
Exotic macrophytes	Alteration of habitat by obstruction of flow and may influence water quality. This is dependent upon the species involved and scale of colonisation.
Exotic aquatic fauna	The disturbance of the stream bottom during feeding may influence the water quality and increase turbidity. Dependent upon the species involved and their abundance.

Criterion	Relevance
Solid waste disposal	A direct anthropogenic impact which alters habitat structurally. A general indication of the misuse and mismanagement of the river.
Indigenous vegetation removal	Impairment of the buffer the vegetation forms to the movement of sediment and other catchment runoff products into the river (Gordon *et al*., 1992). Refers to physical removal for farming, firewood and overgrazing.
Exotic vegetation encroachment	Excludes natural vegetation due to vigorous growth, causing bank instability and decreasing the buffering function of the riparian zone. Allochtonous[1] organic matter input will be changed. Riparian zone habitat diversity is reduced.
Bank erosion	Decrease in bank stability will cause sedimentation and possible collapse of the river bank resulting in a loss or modification of both instream and riparian habitats. Increased erosion can be the result of natural vegetation removal, overgrazing or exotic vegetation encroachment.

The relevant criteria are then weighted and scored according to Kleynhans (1996), as seen in **Table 2**.

[1] denoting a deposit or formation that originated at a distance from its present position.

Table 2: Descriptive classes for the assessment of modifications to habitat integrity (Kleynhans, 1996).

Impact Category	Description	Score
None	No discernible impact or the modification is located in such a way that it has no impact on habitat quality, diversity, size and variability.	0
Small	The modification is limited to very few localities and the impact on habitat quality, diversity, size and variability are also very small.	1-5
Moderate	The modifications are present at a small number of localities and the impact on habitat quality, diversity, size and variability are also limited.	6-10
Large	The modification is generally present with a clearly detrimental impact on habitat quality, diversity, size and variability. Large areas are, however, not influenced.	11-15
Serious	The modification is frequently present and the habitat quality, diversity, size and variability in almost the whole of the defined area are affected. Only small areas are not influenced.	16-20
Critical	The modification is present overall with a high intensity. The habitat quality, diversity, size and variability in almost the whole of the defined section are influenced detrimentally.	21-25

Table 3: Criteria and weights used for the assessment of habitat integrity (Kleynhans, 1996).

Instream Criteria	Weight	Riparian Zone Criteria	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste disposal	6		
TOTAL	**100**	**TOTAL**	**100**

Scores are then calculated based on ratings received from the assessment. The estimated impacts of the criteria (**Table 3**) are then summed and expressed as a percentage to arrive at a provisional habitat integrity assessment. The scores are placed into the Intermediate habitat integrity categories (Kleynhans, 1996) as seen in **Table 4**.

Table 4: Ecological categories classes (Kleynhans, 1996).

Category	Description	Score
A	Unmodified, natural.	90-100
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.	80-90
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.	60-79
D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions has occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the lotic 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.	0

2.1.3 Riparian Vegetation Response Assessment Index (VEGRAI)

Riparian vegetation areas are divided into two sub-zones, marginal and non-marginal zones. This is important given that riparian vegetation distribution and species composition varies in different sub-zones, which has implications for flow-related impacts. The EC of the riparian zone is then assessed using the Riparian Vegetation Response Assessment Index (VEGRAI) level 3 (Kleynhans *et al*., 2007).

Since all VEGRAI assessments are relative to the natural unmodified conditions (reference state) it is necessary and important to define and describe the reference state for the study area. This is done (in part) before going into the field, using historic aerial imagery, present and historic species distributions, general vegetation descriptions of the study area, any anecdotal data available and knowledge of the area and comparison of the study area characteristics to other comparable sections of the stream that might be in a better state. With this information, the reference (and present state) is quantified on site; the assessor reconstructs and quantifies the reference state from the present state by understanding how visible impacts have caused the vegetation to change and respond. Impacts on riparian vegetation at the site are then described and rated. It is important to distinguish between a visible / known impact (such as flow manipulation) and the response of riparian vegetation to other impacts such as erosion and sedimentation, alien invasive species and pollution. If there is no response to riparian vegetation, the impact is noted but not rated since it has no visible / known effect. These impacts are then rated according to a scale from 0 (No Impact) to 5 (Critical Impact). Once the riparian zone and sub- zones have been delineated, the reference and present states have been described and quantified (basal cover is used) and species description for the study area has been compiled, the VEGRAI metrics are rated and qualified (Kleynhans *et al*., 2007).

The riparian ecological integrity was assessed using the spreadsheet tool that is composed of a series of metrics and metric groups, each of which is rated <u>in the field</u> with the guidance of data collection sheets. The metrics in VEGRAI describe the following attributes associated with both the woody and non-woody components of the lower and upper zones of the riparian zone:

- Removal of the riparian vegetation;
- Invasion by alien invasive species;
- Flow modification; and
- Impacts on water quality.

Results from the lower and upper zones of the riparian vegetation are then combined and weighted with a value that reflects the perceived importance of that particular criterion in determining habitat integrity, allowing this to be numerically expressed in relation to the perceived benchmark. The score is then placed into one of six classes, namely A to F (Kleynhans *et al*., 2007).

2.1.4 Macroinvertebrates

2.1.4.1 The South African Scoring System (SASS 5)

The SASS5 is the current index used to assess the status of riverine macroinvertebrates in South Africa. According to Dickens and Graham (2002), the index is based on the presence of aquatic invertebrate families and the perceived sensitivity to water quality changes of these families. Different families exhibit different sensitivities to pollution, these sensitivities range from highly tolerant families (e.g. Chironomidae and Culicidae) to highly sensitive families (e.g. Oligoneuridae). SASS results are expressed both as an index score (SASS score) and the Average Score Per recorded Taxon (ASPT value). Sampled invertebrates were identified using the "Aquatic Invertebrates of South African Rivers" Illustrations book, by Gerber and Gabriel (2002). Identification of organisms was made to family level (Thirion, 2007; Dickens & Graham, 2002; Gerber & Gabriel, 2002).

All SASS5 and ASPT scores are compared with the SASS5 Data Interpretation Guidelines (Dallas, 2007) for the Lowveld Ecoregion (**Figure 3**). This method seeks to develop biological bands depicting the various ecological states and is derived from data contained within the Rivers Database and supplemented with other data not yet in the database.

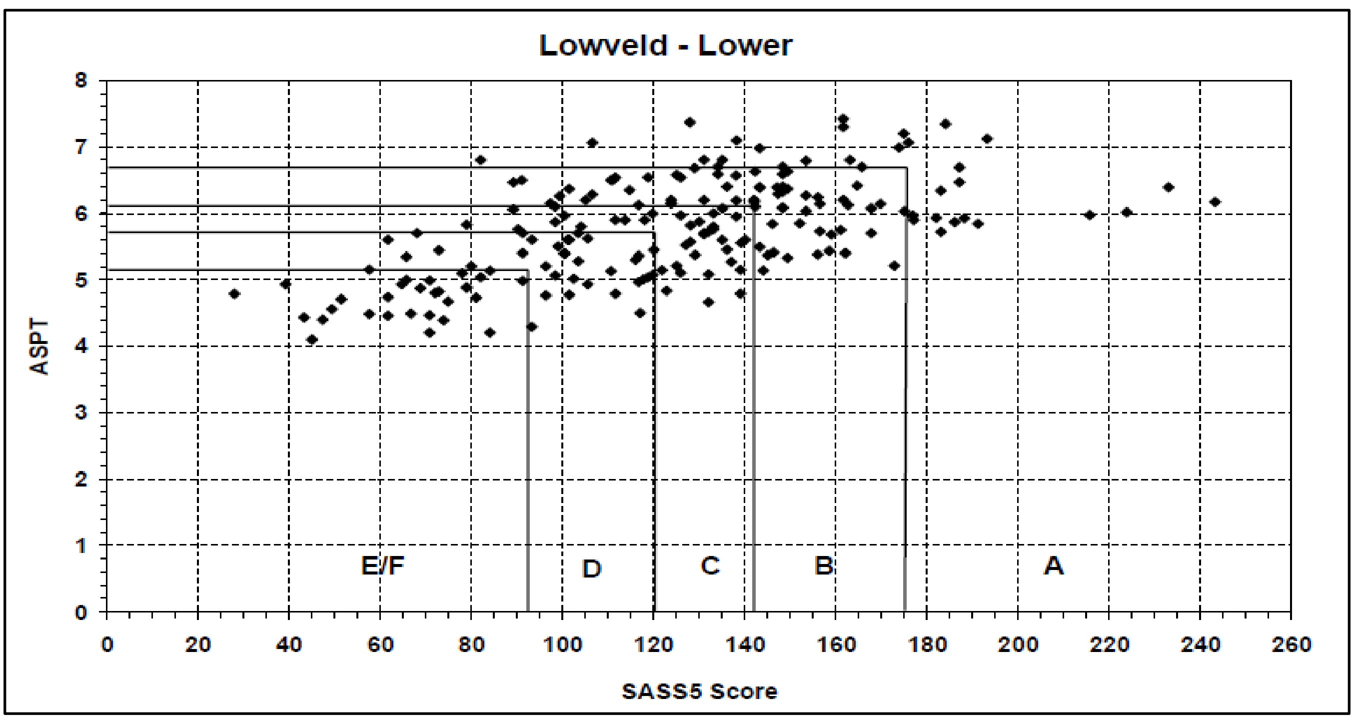

Figure 3: SASS5 Classification using biological bands calculated from percentiles from Dallas (2007) for the Lowveld Ecoregion.

2.1.4.2 **Invertebrate Habitat Assessment System (IHAS)**

The IHAS was specifically designed to be used in conjunction with the SASS5, benthic macroinvertebrate assessment. The IHAS assesses the availability of the biotopes at each site and expresses the availability and suitability of habitat for macroinvertebrates, this is determined as a percentage, where 100% represents "ideal" habitat availability. A description based on the IHAS percentage scores is presented in **Table 5**.

Table 5: Description of IHAS scores with the respective percentage category (McMillan, 1998).

IHAS score	Interpretation
<65%	Habitat diversity and structure is inadequate for supporting a diverse aquatic invertebrate community.
65%-75%	Habitat diversity and structure is adequate for supporting a diverse aquatic invertebrate community.
>75%	Habitat diversity and structure is highly suited for supporting a diverse aquatic invertebrate community.

2.2 Channel Delineation

Riparian areas were delineated based on topographic setting, vegetative indicators as well as the presence or absence of alluvial soils as described in ‘A Practical Field Procedure for Identification and Delineation of Channel and river and Riparian Areas – Edition 1’ (DWAF, 2005) requirements. This manual separates the classification of watercourses into three (3) separate types of channels or sections defined by their position relative to the zone of saturation in the riparian area (**Figure 4**). The classification system separates channels into: those that do not have baseflow (‘A’ Sections); those that sometimes have baseflow (‘B’ Sections) or non-perennial are those that always have baseflow (‘C’ Sections) or perennial. ‘A’ Section channels convey surface runoff immediately after a storm event and are not associated with a riparian zone. ‘B’ Section channels are categorised as channels that sometimes have baseflow, dependant on rainfall events and are therefore non-perennial. They are in contact with the zone of saturation often enough to have vegetation associated with saturated conditions as well as gleyed soil within the channel confines. ‘B’ Section channels are considered hydrologically sensitive as they are associated with riparian habitats.

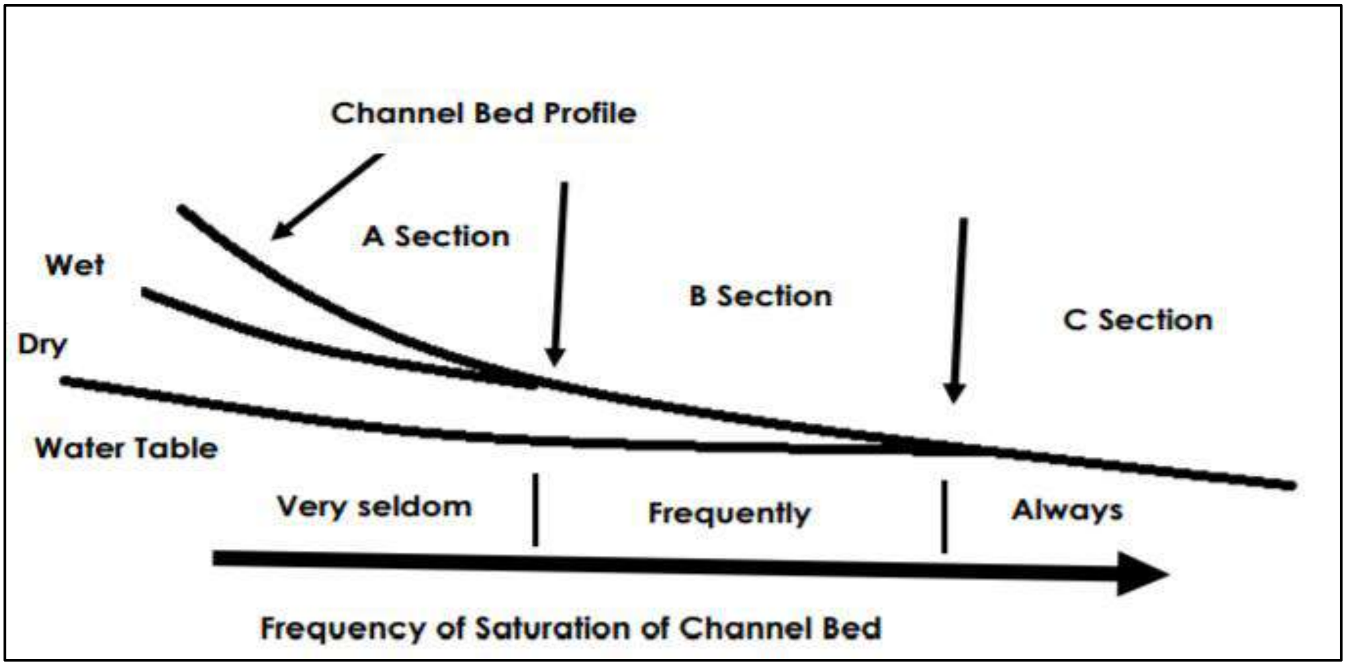

Figure 4: Different zones of wetness found in channels (DWAF, 2005).

Riparian areas perform numerous vital functions including the protection and enhancement of water resources through the following resources:

- Aiding in the storage of water and flood prevention;
- Stabilising stream banks;
- Improving water quality by trapping sediment and nutrients;
- Maintaining natural water temperatures for aquatic species;
- Providing foraging and roosting habitats for birds and other animals;
- Providing corridors for dispersal and migration of different species; and
- Acting as a buffer between aquatic ecosystems and adjacent land uses.

2.3 Risk Assessment to Watercourses

The risk assessment was conducted in accordance with the DWS risk-based water use authorisation approach and delegation guidelines.

The matrix assesses impacts in terms of consequence and likelihood. Consequence is calculated based on the following formula:

Consequence = Severity + Spatial Scale + Duration

Whereas likelihood is calculated as:

Likelihood=Frequency of Activity + Frequency of Incident +Legal Issues + Detection.

Significance is calculated as:

Significance \Risk= Consequence x Likelihood.

Each metric of the severity (flow regime, water quality, geomorphology, biota and habitat) and spatial scale, duration, frequency of the activity, frequency of the incident/impact and detection are rated to a 1 to 5 scale (GNR 509, of the National Water Act, 1998 (Act No. 36 of 1998) for Water Uses as Defined in Section 21(C) or Section 21(I), 2016).

The score is then placed into one of the three classes, with low risks to the watercourse will qualify for a General Authorisation (GA). Medium and high risk activities will require a Section 21(C) and (I) water use licence as per the National Water Act of 1998 (**Table 6**).

Table 6: Significance of the Section 21 C and I ratings matrix as prescribed by the National Water Act 1998 (Act No. 36).

Rating	Class	Management Description
1 – 55	(L) Low Risk	Acceptable as is or consider requirement for mitigation. Impact to watercourses and resource quality small and easily mitigated. Channel and rivers may be excluded.
56 – 169	M) Moderate Risk	Risk and impact on watercourses are notably and require mitigation measures on a higher level, which costs more and require specialist input.
170 – 300	(H) High Risk	Always involves channel and rivers. Watercourse(s) impacts by the activity are such that they impose a long-term threat on a large scale and lowering of the Reserve.

2.4 Ecological Desktop Assessment

It is important to note that many parts of South Africa contain high levels of biodiversity at species and ecosystem level. At any single site there may be large numbers of species or high ecological complexity. Sites also vary in their natural character and uniqueness and the level to which they have previously been disturbed. Assessing the impacts of the mine often requires evaluating the conservation value of the site relative to other natural areas in the surrounding area. Thus, the general approach and angle adopted for this type of study is to identify any potential faunal species that may be affected by the mine. This means that the focus of this report will be on rare, threatened, protected and conservation-worthy species.

Biodiversity issues are assessed by documenting whether any important biodiversity features occur on site, including species, ecosystems or processes that maintain ecosystems and/or species. Rare, threatened, protected and conservation-worthy species and habitats are considered to be the highest priority, the presence of which is most likely to result in significant negative impacts on the ecological environment. The focus on national and provincial priorities and critical biodiversity issues is in line with National Legislation protecting environmental and biodiversity resources.

A desktop assessment was conducted to establish whether any potentially sensitive species/receptors might occur within the study area. The South African National Biodiversity Institute's online biodiversity tool, ADU (Animal Demography Unit) Virtual Museum was used to query a faunal species list (**Appendix A**) for the 2330 DC and 2330 DD Quarter Degree Squares (QDS) within which the study area is situated.

The South African National Biodiversity Institute's (SANBI) online biodiversity tool POSA (Plants of South Africa) was used to query floral species lists (**Appendix B**) for the area surrounding the project site. This was supplemented by researching all available books and peer reviewed websites.

The importance of a baseline study is to provide a reference condition to determine the current state of the environment and to draw comparisons between the potential of the area and current degradation from surrounding land uses. Aerial photographs and satellite imagery were used to delineate potential sensitive ecosystems or vegetation types and these areas were the focus during the field assessment.

To describe the overall site characteristics, and to identify points of interest within the site for evaluation, Google Earth Imagery and the 1:50 000 topographical maps were examined.

This was conducted by researching all available information resources including, but not limited to, the following:

- International Union for Conservation of Nature (IUCN) Red List of Threatened Species;
- The Endangered Wildlife Trust's Red List of Mammals of South Africa, Lesotho and Swaziland; and
- NEMBA List of Threatened or Protected Species (TOPS List);
- Animal Demography Unit (ADU) Virtual Museum;

- SANBI Biodiversity GIS tool; and
- Important Bird and Biodiversity Areas (IBAs) (Birdlife South Africa, 2020).

Biodiversity areas represent terrestrial and aquatic sites identified as Critical Biodiversity Areas (CBAs), Ecological Support Areas (ESA), Other Natural Areas and No Natural Remaining Areas conducted by SANBI.

2.4.1 **Critical Biodiversity Areas**

Critical Biodiversity Areas are those areas required to meet biodiversity thresholds. CBA's are areas of terrestrial or aquatic features (or riparian vegetation alongside CBA aquatic features) which must be protected in their natural state to maintain biodiversity and ecosystem functioning (Desmet *et al*., 2013). According to Desmet *et al* (2013), these CBAs include:

i) Areas that need to be protected in order to meet national biodiversity pattern thresholds (target area);

ii) Areas required to ensure the continued existence and functioning of species and ecosystems (including the delivery of ecosystem services); and/or

iii) Important locations for biodiversity features or rare species.

2.4.2 **Ecological Support Areas**

Ecological Support Areas (ESA) are supporting zones required to prevent the degradation of Critical Biodiversity Areas and Protected Areas. An ESA may include an aquatic or terrestrial feature. ESAs can be further subdivided into Critical Ecological Support Areas (CESA) and Other Ecological Support Areas (OESA). Critical Ecological Support Areas are aquatic features, with their terrestrial buffers, which fall within priority sub-catchments, whose protection is required in order to support the aquatic and terrestrial CBAs. An example might be a river reach which feeds directly into a CBA. Other Ecological Support Areas are all remaining aquatic ecosystems (not classed as CESA or CBA), with their terrestrial buffers, which have a less direct impact on the CBA, e.g. a channel and river that is geographically isolated from a CBA, but contributes to ecological processes such as groundwater recharge, thereby indirectly impacting on a CBA downstream. (Desmet *et al.*, 2010).

2.4.3 **Other Natural Areas**

Other Natural Areas are areas of lesser biodiversity importance whose protection is not required in order to meet national biodiversity thresholds. Other Natural Areas may withstand some loss in terms of biodiversity through the conversion of their natural state for development. However, if all Critical Biodiversity Areas are not protected, certain Other Natural Areas will need to be reclassified as Critical Biodiversity Areas in order to meet thresholds. (Desmet *et al.*, 2010).

No Natural Remaining Areas are those areas that have been irreversibly transformed through urban development, plantation and agriculture and poor land management. As a result, these areas no longer contribute to the biodiversity of the region. However, in some cases transformed land may be classified as an ESA or CBA if they still support biodiversity (Desmet *et al.,* 2010).

2.4.4 **Threatened Ecosystems**

Ecosystem threat status outlines the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition, on which their ability to provide ecosystem services ultimately depends (Driver *et al*., 2012). Ecosystem types are categorised as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), based on the proportion of each ecosystem type that remains in good ecological condition (Driver *et al*., 2012).

2.4.5 **Important Bird Areas**

Important Bird Areas are areas that are important for the long-term survival of threatened, restricted avian species (Birdlife South Africa, 2020). BirdLife's Important Bird and Biodiversity Area concept has been developed and applied for over 30 years. Considerable effort has been devoted to refining and agreeing a set of simple but robust criteria that can be applied worldwide.

Important Bird and Biodiversity Areas (IBAs) are:

- Places of international significance for the conservation of birds and other biodiversity;
- Recognised world-wide as practical tools for conservation;
- Distinct areas amenable to practical conservation action;
- Identified using robust, standardised criteria; and
- Sites that together form part of a wider integrated approach to the conservation and sustainable use of the natural environment.

2.5 Vegetation Assessment

A comprehensive study was carried out to document all species recorded in the area and to predict vegetation characteristics. This was augmented by a site visit and comprised of the following:

A walkover field survey of the site verifying the presence or absence of species predicted to occur on the site included:

i. Identification and location of keystone or indicator species that may be impacted;
ii. Identify important habitats, including channel and rivers, grasslands and savanah;
iii. Identify areas of conservation and/or ecological importance;
iv. Consider invasive alien plant status and rehabilitation potential of natural areas; and
v. An overall condition of the vegetation found in the area, including an assessment of cover and vegetation structure and were classified as vegetation communities.

2.5.1 **Conservation priority and Sensitivity**

The vegetation types were evaluated in terms of conservation priority according to the following categories:

- **High:** Ecologically sensitive and valuable land with high species richness and/or sensitive ecosystems and/or red data species that should be conserved. No development is to be allowed.
- **Medium-high:** Land that is partially disturbed but that is generally ecologically sensitive to development / disturbances.
- **Medium:** Land on which developments with a limited / low impact on the vegetation / ecosystem can be considered. It is recommended that certain portions of the natural vegetation be maintained in open spaces.
- **Medium-low:** Land of which small sections could be considered to be conserved, but where the area in general has little conservation value.
- **Low:** Land that has little conservation value where development will have an insignificant or no impact on the vegetation.

Sensitivity Areas that are of High and Medium-high conservation priority are regarded as High sensitivity areas in which developments should not be allowed

Areas that fall in the Medium, Medium-low and Low conservation priority categories are regarded as Low sensitivity areas in which development may be allowed.

Areas where other environmental factors such as high erodibility and steep slopes that play a significant role are regarded as Moderate sensitivity areas. Developments can be allowed in these areas if suitable mitigation measures can be implemented.

2.5.2 **Alien Invasive Plants**

Invasive alien plants are described as species which are 'non-indigenous' to an area and which have been introduced from other countries either intentionally (for domestic or commercial use) or accidentally; furthermore, they have the ability to reproduce and spread without the direct assistance of people into natural or semi-natural habitats and are destructive to biodiversity and human interests (WESSA-KZN, 2008).

Notice 3 of the National Environmental Management: Biodiversity Act 2004 (Act No, 10 of 2004) lists 379 plant species that are legally declared invasive species. Each species is assigned to one of three categories based on the level of threat posed by the species and the legal status assigned to each:

- **Category 1a –** Plant species that must be combatted or eradicated.
- **Category 1b –** Plant species that must be controlled.
- **Category 2 –** Plant species that must not be allowed to spread outside any property.
- **Category 3 –** Plant species that when occurring in riparian areas must be considered to be category 1b Listed Invasive Species and must be managed according to regulation 3 of NEM:BA, 2014

Please review NEMBA (Act 10 of 2004) for details on these species.

2.6 Faunal Assessment

2.6.1 **Avifaunal assessment**

Generally, when predicting the impacts of the mine on birds, a combination of science, field experience and knowledge from the specialist is required. More specifically the methodology used to predict impacts of the mine was as follows:

- The various data sets discussed above under "sources of information", were collected/collated and examined with the aim of determining the focal species for this study.
- The data were examined to determine the location and abundance of species which may be susceptible to impacts from the mine including both Red Data and non-Red Data.
- The broader study area was visited during a day long site visit. The site was thoroughly traversed to obtain a first-

hand perspective of the mine, and to determine which bird micro habitats are present within the study site. This involved walking, taking photographs, and the use of bird call playbacks to identify bird life present within the study area. Further to this, the observation of feathers and nests were used as species identification tools.

- All opportunist sightings were recorded throughout the study area.
- Avian micro-habitats and sensitive habitats for avifaunal communities were identified and mapped.
- The impacts of the mine on the avifaunal populations were then predicted by analysing data on impacts on wildlife around mining areas throughout South Africa.

2.6.2 **Faunal assessment**

The faunal investigation was focused on mammals, reptiles and amphibians. The following methodology was applied:

- The data sets discussed above under “sources of information” were collected/collated and examined to determine the focus species for this study;
- The data was examined to determine the possible occurrence of any Red Data and non-Red Data species;
- The site was comprehensively assessed during a field investigation to determine fauna and faunal micro habitats present within the site. This included:
    - All animals (mammals, reptiles and amphibians) seen or heard; were recorded.
    - Use was also made of indirect evidence such as animal tracks (footprints, droppings and various burrow types) to identify animals.
    - The majority of amphibians identified were calling adults as well as incidentally observed adults (under rocks, logs etc).
    - Reptiles were actively searched for under suitable refuges such as loosely embedded flat rocks, logs and stumps and identified by actual specimens observed.
- Information was supplemented by historical records, personal accounts from residents within the study area and a comprehensive literature review; and
- The impacts of the mine on faunal species were predicted and mitigation measures were proposed.

2.7 Significance of Identified Impacts on Biodiversity

Significance scoring assesses and predicts the significance of environmental impacts through evaluation of the following factors; probability of the impact; duration of the impact; extent of the impact; and magnitude of the impact. The significance of environmental impacts is then assessed considering any proposed mitigations. The significance of the impact "without mitigation" is the prime determinant of the nature and degree of mitigation required. Each of the above impact factors have been used to assess each potential impact using ranking scales as seen in **Table 7**.

Impact scores given "with mitigation" are based on the assumption that the mitigation measures recommended in this assessment are implemented correctly and rehabilitation of the site is undertaken. Failure to implement mitigation measures during operation will keep impacts at an unacceptably high level.

Unknown parameters are given the highest score (5) as significance scoring follows the Precautionary Principle. The Precautionary Principle is based on the following statement: *When the information available to an evaluator is uncertain as to whether or not the impact of the mine on the environment will be adverse, the evaluator must accept as a matter of precaution, that the impact will be detrimental*. It is a test to determine the acceptability of the mine. It enables the evaluator to determine whether enough information is available to ensure that a reliable decision can be made.

Table 7: Significance scoring used for each potential impact.

Probability	Duration
1 - very improbable	1 - very short duration (0-1years)
2 - improbable	2- short duration (2-5 years)
3 - probable	3 - medium term (5-15 years)
4 - highly probable	4 - long term (>15 years)
5 - definite	5 - permanent/unknown
Extent	**Magnitude**
1 - limited to the site	2 – minor
2 - limited to the local area	4 – low
3 - limited to the region	6 – moderate
4 - national	8 – high
5 - international	10 – very high

Significance Points = (Magnitude + Duration + Extent) x Probability. The maximum value is 100 Significance Points.

Potential Environmental Impacts are rated as high, moderate or low significance as per the following:

<30 significance points = Low environmental significance

31-59 significance points = Moderate environmental significance

>60 significance points = High environmental significance

3 BACKGROUND INFORMATION

3.1 Vegetation

The vegetation along the mining boundaries for this project is diverse and includes three different veld types namely (**Figure 5**): Phalaborwa-Timbavati Mopaneveld (SVmp 7), Granite Lowveld (SVl 3) and the Gravelotte Rocky Bushveld (SVl 7) (Mucina and Rutherford, 2006).

Phalaborwa-Timbavati Mopaneveld

Previously this vegetation unit (altitude from 300 to 600 m) formed part of the larger Arid Lowveld (Acocks, 1953) and more recently is was referred to as the Mopane Bushveld (Low and Rebelo, 1996). The vegetation unit is found in the Limpopo and Mpumalanga Provinces in a band about 40 km west and east of Phalaborwa and south of the Olifants River on the boundary between the Timbavati Game Reserve and the Kruger National Park, including parts of the Umbabat and Klaserie Nature Reserves (Mucina and Rutherford, 2006).

When looking at the broad **vegetation and** landscape pattern it is known for the open tree savannah on undulating plains with the sandy uplands dominated by *Combretum apiculatum*, *Terminalia sericea* and *Colophospermum mopane* trees. The *T. sericea* disappears and *Combretum apiculatum* becomes less common in the clayey bottomlands where it is replaced by mainly *Senegalia nigrescens* and with an increased dominance of *Colophospermum mopane*. Apart from the well-developed field layer the northern section of this unit is famous for the large number of termite mounds on the uplands areas (Mucina and Rutherford, 2006).

The **geology and soils** are dominated by the Quartz-feldspar rocks of the Makhutswi Gneiss (Swazian) with intrusions of the Lekkersmaak Granite (Randian) in the northwest and sandy soils (usually less than 10% clay in the A-horizon) on the uplands (e.g. Clovelly soil form) and clay soils in the bottomlands (e.g. Valsrivier and Sterkspruit soil forms) (Mucina and Rutherford, 2006).

As with the other vegetation units, the **climate** of this community forms part of summer rainfall region with very dry, frost free winters and an average rainfall of 400–600 mm. the mean monthly maximum and minimum temperatures for Phalaborwa range between 38.4°C and 5.7°C for January and July (Mucina and Rutherford, 2006).

The **conservation** status for the unit is “least threatened” with 38% of the targeted 19% statutorily conserved in the Kruger National Park and the rest in the Selati Game Reserve and Umbabat, Timbavati, Klaserie Nature Reserves Target. About 5% has been transformed, mainly by development of human settlements and mining (Mucina and Rutherford, 2006).

Granite Lowveld

This unit (altitude 250 – 700 m) previously were known as the Arid Lowveld and the Lowveld (Acocks, 1953) and later as the Mixed Lowveld Bushveld (Low and Rebelo, 1996) and is mainly found in the Limpopo and Mpumalanga Provinces with pockets in Swaziland and KwaZulu-Natal. The north-south belt on the plains east of the escarpment from Thohoyandou in the north, interrupted in the Bolobedu area, continued in the Bitavi area, with an eastward extension on the plains around the Murchison

Range and southwards to Abel Erasmus Pass, Mica and Hoedspruit areas to the area east of Bushbuckridge. Substantial parts are found in the Kruger National Park spanning areas east of Orpen Camp southwards through Skukuza and Mkuhlu, including undulating terrain west of Skukuza to the basin of the Mbyamiti River (Mucina and Rutherford, 2006).

It continues further southward to the Hectorspruit area with a narrow westward extension up the Crocodile River Valley past Malelane, Kaapmuiden and the Kaap River Valley, entering Swaziland between Jeppe's Reef in the west and the Komati River in the east, through to the area between Manzini and Siphofaneni, including the Grand Valley, narrowing irregularly and marginally entering KwaZulu-Natal near Pongola (Mucina and Rutherford, 2006). The tall shrubland with few trees to moderately dense low woodland on the deep sandy uplands is the characteristic **vegetation and landscape** with *Terminalia sericea*, *Combretum zeyheri* and *C. apiculatum* forming the tree layer. The ground layer is dominated by *Pogonarthria squarrosa*, *Tricholaena monachne* and *Eragrostis rigidior* and the dense thicket to open savanna in the bottomlands are known for the *Senegalia nigrescens*, *Dichrostachys cinerea* and *Grewia bicolor* in the woody layer (Mucina and Rutherford, 2006). The dense herbaceous layer contains the dominant *Digitaria eriantha*, *Panicum maximum* and *Aristida congesta* on fine-textured soils, while brackish bottomlands support *Sporobolus nitens*, *Urochloa mosambicensis* and *Chloris virgata*. At seep lines, where convex topography changes to concave, a dense fringe of *Terminalia sericea* occurs with *Eragrostis gummiflua* in the undergrowth (Mucina and Rutherford, 2006).

As for the **geology and soils**, it is dominated by the Swazian Goudplaats Gneiss, Makhutswi Gneiss and Nelspruit Suite (granite gneiss and migmatite - north to south) with the younger Mpuluzi Granite (Randian) form the major basement geology further south. In this unit, the Archaean granite and gneiss weathered into sandy soils in the uplands and clayey soils with high sodium content in the lowlands (Mucina and Rutherford, 2006).

Climatically the unit is part of the summer rainfall region with frost-free, dry winters and an average rainfall that varies from 450 mm on the eastern flats to 900 mm near the escarpment in the west, with a north-south average peak in Swaziland. The mean monthly maximum and minimum temperatures for Skukuza 39.5°C and –0.1°C for January and June and corresponding values for is Hoedspruit 38.0°C and 3.7°C for January and July (Mucina and Rutherford, 2006).

This vegetation unit is classes as “vulnerable” (**conservation status**) with only 17% of the targeted 19% statutorily conserved in the Kruger National Park and a similar percentage is conserved in private reserves mainly the Selati, Klaserie, Timbavati, Mala Mala, Sabi Sand and Manyeleti Reserves. More than 20% already transformed as a result of cultivation and by settlement development and the area is having a very low to moderate erosion potential (Mucina and Rutherford, 2006).

<u>Gravelotte Rocky Bushveld</u>

Previously referred to as the Arid Lowveld (Acocks, 1953) and the Mixed Lowveld Bushveld (Low and Rebelo, 1996), this unit is found in the Murchison Range neat Gravelotte and include surrounding mountains and hills (e.g. Ga-Mashishimale north of Mica and Seribana) and extending northwards towards Thohoyandou (e.g. hills including Mangombe and Sionwe). The altitude ranges between 450 and 950 m with the highest peaks reaching 1 025 m (Mucina and Rutherford, 2006).

The **vegetation and landscape** is featured by the open deciduous to semi deciduous woodland on rocky slopes and inselbergs that contrasts strongly with the surrounding plains (Mucina and Rutherford, 2006). The varied **geology and soils** is largely composed of schist and amphibolite of the Gravelotte and Giyani Groups, with a few quartzitic and granitic hills with shallow soils (Glenrosa and Mispah forms most common) (Mucina and Rutherford, 2006).

As is the case with the other units, this vegetation type **climate** is associated with the summer rainfall region where infrequent frost occur during the dry winters. The mean annual precipitation ranges 500 mm in the east to 900 mm in the west with the higher rainfall on the higher mountains (Mucina and Rutherford, 2006).

With regard to its **conservation** status, this vegetation unit is listed as “least threatened” with a target set at 19% for formal conservation. However, no parts are conserved in statutory conservation areas with only approximately 7% that is protected in the northern part of the Selati Game Reserve. Conservation of this unit is promoted due to the land use of game and cattle ranching and due to its low agronomic potential. Of the total unit area, more than 15% is transformed as a result of cultivation and settlements. The erosion potential is considered to be very low to moderate (Mucina and Rutherford, 2006), but is higher were slopes are exposed (Mucina and Rutherford, 2006).

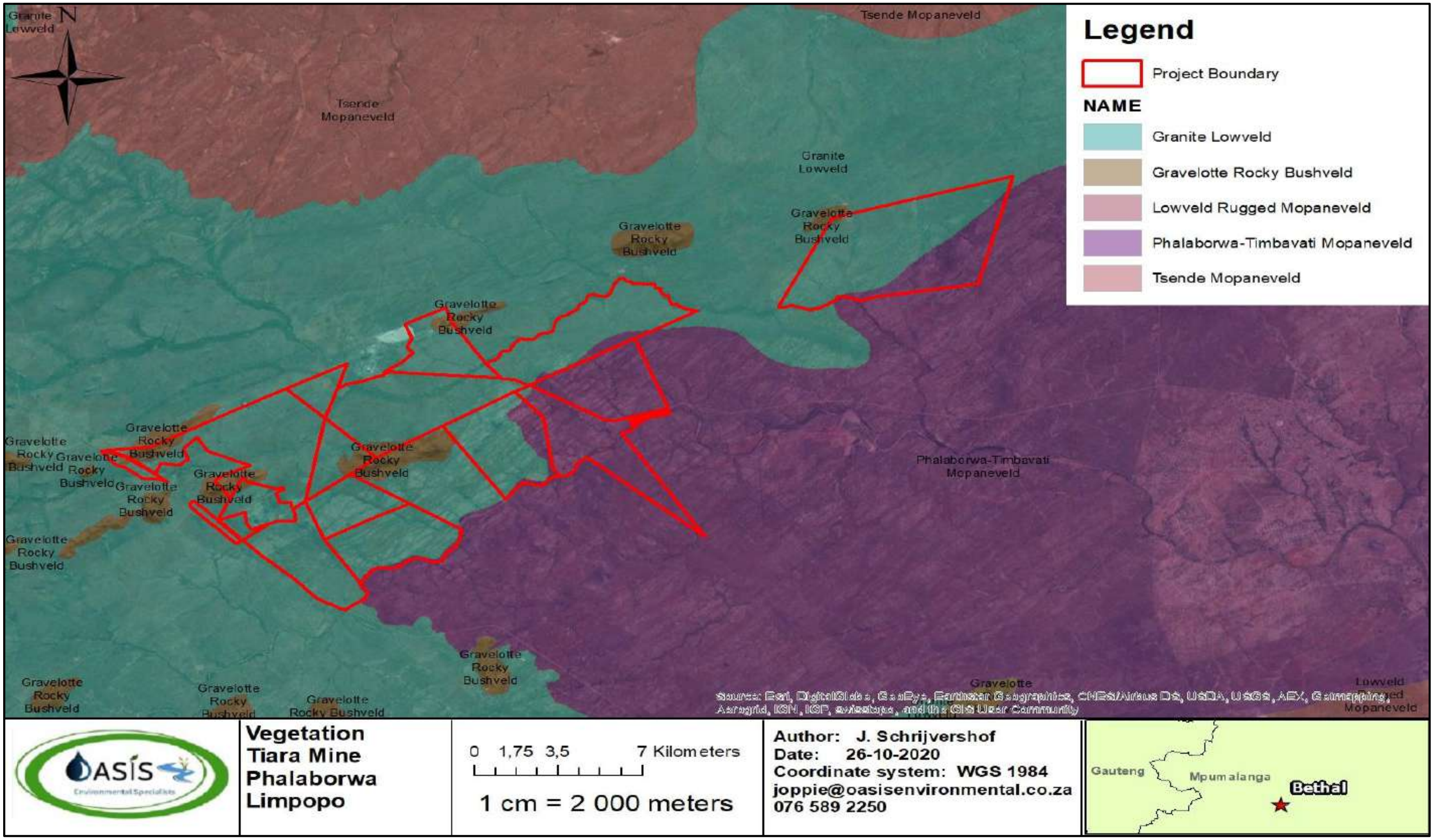

Figure 5: Proposed Tiara Mine - Vegetation map.

3.2 Quaternary catchment and Land Use

The northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA (**Figure 7**).

The land use features within the study site are mainly natural bushveld areas (**Figure 8**). The two rivers in close proximity to the mining area are the Mulati River and the Selati River. The Mulati River is a tributary of the Selati River which joins up with the Olifants River close to the Kruger National Park.

According to the ecological classification for the quaternary catchments B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment); the Mulati is classified in its present state as a Category C (Moderately Modified) Upstream and as a Category B (Largely Natural) downstream. The Selati is classified in its present state as a Category B (Largely Natural) River. The default ecological management class for the relevant quaternary catchments is considered to be a highly sensitive system for the Selati River and moderate for the Mulati in terms of ecological importance with both being a highly ecological sensitive. The attainable ecological management class for the systems is a Category B (largely natural) (**Figure 6**). A summary of the ecological integrity (health) and management categories for the systems in quaternary catchments B72J and B72K is presented in **Table 8**.

Table 8: Sub-Quaternary reach desktop data for the area assessed (DWS, 2013).

SQ Reach	SQR Name	PES Category Median	Mean EI Class	Mean ES Class	Length km	Stream Order	Attainable Pes
B72H-0282	Selati	C	High	High	64,5	2	B
B72J-0257	Mulati	C	High	Moderate	37,7	1	B
B72J-0258	Mulati	B	Moderate	Moderate	32,9	2	C
B72J-0287	Unknown Stream	C	Moderate	Low	22,1	1	C

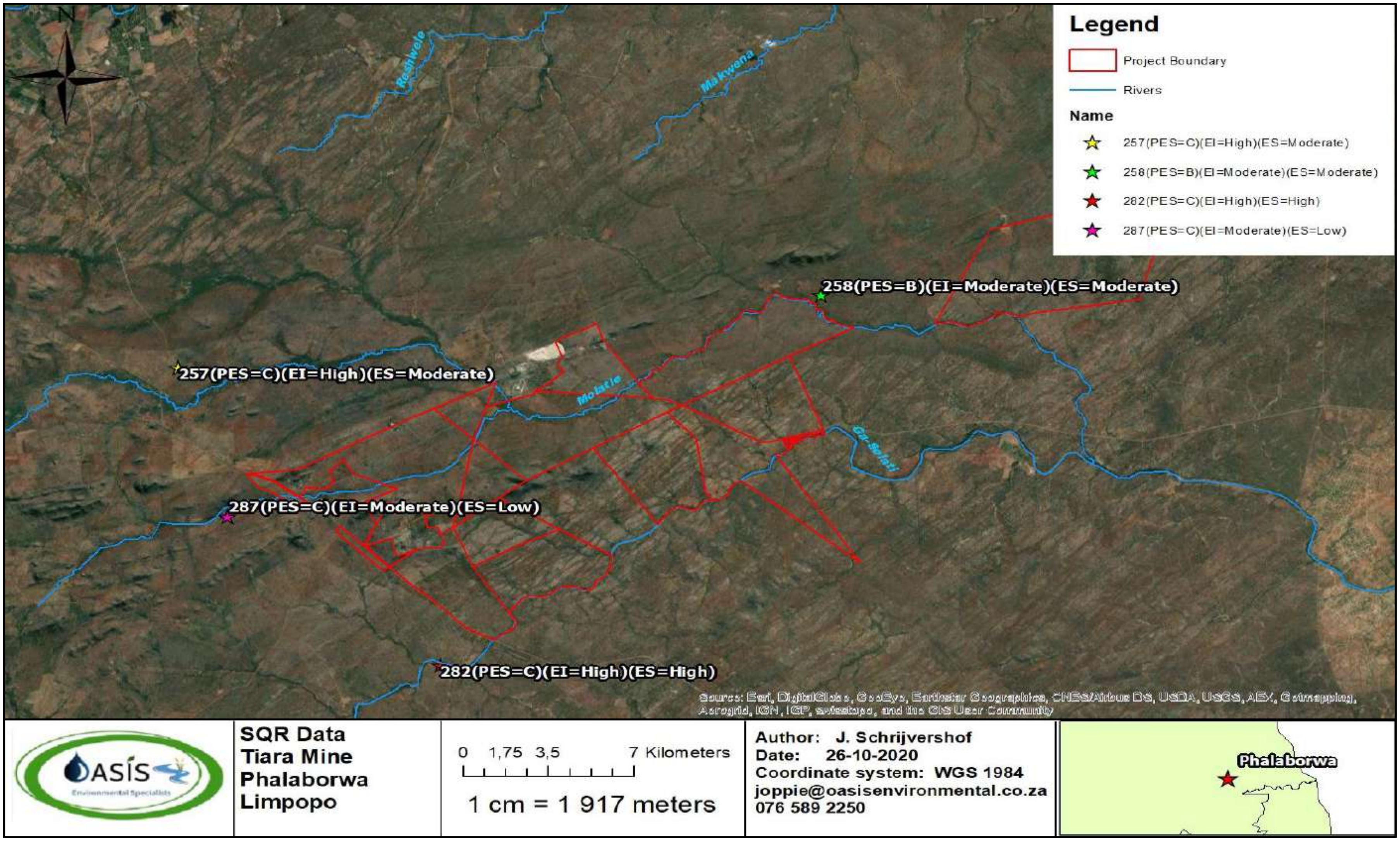

Figure 6: Sub-Quaternary reach desktop data for the Mulati and Selati rivers.

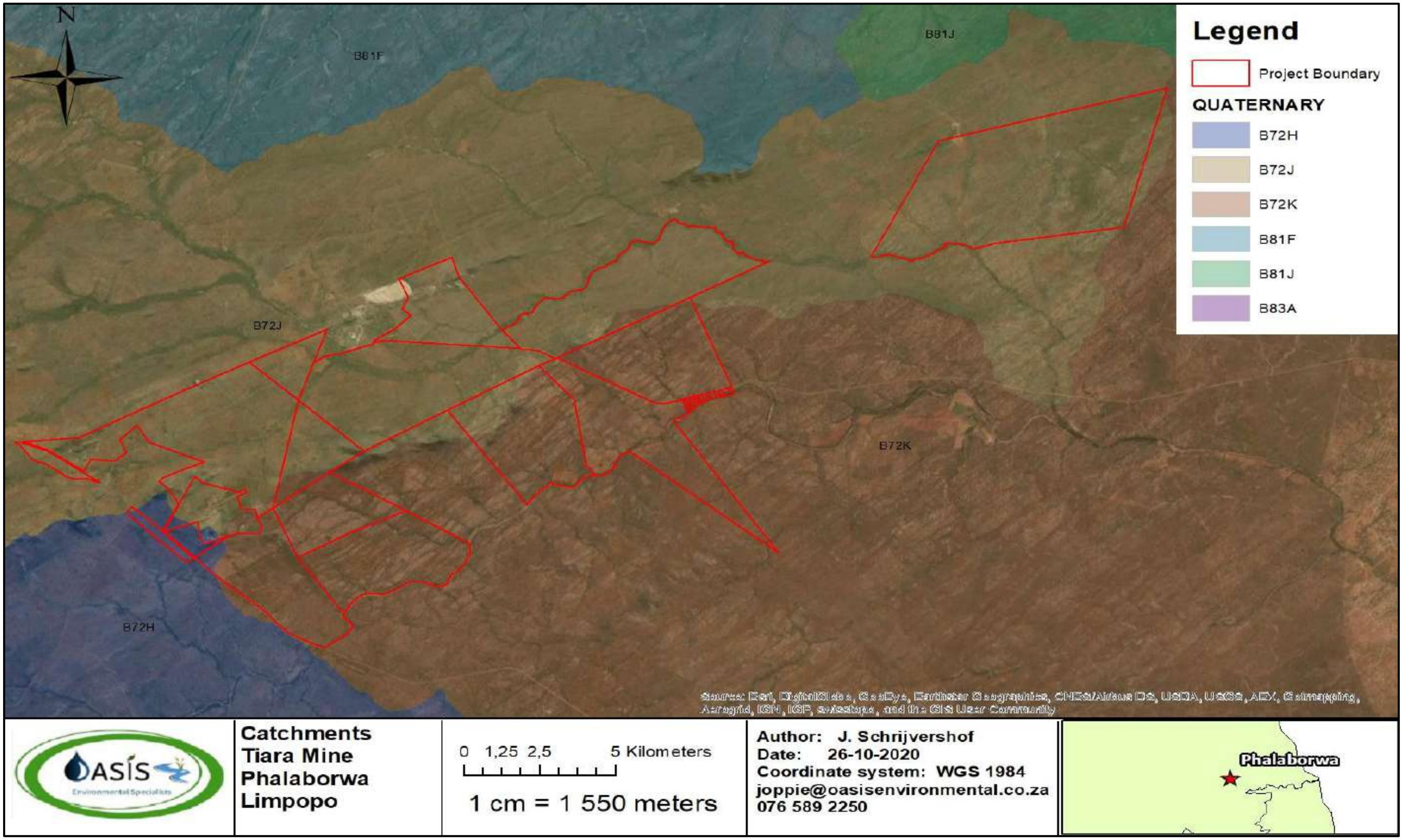

Figure 7: Proposed Tiara Mine - Catchment map.

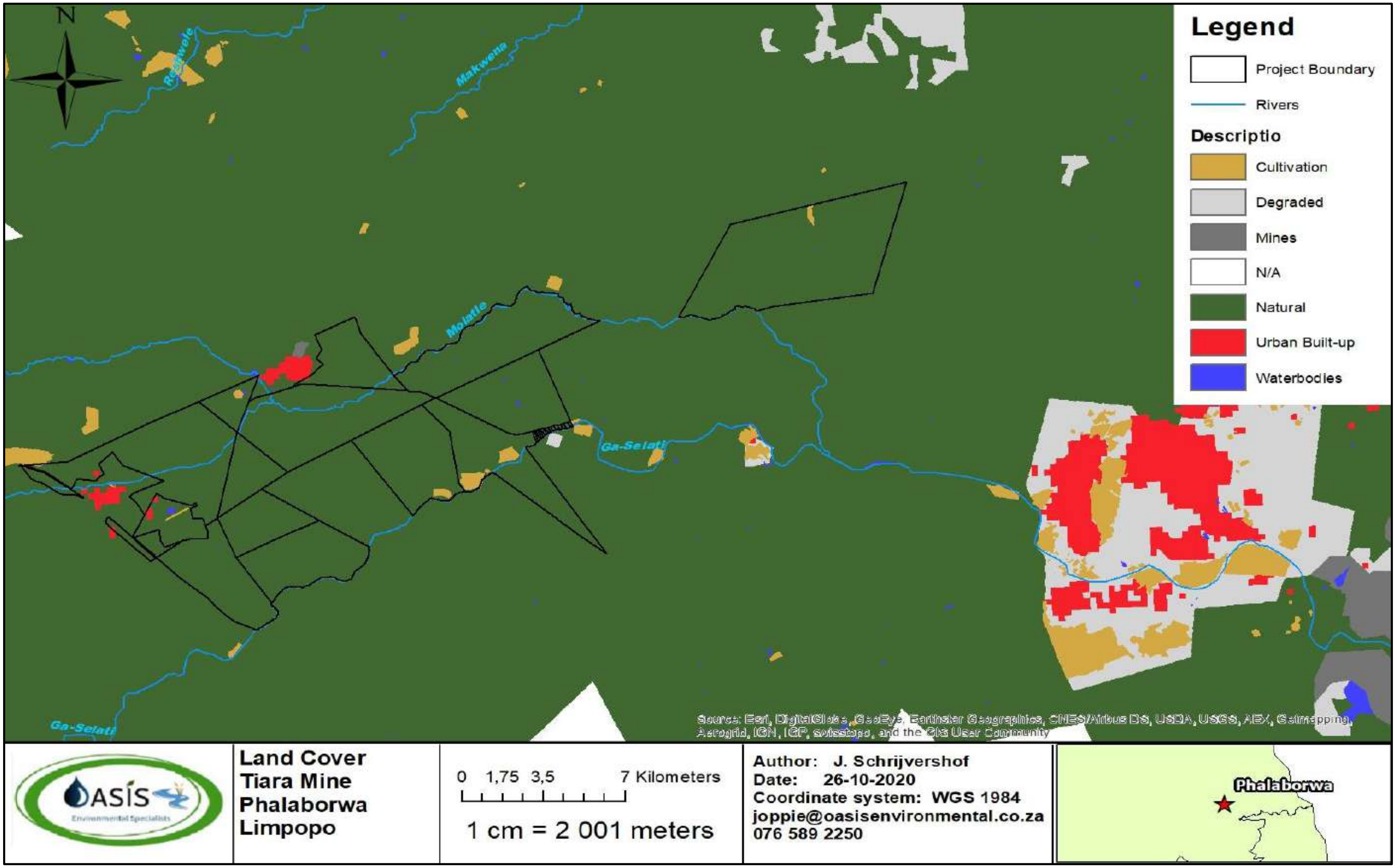

Figure 8: Proposed Tiara Mine – Land cover map.

3.3 Lowveld Ecoregion

Kleynhans *et al*. (2005) describes the Lowveld Ecoregion (3) as a hot and dry region is characterised by plains with a low to moderate relief and vegetation consisting mostly of Lowveld Bushveld types. Open hills with high relief and Low Mountains with high relief are present towards the west on the boundary with the North Eastern Highlands. In the north Mopane Bushveld and Mopane Shrubveld occur. Although several large perennial streams traverse this region, e.g. White and Black Umfolozi, Mkuze, Pongolo, Great Usutu, Komati, Crocodile, Sabie, Olifants, Letaba and Luvuvhu, few perennial streams originate here (**Figure 9**).

Mean annual precipitation: Tends to be moderate towards the west, but low over most of the region.

- Coefficient of variation of annual precipitation: Mostly moderate.
- Drainage density: Mostly low, but high in some of the central areas.
- Stream frequency: Mostly low to medium but high in some of the central areas.
- Slopes <5%: >80% of the area.
- Median annual simulated runoff: Mostly low/moderate, but moderate in areas.
- Mean annual temperature: High to very high.

Table 9: Lowveld Ecoregion attributes (Department of Water Affairs, 2012).

Main attributes	Lowveld
Terrain morphology: Broad division (dominant types in bold (Primary)	Plains; Low Relief; Plains; Moderate Relief; Lowlands, Hills and Mountains; Moderate and High Relief (limited) Open Hills, Lowlands; Mountains; Moderate to High Relief; (limited) Closed Hills; Mountains; Moderate and High Relief

Main attributes	Lowveld
	(Limited)
Vegetation types (Dominant types in bold)	Mopane Bushveld; Mopane Shrubveld; Mixed Lowveld Bushveld; Sour Lowveld Bushveld; Sweet Lowveld Bushveld; Natal Lowveld Bushveld; Lebombo Arid Mountain Bushveld; Mixed Bushveld North Eastern Mountain Grassland.
Altitude (m.a.m.s.l) (secondary)	0-700; 700-1300 limited
MAP (mm) (modifying)	200 to 1000
Coefficient of Variation (% of annual precipitation)	< 20 to 35
Rainfall concentration index	30 to >65
Rainfall seasonality	Early to late summer
Mean annual temp. (°C)	16 to >22
Mean daily max temp. (°C) February	24 to 32
Mean daily max temp. (°C) July	18 to >24
Mean daily min. temp. (°C): February	14 to >20
Mean daily min. temp. (°C): July	4 to >10
Median annual simulated runoff (mm) for quaternary catchment	10 to >250

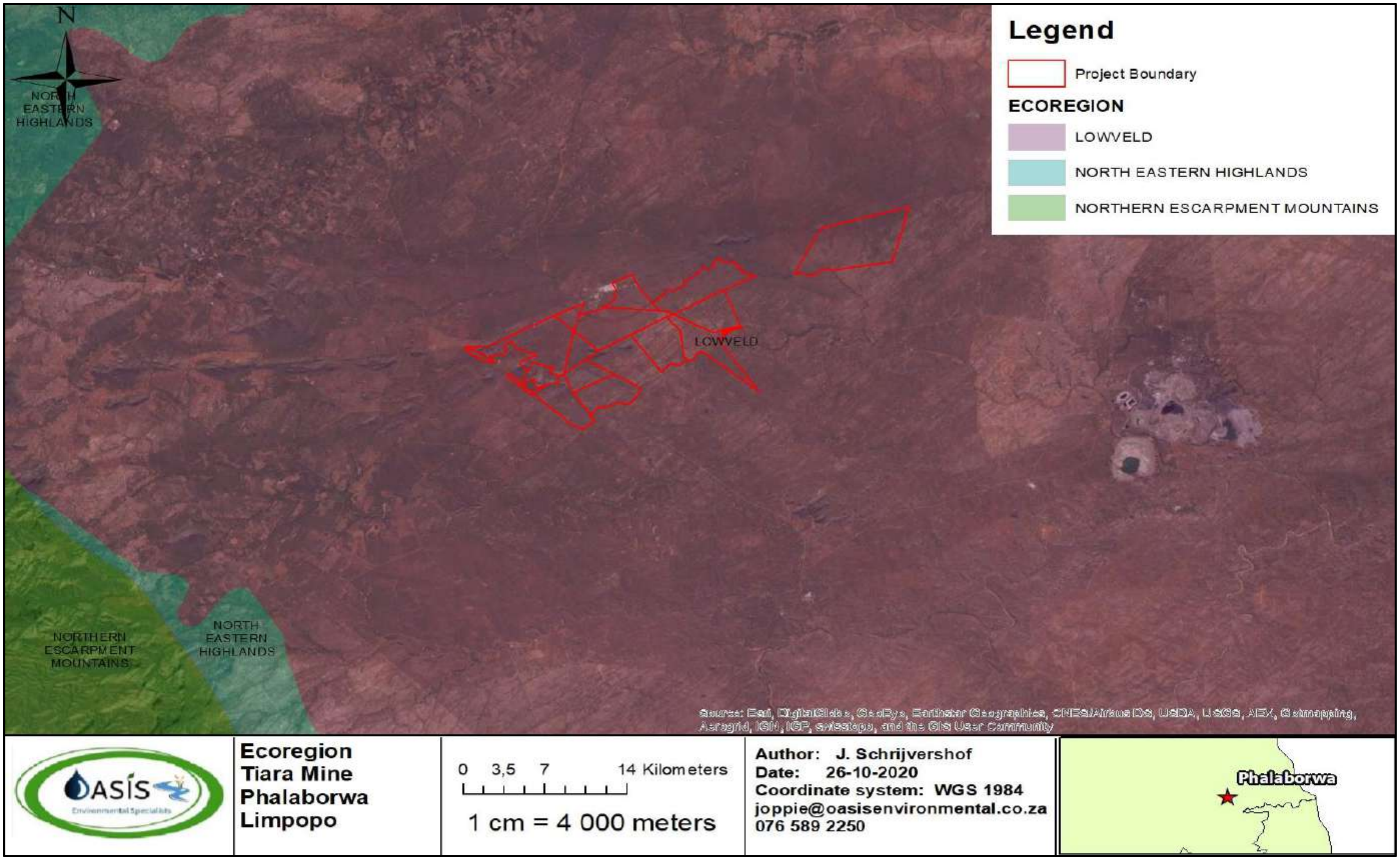

Figure 9: Proposed Tiara Mine - Ecoregion map.

4 RESULTS

A site assessment was conducted on the 15th of October 2020. The sampled sites are illustrated in the **Figure 10 and Figure 11** and the coordinates is provided in **Table 10**. During the site visit it was evident that alien invasive plant infestation and upstream mining activities affected the functionality of the watercourses within the area. It must be noted that the study sites were dry at time at the assessment. The Selati River was dry at the time of the assessment, where the downstream site and the Mulati River has pockets of water at the time of the assessment, although receiving 100 mm a few days before the assessment. This suggest that these systems could be classified as ephemeral streams.

Table 10: Coordinates for the aquatic study site at proposed Tiara Mine.

Site	Coordinates	
Mulati US	23°54'29.47"S	30°33'9.87"E
Mulati MS	23°54'29.49"S	30°43'13.87"E
Mulati DS	23°55'27.24"S	30°53'30.27"E
Selati US	24° 0'21.36"S	30°40'28.36"E
Selati DS	23°55'23.36"S	30°51'21.14"E

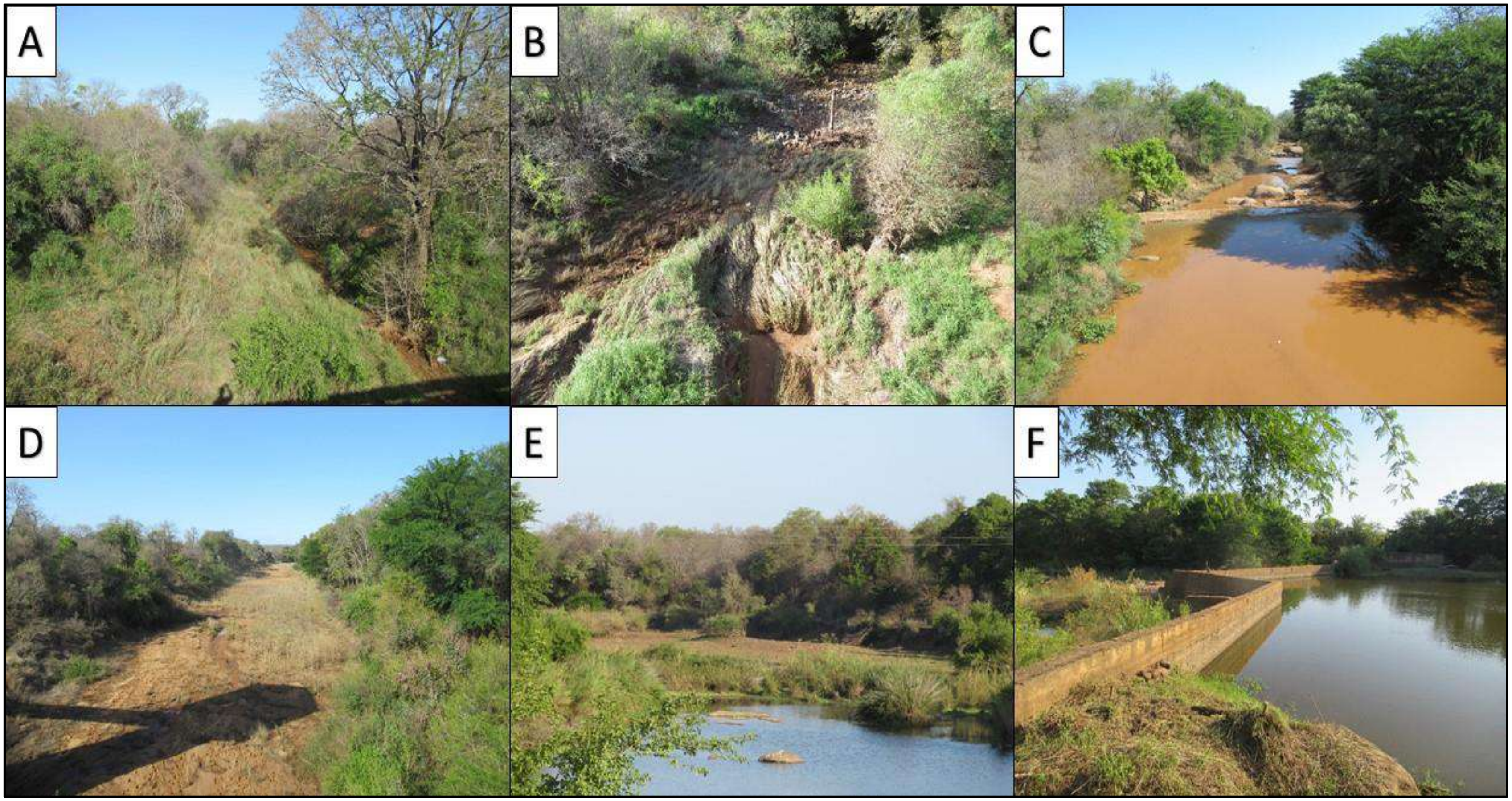

Figure 10: The biomonitoring sites assessed associated with the proposed Tiara Mine where (A) represents the dry upstream site of the Mulati River; (B) the dry midstream site of the Mulati River; (C) the downstream site of the Mulati River with pockets of water (D) the dry upstream site of the Selati River; and (E and F) the downstream site of the Selati River where the site is divided by a weir and was dry below the weir.

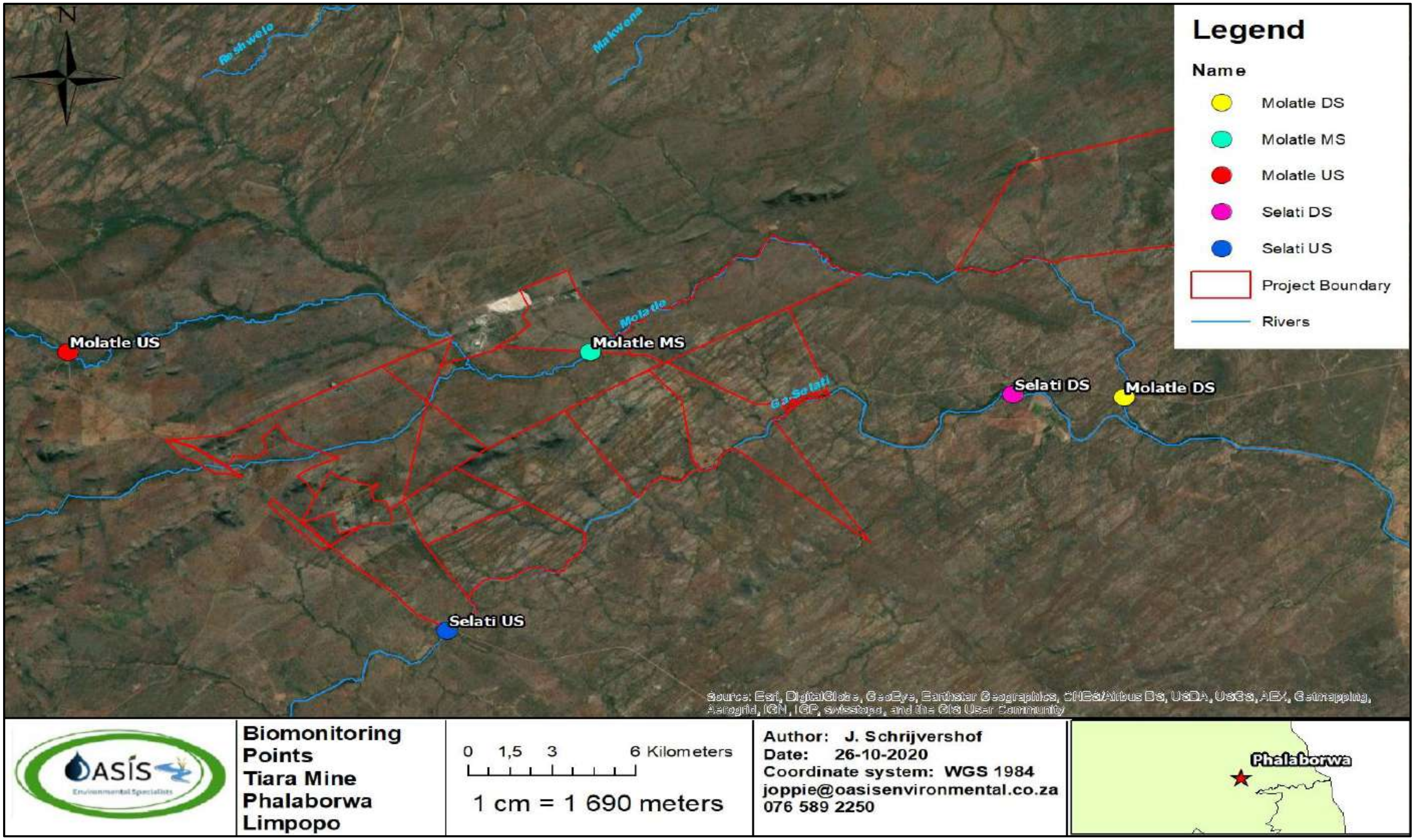

Figure 11: Proposed Tiara Mine - Sample localities of the biomonitoring points on the Mulati River and the Selati River.

4.1 *In Situ* Water Quality

In situ water quality variables was within **unacceptable** limits compared to the Target Water Quality Ranges (TWQRs) for aquatic ecosystems of South Africa. All sites were dry except for the downstream Mulati sit, where some isolated pools were available. The pH was within the neutral range. Temperature was relatively high, where electrical conductivity levels were within recommended guideline levels. Dissolved oxygen (DO) levels were below guideline levels (**Table 11**). Extensive mining and grazing were observed at the time of the assessment at the sample locations.

It must be noted that *in situ* water quality testing cannot identify specific chemicals for the basis for the health determination of a river system.

Table 11: *In situ* water quality results of the stream at the Tiara Mine sites compared to guidelines of the Target Water Quality Ranges (TWQRs) for aquatic ecosystems of South Africa.

Constituents	Guideline values (TWQRs)	Selati US	Selati DS	Mulati US	Mulati DS
pH	6.5-9,5	Dry	Dry	Dry	8,02
Temp (°C)	5 to 30				28,88
Conductivity (µS/cm)	<700				116
Dissolved Oxygen (%)	>80%				48,0
Dissolved Oxygen (mg/L)	>6				3,53

4.2 Intermediate Habitat Integrity Assessment (IHIA)

The IHIA results recorded the sites assessed within a **largely modified state (Category D)**. A category of D indicates that the loss of natural habitat, biota and basic ecosystem functions is largely transformed from reference conditions. The predominant cause for concern was damming, current mining, erosion, grazing, deforestation and alien invasive plants.

The IHIA assesses the number and severity of anthropogenic impacts and the damage they potentially inflict on the habitat integrity of aquatic ecosystems. The results of the IHIA are presented below in **Table 12.**

Table 12: Overall IHIA instream and riparian results for the sites of Tiara Mine.

INSTREAM CRITERIA	WEIGHT	Mulati and Selati	Score
Water abstraction	14	4,00	2,24
Flow modification	13	8,00	4,16
Bed modification	13	8,00	4,16
Channel modification	13	19,00	9,88
Water quality	14	5,00	2,80
Inundation	10	17,00	6,80
Exotic macrophytes	9	14,00	5,04
Exotic fauna	8	8,00	2,56
Solid waste disposal	6	4,00	0,96
TOTAL	100		**61,40**
RIPARIAN ZONE CRITERIA	**WEIGHT**	**Mulati and Selati**	**Score**
Indigenous vegetation removal	13	15,00	7,80
Exotic vegetation encroachment	12	14,00	6,72
Bank erosion	14	16,00	8,96
Channel modification	12	12,00	5,76
Water abstraction	13	14,00	7,28
Inundation	11	19,00	8,36
Flow modification	12	14,00	6,72
Water quality	13	5,00	2,60
TOTAL	100		**45,80**
Overall		**53,60**	

4.3 Riparian Vegetation Assessment Index (VEGRAI)

According to DWAF (2005), vegetation is regarded as a key component to be used in the delineation procedure for Watercourses. Vegetation also forms a central part of the watercourse component in the National Water Act, Act 36 of 1998. Disturbances included damming, current mining, erosion, grazing, deforestation and alien invasive plants

Hydrophytic riparian vegetation consisted of mainly of *Cyperus spp*. *Juncus spp*., *Crinum macowanii* and *Typha capensis* (**Figure 12**).

Figure 12: Overall view of riparian vegetation associated with the watercourses in the study area.

The findings for the vegetation assessment revealed that riparian habitat of the area was **largely modified (Category D)** (**Table 13**). The entire study area has been disturbed as a result of current mining, erosion, alien invasive plant species and overgrazing in the marginal and non-marginal zones.

Table 13: VEGRAI score for the riparian vegetation of the area associated with the proposed Tiara Mine.

Site	Mulati DS
Marginal	57,3
Non-Marginal	40
LEVEL 3 VEGRAI (%)	**52,1**
VEGRAI EC	**D**
AVERAGE CONFIDENCE	3

4.4 Macroinvertebrates

4.4.1 South African Scoring System (SASS5)

During this survey; no sensitive organisms were sampled at any of the study sites. Sampled invertebrates included the *Corixidae, Nepidae, Notonectidae, Dytiscidae, and Physidae,* families. This SASS5 scores for both downstream sites indicate that the stream is **seriously modified (Category E/F) (Figure 13)**. The majority of highly pollution tolerant organisms indicates the pressure from lack of suitable flow at the time of the assessment and these results should be interpreted with low confidence.

Figure 13: SASS 5 Classification using biological bands calculated from percentiles from Dallas (2007) for the Mulati DS at the proposed Tiara Mine in accordance with the Highveld Ecoregion as reference.

4.4.2 **Invertebrate Habitat Assessment System (IHAS).**

The habitat reaches which were assessed for the Mulati DS site, found to be **inadequate**, where biotopes with limited habitat structures were present. The dominant feature of the invertebrate habitat is the mud and gravel substrate which dominates the streams under study. Generally, no stones in or out of current biotope were found to be available throughout the stream with extensive erosion present. Some fringing vegetation were sampled at Mulati DS.

The invertebrate habitat assessment is presented below in **Table 14**.

Table 14: IHAS results for the macro-invertebrate habitat available at the biomonitoring sites associated with proposed Tiara Mine.

Invertebrate Habitat Assessment System								Scores
Sampling Habitat	**0**	**1**	**2**	**3**	**4**	**5**		
Stone in Current								
Total Length of white water rapids (m)	none	0-1	>1-2	>2-3	>3-5	>5		0
Total length of sumberged SIC	none	0-2	>2-5	>5-10	>10			1
Number of Separate SIC areas kicked	0	1	2-3	4-5	6+			1
Average Stone Size (cms)	none	<2>20	2-10	11-20	2-20			1
Amount of surface clear of algae/sediment	n/a	0-25	26-50	51-75	>75			1
Time spent kicking (sampling)	0	<1	<1-2	<2	>2-3	>3		1
						Max	20	5
Vegetation								
Length of fringing vegetation sampled	none	0-0.5	0.5-1	>1-2	2	>2		3
amount of aquatic vegetation/algae sampled	none	0-0.5	>0.5-1	>1				1
fringning vegetation sampled in:	none		run	still		mix		3
type of vegetation	none		1-25	26-50	51-75	>75		2
						Max	15	9
Other Habitat								
Stones out of current (SOOC)	none	0-0.5	0.5-1	1	>1			1
sand sampled	none	under	0-0.5	>0.5-1	1	>1		2
mud sampled	none	under	0-0.5	0.5	>0.5			3
gravel sampled	none	0-0.5	0.5	>0.5				3
bedrock sampled	none	**some**			all			0
algal presence	>2m^2	rocks	1-2	<1m^2	isol	none		4
tray id time		under		correct		over		1
						Max	20	14
Stream condition								
River make up	pool		run	rapid	2 mix	3 mix		0
Average width of stream		>10	>5-10	<1	1-2	>2-5		2
Average depth of stream	>1	1	>0.5-1	0.5	>0.5-0.2!	<0.25		2
approximate velocity of stream	still	slow	fast	med		mix		0
water colour	silty	opaque		discolou		clear		0
recent disturbances	flood/drc	fire	ction	other		none		0
Bank/riparian vegetation is:	none		grass	shrubs	mix			3
Surrounding impact	erosion	farm	trees	other		open		0
left bank cover	0-50	51-75	75-95	>95				3
right bank cover	0-51	51-76	75-96	>96				3
						Max	45	13
Overall							**Total %**	**41**

4.4.3 Fish Assessment

Although no fish species were sample, the SQR fish data available for that specific reach had 12 species of fish expected to occur within that stretch of river according to DWS (2013)). All of the expected fish species are indigenous species and are listed in **Table 15**.

Table 15: Expected fish species to occur within the Selati and Mulati rivers associated with proposed Tiara Mine.

SCIENTIFIC NAMES: REFERENCE SPECIES (INTRODUCED SPECIES EXCLUDED)	REFERENCE FREQUENCY OF OCCURRENCE
Barbus annectens	1
Barbus paludinosus	1
Barbus toppini	1
Barbus trimaculatus	1
Barbus unitaeniatus	1
Barbus viviparus	1
Clarias gariepinus	2
Glossogobius callidus	1
Labeo molybdinus	1
Mesobola brevianalis	1
Oreochromis mossambicus	2
Pseudocrenilabrus philander	1

4.4.4 **Desktop Assessment**

Examination of the National Freshwater Ecosystem Priority Areas (NFEPA) database were undertaken for the proposed Tiara Mine. The NFEPA project aims to produce maps which provide strategic spatial priorities for conserving South Africa's freshwater ecosystems and supporting sustainable use of water resources. They were identified based on a range of criteria dealing with the maintenance of key ecological processes and the conservation of ecosystem types and species associated with rivers, channel and rivers and estuaries (MacFarlane *et al*., 2009). Identification of FEPA Channel and rivers are based on a combination of special features and modelled channel and river conditions that include expert knowledge on features of conservation importance as well as available spatial data on the occurrence of threatened frogs and channel and river-dependent birds.

Several valley bottom and NFEPA channel and rivers were identified within the mining boundary during the desktop assessment, associated with the Selati and Mulati rivers (**Figure 14**). Although no wetlands were found to be present within the area during the site visit, most rivers and dams are listed as wetland areas within the NFEPA database.

However, ground-truthing the existence and condition of FEPA channel and rivers is important to understand local conditions which have an impact on the channel and river system, their functional integrity and health.

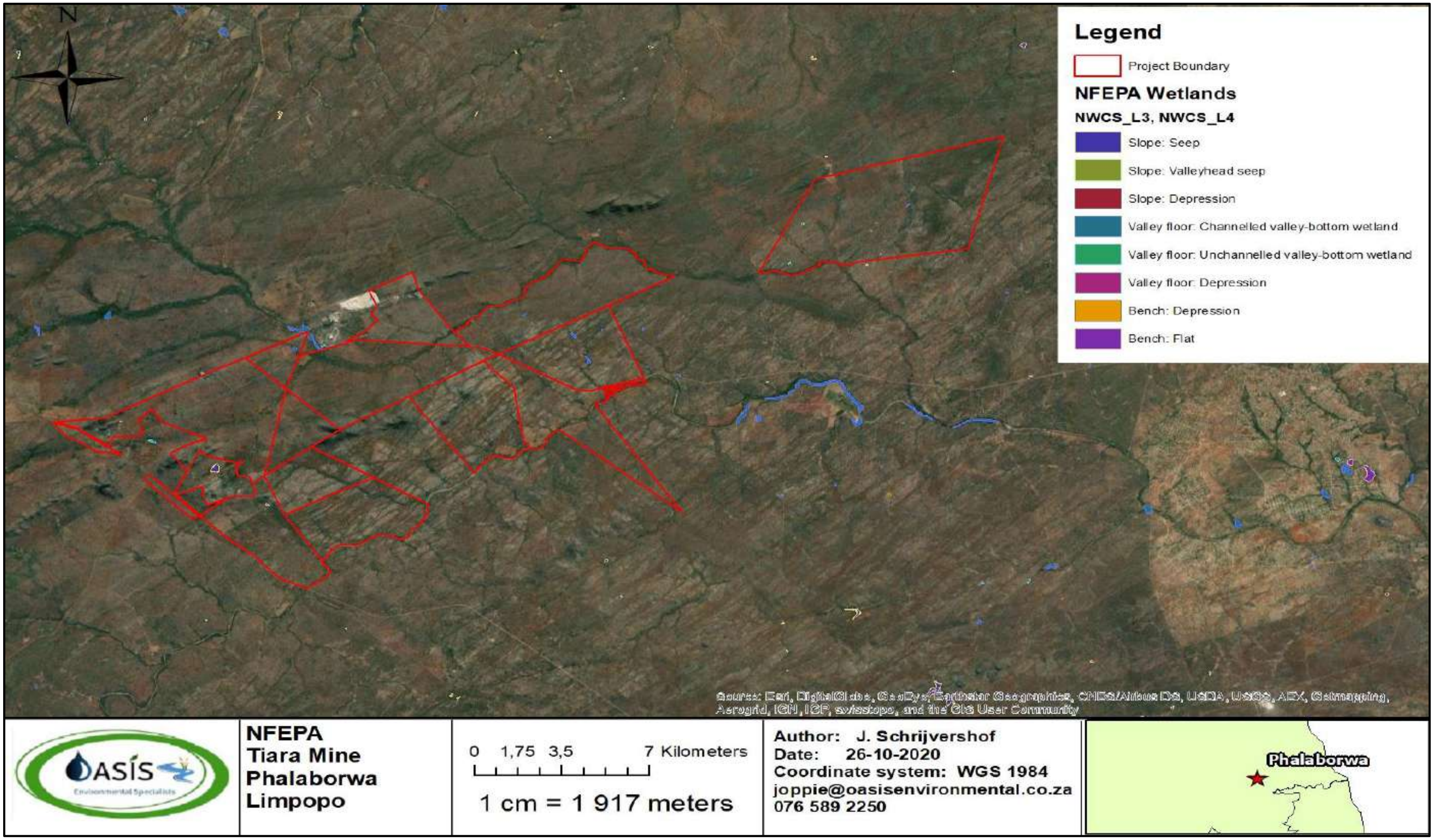

Figure 14: Proposed Tiara Mine - NFEPA Channel and river map.

4.4.5 **Terrain indicator**

The topography of an area is generally a good practical indicator for identifying those parts in the landscape where watercourses are likely to occur. Generally, channel areas and rivers occur as a valley bottom units however subsurface flow can also occur on steep to mid slopes where groundwater discharge is taking place through seeps (DWAF, 2005). In order to classify a channel and river system, the localised landscape setting must be taken into consideration through ground-truthing of the study site after initial desktop investigations (Ollis *et al*., 2014).

The study site can be characterised as having rolling hills with relatively steep sloping topography. The site ranges in altitude from 401 m to 861 m above sea level. A Digital Elevation Model (DEM) of the aerial photography of the site revealed 2 depressions in landscape cutting in the middle of the mining boundary (**Figure 15**). These areas identified during the desktop assessment where then assessed in more detail during the field investigation and confirmed to be the Selati River and the Mulati River with their respective channel areas.

4.4.6 **Channel Areas**

The delineation revealed numerous non perennial ‘A’ Section channels and only two ephemeral ‘B’ Section channels, namely the Mulati River and Selati River. These areas were dry and had small pools due to 100 mm rains prior to the site visit, where basic ecosystem functions were impacted demonstrating a very narrow riparian zone in line with the channel areas. The majority of drainage channels were identified as ‘A’ Section channels without any riparian plant species identified (**Figure 16 and Figure 17**).

Both the ‘A’ Section and ‘B’ Section channels overlaps with the propose mining blocks, which could impact the functionality of these system, especially during rain events, ultimately leading to the Olifants River being impacted further by the mining activities within the Kruger National Park downstream.

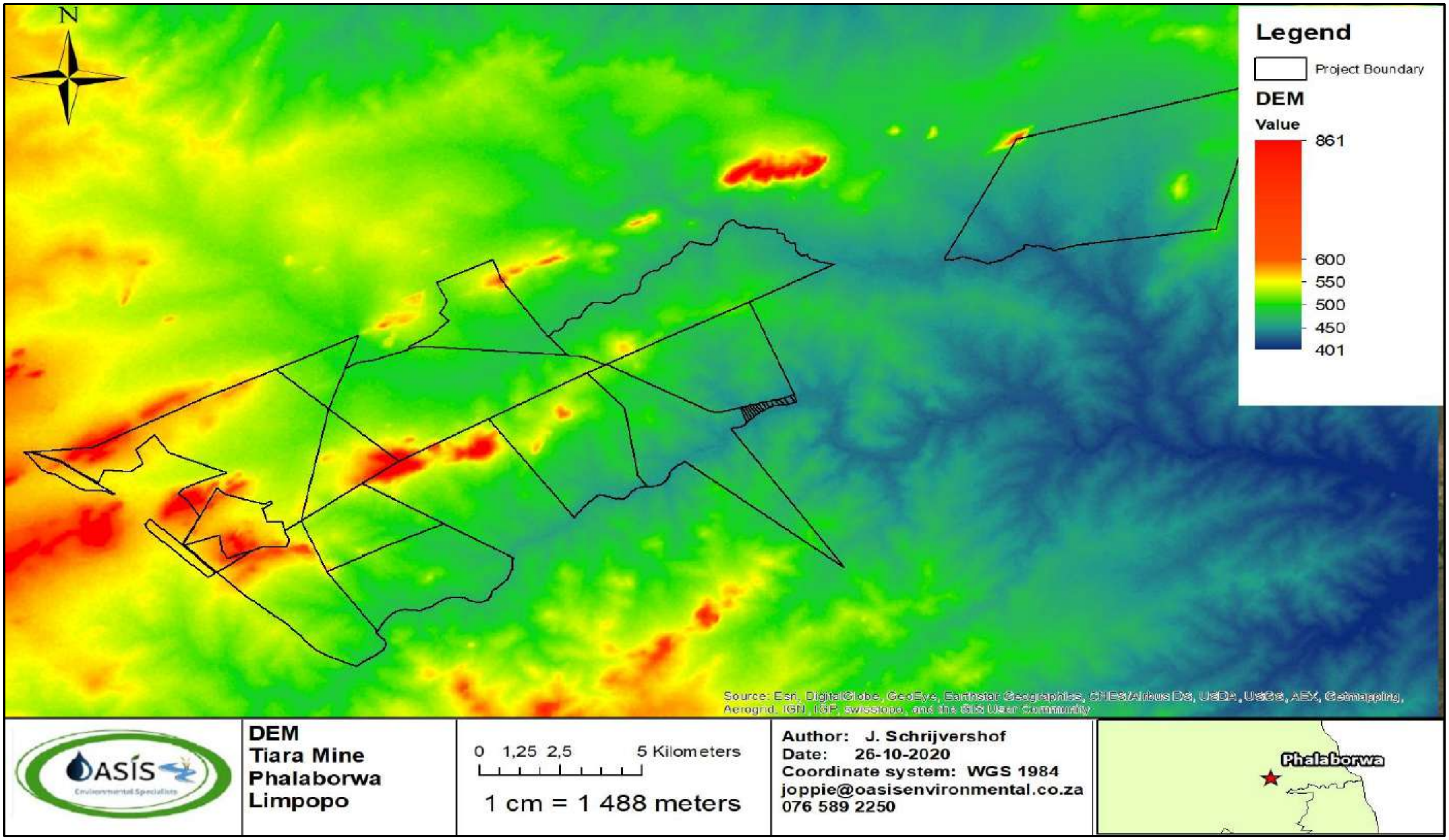

Figure 15: Proposed Tiara Mine - Digital Elevation Model map.

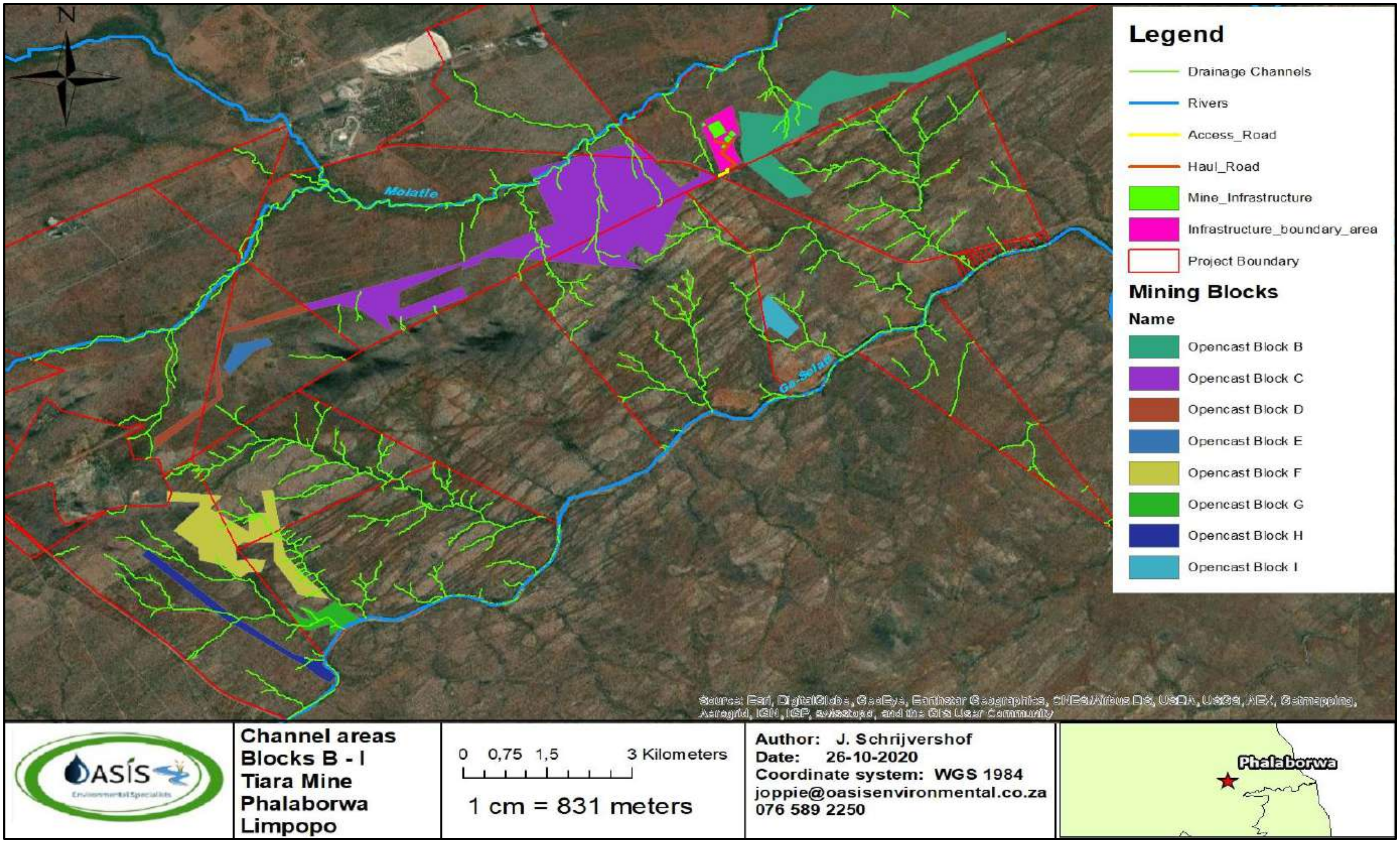

Figure 16: The drainage channels within the proposed Tiara Mine boundary.

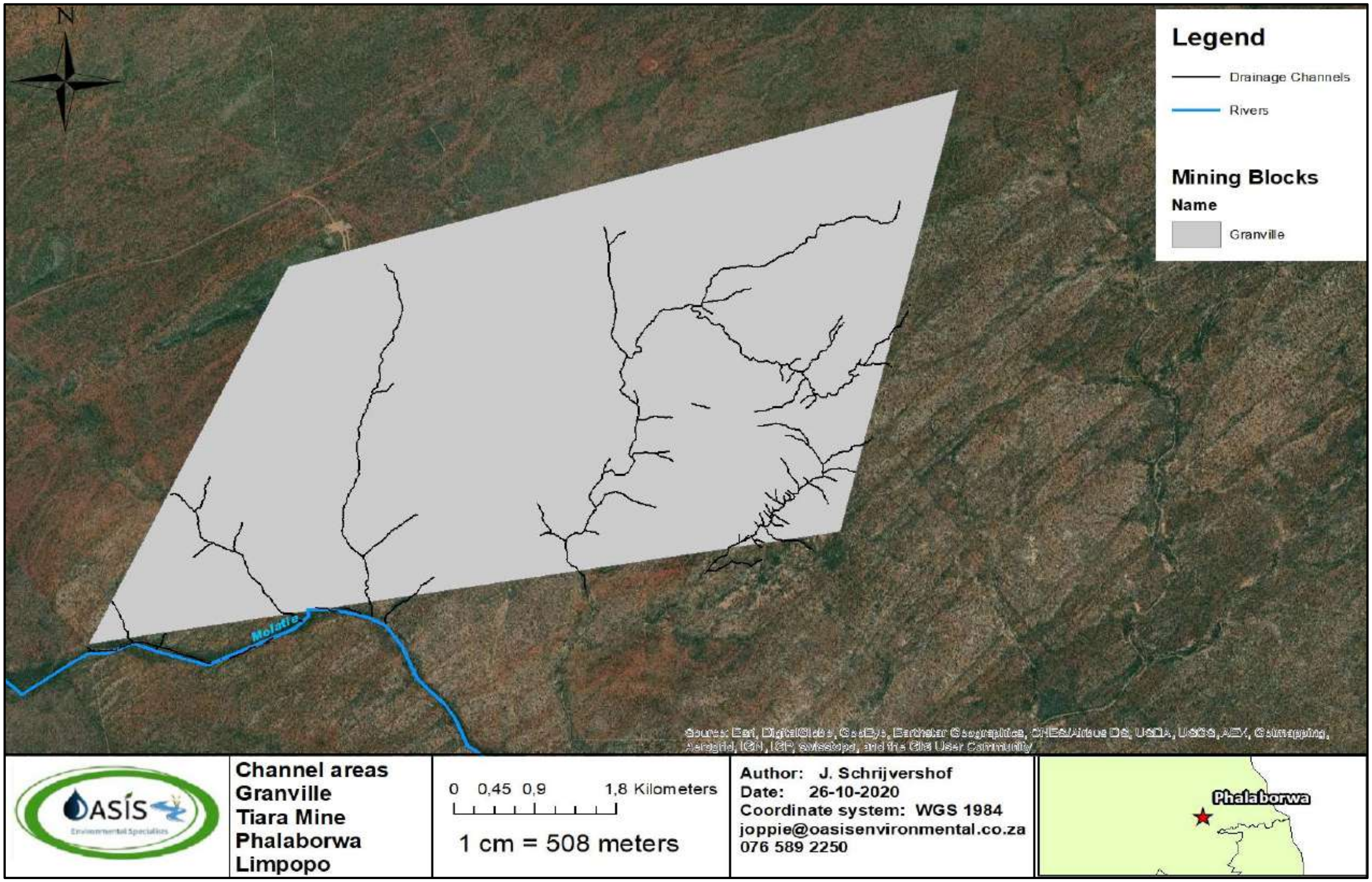

Figure 17: The drainage channels within the proposed Tiara Mine boundary for the Granville portion.

4.5 Ecological Assessment

4.5.1 Critical Biodiversity Areas

According to the biodiversity datasets provided by SANBI (2020), the majority of the application area falls within Ecological Support Areas (ESA) and Critical Biodiversity Areas (CBA) as seen in **Figure 18**. These sections were confirmed to be bushveld and grassland areas during the site visit. These Critical Biodiversity Areas (1) (CBA 1) are classified as irreplaceable sites and are required to meet biodiversity pattern and/or ecological process targets. No Site alternatives are recommended for these areas and are regarded as highly sensitive.

Critical Biodiversity Areas (2) (CBA 2) are classified as best design selected sites and are selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets. Ecological Support Areas (1) (ESA 1) Natural and/or near natural and degraded areas supporting CBAs by maintaining ecological processes. Other Natural Areas are classified as natural and intact but not required to meet targets, or identified as CBA or ESA. No natural habitat remaining areas are not significant to direct biodiversity value.

4.5.2 Threatened Ecosystems and Protected areas

The proposed mining area is overlaps with Granite Lowveld vegetation type which is considered to be a vulnerable ecosystem. No other protected ecosystems are overlapping with the proposed mine activities.

4.5.3 Important Bird Areas

The proposed mining operations fall within close proximity to Important Bird Areas (IBAs), where the proposed mining area falls close to the Kruger National Park (**Figure 19**).

The Kruger National Park is known to support more than 490 bird species, about 57% of the species found in the entire southern African subregion. The diversity of birds can be attributed to the numerous different habitats and the ecotonal nature of the area. There are several important populations of widespread species that do not thrive outside large protected areas. In addition, the riverine forests constitute habitat corridors that are used by some species of the Drakensberg escarpment to move down to the Lowveld to escape the severe escarpment winters. The riverine forests also provide habitat for secretive, river-dependent species such as Pel's Fishing Owl *Scotopelia peli*, White-backed Night Heron *Gorsachius leuconotus* and African Finfoot *Podica senegalensis* (Birdlife, 2020).

The rivers, floodplains, pans, dams and vleis are important for many watercourse dependent and associated birds, such as

Black Stork *Ciconia nigra* (which breeds in the gorges of the nearby Lebombo Mountains), Woolly-necked Stork *C. episcopus*, African Openbill *Anastomus lamelligerus*, Saddle-billed Stork *Ephippiorhynchus senegalensis* and White-crowned Lapwing *Vanellus albiceps*. When conditions are suitable, Pink-backed Pelican *Pelecanus rufescens*, Great White Pelican *P. onocrotalus*, Rufous-bellied Heron *Ardeola rufiventris*, Greater Flamingo *Phoenicopterus roseus*, Lesser Moorhen *Gallinula angulata*, Allen's Gallinule *Porphyrio alleni*, Lesser Jacana *Microparra capensis*, African Marsh Harrier *Circus ranivorus*, Chestnut-banded Plover *Charadrius pallidus* and Black Coucal *Centropus grillii* occur in small numbers. The seasonally flooded grasslands to the north of Shingwedzi hold Corn Crake *Crex crex* in summer (Birdlife, 2020).

Of the wide-ranging species that are rare outside South Africa's large national parks, Marabou Stork *Leptoptilos crumeniferus*, Hooded Vulture *Necrosyrtes monachus*, White-backed Vulture *Gyps africanus*, Lappet-faced Vulture *Torgos tracheliotos*, White-headed Vulture *Aegypius occipitalis*, Martial Eagle *Polemaetus bellicosus*, Bateleur *Terathopius ecaudatus*, Tawny Eagle *Aquila rapax*, Kori Bustard *Ardeotis kori* and Southern Ground-Hornbill *Bucorvus leadbeateri* are locally common in the KNP. Cape Vulture *Gyps coprotheres* regularly forages in the park. Pallid Harrier *Circus macrourus* and African Grass Owl *Tyto capensis* occur in low numbers (Birdlife, 2020).

The varied woodland communities host a plethora of small accipiters, cuckoos, owls, kingfishers, bee-eaters, rollers, hornbills, barbets, robins, cisticolas, flycatchers, shrikes, starlings, sunbirds, weavers, finches and waxbills. The thicket and forest areas support Brown-headed Parrot *Poicephalus cryptoxanthus* and Gorgeous Bush-Shrike *Chlorophoneus viridis*, which are restricted to the East African Coast biome. The small patches of sandveld in the far north-east hold low numbers of Pink-throated Twinspot *Hypargos margaritatus*, while the Lala palm savanna, also in the north-east, supports Lemon-breasted Canary *Crithagra citrinipectus* (Birdlife, 2020).

Near Pafuri, in the extreme north, many species reach the southern limit of their Afrotropical range and are consequently extremely rare within South Africa, although they are considerably more common and widespread just outside the country's borders. Such species include Dickinson's Kestrel *Falco dickinsoni*, Racket-tailed Roller *Coracias spatulata*, Tropical Boubou *Laniarius major*, Mottled Spinetail *Telacanthura ussheri* and Böhm's Spinetail *Neafrapus boehmi*, as well as Grey-headed Parrot *Poicephalus fuscicollis*, which is found in the riparian forests and thickets of the far north. These species are of interest from a South African perspective, but are of little subregional or global conservation significance as the populations are small and peripheral (Birdlife, 2020).

Red-billed Oxpecker *Buphagus erythrorhynchus* is common and widespread, but Yellow-billed Oxpecker *B. africanus* was considered extinct until 1979. This species has recolonised the KNP naturally and is now considered an uncommon breeding resident, occurring throughout the park but especially in the northern half (Birdlife, 2020).

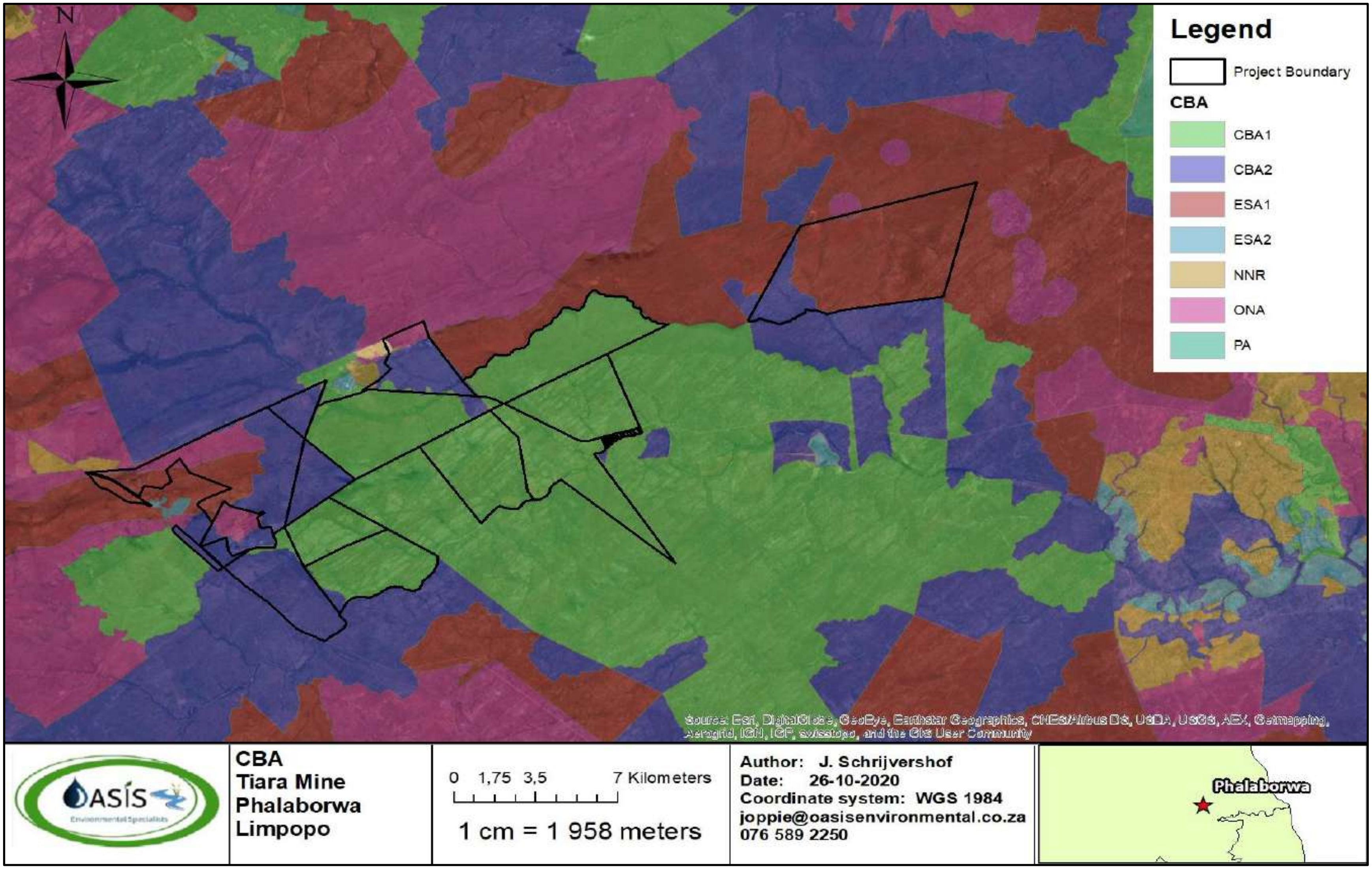

Figure 18: Tiara Mine - Critical Biodiversity Areas map.

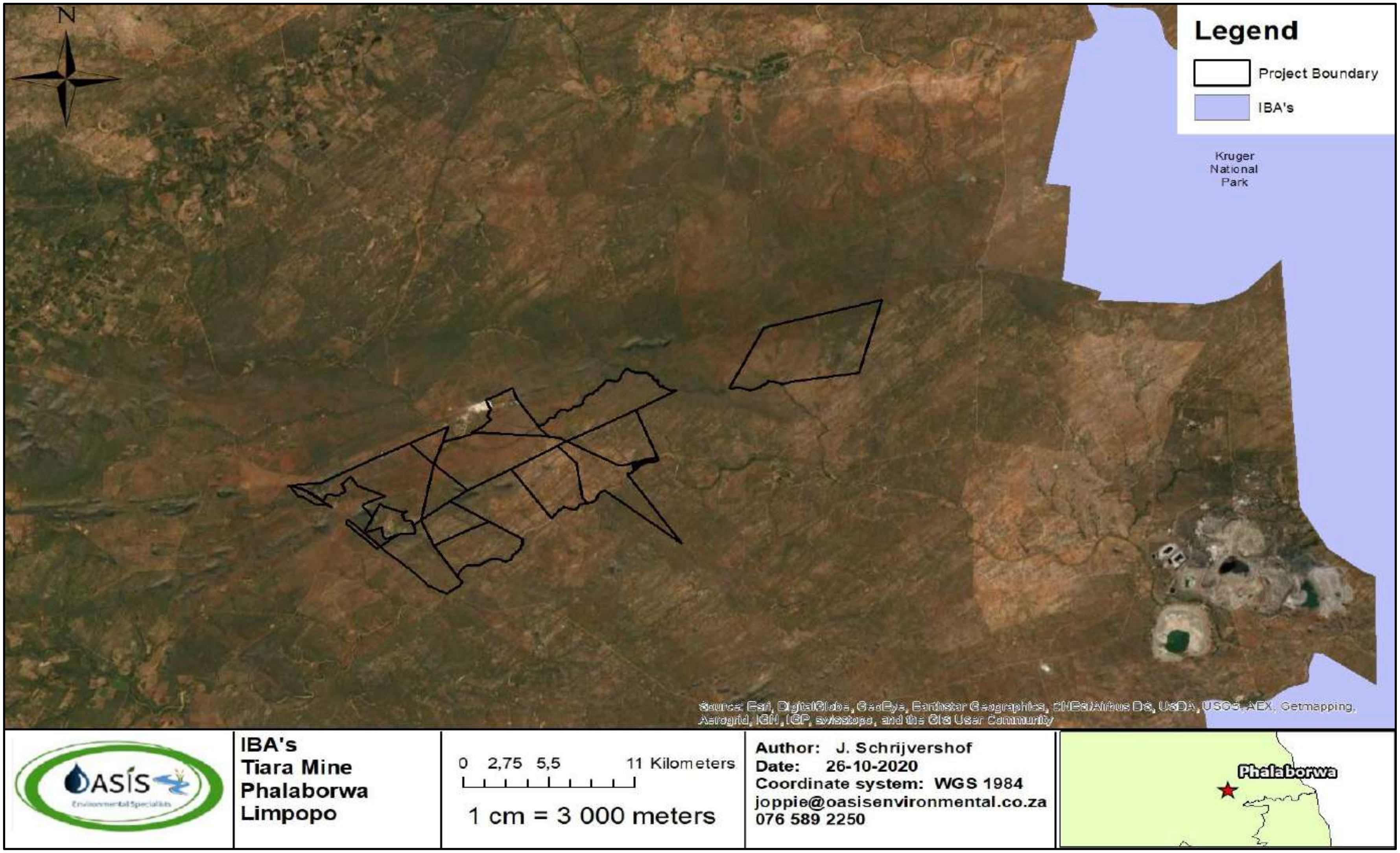

Figure 19: Tiara Mine - Important Bird Areas map.

4.5.4 Vegetation

The majority of the study site consisted of alien invasive vegetation and very little indigenous vegetation, however vegetation normally associated with that area is listed in **Appendix B** depicted from SANBI's POSA list. Information on plant species recorded in that area was extracted from the POSA list, indicate that 283 plant species have been recorded in the area queried of which 279 are endemic species are known to occur within the area queried. (**Table 16**).

The field survey was planned to include all the different habitat types and to target threatened species that may occur in the proposed mining areas. Photographs of important features were taken and will be included in the report. Nine red data species are thought to occur in the area when compared to the plant lists supplied by SANBI (2020). Possible protected trees listed in Mucina and Rutherford (2006) and SANBI species lists (2020) include *Combretum imberbe, Boscia albitrunca, Adansonia digitata, Balanites maughamii subsp. maughamii, Catha edulis, Pterocarpus angolensis, Elaeodendron transvaalense* and *Sclerocarya birrea subsp. Caffra*. This information must be used in the permit applications for the cutting or trimming of trees (from DAFF). According to in the National Environmental Management Biodiversity Act (Act 10 of 2004) (NEMBA) the vegetation type is listed as vulnerable (NEMBA, 2004).

Vegetation near the road is very dense as a result of increased runoff from the hard surfaces. Some areas in the private reserves have vegetation in a good condition. There are a number of small non perennial streams that must be negotiated during construction and care must be taken to ensure the vehicles use existing roads. Erosion can increase if the heavy construction vehicles cross the streams and a rehabilitation plan must be in place prior to construction commences.

Trees in the area include *Breonadia salicina, Sclerocarya birrea, Lannea schweinfurthii, Senegalia caffra, S. nigrescens, Vachellia sieberiana, V. karroo, Dichrostachys sericea, Ziziphus mucronata,Diospyros mespiliformis, Ficus sur, F. sycomorus, Philenoptera violacea, Combretum imberbe, C. apiculatum, C. collinum* and *Philenoptera violacea*.

The IUCN critically endangered (*Encephalartos dyerianus*) is known to be found within the Phalaborwa area's open grasslands and shrublands on the slopes of low granite hills, but was not observed during the site visit.

Table 16: Floral species summary for the area queried around the proposed Tiara Mine.

Number of Families	Number of species	Endemic species	Exotic species	IUCN Red Listed Species
71	292	288	4	9

African Baobab trees (*Adansonia digitata*) were identified within the present landscape (**Figure 20**). Although they are not yet classified by the IUCN's Red List criteria, but they are a part of the "Catalogue of Life." The baobab is a protected tree in South Africa. The effects of drought, desertification, deforestation and over-use of the fruit have been cited as causes for concern for these slow growing species (Osman, 2014). No other protected species were observed during the survey.

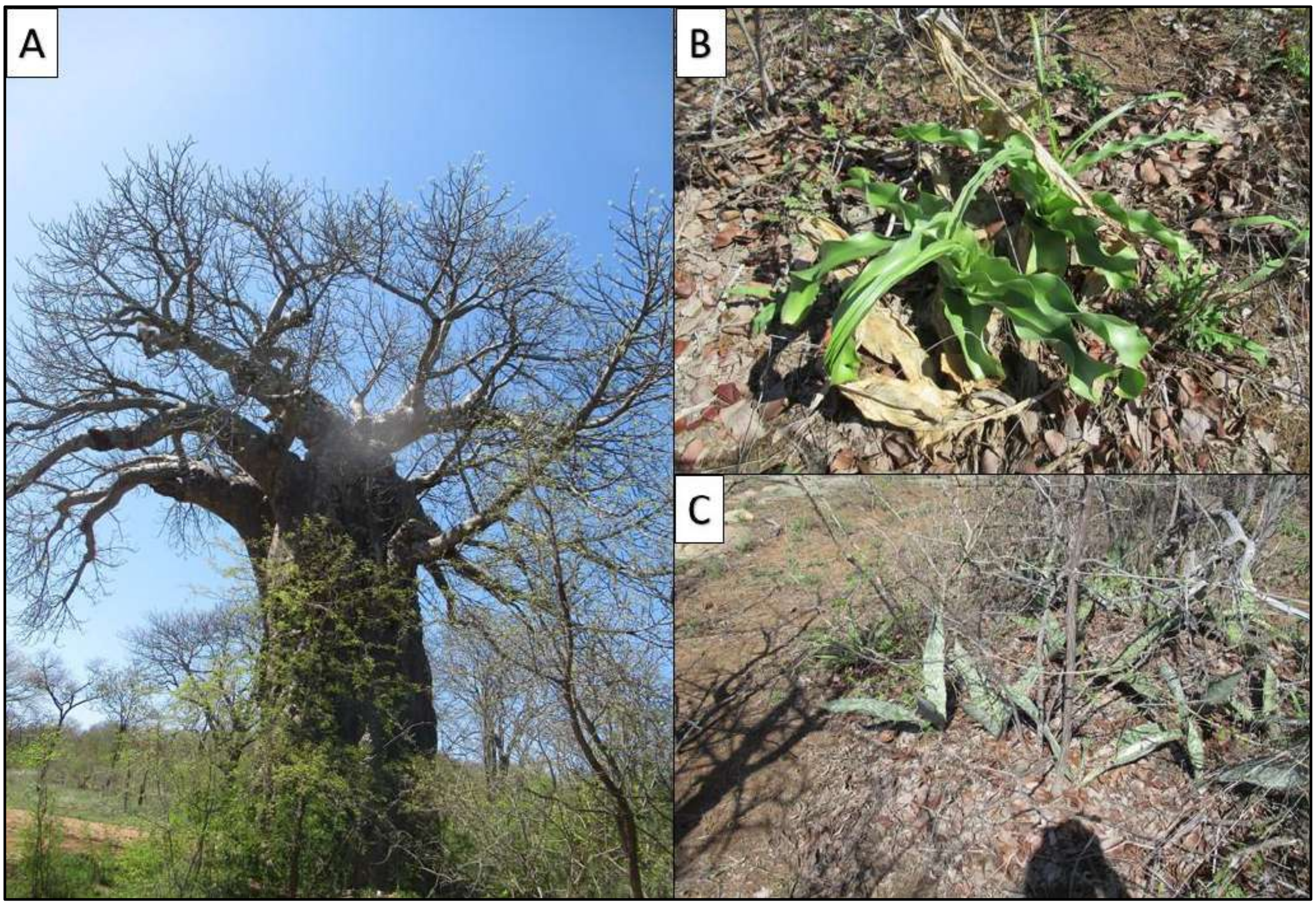

Figure 20: Tiara Mine – Some Unique Vegetation identified included: (A) Baobab Tree (*Adansonia digitata*) (23°51'51.87"S; 30°54'0.58"E), (B) River lily species (*Crinum macowanii*) with the roots and leaves having some medicinal uses as a pain killer and having emetic and laxative properties; (C) Snake plant (*Dracaena trifasciata*).

4.5.5 Alien Invasive Vegetation

National Environmental Management: Biodiversity Act (No. 10 of 2004) categories for invasive species according to Section 21 are as follows:

- Category 1a: Species requiring compulsory control;
- Category 1b: Invasive species controlled by an invasive species management programme;
- Category 2: Invasive species controlled by area, and;
- Category 3: Invasive species controlled by activity.

Certain species have different alien invasive categories for different provinces in South Africa. Very little alien species were identified on site. The dominant plant species identified were alien invasive Castor oil plant (*Ricinus communis*) (category 2) and Spanish reed (*Arundo donax*) (category 1b) within the riparian zones.

4.5.6 Fauna

The faunal component between the game farms/private reserves and open bushveld differs considerably. Within the open areas where deforestation of Mopani forest are occurring, very little evidence of faunal activity was noted. Cattle and goats were noted grazing within these areas. Some spoor and droppings of *Sylvicapra grimmia, Aepyceros melampus, Tragelaphus strepsiceros, Hystrix africaeaustralis* and some smaller rodents were seen.

Between game farms and private reserves the diversity of the animals increased In the cattle areas, more *Sylvicapra grimmia, Aepycerosmelampus, Tragelaphus strepsiceros* and *Raphicerus campestris* activity were noted (higher protection and better habitat). Larger species and rare game are present and include *Loxodonta africana, Syncerus caffer, Panthera pardus, Panthera leo, Crocuta crocuta, Equus quagga, Connochaetes taurinus, Giraffa camelopardalis, Hippotragus niger, Hippotragus equinus* and *Damaliscus lunatus*.

During construction it will be important to liaise with the landowners off the game farms and private reserves. Where dangerous animals are present, it will be important to ensure that game is moved to other camps where possible. A ranger from the farm must be present during construction to ensure the safety of man and animals.

Limited faunal species were observed and the majority was sites near game farms and private reserves and included: Communal spider nests, sociable weaver (*Philetairus socius*), Southern red-billed hornbill (*Tockus erythrorhynchus*), Girrafe liseted as vulnerabe (*Giraffa camelopardalis*), Chacma baboon (*Papio ursinus*) and Bluetailed sandveld lizard (*Nucras caesicaudata*) (**Figure 21**).The fauna expected to occur within that area is listed in **Appendix A**.

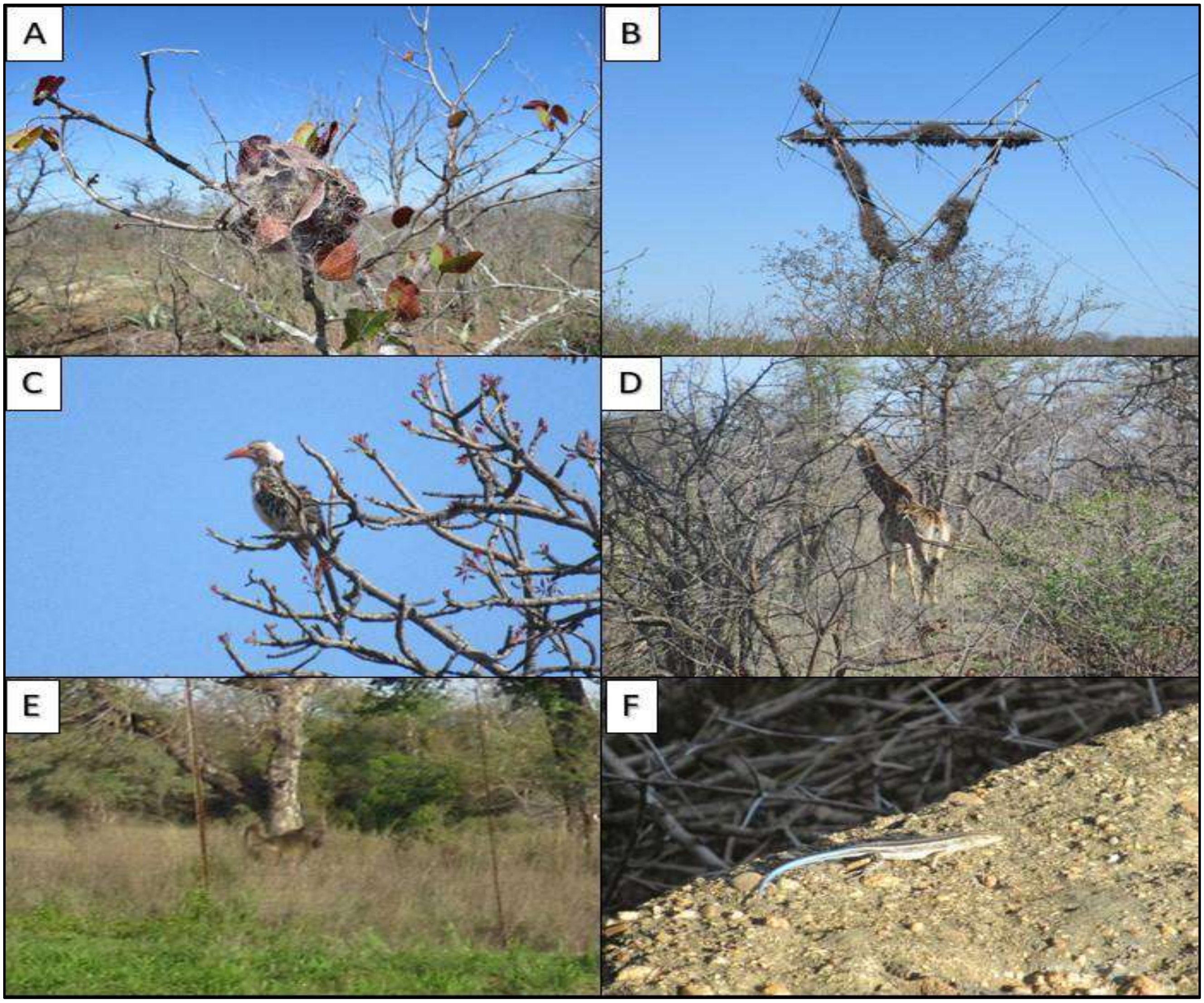

Figure 21: Tiara Mine – Identified fauna included: (A) Communal spider nest; (B) Nesting areas with sociable weaver (*Philetairus socius*); (C) Southern red-billed hornbill (*Tockus erythrorhynchus*); (D) Girrafe (*Giraffa camelopardalis*); (E) Chacma baboon (*Papio ursinus*) and (F) Bluetailed sandveld lizard (*Nucras caesicaudata*),

4.5.7 Sensitivity Mapping

All bushveld areas and watercourses still intact can be considered highly sensitive areas serves as a breeding and foraging habitat for a number of faunal species. These areas can be regarded as ecologically irreplaceable and covers the majority of the area. It will be nearly impossible to imitate these areas after mining has been completed with a rehabilitation programme. Historical transformed Grasslands with cultivation which have been considered as moderately sensitive as they have been disturbed by surrounding anthropogenic activities, but some vegetation has started establishing again. Current transformed land by mining operation and agriculture can be considered low sensitive and covers the majority of the area. These areas are illustrated in **Figure 22**.

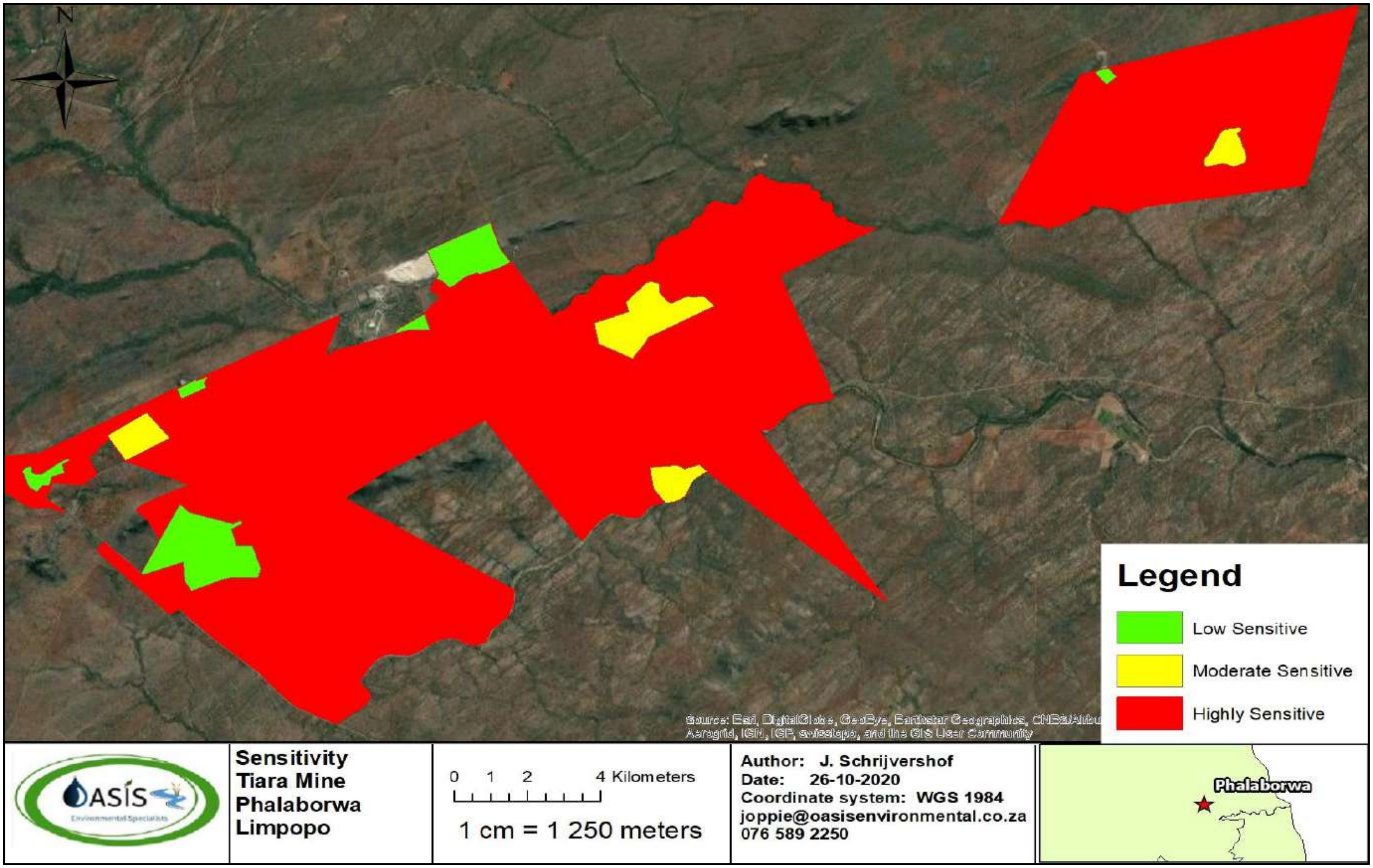

Figure 22: Tiara Mine - Sensitivity map.

5 RISK ASSESSMENT OF WATERCOURSES

The risk assessment focussed on the impacts associated with the proposed Tiara Mine on watercourses as mentioned above.

Vegetation clearing will occur and this will lead to increased turbidity and sedimentation in the stream as well as altered flow patterns. The machinery used has a risk of hydrocarbon spills into the rivers and channels as discussed.

There are impacts on the flow patterns to the stream as well as possibly increased nutrient levels from the waste materials entering the water course.

This report highlights the findings for a one site survey, limiting the confidence for the risk assessment in **Table 17 without mitigation and Table 18 with mitigation**.

The Tiara Mine operation will have following support infrastructure (**Figure 23**) using truck and shovel opencast mining include the following:

- Screening and crushing machine;
- Processing plant;
- Run of Mine (RoM) stockpiles;
- Mobile office complex;
- Process water reservoir/tank;
- Portable water tank (Jojo tanks);
- Ablution facility;
- Store house;
- Workshop;
- 3 x Komatsu D 155 Bulldozer;
- 3 x Volvo 460 Hydraulic Excavators;
- Volvo A30 Articulated 6X6 Dump Trucks;
- Volvo D65 Bulldozer;
- 1 x Volvo 72 Motor Grader;
- 1 x 12 000 litre Water Browser for dust suppression; and
- Security gate (boom gate) and fence (five strand barbed wire or Clear-Vu fence).

Figure 23: Tiara Mine – Proposed Infrastructure

Construction/Establishment Phase

Construction/establishment activities associated with bulk earthworks (such as excavations, reshaping, back-filling and compaction) can alter natural patterns of surface runoff reaching water resources downslope/downstream. Excavations may impound and redirect water, starving downstream water resources. Infilling, compaction and rutting of soils caused by construction/establishment alter the patterns of diffuse surface and sub-surface flows by altering micro-topography and the permeability of soil profiles. Changes in flow patterns within aquatic ecosystems will affect hydrological functionality and ecosystem integrity. Increased runoff velocities linked to concentrated flow paths created during construction/establishment will lead to erosion and sedimentation. Should temporary damming and abstraction of water take place, a short-term reduction of flows to downstream riverine habitat will also result in alterations of the sediment balance (Macfarlane *et al*., 2014).

Upgrading of existing access roads and bridges (i.e., road widening, replacement of existing culverts) and construction/establishment of mine and mine infrastructure will result in increased sediment runoff and sedimentation in the aquatic habitat. Site preparation for the mine and all associated infrastructure will entail blasting, drilling, dewatering, clearing, grubbing, grading and ground preparation as well as the creation of containment facilities that will eliminate some stream reaches and intercept all surface run-off within the mine area. Impacts associated with this activity include increased erosion and sediment deposition in the receiving aquatic environment.

Operational Phase

Increased sedimentation may occur as a result from the runoff from the waste rock dump and blasting. This has the potential to change habitat structure within the receiving environment and this will in turn result in changes in ecosystem function. Changes in habitat structure due to sedimentation would result in changes in the species composition.

Water quality impairment has the potential to change ecosystem function, change community structure as species sensitive to water quality impairment are eliminated and tolerant species increase in number, this results in a loss of biodiversity of sensitive species.

Invasive alien plants have far reaching detrimental effects on native biota and has been widely accepted as being a leading cause of biodiversity loss. They typically have rapid reproductive turnover and are able to outcompete native species for environmental resources, alter soil stability, and promote erosion, change litter accumulation and soil properties. In addition, certain alien plants exacerbate soil erosion whilst others contribute to a reduction in stream flow thereby potentially increasing sediment inputs and altering natural hydrology of receiving watercourses. These impacts negatively affect areas that are largely natural (with low existing weed levels) greater than for areas already characterised by dense infestations of alien plants with low indigenous plant diversity (Macfarlane *et al*., 2014).

5.1.1 Sedimentation and soil erosion

Soil erosion will result in the deposition of sediment into the watercourses; posing a risk to the downstream catchment geomorphological/functional integrity. Subsequent impacts that are likely to result are: a loss of instream flow including aquatic refugia and flow dependent taxa; sedimentation of the watercourse that will be destructive to many faunal species affecting their habitat; breeding and feeding cycles.

Some of the key biological effects related to the deposition of sediment and suspension of fine sediment within the watercourses includes:

- Habitat alteration downstream of crossing points due to increased sediment deposition (degradation of coarse riverbed habitats by the infilling of interstitial spaces and the reduction of inter-granular flow for example);
- Reductions in photosynthetic activity and primary production caused by sediments impeding light penetration;
- Reduced density and diversity in benthic invertebrate communities as a result of habitat degradation, blanketing of fish spawning sites and the establishment of more tolerant taxa or exotic species; and
- Changes to the behaviour and feeding ability of fish at low levels of suspended sediments, while physiological damage and mortality can occur at very high concentrations of suspended sediment resulting in clogging of fish gills, interference in embryogenesis and larval development of amphibians and mortality of filter-feeding macro-invertebrates.

During the operational phase of the plants rainfall is likely to filter through into the stockpiles and waste dumps. This water is likely to accumulate particles and pollutants that will pose a risk to the surrounding water courses. Sediment that washes off the waste dump and blasting areas during periods of rainfall will also contribute to increased sedimentation in the aquatic environment.

Erosion and sedimentation impacts are linked to alterations in hydrological regimes as a result of increased storm water floodpeaks associated with increased impermeable surfaces and the concentration of flows. Increases in peak discharge may significantly increase stream power, increasing the risk of erosion (localised scouring and incision) and resultant sedimentation of watercourses. Local site factors such as soil erodibility, vegetation cover, gradient of local slopes and regional rainfall/runoff intensity will affect the probability and intensity of erosion impacts (Macfarlane *et al*., 2014). Typical results of erosion & sedimentation on water resources may include:

- Locally increased channel slopes;
- Loss of in-stream biotope diversity due to scouring or blanketing of sites with sediment;
- Localised scouring at stormwater discharge points into watercourses;

- Headcut migration upstream and subsequent deepening of channels (where base level lowering has occurred);
- Lowering of the local water table and subsequent desiccation of adjacent to the river and riparian areas;
- Relatively higher channel banks that may exceed critical height resulting in bank failure/collapse;
- Addition of sediment to the water column (increased turbidity) affecting suitability for aquatic organisms; and
- Deposition of large masses of sediment downstream causing localised channel braiding, instability of the river banks and alterations in water distribution.

5.1.2 **Pollution of water resources and soil**

Changes to the water quality will result in changes to the ecosystem structure and function as well as a potential loss of biodiversity. Water quality pollution leads to modification of the species composition where sensitive species are lost and organisms tolerant to environmental changes dominate the community structure. Any substances entering and polluting watercourses will directly impact downstream ecology through surface runoff during rainfall events, or subsurface water movement, particularly during the wetter summer months.

Contaminants such as hydrocarbons, solids, pathogens and hazardous materials may enter watercourses (examples include petrol/diesel, oil/grease, paint, cement/concrete and other hazardous substances). These contaminants negatively affect aquatic ecosystems including sensitive or intolerant species of flora and fauna. Where significant changes in water quality occur, this will ultimately result in a shift in aquatic species composition, favouring more tolerant species, and potentially resulting in the localised exclusion of sensitive species. Water quality monitoring must be implemented to ensure sustainable management of water sources within that area. Sudden drastic changes in water quality can also have chronic effects on aquatic biota leading to localised extinctions. Deterioration in water quality will also affect its suitability for human domestic/agricultural use and have far reaching impacts for local communities who may rely on rivers as water supply (Macfarlane *et al*., 2014).

5.1.3 **Alien Invasive Species**

There are minimal alien invasive plant species currently present within the area. Any ground disturbance provides an opportunity for alien invasive plant species to spread and for new species to establish themselves in the areas. Alien invader plant species pose an ecological threat as they alter habitat structure, lower biodiversity (both number and “quality” of species), change nutrient cycling and productivity, and modify food webs (Zedler & Kercher, 2004). Such changes on the ecology of the riparian habitat have/will have a detrimental impact on its ability to maintain both floral and faunal biodiversity. Invasive alien plant species, particularly woody species, have much increased water usage compared with indigenous vegetation. Many alien invasive plant species are particularly found in riparian ecosystems and their invasion results in the destruction of indigenous species; increased inflammable biomass (high fire intensity); erosion; clogging of waterways such as small streams and drainage channels causing decreased river flows and incision of river beds and banks. This results in an overall impact on the hydrological functioning of the system.

Physical alteration of cross-sectional and longitudinal profiles of rivers may also result from bulk earthworks associated with the plants for example, altering natural water flow and sediment dynamics within rivers, having a knock-on effect on habitat and ecosystem dynamics. These impacts can stimulate erosion, as well as potential sedimentation of downstream habitats and a change to water regimes of adjoining riverine and riparian habitat. Areas that are mainly natural/intact would be most affected by these impacts (Macfarlane *et al*., 2014).

5.1.4 **Mitigation**

The proposed Tiara Mine will have negative effects on the environment. The following mitigation measures may reduce the severity of impacts:

- Design and implementation of a suitable stormwater system;
- Rehabilitation of the disturbed areas;
- Limiting instream sedimentation;
- Minimising pollutants entering the rivers and channels areas;
- Implement a programme for the clearing/eradication of alien species including long term control of such species;
- A 100 m buffer implemented for the watercourses;
- Water quality monitoring must take place every month during operational phases; and
- Biomonitoring must take place annually during hi flow season.

Sedimentation and soil erosion

Mitigation options

- Alien vegetation must be cleared prior to clearing/stripping new areas, to ensure alien vegetation is not spread to other areas.
- A topsoil stripping and stockpiling guideline must be completed to ensure rehabilitation success.
- Attenuation of stormwater from any establishment and its associated infrastructure is important to control the velocity of runoff towards the channel and river systems. Attenuation structures must be placed between the development and associated infrastructure and the river.
- Attenuation measures must include, but are not limited to - the use of sand bags, erosion control blankets, and silt fences.
- Long term attenuation measures, such as attenuation/infiltration trenches, swales must be established to control stormwater from hardened surfaces so as to Sustainable Urban Drainage Systems (SUDS): All storm water runoff from the site must be supplemented by an appropriate road drainage system that must include open, grass-lined channels/swales rather than simply relying on underground piped systems or concrete V-drains. SUDS will encourage infiltration across the site, provide for the filtration and removal of pollutants and provide for some degree of flow attenuation by reducing the energy and velocity of storm water flows through increased roughness when compared with pipes and concrete V-drains.
- Do not allow surface water or stormwater to be concentrated, or to flow down cut or fill slopes without erosion protection measures being in place.
- Vegetation clearing must be undertaken as and when necessary in phases.
- Materials or the plant and plant infrastructure, other than sourced from the approved quarries/pits, must be sourced from a licensed commercial source.
- Any topsoil removed from the project footprint must be stockpiled separately from subsoil material and be stored suitably for use in rehabilitation activities.
- Install sediment barriers (silt catchers and Reno mattresses) along any drainage areas to prevent the migration of silt.
- All demarcated sensitive zones outside of the mine area are strictly off limits during any mining activity.
- Exposed soils must be rehabilitated as soon as practically possible to limit the risk of erosion. Erosion control measures must be employed where required.
- Stabilise, re-shape and rehabilitate disturbed areas as soon as practically possible (within 3 weeks of disturbance) with indigenous channel and river and riparian vegetation. Such rehabilitation should be informed by a suitable replanting and re-vegetation programme, sand bags, silt fencing, etc. A mix of rapidly germinating indigenous vegetation must be used.

- Riparian vegetation bordering on drainage lines and rivers will be considered environmentally sensitive and impacts on these habitats should be avoided.
- If erosion has taken place, rehabilitation will commence as soon as possible.
- All roads need to be maintained and any erosion ditches forming along the road filled and compacted.
- Berms/ earthen walls should be vegetated in order to avoid erosion and sedimentation.
- Runoff water from the waste dumps, stockpiles and contaminated stormwater will be channelled into newly pollution control dams to avoid effects on the channel and river system. The water in these pollution control dams will be reused during the mining operations.
- Demarcated and bunded stockpiles and waste dumps will also be placed in areas where groundwater and surface water pollution can be avoided.
- The runoff will be routinely monitored for acidity and salinity as an early warning for potential increases in salinity or acidic drainage water.

Pollution of water resources and soil

Mitigation options

- Demarcate riverine and channel areas to avoid unauthorised access.
- No washing of any equipment in close proximity to a watercourse is permitted.
- No releases of any substances that could be toxic to fauna or faunal habitats within the channels or any watercourses is permitted.
- Spillages of fuels, oils and other potentially harmful chemicals must be cleaned up immediately and contaminants properly drained and disposed of using proper solid/hazardous waste facilities (not to be disposed of within the natural environment). Any contaminated soil must be removed and the affected area rehabilitated immediately.
- Portable toilets must be placed on impervious level surfaces that are lipped to prevent spillage. The general consensus is that they should be within 30 m to 50 m of a work face
- Cut-off trenches must be constructed to prevent any harmful substances from entering the channel and river area.
- Education of workers is key to establishing good pollution prevention practices. Training programs must provide information on material handling and spill prevention and response, to better prepare employees in case of an emergency.
- Signs should also be placed at appropriate locations to remind workers of good housekeeping practices including litter and pollution control.

- The proper storage and handling of hazardous substances (hydrocarbons and chemicals) needs to been ensured. All employees handling fuels and other hazardous materials are to be properly trained. Storage containers must be regularly inspected so as to prevent leaks.
- Ensure that any rubbish/litter is cleared once a month as to minimise litter near the channel and river areas. These will need to be cleaned out in accordance with a regular maintenance programme.
- Industry Best Practise Guidelines and Standards needs to be implemented in terms of tailings storage design. Built-in engineering designs such as drainage systems and decanting pools are recognised as mitigation measures.
- Water quality will be monthly monitored with the site activities. This includes sites upstream and downstream.
- Ensure pollution sources are isolated through clean and dirty water separation and monitor this throughout the lifespan of the Tiara Mine.
- All contractors and employees should undergo induction which is to include a component of environmental awareness

Alien Invasive Species

<u>Mitigation Options</u>

- An alien invasive management programme must be incorporated into an Environmental Management Programme.
- Ongoing alien plant control must be undertaken, particularly in the disturbed areas as these areas will quickly be colonised by invasive alien species, especially in the riparian zone, which is particularly sensitive to AIP infestation.
- Herbicides must be carefully applied, in order to prevent any chemicals from entering the river. Spraying of herbicides within or near to the channel and river areas is strictly forbidden.
- Re-instate indigenous vegetation (grasses and indigenous trees) in disturbed areas.

Table 17: Significance ratings matrix for the impacts without mitigation measures being implemented for proposed Tiara Mine.

No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level
1	Construction phase	**Proposed Tiara Mine**	Stream Diversion Work Revetments (Rock Platform) Culvert structures Access routes for culvert Vegetation clearing Use of heavy machinery	Flow alterations due to erosion and sedimentation	5	3	5	5	4,5	3	3	10,5	4	3	5	3	15	157,5	M	70
2	Construction phase	**Proposed Tiara Mine**	Culvert structures Use of heavy machinery using oils and fuels during vegatation clearing Accidental spillages of chemicals, cements, oils, etc.	Pollution of watercourse	2	4	2	5	3,25	3	3	9,25	4	3	5	3	15	138,8	M	70
3	Construction phase	**Proposed Tiara Mine**	Access routes for culvert construction Installation of road drainage Use of heavy machinery Bank trampling leading to erosion	Spread of alien vegetation	3	3	4	5	3,75	3	3	9,75	4	3	5	3	15	146,3	M	70
4	Operational phase	**Proposed Tiara Mine**	Increased traffic Burning and handling hazardous materials Bank Erosion	Flow alterations due to erosion and sedimentation	5	2	5	5	4,25	3	5	12,25	5	5	5	3	18	220,5	H	80
5	Operational phase	**Proposed Tiara Mine**	Increased traffic leading to potential accidential spills of hydrocarbon materials Hazardous materials entering the watercourses from the Ash and Power Plant Increased road runoff during rainfall events	Pollution of watercourse	2	5	2	2	2,75	3	5	10,75	5	5	5	3	18	193,5	H	80
6	Operational phase	**Proposed Tiara Mine**	Increased runoff from hardened surfaces Clearing of indigenous vegetation	Spread of alien vegetation	3	3	3	3	3	3	5	11	5	5	5	3	18	198	H	80

Table 18: Significance ratings matrix for the impacts with mitigation measures being implemented for proposed Tiara Mine.

No.	Phases	Activity	Aspect	Impact	Flow Regime	Physico & Chemical (Water Quality)	Habitat (Geomorph + Vegetation)	Biota	Severity	Spatial scale	Duration	Consequence	Frequency of activity	Frequency of impact	Legal Issues	Detection	Likelihood	Significance	Risk Rating	Confidence level
1	Construction phase	**Proposed Tiara Mine**	Stream Diversion Work Revetments (Rock Platform) Culvert structures Access routes for culvert Vegetation clearing Use of heavy machinery	Flow alterations due to erosion and sedimentation	3	2	3	3	2,75	2	3	7,75	4	3	5	3	15	116,3	M	70
2	Construction phase	**Proposed Tiara Mine**	Culvert structures Use of heavy machinery using oils and fuels during vegatation clearing Accidental spillages of chemicals, cements, oils, etc.	Pollution of watercourse	2	4	2	3	2,75	2	3	7,75	4	3	5	3	15	116,3	M	70
3	Construction phase	**Proposed Tiara Mine**	Access routes for culvert construction Installation of road drainage Use of heavy machinery Bank trampling leading to erosion	Spread of alien vegetation	3	3	3	3	3	2	3	8	4	3	5	3	15	120	M	70
4	Operational phase	**Proposed Tiara Mine**	Increased traffic Burning and handling hazardous materials Bank Erosion	Flow alterations due to erosion and sedimentation	4	2	4	4	3,5	3	5	11,5	4	4	5	3	16	184	H	80
5	Operational phase	**Proposed Tiara Mine**	Increased traffic leading to potential accidential spills of hydrocarbon materials Hazardous materials entering the watercourses from the Ash and Power Plant Increased road runoff during rainfall events	Pollution of watercourse	2	4	2	4	3	3	5	11	4	5	5	3	17	187	H	80
6	Operational phase	**Proposed Tiara Mine**	Increased runoff from hardened surfaces Clearing of indigenous vegetation	Spread of alien vegetation	4	2	4	2	3	3	5	11	4	5	5	3	17	187	H	80

5.2 River and Channel Buffer

The river and channel areas assessed within the proposed Tiara Mine boundary, covers a great area and the buffer calculated for this should be implemented and adhered to by mine management.

The buffer tool aims to provide a method for determining appropriate buffer-widths for developments associated with channel and rivers, rivers or estuaries. This method takes into account a number of different factors in determining the buffer width including the impact on water resources, climatic factors and the sensitivity of the water resource

The calculated results indicate that a 100 m buffer is appropriate for the protection of the ecosystem services provided by the channel and river systems (**Figure 24**). Any activity must occur outside of the recommended 100 m buffer zone.

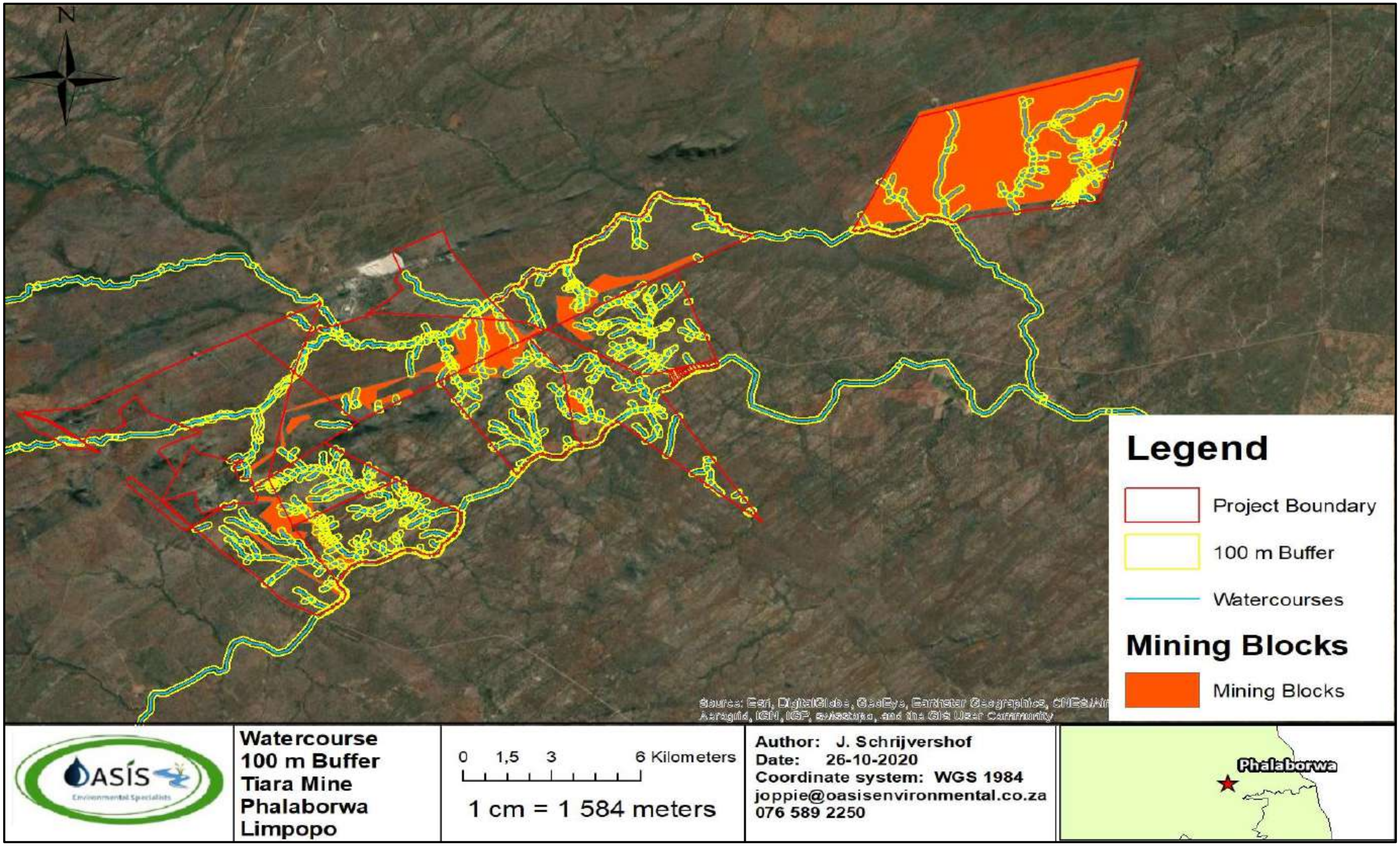

Figure 24: Tiara Mine - Watercourse 100 m Buffer map.

6 IMPACTS ON BIODIVERSITY

Any development activity in a natural system will have an impact on the surrounding environment, usually in a negative way. The purpose of this phase of the study was to identify and assess the significance of the potential impacts caused by the proposed development and to provide a description of the mitigation required so as to limit the identified impacts on the biodiversity.

A number of potential impacts relating to the loss of indigenous vegetation, floral habitat and ecological structure, loss of floral diversity and ecological integrity, proliferation of alien invasive species, loss of plant species of conservation concern, loss of faunal habitat, direct faunal impacts and disturbance to fauna are predicted to occur as a result of the proposed Tiara Mine. These impacts will cause permanent damage to the environment and can never be fully reversed or mitigated.

6.1.1 **Loss of Species of Conservation Concern**

Due to the removal of vegetation within the project area, loss of floral diversity is inevitable. There will be a resultant increase in the risk of alien plant species that colonise the area, subsequently decreasing the indigenous species richness and composition of the area. The loss of ground cover will also expose soil leading to soil desiccation.

The proposed mining development is likely to have a negative impact in terms of loss of ecological connectivity through the clearing of vegetation. This will result in habitat fragmentation. Loss of habitat and habitat fragmentation will disrupt ecological functioning, negatively affecting the ecological integrity of the area. Small fragments of vegetation may not be large enough to support viable populations of pollinators and seed dispersers, resulting in the decreased reproduction of plant species. Moreover, an extinction debt may be present in cleared or fragmented areas, whereby, as a consequence to reduced floral diversity and disturbance to population structure, future extinction of local populations is unavoidable.

Crinum macowanii is still common and assessed as Least Concern (LC) on the Red List, but a decline in the number of wild plants has been observed. Bulbs are harvested and sold on medicinal plant markets. These plants require specialised habitats and their removal will have cumulative impacts of reduced species richness and composition.

From a faunal perspective, endemic species and species of concern have specific habitat requirements and the impacts of the proposed mine will have significant effects on these species. The reptile species are slow moving and will likely be targeted during the construction and operational phase.

Table 19: Impacts associated with the loss of species of conservation concern

Setting up infrastructure and moving onto site				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	10	**80 (Very High)**
Operational Phase				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	8	**70 (Very High)**

6.1.2 **Loss of indigenous vegetation, floral and faunal habitat and ecological structure of water resources and soil**

The proposed mining operation will result in the destruction of vegetation, floral habitat and a complete loss of faunal habitats within the area. This will directly impact the ecological condition of natural vegetation and habitat availability. These activities will have an impact on foraging, breeding and roosting ecology of faunal species. Loss of vegetation generally affects nutrient cycles, removes the organic litter layer and results in habitat fragmentation and destruction of wildlife corridors.

The vegetation on the proposed mine site itself is regarded as intact and species diverse. Disturbance of soil and removal of vegetation will promote the establishment and of alien invasive species.

Cumulative impacts include a decrease in floral habitat and ecological structure will lead to the proliferation of alien invasive species, a potential loss of red listed plant species, habitat fragmentation and an overall decrease in species richness in the area. The large land surface alterations will also change the composition of the ecosystem on the edge of structures. This will result in a loss of cohesiveness between larger fragments of habitat limiting gene exchanges and resources between these areas.

Loss of vegetation, in the case of a mine is irreversible, and although rehabilitation will take place after the mine is closed, restoration of the natural habitat on site cannot be achieved. This is particularly significant in an area where endemism of both flora and fauna is considered high and in ecologically sensitive areas.

Table 20: Impacts associated with the loss of indigenous vegetation, floral and faunal habitat and ecological structure

Setting up infrastructure and moving onto site				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	10	**80 (Very High)**
Operational Phase				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	10	**80 (Very High)**

6.1.3 **Alien Invasive Species**

Alien invasive species will quickly encroach into disturbed areas. Alien species generally out-compete indigenous species for water, light, space and nutrients as they are adaptable to changing conditions and are able to easily invade a wide range of ecological niches (Bromilow, 2010). Alien invader plant species pose an ecological threat as they alter habitat structure, lower biodiversity (both number and “quality” of species), change nutrient cycling and productivity, and modify food webs (Zedler, 2004). This negatively affects the ability of the disturbed area to maintain floral biodiversity.

Table 21: Impacts associated with the proliferation of alien invasive species

Setting up infrastructure and moving onto site				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	10	**80 (Very High)**
Operational Phase				
Probability	**Duration**	**Extent**	**Magnitude**	**Significance score**
5	4	2	10	**80 (Very High)**

6.1.4 Mitigation

- The mining footprint should be kept as small and as linear as possible.
- During the construction phase, workers must be limited to areas under construction and access to the undeveloped areas must be strictly controlled.
- The boundaries of the development footprint areas are to be clearly demarcated and it must be ensured that all activities remain within the demarcated footprint area. No activities are to infringe upon any channels and/or rivers.
- Edge effects of all phases, such as erosion and alien plant species proliferation, which will affect faunal habitats adjacent to the development area, need to be strictly managed. This can be achieved through the chemically and mechanically removing alien invasive vegetation within the mining footprint. The removal of this vegetation will provide job opportunities for community members.
- Any natural areas beyond the development footprint, which have been affected by the construction activities, must be rehabilitated using indigenous plant species. Rehabilitation must take place concurrent to operations, and post-closure.
- The clearing of vegetation, during the construction phase, must be kept to a minimum and must be within the

project boundaries.

- Harvesting and collection of any flora must be strictly prohibited.
- Erosion control measures must be implemented in areas sensitive to erosion such as exposed soil, edges of slopes (including trenches cut for construction) etc. These measures include but are not limited to - the use of sand bags, hessian sheets, silt fences and retention or replacement of vegetation.
- Avoid known areas of faunal and floral species of special concern as indicated on the relevant maps.
- Avoidance of sensitive areas, as these areas are ecologically irreplaceable.
- Maintain top soil biological activity by stockpiling soils without compacting them. This keeps the seed bank in the topsoil viable if the topsoil is replaced within a year. This viable seedbank will create an effective basis for rehabilitated areas where these soils are used.
- Education and awareness campaigns on faunal species and their habitat are recommended to help increase awareness, respect and responsibility towards the environment for all staff and contractors.
- Disturbed areas must be rehabilitated immediately after construction has been completed in that area by planting appropriate indigenous plant species.
- If mining is permitted, rehabilitated areas must be monitored to ensure the establishment of re-vegetated areas to a ground of cover of at least 85%.
- Once pegged, a qualified botanist must walk the site to identify all conservation-important species. These species must be translocated to a suitable habitat outside of the construction footprint, prior to any construction activities.
- Plant permits must be obtained from the relevant authorities prior to any construction activities commencing.
- Any protected plants that are removed must be replaced at a ratio of 1:10 (10 plants must be planted for every 1 plant removed).
- It is highly recommended that a speed limit of 30km/h is implemented on all roads running through the proposed mining area during all phases in order to minimise risk to fauna from vehicles and that signage is erected to this effect. Should an animal be killed by a vehicle, the incident must be reported immediately to the ECO and to the Endangered Wildlife Trust (www.ewt.org.za), to monitor road kills. EWT Wildlife and Roads project has been set up to monitor and investigate the effects of road kills in South Africa.
- Any bird nests that are found during the construction period must be reported to the Environmental Control Officer

(ECO).

- It is essential that as transformation takes place on site, a qualified herpetologist must be present on site to identify and safely remove all reptiles or other slow moving species, should they occur on the proposed development site.
- No trapping or hunting of fauna is to take place. Access control must be implemented to ensure that no illegal trapping or poaching takes place.
- Where possible, species should be left in their natural environment.
- Should any Red Data faunal species be noted within the development footprint areas, these species must be relocated to similar habitat with the assistance of a suitably qualified ecologist.
- Any species directly threatened by the construction activities must be removed to a safe location by the ECO or qualified Ecologist. Floral species of special concern must be relocated or placed in a nursery.
- If the proposed Tiara Mine proceeds, it must contribute meaningfully to conservation in the region. Conservation of natural land and the creation of corridors in the area would aid ecosystems, and fauna and flora. Corridors and conservation areas should be identified by qualified ecologists for a Biodiversity Action Plan (BAP).
- Avoidance of river and channel areas as far as possible (100 m buffer), these areas are regarded as highly sensitive areas.
- Search and rescue for reptiles and other vulnerable species, before areas are cleared.
- Environmental induction for all staff and contractors on-site.
- Any disturbed areas should be rehabilitated in line with the rehabilitation guidelines, this includes the clearing of alien vegetation, following the guidelines of a suitable alien invasive plant management plan.
- The site must be regularly monitored for re-growth of alien invasive species, and any new seedlings etc. eradicated using methods appropriate for the particular species, whether mechanical, chemical or biological.
- Protect as much indigenous vegetation as possible.
- An alien invasive management programme must be incorporated into an Environmental Management Programme.
- Ongoing alien plant control must be undertaken in the disturbed areas as these areas will quickly be colonised by invasive alien species, especially in the riparian zone, which is particularly sensitive to AIP infestation.
- Herbicides must be carefully applied, in order to prevent any chemicals from entering the river. Spraying of herbicides within or near to the channel and river areas is strictly forbidden.

- Re-instate indigenous vegetation (grasses and indigenous trees) in disturbed areas directly after mining ceases so as to stabilise against erosion and sedimentation.

7 REHABILTATION PLAN

The directive mine manager and Environmental Control Officer (ECO) from Tiara Mine is responsible and will play a major role in ensuring that this rehabilitation plan and mine closure is effectively managed and implemented. This plan is environmental legally binding and must be implemented to fulfil the requirements of relevant legislations and recommendations.

Tiara Mine will be responsible for the appointment of the ECO, Dam Engineers and relevant specialists to perform rehabilitation and monitoring activities as well as alien vegetation removal and control. The rehabilitation works have to be signed off by a suitably qualified environmental specialists.

The hardened surfaces adjacent to watercourses will only marginally increase the velocity and volume of stormwater entering the channel and river areas. However, one must take into account the steepness of the topography of the surrounding area. Stormwater will increase in velocity substantially before entering the channel and river areas at the base of these steep adjacent hills. The root cause of absence of offsite stormwater management must therefore be addressed in order to begin to protect, rehabilitate and manage the watercourse areas. The current lack of adequate stormwater control impacting can create erosion in all the channel and riverine areas. Failure to address this is likely to lead to the complete destruction of the majority of the river systems in the future.

Findings from the rivers assessed that are associated with the causes of degradation can be summarised as relating to three fundamental issues:

- Soil erosion and gully formation, either as a result of a lack of stormwater management in the larger catchment or as a result of local activities including mining, overgrazing and crops in all watercourses; and
- The dominance of alien invasive plant species in large areas of the channel and river systems.

In order to address these impacts a channel and river management plan that establishes favourable hydrological conditions in the delineated channel and river systems and allows for the regeneration of the functional integrity of the channel and rivers is needed.

7.1 Soil Erosion and Gully Formation

The soil-vegetation interplay is generally in equilibrium with the energy expanded on them by the surface waters that flow through them. Stability is maintained as long as conditions in the catchment remain static and in a good state of conservation (Russel, 2009).

The first step in addressing soil erosion and gully formation in a channel and river is therefore to look at the impacts causing this degradation in the channel and river's catchment area. It is important to note that a channel and river is a mirror of its catchment; a degraded catchment equals a degraded channel and river. Overgrazing is one of the two major contributions to soil erosion, the other being a lack of stormwater control; it should be noted that the former is an important contributor to the latter.

The approach to watercourse conservation and sustainable use therefore needs to take into account the current pressures and threats facing the watercourses and provide a general recognition. The first step in reversing the effects of overgrazing is therefore the removal of livestock from these areas for a predetermined period of time.

A number of governmental and poverty-relief organisations can be utilised to provide education to the surrounding community on the benefits associated with rehabilitating these areas and stopping the overgrazing of these areas as well as providing job opportunities in conducting the actual rehabilitation works.

7.2 Watercourse Rehabilitation

7.2.1 **Fix any erosion points created**

- Any erosion features created need to be stabilised.
- Earthen berms or plugs, rock packs or gabions may be used for the plugging of erosion gullies.
- For earthen structures used to fill erosion points, the soil used needs to be properly compacted.

7.2.2 **Reinstate soils and prepare planting area**

- Stockpiled soils shall be placed in the reverse order as to which it was removed (i.e. subsoil first followed by topsoil).
- Reinstated soil is not to be compacted too heavily, as this will prevent water saturation and proper plant growth during rehabilitation. Where significant soil compaction has occurred, the soil may need to be ripped in order to reduce the bulk density of the soil such that vegetation can become established at the site.
- Where good topsoil exists, no specific preparation is required.

- An average depth of 30 cm to 50 cm topsoil should be maintained across the disturbed area where possible to provide sufficient depth for rooting of indigenous plants.

7.2.3 Remove any waste products

- All waste products (spoils, hazardous substances and general litter) need to be removed from riparian areas and disposed of in proper local waste facilities.
- Minimise additional disturbance by limiting the use of heavy vehicles and personnel during clean-up operations.

7.2.4 Reinstate vegetation

- A specialist should be contracted to supervise the rehabilitation of channel and river/riparian areas disturbed.
- Vegetation is to be reinstated as soon as weather conditions allow for plant growth.
- A suitable replanting/re-vegetation programme should be implemented. This should comprise a mix of rapidly germinating indigenous species grasses, shrubs and trees naturally occurring in the affected habitat and adapted to stabilizing areas.
- It would be advisable to plant at the onset of the wet season (early spring – August to October) so that watering requirements are minimal.
- Do not use fertilizer, lime, or mulch unless required.
- The three main methods of re-vegetating channel and river areas include: seeding, cuttings and the transplanting of whole plants
- Monitor re-vegetation progress and administer alien plant control.
- Recovery of disturbed areas should be assessed by the ECO. Any areas that are not progressing satisfactorily must be identified (e.g. on a map) and action must be taken to actively re-vegetate these areas. If natural recovery is progressing well, no further intervention may be required.
- The use of herbicides in IAP control will require an investigation into the necessity, type to be used, effectiveness and impacts of the agent on aquatic biota.
- Implement alien invasive plant control as stipulated below to ensure that alien plants are actively managed and eradicated from the site, with adequate monitoring and follow-up measures.

7.2.5 Control of Alien Invasive and Problem Plant Species

This must be conducted by a registered pest control operator, specialising in alien invasive plant control. Alien plant invasions cause a decline in species diversity, local extinction of indigenous species and ecological imbalance. Thus, preventing the onset of an alien invasion and management of further spreading is required as they outcompete the indigenous plant species and quickly establish themselves in an area. Therefore, a national strategy has been compiled and identifies four primary categories of programs to address the management of alien invasive plant species and they are as follows:

- **Prevention—**Keep the invasive species out;
- **Early detection and rapid response—**Detect and eradicate invasive species to stop them from spreading;
- **Control and management—**Eliminate or control the problem of invasive species; and
- **Rehabilitation and restoration—**Heal, minimize, or reverse the harmful effects from invasive species.

The occurrence of alien invasive plants not only affect the growth and distribution of natural endemic plants, they also use more water than indigenous plants, some have toxic fruits or leaves which when consumed could be poisonous and lead to fatality. Therefore, alien invasive plant species need to be controlled or removed and the following section contains different methods that could be used to control AIP.

The ultimate aim of an alien invasive species management programme is to eradicate species completely. This is often very difficult as many of the species have seeds that remain viable for a very long time and even after physical removal of plants, the seeds germinate to form new infestations. An alien invasive management programme therefore must be an ongoing practice over many years and should follow the following phases:

A. The initial bulk eradication of alien invasive species by chemical or mechanical means, and in some instances biological control agents. This may also require rehabilitation if large stands of alien invasive species are removed. Local, indigenous species should be planted in the disturbed areas;

B. There should also be immediate follow up and all seedlings should be pulled out and removed. This should be done regularly, although the timeframes will vary from species to species depending on their growth forms and rates; and

C. Finally, areas that appear to be under controlled must continue to be managed and observation of these sites should continue on at least an annual basis. Rehabilitation at sites should also be monitored and action taken immediately if issues occur.

Various control methods are available for control of alien invasive species, including mechanical, chemical and biological control. In most instances, mechanical means are utilised and include physical removal of plants. Research on use of herbicides has been conducted on many species and can be applied in conjunction with mechanical methods. For some species, herbicides have not yet been fully researched and/or herbicides have not been registered and they need to be mechanically controlled.

Biological control of alien invasive species is also an ongoing process and some biological control agents have been released on various alien invasive species and show varying degrees of success. Biological control options need to be carried out with specialist advice from academic or research institutes involved in research of alien invasive species.

Control options utilised must take into account the species being controlled and should take into account the ecosystem in which the control options are being applied. Some of the herbicides registered for control of alien invasive species should not be used in riparian areas, and some should be preferably used over others in areas where natural grass cover occurs. Some herbicides should only be utilised after consultation with a Working for Water technical advisor.

The control options are discussed below as individual actions, but in many cases integrated measures (more than one (1) control measure) are taken for more effective control of alien invasive species. As already mentioned, research with regard to herbicide application and biological control is lacking for certain alien invasive species and these, especially if listed as Category 1 invasive species, need to be managed and mechanical control of these species should be considered as a default control option.

8 MONITORING

The monitoring programme must include sites/locations where biological monitoring has occurred previously, if possible. The sites included in this study will be sufficient to include in future monitoring applications during the high and low flow season. The objectives of the programme would be to monitor the state of the channel and river system through the measurement of physical and biological properties. It is the project manager and lead environmental manager/consultant's responsibility to ensure the correct implementation of the monitoring programme.

As of this study the baseline data is established and can be used to compare with in future studies as a means to determine if ecological degradation or improvement has occurred. Key performance indicators would include the improvement of biotic communities associated with the project area. Implement a suitable bi-annual monitoring surveys for the lifetime of the project. The following parameters should be monitored by qualified specialists:

- Monthly water quality monitoring;
- Annual biomonitoring during high flow season on the Ephemeral systems with water (SASS 5 and IHAS); and
- Bi-annual riparian vegetation monitoring.

If modifications to the system occur, a reduced biological diversity will be observed. Proliferation of pollution tolerant species may also be an indication of a deterioration of ecological integrity. If there is further reduction in species diversity further studies should be undertaken which should include water quality analysis as well as the accumulation of pollutants in the sediments, however, if mitigation measures are followed this may be avoided or reduced.

9 CONCLUSION & RECOMMENDATIONS

According to the ecological classification for the quaternary catchments B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment); the Mulati is classified in its present state as a **Category C (Moderately Modified)** Upstream and as a **Category B (Largely Natural)** downstream. The Selati is classified in its present state as a **Category B (Largely Natural)** River. The default ecological management class for the relevant quaternary catchments is considered to be a **highly sensitive** system for the Selati River and **moderate** for the Mulati in terms of ecological importance with both being a **highly ecological sensitive**. The attainable ecological management class for the systems is a Category B (largely natural).

The Selati River was dry at the time of the assessment, where the downstream site and the Mulati River has pockets of water at the time of the assessment, although receiving 100 mm a few days before the assessment. This suggest that these systems could be classified as ephemeral streams.

From the *in situ* water quality the pH was found to be within the neutral range. Temperature was relatively high, where electrical conductivity levels were within recommended guideline levels. Dissolved oxygen (DO) levels were below guideline levels. Extensive mining and grazing were observed at the time of the assessment at the sample locations.

The IHIA results recorded the sites assessed within a **largely modified state (Category D)**. A category of D indicates that the loss of natural habitat, biota and basic ecosystem functions is largely transformed from reference conditions. The predominant cause for concern was damming, current mining, erosion, grazing, deforestation and alien invasive plants. Hydrophytic riparian vegetation consisted of mainly of *Cyperus spp*. *Crinum macowanii, Juncus spp*. and *Typha capensis.* The findings for the vegetation assessment revealed that riparian habitat of the area was **largely modified (Category D)** with deforestation within the non-marginal zone and alien invasive vegetation within the marginal zone.

During this survey; no sensitive organisms were sampled at any of the study sites. Sampled invertebrates included the *Corixidae, Nepidae, Notonectidae, Dytiscidae, and Physidae,* families. This SASS5 scores for both downstream sites indicate that the stream is **seriously modified (Category E/F)**. The majority of highly pollution tolerant organisms indicates the pressure from lack of suitable flow at the time of the assessment and these results should be interpreted with low confidence.

The habitat reaches which were assessed for the Mulati DS site, found to be **inadequate**, where biotopes with limited habitat structures were present. The dominant feature of the invertebrate habitat is the mud and gravel substrate which dominates the streams under study. Generally, no stones in or out of current biotope were found to be available throughout the stream with extensive erosion present. Some fringing vegetation were sampled at the downstream Mulati River site.

Although no fish species were sample, the SQR fish data available for that specific reach had 12 species of fish expected to occur within that stretch of river according to DWS (2013).

Several valley bottom and NFEPA channel and rivers were identified within the mining boundary during the desktop assessment, associated with the Selati and Mulati rivers. Although **no wetlands** were found to be present within the area during the site visit, most rivers and dams are listed as wetland areas within the NFEPA database.

The channel delineation revealed numerous non perennial 'A' Section channels and only two ephemeral 'B' Section channels, namely the Mulati River and Selati River. These areas were dry and had small pools due to 100 mm rains prior to the site visit, where basic ecosystem functions were impacted demonstrating a very narrow riparian zone in line with the channel areas. The majority of drainage channels were identified as 'A' Section channels without any riparian plant species identified

Both the 'A' Section and 'B' Section channels overlaps with the propose mining blocks, which could impact the functionality of these system, especially during rain events, ultimately leading to the Olifants River being impacted further by the mining activities within the Kruger National Park downstream.

According to the biodiversity datasets provided by SANBI (2020), the majority of the application area falls within Ecological Support Areas (ESA) and Critical Biodiversity Areas (CBA). These Critical Biodiversity Areas (1) (CBA 1) are classified as irreplaceable sites and are required to meet biodiversity pattern and/or ecological process targets. No Site alternatives are recommended for these areas and are regarded as highly sensitive. Critical Biodiversity Areas (2) (CBA 2) are classified as best design selected sites and are selected to meet biodiversity pattern and/or ecological process targets. Alternative sites may be available to meet targets. Ecological Support Areas (1) (ESA 1) are natural and/or near natural and degraded areas supporting CBAs by maintaining ecological processes.

Information on plant species recorded in that area was extracted from the POSA list, indicate that 292 plant species have been recorded in the area queried of which 288 are endemic species are known to occur within the area queried. Nine possible red data protected trees listed in Mucina and Rutherford (2006) and SANBI species lists (2020) are thought to occur with the area and include *Combretum imberbe, Boscia albitrunca, Adansonia digitata, Balanites maughamii subsp. maughamii, Catha edulis, Pterocarpus angolensis, Elaeodendron transvaalense* and *Sclerocarya birrea subsp. Caffra*. This information must be used in the permit applications for the cutting or trimming of trees (from DAFF). According to in the National Environmental Management Biodiversity Act (Act 10 of 2004) (NEMBA) the vegetation type is listed as vulnerable (NEMBA, 2004). The IUCN critically endangered (*Encephalartos dyerianus*) is known to be found within the Phalaborwa area's open grasslands and shrublands on the slopes of low granite hills, but was not observed during the site visit.

Observed trees in the area include *Breonadia salicina, Sclerocarya birrea, Lannea schweinfurthii, Senegalia caffra, S. nigrescens, Vachellia sieberiana, V. karroo, Dichrostachys sericea, Ziziphus mucronata,Diospyros mespiliformis, Ficus sur, F. sycomorus, Philenoptera violacea, Combretum imberbe, C. apiculatum, C. collinum* and *Philenoptera violacea*.

African Baobab trees (*Adansonia digitata*) were identified within the present landscape. Although they are not yet classified by the IUCN's Red List criteria, but they are a part of the "Catalogue of Life." The baobab is a protected tree in South Africa. The effects of drought, desertification, deforestation and over-use of the fruit have been cited as causes for concern for these slow growing species (Osman, 2014). No other protected species were observed during the survey. River lily species (*Crinum macowanii*) with the roots and leaves having some medicinal uses as a pain killer and having emetic and laxative properties were found closer to watercourse areas.

Very little alien species were identified on site. The dominant plant species identified were alien invasive Castor oil plant (*Ricinus communis*) (category 2) and Spanish reed (*Arundo donax*) (category 1b) within the riparian zones.

The faunal component between the game farms/private reserves and open bushveld differs considerably. Within the open areas where deforestation of Mopani forest are occurring, very little evidence of faunal activity was noted. Cattle and goats were noted grazing within these areas. Some spoor and droppings of *Sylvicapra grimmia, Aepyceros melampus, Tragelaphus strepsiceros, Hystrix africaeaustralis* and some smaller rodents were seen.

Between game farms and private reserves the diversity of the animals increased In the cattle areas, more *Sylvicapra grimmia, Aepycerosmelampus, Tragelaphus strepsiceros* and *Raphicerus campestris* activity were noted (higher protection and better habitat). Larger species and rare game are present and include *Loxodonta africana, Syncerus caffer, Panthera pardus, Panthera leo, Crocuta crocuta, Equus quagga, Connochaetes taurinus, Giraffa camelopardalis, Hippotragus niger, Hippotragus equinus* and *Damaliscus lunatus*.

Limited faunal species were observed and the majority was sites near game farms and private reserves and included: Communal spider nests, sociable weaver (*Philetairus socius*), Southern red-billed hornbill (*Tockus erythrorhynchus*), Girrafe liseted as vulnerabe (*Giraffa camelopardalis*), Chacma baboon (*Papio ursinus*) and Bluetailed sandveld lizard (*Nucras caesicaudata*). The proposed mining operations fall within close proximity to Important Bird Areas (IBAs), where the proposed mining area falls close to the Kruger National Park.

All bushveld areas and watercourses still intact can be considered highly sensitive areas serves as a breeding and foraging habitat for a number of faunal species. These areas can be regarded as ecologically irreplaceable and covers the majority of the area. It will be nearly impossible to imitate these areas after mining has been completed with a rehabilitation programme. Historical transformed Grasslands with cultivation which have been considered as moderately sensitive as they have been disturbed by surrounding anthropogenic activities, but some vegetation has started establishing again. Current transformed land by mining operation and agriculture can be considered low sensitive and covers the majority of the area.

All expected faunal species are listed in **Appendix A** for QDS 2330DC and 2330DD and all floral species are listed in A**ppendix B** for the Phalaborwa area.

The risk assessment on the channel and river areas for the current mining operations were rated as a **moderate impact without and without mitigation for construction and establishment** and as a **high impact with and without mitigation**, although there is a significant lowering in the impact scores when mitigation is being implemented. Identified impacts to watercourses pertaining to erosion, sedimentation, water quality and quantity alterations and the continued spread of alien invasive species were assessed. The proposed Tiara Mine already lies within pristine bushveld landscape and should mining commence, that mitigation measures must being implemented appropriately as it could reduce impacts immensely for the operational phase as these systems drain into the receiving Olifants System eventually.

A number of potential ecological impacts relating to proliferation of alien invasive species, loss of species of conservation concern, loss of indigenous vegetation, floral and faunal habitat and ecological structure of water resources and soil, loss of floral diversity and ecological integrity. The significance of potential impacts on biodiversity within the area was rated as a **very high significance with and without mitigation** as the proposed areas lies in a prestine bushveld area owned by private game reserves and with the implementation of a suitable rehabilitation programme, could not reach the historical ecological importance and status.

During construction it will be important to liaise with the landowners off the game farms and private reserves. Where dangerous animals are present, it will be important to ensure that game is moved to other camps where possible. A ranger from the farm must be present during construction to ensure the safety of man and animals.

Provided mitigation measures are to be implemented within an environmental management programme (EMPr) and the significance of any negative impacts reduced should the mining commence. Potential impacts associated with the construction and operational phase include:

- Increased sedimentation and water quality impairment due to runoff from waste dumps;
- Water quality contamination due to runoff or seepage from any tailings storage facility;
- Alteration of natural flow regime due to discharge of pit water;
- Increased utilisation of aquatic resources by local population; and
- Habitat loss associated with the stream diversion.

Should mining commence the following mitigation measures, aimed at minimising the afore-mentioned impacts, include (but are not limited to):

- Design and implementation of a suitable stormwater system;
- Rehabilitation of the disturbed areas;
- Limiting instream sedimentation;
- Minimising pollutants entering the watercourse;
- Implement a programme for the clearing/eradication of alien species including long term control of such species;
- A 100 m buffer was implemented for the channel and river systems;
- Ongoing water quality monitoring must take place; and
- Biomonitoring where/if flow conditions allow for effective sampling analysis must take place annually to determine any trends in ecology and hydrology.

The proposed mining activities are planned for an ecologically pristine site of high sensitivity, which can never be fully rehabilitated and ecologically restored to its pre-mining condition. The proposed mine is expected to have a serious long term negative impact on the project area and the surrounding environment.

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GLOSSARY

Catchment: The area where water from atmospheric precipitation becomes concentrated and drains downslope into a river, lake or channel and river. The term includes all land surface, streams, rivers and lakes between the source and where the water enters the ocean.

Delineation: Refers to the technique of establishing the boundary of a resource such as a channel and river or riparian area.

Invasive alien species: Invasive alien species means any non-indigenous plant or animal species whose establishment and spread outside of its natural range threatens natural ecosystems, habitats or other species or has the potential to threaten ecosystems, habitats or other species.

Mitigate/Mitigation: Mitigating channel and river impacts refers to reactive practical actions that minimise or reduce *in situ* channel and river impacts. Examples of mitigation include “changes to the scale, design, location, siting, process, sequencing, phasing, and management and/or monitoring of the proposed activity, as well as restoration or rehabilitation of sites”. Mitigation actions can take place anywhere, as long as their effect is to reduce the effect on the site where change in ecological character is likely, or the values of the site are affected by those changes (Ramsar Convention, 2012).

Water course: Means a river or spring; a natural channel in which water flows regularly or intermittently: a channel and river, lake or dam into which, or from which, water flows: und any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks (National Water Act, 1998).

APPENDIX A – FAUNAL SPECIES LIST FOR 2330 DC AND 2330 DD

INSECTA			
Aeshnidae	*Anax imperator*	Blue Emperor	Least concern
Aeshnidae	*Anax ephippiger*	Vagrant Emperor	Least concern
Hesperiidae	*Abantis tettensis*	Spotted velvet skipper	Least Concern (SABCA 2013)
Hesperiidae	*Abantis venosa*	Veined skipper	Least Concern (SABCA 2013)
Erebidae	*Achaea catella*		Not listed
Erebidae	*Achaea echo*		Not listed
Nymphalidae	*Acraea aglaonice*	Clear-spotted acraea	Least Concern (SABCA 2013)
Nymphalidae	*Acraea anemosa*	Broad-bordered acraea	Least Concern (SABCA 2013)
Nymphalidae	*Acraea caldarena caldarena*	Black-tipped acraea	Least Concern (SABCA 2013)
Nymphalidae	*Acraea natalica*	Black-based acraea	Least Concern (SABCA 2013)
Nymphalidae	*Acraea neobule neobule*	Wandering donkey acraea	Least Concern (SABCA 2013)
Nymphalidae	*Acraea oncaea*	Window acraea	Least Concern (SABCA 2013)
Pieridae	*Afrodryas leda*	Autumn-leaf vagrant	Least Concern (SABCA 2013)
Lycaenidae	*Aloeides damarensis damarensis*	Damara russet	Least Concern (SABCA 2013)
Aeshnidae	*Anax tristis*	Black Emperor	Least concern

Lycaenidae	*Anthene amarah amarah*	Black-striped ciliate blue	Least Concern (SABCA 2013)
Lycaenidae	*Anthene livida livida*	Pale ciliate blue	Least Concern (SABCA 2013)
Thyretidae	*Arniocera auriguttata*		Not listed
Thyretidae	*Arniocera erythropyga*		Not listed
Lycaenidae	*Axiocerses amanga amanga*	Bush scarlet	Least Concern (SABCA 2013)
Lycaenidae	*Azanus jesous*	Topaz babul blue	Least Concern (SABCA 2013)
Lycaenidae	*Azanus moriqua*	Black-bordered babul blue	Least Concern (SABCA 2013)
Lycaenidae	*Azanus natalensis*	Natal babul blue	Least Concern (SABCA 2013)
Lycaenidae	*Azanus ubaldus*	Velvet-spotted babul blue	Least Concern (SABCA 2013)
Pieridae	*Belenois aurota*	Pioneer caper white	Least Concern (SABCA 2013)
Pieridae	*Belenois creona severina*	African caper white	Least Concern (SABCA 2013)
Pieridae	*Belenois gidica abyssinica*	African veined white	Least Concern (SABCA 2013)
Hesperiidae	*Borbo fallax*	False swift	Least Concern (SABCA 2013)
Libellulidae	*Bradinopyga cornuta*	Horned Rockdweller	Least concern
Nymphalidae	*Byblia ilithyia*	Spotted joker	Least Concern (SABCA 2013)
Lycaenidae	*Cacyreus virilis*	Mocker bronze	Least Concern (SABCA 2013)

Erebidae	*Calliodes pretiosissima*		Not listed
Pieridae	*Catopsilia florella*	African migrant	Least Concern (SABCA 2013)
Sphingidae	*Cephonodes hylas hylas*		Not listed
Coenagrionidae	*Ceriagrion glabrum*	Common Citril	Least concern
Nymphalidae	*Charaxes achaemenes achaemenes*	Bushveld charaxes	Least Concern (SABCA 2013)
Nymphalidae	*Charaxes jahlusa rex*	Pearl-spotted charaxes	Least Concern (SABCA 2013)
Nymphalidae	*Charaxes phaeus*	Demon charaxes	Least Concern (SABCA 2013)
Nymphalidae	*Charaxes saturnus saturnus*	Foxy charaxes	Least Concern (SABCA 2013)
Nymphalidae	*Charaxes varanes varanes*	Pearl charaxes	Least Concern (SABCA 2013)
Nymphalidae	*Charaxes zoolina*	Club-tailed charaxes	Least Concern (SABCA 2013)
Lycaenidae	*Chilades trochylus*	Grass jewel blue	Least Concern (SABCA 2013)
Lycaenidae	*Cigaritis ella*	Ella's silverline	Least Concern (SABCA 2013)
Lycaenidae	*Cigaritis natalensis*	Natal silverline	Least Concern (SABCA 2013)
Hesperiidae	*Coeliades pisistratus*	Two-pip policeman	Least Concern (SABCA 2013)
Nymphalidae	*Coenyropsis natalii natalii*	Orange lined ringlet	Least Concern (SABCA 2013)
Pieridae	*Colotis annae annae*	Scarlet tip	Least Concern (SABCA 2013)

Pieridae	*Colotis antevippe gavisa*	Red tip	Least Concern (SABCA 2013)
Pieridae	*Colotis euippe omphale*	Southern round-winged orange tip	Least Concern (LEAST CONCERN)
Pieridae	*Colotis evagore antigone*	Small orange tip	Least Concern (SABCA 2013)
Pieridae	*Colotis evenina evenina*	African orange tip	Least Concern (SABCA 2013)
Pieridae	*Colotis ione*	Bushveld purple tip	Least Concern (SABCA 2013)
Pieridae	*Colotis vesta argillaceus*	Southern veined arab	Least Concern (SABCA 2013)
Libellulidae	*Crocothemis erythraea*	Broad Scarlet	Least concern
Lycaenidae	*Crudaria leroma*	Silver-spotted grey	Least Concern (SABCA 2013)
Lycaenidae	*Cupidopsis jobates jobates*	Tailed meadow blue	Least Concern (SABCA 2013)
Nymphalidae	*Danaus chrysippus orientis*	African plain tiger	Least Concern (SABCA 2013)
Lycaenidae	*Deudorix dinochares*	Apricot playboy	Least Concern (SABCA 2013)
Libellulidae	*Diplacodes luminans*	Barbet Percher	Least concern
Erebidae	*Dysgonia torrida*		Not listed
Lycaenidae	*Eicochrysops messapus mahallakoaena*	Cupreous ash blue	Least Concern (SABCA 2013)
Lycaenidae	*Euchrysops osiris*	Osiris smoky blue	Least Concern (SABCA 2013)
Pieridae	*Eurema brigitta brigitta*	Broad-bordered grass yellow	Least Concern (SABCA 2013)

Hesperiidae	*Gegenes pumilio gambica*	Dark dodger	Least Concern (SABCA 2013)
Hesperiidae	*Gomalia elma elma*	Green-marbled skipper	Least Concern (SABCA 2013)
Erebidae	*Grammodes stolida*		Not listed
Papilionidae	*Graphium antheus*	Large striped swordtail	Least Concern (SABCA 2013)
Papilionidae	*Graphium morania*	White lady	Least Concern (SABCA 2013)
Nymphalidae	*Hamanumida daedalus*	Guineafowl	Least Concern (SABCA 2013)
Nymphalidae	*Hypolimnas anthedon wahlbergi*	Variable diadem	Least Concern (SABCA 2013)
Nymphalidae	*Hypolimnas misippus*	Common diadem	Least Concern (SABCA 2013)
Lycaenidae	*Hypolycaena philippus philippus*	Purple-brown hairstreak	Least Concern (SABCA 2013)
Gomphidae	*Ictinogomphus ferox*	Common Tigertail	Least concern
Nymphalidae	*Junonia hierta cebrene*	Yellow pansy	Least Concern (SABCA 2013)
Nymphalidae	*Junonia natalica natalica*	Brown commodore	Least Concern (SABCA 2013)
Nymphalidae	*Junonia oenone oenone*	Dark blue pansy	Least Concern (SABCA 2013)
Nymphalidae	*Junonia terea elgiva*	Soldier pansy	Least Concern (SABCA 2013)
Hesperiidae	*Kedestes callicles*	Pale ranger	Least Concern (SABCA 2013)

Hesperiidae	*Kedestes macomo*	Macomo ranger	Least Concern (SABCA 2013)
Myrmeleontidae	*Lachlathetes moestus*		Not listed
Lycaenidae	*Lampides boeticus*	Pea blue	Least Concern (SABCA 2013)
Lycaenidae	*Lepidochrysops glauca*	Silvery giant cupid	Least Concern (SABCA 2013)
Lycaenidae	*Lepidochrysops plebeia plebeia*	Twin-spot giant cupid	Least Concern (SABCA 2013)
Lycaenidae	*Leptomyrina henningi henningi*	Plain black-eye	Least Concern (SABCA 2013)
Lycaenidae	*Leptotes brevidentatus*	Short-toothed zebra blue	Least Concern (SABCA 2013)
Lycaenidae	*Leptotes pirithous pirithous*	Common zebra blue	Least Concern (SABCA 2013)
Lestidae	*Lestes pallidus*	Pallid Spreadwing	Least concern
Hesperiidae	*Leucochitonea levubu*	White-cloaked skipper	Least Concern (SABCA 2013)
Pieridae	*Mylothris agathina agathina*	Eastern dotted border	Least Concern (SABCA 2013)
Libellulidae	*Nesciothemis farinosa*	Eastern Blacktail	Least concern
Libellulidae	*Palpopleura lucia*	Lucia Widow	Least concern
Papilionidae	*Papilio demodocus demodocus*	Citrus swallowtail	Least Concern (SABCA 2013)
Papilionidae	*Papilio nireus lyaeus*	Narrow green-banded swallowtail	Least Concern (SABCA 2013)
Nymphalidae	*Physcaeneura panda*	Dark-webbed ringlet	Least Concern (SABCA 2013)

Pieridae	*Pinacopteryx eriphia eriphia*	Zebra white	Least Concern (SABCA 2013)
Erebidae	*Plecopterodes moderata*		Not listed
Nymphalidae	*Precis archesia archesia*	Garden inspector	Least Concern (SABCA 2013)
Coenagrionidae	*Pseudagrion kersteni*	Powder-faced Sprite	Least concern
Lycaenidae	*Pseudonacaduba sichela sichela*	Dusky line blue	Least Concern (SABCA 2013)
Libellulidae	*Rhyothemis semihyalina*	Phantom Flutterer	Least concern
Hesperiidae	*Sarangesa seineri seineri*	Dark elfin	Least Concern (SABCA 2013)
Scarabaeidae	*Scarabaeus galenus*		Not listed
Scarabaeidae	*Scarabaeus nigroaeneus*		Not listed
Hesperiidae	*Spialia colotes transvaaliae*	Bushveld sandman	Least Concern (SABCA 2013)
Hesperiidae	*Spialia delagoae*	Delagoa sandman	Least Concern (SABCA 2013)
Hesperiidae	*Spialia ferax*	Striped sandman	Least Concern (SABCA 2013)
Hesperiidae	*Spialia spio*	Mountain sandman	Least Concern (SABCA 2013)
Lycaenidae	*Stugeta bowkeri tearei*	Bowker's marbled sapphire	Least Concern (SABCA 2013)
Libellulidae	*Sympetrum fonscolombii*	Red-veined Darter or Nomad	Least concern
Lycaenidae	*Tarucus sybaris sybaris*	Dotted pierrot	Least Concern (SABCA 2013)
Pieridae	*Teracolus agoye agoye*	Speckled sulphur tip	Least Concern (SABCA 2013)

Pieridae	*Teracolus eris eris*	Banded gold tip	Least Concern (SABCA 2013)
Pieridae	*Teracolus subfasciatus*	Lemon traveller	Least Concern (SABCA 2013)
Libellulidae	*Tramea basilaris*	Keyhole Glider	Least concern
Libellulidae	*Trithemis arteriosa*	Red-veined Dropwing	Least concern
Libellulidae	*Urothemis assignata*	Red Basker	Least concern
Nymphalidae	*Vanessa cardui*	Painted lady	Least Concern (SABCA 2013)
Lycaenidae	*Zizeeria knysna knysna*	African grass blue	Least Concern (SABCA 2013)
Lycaenidae	*Zizula hylax*	Tiny grass blue	Least Concern (SABCA 2013)
ARACHNIDA			
Buthidae	*Parabuthus mossambicensis*		Not listed
Theraphosidae	*Augacephalus junodi*		Not listed
Theraphosidae	*Ceratogyrus darlingi*		Not listed
Hormuridae	*Hadogenes troglodytes*		Not listed
Idiopidae	*Idiops sp.*		Not listed
Theraphosidae	*Idiothele nigrofulva*		Not listed
Aranaeidae	*Nephila senegalensis*	Banded-legged golden orb-web spider	Not listed
Hormuridae	*Opisthacanthus asper*		Not listed
Scorpionidae	*Opistophthalmus glabrifrons*		Not listed
Buthidae	*Parabuthus transvaalicus*		Not listed

Buthidae	*Pseudolychas ochraceus*		Not listed
Buthidae	*Uroplectes olivaceus*		Not listed
Buthidae	*Uroplectes vittatus*		Not listed
AMPHIBIA			
Phrynobatrachidae	*Phrynobatrachus mababiensis*	Dwarf Puddle Frog	Least Concern (IUCN, 2014)
Phrynobatrachidae	*Phrynobatrachus natalensis*	Snoring Puddle Frog	Least Concern (IUCN, 2013)
Microhylidae	*Phrynomantis bifasciatus*	Banded Rubber Frog	Least Concern
Bufonidae	*Poyntonophrynus fenoulheti*	Northern Pygmy Toad	Least Concern
Ptychadenidae	*Ptychadena anchietae*	Plain Grass Frog	Least Concern
Ptychadenidae	*Ptychadena mossambica*	Broadbanded Grass Frog	Least Concern
Pyxicephalidae	*Pyxicephalus edulis*	African Bull Frog	Least Concern
Bufonidae	*Schismaderma carens*	Red Toad	Least Concern
Bufonidae	*Sclerophrys garmani*	Olive Toad	Least Concern (IUCN, 2016)
Bufonidae	*Sclerophrys gutturalis*	Guttural Toad	Least Concern (IUCN, 2016)
Bufonidae	*Sclerophrys pusilla*	Flatbacked Toad	Least Concern (IUCN, 2016)
Pyxicephalidae	*Tomopterna marmorata*	Russetbacked Sand Frog	Least Concern
Pipidae	*Xenopus muelleri*	Tropical Platanna	Least Concern
REPTILIA			
Chamaeleonidae	*Chamaeleo dilepis*	Common Flap-neck Chameleon	Least Concern (SARCA 2014)

Typhlopidae	*Afrotyphlops schlegelii*	Schlegel's Beaked Blind Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Amblyodipsas polylepis polylepis*	Common Purple-glossed Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Aparallactus capensis*	Black-headed Centipede-eater	Least Concern (SARCA 2014)
Lamprophiidae	*Aparallactus lunulatus lunulatus*	Reticulated Centipede-eater	Least Concern (SARCA 2014)
Lamprophiidae	*Atractaspis bibronii*	Bibron's Stiletto Snake	Least Concern (SARCA 2014)
Viperidae	*Bitis arietans arietans*	Puff Adder	Least Concern (SARCA 2014)
Lamprophiidae	*Boaedon capensis*	Brown House Snake	Least Concern (SARCA 2014)
Viperidae	*Causus defilippii*	Snouted Night Adder	Least Concern (SARCA 2014)
Gekkonidae	*Chondrodactylus turneri*	Turner's Gecko	Least Concern (SARCA 2014)
Cordylidae	*Cordylus jonesii*	Jones' Girdled Lizard	Least Concern (SARCA 2014)
Colubridae	*Crotaphopeltis hotamboeia*	Red-lipped Snake	Least Concern (SARCA 2014)
Colubridae	*Dasypeltis scabra*	Rhombic Egg-eater	Least Concern (SARCA 2014)
Elapidae	*Dendroaspis polylepis*	Black Mamba	Least Concern (SARCA 2014)
Colubridae	*Dipsadoboa aulica*	Marbled Tree Snake	Least Concern (SARCA 2014)
Colubridae	*Dispholidus typus viridis*	Northern Boomslang	Not evaluated

Elapidae	*Elapsoidea boulengeri*	Boulenger's Garter Snake	Least Concern (SARCA 2014)
Gerrhosauridae	*Gerrhosaurus intermedius*	Eastern Black-lined Plated Lizard	Least Concern (SARCA 2014)
Gekkonidae	*Hemidactylus mabouia*	Common Tropical House Gecko	Least Concern (SARCA 2014)
Lamprophiidae	*Hemirhagerrhis nototaenia*	Eastern Bark Snake	Least Concern (SARCA 2014)
Gekkonidae	*Homopholis wahlbergii*	Wahlberg's Velvet Gecko	Least Concern (SARCA 2014)
Testudinidae	*Kinixys spekii*	Speke's Hinged Tortoise	Least Concern (SARCA 2014)
Leptotyphlopidae	*Leptotyphlops incognitus*	Incognito Thread Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Limaformosa capensis*	Common File Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Lycophidion capense capense*	Cape Wolf Snake	Least Concern (SARCA 2014)
Gekkonidae	*Lygodactylus capensis*	Common Dwarf Gecko	Least Concern (SARCA 2014)
Gerrhosauridae	*Matobosaurus validus*	Common Giant Plated Lizard	Least Concern (SARCA 2014)
Scincidae	*Mochlus sundevallii*	Sundevall's Writhing Skink	Least Concern (SARCA 2014)
Elapidae	*Naja annulifera*	Snouted Cobra	Least Concern (SARCA 2014)
Elapidae	*Naja mossambica*	Mozambique Spitting Cobra	Least Concern (SARCA 2014)
Lacertidae	*Nucras holubi*	Holub's Sandveld Lizard	Least Concern (SARCA 2014)

Gekkonidae	*Pachydactylus punctatus*	Speckled Gecko	Least Concern (SARCA 2014)
Gekkonidae	*Pachydactylus vansoni*	Van Son's Gecko	Least Concern (SARCA 2014)
Pelomedusidae	*Pelusios sinuatus*	Serrated Hinged Terrapin	Least Concern (SARCA 2014)
Colubridae	*Philothamnus hoplogaster*	South Eastern Green Snake	Least Concern (SARCA 2014)
Cordylidae	*Platysaurus intermedius intermedius*	Common Flat Lizard	Least Concern (SARCA 2014)
Lamprophiidae	*Prosymna stuhlmannii*	East African Shovel-snout	Least Concern (SARCA 2014)
Lamprophiidae	*Psammophis mossambicus*	Olive Grass Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Psammophis subtaeniatus*	Western Yellow-bellied Sand Snake	Least Concern (SARCA 2014)
Lamprophiidae	*Psammophylax tritaeniatus*	Striped Grass Snake	Least Concern (SARCA 2014)
Pythonidae	*Python natalensis*	Southern African Python	Least Concern (SARCA 2014)
Scincidae	*Scelotes bidigittatus*	Lowveld Dwarf Burrowing Skink	Least Concern (SARCA 2014)
Cordylidae	*Smaug vandami*	Van Dam's Girdled Lizard	Least Concern (SARCA 2014)
Testudinidae	*Stigmochelys pardalis*	Leopard Tortoise	Least Concern (SARCA 2014)
Scincidae	*Trachylepis damarana*	Damara Variable Skink	Not listed
Scincidae	*Trachylepis margaritifera*	Rainbow Skink	Least Concern (SARCA 2014)

Scincidae	*Trachylepis striata*	Striped Skink	Least Concern (SARCA 2014)
Scincidae	*Trachylepis varia sensu lato*	Common Variable Skink Complex	Least Concern (SARCA 2014)
Scincidae	*Trachylepis varia sensu lato*	Common Variable Skink Complex	Least Concern (SARCA 2014)
Scincidae	*Trachylepis varia sensu stricto*	Common Variable Skink	Not listed
Varanidae	*Varanus albigularis albigularis*	Rock Monitor	Least Concern (SARCA 2014)
MAMMALIA			
Bovidae	*Aepyceros melampus*	Impala	Least Concern
Felidae	*Acinonyx jubatus*	Cheetah	Vulnerable (2016)
Muridae	*Aethomys ineptus*	Tete Veld Aethomys	Least Concern (2016)
Canidae	*Canis mesomelas*	Black-backed Jackal	Least Concern (2016)
Felidae	*Caracal caracal*	Caracal	Least Concern (2016)
Viverridae	*Civettictis civetta*	African Civet	Least Concern (2016)
Bovidae	*Connochaetes taurinus taurinus*		Least Concern (2016)
Hyaenidae	*Crocuta crocuta*	Spotted Hyaena	Near Threatened (2016)
Macroscelididae	*Elephantulus brachyrhynchus*	Short-snouted Elephant Shrew	Least Concern (2016)
Equidae	*Equus quagga*	Plains Zebra	Least Concern (2016)
Giraffidae	*Giraffa giraffa giraffa*	South African Giraffe	Vulnerable
Herpestidae	*Helogale parvula*	Common Dwarf Mongoose	Least Concern (2016)
Hyaenidae	*Hyaena brunnea*	Brown Hyena	Near Threatened (2015)
Bovidae	*Kobus ellipsiprymnus ellipsiprymnus*		Least Concern (2016)

Muridae	*Lemniscomys rosalia*	Single-Striped Lemniscomys	Least Concern (2016)
Felidae	*Leptailurus serval*	Serval	Near Threatened (2016)
Leporidae	*Lepus saxatilis*	Scrub Hare	Least Concern
Elephantidae	*Loxodonta africana*	African Bush Elephant	Vulnerable (2008)
Mustelidae	*Mellivora capensis*	Honey Badger	Least Concern (2016)
Nycteridae	*Nycteris thebaica*	Egyptian Slit-faced Bat	Least Concern (2016)
Felidae	*Panthera pardus*	Leopard	Vulnerable (2016)
Cercopithecidae	*Papio ursinus*	Chacma Baboon	Least Concern (2016)
Bovidae	*Pelea capreolus*	Vaal Rhebok	Near Threatened (2016)
Bovidae	*Raphicerus campestris*	Steenbok	Least Concern (2016)
Bovidae	*Taurotragus oryx*	Common Eland	Least Concern (2016)
Bovidae	*Tragelaphus scriptus*	Bushbuck	Least Concern
Bovidae	*Tragelaphus strepsiceros*	Greater Kudu	Least Concern (2016)
AVES			
Accipitridae	*Gyps africanus*	White-backed Vulture	Global: CR; BLSA: CR
Sturnidae	*Acridotheres tristis*	Common Myna	Alien
Anatidae	*Alopochen aegyptiacus*	Egyptian Goose	Alien
Ploceidae	*Anaplectes rubriceps*	Red-headed Weaver	Least concern
Cisticolidae	*Apalis flavida*	Yellow-breasted Apalis	Least concern
Apodidae	*Apus barbatus*	African Black (Black) Swift	Least concern
Apodidae	*Apus caffer*	White-rumped Swift	Least concern
Ploceidae	*Bubalornis niger*	Red-billed Buffalo-Weaver	Least concern

Cisticolidae	*Calamonastes stierlingi*	Stierling's Wren-Warbler	Least concern
Cisticolidae	*Camaroptera brevicaudata*	Grey-backed Camaroptera (split)	Not Listed
Pycnonotidae	*Chlorocichla flaviventris*	Yellow-bellied Greenbul (Bulbul)	Least concern
Sturnidae	*Cinnyricinclus leucogaster*	Violet-backed (Plum-coloured, Amethyst) Starling	Least concern
Coraciidae	*Coracias caudata (C. caudatus)*	Lilac-breasted Roller	Least concern
Muscicapidae	*Cossypha humeralis*	White-throated Robin-Chat	Least concern
Dicruridae	*Dicrurus adsimilis*	Fork-tailed Drongo	Least concern
Malaconotidae	*Dryoscopus cubla*	Black-backed (Southern) Puffback	Least concern
Fringillidae	*Emberiza flaviventris*	Golden-breasted Bunting	Least concern
Fringillidae	*Emberiza tahapisi*	Cinnamon-breasted (Rock) Bunting	Least concern
Passeridae	*Gymnoris superciliaris*	Yellow-throated Bush Sparrow (Yellow-throated Petronia)	Least concern
Accipitridae	*Gyps africanus*	White-backed Vulture	Global: CR; BLSA: CR
Accipitridae	*Gyps coprotheres*	Cape Vulture (Griffon)	Global: EN; BLSA: EN
Estrildidae	*Lagonosticta rhodopareia*	Jameson's Firefinch	Least concern
Sturnidae	*Lamprotornis nitens*	Cape Glossy (Glossy) Starling	Least concern
Lybiidae	*Lybius torquatus*	Black-collared Barbet	Least concern
Meropidae	Merops apiaster	European Bee-eater	Least concern
Nectariniidae	Nectarinia [Chalcomitra] amethystina	Amethyst (Black) Sunbird	Least concern
Nectariniidae	Nectarinia [Chalcomitra] senegalensis	Scarlet-chested Sunbird	Least concern

Nectariniidae	Nectarinia [Cinnyris] talatala	White-bellied (breasted) Sunbird	Least concern
Sturnidae	Onychognathus morio	Red-winged Starling	Least concern
Oriolidae	Oriolus larvatus	Black-headed (Eastern) Oriole	Least concern
Paridae	Parus niger	Southern Black Tit	Least concern
Phoeniculidae	Phoeniculus purpureus	Green (Red-billed) Wood-hoopoe	Least concern
Ploceidae	Ploceus intermedius	Lesser Masked Weaver	Least concern
Ploceidae	Ploceus velatus	Southern Masked-Weaver	Least concern
Cisticolidae	Prinia subflava	Tawny-flanked Prinia	Least concern
Malaconotidae	Prionops plumatus	White-crested Helmet-Shrike	Least concern
Muscicapidae	Psophocichla litsipsirupa	Groundscraper Thrush	Least concern
Phasianidae	Pternistis natalensis	Natal Spurfowl (Francolin)	Least concern
Pycnonotidae	Pycnonotus tricolor	Dark-capped (Black-eyed) Bulbul	Not listed
Estrildidae	Pytilia melba	Green-winged (Melba) Pytilia (Finch)	Least concern
Rhinopomastidae	Rhinopomastus cyanomelas	Common Scimitarbill	Least concern
Columbidae	Streptopelia senegalensis	Laughing (Palm) Dove	Least concern
Sylviidae	Sylvietta rufescens	Long-billed (Cape) Crombec	Least concern
Apodidae	Tachymarptis melba	Alpine Swift	Least concern
Malaconotidae	Tchagra senegala	Black-crowned Tchagra	Least concern
Accipitridae	Terathopius ecaudatus	Bateleur	Global: NT; BLSA: EN
Muscicapidae	Thamnolaea cinnamomeiventris	Mocking Cliff-Chat	Least concern
Bucerotidae	Tockus nasutus	African Grey Hornbill	Least concern

Upupidae	Upupa africana	African Hoopoe	Not listed
Estrildidae	Uraeginthus angolensis	Blue Waxbill	Least concern
Coliidae	Urocolius indicus	Red-faced Mousebird	Least concern

APPENDIX B – FLORAL SPECIES LIST ACCORDING TO SANBI'S PLANTS OF SOUTH AFRICA FOR THE PHALABORWA AND GRAVELOTTE AREA (POSA).

Family	Genus	Species	IUCN	Ecology
Fabaceae	*Senna*	*italica*	LC	Indigenous
Agavaceae	*Chlorophytum*	*cooperi*	LC	Indigenous
Convolvulaceae	*Merremia*	*kentrocaulos*	LC	Indigenous
Burseraceae	*Commiphora*	*glandulosa*	LC	Indigenous
Thelypteridaceae	*Cyclosorus*	*interruptus*	LC	Indigenous
Fabaceae	*Tephrosia*	*rhodesica*	LC	Indigenous
Fabaceae	*Crotalaria*	*monteiroi*	LC	Indigenous
Euphorbiaceae	*Jatropha*	*zeyheri*	LC	Indigenous
Asteraceae	*Litogyne*	*gariepina*	LC	Indigenous
Apocynaceae	*Brachystelma*	*brevipedicellatum*	LC	Indigenous; Endemic
Rubiaceae	*Anthospermum*	*rigidum*	LC	Indigenous
Apocynaceae	*Raphionacme*	*velutina*	LC	Indigenous
Fabaceae	*Macrotyloma*	*axillare*	LC	Indigenous
Malvaceae	*Grewia*	*flava*	LC	Indigenous
Rubiaceae	*Pentanisia*	*angustifolia*	LC	Indigenous
Asteraceae	*Helichrysum*	*odoratissimum*		Indigenous
Poaceae	*Pogonarthria*	*squarrosa*	LC	Indigenous
Malvaceae	*Hermannia*	*cristata*	LC	Indigenous
Apocynaceae	*Fockea*	*angustifolia*	LC	Indigenous
Apocynaceae	*Carissa*	*spinarum*		Indigenous
Poaceae	*Anthephora*	*pubescens*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Poaceae	*Eragrostis*	*curvula*	LC	Indigenous
Rubiaceae	*Cordylostigma*	*virgatum*		Indigenous
Turneraceae	*Tricliceras*	*longepedunculatum*	LC	Indigenous
Asteraceae	*Pseudognaphalium*	*luteoalbum*	LC	Not indigenous; cryptogenic
Amaranthaceae	*Hermbstaedtia*	*odorata*	NE	Indigenous
Malvaceae	*Hermannia*	*geniculata*	LC	Indigenous
Fabaceae	*Philenoptera*	*violacea*	LC	Indigenous
Apocynaceae	*Ceropegia*	*nilotica*	LC	Indigenous
Fabaceae	*Indigofera*	*schimperi*	LC	Indigenous
Poaceae	*Urochloa*	*mosambicensis*	LC	Indigenous
Ebenaceae	*Diospyros*	*mespiliformis*	LC	Indigenous
Fabaceae	*Crotalaria*	*magaliesbergensis*	LC	Indigenous; Endemic
Ruscaceae	*Eriospermum*	*mackenii*	NE	Indigenous
Boraginaceae	*Heliotropium*	*nelsonii*	LC	Indigenous
Poaceae	*Setaria*	*homonyma*	LC	Indigenous
Euphorbiaceae	*Euphorbia*	*guerichiana*	LC	Indigenous
Apocynaceae	*Huernia*	*zebrina*	LC	Indigenous; Endemic
Poaceae	*Sporobolus*	*ioclados*	LC	Indigenous
Asteraceae	*Tolpis*	*capensis*	LC	Indigenous
Convolvulaceae	*Ipomoea*	*magnusiana*	LC	Indigenous
Burseraceae	*Commiphora*	*africana*	LC	Indigenous
Fabaceae	*Peltophorum*	*africanum*	LC	Indigenous
Dipsacaceae	*Cephalaria*	*zeyheriana*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Malvaceae	*Hermannia*	*glanduligera*	LC	Indigenous
Apocynaceae	*Sisyranthus*	*imberbis*	LC	Indigenous
Asteraceae	*Gerbera*	*ambigua*	LC	Indigenous
Meliaceae	*Turraea*	*nilotica*	LC	Indigenous
Fabaceae	*Senegalia*	*schweinfurthii*	LC	Indigenous
Talinaceae	*Talinum*	*portulacifolium*		Indigenous
Cucurbitaceae	*Momordica*	*foetida*	LC	Indigenous
Rubiaceae	*Anthospermum*	*herbaceum*	LC	Indigenous
Poaceae	*Schizachyrium*	*jeffreysii*	LC	Indigenous
Polygalaceae	*Polygala*	*hottentotta*	LC	Indigenous
Celastraceae	*Mystroxylon*	*aethiopicum*	LC	Indigenous; Endemic
Fabaceae	*Piliostigma*	*thonningii*	LC	Indigenous
Meliaceae	*Ekebergia*	*capensis*	LC	Indigenous
Salicaceae	*Dovyalis*	*lucida*	LC	Indigenous
Asteraceae	*Cyanthillium*	*wollastonii*		Indigenous
Ricciaceae	*Riccia*	*cavernosa*		Indigenous
Fabaceae	*Indigofera*	*heterotricha*	LC	Indigenous
Fabaceae	*Neorautanenia*	*mitis*	LC	Indigenous
Fabaceae	*Senegalia*	*polyacantha*	LC	Indigenous
Apocynaceae	*Brachystelma*	*oianthum*	LC	Indigenous; Endemic
Scrophulariaceae	*Selago*	*procera*	LC	Indigenous
Fabaceae	*Eriosema*	*cordatum*	LC	Indigenous
Cucurbitaceae	*Acanthosicyos*	*naudinianus*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Asteraceae	*Dicoma*	*anomala*	LC	Indigenous
Poaceae	*Setaria*	*megaphylla*	LC	Indigenous
Poaceae	*Aristida*	*congesta*	LC	Indigenous
Thymelaeaceae	*Struthiola*	*pondoensis*	LC	Indigenous; Endemic
Asteraceae	*Denekia*	*capensis*	LC	Indigenous
Fabaceae	*Aeschynomene*	*nyassana*	LC	Indigenous
Fabaceae	*Bolusanthus*	*speciosus*	LC	Indigenous
Maesaceae	*Maesa*	*lanceolata*	LC	Indigenous
Fabaceae	*Indigofera*	*hilaris*	LC	Indigenous
Poaceae	*Eragrostis*	*obtusa*	LC	Indigenous
Combretaceae	*Combretum*	*molle*	LC	Indigenous
Plumbaginaceae	*Plumbago*	*zeylanica*		Not indigenous; Naturalised
Apocynaceae	*Xysmalobium*	*acerateoides*	LC	Indigenous
Combretaceae	*Combretum*	*collinum*	LC	Indigenous
Rubiaceae	*Sericanthe*	*andongensis*	LC	Indigenous; Endemic
Boraginaceae	*Trichodesma*	*zeylanicum*	LC	Indigenous
Smilacaceae	*Smilax*	*anceps*	LC	Indigenous
Fabaceae	*Vachellia*	*karroo*	LC	Indigenous
Combretaceae	*Combretum*	*hereroense*		Indigenous
Pteridaceae	*Actiniopteris*	*radiata*	LC	Indigenous
Asteraceae	*Helichrysum*	*kraussii*	LC	Indigenous
Scrophulariaceae	*Selago*	*peduncularis*	LC	Indigenous; Endemic
Fabaceae	*Colophospermum*	*mopane*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Moraceae	*Ficus*	*stuhlmannii*	LC	Indigenous
Asteraceae	*Calostephane*	*divaricata*	LC	Indigenous
Asphodelaceae	*Aloe*	*lutescens*	LC	Indigenous
Poaceae	*Eragrostis*	*sp.*		
Vitaceae	*Cyphostemma*	*sp.*		
Cannabaceae	*Celtis*	*africana*	LC	Indigenous
Cyperaceae	*Cyperus*	*indecorus*	NE	Indigenous
Malvaceae	*Grewia*	*subspathulata*	LC	Indigenous
Fabaceae	*Pterocarpus*	*rotundifolius*	LC	Indigenous
Fabaceae	*Indigofera*	*vicioides*		Indigenous
Asteraceae	*Afroaster*	*serrulatus*	LC	Indigenous
Elatinaceae	*Bergia*	*capensis*	LC	Indigenous
Apocynaceae	*Schizoglossum*	*cordifolium*	LC	Indigenous
Cucurbitaceae	*Zehneria*	*scabra*		Indigenous
Poaceae	*Melinis*	*repens*	LC	Indigenous
Lamiaceae	*Volkameria*	*glabra*	LC	Indigenous
Hydrocharitaceae	*Ottelia*	*ulvifolia*	LC	Indigenous
Poaceae	*Eleusine*	*coracana*	LC	Indigenous
Phyllanthaceae	*Phyllanthus*	*maderaspatensis*	LC	Indigenous
Acanthaceae	*Ruspolia*	*australis*		Indigenous
Asteraceae	*Nidorella*	*resedifolia*	LC	Indigenous
Fabaceae	*Senna*	*petersiana*	LC	Indigenous
Polytrichaceae	*Polytrichum*	*commune*		Indigenous

Family	Genus	Species	IUCN	Ecology
Icacinaceae	*Apodytes*	*dimidiata*	LC	Indigenous
Vitaceae	*Rhoicissus*	*revoilii*	LC	Indigenous
Urticaceae	*Laportea*	*peduncularis*	LC	Indigenous
Euphorbiaceae	*Croton*	*gratissimus*	LC	Indigenous
Acanthaceae	*Barleria*	*heterotricha*		Indigenous
Rubiaceae	*Agathisanthemum*	*bojeri*	LC	Indigenous
Celastraceae	*Gymnosporia*	*harveyana*	LC	Indigenous
Cucurbitaceae	*Cucumis*	*zeyheri*	LC	Indigenous
Malvaceae	*Abutilon*	*austro-africanum*	LC	Indigenous
Asteraceae	*Flaveria*	*bidentis*		Not indigenous; Naturalised; Invasive
Fabaceae	*Indigofera*	*sanguinea*	LC	Indigenous
Vitaceae	*Cissus*	*cornifolia*	LC	Indigenous
Fabaceae	*Dolichos*	*trilobus*	LC	Indigenous
Hyacinthaceae	*Drimia*	*intricata*	LC	Indigenous
Poaceae	*Panicum*	*deustum*	LC	Indigenous
Lamiaceae	*Rotheca*	*hirsuta*	LC	Indigenous
Fabaceae	*Senna*	*occidentalis*	NE	Not indigenous; Naturalised; Invasive
Rubiaceae	*Pentodon*	*pentandrus*	LC	Indigenous
Malvaceae	*Grewia*	*monticola*	LC	Indigenous
Apocynaceae	*Brachystelma*	*gemmeum*	LC	Indigenous; Endemic
Ditrichaceae	*Ditrichum*	*brachypodum*		Indigenous
Poaceae	*Aristida*	*scabrivalvis*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Poaceae	*Stipagrostis*	*hirtigluma*	LC	Indigenous
Poaceae	*Brachiaria*	*deflexa*	LC	Indigenous
Haloragaceae	*Laurembergia*	*repens*	LC	Indigenous
Apocynaceae	*Aspidoglossum*	*ovalifolium*	LC	Indigenous
Acanthaceae	*Justicia*	*debilis*		Indigenous
Apocynaceae	*Ceropegia*	*pachystelma*	LC	Indigenous
Asteraceae	*Senecio*	*sp.*		
Acanthaceae	*Barleria*	*elegans*	LC	Indigenous
Apocynaceae	*Brachystelma*	*villosum*	DD	Indigenous
Poaceae	*Urochloa*	*brachyura*	LC	Indigenous
Polygonaceae	*Oxygonum*	*sinuatum*		Indigenous
Malvaceae	*Hibiscus*	*praeteritus*	LC	Indigenous
Capparaceae	*Maerua*	*angolensis*		Indigenous
Commelinaceae	*Commelina*	*zambesica*	LC	Indigenous
Lamiaceae	*Stachys*	*arachnoidea*	LC	Indigenous
Malpighiaceae	*Sphedamnocarpus*	*pruriens*	LC	Indigenous
Icacinaceae	*Pyrenacantha*	*grandiflora*	LC	Indigenous
Mniaceae	*Mielichhoferia*	*bryoides*		Indigenous
Fabaceae	*Indigofera*	*filipes*	LC	Indigenous
Marsileaceae	*Marsilea*	*ephippiocarpa*	LC	Indigenous
Poaceae	*Setaria*	*nigrirostris*	LC	Indigenous
Poaceae	*Eragrostis*	*superba*	LC	Indigenous
Arecaceae	*Borassus*	*aethiopum*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Acanthaceae	*Blepharis*	*serrulata*	LC	Indigenous
Poaceae	*Bothriochloa*	*radicans*	LC	Indigenous
Poaceae	*Sporobolus*	*nitens*	LC	Indigenous
Geraniaceae	*Pelargonium*	*dolomiticum*	LC	Indigenous
Euphorbiaceae	*Acalypha*	*peduncularis*	LC	Indigenous
Pontederiaceae	*Heteranthera*	*callifolia*	LC	Indigenous
Asphodelaceae	*Aloe*	*vandermerwei*		Indigenous; Endemic
Pteridaceae	*Pellaea*	*calomelanos*	LC	Indigenous
Lamiaceae	*Orthosiphon*	*suffrutescens*	LC	Indigenous
Poaceae	*Enneapogon*	*scoparius*	LC	Indigenous
Poaceae	*Cenchrus*	*ciliaris*	LC	Indigenous
Poaceae	*Panicum*	*maximum*	LC	Indigenous
Selaginellaceae	*Selaginella*	*dregei*	LC	Indigenous
Asteraceae	*Gymnanthemum*	*myrianthum*	LC	Indigenous
Balsaminaceae	*Impatiens*	*sylvicola*	LC	Indigenous
Proteaceae	*Protea*	*rubropilosa*	LC	Indigenous; Endemic
Orobanchaceae	*Striga*	*asiatica*	LC	Indigenous
Malvaceae	*Dombeya*	*rotundifolia*	LC	Indigenous
Fabaceae	*Indigofera*	*homblei*	LC	Indigenous
Acanthaceae	*Crossandra*	*greenstockii*	LC	Indigenous
Euphorbiaceae	*Jatropha*	*latifolia*	NE	Indigenous; Endemic
Fabaceae	*Decorsea*	*schlechteri*	LC	Indigenous
Fabaceae	*Ormocarpum*	*trichocarpum*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Acanthaceae	*Barleria*	*senensis*	LC	Indigenous
Passifloraceae	*Adenia*	*digitata*	LC	Indigenous
Poaceae	*Andropogon*	*eucomus*	LC	Indigenous
Proteaceae	*Protea*	*gaguedi*	LC	Indigenous
Poaceae	*Elionurus*	*muticus*	LC	Indigenous
Thymelaeaceae	*Lasiosiphon*	*kraussianus*		Indigenous
Euphorbiaceae	*Acalypha*	*wilmsii*	LC	Indigenous
Acanthaceae	*Megalochlamys*	*revoluta*	LC	Indigenous
Turneraceae	*Tricliceras*	*laceratum*	LC	Indigenous
Heteropyxidaceae	*Heteropyxis*	*natalensis*	LC	Indigenous
Fabaceae	*Tephrosia*	*macropoda*	LC	Indigenous
Fabaceae	*Aeschynomene*	*rehmannii*	LC	Indigenous
Fabaceae	*Dichrostachys*	*cinerea*	NE	Indigenous
Convolvulaceae	*Ipomoea*	*albivenia*	LC	Indigenous
Apocynaceae	*Raphionacme*	*procumbens*	LC	Indigenous
Malpighiaceae	*Triaspis*	*hypericoides*	LC	Indigenous
Apocynaceae	*Brachystelma*	*stenophyllum*	LC	Indigenous
Convolvulaceae	*Ipomoea*	*crassipes*	LC	Indigenous
Poaceae	*Eragrostis*	*rotifer*	LC	Indigenous
Melastomataceae	*Dissotis*	*princeps*	LC	Indigenous
Acanthaceae	*Dicliptera*	*clinopodia*	LC	Indigenous
Vitaceae	*Cyphostemma*	*woodii*	LC	Indigenous
Solanaceae	*Solanum*	*campylacanthum*		Indigenous

Family	Genus	Species	IUCN	Ecology
Asphodelaceae	*Aloe*	*zebrina*	LC	Indigenous
Phyllanthaceae	*Flueggea*	*virosa*	LC	Indigenous
Lamiaceae	*Pycnostachys*	*urticifolia*	LC	Indigenous
Celastraceae	*Maytenus*	*undata*	LC	Indigenous
Asteraceae	*Gymnanthemum*	*crataegifolium*	LC	Indigenous
Poaceae	*Aristida*	*pilgeri*	LC	Indigenous
Apocynaceae	*Ceropegia*	*decidua*	LC	Indigenous
Rubiaceae	*Keetia*	*gueinzii*	LC	Indigenous
Rosaceae	*Cliffortia*	*linearifolia*	LC	Indigenous
Acanthaceae	*Dicliptera*	*eenii*	LC	Indigenous
Leucobryaceae	*Campylopus*	*robillardei*		Indigenous
Poaceae	*Chloris*	*pycnothrix*	LC	Indigenous
Malvaceae	*Pavonia*	*columella*	LC	Indigenous
Scrophulariaceae	*Diclis*	*reptans*	LC	Indigenous
Combretaceae	*Combretum*	*apiculatum*	LC	Indigenous
Poaceae	*Festuca*	*costata*	LC	Indigenous
Poaceae	*Digitaria*	*eriantha*	LC	Indigenous
Chrysobalanaceae	*Parinari*	*curatellifolia*	LC	Indigenous
Euphorbiaceae	*Acalypha*	*caperonioides*	DD	Indigenous
Poaceae	*Enneapogon*	*cenchroides*	LC	Indigenous
Convolvulaceae	*Ipomoea*	*bolusiana*	LC	Indigenous
Santalaceae	*Viscum*	*verrucosum*	LC	Indigenous
Fabaceae	*Indigofera*	*daleoides*	NE	Indigenous

Family	Genus	Species	IUCN	Ecology
Fabaceae	*Rhynchosia*	*sp.*		
Dryopteridaceae	*Dryopteris*	*lewalleana*	LC	Indigenous
Poaceae	*Sporobolus*	*sp.*		
Apocynaceae	*Ceropegia*	*crassifolia*	LC	Indigenous
Scrophulariaceae	*Chaenostoma*	*platysepalum*	LC	Indigenous; Endemic
Poaceae	*Oropetium*	*capense*	LC	Indigenous
Asteraceae	*Stomatanthes*	*africanus*	LC	Indigenous
Malvaceae	*Azanza*	*garckeana*	LC	Indigenous
Capparaceae	*Boscia*	*albitrunca*	LC	Indigenous
Acanthaceae	*Phaulopsis*	*imbricata*	LC	Indigenous
Phyllanthaceae	*Andrachne*	*ovalis*	LC	Indigenous
Phyllanthaceae	*Bridelia*	*micrantha*	LC	Indigenous
Bryaceae	*Brachymenium*	*acuminatum*		Indigenous
Fabaceae	*Tephrosia*	*polystachya*	LC	Indigenous
Anacardiaceae	*Sclerocarya*	*birrea*	LC	Indigenous
Fabaceae	*Rhynchosia*	*minima*	NE	Indigenous
Malvaceae	*Triumfetta*	*welwitschii*	LC	Indigenous
Cleomaceae	*Cleome*	*angustifolia*	LC	Indigenous
Burseraceae	*Commiphora*	*mollis*	LC	Indigenous
Fabaceae	*Cassia*	*abbreviata*	LC	Indigenous
Asteraceae	*Gymnanthemum*	*coloratum*	LC	Indigenous
Oxalidaceae	*Oxalis*	*smithiana*	LC	Indigenous
Polygalaceae	*Polygala*	*virgata*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Asteraceae	*Lactuca*	*inermis*	LC	Indigenous
Malvaceae	*Gossypium*	*herbaceum*	LC	Indigenous
Cucurbitaceae	*Coccinia*	*sessilifolia*	LC	Indigenous
Rubiaceae	*Conostomium*	*natalense*	LC	Indigenous
Poaceae	*Perotis*	*sp.*		
Malvaceae	*Grewia*	*bicolor*	LC	Indigenous
Lamiaceae	*Ocimum*	*labiatum*	LC	Indigenous
Salicaceae	*Trimeria*	*grandifolia*	LC	Indigenous
Sapindaceae	*Cardiospermum*	*halicacabum*	LC	Indigenous
Apocynaceae	*Pentarrhinum*	*insipidum*	LC	Indigenous
Malvaceae	*Hermannia*	*modesta*	LC	Indigenous
Apocynaceae	*Tavaresia*	*meintjesii*	DD	Indigenous
Acanthaceae	*Justicia*	*flava*	LC	Indigenous
Asteraceae	*Afroaster*	*comptonii*	LC	Indigenous
Poaceae	*Schmidtia*	*pappophoroides*	LC	Indigenous
Santalaceae	*Thesium*	*asterias*	LC	Indigenous
Asteraceae	*Parapolydora*	*fastigiata*		Indigenous
Meliaceae	*Turraea*	*obtusifolia*	LC	Indigenous
Fabaceae	*Mundulea*	*sericea*	LC	Indigenous
Acanthaceae	*Barleria*	*saxatilis*	LC	Indigenous
Poaceae	*Sorghum*	*bicolor*	LC	Indigenous
Lamiaceae	*Tetradenia*	*brevispicata*	LC	Indigenous
Malvaceae	*Adansonia*	*digitata*	LC	Indigenous

Family	Genus	Species	IUCN	Ecology
Polygalaceae	*Polygala*	*sphenoptera*	LC	Indigenous
Pteridaceae	*Cheilanthes*	*hirta*		Indigenous
Fabaceae	*Eriosema*	*ellipticifolium*	LC	Indigenous
Pteridaceae	*Cheilanthes*	*viridis*	LC	Indigenous
Ricciaceae	*Riccia*	*okahandjana*		Indigenous
Anacardiaceae	*Searsia*	*gueinzii*	LC	Indigenous
Scrophulariaceae	*Nemesia*	*rupicola*	LC	Indigenous
Poaceae	*Eragrostis*	*plana*	LC	Indigenous
Rhamnaceae	*Ziziphus*	*mucronata*	LC	Indigenous
Rosaceae	*Alchemilla*	*cryptantha*	LC	Indigenous
Combretaceae	*Combretum*	*imberbe*	Protected	Indigenous
Brassicaceae	*Boscia*	*albitrunca*	Protected	Indigenous
Malvaceae	*Adansonia*	*digitata*	Protected	Indigenous
Zygophyllaceae	*Balanites*	*maughamii*	Protected	Indigenous
Celastraceae	*Catha*	*edulis*	Protected	Indigenous
Fabaceae	*Pterocarpus*	*angolensis*	Near Threatened	Indigenous
Celastraceae	*Elaeodendron*	*transvaalense*	Protected	Indigenous
Anacardiaceae	*Sclerocarya*	*birrea*	Protected	Indigenous
Zamiaceae	*Encephalartos*	*dyerianus*	Critically Endangered	Indigenous

Appendix 2 - Hydrological Assessment and Floodline Delineation Report

HYDROLOGICAL ASSESSMENT AND FLOODLINE DELINEATION REPORT FOR TIARA GRANVILLE EMERALD AND QUARTZ MINE, MAGISTERIAL DISTRICT OF PHALABORWA, LIMPOPO PROVINCE.

TIARA MINING (PTY) LTD

Report Number:	**HYFLO -2020-10**
Date:	**14 December 2020**

SAKHAL AND TOBE ENVIRONMENTAL

REPORT

APPROVAL

PROJECT TITLE:	Hydrological Assessment and Floodline Delineation Report for Tiara Granville Emerald and Quartz Mine, Magisterial District of Phalaborwa, Limpopo Province.
PREPARED FOR:	**TIARA MINING (PTY) LTD** P. O. Box 314, Plettenberg, 6600
COMPILED BY:	**Mr. Mandla Masango** (BESc. Hons Hydrology & Water Resources)
APPROVED BY:	**SAKHAL AND TOBE ENVIRONMENTAL (PTY) LTD** Spaces, Lone Creek Crescent Waterfall City, Midrand, 1686 Info@stenvironmental.co.za **This Report is approved** **Mr. Rasifudi K.J (MSc, Pr. Sci. Nat - 400058/18)**
DATE OF REPORT:	14 December 2020
REPORT STATUS:	Final Draft Version 02
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EXECUTIVE SUMMARY

Tiara Mining (Pty) Ltd (herein referred to as "**Tiara**") had lodged an application for a Mining Right in terms of section 22 of the **MPRDA,** for the proposed Tiara Granville Emerald and Quartz Mine. The proposed mining operation is located on the remaining extent (RE) and portion 12 of the farm BVB Ranch 776 LT, RE of the farm Josephine 749 LT, Buffalo Ranch 834 LT, RE of the farm Danie 789 LT, Granville 767 LT, portion 6 and RE of the farm Farrel 781 LT as well as RE of the farm Willie 787 LT, all located within the Magisterial District of Phalaborwa, Limpopo Province.

The proposed mining will be an open cast mine in quaternary catchment B72J. The mining activities will involve truck and shovel opencast mining method with crushing and screening unit as well as processing plant (washing plant). Mine workings will reach a considerable depth of about 70 mbgl. The mining infrastructure covers an area of approximately 48 ha (0.48 km^2).

The terms of reference of the report included compiling a 1:50yr and 1:100yr flood line which includes a hydrological impact assessment to assess and identify potential impacts that may arise from the mining and associated activities. The study approach began with the determination of the hydrological characteristic of the region and the project site through data sourcing; derivation of watercourses; design flood estimation and mapping; and finally the investigation of surface water impacts of the activity from the construction phase, operational phase and the decommissioning phase.

The study has found that the ground clearing, top soil removal, and depressions from excavations activities will have a high risk of impact during the construction phase. Stockpiles, pollution control dams and discard dumps pose a higher risk of surface water contamination during the operation phase. There are also risks on failure of the pollution control dams and discard dumps during the operation phase. During the decommissioning phase runoff from pollution control dams and drainage from discard dump if it continues to yield polluted water would pose a risk to pollution of surface water. All the significant high risk activities which were identified to cause impacts, specific mitigation measures were recommended for each to mitigate the significance of the impacts from high to medium or lower.

The following recommendations were made:

- The mining infrastructure and activities should be outside of the delineated 1:50yr and 1:100yr floodlines; and outside the 100 m buffer from the first order streams;
- Water quality monitoring points must be established on the secondary watercourses to monitor water quality upstream the (disturbance areas – stockpiles, pollution dams and discard dump) and downstream these areas;
- It must be ensured that clean and dirty water separation infrastructure is in place prior to the commencement of construction;
- Appropriate storm water management plan must be in place to contain at least 1:50 year rainfall event and minimise dirty water area;
- Storm water infrastructure must be maintain, and if possible ensure that sediments are effectively captured and returned on-site to minimise sediment loss and siltation of the water resource;
- Ensure regular inspection and maintenance of the pollution control dams and discard dump to avoid failure;
- Dirty water separation systems must be maintained until the site is rehabilitated and free draining.

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1 Introduction

1.1 Background

Tiara Mining (Pty) Ltd (herein referred to as "**Tiara**") is a South African mining company duly incorporated in 1988 in terms of section 14 of the Companies Act, 2008, with the Companies and Intellectual Property Commission of the Republic of South Africa. The company is engaged in Mineral Exploration, Mining and Mineral Processing. The company **(Tiara)** is a holder of the following Prospecting Rights granted by the Department of Mineral Resources (DMR) Limpopo Regional Office in terms of section 17 of the Mineral and Petroleum Resources Development Act **(MPRDA**), 2002 (Act No. 28 of 2002):

- **LP 30/5/1/1/4/389 PR;**
- **LP 30/5/1/1/4/388 PR;**
- **LP 30/5/1/1/4/206 PR;**
- **LP 30/5/1/1/4/207 PR.**

Tiara had lodged an application for a Mining Right in terms of section 22 of the **MPRDA,** for the proposed Tiara Granville Emerald and Quartz Mine. The proposed mining operation is located on the remaining extent (RE) and portion 12 of the farm BVB Ranch 776 LT, RE of the farm Josephine 749 LT, Buffalo Ranch 834 LT, RE of the farm Danie 789 LT, Granville 767 LT, portion 6 and RE of the farm Farrel 781 LT as well as RE of the farm Willie 787 LT, all located within the Magisterial District of Phalaborwa, Limpopo Province.

The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)) using truck and shovel opencast mining method.

The extent of the area applied for covers approximately 16 988 hectares. The project area is represented in the Figure 1.1 in the proceeding sub-section 1.2. The life of mine (LoM) is estimated at 30 (thirty) years with Run of Mine (RoM) of approximately 35 700 tonnes per month (tpa). The construction phase is expected to commence in the first quarter (Q1) of 2021, with first sealable product delivered in Q2 of 2020. Process water supply will be sourced from Mulati River as well as developed new groundwater abstraction boreholes on site.

1.2 Property Description

The proposed project area lies on the eastern parts of the Limpopo Province within the Magisterial District of Phalaborwa. Limpopo Province is bounded by Zimbabwe to the north, Mozambique to the north-east, Mpumalanga Province to the south-east, on the northern parts by Gauteng Province, North West Province to the south-western boundary, and lastly Botswana on the north-west border. The project site falls within ward 2 of Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. Tiara Granville Emerald and Quartz Mine is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. Immediate residential areas include Murchison, Gravelotte, Namakgale and Phalaborwa. The project site covers an area of about 16 988 hectares and lies at geographical coordinates -23.906000° and 30.744000°. Access to the site is via a gravel road connected to the R71 main road. The R71 main road connects Murchison and Gravelotte to the town Namakgale and Phalaborwa.

The locality map of proposed Tiara Granville Emerald and Quartz Mine is presented in Figure 1.1, while the full property details are given in Table 1-1 below.

Table 1-1 Property Full Details

Property Name	Property Number	Registration Division	Property Portion	Aerial Extent	Property Owner	Title Deed Number
BVB Ranch	776	LT	R/E	1521.3430 ha	Sebakwe Trust	T44543/82
BVB Ranch	776	LT	Ptn 12	1060.64 ha	Lepelle Industrial and Mining	T17491/12
Josephine	749	LT	Full extent	2239.2351 ha	Piet Warren	T108963/98
Buffalo Ranch	834	LT	Full extent	1238.0700 ha	J and L Fourie Trust	T105216/97
Danie	789	LT	R/E	2491.3629 ha	Pedal Trading	T24795/2001
Farrel	781	LT	R/E	2126.9222 ha	PP Mare Boerdery	T35531.84
Farrel	781	LT	Ptn 6	447.8404	PP Mare Boerdery	T35531/84
Willie	787	LT	R/E	2789.0412 ha	HB Dunn	T22791/78
Granville	767	LT	Full extent	3073.5000 ha	Ba-Phalaborwa Local Municipality	T26006/2013

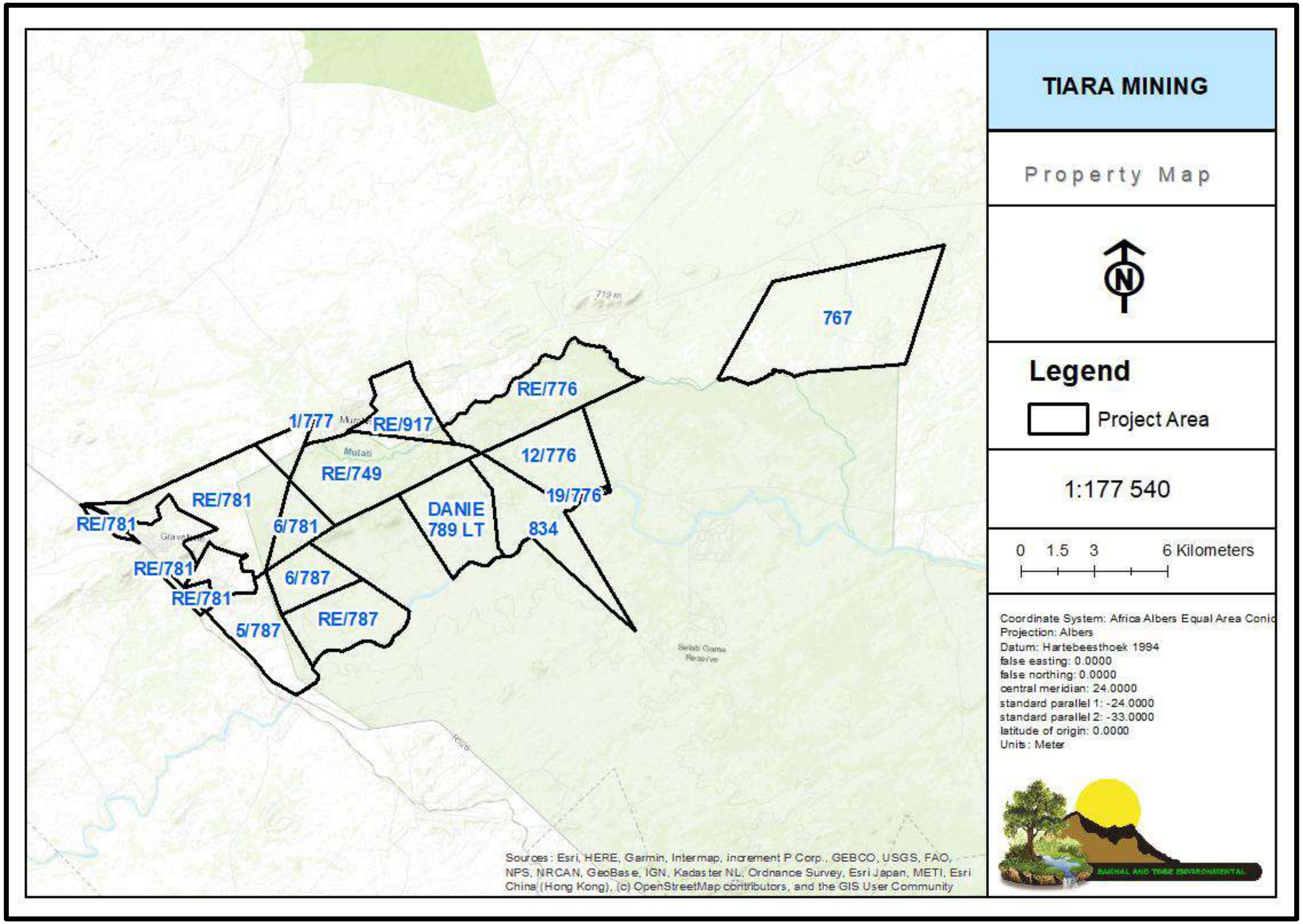

Figure 1.1: Tiara Granville Emerald and Quartz Mine Locality Map

1.3 Description of the Activity

1.3.1 Activity Life Description

The proposed Tiara Granville Quartz Mine Life of Mine (LoM) is estimated at 30 years ending in year 2051. Construction is expected to commence in the first quarter (Q1) of 2021, whilst the operational phase (production) is scheduled for the second quarter (Q2) of 2021. Mining will commence in the north-eastern parts of the project area (on the Granville 767 LT, BVB Ranch 776 LT and Buffalo Ranch 834 LT) moving towards the south-westerly direction into the farm Farrel 781 LT, Josephine 749 LT, Willie 787 LT as well as Danie 789 LT.

1.3.2 Mining Method

Tiara Granville Quartz and Emerald mine involves truck and shovel opencast mining method with crushing and screening unit as well as processing plant (washing plant). Mine workings will reach a considerable depth of about 70 mbgl. Mining will commence in the north-eastern parts of the mining right application area and will progress in a south-westerly direction. Drilling and blasting of the rock face will be conducted on a predetermined schedule in accordance with projected volumes of production and will be undertaken by professionals and with the required safety procedures applied. The mining method will include:

- Clearance of the vegetation
- Stripping of topsoil to prepare box-cut area or bench
- The topsoil will be loaded onto dump trucks by excavators and hauled to areas that require rehabilitation or topsoil stockpile area;
- Drilling and blasting may occasionally be required
- Drilling operations will commence in the front of the advancing pit after the topsoil has been removed;
- The removed Run of Mine (RoM) will be stockpiled using excavators; and
- Thereafter RoM will be transported to the washing plant by means of haul trucks with a loading capacity of approximately 40 tons.

- Drilling and Blasting

Blast holes of 65 mm diameter and 15 m depth will be drilled by rotary percussion crawl track drill rigs, drilling a chevron pattern according to a spacing and burden distance of 1.2 metres. Anfex and powercord together with the appropriate detonating relays will be used to charge up the individual benches. It is anticipated that blasting will take place once a week. Blasting will be outsourced and done by competent and authorized drilling and blasting personnel.

- Strip Ratio

During the initial mining period, waste stripping of the ridge peaks will be minimal. As mining progressively deepens, the overburden removal will increase until the maximum width of the pit has been reached. Average stripping ratio for the main pit is 1.9 m^3

1.3.3 Mineral Processing

The mined material (RoM) at Tiara Granville Quartz and Emerald Mine will be transported by dump truck to a RoM stockpile area which will be located in close proximity to the crushing and screening plant. Front-end loader (FEL) will be used to transported the RoM to the 850 mm static grizzly screen and then crushed in a primary jaw crusher (- 200 mm) and secondary jaw crusher (-50 mm). The crushed product will then be stored in a 25 000 tons stockpile (live stockpile) and routed to washing plant (DMS) for processing through conveyor belt system. The processing plant will be designed to process approximately 1 600 tons per hour (tph) of RoM from the live stockpile. Furthermore, The washing plant as well as other mine support infrastructure such as pollution control dam, tailing storage facility, mine office complex, workshop, diesel bay and stores will be located on the remaining extent of the farm BVB Ranch 776 LT.

1.3.4 Activity Infrastructure Requirements

Infrastructure for mining and related operations at the proposed Tiara Granville Quartz and Emerald Mine will include the following support infrastructure:

- RoM crushing and screening plant;
- Washing (processing) plant;
- Discard dumps

- Access and haul roads;
- Topsoil stockpile;
- Power supply (sub-station);
- Raw water reservoirs;
- Potable water treatment plant;
- Pollution Control Dams/Return Water Dam;
- Weighbridge;
- Solid waste management area;
- Mobile offices (including ablution facilities);
- Workshop;
- Store and storage yard;
- Diesel bay;
- Security guard house;
- Package sewage treatment plant;
- Contractors camp;
- Heavy duty vehicle parking areas

1.3.5 KEY WATER USES

Based on the project description discussed in this report, there are mine related activities falling within the ambit of water uses defined in section 21 of the National Water Act, 1998 (Act No. 36 of 1998) **("NWA").** A summary of the water uses associated with the proposed Tiara Granville Quartz and Emerald Mine are provided in the Table 1-2 below.

Table 1-2 Summary of Key Water Uses

Section 21 Water Use	Activity Description	Operational Status
Section 21(a) taking water from a water resource	Groundwater abstraction boreholes	Proposed
	Reuse of water removed from the opencast mine working	Proposed
Section 21 (b) storing water	Raw water reservoir	Proposed
	Potable water storage tank	Proposed

Section 21 Water Use	Activity Description	Operational Status
Section 21 (c and i) impeding or diverting the flow of water in a watercourse and altering the bed and banks of a watercourse	Altering the tributaries of Ga-Selati River and Molatle River	Proposed
Section 21(g) disposing of waste in a manner which may detrimentally impact on a water resource	Package sewage treatment plant	Proposed
	Pollution control dam	Proposed
	Run of Mine (RoM) stockpiles	Proposed
	Waste rock stockpiles	Proposed
	Backfilling of the opencast mine workings	Proposed
	Tailings storage facility (discard dump)	
	Dust suppression	Proposed
Section 21 (j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or the safety of people	Dewatering of the opencast mine workings	Proposed

1.3.6 Key Waste Streams

According to this Mining Works Programme (MWP), the following waste streams will be generated at the Tiara Granville Quartz and Emerald Mine:

- General domestic waste (e.g. food waste, papers, plastics, glass, cans, garden waste, etc.);
- Sewage and sullage from the office, change house and workshop;
- Waste rock;
- Spent oil and grease from mine workshops, as well as hydrocarbon containers;
- Fluorescent tubes, old batteries, waste paints;
- Scrap waste (scrap metals, empty chemical containers, and metal off-cuts);
- Wood waste (packaging material);

1.4 Scope of Work

The terms of reference of the report included compiling a 1:50 year and 1:100 year flood line which includes a hydrological impact assessment to assess and identify potential impacts that may arise from the mining and associated activities. i.e. this report assesses the impact to surface water resources by the project. As part of the proposed emerald and quartz mining activities on the properties described in this report, it is a requirement for the 1:50yr and 1:100yr flood lines to be delineated to meet with the National Water Act (36 of 1998).

The flood line determination and impact assessment on surface water resources have followed the following process:

- The regional setting is defined in terms of the hydrology and the climate;
- The Quaternary scale surface water drainage is described and evaluated using historic record;
- The local scale drainage is derived and delineated using hydrological spatial tools;
- The water quality of the Quaternary scale and local scale drainage is assessed through historic records. No in-situ sampling and analyses were conducted for this study;
- The design rainfall of the study area was determined;
- The selection of an appropriate method for the calculation of design flood peak discharge values for the derived watercourses;
- The 1-dimensionsal hydraulic modelling of the areas inundated by the 1:50 and 1:100 year design flood events;
- Impacts to the surface water resources and drainage network are evaluated for the project against the defined catchment status;
- Management measures are recommended for reducing the risk of impacts and the resultant impacts re-assessed.

1.5 Study Approach

The following approach was adopted for this study:

a) Literature Review

A review of literature of previous studies on this catchment was conducted, this provided information to enable proper assessments and substitution for data were there are limitations.

b) Hydrological Impact Assessment and Flood Delineation

The hydrological impacts for coal mining were assessed and quantified for all phases of the project which is the conception and decommissioning phase with the following factors addressed:

- The proposed project footprint was assessed and its impact on hydrology determined;
- Flood peaks were calculated for the 1:50yr and 1:10yr recurrence interval;
- The project impact on Mean Annual Runoff (MAR) was determined;
- Flood lines were determined and delineated for both the 50 and 100 year recurrence interval design rainfall;
- A 100m buffer zone were delineated for Strahler order 1 delineated streams;
- A 500 m buffer was delineated for the identified wetland types.

c) Hydrological Impacts Reporting

Report on the following with regard to hydrological impacts:

- Identification and mapping of sensitive areas, affected receptors and areas of influence
- Direct, indirect, irreversible and cumulative impact of anticipated activities on the surface water resources
- Compliance with legal and policy framework;
- Recommendation of mitigating and monitoring measures.

1.6 Assumptions and Limitations

- This study is limited to a Floodline Determination and a Hydrological Assessment;
- There is no historical water quality data in the study area;
- This study assumes that the project proponents will always strive to avoid, mitigate or offset potentially negative project-related impacts on the water resources. Impact avoidance is regarded as the best form of mitigation and should be prioritised as the primary means of mitigation. It further assumes that the project proponents will seek to enhance potential positive impacts on the environment.

1.7 Legislative Framework

Water management is controlled by the National Water Act (NWA), 1998 (Act 36 of 1998), which is the primary statute providing the legal basis for water resource management in South Africa and has to ensure ecological integrity, economic growth and social equity when managing and using water. The Acts and Regulations that pertain to the surface water include:

- The Constitution of the Republic of South Africa (Act 108 of 1996);
- The National Water Act, Act 36 of 1998 (hereafter referred to as NWA);
- Section 21 (c) water use activity - Impeding or diverting the flow of water in a watercourse and 21 (i) - Altering the bed, banks, course or characteristics of a watercourse;
- Section 26 (1) provides for the development of regulations requiring monitoring, measurement and recording as well as the effects to be achieved through management practices prior to discharge or disposal;
- The NWA introduced the concept of Integrated Water Resource Management (IWRM), comprising all aspects of the water resource, including water quality, water quantity and the aquatic ecosystem quality. The IWRM approach provides for both resource directed measures and source directed controls. Resource directed measures aim to protect and manage the receiving environment, whilst source directed controls aims to control the impacts at source;

- The National Environmental Management Act, Act 107 of 1998 (hereafter referred to as NEMA);
- National Environmental Management: Waste Act, 2008 (Act 59 of 2008) (NEM: WA);
- Government Notice (GN) R991 of 18 May 1984: Requirements for the purification of waste water or effluent.

2 Hydrological Determinants

2.1 Regional hydrological setting

The proposed Tiara Granville Quartz and Emerald mine is located within the Olifants Water Management Area (WMA) in Quaternary Catchments B72K (Ga-Selati River) and B72J (Molatle River). The mining area required will fall mostly on B72K Quaternary Catchments. The regional hydrological setting of the drainage regions, the primary and secondary rivers are shown in Figure 2.1 below.

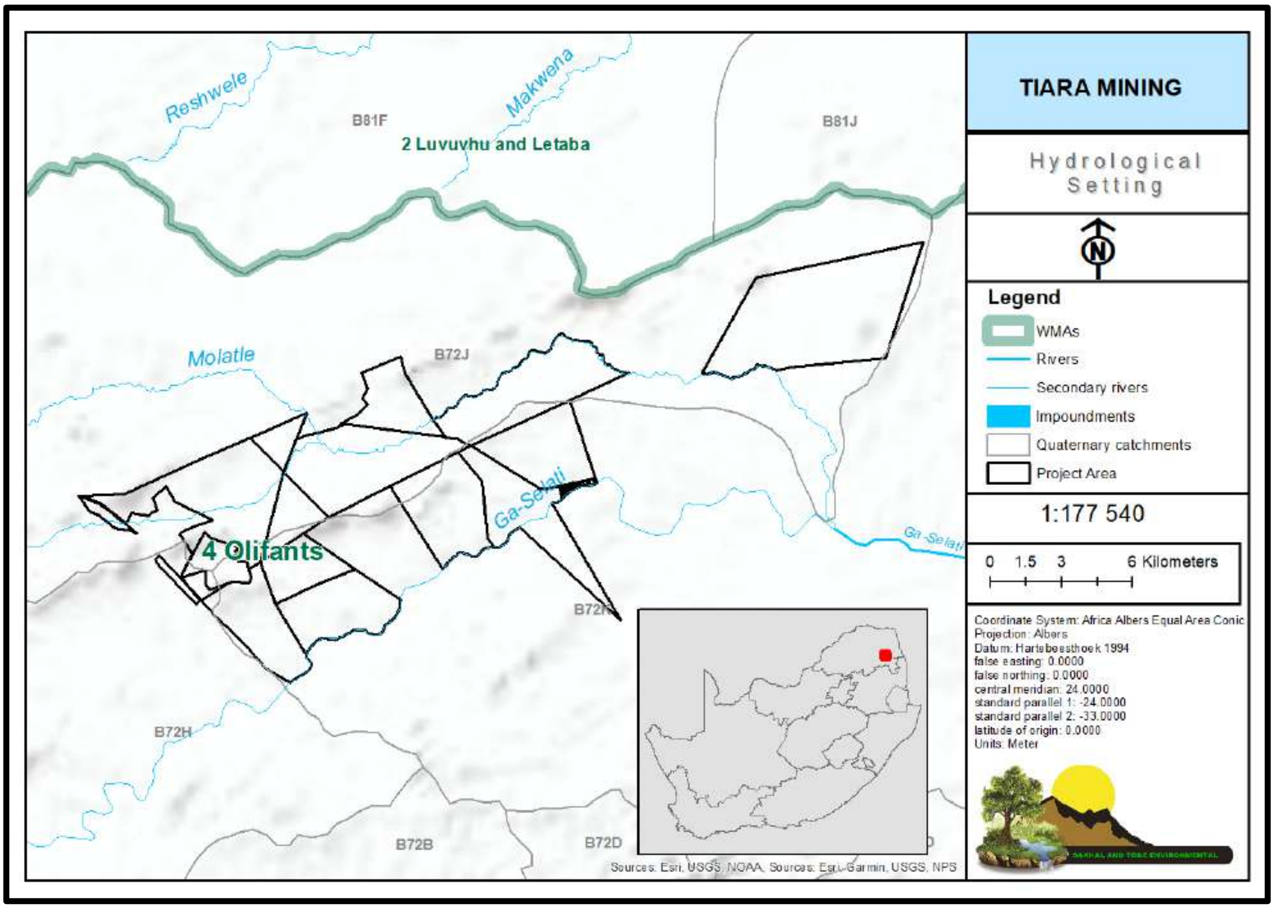

Figure 2.1: Regional Hydrological Setting

The Molatle River is a secondary River and a tributary of the Ga-Selati River, their confluence located downstream the project area at the outlet of quaternary catchment B72J.

2.2 Climate

The average climate conditions of Quaternary Catchment B72J are given in the Figure 2.2, based on data for the virtual centroid station forB72J (Schulze and Maharaj, 2006) which was extracted from the SAPWAT tool (Van Heerden *et.al.* 2016). B72J is the Quaternary Catchment that significantly most of the required mining area will be located. The climatic variables presented on the datasets are temperature, daylight hours, monthly rainfall and reference evapotranspiration (evaporation and transpiration from grass cover under ideal conditions).

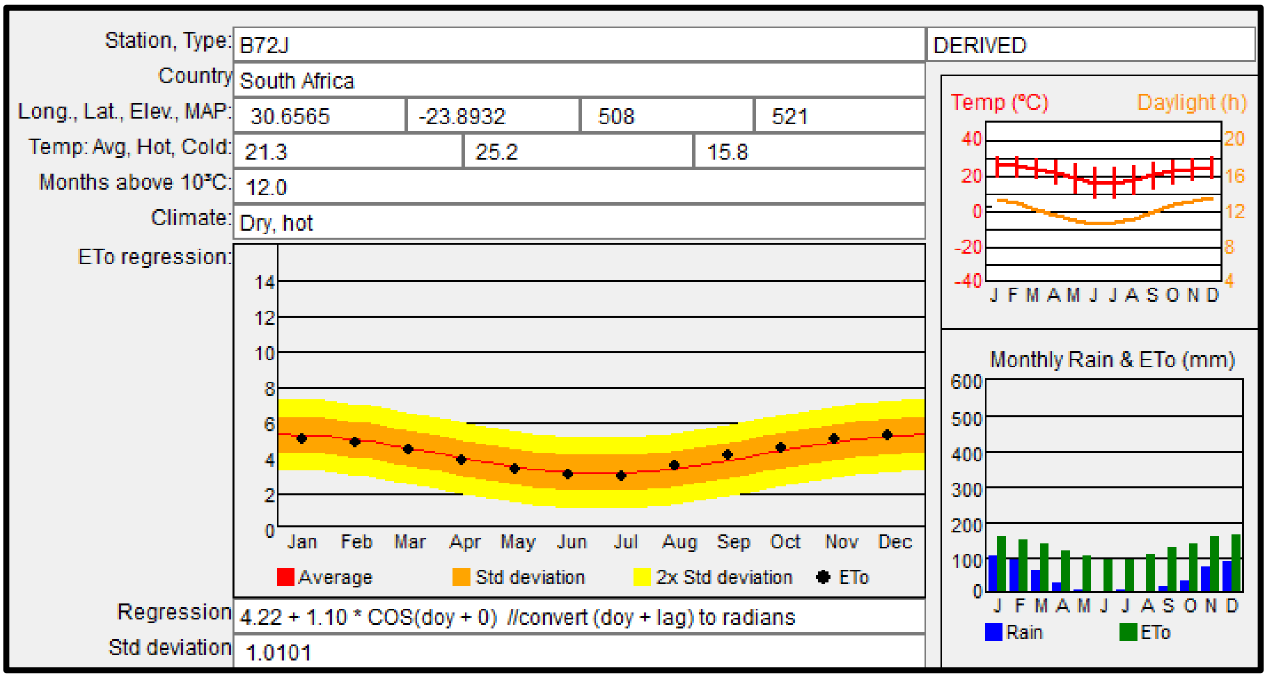

Figure 2.2: Average Climate B72J (Schulze and Maharaj, 2006)

The climate of this region can be generally classified as dry hot with dry winter and summer months. The average monthly temperature is 21.3 °c while the average summer and winter temperature are 25.1°c and 15.8 °c respectively. Due to the dry hot climate, the average monthly evapotranspiration from a standard crop is always greater than the average monthly rainfall as presented in the figure above. The Mean Annual Precipitation (MAP) of the Quaternary Catchment B72J is 521 mm which is around the national annual average which ranges from 500 - 600 mm. The region receives the lowest rainfall in June and July, and the highest rainfall received in January and February.

Catchment evaporation data was sourced from the WR2012 which provided monthly S-Pan evaporation for the period 1920 - 2009. The tabulation below provides a summary of the monthly evaporation distribution (S-Pan) for this region. The total evaporation is 1550 mm per annum.

Table 2-1: Monthly Average Evaporation Distribution (Class S Pan)

Month	Evaporation (mm)	Month	Evaporation (mm)
Jan	159	Jul	83
Feb	137	Aug	113
Mar	134	Sep	146
Apr	108	Oct	173
May	93	Nov	163
Jun	75	Dec	166
		Total	**1 550**

Rainfall data was obtained from the South African Weather Services (SAWS) rainfall station 0680354_W (MURCHISON-M). It contains historical point rainfall data for over 96 years recorded from 1903 to 2000. The observed MAP at this station is 524 mm. The Table 2-2 below provides a summary of the monthly rainfall distribution for the rain station.

Table 2-2: Monthly Average Rainfall Distribution

Month	Rainfall(mm)	Month	Rainfall (mm)
Jan	103	Jul	6
Feb	101	Aug	4
Mar	67	Sep	12
Apr	31	Oct	34
May	9	Nov	65
Jun	4	Dec	94
		Total	**531**

The mean rainfall received in a year is 531 mm which is lower than the evaporation total of 1550 mm. This data has also illustrated that there is high losses of water due to evaporation in this dry hot climatic region.

2.3 Streamflow

The streamflow data available upstream of the project area on the Ga-Selati River is that of gauging station B7H008. The station has historical flow records from 1956 to 2000. The location of B7H008 in relation to the project area is presented in Figure 2.3 below.

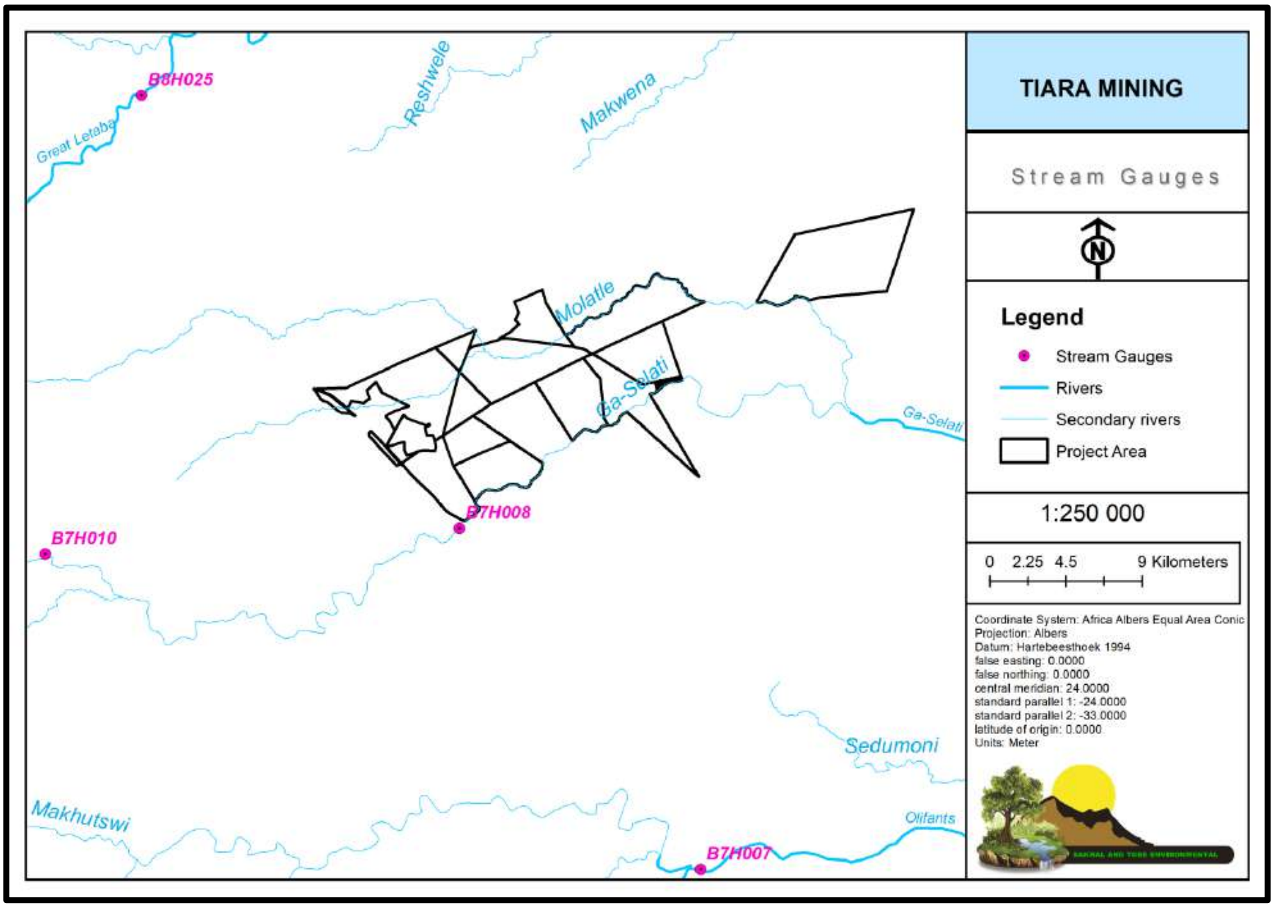

Figure 2.3: Locality of Stream Gauges

There are no flow gauges on the Molatle River of Quaternary catchment B72J. The observed flows at B7H008 were used for frequency analysis to determine the design flow peaks for flood determination of the project area.

2.4 Surface water quality

Department of Water and Sanitation (DWS) have an extensive water quality monitoring sites throughout the country as part of the National Chemical Monitoring programme (NCMP). Data sourced from these water quality monitoring sites has been used to determine water quality trends and also setting up the Resource Water Quality Objectives (RWQO) for some of the Water Management Areas in the country like the

Upper and Lower Vaal, the Upper and Lower Orange etc. Resource Quality Objectives indicates the recommended water quality at a certain monitoring site as informed by the needs of the water users and other stakeholders with respect to the in-stream water quality of the water resources in their catchments.

In the Water Resource study of 2012 the water quality of B72J was assumed to be the same as that of B72E based on data from a monitoring site B7H002Q01 (NGWABITSI RIVER AT TOURS). This assumption was made based on the similarities of land uses between the two quaternary catchments. The water quality data is presented in the Table 2-3 below. The MAR for B72E is 10.8 mcm, while for B72J is 11.4 mcm.

Table 2-3: Water Quality status (WR2012)

NO3+NO2-N (mg/l)		NH4-N (mg/l)		F (mg/l)		PO4-P (mg/l)		SO4 (mg/l)		TDS (mg/l)	
P50	**P95**	**P50**	**P95**	**P50**	**P95**	**P50**	**P95**	**P50**	**P95**	**P50**	**P95**
0.05	0.25	0.02	0.11	0.13	0.30	0.02	0.04	3	11	114	198

The station at B72E contains limited data record with gives uncertainty in the conclusion of the water quality of the catchment.

2.5 Site Specific Water Resources

The study area is dominated by non-perennial streams and secondary rivers. These non-perennial streams are either ephemeral or intermittent. Ephemeral streams are stream channels that carry water only during and immediately after periods of rainfall, and intermittent channel streams are those that carry water a considerable period of time but cease to flow occasionally or seasonally.

In assisting with decision making as to which water courses should the 1:50yr and 1:100yr floodline be delineated for within the project area. A stream ordering approach by Strahler 1952 was applied. In this approach perennial streams without tributaries are termed first-order, when two streams of equal order come together; the downstream reach is increased one order (See Figure 2.4 below).

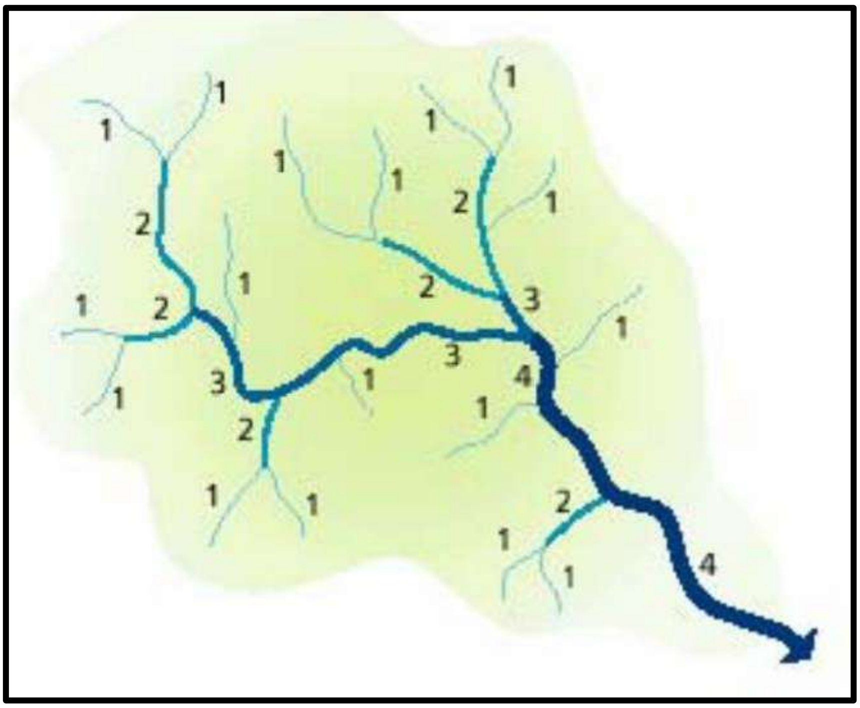

Figure 2.4: Stream order (Strahler, 1952)

Although the study area consists of two secondary rivers and non-perennial streams, this approach was crucial to differentiate between significant streams with the capability of flooding and those without a flood risk. The Strahler order for the project area ranged from order 1 to 4 is presented in Figure 2.5, together with the delineated catchment. Stream order 4 is a stream which is a recipient of three streams coming together.

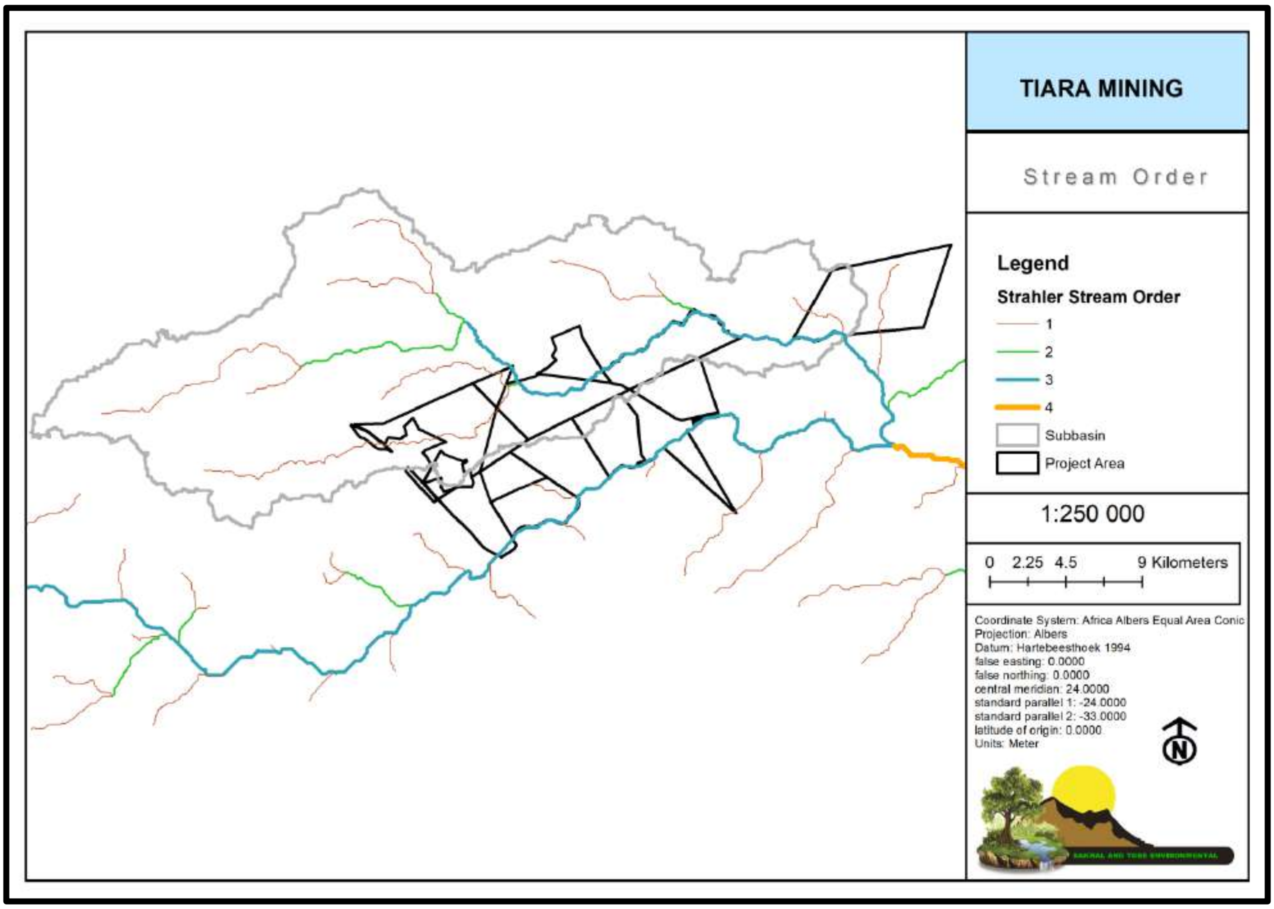

Figure 2.5: Derived sub-basins and Strahler order 2- 4 streams

Stream order 3 streams conceded with the secondary rivers, Molatle and Ga-Selati Rivers, these are the Rivers for which floodlines were determined, while a stream buffer of 100 m was applied on the first order streams.

Also presented in the figure is the derived catchment, it was derived based on a 5 m digital elevation model (DEM) which was also derived for the project area. The characteristics of the derived catchment are given in the Table 2-4 below.

Table 2-4: Derived sub-basin characteristics

Name	Basin Slope %	Tc (hr)	Area km2	Hydraulic length (km)
Tiara	3.229	31.4	479	72

2.6 Topography

The 5 m DEM derived from elevation points for the project area is presented in the Figure 2.6 below.

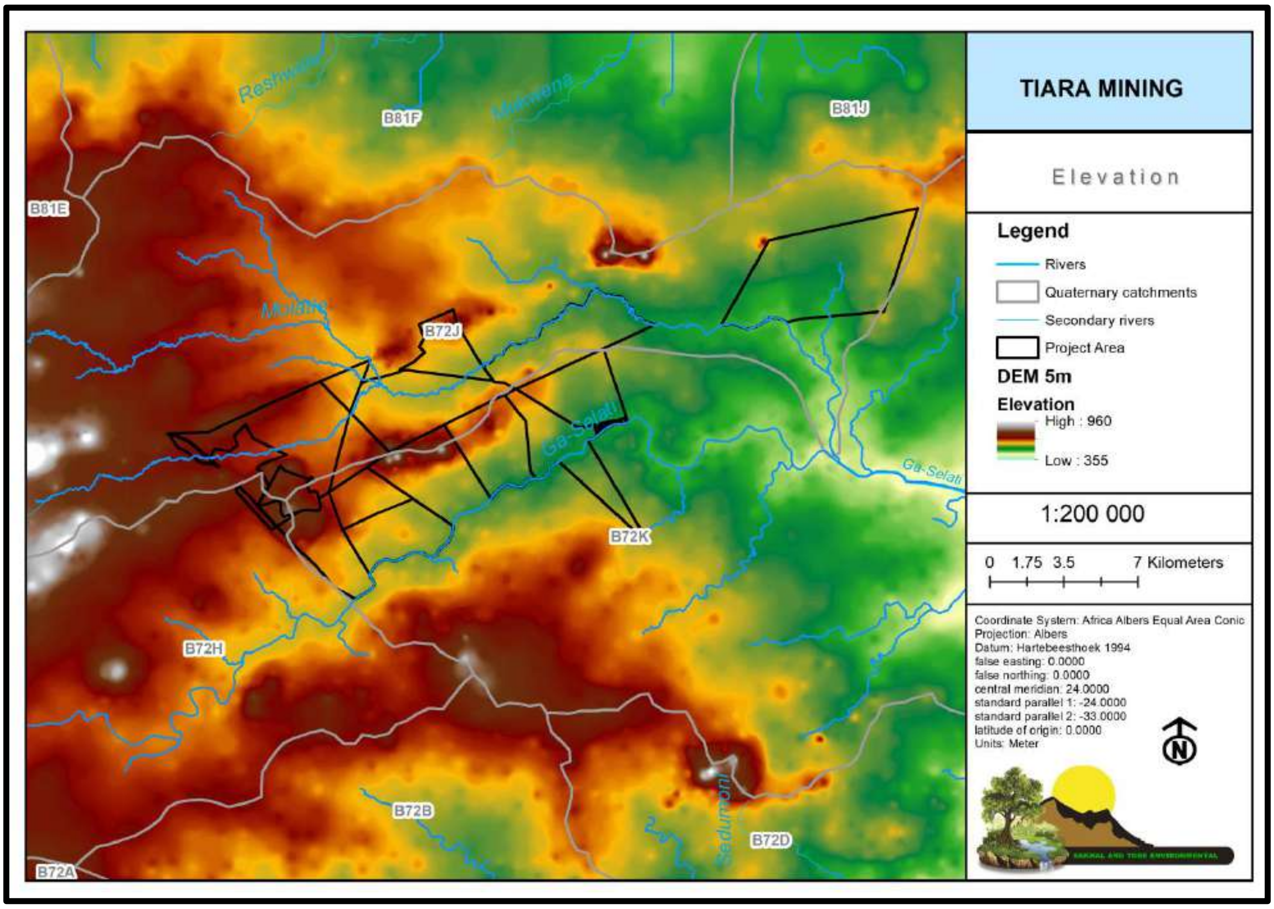

Figure 2.6: Elevation

The elevation of the vicinity of the project area ranges from 355 m above mean sea level (amsl) at the lower reaches and to 980 m amsl at the headwaters of the rivers. The land use of this area is dominantly grasslands and open bushes.

3 Floodline Delineation

The aim of the flood modelling undertaken as part of this study was to fulfil the requirements of the National Water Act (Act 36 of 1998) and more particularly, Government Notice 704 (Government Gazette 20118 of June 1999) (hereafter referred to as GN 704). The final mining plan will need to consider the specific provisions of GN704. The principle condition of GN 704 applicable to this project with regards to flooding is summarised as follows:

Condition 4 which define the area in which mine workings or associated structures may be located with reference to a watercourse and associated flooding. The 50 year flood-line and 100 year flood line are used for defining suitable locations for mine workings (mining, underground mining or excavations) and associated structures respectively. Where the flood line is less than 100 metres away from the watercourse, then a minimum watercourse buffer distance of 100 metres is required for both mine workings and associated structures.

In order to satisfy the Gazette notice referred to above, it was necessary to determine the peak flows for the design floods with return period of 1:50 and 1:100. The flood line was then delineated in order to arrive at a determination if the mining location meets the Gazette conditions of being located more than the 1:100 m flood line and 100 metres away from the watercourse, which a buffer was delineated for all first order streams derived in the project area.

3.1 Design Rainfall

An important input required for the estimation of design floods is design rainfall. Design rainfall values were extracted for the project area using the Design Rainfall Utility developed by Smithers and Schulze (2000) and are listed in the tabulation for the project area.

Table 3-1: Design rainfall for Project area

Duration	Return Period (years) Design rainfall Depth (mm)						
	1 : 2	1: 5	1: 10	1: 20	1: 50	1: 100	1: 200
24 h	75	109	134	160	197	227	260

3.2 Design Flood Hydrology

According to Smithers and Schulze (2001) design floods can be estimated using two main approaches, the rainfall based methods and through analysis of streamflow data. These are well illustrated in the figure below.

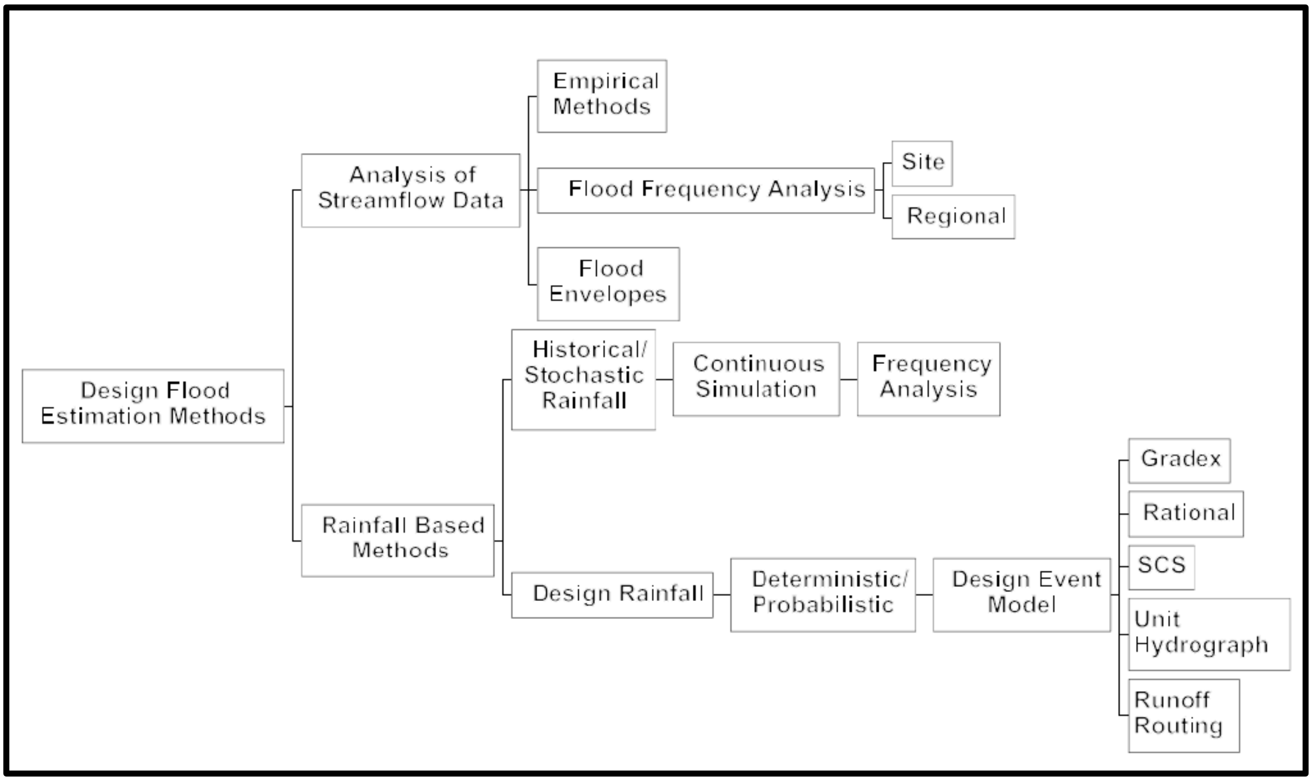

Figure 3.1: Methods for estimating design floods (after Smithers and Schulze, 2001)

For the estimation of flood peaks for the delineated catchment of the Molatle River, three rainfall based methods were used.

- The Rational Method

The Rational method is a simple method that uses catchment characteristics and storm rainfall to reproduce flood peaks. Although it is generally recommended that the method only be applied to catchments smaller than 15 km^2, it has been used successfully for larger catchments, by more experienced users.

- Unit Hydrograph Method

This method was developed by the Hydrological Research Unit HRU 3/69 and 1/72. It is recommended for catchments ranging 20 km^2 < A < 10 000 km^2.

The basic assumption in the Unit Hydrograph method is that a unit of effective precipitation (that part of the precipitation which results in direct runoff), uniformly distributed over the catchment in both time and space, will result in a uniquely shaped hydrograph for that catchment. Further assumptions are that the ordinates of the hydrograph are linearly proportional to the volume of effective precipitation and that the shape is independent of antecedent conditions. While a hydrograph shape must clearly be dependent on antecedent conditions, this assumption implies that the hydrograph is related to the average state of the catchment.

- Direct Runoff Hydrograph Method

This method was developed by the Hydrological Research Unit (1974). It is based on the proven assumption that a hydrograph can be reproduced with reasonable accuracy by routing the corresponding areal rainfall which is uniformly distributed over the catchment after reducing it by storm loss. The catchment is considered to be a simple reservoir-type storage to which the Muskingum routing method is applied. Applicability - Catchment area: 20 km^2 < A < 20 000 $km^{2.}$.

Results from the three methods, showed that the rational method had estimated the highest design flood peaks, while the Unit Hydrograph method gave the lowest design flood peaks. To be conservative in the design and risk planning, the recommended design flood peaks were that resulting from the Direct Runoff hydrograph, the recommended flood peaks used on Molatle River are given in Table 3-2 below.

Table 3-2 Design Floods for Molatle River

Exceedance Probability (%)	50	20	10	5	2	1	0.5
Return Period (years)	1 : 2	1: 5	1: 10	1: 20	1: 50	1: 100	1: 200
Design Floods (m^3/s)	52	93	129	172	238	296	363

Where long records of streamflow are available at a site, a frequency analysis of observed data may be performed to estimate design floods. The procedures for direct frequency analysis of observed peak discharge often involves selecting and fitting an appropriate theoretical probability distribution to the data. These procedures are referenced in standard hydrology texts (e.g. Chow et al., 1988; Stedinger et al., 1993).

Design flood estimations for the project area on Ga-Selati River were performed by frequency analysis of data in the upstream station (B7H008). The flood frequency analysis data and the return periods are given in the Table 3-3 below:

Table 3-3 B7H008 Flood Frequency Analysis

Exceedance Probability (%)	50	20	10	5	2	1	0.5
Return Period (years)	1 : 2	1: 5	1: 10	1: 20	1: 50	1: 100	1: 200
Design Floods (m^3/s)	0	3	6	9	31	85	1777

3.3 Hydraulic Modelling

The HEC-RAS Model (US Army Corp of Engineers) was used to undertake the 1-dimensional hydraulic modelling to determine the extent of the 1:50 and 1:100 year return period flood events. HEC-RAS is a hydraulic programme designed to perform one-dimensional hydraulic calculations for a range of applications, from a single watercourse to a full network of natural or constructed channels. The software is used worldwide and has consequently been thoroughly tested through numerous case studies.

In order to setup the HEC-RAS model for hydraulic modelling, elevation points (Figure 3.2) were collected and were used to derive a Digital Elevation Model (DEM). The elevation points were then converted to DEM using an inverse distance weighting method. This formed the basis for geometric input data into the model.

HEC-RAS uses the Manning's roughness coefficient (n) in hydraulic calculations in order to assess the frictional impact that soils and the land cover has on the water flow velocities and discharge. The roughness coefficients for the hydraulic modelling were assigned to the river channels and river banks according to the classification by Chow (1959). The cross sections which were used as input geometric data for the derived streams for which floodlines are to be delineated and are presented in Figure 3.3.

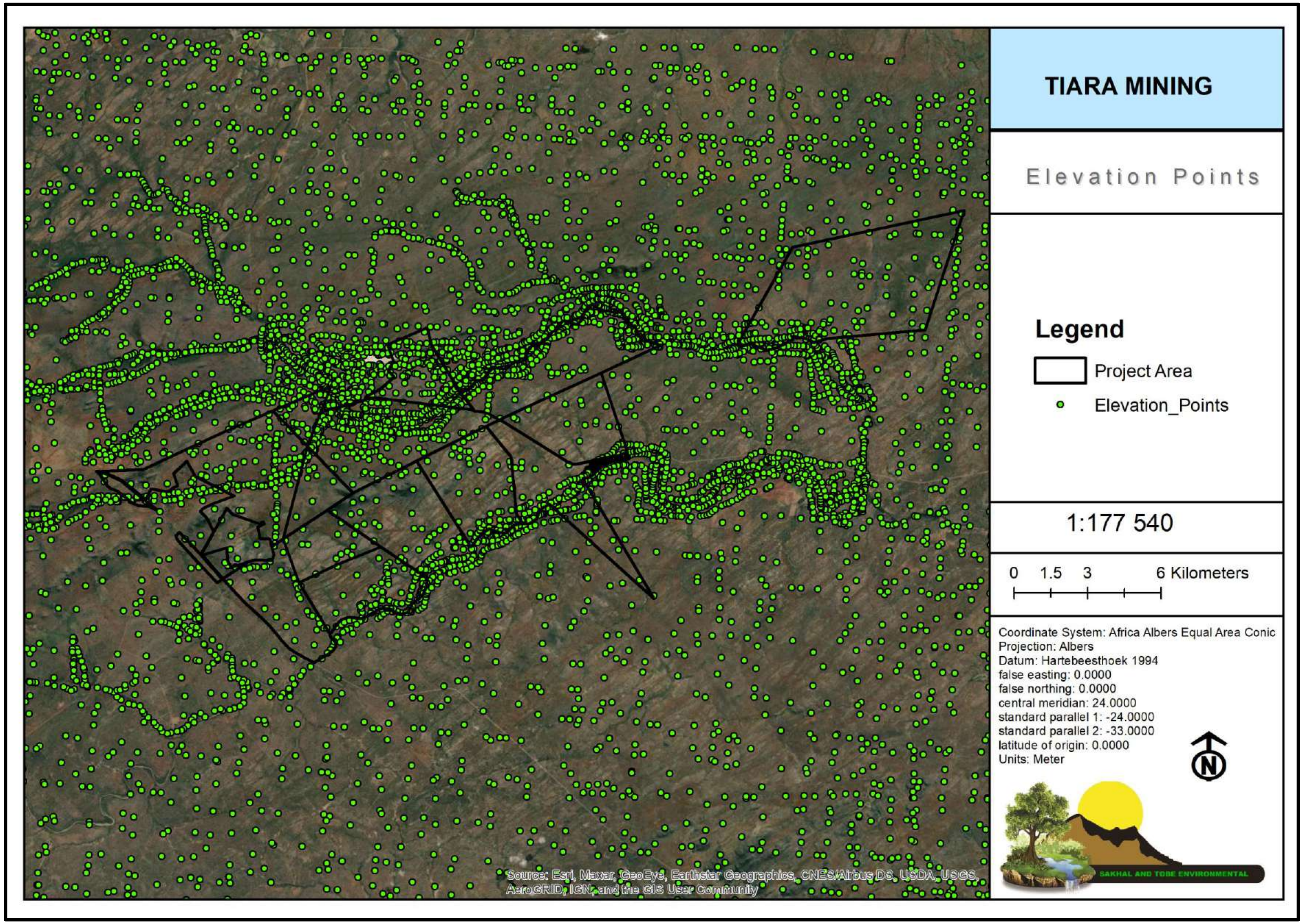

Figure 3.2: Elevation Point Collected

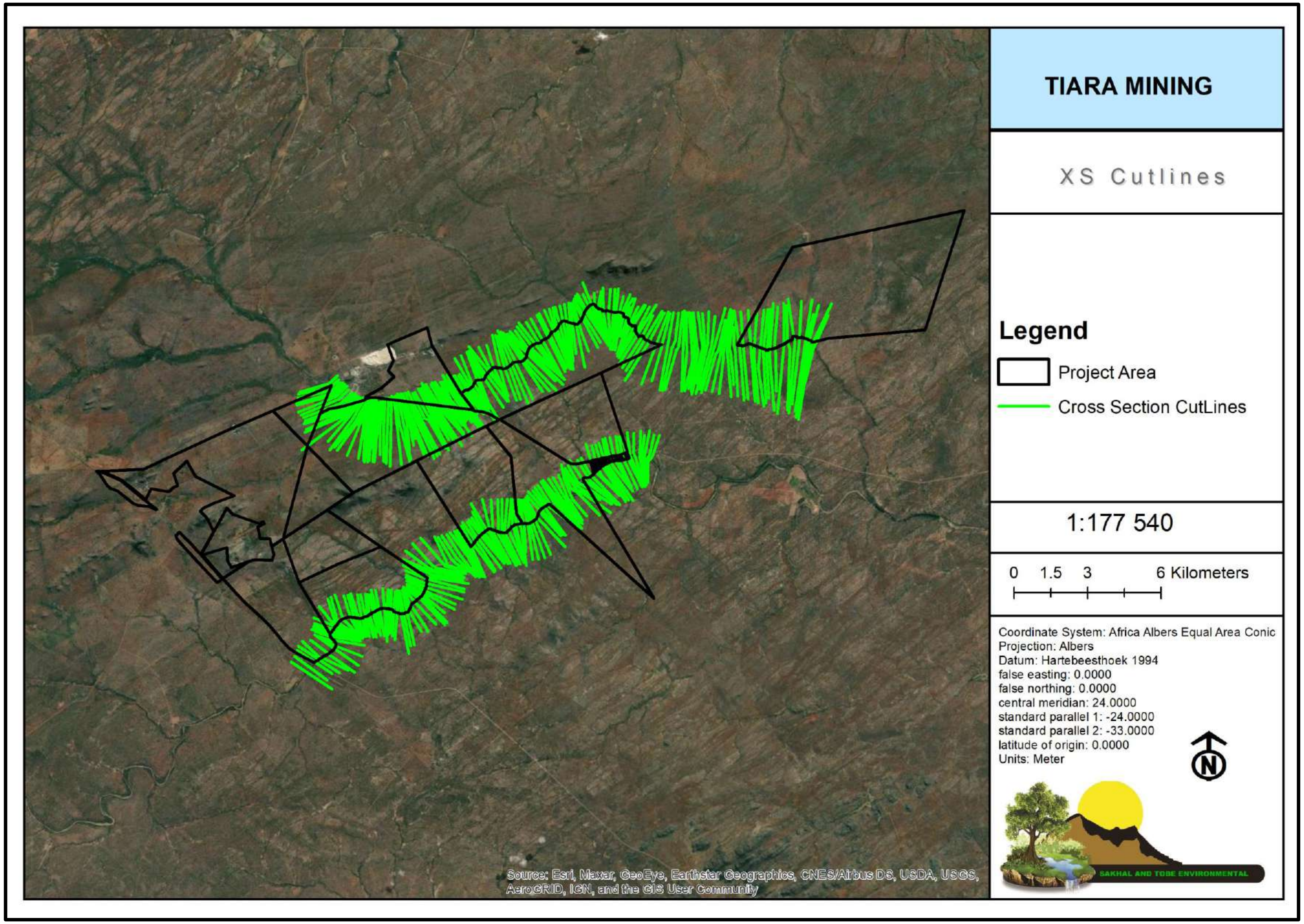

Figure 3.3: Cross Sections Cutlines

3.4 Results

3.4.1 Design floods estimation

The 1:50 and 1:100 year design floods estimated for Malotle and Ga-Selati River at the project area presented in the tabulation below.

Table 3-4: Estimated design flood peaks

River Name	Design flood peaks (M^3/s)	
	1: 50 year	1: 100 year
Malotle	238	296
Ga-Selati	31	85

3.4.2 Flood Delineations

The 1:50 year floodline delineated and mapped for the secondary rivers streams is presented in Figure 3.4; the 1:100 year floodline is presented in Figure 3.5; and the 100m buffering of the derived first order streams is presented in Figure 3.6. The Tiara Granville Quartz and Emerald mining is still a proposed activity and therefore the delineated floodlines are for planning purposes to ensure that all mining activities and infrastructure are not within the floodlines, and that the first order streams are not altered but are protected.

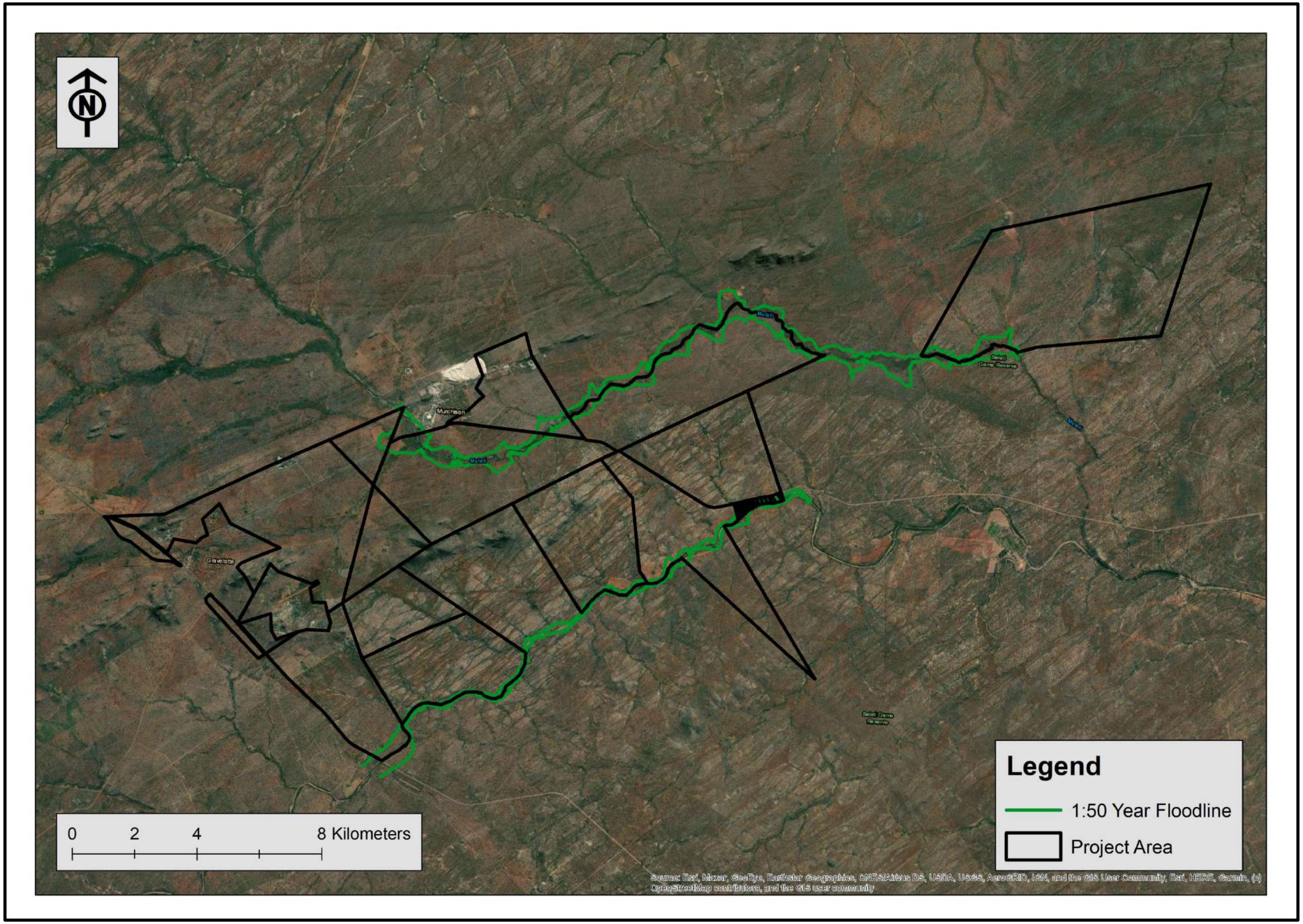

Figure 3.4: 1:50 year Floodline Delineated

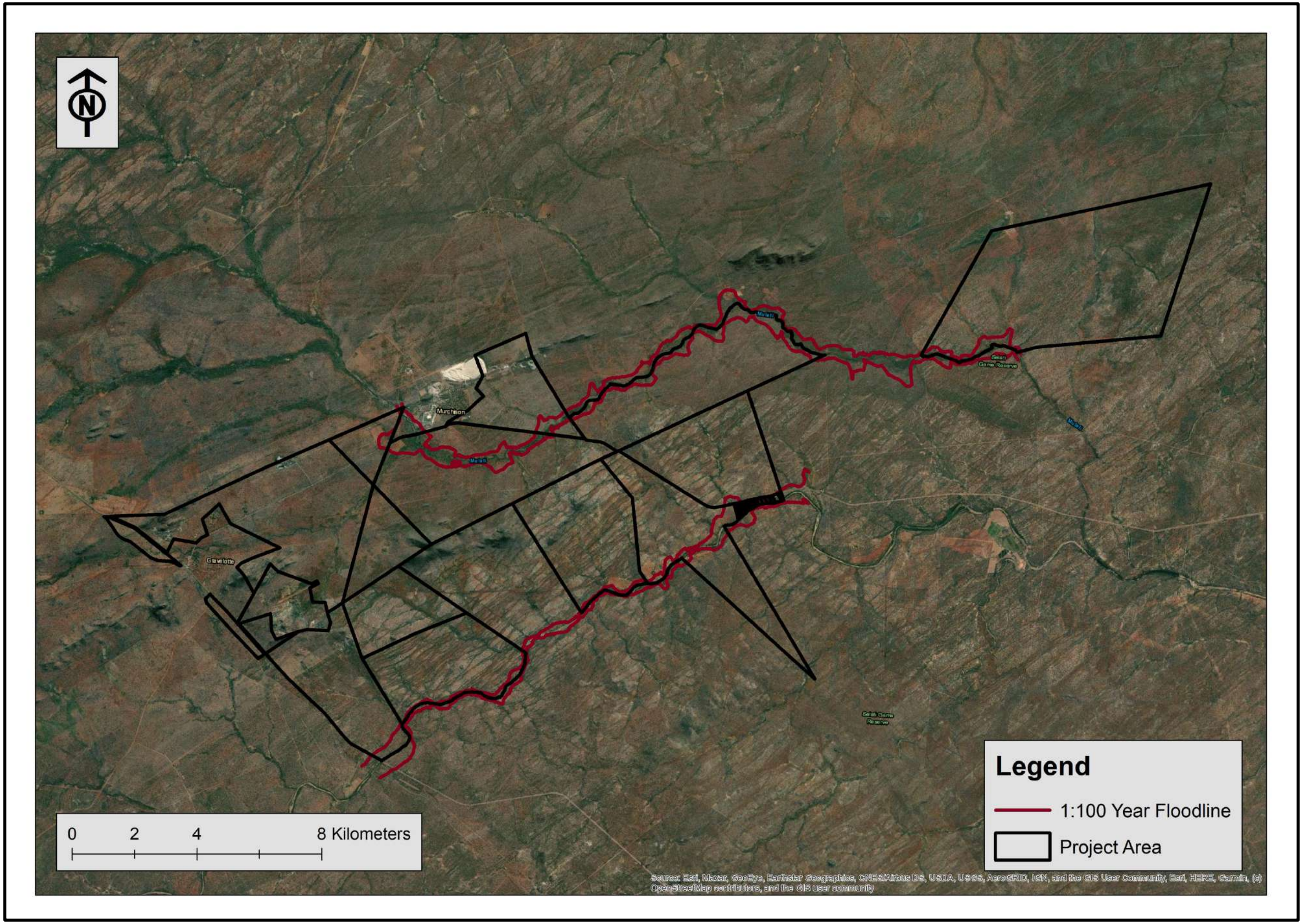

Figure 3.5: 1:100 year Floodline Delineated

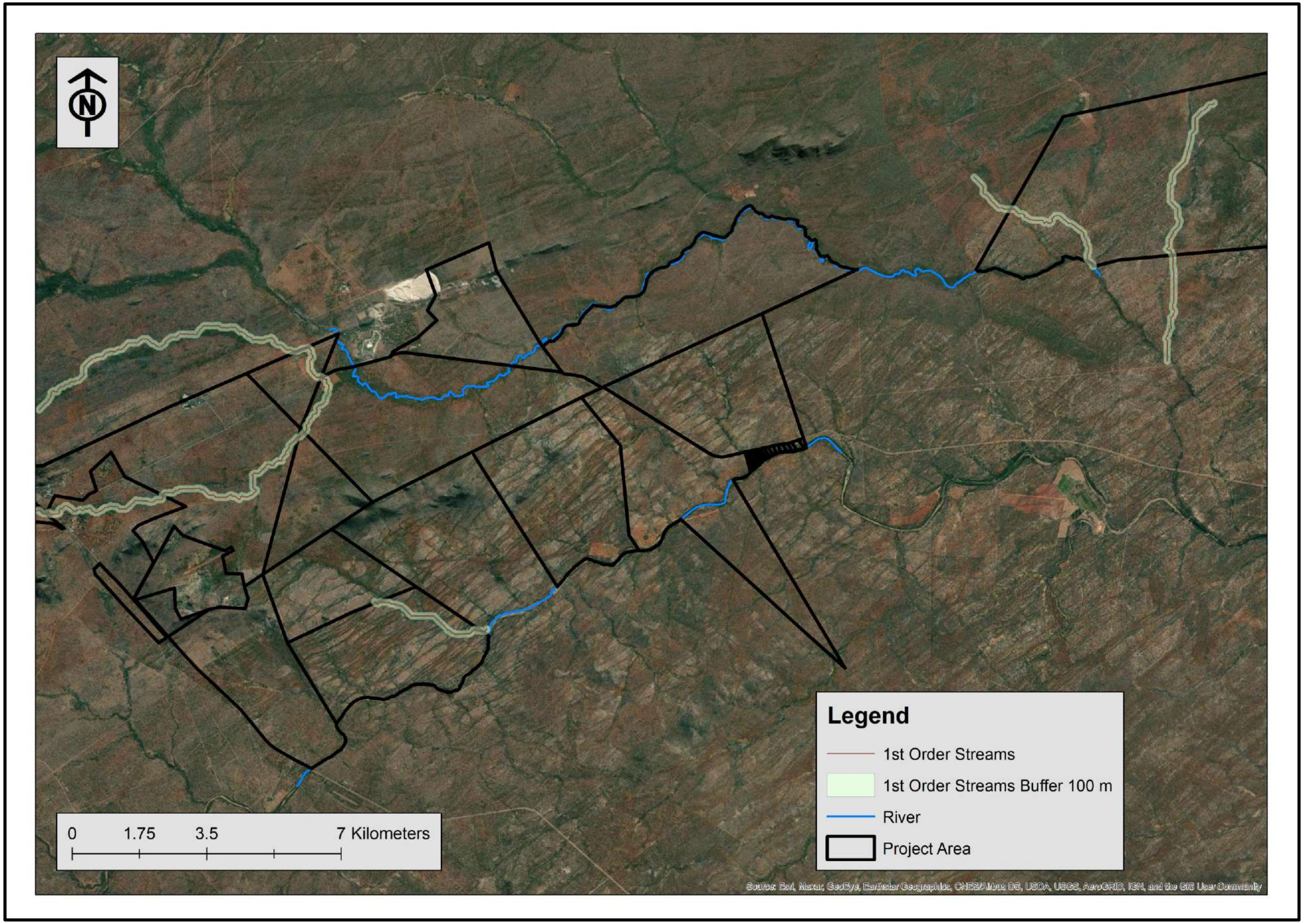

Figure 3.6: 100 m Buffer for Strahler order 1 Streams

4 Key Impacts Discussion

The following key issues have been identified from a hydrological perspective. These issues are discussed below, while their impact and possible mitigating measures are discussed in the proceeding chapter.

4.1 Changes in Catchment Characteristics

The characteristics of the catchment would be altered by the proposed development. Table 4-1 provides a list of proposed mining infrastructure affecting surface water hydrology. Infrastructure has been classified as "dirty" or "clean" in terms of the DWA Best Practice Guidelines (BPG). Every effort must be made to keep "clean" areas clean and to collect and contain runoff from "dirty" areas. The total area of infrastructure will be approximately 48 ha (0.48 km^2) with areas of each specific infrastructure units still to be determined.

Table 4-1: Proposed Mining Infrastructure

Description	Dirty or Clean
Top Soil Stockpile	Dirty
Power supply (Substation)	Moderate
Contractor's Camp	Clean
Package sewage treatment plant	Dirty
Mobile Offices	Clean
Water Pipelines	Clean
Raw Water Reservoir	Clean
Potable water treatment plant	Moderate
Diesel Bay	Dirty
Ablution Facilities	Dirty
Mine Office complex	Clean
Access Roads	Moderate
Heavy Duty vehicle Parking	Moderate
Washing (Processing plant)	Dirty
RoM crushing and screening plant	Dirty
Pollution control dams **(PCDs)**	Dirty
Discard dumps	Dirty

Description	Dirty or Clean
Solid waste management area	Dirty
Overburden stockpiles	Dirty
Weighbridge	Moderate
Workshops	Clean
storage yard	Moderate
Mine stores	Clean
Security guard house	Clean

Surface water runoff from clean areas should be discharged directly to natural watercourses and not contained or contaminated. Clean storm water should only be contained if the volume of the runoff poses a risk (for attenuation purposes), if the water cannot be discharged to watercourses by gravitation, or when the clean area is small and located within a large dirty area. Given the naturally moderate basin slope of 3% (steep) for the project area, there will be a need for attenuation (reduce flood peak) of the clean storm water.

Surface water runoff from dirty areas should be collected and contained in order to ensure that the following objectives are met:

- Minimisation of contaminated areas and reuse of dirty water (wherever possible)
- Prevention of overflows and minimisation of seepage losses from storage facilities (such as pollution control dams)
- Prevention of further deterioration of water quality
- Separation of dirty water in terms of degree of contamination (very dirty water should be kept separate from moderately dirty water)

Certain infrastructure, such as the crushing, washing and processing plants, pollution control dams, discard dumps and stockpiling areas would cause an increase in hydrologically ineffective areas. Being dirty, surface water emanating from these areas would be captured and treated to a quality level as close to source as possible. Consequently, the MAR would decrease as shown in Table 4-2 on proceeding subsection 4.4.

4.2 Removal or Alteration of Natural Water Courses

The activities of mining Quartz and Emerald mining should not alter the natural water courses as derived in this report; furthermore, mitigation measures should be put in place to ensure that the stability of the water courses (including identified wetlands) is maintained. Culverts and bridges should be constructed were the access roads crosses the streams and alteration of the identified wetlands types should be avoided.

4.3 Change in Peak Runoff and Discharge Volumes

Peak runoff for the catchment has been determined. Most of the areas with mining infrastructure will be ineffective to produce runoff or produce little runoff, therefore resulting in reduction of catchment discharge volumes.

4.4 Changes in Mean Annual Runoff

The net (natural) MAR of catchment B72J has been fluctuating over time. This was captured in the Water Resource (WR) studies from 1990 to 2012 using data from 1920 to 2009. The net (natural) MAR was recorded as: 11.4 mcm in WR90, 11.4 mcm in WR2005, 11.49 mcm in WR2012. The mining associated infrastructure is estimated to take-up approximately 48 ha (0.48 km^2) of the effective catchment area.

For this project, WR2012 quaternary runoff data (Middleton and Bailey, 2012) was estimated for the 48 ha area to be taken up by the project in order to obtain runoff volume that will be reduced. The Mean Annual Runoff (MAR) to be reduced was calculated relative to B72J catchment area using the following equation:

$$Q_1 = \sqrt{\frac{A_1}{A_2}} \times Q_2$$

Where: Q_1 is the MAR reduced by activity (mcm); $A_1$is the project infrastructure area (km^2); A_2 is the area for quaternary catchment V31G; and Q_2 is the natural MAR of V31G.

Results of the calculated project site MAR made using the equation above is given in Table 4-2. The percentage reduction of MAR of B72J due to the proposed mining activity and its associated surface infrastructure with an area of approximately 48 ha is given in Table 4-3. The Quaternary Catchment B72J net natural MAR will be reduced by 0.03 % due to the proposed mining activities.

Table 4-2: Project site MAR

Quaternary Catchment B72J Area (Km²)	Project site Area (Km²)	Baseline Quaternary Catchment B72J MAR (mcm)	Project Site MAR (mcm)
538	0.48	11.29	0.34

Table 4-3: Anticipated Post Development Reduction in MAR

Project Site MAR (mcm)	Post Development B72J MAR (mcm)	Reduction in V31G MAR (%)
0.34	10.95	0.03

Most of this 0.03 % contribution runoff will be collected and/or channelled to dirty water storage dams. The impact of this change in MAR will be discussed under the impact assessment sections in **Chapter 5.**

4.5 Increased Sediment Yield

The proposed mine infrastructure would require removal of vegetation and the stripping of topsoil. This would increase the erosion potential of the catchment and subsequently result in increased sediment in to the Ga-Selati and Molatle Rivers. Furthermore, the construction access roads to general mining activities such as excavation would increase the quantity of airborne dust. This dust would settle on the ground surface where it would present an additional source of sediment during rain events. The impact of this change on surface water hydrology is discussed in the next chapter.

4.6 Increase in Pollutant Load

The mine will use a septic ablution facility instead of the pit latrine. This will inevitably reduce the risk of surface water resources being contaminated by untreated sewage. Mining processes are dirty by nature, and are therefore potential major source of pollutants. Whilst the proposed mining infrastructure has been classified as either "clean" or "dirty," it is imperative that surface water runoff from the dirty areas is captured and adequately treated. Wherever possible, treated water should be reused in the mining process. Hydrocarbons, such as oils and petroleum fuels, represent a potential threat to surface water quality. As such, the potential impact of accidental spillages should be assessed and mitigated.

5 Surface Water Impact Assessment

This exercise of risk identification and mitigation involves identification of water courses within the proposed project properties as well as the description of the identified risks the receiving environment might incur during the various phases of the project. In this project area the first to fourth order streams were identified and delineated as watercourses that must be protected and are at a risk of being impacted upon by the coal mining and associated activities.

The risk rating matrix methodology used is based on the following quantitative measures:

- **Magnitude (M)** of the impact occurrence - This indicates whether the impact is likely to be destructive or have a lesser effect;
- **Duration (D)** of impact occurrence - This refers to the period of time that the impact may be operative for (i.e. the lifetime of the impact);
- **Scale (S)** of impact occurrence - This indicates the spatial extent that may be affected by the impact and further describes the possibility that adjoining areas may be impacted upon. (The area in which the impact will be expressed); and
- **Probability (P)** of impact occurrence - This refers to the likelihood of the impact actually occurring.

The ratings to be assigned are described in **Table 5-1.** The ratings are then combined to determine the risk significance value for the impact according to the following equation:

Risk significance value = (magnitude + duration + intensity) x probability

The maximum risk significance value that can be achieved is 100 and ratings are scaled from high, medium to low in respect to their environmental impact. The ranking system used in the study is presented in **Table 5-2**.

Table 5-1: Risk Rating Matrix

Status of Impact	
+: Positive (A benefit to the receiving environment) **N:** Neutral (No cost or benefit to the receiving environment) **-:** Negative (A cost to the receiving environment)	
Magnitude: = M	**Duration: = D**
10: Very high/don't know	5: Permanent
8: High	4: Long-term (ceases with the operational life)
6: Moderate	3: Medium-term (5-15 years)
4: Low	2: Short-term (0-5 years)
2: Minor	1: Immediate
0: Not applicable/none/negligible	0: Not applicable/none/negligible
Scale: = S	**Probability: = P**
5: International	5: Definite/don't know
4: National	4: Highly probable
3: Regional	3: Medium probability
2: Local	2: Low probability
1: Site only	1: Improbable
0: Not applicable/none/negligible	0: Not applicable/none/negligible

Table 5-2: Risk Assessment Significance Value

The maximum value that can be achieved is 100 Significance Points (SP). Environmental effects were rated as follows:		
Significance	**Environmental Significance Points**	**Colour Code**
High (positive)	>60	H
Medium (positive)	30 to 60	M
Low (positive)	<30	L
Neutral	0	N
Low (negative)	< -30	L
Medium (negative)	-30 to -60	M
High (negative)	> -60	H

5.1 Construction Phase

This is a new proposed project with no infrastructure in place yet. The construction phase of the proposed development will involve pre-stripping of vegetation to clear the open cast area, followed by the removal of topsoil and overburden material during construction.

The potential impacts of the project during the construction phase before and after mitigation are listed and ranked in **Table 5-3**.

5.1.1 Surface Water Contamination

Truck oils and fuel could leak and spill to water resources. All oils and fuels must be stored in banded areas and any spillages must be managed immediately in accordance with the Emergency Response plan. The emergency response plan must be provided by contractors. This will reduce the risks from High to low.

5.1.2 Siltation of Surface Watercourse

Ground clearance and top soils removal will expose soil and make it susceptible to erosion. Prior to construction; clean and dirty separation infrastructure need to be in place to manage runoff velocity preventing erosion gullies. The Risk will be reduced from high to low.

Table 5-3: Tiara Granville Emerald and Quartz Mine Construction Phase

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE TIARA GRANVILLE EMERALD AND QUARTZ MINE	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
CONSTRUCTION PHASE ACTIVITIES: SITE PREPARATION, GROUND CLEARING AND EXCAVATIONS																	
TIARA GRANVILLE EMERALD AND QUARTZ MINE AREAS: ALL INFRASTRUCTURE DEVELOPMENT SITES																	
Siltation of surface water resources & associated soil erosion	All mine infrastructure development areas	Ground clearing, top soil removal and construction – expose soil	10	4	3	5	85	-	H	Ensure that clean and dirty water separation infrastructure is in place prior to the commencement of construction.	4	4	1	2	18	-	L
Reduced runoff to surface water resources		Construction - depressions from excavations	10	4	2	5	80	-	H	Appropriate storm water management plan to contain at least 1:50 year rainfall event and minimise dirty water area.	6	1	1	3	24	-	L
Surface water contamination		Waste handling – fuel and oil spills	6	3	3	3	36	-	M	Prevent spillage of fuel and oils.	4	3	2	2	18	-	L

5.2 Operational Phase

Tiara Granville Quartz and Emerald mine involves truck and shovel opencast mining method with crushing and screening unit as well as processing plant (washing plant). Mine workings will reach a considerable depth of about 70 mbgl. Drilling and blasting of the rock face will be conducted on a predetermined schedule in accordance with projected volumes of production and will be undertaken by professionals and with the required safety procedures applied. The mining method will include:

- Clearance of the vegetation
- Stripping of topsoil to prepare box-cut area or bench
- The topsoil will be loaded onto dump trucks by excavators and hauled to areas that require rehabilitation or topsoil stockpile area;
- Drilling and blasting may occasionally be required
- Drilling operations will commence in the front of the advancing pit after the topsoil has been removed;
- The removed Run of Mine (RoM) will be stockpiled using excavators; and
- Thereafter RoM will be transported to the washing plant by means of haul trucks with a loading capacity of approximately 40 tons.

The potential impacts of the project during the operation phase before and after mitigation are listed and ranked in Table 5-4.

5.2.1 Stream Runoff Reduction

At a local scale, clean water run-off must be diverted around areas of disturbance. Where practicable, sediments must be captured and retained on-site. This will reduce ranking from medium to low.

Table 5-4: Tiara Granville Emerald and Quartz Mine Operational Phase

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE TIARA GRANVILLE EMERALD AND QUARTZ MINE	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
CONSTRUCTION PHASE ACTIVITIES: PROCESSING, DISCARD DUMP AND WASTER DISPOSAL																	
TIARA GRANVILLE EMERALD AND QUARTZ MINE AREAS: ALL MINING AREAS																	
Deterioration of surface water quality	Stockpiles, pollution control dams and Discard dump	Stockpiles, pollution control dams and Discard dump – contaminated runoff	10	4	3	4	68	-	H	Divert and capture dirty runoff water, including runoff from discard dump. Design pollution control dams to contain at least 1:50 year rainfall event.	6	4	3	4	52	-	M
Siltation of water resources	All mine areas	All operation activities - exposure of soil surfaces and ineffective rehabilitation	8	4	3	4	60	-	M	Maintain storm water infrastructure, ensure sediments are effectively captured and returned on-site.	6	4	3	4	52	-	M
Pollution of water resources	Discard Dump and pollution control dams	Pollution control dam & discard dump – risk of failure	10	4	3	4	68	-	H	Ensure regular inspection and maintenance of the pollution control dams and discard dump	6	4	3	3	39	-	M

Table 5-5: Tiara Granville Emerald and Quartz Mine Closure Risk Assessment

POTENTIAL ENVIRONMENTAL IMPACT	APPLICABLE TIARA GRANVILLE EMERALD AND QUARTZ MINE	ACTIVITY	ENVIRONMENTAL SIGNIFICANCE BEFORE MITIGATION							RECOMMENDED MITIGATION MEASURES	ENVIRONMENTAL SIGNIFICANCE AFTER MITIGATION						
			M	D	S	P	TOTAL	STATUS	SP		M	D	S	P	TOTAL	STATUS	SP
CONSTRUCTION PHASE ACTIVITIES: REMOVAL OF INFRASTRUCTURE AND RUBBLE, REHABILITATION OF DISTURBED AREAS																	
TIARA GRANVILLE EMERALD AND QUARTZ MINE AREAS: ALL MINING AREAS																	
Pollution of water resources	All mining areas	Removal of infrastructure - improper waste handling and fuel/oil spills	8	4	3	4	60	-	M	Manage waste effectively to prevent pollution of water resources.	4	5	2	1	11	-	L
Runoff from PCDs and drainage from discard dump continue to yield polluted water	Pollution control dams and discard dumps	Rehabilitation	8	5	3	4	64	-	H	Maintain dirty water separation systems until the site is rehabilitated and free draining.	6	5	1	2	24	-	L
Pollution of water resources	All mining areas	Removal of infrastruc ture - including water and pipelines	8	4	3	4	60	-	M	Rehabilitate as soon as possible, maintain erosion control for the duration of rehabilitation	4	2	2	3	24	-	L

6 Conclusions and Recommendations

Tiara Granville Quartz and Emerald mine proposes to establish an open cast mine in quaternary catchment B72J in the Limpopo Province. The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)). The mining activities will involve truck and shovel opencast mining method with crushing and screening unit as well as processing plant (washing plant). Mine workings will reach a considerable depth of about 70 mbgl. The mining infrastructure covers an area of approximately 0.48 km^2.

The climate of this region can be generally classified as dry hot with dry winter and summer months. Due to the dry hot climate, the average monthly evapotranspiration from a standard crop is always greater than the average monthly rainfall. The Mean Annual Precipitation (MAP) of the Quaternary Catchment B72J is 521 mm which is around the national annual average which ranges from 500 - 600 mm. Six different types of wetlands were found to exist in the study area i.e. seep, channelled valley-bottom; un-channelled valley-bottom; valley flow and bench depression; and flat wetlands.

The 1:50 and 1: 100 year floodlines were delineated and mapped for the secondary rivers streams; the 100m buffering was applied for the derived first order streams, while a 500 m buffer was applied for wetlands identified within the project area. The Tiara Granville Quartz and Emerald mining is still a proposed activity and therefore the delineated floodlines are for planning purposes to ensure that all mining activities and infrastructure are not within the floodlines, and that the first order streams are not altered but are protected.

The ground clearing, top soil removal, and depressions from excavations activities were found to have a high risk of impact during the construction phase. Stockpiles, pollution control dams and discard dumps pose a higher risk of surface water contamination during the construction phase. There are also risks on failure of the pollution control dams and discard dumps during the operation phase. During the decommissioning phase runoff from pollution control dams and drainage from discard dump if it continues to yield polluted water would pose a risk to pollution of surface water.

The following recommendations are made:

- The mining infrastructure and activities should be outside of the delineated 1:50yr and 1:100yr floodlines; outside the 100 m buffer from the first order streams;
- Water quality monitoring points must be established on the secondary watercourses to monitor water quality upstream the (disturbance areas – stockpiles, pollution dams and discard dump) and downstream these areas;
- It must be ensured that clean and dirty water separation infrastructure is in place prior to the commencement of construction;
- Appropriate storm water management plan must be in place to contain at least 1:50 year rainfall event and minimise dirty water area;
- Storm water infrastructure must be maintain, and if possible ensure that sediments are effectively captured and returned on-site to minimise sediment loss and siltation of the water resource;
- Ensure regular inspection and maintenance of the pollution control dams and discard dump to avoid failure;
- Dirty water separation systems must be maintained until the site is rehabilitated and free draining.

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Appendix 3 - Granville Emerald and Quartz Stormwater Management Plan

TIARA GRANVILLE EMERALD AND QUARTZ MINING OPERATION, LIPOMPO PROVINCE

November 2020
Version 01

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PROJECT TITLE:

TIARA GRANVILLE EMERALD AND QUARTZ MINING OPERATION, LIPOMPO PROVINCE

Report Reference Number	**ZN - 1935**
Date	**19 May 2020**
Report Version	**Draft**

SPECIALIST DECLARATION:

Zonhla Hydro and Enviro Consulting (Pty) Ltd have been appointed to compile an independent Stormwater Management Plan for the proposed Tiara (Pty) Ltd Granville Emerald and Quartz Mine. Zonhla have undertaken this study in an objective manner, even if this results in views and findings that are not favourable to the applicant or client. Zonhla have the expertise required to undertake the necessary Stormwater Management Plan study and the resultant report presents the results in an objective manner. The main author of the report, Mr. Nhlakanipho Zondi, is a senior hydrologist at Zonhla, has a BSc Honours in Hydrology with excess of nine years of experience in various hydrological studies and is professionally registered with South African Counsel for Natural Scientific Professions (SACNSP).

Verification	Name	Signature	Date
Prepared By	Nhlakanipho Zondi ***Pr. Sci. Nat***		30 November 2020

TIARA GRANVILLE EMERALD AND QUARTZ MINING OPERATION, LIPOMPO PROVINCE

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FIGURES

1 INTRODUCTION

Zonhla Hydro and Enviro Consulting (Pty) Ltd (hereafter referred to as Zonhla) were appointed by Sakhal and Tobe Environmental (Pty) Ltd to undertake a Stormwater Management Plan (SWMP), for the proposed Tiara (Pty) Ltd Granville Emerald and Quartz Operation. The mining project is situated on the Farms BVB Ranch 776 LT, Josephine 749 LT, Buffalo Ranch 834 LT, Danie 789 LT, Granville 767 LT and Farrel 781 LT in the Limpopo Province. The SWMP specialist study is required as part of a Water Use Licence Application (WULA) process as stipulated in Section 21 of the National Water Act No. 36 of 1998 (NWA).

This SWMP has been developed in line with the requirements of General Notice (GN) 704 of the NWA No. 36 of 1998, as outlined in the Department of Water and Sanitation (DWS), Best Practice Guidelines (BPGs) - G1 (2006) as well as BPGs - A5 and A6 (2008).

2 SITE DESCRIPTION

2.1 Locality

The location of the Tiara Mine is presented in **Figure 2-1**. As depicted in this map, the study area is located approximately 34 km west of the town of Phalaborwa, within the Ba-Phalaborwa Local Municipality of the Limpopo Province. More specifically, the study site is located on the Farms BVB Ranch 776 LT, Josephine 749 LT, Buffalo Ranch 834 LT, Danie 789 LT, Granville 767 LT and Farrel 781. A site plan, presenting the layout of infrastructure associated with the proposed Tiara Mine is provided in **Figure 2-2**.

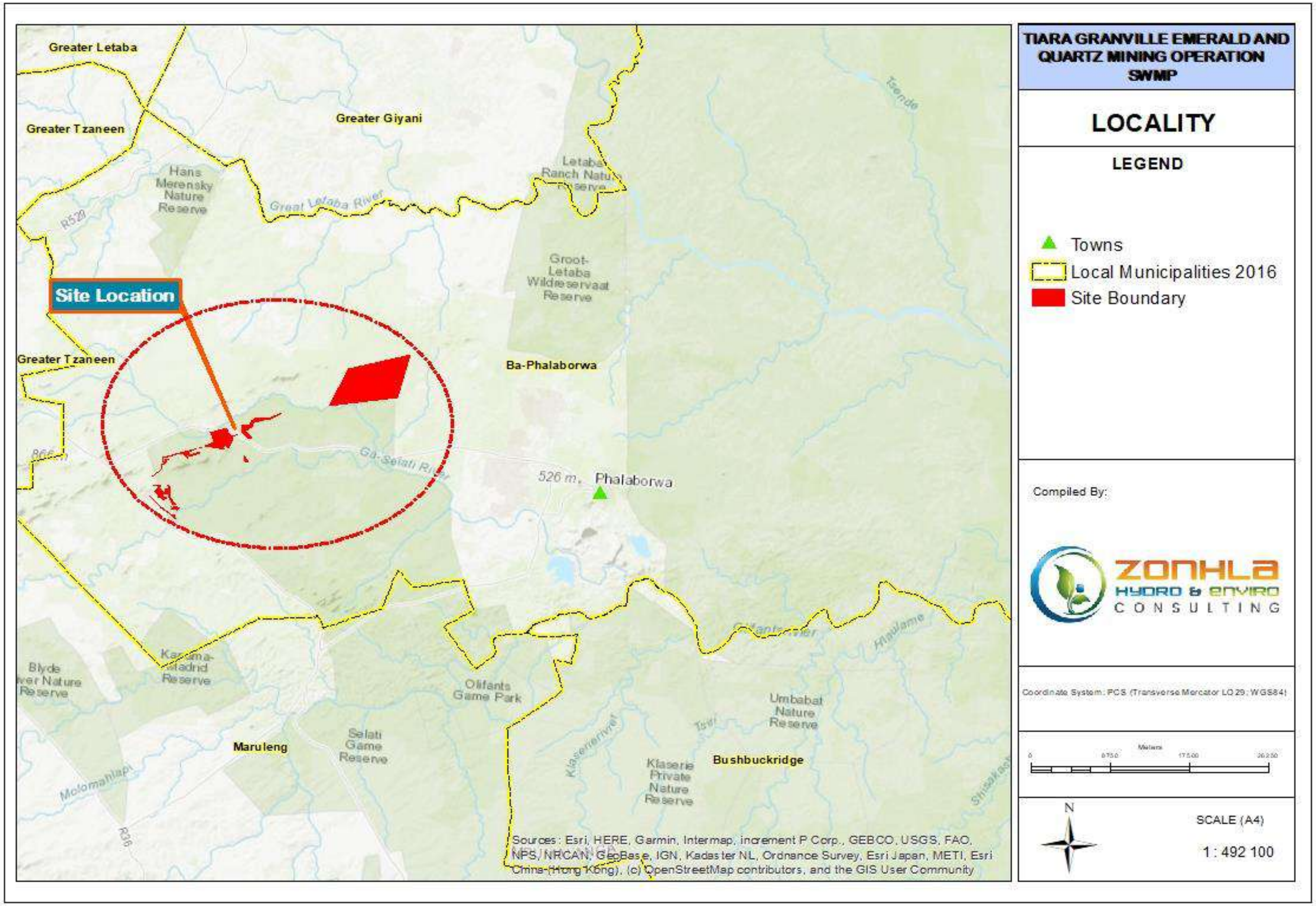

Figure 2-1: Locality Map of the Tiara (Pty) Ltd Granville Emerald and Quartz Mine

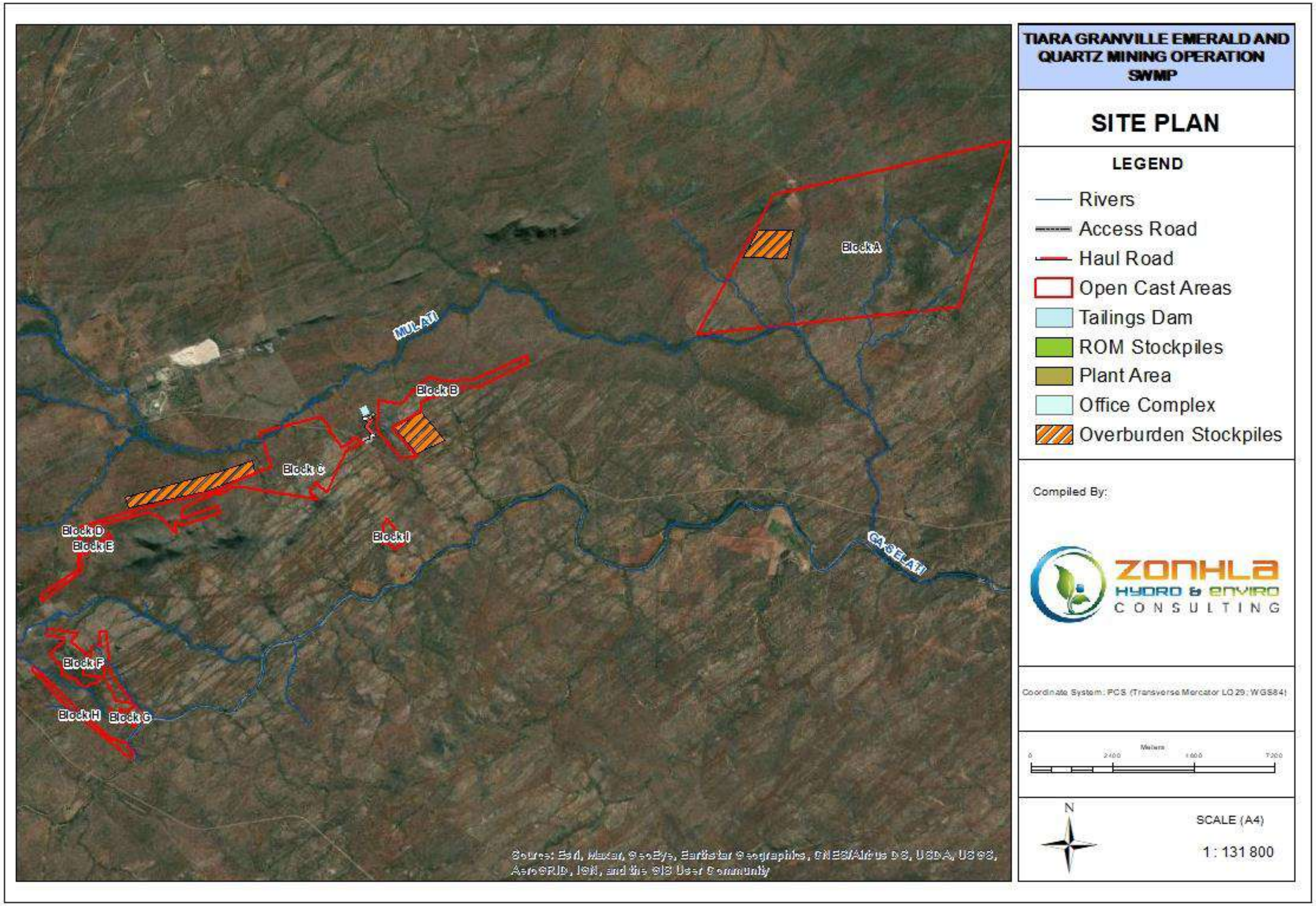

Figure 2-2: Site Plan of the Tiara (Pty) Ltd Granville Emerald and Quartz Mine

2.2 Proposed Mine Infrastructure

The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)) using truck and shovel opencast mining method.

The operation will have following support infrastructure:

- Screening and crushing machine;
- Processing plant;
- Run of Mine (RoM) stockpiles;
- Mobile office complex;
- Process water reservoir/tank;
- Portable water tank (Jojo tanks);
- Ablution facility;
- Store house;
- Workshop;
- 3 x Komatsu D 155 Bulldozer;
- 3 x Volvo 460 Hydraulic Excavators;
- 6 x Volvo A30 Articulated 6X6 Dump Trucks;
- 6 x Volvo D65 Bulldozer;
- 1 x Volvo 72 Motor Grader;
- 1 x 12 000 litre Water Browser for dust suppression;
- Security gate (boom gate); and
- fence (five strand barbed wire or Clear-Vu fence).

3 STORMWATER MANAGEMENT PLAN METHODOLOGY

The DWS BPGs-G1 (2006) in conjunction with the DWS BPGs A5 and A6 (2008), which were developed specifically for stormwater management in surface and underground mining, were used as a basis for the development of this SWMP. These guidelines are based on the requirements of GN 704 of the NWA No. 36 of 1998. The basic principles of a SWMP, which were followed in this study, are outlined below:

1. Clean water must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system, while preventing, or minimising, the risk of spillage of clean water into dirty water systems.
2. Dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage, or seepage, into clean water systems must be minimised.
3. The SWMP must be sustainable over the life cycle of the dirty areas, over different hydrological cycles and it must incorporate principles of risk management.
4. The statutory requirements of various regulatory agencies and the interests of stakeholders must be considered and incorporated.

An effective stormwater management system is essential to ensure operations at the proposed mine are uninterrupted and to protect the downstream water resources. The main purpose of this SWMP is to ensure that the risk of polluting water resources downstream of the Tiara Mine site is minimised. This entails the management of dirty water generated at the pits, run-of-mine (ROM) stockpiles, processing plant, fuel and hydrocarbon stores, wash bay and workshop area.

In order for the SWMP to be compliant with statutory requirements, the sizing of the stormwater management infrastructure must be done using the 1:50-year return period storm event. For this purpose, the Rational Method was used to calculate peak discharge values used in the sizing of the stormwater infrastructure (i.e. diversion berms and channels), while the Soil Conservation Service – South Africa (SCS-SA) method can be used to size the pollution control dams. One of the main inputs in deterministic methods for peak discharge calculations (such as the Rational and SCS-SA Methods) is the design rainfall. The following section presents the design rainfall values used in this study.

3.1 Design Rainfall

Design rainfall for the site was obtained from the Design Rainfall Estimation Program (Smithers and Schulze, 2003). Design rainfall depths for various durations, used in the calculation of the 1:50-year return period design flood peaks, are presented in **Table 3-1**.

Table 3-1: 1:50-Year Return Period Design Rainfall Values

Duration	1:50 Year Design Rainfall Depths (mm)
5 min	21.7
10 min	34.8
15 min	45.9
30 min	63.5
45 min	76.7
1 hour	87.8
1.5 hour	106.1
2 hour	121.3
4 hour	141.6
6 hour	155.0
8 hour	165.2
10 hour	173.7
12 hour	180.9
16 hour	192.8
20 hour	202.7
24 hour	211.1
2 day	219.3
3 day	250.1
4 day	273.5
5 day	293.2
6 day	310.4
7 day	325.6

3.2 Rational Method Description

The Rational Method is widely used throughout the world for both small rural and urban catchments (Pilgrim and Cordery,1993) and is the most widely used method of estimating design flood peak discharge values. The peak flow equation is based on a runoff coefficient (C), average rainfall intensity (I) and the effective area of the catchment (A).

The Rational formula is defined as:

$$Q = 0.278(CIA) \qquad \textbf{Equation 1}$$

Where:

Q = peak flow (m^3/s)

C = run-off coefficient (dimensionless)

I = average rainfall intensity over catchment (mm/hour)

A = effective area of catchment (km^2)

The Rational formula has the following assumptions:

- The rainfall has a uniform spatial distribution across the total contributing catchment;
- The rainfall has a uniform time distribution for at least a duration equal to the time of concentration (Tc);
- The peak discharge occurs when the total catchment contributes to the flow occurring at the end of the critical storm duration, or time of concentration;
- Catchment C factor remains constant for the storm duration, or the time of concentration; and
- The return period of the peak flow, T, is the same as that of the corresponding rainfall intensity.

Catchment C Factors, required as input into the Rational Method, are determined by accounting for a combination of catchment landcover types (C_v), soils (C_p) and slope (C_s). Catchment C Factors applied to each respective catchment area are provided in **Sections 4.1** and **4.2**.

3.3 Soil Conservation Service Method Description

In order to size the pollution control dams, the SCS-SA Stormflow Equation was applied. This method provides stormflow depths equating to specific recurrence interval storm events, and was developed by Schulze, Schmidt and Smithers (1992). The SCS stormflow depth equation used in this study is presented as follows:

$$Q = (P - I_ą)^2/(P - I_ą + S) \text{ for } P > I_ą \qquad \textbf{Equation 2}$$

Where:

Q = stormflow depth (mm)

P = daily design rainfall depth (mm), usually input as a one-day for a given return period event

S = potential maximum soil water retention (mm)

$I_ą$ = initial losses, dependent on antecedent soil moisture conditions (mm) = 0.1S

4 CONCEPTUAL STORMWATER MANAGEMENT PLAN DESIGN

This SWMP has been divided into two sections presenting clean stormwater and dirty stormwater management recommendations. The sources of contamination for the site were identified as pits areas, ROM stockpile areas, processing plant, overburden materials, hydrocarbon spills and general waste.

The main focus for the clean stormwater management was to limit the natural upper catchment runoff from entering the mine area and that of the dirty stormwater management was to limit contaminated water and hydrocarbons spills from entering the environment (water resources) downstream of the Tiara Mine.

The following sections provide details on the proposed stormwater infrastructure to achieve the clean and dirty water separation, as required in GN704 of the NWA No. 36 of 1998.

4.1 Proposed Clean Stormwater Management Plan

As per principal one of the BPG – G1 (Storm Water Management), clean stormwater runoff must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system, while preventing or minimising the risk of mixing clean and dirty stormwater runoff. In order to accomplish this at the Tiara Mine site, two lined clean stormwater diversion Channels and Berm (CB 01 to CB 04) within the mine infrastructure areas together with six lined clean stormwater diversion channels (CB 01 - CB 04, CB13 and CB 14) and eight diversion berms (PCB 05 to PCB 12) upstream of the pit areas, are proposed to capture and divert clean stormwater runoff around the mine site into the environment, as presented in **Figures 4-1 to 4-6.**

As depicted in **Figures 4-1 to 4-6** (orange and yellow coloured berms and channels), the following lined clean water diversion berms and channels are proposed:

- Channel CB 01, which is proposed to divert clean stormwater runoff around the processing plant area;
- Channel CB 02, is proposed to divert clean stormwater runoff around the ROM stockpile area;
- Berm CB 03, is proposed to capture and divert clean stormwater runoff around the western boundary of the Tailings Dam;

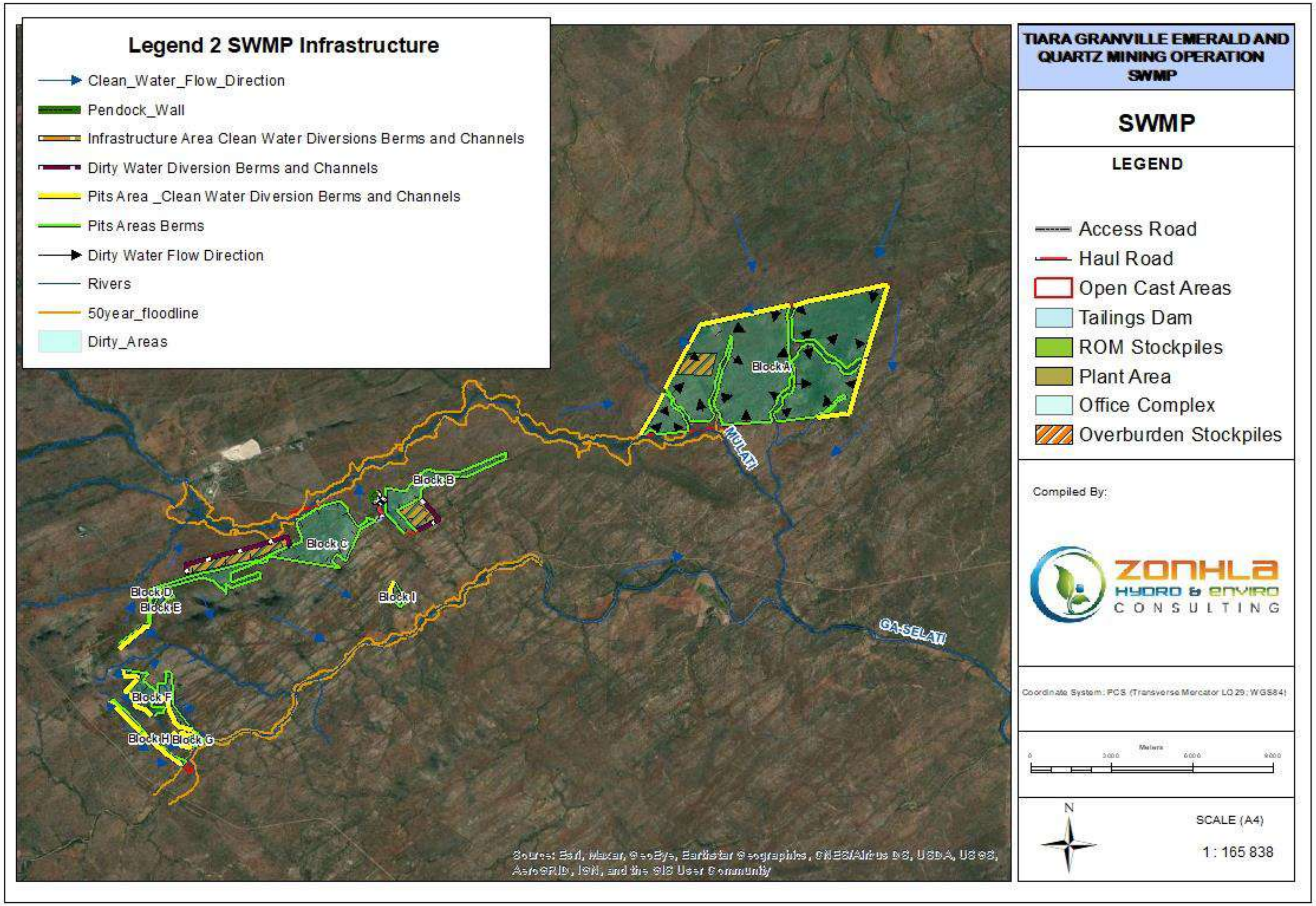

Figure 4-1: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure

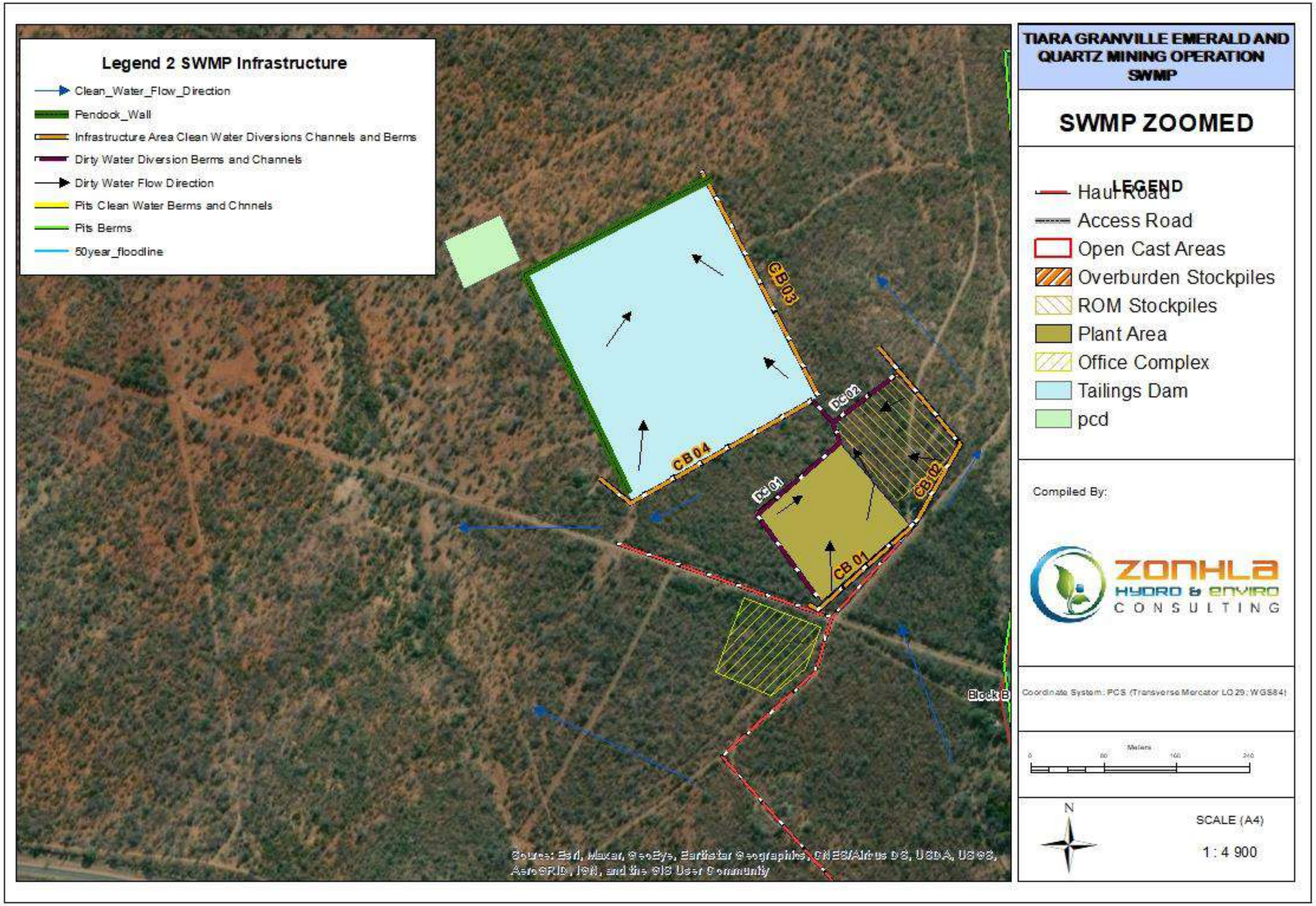

Figure 4-2: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure for Infrastructure Area

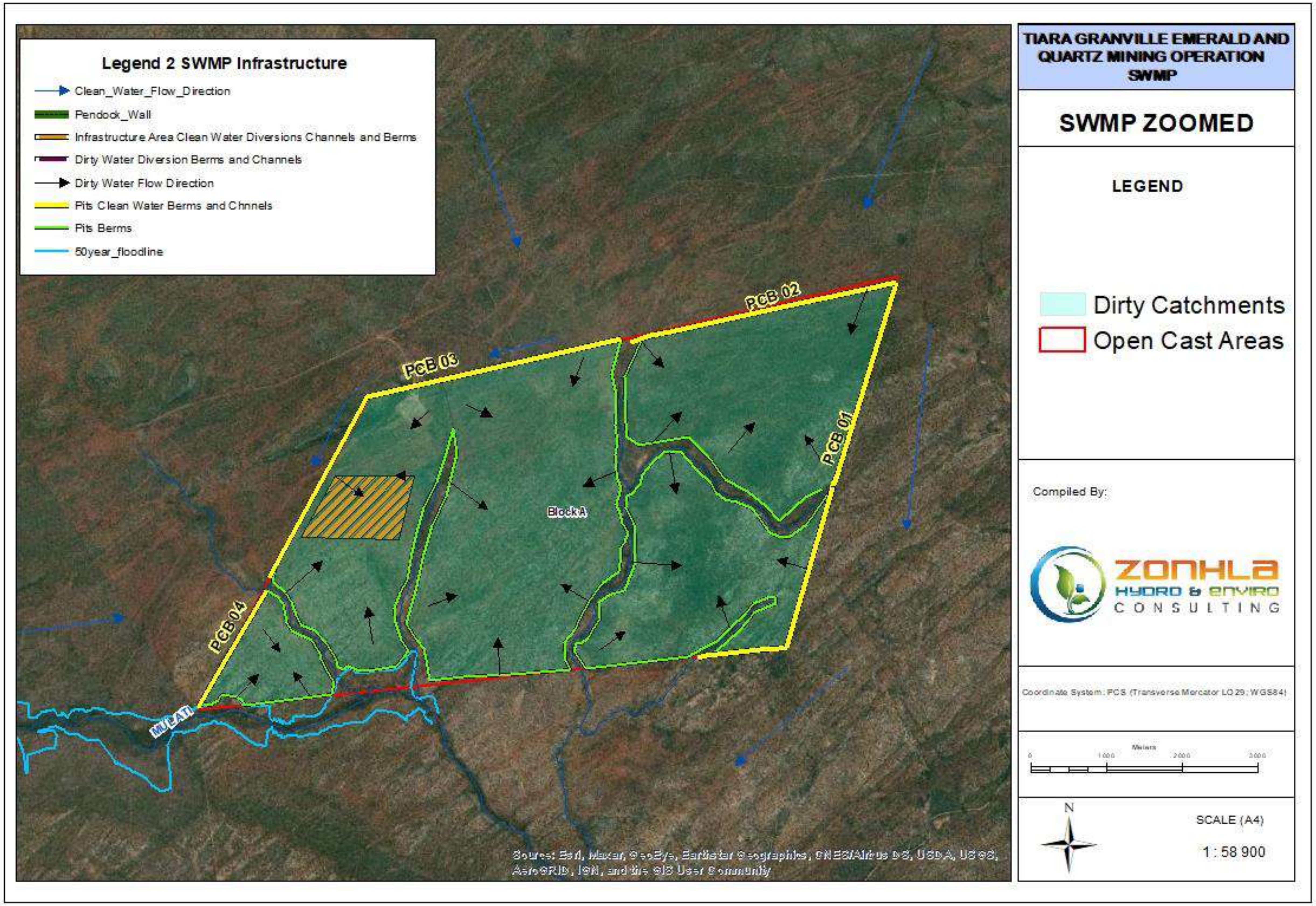

Figure 4-3: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure for Block A

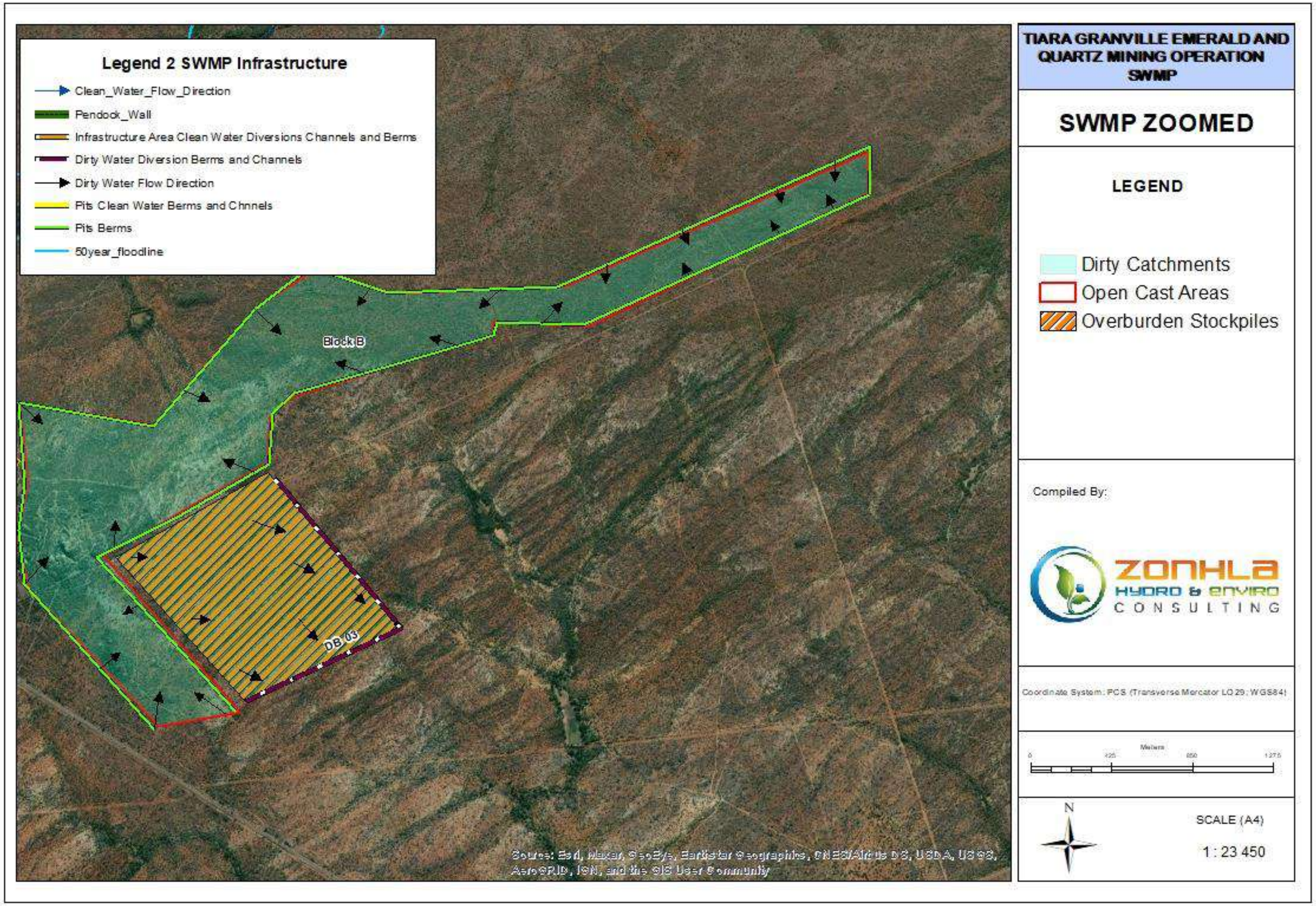

Figure 4-4: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure for Block B

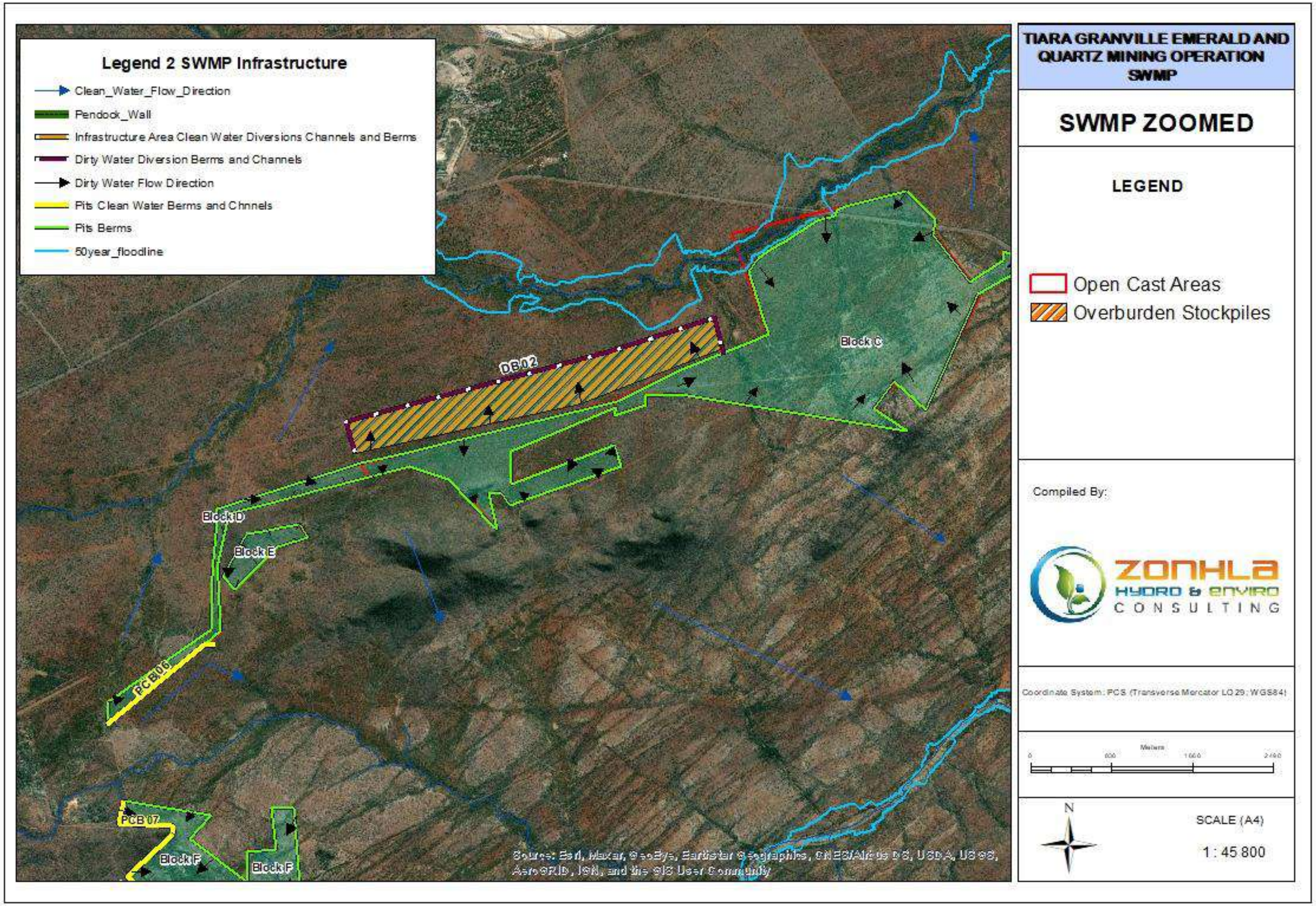

Figure 4-5: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure for Block C to E

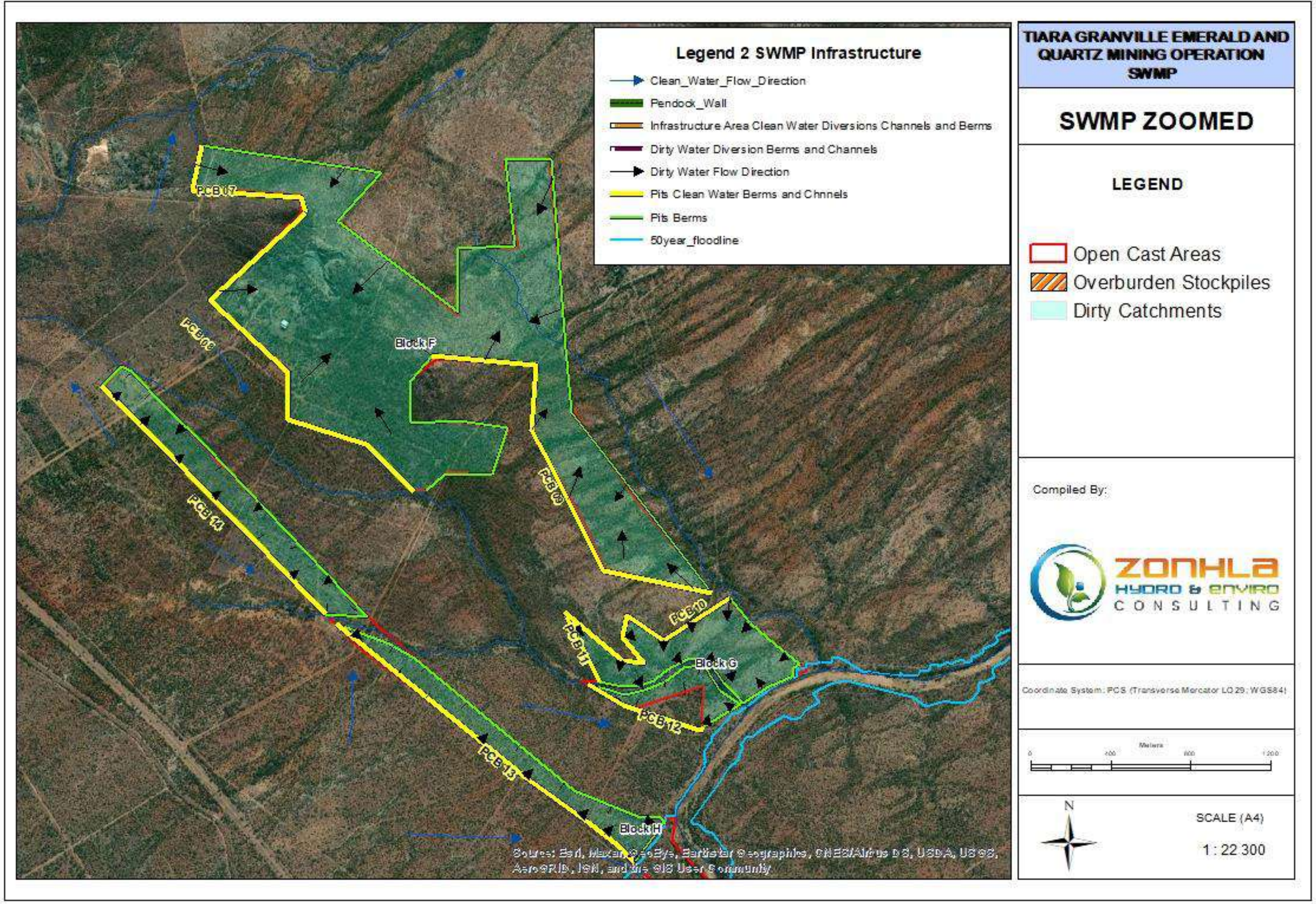

Figure 4-6: Tiara Mine (Pty) Ltd Proposed Stormwater Management Infrastructure for Block F and G

- Berm CB 04, is proposed to capture and divert clean stormwater around the north boundary of the Tailings Dam;
- Channel PCB 01, which is proposed to capture the clean stormwater runoff around the west boundary of Block A Pit area and divert it into the environment;
- Channel PCB 02, is proposed to capture the clean stormwater runoff emanation from the north of Block A Pit area and divert it into the environment;
- Channel PCB 03, is proposed to capture the clean stormwater runoff emanation from the north of Block A Pit area and divert it to the east southern boundary into the environment;
- Channel PCB 04, is proposed to capture the clean stormwater runoff emanation from the east of Block A Pit area and divert it to the southerly direction into the environment;
- Berm PCB 05, is proposed to capture the clean stormwater runoff emanating from the southern boundary of Block D Pit area and divert it to the westerly direction into the environment;
- Berm PCB 06, is proposed to capture the clean stormwater runoff emanating from the north eastern boundary of Block I Pit area and divert it to the southerly direction into the environment .
- Berms PCB 07 to PCB 12, are proposed to capture the clean stormwater runoff emanating from the eastern boundary of Block F Pit area and divert it to the southerly direction into the environment
- Channels PCB 13 and PCB 14, are proposed to capture the clean stormwater runoff emanating from the eastern boundary of Block H Pits area and divert it southerly into the environment.

As mentioned previously, in order to meet with statutory requirements, stormwater management infrastructure needs to be sized to accommodate the 1:50-year design flood event. The method used to calculate the 1:50-year peak discharge and used to provide recommendations pertaining to the dimensions of the clean diversion berms and channels was the Rational Method, as described in **Section 3.2.**

Catchment characteristics of areas contributing flow to the proposed clean stormwater berms and channels, including catchment C Factors and resultant peak discharge values are presented in **Tables 4-1** and **Table 4-2**. Based on the calculated 1:50-year peak discharge values, dimensions of the proposed clean stormwater management infrastructure are presented in **Table 4-3**.

Table 4-1: Clean Stormwater Management Infrastructure Catchment Characteristics

Catchment	Catchment Area (km2)	Stream Length (m)	Slope (m/m)	Time of Concentration (hrs)
Channel CB 01	0.0200	0.15	0.03509	0.25
Channel CB 02	0.0200	0.24	0.01667	0.25
Berm CB 03	0.0700	0.28	0.06235	0.25
Berm CB 04	0.0400	0.27	0.01954	0.25
Channel PCB 01	2.8000	6.00	0.00067	4.40
Channel PCB 02	6.1000	3.20	0.00042	3.25
Channel PCB 03	10.0000	6.10	0.00175	3.08
Channel PCB 04	4.7000	3.60	0.00148	2.18
Berm PCB 05	0.1300	0.83	0.01293	0.31
Berm PCB 06	0.2600	1.40	0.00285	0.82
Berm PCB 07	0.1600	0.56	0.02372	0.25
Berm PCB 08	0.7800	2.16	0.00617	0.85
Berm PCB 09	0.3700	2.20	0.00303	1.14
Berm PCB 10	0.1000	1.40	0.00286	0.82
Berm PCB 11	0.0940	0.39	0.02057	0.25
Berm PCB 12	0.2900	0.63	0.00213	0.49
Channel PCB 13	3.0000	1.90	0.00140	1.36
Channel PCB 14	3.6000	1.60	0.00083	1.46

Table 4-2: Clean Stormwater Management Infrastructure Peak Discharge Calculation Results

Berm Name	1:50-Year Average Rainfall Intensity (mm) (PI), Based on Tc of 15 minutes	Catchment C Factor	1:50-Year Peak Discharge (m^3/s)
Channel CB 01	183.60	0.33	0.34
Channel CB 02	183.60	0.33	0.34
Berm CB 03	183.60	0.33	1.17
Berm CB 04	183.60	0.29	0.59

Berm Name	1:50-Year Average Rainfall Intensity (mm) (PI), Based on Tc of 15 minutes	Catchment C Factor	1:50-Year Peak Discharge (m^3/s)
Channel PCB 01	32.78	0.29	7.32
Channel PCB 02	41.21	0.29	20.06
Channel PCB 03	42.99	0.29	34.2904
Channel PCB 04	56.39	0.29	21.14
Berm PCB 05	163.16	0.33	1.94
Berm PCB 06	97.21	0.33	2.31
Berm PCB 07	183.60	0.33	2.68
Berm PCB 08	95.40	0.33	6.79
Berm PCB 09	81.71	0.33	2.76
Berm PCB 10	97.34	0.33	0.8
Berm PCB 11	183.60	0.33	1.58
Berm PCB 12	127.70	0.33	3.38
Channel PCB 13	74.15	0.33	20.31
Channel PCB 14	71.67	0.33	23.56

Table 4-3: Proposed Clean Stormwater Management Infrastructure Dimensions

<table>
<tr><th>Berm Name</th><th>Type</th><th>Top Width (m)</th><th>Bottom Width (m)</th><th>Height/Depth (m)</th></tr>
<tr><td>Channel CB 01</td><td>Earth Embankment</td><td colspan="2" rowspan="2">Not Applicable</td><td>0.5</td></tr>
<tr><td>Channel CB 02</td><td>Earth Embankment</td><td>0.5</td></tr>
<tr><td>Berm CB 03</td><td>Lined Trapezoidal Channel</td><td>0.6</td><td>0.8</td><td>0.8</td></tr>
<tr><td>Channel CB 04</td><td>Lined Trapezoidal Channel</td><td>0.6</td><td>0.8</td><td>0.8</td></tr>
<tr><td>Channel PCB 01</td><td>Lined Trapezoidal Channel</td><td>1</td><td>1.5</td><td>1.0</td></tr>
<tr><td>Channel PCB 02</td><td>Lined Trapezoidal Channel</td><td>1.2</td><td>1.6</td><td>1.6</td></tr>
<tr><td>Channel PCB 03</td><td>Earth Embankment</td><td>1.8</td><td>2.5</td><td>2.5</td></tr>
<tr><td>Channel PCB 04</td><td>Earth Embankment</td><td>1.2</td><td>1.6</td><td>1.6</td></tr>
<tr><td>Berm PCB 05</td><td>Earth Embankment</td><td colspan="2" rowspan="6">Not Applicable</td><td>0.6</td></tr>
<tr><td>Berm PCB 06</td><td>Earth Embankment</td><td>0.8</td></tr>
<tr><td>Berm PCB 07</td><td>Earth Embankment</td><td>0.8</td></tr>
<tr><td>Berm PCB 08</td><td>Earth Embankment</td><td>1.2</td></tr>
<tr><td>Berm PCB 09</td><td>Earth Embankment</td><td>0.8</td></tr>
<tr><td>Berm PCB 10</td><td>Earth Embankment</td><td>0.5</td></tr>
</table>

Berm Name	Type	Top Width (m)	Bottom Width (m)	Height/Depth (m)
Berm PCB 11	Earth Embankment			0.6
Berm PCB 12	Earth Embankment			1
Channel PCB 13	Lined Trapezoidal Channel	1.2	1.6	1.6
Channel PCB 14	Lined Trapezoidal Channel	1.2	1.6	1.6

4.2 Proposed Dirty Stormwater Runoff Management

As per principle two of the BPGs – G1 (Storm Water Management), dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage or seepage into the clean water systems must be minimised. The main concern for the dirty stormwater management is to limit contaminated runoff and hydrocarbon spills from entering the environment downstream of the mine.

The dirty stormwater runoff in the Tiara Mine will originates from the Processing Plant, ROM Stockpile Area, Pit Ares and Overburden Area. Four dirty water diversion infrastructure are proposed to be constructed on the downstream boundaries of the dirty water catchment areas, as depicted in **Figures 4-1 to 4-6**. The proposed channels and berms should be lined, in order to limit infiltration of dirty water into the clean water system.

The proposed stormwater management infrastructure for contaminated stormwater runoff are depicted in **Figure 4-1 to 4-6** (purple coloured berms and channels) and includes:

- Channel DC 01, is proposed to collect all dirty stormwater runoff emanating from the washing plant area/processing plant and divert it into the tailings dam,
- Channel DC 02, is proposed to capture dirty stormwater runoff emanating from the western boundary of the ROM Stockpile Area and direct it into the tailings dams;
- Berm DB 01, is proposed to capture all the runoff sediments emanating from the overburden stockpile area 1 and
- Berm DB 02, is proposed to capture all the runoff sediments emanating from the overburden stockpile area 2.

As mentioned previously, in order to meet the statutory requirements, stormwater management infrastructure needs to be sized to accommodate the 1:50-year design flood event. The method used to calculate the 1:50-year peak discharges, as well as used to provide recommendations pertaining to the dimensions of the dirty diversion channels and berms was the Rational Method, as described in **Section 3.2**. A minimum time of concentration of 15 minutes was assumed for all the dirty water catchments for the purpose of determining design rainfall depths. The catchment characteristics, C Factor and resultant peak discharge values are presented in **Tables 4-4** and **Table 4-5**. Based on the calculated 1:50-year peak discharge values, dimensions of the proposed dirty stormwater management infrastructure are presented in **Table 4-6**.

Table 4-4: Dirty Stormwater Management Infrastructure Catchments Characteristics

Catchment	Catchment Area (km^2)	Stream Length (m)	Slope (m/m)	Time of Concentration (hrs)
Channel DC 01	0.02	0.26	0.00521	0.25
Channel DC02	0.01	0.12	0.02241	0.25
Berm DB 03	0.93	0.49	0.00274	0.25
Berm DB 04	1.64	0.49	0.00273	0.25

Table 4-5: Dirty Stormwater Management Infrastructure Peak Discharge Calculation Results

Channel Name	1:50 Year Average Rainfall Intensity (mm) (PI)	Catchment C Factor	1:50 Year Peak Discharge (m^3/s)
Channel DC 01	183.60	0.35	0.34
Channel DC02	183.60	0.35	0.16
Berm DB 01	183.60	0.35	13.62
Berm DB 02	183.60	0.35	24.02

Table 4-6: Proposed Dirty Stormwater Management Infrastructure Dimensions

Channel Name	Type	Top Width (m)	Bottom Width (m))	Height/ Depth (m)
Channel DC 01	Lined Trapezoidal	0.7	0.6	0.60
Channel DC 02	Lined Trapezoidal	0.7	0.6	0.60
Berm DB 01	Rock aggregate	Not Applicable		1.0
Berm DB 02	Rock aggregate			1.4

In addition, the proposed stormwater management recommendations for the contaminated stormwater runoff through hydrocarbons spills and general waste in order to prevent the contamination of the downstream water resources are as follows:

- The wash bay area should be bunded and installed with an oil separator to separate out hydrocarbons from water emanating from the washing of trucks and machinery;
- Diesel and fuel tanks on site should be bunded. If possible, diesel refilling station should be located in the wash bay area, so that any spillages during the vehicle refilling can be limited to within the wash bay area and get directed into the oil separator to separate out hydrocarbons before discharging to the environment;

- The workshop area should be roofed, therefore, to limit spillages/oil leaks that may occur while working on vehicles to not to mix with stormwater runoff and be limited to within the workshop area. All water emanating from the workshop floor during cleaning should be directed to the oil separator, to ensure hydrocarbons are separated before discharging to environment;
- At all times dip trays must be placed under the earth moving equipment's and trucks when parked or not in use. This will avoid hydrocarbon contamination of surface water resources, through oil leaks;
- Waste bins for disposing of general and industrial waste materials (i.e. metal, plastic and paper), should be provided and be placed at the strategic locations on site, in order to minimise scattering of waste around the site. Waste must be regularly removed from the site by the registered waste service provider and be disposed of to the appropriate waste handling facilities; and
- Effluent waste must be directed into a properly designed septic tanks and/or soak ways and be collect from site, when necessary, by the registered waste service provider and be disposed of to the registered waste handling facility.

4.2.1 Dams Capacity Assessments

As depicted in **Figure 4-1**, the tailings dam and pollution control dam were proposed for the site during the planning phase of the project. The size of the tailings dam and pollution control dam will be determined by the mine design engineers, after they have determined the waste volumes to be stored in these facilities.

4.3 Stormwater Management Infrastructure Maintenance

Stormwater infrastructure should be monitored and maintained in order to ensure that the system is fully functional in accordance with the design specifications. Regular maintenance is therefore required and should include the following:

- Assessments of the stormwater system at the start and end of the wet season and after any major storm events, so that any debris, sediment or excessive vegetation can be removed. This should include, but not be limited to the:
  - Clean and dirty stormwater channels;
  - Berms (for clean and clean stormwater infrastructure);
  - Oil traps; and
  - Bunded areas.

- Regular trimming and/or removal of vegetation within the stormwater channels and berms is recommended. All alien invasive plants should be removed;
- Regular removal of sediments from the channels. This maintenance will ensure the system functions at its designed capacity and that sediment loading is not increased in the receiving hydrological environment. All sediments removed should only be disposed off to the slurry dams;
- Monitoring of any root growth to ensure that vegetation does not cause any damage to the stormwater infrastructure;
- An annual assessment of the stormwater system to check for any structural defects or damage that may arise from normal use. Any identified damage must be repaired as soon as possible and
- It is the responsibility of the mine management to implement the stormwater management maintenance interventions.

5 CONCLUSION

The objective of this study was to develop a conceptual SWMP for the proposed Tiara (Pty) Ltd Granville Emerald and Quartz Operation Mine near the Phalaborwa town, in the Limpopo Province. This SWMP has been undertaken in compliance with the requirements of GN 704 of the NWA (Act No. 36 of 1998) and based on principles of the DWS, BPGs – G1 (2006), in conjunction with the DWS, BPGs – A5 and A6 (2008), to support the WULA process for the proposed Tiara Mine.

All stormwater infrastructure were sized based on the 1:50-year return period storm event. The Rational Method was used to determine the 1:50-year peak discharge values used in sizing of the various stormwater infrastructure.

As per principal one of the DWS, BGPs - G1, clean stormwater runoff must be kept clean and be routed to a natural watercourse by a system separate from the dirty water system, while preventing or minimising the risk of mixing clean and dirty stormwater runoff. Four lined clean stormwater diversion infrastructure (CB 01 to CB 04) within the mine infrastructure areas together with six lined clean stormwater diversion channels (CB 01 - CB 04, CB13 and CB 14) and eight diversion berms (PCB 05 to PCB 12) upstream of the pit areas, have been proposed for the Tiara Mine.

As per principle two of the DWS, BPGs - G1, which states that dirty water must be collected and contained in a system separate from the clean water system and the risk of spillage or seepage into the clean water systems must be minimised, the minimum required sizes of the stormwater infrastructure were calculated. Based on the assessment, Four dirty water diversion infrastructure are proposed to be constructed on the downstream boundaries of the dirty water catchment areas (i.e. Channels DC 01 and DC 01, together with Berms DB 01 and DB 02).

A number of recommendations were put forward in dealing with the hydrocarbon spills and leaks. These were mainly the installation of an oil separator in the wash bay to ensure hydrocarbons are separated before discharging to the environment, all diesel and fuel tanks are to be bunded and the workshop area must be roofed to limit spillages that may occur while working on vehicles to not to mix with stormwater runoff and be limited to within the workshop area. In addition, dip trays must be placed under the earth moving equipment's and trucks when parked or not in used, in order to avoid hydrocarbon contamination of surface water resources, through oil leaks. In addition, general and effluent waste management measures have been put forward, generally dealing with handling of waste on site and disposing of waste.

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Appendix 4 - Tiara Waste Classification

ENVIRONMENTAL & ENGINEERING

REPORT

ARCHEAN RESOURCES: TIARA GRANVILLE EMERALD AND QUARTZ MINING OPERATION

WASTE CLASSIFICATION AS PART OF THE EIA

REPORT REF: 20-1194-GEOH

2020/01/22

VERSION CC

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DD– draft				Client review
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Client			

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DECLARATION OF INDEPENDENCE

I, Elida Naude, declare that;

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing:
    - any decision to be taken with respect to the application by the competent authority; and
    - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

ENaude

2021/01/18

Signature **Date**

Mrs. Elida Naude

MSc Geohydrology (UFS)

Pr.Sci.Nat. (400286/14)

EXECUTIVE SUMMARY

BACKGROUND

Eco Elementum Geohydrology (Pty) Ltd was contracted by Archean Resources (Pty) Ltd to conduct a Waste Classification as part of the EIA for the proposed Tiara Granville Emerald and Quartz Mining Operation. The Tiara project is located on the remaining extent (R/E) and portion 12 of the farm BVB Ranch 776 LT, R/E of the farm Josephine 749 LT, Buffalo Ranch 834 LT, R/E of the farm Danie 789 LT, Granville 767 LT, portion 6 and R/E of the farm Farrel 781 LT as well as R/E of the farm Willie 787 LT, all located within the Magisterial District of Phalaborwa, Limpopo Province.

The Tiara project is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. The project falls within Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. The northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA.

The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)) using truck and shovel opencast mining method.

The operation will have following support infrastructure:

- Screening and crushing machine;
- Processing plant;
- Run of Mine (RoM) stockpiles;
- Mobile office complex;
- Process water reservoir/tank;
- Portable water tank (Jojo tanks);
- Ablution facility;
- Store house; and
- Workshop.

CONCLUSION / RECOMMENDATION

The following conclusions can be drawn from the findings of the waste classification of the samples at Tiara mining area:

- Four samples were collected on site from the Tiara mining area. The samples were taken as follow:
    - In-Pit 1.
    - In-Pit 2.
    - Pit 1 Overburden, and
    - Pit 2 Overburden.
- Oxide elements with major concentrations (>1%) in the four samples include:
    - Silica (Si).
    - Aluminium (Al).
    - Iron (Fe).
    - Titanium (Ti)- in Pit 2 Overburden.
    - Calcium (Ca) – in Pit 2 Overburden.
    - Magnesium (Mg).
    - Sodium (Na) and
    - Potassium (K).

- The XRD results confirm the domination of Quartz, Plagioclase and Biotite in most of the samples. In the Pit 2 Overburden sample Quartz, Chlorite and Hornblende dominates.
- According to Regulation 7(6) of GNR635 the samples at Tiara mining area, are all classified as a Type 3 waste. Type 3 waste may only be disposed of at a Class C landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998). It should however be considered that:
    - All four samples have a non-acid generating potential,
    - None of the samples have a leachate concentration exceeding the LCT0 limits,
    - Considering the results as summarized above, it may be motivated to the relevant Department to make use a Class D liner instead.

Tiara	GNR635	ARD Generation Potential	Landfill Liner Design
Pit/1/Overburden	Type 3	Non-acid generating potential	Class C
Pit/2/Overburden	Type 3	Non-acid generating potential	Class C
In-Pit/1	Type 3	Non-acid generating potential	Class C
In-Pit/2	Type 3	Non-acid generating potential	Class C

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List of Abbreviations

ABA-	Acid-base Accounting
ARD-	Acid Rock Drainage
EIA-	Environmental Impact Assessment
EMP-	Environmental Management Plan
Mg/l-	Milligrams per litre
Mg/kg-	Milligrams per kilogram
Meq/l –	Milliequivalent per litre
MAP-	Mean Annual Precipitation
mm-	Millimetre
mm/a-	Millimetres per annum
mS/m-	Millisiemens per metre
m^3-	Cubic metre
PCD-	Pollution Control Dam
PPM-	Parts Per Million

1. INTRODUCTION

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The Tiara project is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. The project falls within Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. The northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA.

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The operation will have following support infrastructure:

- Screening and crushing machine;
- Processing plant;
- Run of Mine (RoM) stockpiles;
- Mobile office complex;
- Process water reservoir/tank;
- Portable water tank (Jojo tanks);
- Ablution facility;
- Store house; and
- Workshop.

The location of the Tiara mining area is indicated in Figure 1 and the positions of the sampling point indicated in Figure 2.

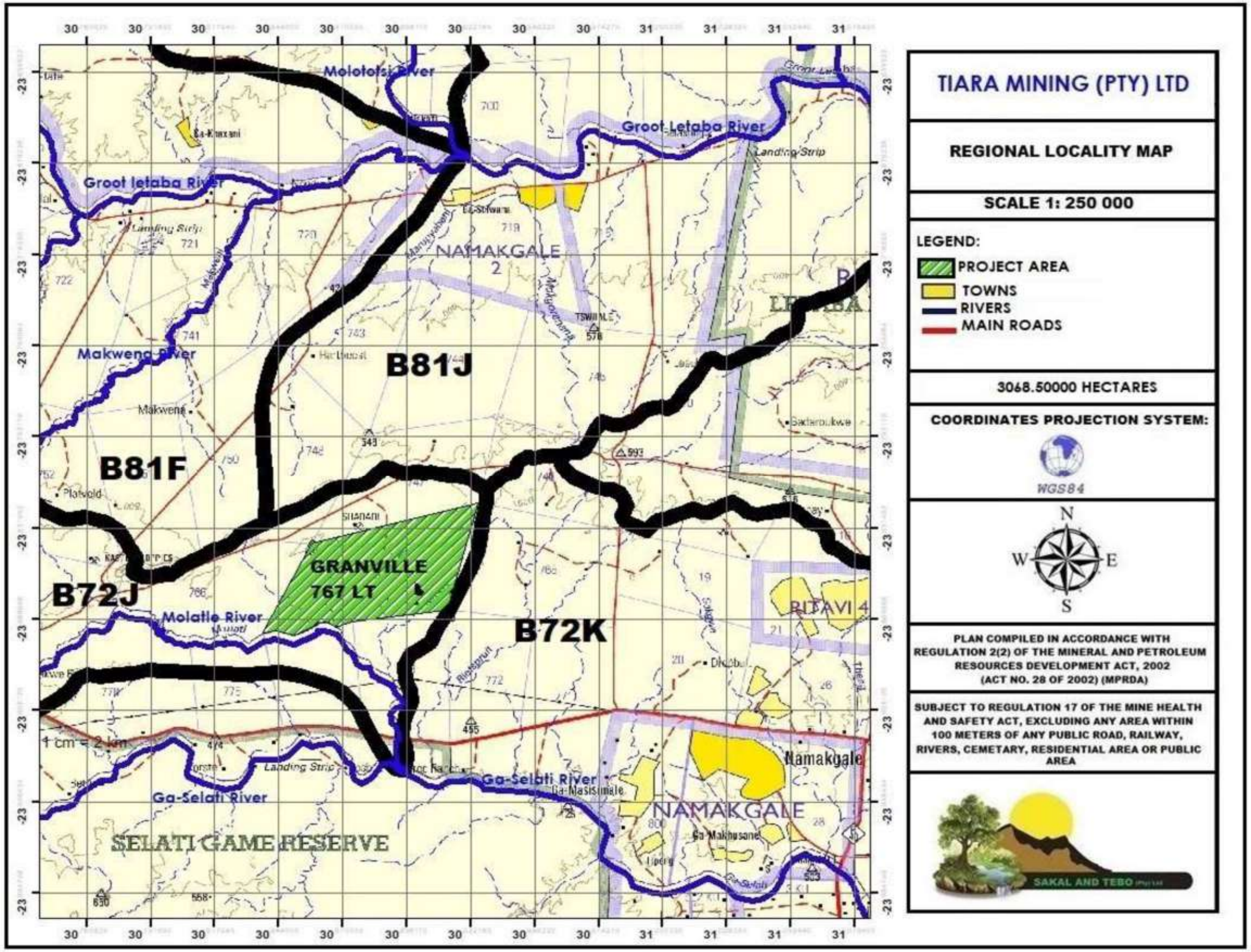

Figure 1: Tiara mining project, Phalaborwa, Limpopo, South Africa.

2. OBJECTIVES

Mining and mineral processing residues, such as overburden and waste rock, is governed under the National Environmental Management Waste Act (58 of 2008) (NEM:WA). In terms of waste classification, NEM:WA refers to three regulations. These are regulation 634 (GNR634), regulation 635 (GNR635) and regulation 636 (GNR636), promulgated under NEM:WA and published in Government Gazette No 36784 of 23 August 2013.

GNR634 (Waste Classification and Management Regulations) provides generic regulations for the classification and management of waste. GNR635 (National Norms and Standards for the Assessment of Waste for Landfill Disposal) provides regulations governing the waste material assessment methodology, while GNR636 (National Norms and Standards for Disposal of Waste to Landfill) provides regulations for selecting the appropriate barrier system subject to the results of the assessment under GNR635.

The objective of this material characterisation and classification study is to characterise the materials that will be generated in the Tiara mining processes from a waste perspective and to determine whether the nature and chemical properties of the materials require implementation of precautionary measures for the management thereof. The principles adopted for the classification, are taken from the National Norms and Standards for the Assessment of Waste for Landfill Disposal (GNR635).

3. METHODOLOGY

The main aim of this report is to discuss the main impacts of the mining in terms of waste at the Tiara mining area. This methodology will include discussions on:

- Collection of samples to be analysed;
- Submission of samples to laboratory: UIS Analytical Services is an ISO/IEC 17025 accredited laboratory.
- The following analyses were performed by UIS:
  1. Total Trace Elements- ICP-MS (ICP-MS,UV-Vis).
  2. Water Leaching- ICP-MS Perkin Elmer NexION 300D.
  3. Major & Minor Elements - ICP-OES, Leco Truspec.
  4. Acid-base Accounting- EPA 600 Modified Sobek.
  5. XRD (not requested but was supplied by the lab)- Diffractograms were obtained using a Malvern Panalytical Aeris diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert High score plus software. The relative phase amounts (weight %) were estimated using the Rietveld method.
- Interpretation of the analyses:
  - Mining and mineral processing residues, is governed under the National Environmental Management Waste Act (58 of 2008) (NEM:WA). In terms of waste classification, NEM:WA refers to three regulations. These are regulation 634 (GNR634), regulation 635 (GNR635) and regulation 636 (GNR636), promulgated under NEM:WA and published in Government Gazette No 36784 of 23 August 2013.
  - GNR634 (Waste Classification and Management Regulations): generic regulations for the classification and management of waste.
  - GNR635 (National Norms and Standards for the Assessment of Waste for Landfill Disposal): regulations governing the waste material assessment methodology,
  - GNR636 (National Norms and Standards for Disposal of Waste to Landfill): regulations for selecting the appropriate barrier system subject to the results of the assessment under GNR635.

4. WASTE CLASSIFICATION AND CHARACTERISTICS

Four samples were collected on site from the mining area bordering the proposed Tiara operations. The samples were taken from the two pits as well as the overburden adjacent to the two pits.

- In-Pit 1: Rock within the pit that will be mined for minerals and eventually waste rock stockpiling;
- In-Pit 2: Rock within the pit that will be mined for minerals and eventually waste rock stockpiling;
- Pit 1 Overburden, and
- Pit 2 Overburden.

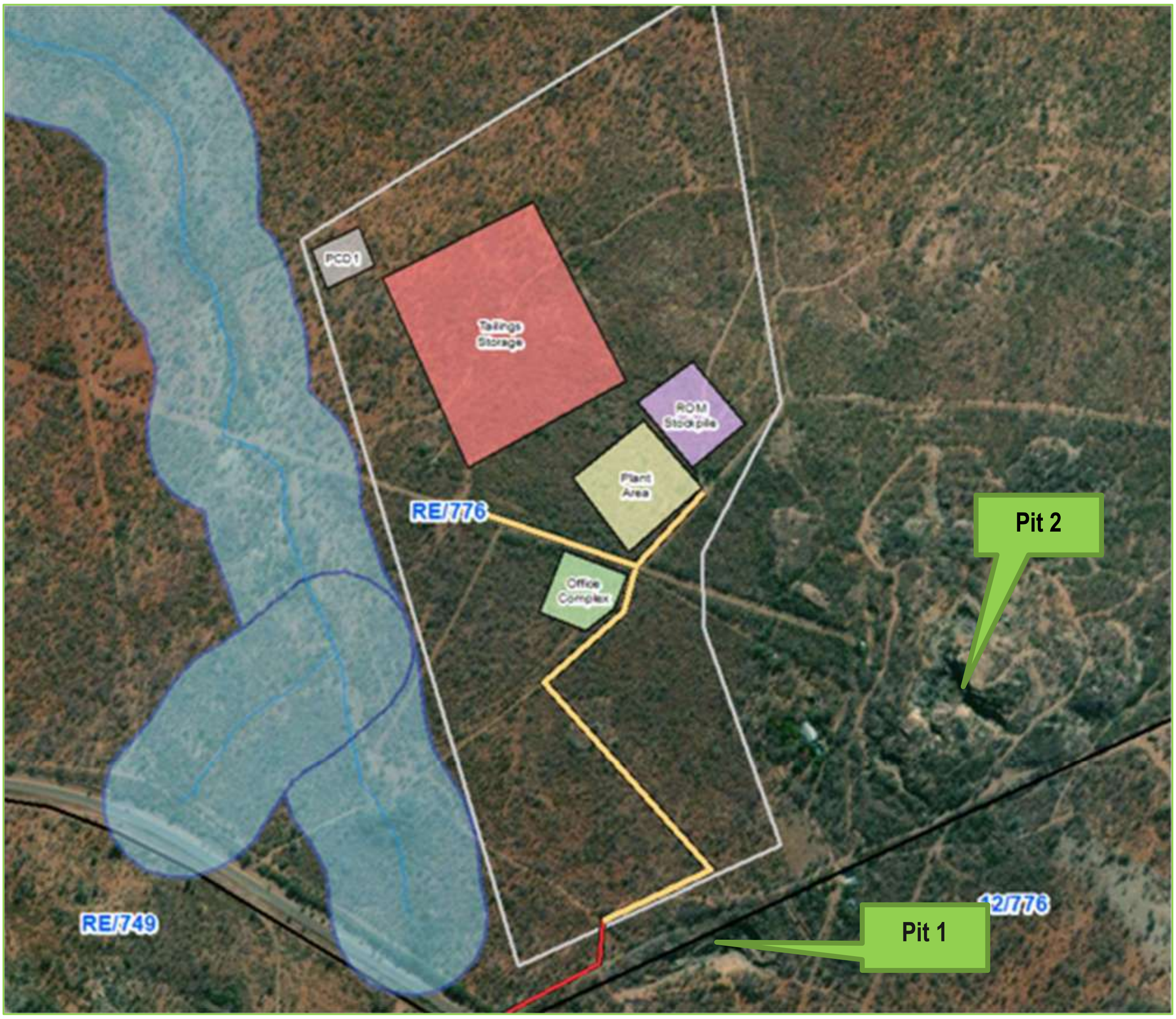

Figure 2: Pit 1 and Pit 2 from which rock and overburden samples were taken in relation to the proposed Tiara mining operations.

4.1 Major & Minor Elements & XRD Results

The major and minor elements were determined by ICP-OES & Leco Truspec method. The major and minor elements for the samples in the proposed Tiara mining area is indicated in Table 2. Oxide elements with major concentrations (>1%) include:

- Silica (Si);
- Aluminium (Al);
- Iron (Fe);
- Titanium (Ti)- in Pit 2 Overburden;

- Calcium (Ca) – in Pit 2 Overburden;
- Magnesium (Mg);
- Sodium (Na) and
- Potassium (K).

Loss on ignition is a method that consists of strongly heating a sample, containing organic carbon, at a specified temperature, allowing volatile substances to escape, until its mass ceases to change. LOI was recorded as low at less than 3%. This is also confirmed by the low C content in the samples.

The material was prepared for XRD analysis using a back loading preparation method. The XRD results for the Tiara samples are presented in Table 2. The results confirm the domination of Quartz, Plagioclase and Biotite in most of the samples. In the Pit 2 Overburden sample Quartz, Chlorite and Hornblende dominates.

Table 1: Major and minor elements for the Tiara samples.

		Pit/1/Overburden	Pit/2/Overburden	In-Pit/1	In-Pit/2
SiO2	%	77,1	52,5	58,9	48,7
Al2O3	%	9,75	10,7	11,7	12,0
Fe(tot)	%	2,44	7,82	5,90	4,22
Fe2O3	%	3,49	11,2	8,43	6,03
TiO2	%	0,161	1,26	0,385	0,14
CaO	%	0,530	5,62	0,275	0,809
MgO	%	2,39	11,8	10,6	21,2
Na2O	%	3,28	2,10	1,19	0,68
K2O	%	1,85	1,69	5,71	7,80
MnO	%	0,144	0,141	0,158	0,132
P	%	0,012	0,106	0,036	0,050
Ba	%	0,004	0,029	0,139	0,014
Cr	%	0,027	0,103	0,167	0,204
Cu	%	0,001	0,007	0,003	0,004
Ni	%	0,012	0,048	0,066	0,084
Sr	%	0,004	0,010	0,009	0,001
V	%	0,001	0,019	0,012	0,007
Zn	%	0,018	0,011	0,018	0,010
Moisture	%	-0,08	-0,20	-0,18	-0,12
LOI	%	0,81	2,83	1,79	1,68
C	%	0,028	0,014	0,008	0,074
S	%	0,002	0,011	0,003	0,009

Table 2: XRD results for the Tiara samples.

	Chemical Compound	Pit/1/Overburden	Pit/2/Overburden	In-Pit/1	In-Pit/2
Quartz [%]	SiO2	63,2	17,9	45,9	24,5
Plagioclase [%]	(Na,Ca)(Si,Al)4O8	29,5	6,8	15,2	9,8
Biotite	$K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$	7,3	9,9	38,9	65,7
Chlorite	$(Fe, Mg, Al)_6(Si, Al)_4O_{10}(OH)_8$	0	23	0	0
Hornblende	$(Ca,Na)_2(Mg,Fe,Al)_5(Al,Si)_8O_{22}(OH)_2$	0	32,6	0	0
Talce	$Mg_3Si_4O_{10}(OH)_2$	0	9,1	0	0
Lizardite	$Mg_3Si_2O_5(OH)_4$	0	0,7	0	0

4.2 Waste Assessment

4.2.1 Standard Assessment Methodology:

1. To assess waste for the purpose of disposal to landfill, the following are required-
    a. Identification of chemical substances present in the waste; and
    b. Sampling and analysis to determine the total concentrations (TC) and leachable concentrations (LC) of the elements and chemical substances that have been identified in the waste and that are specified in Table 4.
2. Within three years of the date of commencement of the Regulations, all analyses of the TC and LC of elements and chemical substances in waste must be conducted by laboratories accredited by South African National Accreditation System (SANAS) to conduct the particular techniques and analysis methods required.
3. The TC and LC limits of the chemical substances in the waste must be compared to the threshold specified in Table 4 for total concentrations (TCT limits) and leachable concentrations (LCT limits) of specific elements and chemical substances.
4. Based on the TC and LC limits of the elements and chemical substances in the waste exceeding the corresponding TCT and LCT limits respectively, the specific type of waste for disposal to landfill must be determined as follows:
    - Type 0 Waste: if concentrations above LCT3 or TCT2 limits (LC > LCT3 or TC > TCT2);
    - Type 1 Waste: if concentrations are above the LCT2 but below or equal to LCT3 limits, or above the TCT1 but below or equal to TCT2 limits (LCT2 < LC ≤ LCT3 or TCT1 < TC ≤ TCT2);
    - Type 2 Waste: if concentrations are above the LCT1 but below or equal to LCT2 and all concentrations below or equal to TCT1 limits (LCT1 < LC ≤ LCT2 and TC ≤ TCT1);
    - Type 3 Waste: if concentrations are above the LCT0 but below or equal to LCT1 and all TC concentrations below or equal to TCT1 limits (LCT0 < LC ≤ LCT1 and TC ≤ TCT1); and
    - Type 4 Waste: if all concentration levels for metal ions and inorganic anions below or equal to both LCT0 and TCT0 limits (LC ≤ LCT0 and TC ≤ TCT0) and with all chemical substance concentration levels also below the total concentration limits for organics and pesticides.

Table 3: The liner requirements/barrier design requirements, based on the type of waste, as detailed in GN R.636.

Type 0 Waste	The disposal of Type 0 waste to landfill is not allowed. The waste must be treated and re-assessed in terms of the *Standard for Assessment of Waste for Landfill Disposal.*
Type 1 Waste	Type 1 waste may only be disposed of at a Class A landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a Hh / HH landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).
Type 2 Waste	Type 2 waste may only be disposed of at a Class B landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).
Type 3 Waste	Type 3 waste may only be disposed of at a Class C landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).

Type 4 Waste	Disposal allowed at a landfill with a Class D landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB- landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).

4.2.2 Waste Classification Results

The TC and LC results for Tiara mining area are indicated in Table 4. Cells highlighted in green indicates concentrations exceeding TCT0 or LCT0, yellow cells indicate concentrations exceeding LCT1, orange cells indicate concentrations exceeding TCT1 and LCT2 and red cells indicate concentrations exceeding TCT2 and LCT3 threshold levels of the GNR635.

Several trace elements exceeded the TCT limits in the Tiara samples and based on the results the following apply:

- As: > TCT0 in Pit 2 Overburden= Type 3.
- Ba: > TCT0 in all samples except Pit 1 Overburden = Type 3.
- Co: > TCT0 in In-Pit1 and In-Pit2 = Type 3.
- Cu: > TCT0 in In-Pit2 and Pit 2 Overburden = Type 3.
- Mn & Ni: > TCT0 in all four samples = Type 3.

According to Regulation 7(6) of GNR635 the samples at Tiara mining area all four samples are classified as a Type 3 waste. Type 3 waste may only be disposed of at a Class C landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).

The leachate contamination emanating from the material sampled for the Tiara mining project remained below the LCT0 limit. The leachate contamination potential together with the absence of acid generating material makes the requirement of a Class C barrier for the overburden and waste rock stockpiling unnecessarily severe. It is therefore recommended that the relevant Department be approached with a request for relaxation of the required containment barrier to Class D.

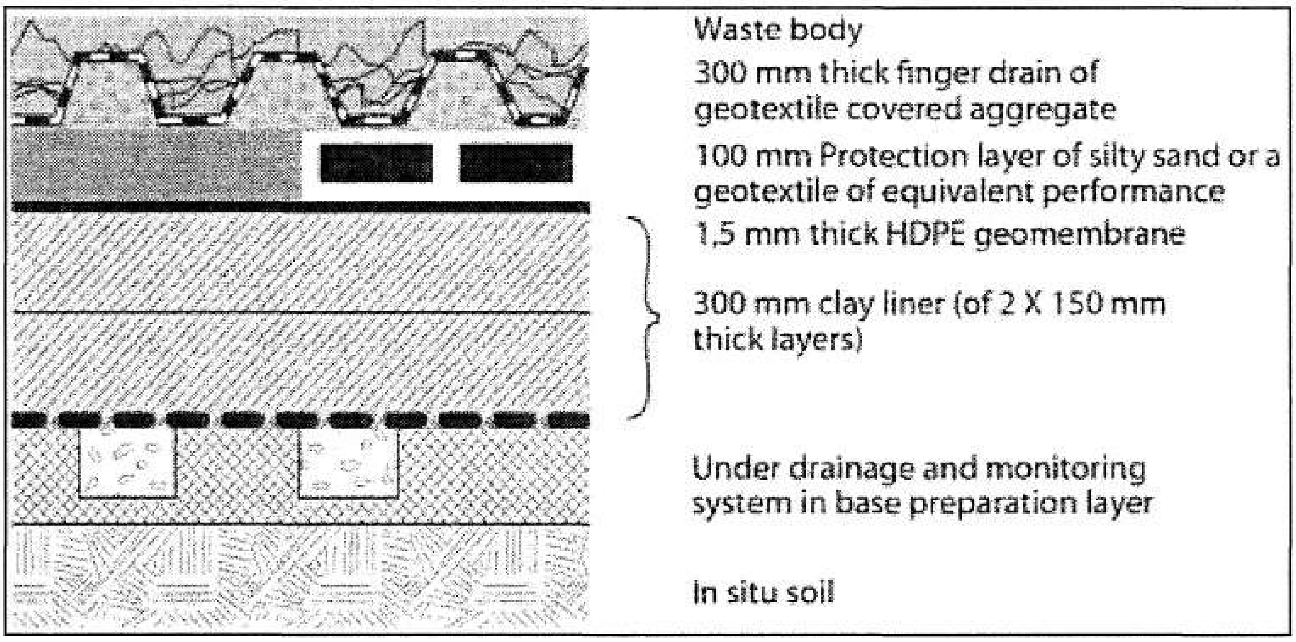

Figure 3: Class C containment liner design.

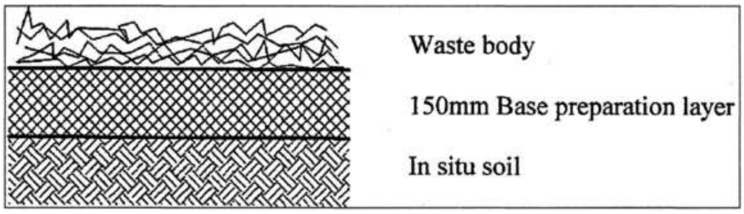

Figure 4: Class D containment barrier design.

Table 4: Total Concentrations (TC) and Leachate Concentration (LC) results for the samples at Tiara mining area.

Determinant		Pit/1/Overburden		Pit/2/Overburden		In-Pit/1		In-Pit/2		Threshold Levels (GNR 635)							Waste Type
		TC	LC	TC	LC	TC	LC	TC	LC	TCT0	TCT1	TCT2	LCT0	LCT1	LCT2	LCT3	
		$mg.kg^{-1}$	$mg.L^{-1}$	$mg.kg^{-1}$	$mg.L^{-1}$	$mg.kg^{-1}$	$mg.L^{-1}$	$mg.kg^{-1}$	$mg.L^{-1}$	$mg.kg^{-1}$			$mg.L^{-1}$				
Metal Ions	As, Arsenic	1,30	0,002	9,40	0,003	0,87	0,003	1,43	0,003	5.8	500	2 000	0.01	0.5	1	4	Type 3
	B, Boron	3,54	0,058	2,76	0,064	1,74	0,065	1,69	0,067	150	15 000	60 000	0.5	25	50	200	Type 4
	Ba, Barium	37,9	0,110	339	0,108	1162	0,086	120	0,079	62.5	6 250	25 000	0.7	35	70	280	Type 3
	Cd, Cadmium	0,06	<0.0001	0,18	<0.0001	0,05	<0.0001	0,05	<0.0001	7.5	260	1 040	0.003	0.15	0.3	1.2	Type 4
	Co, Cobalt	10,0	0,002	47,6	0,002	53,4	<0.001	56,0	0,001	50	5 000	20 000	0.5	25	50	200	Type 3
	Cr Total, Chromium Total	264	0,013	951	0,020	1550	0,018	1839	0,014	46 000	800 000	N/A	0.1	5	10	40	Type 4
	Cr(VI), Chromium (VI)	<5	<0.05	<5	<0.05	<5	<0.05	<5	<0.05	6.5	500	2 000	0.05	2.5	5	20	Type 4
	Cu, Copper	12,7	0,007	58,1	0,005	14,8	0,004	19,2	0,004	16	19 500	78 000	2	100	200	800	Type 3
	Hg, Mercury	0,02	<0.0001	0,02	<0.0001	<0.01	<0.0001	0,01	<0.0001	0.93	160	640	0.006	0.3	0.6	2.4	Type 4
	Mn, Manganese	1098	0,094	1073	0,029	1189	0,031	1067	0,019	1 000	25 000	100 000	0.5	25	50	200	Type 3
	Mo, Molybdenum	0,43	<0.001	0,87	<0.001	0,19	<0.001	0,09	<0.001	40	1 000	4 000	0.07	3.5	7	28	Type 4
	Ni, Nickel	122	0,006	442	0,017	595	0,008	784	0,009	91	10 600	42 400	0.07	3.5	7	28	Type 3
	Pb, Lead	19,3	0,006	6,98	<0.001	6,71	0,003	3,08	<0.001	20	1 900	7 600	0.01	0.5	1	4	Type 4
	Sb, Antimony	0,42	0,010	0,38	0,013	0,26	0,005	0,60	<0.001	10	75	300	0.02	1	2	8	Type 4
	Se, Selenium	0,01	<0.001	0,20	0,005	0,15	0,006	0,10	<0.001	10	50	200	0.01	0.5	1	4	Type 4
	V, Vanadium	12,1	0,002	143	0,011	88,3	0,011	59,9	0,005	150	2 680	10 720	0.2	10	20	80	Type 4
	Zn, Zinc	159	0,018	97,1	0,005	140	0,007	107	0,009	240	160 000	640 000	5	250	500	2 000	Type 4
Inorganic Ions	Total Dissolved Solids*		50,0		70,0		54,0		48,1	N/A	N/A	N/A	1 000	12 500	25 000	100 000	Type 4
	Fluoride as F		0,21		0,19		0,25		0,56	100	10 000	40 000	1.5	75	150	600	Type 4
	Chloride as Cl		0,62		0,88		1,00		0,64	N/A	N/A	N/A	300	15 000	30 000	120 000	Type 4
	Nitrate as N		<0.1		0,21		0,21		0,13	N/A	N/A	N/A	11	550	1 100	4 400	Type 4
	Sulphate as SO_4		10,7		11,3		11,0		10,9	N/A	N/A	N/A	250	12 500	25 000	100 000	Type 4

4.3 Acid-base Accounting

4.3.1 Acid-base Accounting Assessment Methodology

Guidelines from Price et al. (1997) in conjunction with Soregaroli and Lawrence (1997), Morin and Hutt (2007), MEND (2009) and De Wet (2012) were incorporated to assess the acid generating potential of the sampled material at the proposed Tiara mining operations.

Table 5: Guidelines from Price et al.(1997) & Soregaroli and Lawrence (1997).

Sulphide Sulphur	NPR (NP / AP)	ARD Potential	Comments
<0.3%	-	None	No further ARD testing required provided there are no other metal leaching concerns. Exceptions: host rock with no basic minerals, sulphide minerals that are weakly acid soluble.
>0.3%	<1	Likely	Likely to be Acid generating.
	1 - 2	Possibly	Possibly ARD generating if NP is insufficiently reactive or is depleted at a rate faster than that of sulphides.
	2 – 4	Low	Not potentially ARD generating unless significant preferential exposure of sulphides occur along fractures or extremely reactive sulphides are present together with insufficiently reactive NP.
	>4	None	No further ARD testing required unless materials are to be used as a source of alkalinity.

Table 6: Guidelines from Morin and Hutt (2007) and MEND (2009).

Paste pH	NPR	Potential for ARD	Comments
<6	<1	Acid Generating (AG)	Net acid generating, and already acidic.
>6	1 ≤ NPR ≤ 2	Potentially acid generating (PAG)	Potentially acid generating unless sulphide minerals is non-reactive. Thus, samples are net acid generating, but not yet acidic.
<6 and >6		Uncertain	Possibly acid generating if NP is insufficiently reactive or is depleted at a rate faster than sulphides.

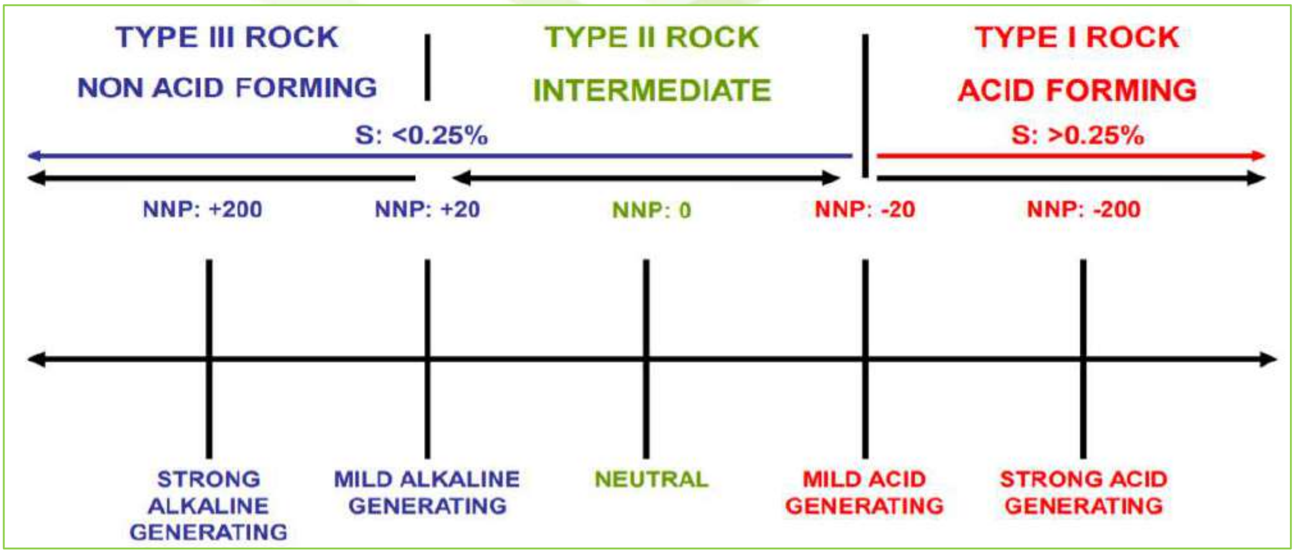

Figure 5: Rock Type Classification (De Wet, 2012).

4.3.2 Acid-base Accounting Results

ABA tests were conducted for the Tiara mining area. Four samples were subjected to ABA analyses. The analysis was conducted by UIS lab in Pretoria.

According to the results of the ABA tests, the Tiara samples are Type III rock type and therefore does not have an acid generating potential (NPR >4 and S<0.25%).

Table 7: ABA results for Tiara.

Method : EPA 600 Modified Sobek	Unit	Pit/1/Overburden	Pit/2/Overburden	In-Pit/1	In-Pit/2
Paste pH		9,14	9,00	9,29	8,95
Total Sulphur	%	<0.003	0,011	<0.003	0,009
Acid Potential (AP)	kg $CaCO_3$/t	0,00	0,34	0,00	0,29
Neutralization Potential (NP)	kg $CaCO_3$/t	6,03	14,63	12,08	10,27
Nett Neutralization Potential (NNP)	kg $CaCO_3$/t	6,03	14,3	12,1	10,0
Neutralising Potential Ratio (NPR) (NP: AP)	NP:AP	0,00	43,3	0,00	35,1
Total Carbon	%	0,028	0,014	0,008	0,074
Rock Type		Type III	Type III	Type III	Type III

4.4 Tiara Assessment Summary

A summary of the Tiara sample assessment results is provided in Table 8.

Table 8: Samples from Tiara assessment summary.

Tiara	GNR635	ARD Generation Potential	Landfill Liner Design
Pit/1/Overburden	Type 3	Non-acid generating potential	Class C
Pit/2/Overburden	Type 3	Non-acid generating potential	Class C
In-Pit/1	Type 3	Non-acid generating potential	Class C
In-Pit/2	Type 3	Non-acid generating potential	Class C

- All four samples are Type 3 wastes which requires a Class C lining.
- All four samples have a non-acid generating potential.
- None of the samples have a leachate concentration exceeding the LCT0 limits.
- Considering the results as summarized above, it may be motivated to the relevant Department to make use a Class D liner instead.

5. CONCLUSIONS & RECOMMENDATIONS

The following conclusions can be drawn from the findings of the waste classification of the samples at Tiara mining area:

- Four samples were collected on site from the Tiara mining area. The samples were taken as follow:
    - In-Pit 1;
    - In-Pit 2;
    - Pit 1 Overburden, and
    - Pit 2 Overburden.
- Oxide elements with major concentrations (>1%) in the four samples include:
    - Silica (Si);
    - Aluminium (Al);
    - Iron (Fe);
    - Titanium (Ti)- in Pit 2 Overburden;
    - Calcium (Ca) – in Pit 2 Overburden;
    - Magnesium (Mg);
    - Sodium (Na) and
    - Potassium (K).
- The XRD results confirm the domination of Quartz, Plagioclase and Biotite in most of the samples. In the Pit 2 Overburden sample Quartz, Chlorite and Hornblende dominates.
- According to Regulation 7(6) of GNR635 the samples at Tiara mining area, are all classified as a Type 3 waste. Type 3 waste may only be disposed of at a Class C landfill designed in accordance with Section 3(1) and 3(2), or, subject to Section 3(4), may be disposed of at a landfill site designed and operated in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd Ed., DWAF, 1998).
- It should however be considered that:
    - All four samples have a non-acid generating potential,
    - None of the samples have a leachate concentration exceeding the LCT0 limits,
    - Considering the results as summarized above, it may be motivated to the relevant Department to make use a Class D liner instead.

6. REFERENCES

- De Wet, L. 2012. ***Acid Base Accounting of Mining Ore and Waste***. Waterlab
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- Morin, K. and Hutt, N. 2007. ***Morrison Project - Prediction of Metal Leaching and Acid Rock Drainage, Phase 1***. Mine site Drainage Assessment Group, 588p.
- Price W.A., Morin K., Hutt N. 1997. ***Guidelines for prediction of acid rock drainage and metal leaching for mines in British Columbia: Part II. Recommended procedures for static and kinetic tests***. *In: Proceedings of the Fourth International Conference on Acid Rock Drainage*. Vancouver, B.C. Canada, 1, pp15–30.
- SANS 10234:2019, Edition 2. SOUTH AFRICAN NATIONAL STANDARD. ***Globally Harmonized System of classification and labelling of chemicals (GHS).***
- Soregaroli, B.A.; Lawrence, R.W. 1997. *Waste Rock Characterization at Dublin Gulch: A Case study.* ***Proceedings of the 4th International Conference on Acid Rock Drainage***, *Vancouver, BC, p 631-645*.

7. LABORATORY RESULTS

ANALYTICAL REPORT: Acid / Base Accounting (ABA)

To:	Eco Elementum	Date of Request: 23/12/2018	UIS Analytical Services
Attention:	Elida Naude		Analytical Chemistry Laboratories 4, 6
Tel:	076 913 1244		
E-mail:	chrisf@ecoe.co.za vernon@ecoe.co.za		Fax: (012) 665 4294

Certificate of analysis: 34656

Note: No unauthorised copies may be made of this report.

Lims ID	Sample ID	Paste pH	Total Sulphur	Acid Potential (AP)	Neutralization Potential (NP)	Nett Neutralization Potential (NNP)	Neutralising Potential Ratio (NPR) (NP : AP)	Total Carbon
			%	kg CaCO3/t	kg CaCO3/t	kg CaCO3/t	NP:AP	%
750941	Pit/1/Overburden	9.14	<0.003	0.00	6.03	6.03	0.00	0.028
750942	Pit/2/Overburden	9.00	0.011	0.34	14.63	14.3	43.3	0.014
750943	In-Pit/1	9.29	<0.003	0.00	12.08	12.1	0.00	0.008
750944	In-Pit/2	8.95	0.009	0.29	10.27	10.0	35.1	0.074
750941 QC	Duplicate	9.13	<0.003	0.00	6.01	6.01	0.00	0.026

Note: Negative NP values are obtained when the volume of NaOH(0.1N) titrated (pH:8.3) is greater than the volume of HCl(1N) to reduce the pH of the sample to 2.0-2.5. Any negative NP values are corrected to 0.00

		Chemical elements:	ABA
		Instrument:	Methohm Titrino, LECO CS 230
		Method	EPA 600 Modified Sobek
Date:	27.11.2020	Date:	15.12.2020
Analysed by:	L van der Walt	Authorised :	J Oberholzer

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Updated- 22/1/2021

ANALYTICAL REPORT: Major and Minor Elements

To:	**Eco Elementum Geohydrology**	Date requested: 24.10.2020	UIS Analytical Services
Attention:	**Elida Naude**		Analytical Chemistry
Project ID:			Laboratories 4, 6
Site Location:			Tel: (012) 665 4291
Order No:			Fax: (012) 665 4294

Certificate of analysis: 34656

Note: all results in percentage (%) unless specified otherwise

LIMS ID	SAMPLE ID	SiO2	Al2O3	Fe(tot)	Fe2O3	TiO2	CaO	MgO	Na2O	K2O	MnO
		%	%	%	%	%	%	%	%	%	%
750941	Pit/1/Overburden	77.1	9.75	2.44	3.49	0.161	0.530	2.39	3.28	1.85	0.144
750942	Pit/2/Overburden	52.5	10.7	7.82	11.2	1.26	5.62	11.8	2.10	1.69	0.141
750943	In-Pit/1	58.9	11.7	5.90	8.43	0.385	0.275	10.6	1.19	5.71	0.158
750944	In-Pit/2	48.7	12.0	4.22	6.03	0.14	0.809	21.2	0.68	7.80	0.132
750941 QC	Duplicate	76.9	9.57	2.44	3.48	0.157	0.503	2.33	3.57	1.98	0.144

LIMS ID	SAMPLE ID	P	Ba	Cr	Cu	Ni	Sr	V	Zn	Moisture	LOI	C	S
		%	%	%	%	%	%	%	%	%	%	%	%
750941	Pit/1/Overburden	0.012	0.004	0.027	0.001	0.012	0.004	0.001	0.018	-0.08	0.81	0.028	0.002
750942	Pit/2/Overburden	0.106	0.029	0.103	0.007	0.048	0.010	0.019	0.011	-0.20	2.83	0.014	0.011
750943	In-Pit/1	0.036	0.139	0.167	0.003	0.066	0.009	0.012	0.018	-0.18	1.79	0.008	0.003
750944	In-Pit/2	0.050	0.014	0.204	0.004	0.084	0.001	0.007	0.010	-0.12	1.68	0.074	0.009
750941 QC	Duplicate	0.011	0.004	0.029	0.001	0.014	0.004	0.002	0.016	-0.16	0.98	0.026	0.004

		Chemical elements:	Si,Al,Fe,Ti,Ca,Mg,Na,K,Mn,P,Ba,Cr,Cu,Ni,Sr,V,Zn
		Instrument:	ICP-OES, Leco Truspec
		Method	Major elements in soil/ore by ICP-OES,
Date	29.11.2020	Date:	15.12.2020
Analysed by:	MA Motsepe	Authorised :	JJ Oberholzer

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ECO ELEMENTUM ENVIRONMENTAL & ENGINEERING

ANALYTICAL REPORT: Total Trace elements

No unauthorised copies may be made of this report.

UIS analytical services

To:	Eco Elementum Geohydrology	Date of Request : 24.10.2020	UIS Analytical Services
Attention:	Elida Naude		Analytical Chemistry
Project ID:			Laboratories 4, 6
Site Location:			Tel: (012) 665 4291
Order No:			Fax: (012) 665 4294

Certificate of analysis: 34656

Note: all results in parts per million (mg/kg) unless specified otherwise

Lims ID	Sample ID	Ag	As	B	Ba	Be	Bi	Cd	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	Hg	Ho	La	Li	Mn	Mo
	Total trace elements	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
750941	Pit/1/Overburden	0.05	1.30	3.54	37.9	4.93	0.25	0.06	11.8	10.0	264	57.4	12.7	30.3	1.18	2.10	0.02	0.26	4.51	179	1098	0.43
750942	Pit/2/Overburden	0.11	9.40	2.76	339	24.3	1.74	0.18	92.7	47.6	951	126	58.1	11.9	2.10	6.44	0.02	1.85	68.0	56.3	1073	0.87
750943	In-Pit/1	0.06	0.87	1.74	1162	16.6	1.15	0.05	29.6	53.4	1550	267	14.8	14.3	1.83	3.06	<0.01	0.44	21.1	320	1189	0.19
750944	In-Pit/2	0.02	1.43	1.69	120	48.0	0.48	0.05	6.06	56.0	1839	523	19.2	11.6	3.00	0.52	0.01	0.26	3.94	598	1067	0.09
750941 QC	Duplicate	0.05	1.38	3.49	38.0	4.93	0.25	0.06	11.6	10.1	275	57.8	12.6	30.7	1.18	2.08	0.02	0.27	4.53	179	1091	0.44

Lims ID	Sample ID	Nb	Nd	Ni	Pb	Rb	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Tl	U	V	W	Y	Zn	Zr	Cr6+
	Total trace elements	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
750941	Pit/1/Overburden	37.5	3.81	122	19.3	206	0.42	4.19	0.01	6.46	22.2	4.24	0.07	3.23	3.23	2.07	12.1	0.66	4.69	159	27.7	<5
750942	Pit/2/Overburden	11.2	50.1	442	6.98	117	0.38	12.5	0.20	2.06	84.0	1.29	0.04	2.50	0.99	0.69	143	0.42	33.0	97.1	119	<5
750943	In-Pit/1	8.10	14.3	595	6.71	550	0.26	6.06	0.15	3.50	57.4	2.21	0.08	2.96	5.81	0.55	88.3	0.83	7.84	140	49.6	<5
750944	In-Pit/2	16.7	3.36	784	3.08	901	0.60	5.42	0.10	2.49	15.3	4.67	0.19	0.29	7.22	0.11	59.9	0.20	4.53	107	7.76	<5
750941 QC	Duplicate	37.3	3.85	123	19.3	206	0.42	4.32	0.01	6.47	22.5	4.23	0.07	3.31	3.26	2.10	12.1	0.66	4.83	161	27.7	<5

Chemical elements:	Ag, , As, Au, B, Ba, Be, Bi, Cd, Ce, Co, Cr, Cs, Cu, Ga, Ge, Hf, Hg, Ho, Ir, La, Li, Mn, Mo, Nb, Nd, Ni, Pb, Pt, Rb, Sb, Sc, Se, Sn, Sr, Ta, Te, Th, Tl, U, V, W, Y, Zn, Zr,Cr6+
Instrument:	ICP-MS,UV-Vis
Method	Trace Elements in soil/ore by ICP-MS

Date:	29.11.2020	Date:	15.12.2020
Analysed by:	MA Motsepe	Authorised :	JJ Oberholzer

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ECO ELEMENTUM ENVIRONMENTAL & ENGINEERING

ANALYTICAL REPORT: Water Leach

No unauthorised copies may be made of this report

UIS analytical services

To:	Eco Elementum Geohydrology
Attention:	Elida Naude
Project ID:	
Site Location:	
Order No:	n/a

Date of Request :24.10.2020

UIS Analytical Services
Analytical Chemistry
Laboratories 4, 6
Fax (012) 665 4294

Certificate of analysis: 34656

Note: all results in parts per million (ppm) unless specified otherwise

Lims ID	Sample ID	Ag	Al	As	Au	B	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs
	WATER LEACH 1:20	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	<0.001	0.021	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.06	<0.0001	<0.001	<0.001	<0.001	<0.001
750945	Pit/1/Overburden/Water/Leach	<0.001	1.83	0.002	<0.001	0.058	0.110	<0.001	<0.001	1.40	<0.0001	0.003	0.002	0.013	0.002
750945 QC	Duplicate	<0.001	1.80	0.002	<0.001	0.063	0.108	<0.001	<0.001	1.43	<0.0001	0.002	0.002	0.012	0.002
750946	Pit/2/Overburden/Water/Leach	<0.001	1.31	0.003	<0.001	0.064	0.108	0.001	<0.001	1.47	<0.0001	<0.001	0.002	0.020	0.005
750947	In-Pit/1/Water/Leach	<0.001	2.05	0.003	<0.001	0.065	0.086	<0.001	<0.001	0.56	<0.0001	0.004	<0.001	0.018	0.002
750948	In-Pit/2/Water/Leach	<0.001	0.938	0.003	<0.001	0.067	0.079	<0.001	<0.001	1.11	<0.0001	<0.001	0.001	0.014	0.002

Lims ID	Sample ID	Cu	Fe	Ga	Ge	Hf	Hg	Ho	Ir	K	La	Li	Mg	Mn	Mo	Na	Nb
	WATER LEACH 1:20	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	<0.001	0.03	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	0.02	<0.001	<0.001	0.033	0.006	<0.001	0.25	<0.001
750945	Pit/1/Overburden/Water/Leach	0.007	1.61	0.002	<0.001	<0.001	<0.0001	<0.001	<0.001	2.70	<0.001	0.010	1.43	0.094	<0.001	4.60	<0.001
750945 QC	Duplicate	0.007	1.61	0.002	<0.001	<0.001	<0.0001	<0.001	<0.001	2.69	<0.001	0.009	1.43	0.095	<0.001	4.55	<0.001
750946	Pit/2/Overburden/Water/Leach	0.005	3.04	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	2.42	<0.001	0.007	2.78	0.029	<0.001	4.70	<0.001
750947	In-Pit/1/Water/Leach	0.004	1.70	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	1.87	0.002	0.013	1.72	0.031	<0.001	6.94	<0.001
750948	In-Pit/2/Water/Leach	0.004	0.84	<0.001	<0.001	<0.001	<0.0001	<0.001	<0.001	2.63	<0.001	0.020	2.11	0.019	<0.001	4.07	<0.001

Lims ID	Sample ID	pH	pH Temp	TDS	EC	TDS by Sum	TDS by EC	P Alk.	M Alk.	F	Cl	NO2	NO3	NO3 as N	PO4
	WATER LEACH 1:20		Deg C	mg/l	mS/m	mg/l	mg/l	mg/l CaCO3	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	6.04	22.5	<30	1.37	n/a	9.6	<0.6	<3.5	<0.1	<0.25	<0.2	<0.3	<0.1	<0.8
750945	Pit/1/Overburden/Water/Leach	7.29	23.3	50.0	3.36	43.5	23.5	<0.6	9.70	0.21	0.62	<0.2	<0.3	<0.1	<0.8
750945 QC	Duplicate	7.34	23.5	50.0	3.33	43.4	23.3	<0.6	9.90	0.21	0.62	<0.2	<0.3	<0.1	<0.8
750946	Pit/2/Overburden/Water/Leach	8.72	23.5	70.0	3.31	54.9	23.2	<0.6	10.1	0.19	0.88	1.26	0.94	0.21	<0.8
750947	In-Pit/1/Water/Leach	8.51	23.7	54.0	3.26	48.6	22.8	<0.6	10.5	0.25	1.00	1.15	0.95	0.21	<0.8
750948	In-Pit/2/Water/Leach	8.01	23.9	48.1	2.73	41.1	19.1	<0.6	7.00	0.56	0.64	<0.2	0.57	0.13	<0.8

Lims ID	Sample ID	SO4	Sum of Cations	Sum of Anions	Ion Balance	NH4	NH3	Acidity to pH8.3	CN (free)	CN (Total)	Cr 6+	TSS	TOC
	WATER LEACH 1:20	mg/l	me/l	me/l	%	mg/l	mg/l	mg/l CaCO3	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	<0.3	n/a	n/a	n/a						<0.05		
750945	Pit/1/Overburden/Water/Leach	10.7	0.7	0.73	-0.17						<0.05		
750945 QC	Duplicate	10.7	0.7	0.73	-0.50						<0.05		
750946	Pit/2/Overburden/Water/Leach	11.3	0.8	0.96	-7.0						<0.05		
750947	In-Pit/1/Water/Leach	11.0	0.82	0.82	-0.22						<0.05		
750948	In-Pit/2/Water/Leach	10.9	0.62	0.72	-7.95						<0.05		

Chemical elements: Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Fe, Ga, Ge, Hf, Hg, Ho, Ir, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, Pb, Pt, Rb, Sb, Sc, Se, Si, Sn, Sr, Ta, Te, Th, Ti, Tl, U, V, W, Y, Zn, Zr — Anions, pH, NH4, Alkalinity, CN, Cr6+

Instrument: ICP-MS Perkin Elmer NexION 300D — Ion Chromatography — Spectrophotometer — Ion Selective Probe

Date:	02.12.2020	Date:	16.12.2020
Analysed by:	UIS Waterlab/MA Motsepe	Authorised:	JJ Oberholzer

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UIS analytical services

To:	Eco Elementum Geohydrology
Attention:	Elida Naude
Project ID:	
Site Location:	
Order No:	n/a

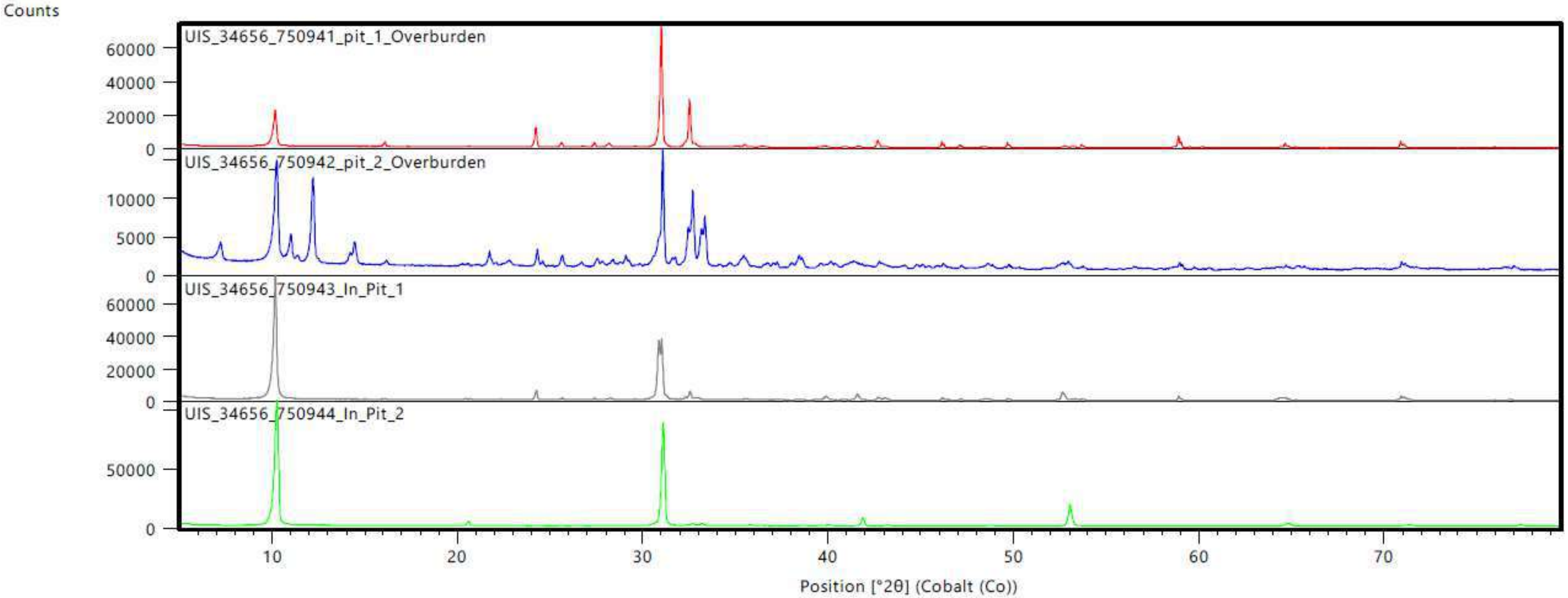
Lims ID	Sample ID	Nd	Ni	Pb	Pt	Rb	Sb	Sc	Se	Si	Sn	Sr
	WATER LEACH 1:20	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
750945	Pit/1/Overburden/Water/Leach	0.001	0.006	0.006	<0.001	0.015	0.010	<0.001	<0.001	4.470	<0.001	0.017
750945 QC	Duplicate	<0.001	0.005	0.006	<0.001	0.017	0.010	<0.001	<0.001	4.414	0.001	0.011
750946	Pit/2/Overburden/Water/Leach	<0.001	0.017	<0.001	<0.001	0.006	0.013	<0.001	0.005	6.697	<0.001	0.009
750947	In-Pit/1/Water/Leach	0.002	0.008	0.003	<0.001	0.009	0.005	<0.001	0.006	4.690	<0.001	0.005
750948	In-Pit/2/Water/Leach	<0.001	0.009	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	4.554	<0.001	0.008

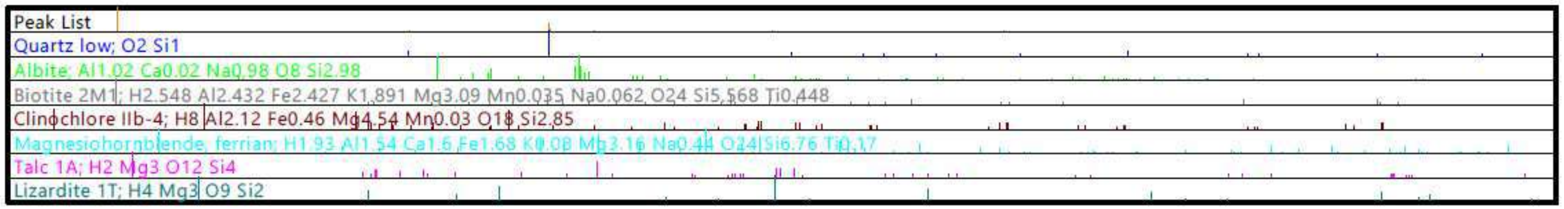
Lims ID	Sample ID	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
	WATER LEACH 1:20	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	Leach Blank	<0.001	<0.001	<0.0001	<0.001	<0.001	<0.0001	0.001	<0.001	<0.001	0.001	<0.001
750945	Pit/1/Overburden/Water/Leach	<0.001	<0.001	0.0005	0.040	<0.001	0.0004	0.002	<0.001	0.001	0.018	<0.001
750945 QC	Duplicate	<0.001	<0.001	0.0004	0.040	<0.001	0.0004	0.003	<0.001	<0.001	0.019	<0.001
750946	Pit/2/Overburden/Water/Leach	<0.001	<0.001	<0.0001	0.053	<0.001	<0.0001	0.011	<0.001	<0.001	0.005	<0.001
750947	In-Pit/1/Water/Leach	<0.001	<0.001	0.0002	0.025	<0.001	<0.0001	0.011	<0.001	<0.001	0.007	<0.001
750948	In-Pit/2/Water/Leach	<0.001	<0.001	<0.0001	0.006	<0.001	<0.0001	0.005	<0.001	<0.001	0.009	<0.001

Updated- 22/1/2021

	Quartz	Plagioclase	Biotite	Chlorite	Hornblende	Talce	Lizarditee
UIS_34656_750941_pit_1_Overburden	63.2	29.5	7.3	0	0	0	0
UIS_34656_750942_pit_2_Overburden	17.9	6.8	9.9	23	32.6	9.1	0.7
UIS_34656_750943_In_Pit_1	45.9	15.2	38.9	0	0	0	0
UIS_34656_750944_In_Pit_2	24.5	9.8	65.7	0	0	0	0

0 = n.d. – not detected above the detection limit of 0.5-3 weight per cent





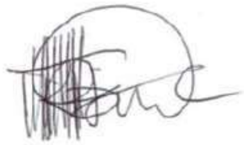
Appendix 5 -Tiara Geohydrological Report

GEOHYDROLOGICAL INVESTIGATION AND NUMERICAL CONCEPTUAL MODEL FOR THE PROPOSED TIARA GRANVILLE EMERALD AND QUARTZ MINING OPERATION, MAGISTERIAL DISTRICT OF PHALABORWA, LIMPOPO PROVINCE

TIARA MINING

J7 Royal Group
Water & Environmental Engineering Consultants

APPROVALS

J7 ROYAL GROUP (PTY) LTD	
 **Mr. Mandla Masango** Hydrologist	Date: **30 November 2020**
 **Mr. Joubert Bulasigobo** Hydrogeologist	Date: **30 November 2020**

PROJECT INFORMATION

REPORT DETAILS

Report Name:	**Geohydrological Investigation and Numerical Conceptual Model for Tiara Granville Emerald and Quartz Mine, Phalaborwa Magisterial District, Limpopo Province**
Report Number:	HWM/2011-04
Project Number:	HWR/2011-04/GHMR
Date:	25th November 2020
Report Status:	**Draft Report**

APPLICANT (PROPONENT)

Company Name:	**TIARA MINING (PTY) LIMITED**
Registration Number:	1988/001160/07
Contact Person:	Mr. Robert Michael Scholtz
Designation:	Managing Director
Tel:	(+27) 44 533 6403/ (+27) 082 449 6383
Email:	mike@tiaramining.com
Postal Address:	P. O. Box 314, Plettenberg, 6600

CONSULTANT

Company Name:	**J7 ROYAL GROUP (WATER & ENVIRONMENTAL)**
Contact Person:	Mr. Joubert Bulasigobo
Designation:	Hydrogeologist
Tel:	(+27) 011-312 0294
Email:	Joubert@j7royalgroup.co.za
Physical Address:	Birchwood Court, 43 Montrose Street, Vorna Valley, Midrand

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LIST OF ABBREVIATIONS

ABA	Acid Base Accounting
AP	Acid Potential;
BPEO	Best Practicable Environmental Option
CDT	Constant Discharge Test
CMB	Chloride Mass Balance
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
EC	Electrical Conductivity
EMPR	Environmental Management Programme Report
EWR	Environmental water requirements
GRDM	Groundwater Resource Directed Measures
I&AP	Interested and Affected Party
IGS	Institute for Groundwater Studies
LCT	Leachable Concentration Threshold
MAMSL	Meter Above Mean Sea Level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MBGL	Meter Below Ground Level
NAG	Net- Acid Generation
NGA	National Groundwater Archive

NEMA	National Environmental Management Act, 1998
NNP	Net neutralising potential
NP	Neutralisation Potential
NPR	Neutralising Potential Ratio
NWA	National Water Act, 1998
PSC	Present Status Category
PSP	Professional Service Provider
RT	Recovery Test
ROM	Run of Mine
SDT	Step Drawdown Test
SPLP	Synthetic Precipitation Leaching Procedure
TCT	Total Concentration Threshold
TDS	Total Dissolved Solids
TWQR	Target Water Quality Range
WARMS	Water Authorisation and Registration Management System
WMA	Water Management Area
WR2012	Water Resources of South Africa 2012
WRPM	Water Resources Planning Model
WULA	Water Use Licence Application
WUL	Water Use Licence
XRD	X-ray Diffraction

XRF	X-ray Florescence

GLOSSARY OF TERMS

Advection is the process by which solutes are transported by the bulk motion of the flowing groundwater.

Anisotropic is an indication of some physical property varying with direction.

Cone of depression is a depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a borehole from which water is being withdrawn. It defines the area of influence of a borehole.

A **confined aquifer** is a formation in which the groundwater is isolated from the atmosphere at the point of discharge by impermeable geologic formations; confined groundwater is generally subject to pressure greater than atmospheric.

The **Darcy flux** is the flow rate per unit area (m/d) in the aquifer and is controlled by the hydraulic conductivity and the piezometric gradient.

Dispersion is the measure of spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.

Drawdown is the distance between the static water level and the surface of the cone of depression.

Effective porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices that are connected.

Groundwater table is the surface between the zone of saturation and the zone of aeration; the surface of an unconfined aquifer.

A **fault** is a fracture or a zone of fractures along which there has been displacement.

Hydrodynamic dispersion comprises of processes namely mechanical dispersion and molecular diffusion.

Hydraulic conductivity (**K**) is the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the area [L/T]. Hydraulic conductivity is a function of the permeability and the fluid's density and viscosity.

Hydraulic gradient is the rate of change in the total head per unit distance of flow in a given direction.

Heterogeneous indicates non-uniformity in a structure.

Karstic topography is a type of topography that is formed on limestone, gypsum, and other rocks by dissolution, and is characterised by sinkholes, caves and underground drainage.

Mechanical dispersion is the process whereby the initially close group of pollutants are spread in a longitudinal as well as a transverse direction because of velocity distributions.

Molecular diffusion is the dispersion of a chemical caused by the kinetic activity of the ionic or molecular constituents.

Observation borehole is a borehole drilled in a selected location for the purpose of observing parameters such as water levels.

Permeability is related to hydraulic conductivity, but is independent of the fluid density and viscosity and has the dimensions L^2. Hydraulic conductivity is therefore used in all the calculations.

Piezometric head (ϕ) is the sum of the elevation and pressure head. An unconfined aquifer has a water table and a confined aquifer has a piezometric surface, which represents a pressure head. The piezometric head is also referred to as the hydraulic head.

Porosity is the percentage of the bulk volume of a rock or soil that is occupied by interstices, whether isolated or connected.

Pumping tests are conducted to determine aquifer or borehole characteristics.

Recharge is the addition of water to the zone of saturation; also, the amount of water added.

Remediation refers to the improvement of contaminated land or degraded water resource to a situation where a new viable sequential land use or acceptable water resource status is established.

Sandstone is a sedimentary rock composed of abundant rounded or angular fragments of sand set in a fine-grained matrix (silt or clay) and more or less firmly united by a cementing material.

Shale is a fine-grained sedimentary rock formed by the consolidation of clay, silt or mud. It is characterised by finely laminated structure and is sufficiently indurated so that it will not fall apart on wetting.

Specific storage (S0), of a saturated confined aquifer is the volume of water that a unit volume of aquifer releases from storage under a unit decline in hydraulic head. In the case of an unconfined (phreatic, water table) aquifer, specific yield is the water that is released or drained from storage per unit decline in the water table.

Static water level is the level of water in a borehole that is not being affected by withdrawal of groundwater.

Storativity is the two-dimensional form of the specific storage and is defined as the specific storage multiplied by the saturated aquifer thickness.

Total Dissolved Solids (TDS) is a term that expresses the quantity of dissolved material in a sample of water.

Transmissivity (T) is the two-dimensional form of hydraulic conductivity and is defined as the hydraulic conductivity multiplied by the saturated thickness.

An **unconfined, water table or phreatic aquifers** are different terms used for the same aquifer type, which is bounded from below by an impermeable layer. The upper boundary is the water table, which is in contact with the atmosphere so that the system is open.

Vadose zone is the zone containing water under pressure less than that of the atmosphere, including soil water, intermediate vadose water, and capillary water. This zone is limited above by the land surface and below by the surface of the zone of saturation, that is, the water table.

Water table is the surface between the vadose zone and the groundwater, that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

1 Introduction

Tiara Mining (Pty) Ltd (herein referred to as "**Tiara**") a South African mining company duly incorporated in 1988 in terms of section 14 of the Companies Act, 2008, with the Companies and Intellectual Property Commission of the Republic of South Africa is engaged in Mineral Exploration, Mining and Mineral Processing. The company **(Tiara)** is a holder of the following Prospecting Rights granted by the Department of Mineral Resources (DMR) Limpopo Regional Office in terms of section 17 of the Mineral and Petroleum Resources Development Act **(MPRDA**), 2002 (Act No. 28 of 2002):

- **LP 30/5/1/1/4/389 PR;**
- **LP 30/5/1/1/4/388 PR;**
- **LP 30/5/1/1/4/206 PR;**
- **LP 30/5/1/1/4/207 PR.**

Tiara intend to lodge an application for a Mining Right in terms of section 22 of the **MPRDA,** for the proposed Tiara Granville Emerald and Quartz Mine. The proposed mining operation is located on the remaining extent **(R/E)** and portion 12 of the farm BVB Ranch 776 LT, R/E of the farm Josephine 749 LT, Buffalo Ranch 834 LT, R/E of the farm Danie 789 LT, Granville 767 LT, portion 6 and R/E of the farm Farrel 781 LT as well as R/E of the farm Willie 787 LT, all located within the Magisterial District of Phalaborwa, Limpopo Province.

The proposed project is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. The project falls within Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. The northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA.

The proposed mining operation will involve mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa)) using truck and shovel opencast mining method. The operation will have following support infrastructure:

- Screening and crushing machine;
- Processing plant;
- Run of Mine (RoM) stockpiles;
- Mobile office complex;
- Process water reservoir/tank;
- Portable water tank (Jojo tanks);
- Ablution facility;
- Store house;
- Workshop;
- Water Browser for dust suppression;
- Security gate (boom gate) and fence (five strand barbed wire or Clear-Vu fence).

The extent of the area applied for covers approximately 16987.9548 hectares. The project area is represented in the figure below. The life of mine (LoM) is estimated at 30 (thirty) years with Run of Mine (RoM) of 35 700 tonnes per month (tpa). The construction phase is expected to commence in the first quarter (Q1) of 2021, with first sealable product delivered in Q2 of 2020. Process water supply will be sourced from Mulati River as well as developing new groundwater abstraction boreholes on site).

J7 Royal Group (Pty) Ltd was appointed by Sakal and Tebo (Pty) Ltd to compile a hydrogeological baseline investigation and numerical conceptual model as part of an Integrated Environmental Authorisation process for the proposed Tiara Granville Quartz and Emerald Mine Mining Right application.

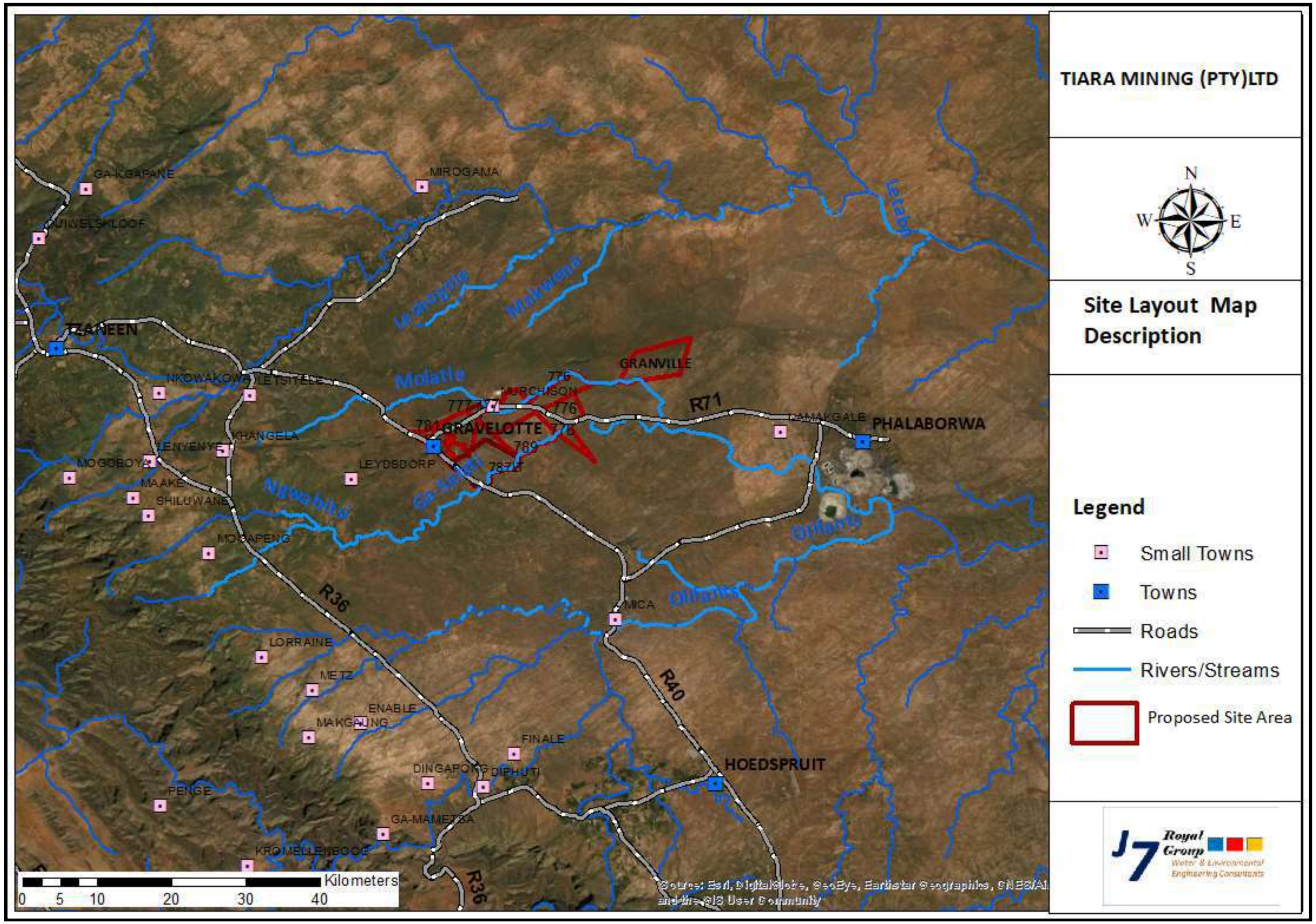


Figure 1-1: Regional Locality Map for the Proposed Tiara Granville Quartz and Emerald Mine

1.1 Regional Setting and Locality of the Activity

The proposed project area lies on the eastern parts of the Limpopo Province within the Magisterial District of Phalaborwa. Limpopo Province is bounded by Zimbabwe to the north, Mozambique to the north-east, Mpumalanga Province to the south-east, on the northern parts by Gauteng Province, North West Province to the south-western boundary, and lastly Botswana on the north-west border. The project site falls within ward 2 of Ba-Phalaborwa Local Municipality which is under Mopani District Municipality. Tiara Granville Emerald and Quartz Mine is located approximately 34 km west from the town of Phalaborwa. The town Murchison lies about 375 m north from the farm Josephine 749 LT. Immediate residential areas include Murchison, Gravelotte, Namakgale and Phalaborwa. The project site covers an area of about 16 987.9548 hectares and lies at geographical coordinates -23.906000° south and 30.744000° east. Access to the site is via a gravel road connected to the R71 main road. The R71 main road connects Murchison and Gravelotte to the town Namakgale and Phalaborwa.

Furthermore, the northern parts of the project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA.

In addition, no record of land claims has been made on this property at this stage. The property deed enquiry documents are attached as Annexure B.

Table 1-1: Property Details

Property Name	Property Number	Registration Division	Property Portion	Aerial Extent	Property Owner	Title Deed Number
BVB Ranch	776	LT	R/E	1521.3430 ha	Sebakwe Trust	T44543/82
BVB Ranch	776	LT	Ptn 12	1060.64 ha	Lepelle Industrial and Mining	T17491/12
Josephine	749	LT	Full extent	2239.2351 ha	Piet Warren	T108963/98
Buffalo Ranch	834	LT	Full extent	1238.0700 ha	J and L Fourie Trust	T105216/97
Danie	789	LT	R/E	2491.3629 ha	Pedal Trading	T24795/2001

Property Name	Property Number	Registration Division	Property Portion	Aerial Extent	Property Owner	Title Deed Number
Farrel	781	LT	R/E	2126.9222 ha	PP Mare Boerdery	T35531.84
Farrel	781	LT	Ptn 6	447.8404	PP Mare Boerdery	T35531/84
Willie	787	LT	R/E	2789.0412 ha	HB Dunn	T22791/78
Granville	767	LT	Full extent	3073.5000 ha	Ba-Phalaborwa Local Municipality	T26006/2013

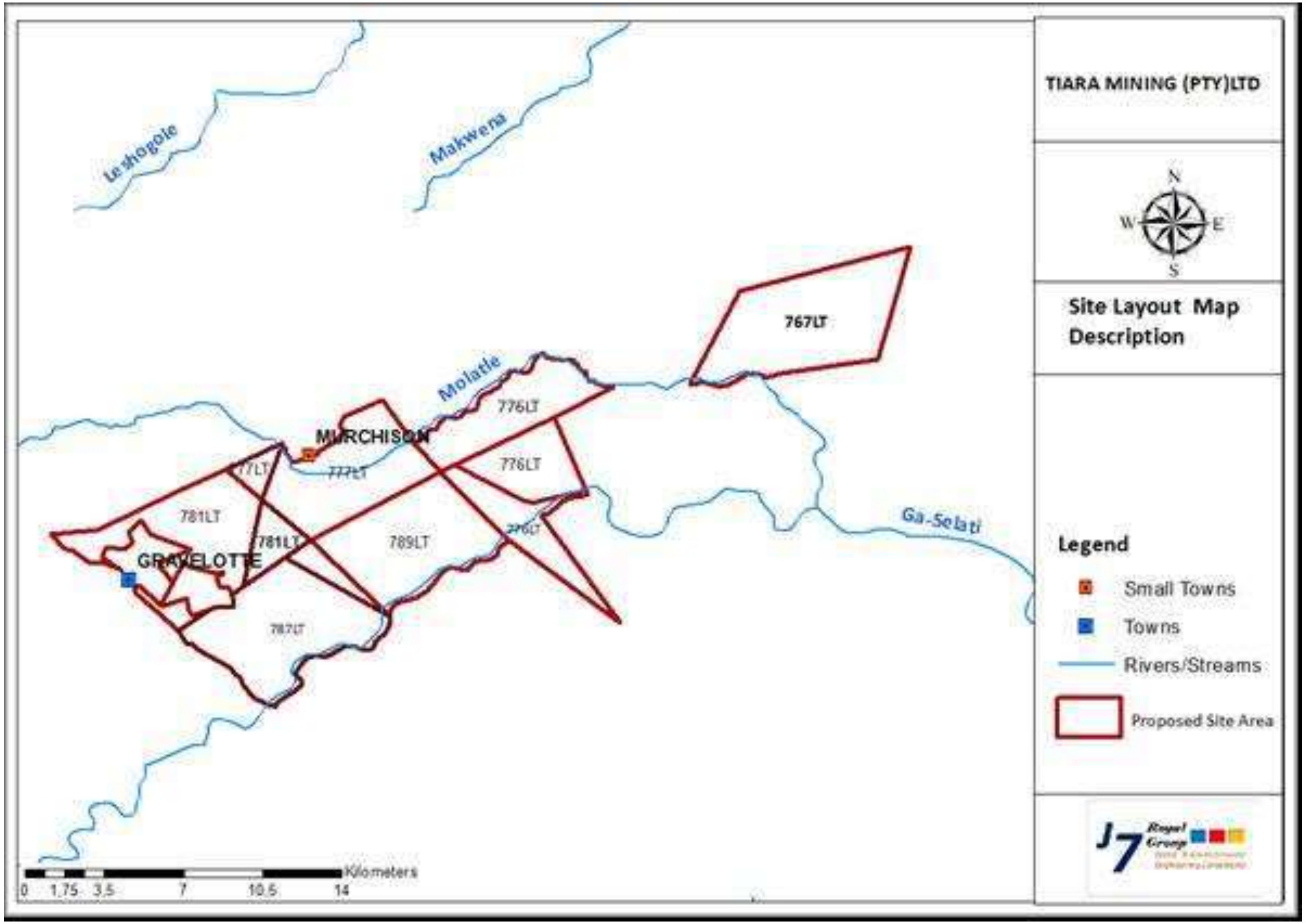


Figure 1-2: Layout of Project Properties

1.2 Project Description and Mining Method

Tiara Granville Quartz and Emerald mine involves truck and shovel opencast mining method with crushing and screening unit as well as processing plant (washing plant). Mine workings will reach a considerable depth of about 70 mbgl. Mining will commence in the north-eastern parts of the mining right application area and will progress in a south-westerly direction. Drilling and blasting of the rock face will be conducted on a predetermined schedule in accordance with projected volumes of production and will be undertaken by professionals and with the required safety procedures applied. The mining method will include:

- Clearance of the vegetation
- Stripping of topsoil to prepare box-cut area or bench
- The topsoil will be loaded onto dump trucks by excavators and hauled to areas that require rehabilitation or topsoil stockpile area;
- Drilling and blasting may occasionally be required
- Drilling operations will commence in the front of the advancing pit after the topsoil has been removed;
- The removed Run of Mine (RoM) will be stockpiled using excavators; and
- Thereafter RoM will be transported to the washing plant by means of haul trucks with a loading capacity of approximately 40 tons.

The proposed Tiara Granville Quartz Mine Life of Mine (LoM) is estimated at 30 years ending in year 2051. Construction is expected to commence in the first quarter (Q1) of 2021, whilst the operational phase (production) is scheduled for the second quarter (Q2) of 2021. Mining will commence in the north-eastern parts of the project area (on the Granville 767 LT, BVB Ranch 776 LT and Buffalo Ranch 834 LT) moving towards the south-westerly direction into the farm Farrel 781 LT, Josephine 749 LT, Willie 787 LT as well as Danie 789 LT. The proposed mine schedule for Tiara Granville Quartz Mine is depicted in the figures below.

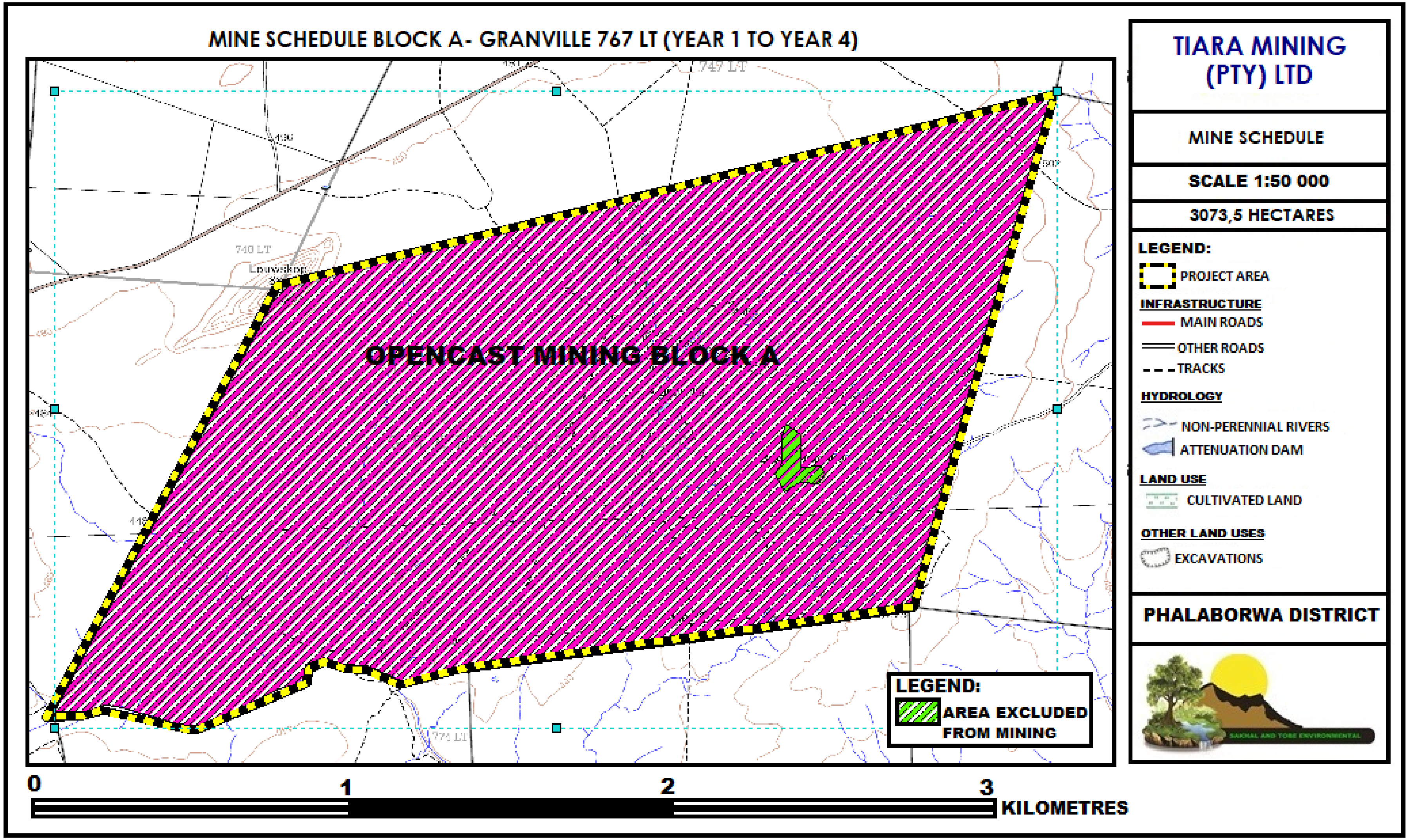


Figure 1-3: Proposed Mining Schedule (Year 1 to Year 4)

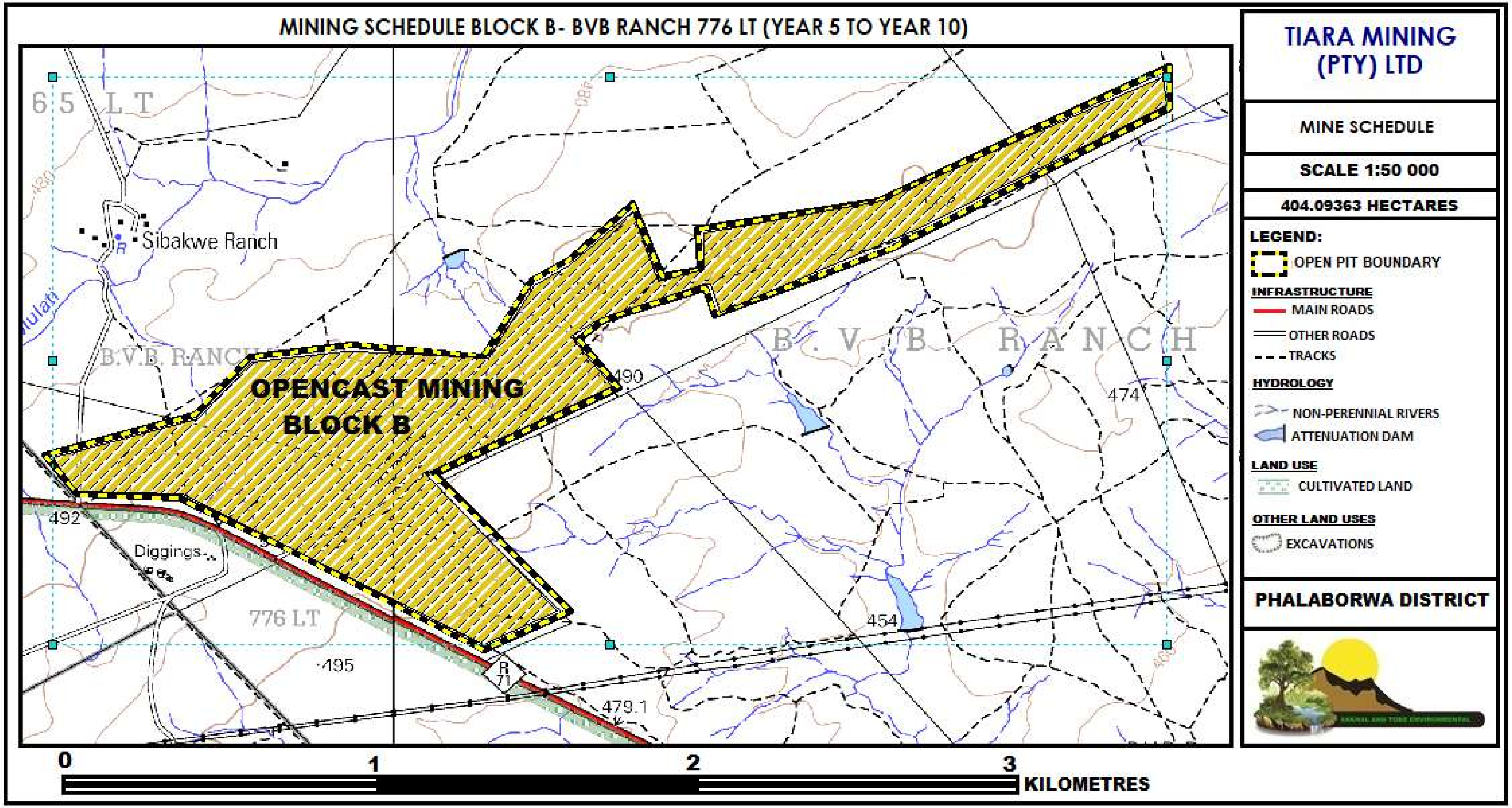


Figure 1-4: Proposed Mining Schedule (Year 5 to Year 10)

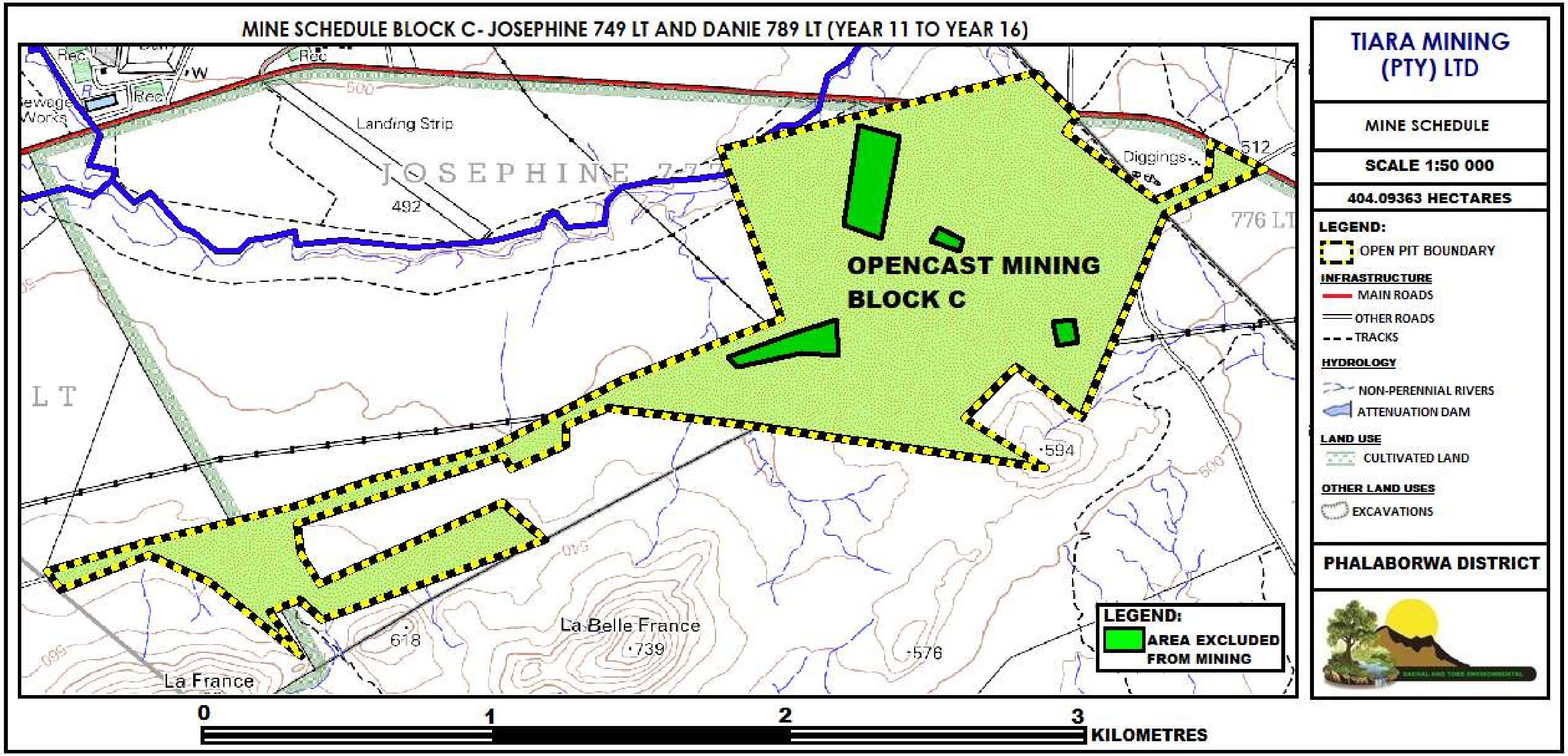


Figure 1-5: Proposed Mining Schedule (Year 11 to Year 16)

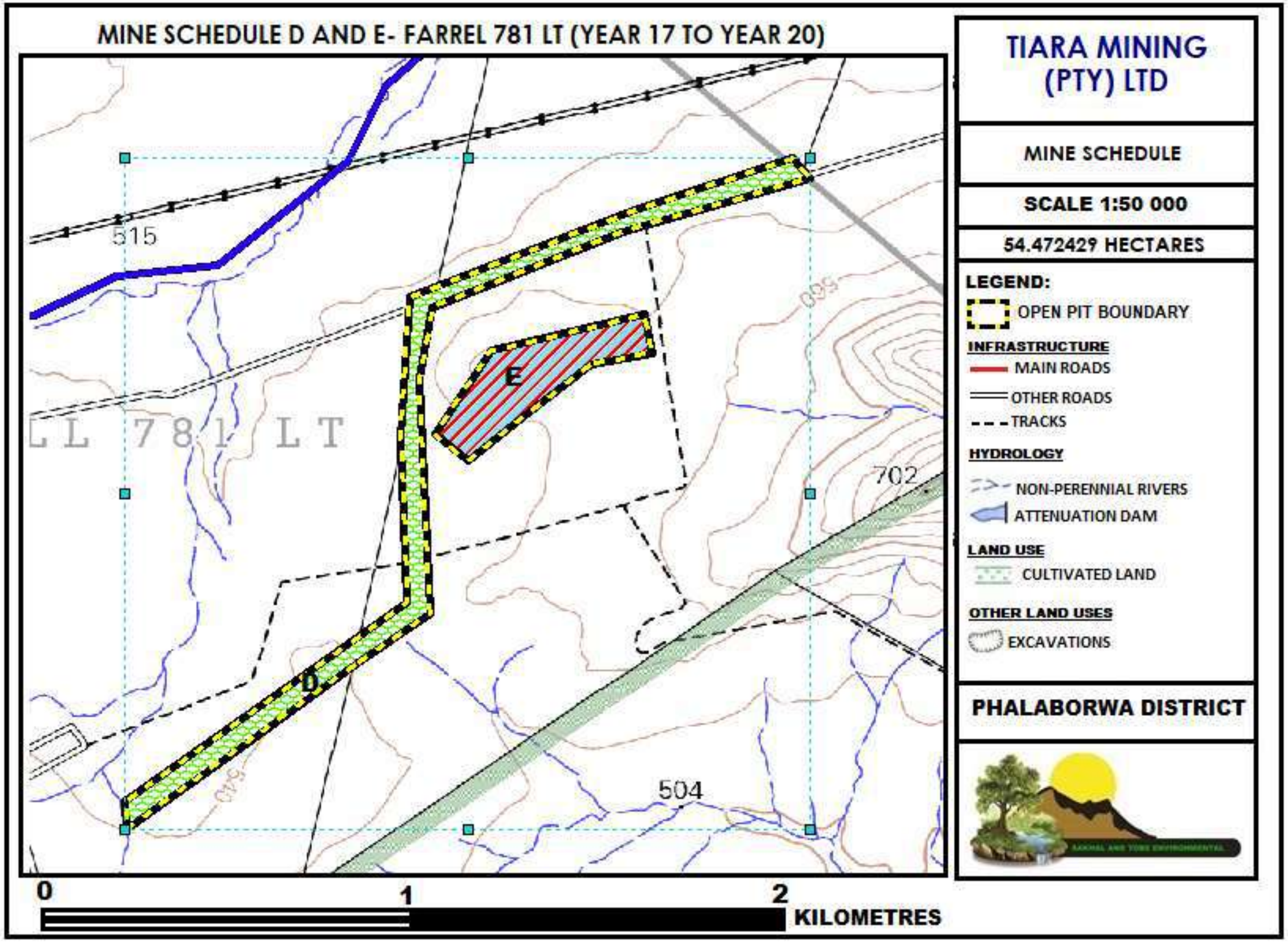

MINE SCHEDULE D AND E- FARREL 781 LT (YEAR 17 TO YEAR 20)
TIARA MINING (PTY) LTD
MINE SCHEDULE
SCALE 1:50 000
54.472429 HECTARES
LEGEND:
OPEN PIT BOUNDARY
INFRASTRUCTURE
MAIN ROADS
OTHER ROADS
TRACKS
HYDROLOGY
NON-PERENNIAL RIVERS
ATTENUATION DAM
LAND USE
CULTIVATED LAND
OTHER LAND USES
EXCAVATIONS
PHALABORWA DISTRICT
515
702
504
E
D
0
1
2
KILOMETRES

Figure 1-6: Proposed Mining Schedule (Year 17 to Year 20)

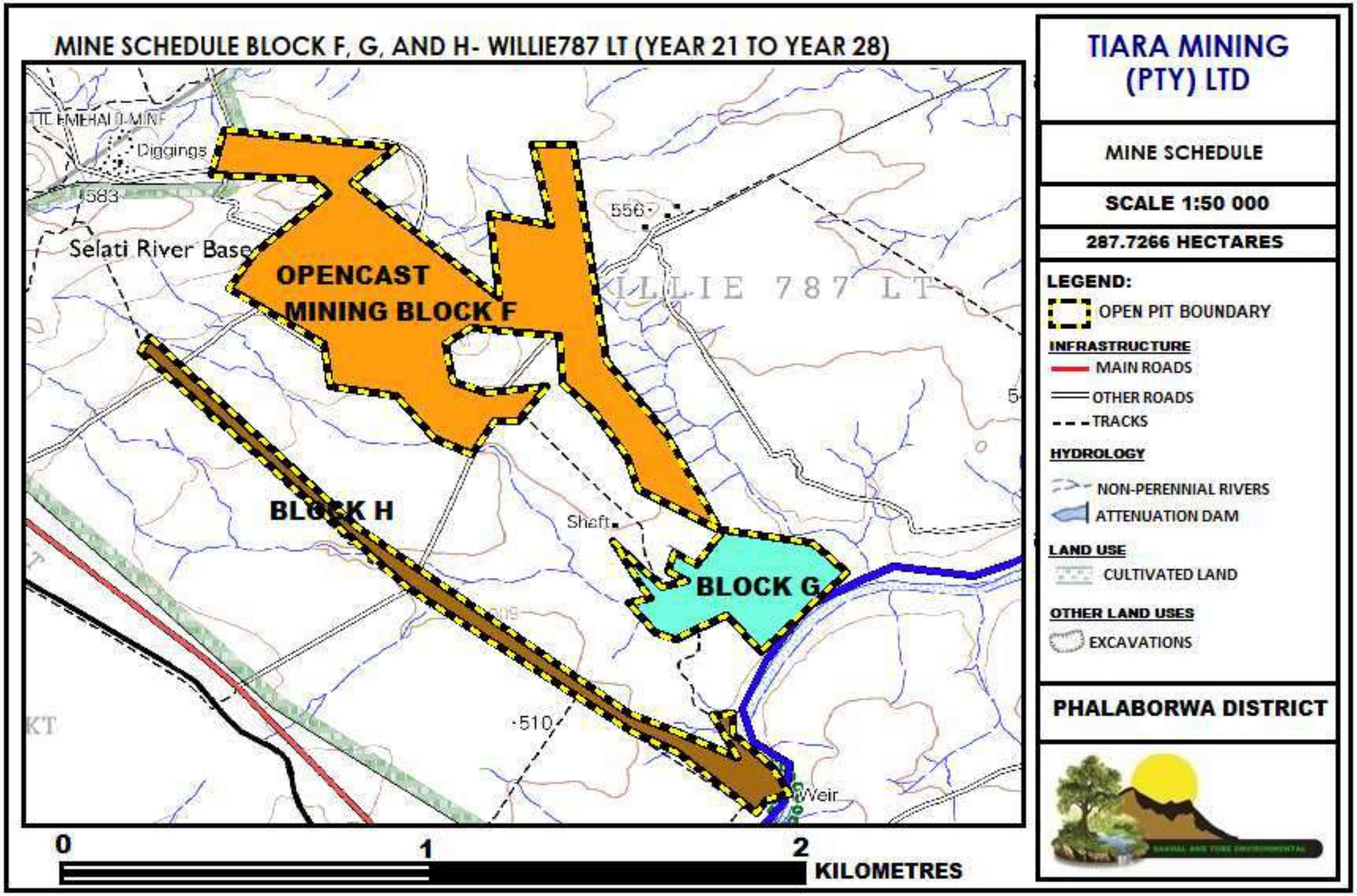


Figure 1-7: Proposed Mining Schedule (Year 21 to Year 28)

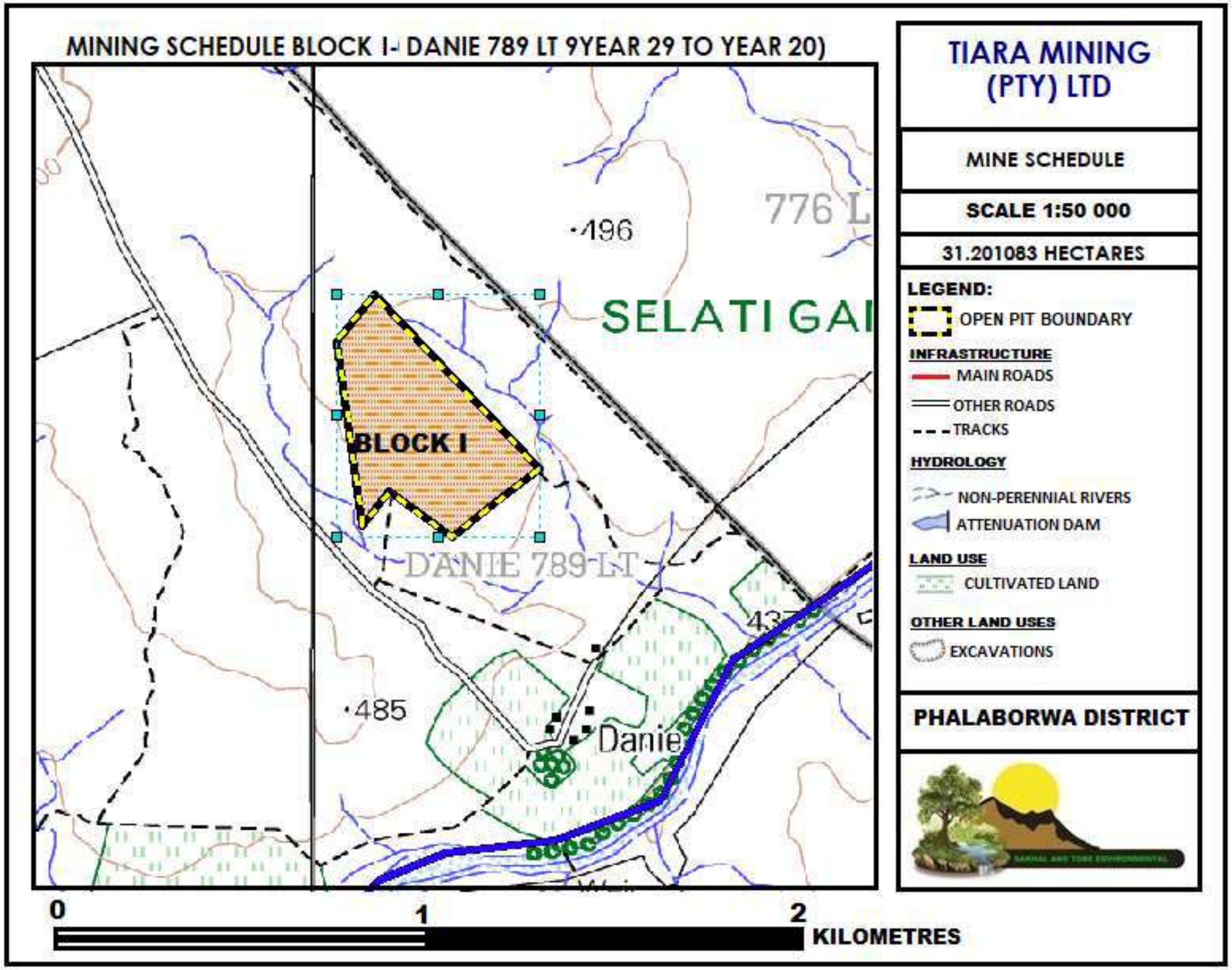


Figure 1-8: Proposed Mining Schedule (Year 29 to Year 30)

1.3 Objectives of the study

J7 Royal Group conducted a hydrogeological specialist study in order to evaluate and quantify the potential impacts of the proposed mining operation and related activities on the local and regional groundwater regime as part of the environmental impact assessment and to support the requirements of an Integrated Water Use Licence application for the proposed Tiara Granville Quartz and Emerald Mine. In addition, the main objectives of the groundwater investigation and numerical model include the following:

- Characterize the fundamental groundwater situations;
- Conduct a hydro-census to evaluate the groundwater regime locally and regionally with potential groundwater users as well as include the mining right area;
- Describe the water bearing strata in the area;
- Describe the current groundwater level distribution and flow directions;
- Describe baseline groundwater quality;
- Evaluate potential groundwater inflow into the underground workings; and
- Evaluate the impacts of mining on the groundwater system including quantity and quality impacts on existing users, during operational and post closure phases;
- Compilation of an environmental impact assessment matrix with specified reference to construction, operation and post-closure phases.

1.4 Scope of Work

The scope of work is stipulated below:

- Review of existing information and gap analyses;
- Field investigation and site assessment- site visit, hydro-census survey and baseline water quality assessment;
- Site characterization- aquifer testing (falling head tests);
- Development of a numerical groundwater and mass transport flow model;
- Compilation of an impact assessment and monitoring protocol;
- Compilation of a detailed hydrogeological specialist report and quantifying recommendations that should be addressed in future studies.

1.5 Declaration of Independence

J7 Royal Group is an independent consulting company and do not have any vested interest (financially) in the proposed project other than the remuneration for work performed in terms of the specification in the scope of work.

1.6 Approach to the Study

From the existing data collected data we can determine generic hydrogeological model outputs and conduct the assessment of the mining impacts. The scope of this study includes the following tasks:

- Desktop study - collation of all assembled data, geochemical data into a hydrogeological conceptual model for the proposed underground mine;
- Hydrocensus - an update of the water levels and groundwater quality; and
- A simplified groundwater model to provide outputs from the impacts assessment and support to other specialist studies undertaken.

2 Baseline Environmental Situation

2.1 Drainage Catchment

The project area falls within quaternary catchment B83A and B81J (Groot Letaba River Catchments) of the Luvuvhu and Letaba water management area (WMA), whilst the southern portions lies within B72J (Ga-Selati River Catchment) and B72K (Molatle River Catchment) under the Olifants WMA. Few non-perennial streams are the headwaters streams or source streams at the imitation points of all river networks of the site or project area.

The Ga-Selati River has its source in rugged mountains uplands. Descending a steep escarpment, it flows through savannah lowland where it is heavily utilised for irrigated agriculture. The increasing demands for water by agriculture have resulted in less for other downstream users, notably private game farms. The flow is highly variable because of occasional severe droughts and floods. The Ga-Selati River is dry for most of its length. Ga-Selati reaches its confluence with Olifants River and the water quality of the Ga-Selati is poor. The Ga-Selati River's largest tributaries are the Ngwabitsi River and the Mulati River. In the dry season, the riverbed of the Ga-Selati is dry for most of its length. This river is heavily polluted owing to mining activity at Phalaborwa in its lower course (Arthur Chapman, 2006).

2.2 National Groundwater Archive (NGA)

A review of Water Use Allocation and Registration Management System (WARMS) database and the National Groundwater Archive (NGA) database of registered boreholes in the vicinity of the proposed mining operation shows many boreholes near the site that are registered. No drilled boreholes were identified on site during site visit. All the boreholes in the databases for the surrounding catchments areas are shown in figures below.

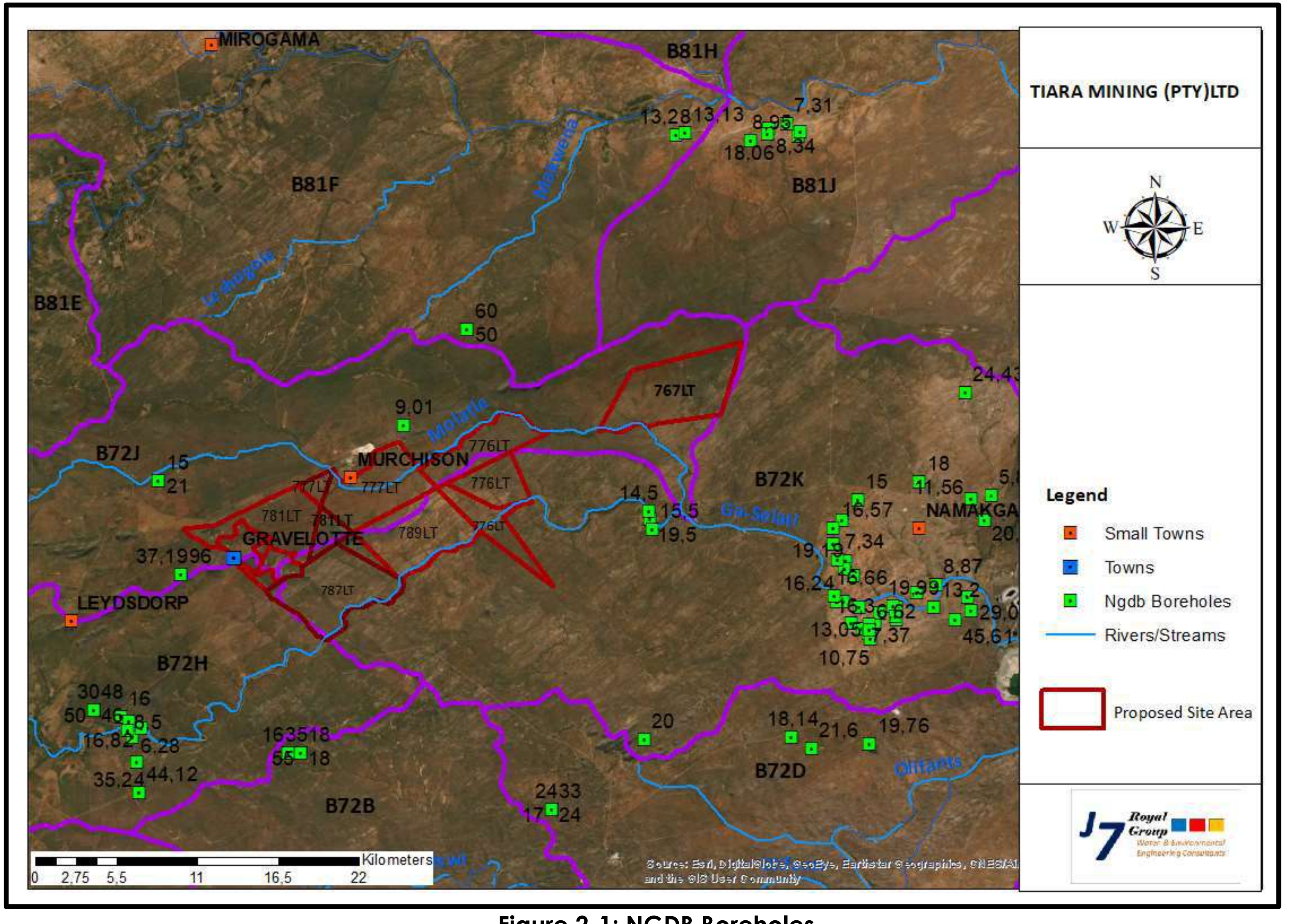


Figure 2-1: NGDB Boreholes

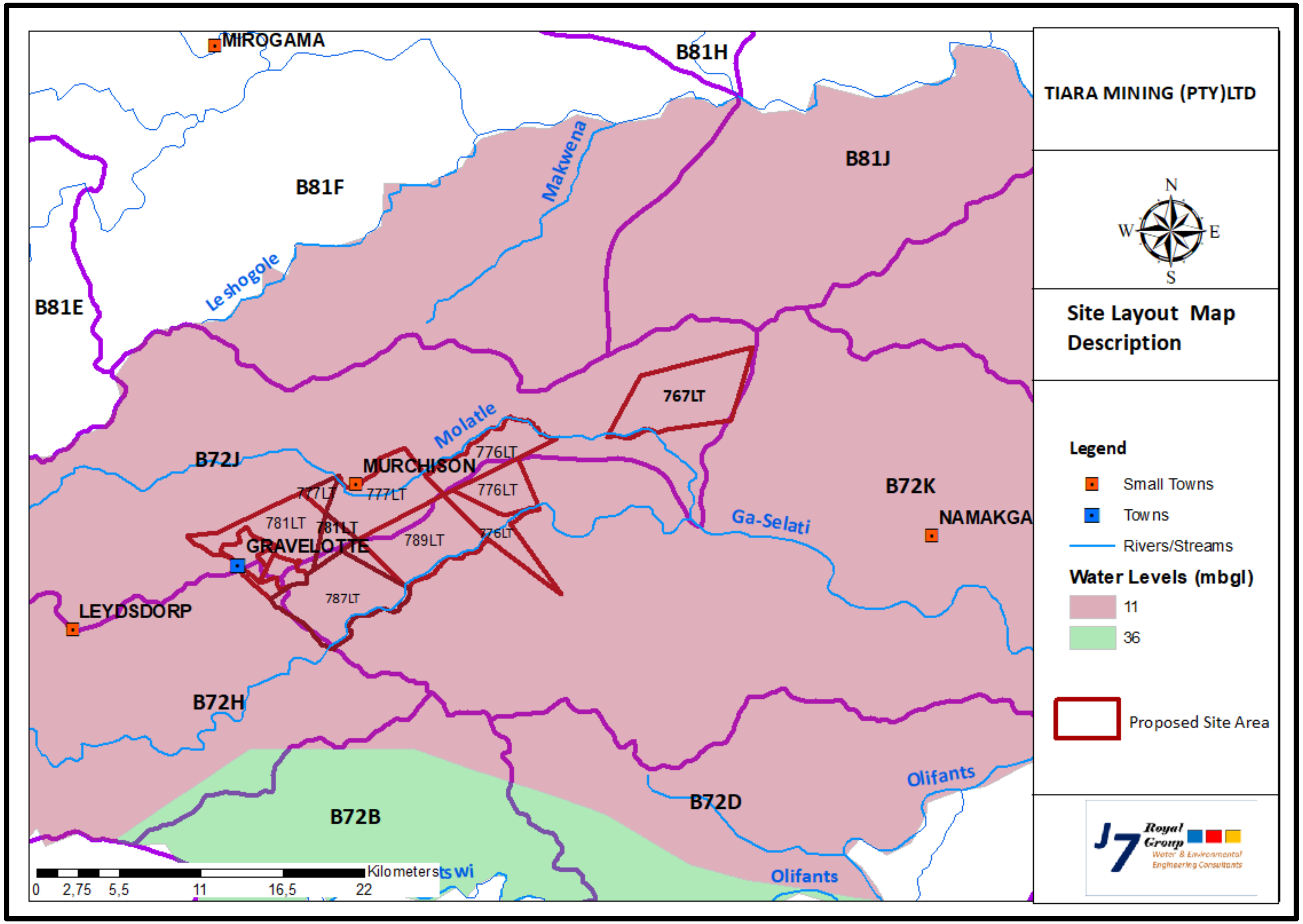


Figure 2-2: Water Levels (mbgl)

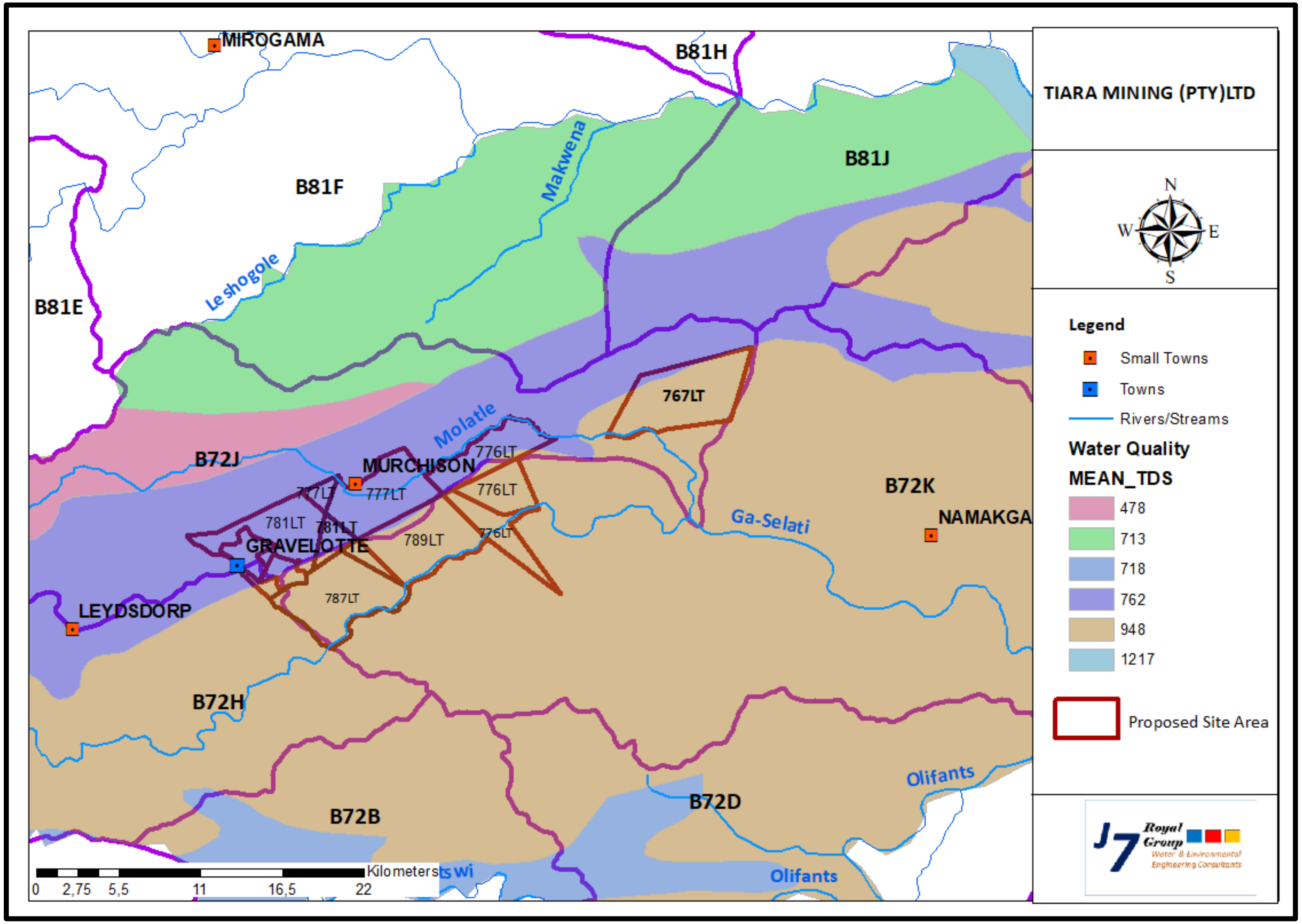


Figure 2-3: Levels of Total Dissolved Solids (TDS)

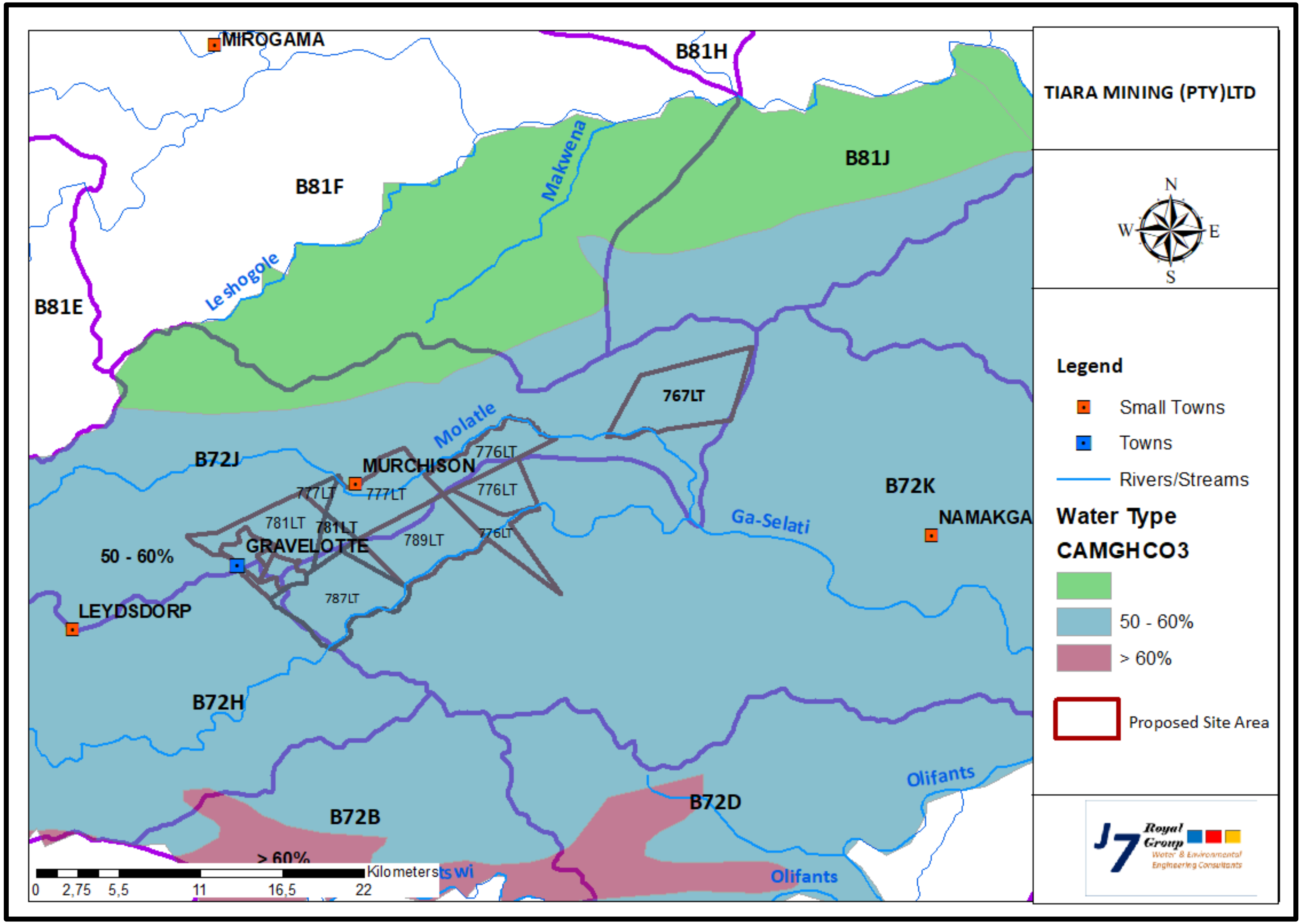


Figure 2-4: Water Quality Type

2.3 Water Levels and Chemistry

The water level is currently reported to be around 11-36 m below ground level but they fluctuates considerably. Annual recharge for the aquifer system is defined as being 1-3 % of the mean annual precipitation (MAP). The area yields relatively low transmissivity ranging between 0.1-0.5 m2/d. Hydraulic conductivities for the aquifers is roughly 0.0069 m/d. .The aquifer is described as 'fairly good. The groundwater chemistry of several boreholes within the vicinity of the project area indicates as that having a calcium-magnesium-bicarbonate character (Ca-Mg-HCO3).The groundwater shows low salinity. The water indicates that it's fresh and of drinking water quality but hard in nature and causes scaling problems with the high calcium and magnesium concentrations. In general, the DWS regional data indicates the following

- The mean annual recharge from precipitation is roughly around 1-3 mm/annum;
- The groundwater component to base flow in rivers in this area is low;
- Boreholes in the area have 40-60% probability of a successful borehole drilled;
- Average borehole yield is 0.1-0.5 ℓ/s.

2.4 Topography

The headwaters of the Ga-Selati River are located in Drakensberg Mountains. The upper catchment, chief water resource for the drier plains is only 3-5 % of the total Ga-Selati River catchment area. After a short run of 3-5 km of mountain upland, and dropping of 800m from its roughly 1600m origin, the headwaters stream exists the montane area onto the lowveld, which is a relatively flat and low –lying savannah (500-600 m amsl). Thereafter the river drops another 500 m over the next 90 km to its confluence with the larger Olifants River at the Phalaborwa Mine (Arthur Chapman, 2006).

The vegetation of the area covered is characterised by grassland savannah with scattered clumps of trees. Farming is predominantly subsidence. The general region is also characterised by a number of mining operations in Phalaborwa, many of which are open pit operations.

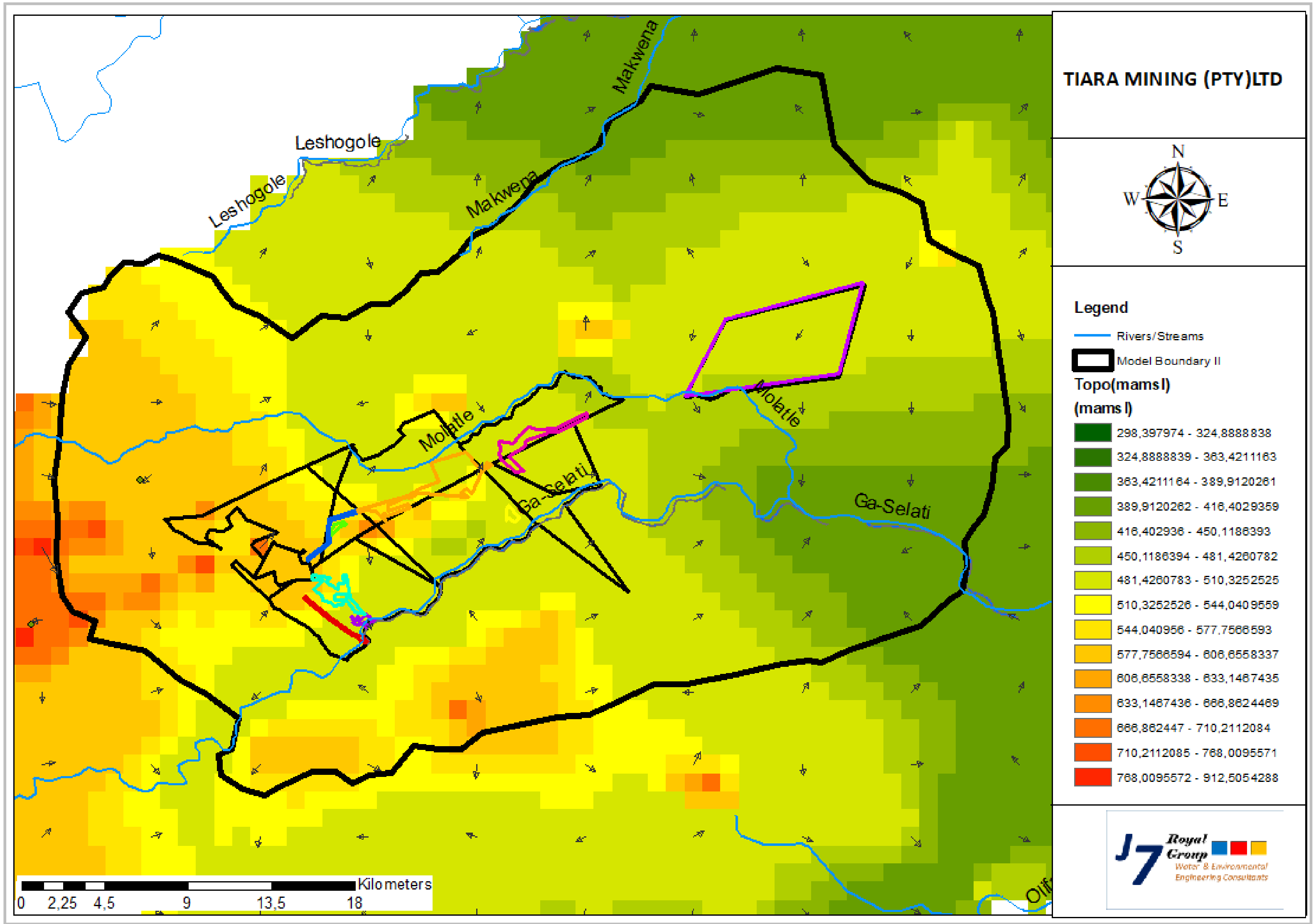


Figure 2-5: Topographical Map of the Project Area

2.5 Regional Geology

The Murchison greenstone belt is one of several greenstone belts that occur within the Archean granite-greenstone terrain of the Kaapvaal Craton of South Africa. It is situated in the Easternn Transvaal Lowveld in the north-eastern part of the Kaapval Craton. This Archean Schist belt has an east-north-easterly trend, is 140 km long and typically 5 to 10 km wide. The Murchison belt consists of a sequence of volcanic and sedimentary rocks of low metamorphic grade intruded and surrounded by Archean granites and gneisses. In general terms, the belt is considered to represent a fairly typical greenstone assemblage although it does have some unique features (Viljoen et al., 1975, 1978).

The present day economic importance of this geological entity derives primary from the fact that the mines along the Murchison belt are majot produces of antimony. Viljoen et al (1978) oints out that the antimony minerazation occurs along the so-called "Antimony Line" within thickened carbonate masses and is more specifically associated with siliceous and often fuchsitic zones within the carbonate structures. Furthermore, pyritic copper/zinc mineralization of probable volcanogenic origin occurring along the "Copper/Zinc Line" is associated with a quartz porphyry assemblage. Emeralds occur in biotite leucogranite and pegmatiitic phases of the muscovite granite are intrusive in ultramafic schists. Minor gold mineralization in the form of cinnabar occurs at one main locality.

2.5.1 Local Geology

The emerald deposits associated with rocks of the Murchison greenstone belt **(MGB)** in the Gravelotte area are described here, with specific reference to claims forming parts of the farms BVB Ranch 776 LT and Granville 767 LT. The overall regional geology of the area is discussed briefly, as is the history of the exploration and mining for emeralds in the area.

The MGB is one of several remnants of ancient (Archaean) sequences of deformed and metamorphosed volcanic and sedimentary rocks, set in granitic host rocks, in the eastern part of the Limpopo and Mpumalanga Provinces. The MGB is believed to have undergone several phases of deformation over a prolonged period, during which mineralization of various types developed, including: 1) antimony-gold mineralization on the so-called "Antimony Line" along the centre of the belt; 2) gold associated with pyrite and quartz veining in the Blue Jacket area, close to Gravelotte; 3) gold associated with pyrite, pyrrhotite and arsenopyrite near Kasteel Koppies, between BVB Ranch and Granville; 4) volcanogenic Cu-Zn sulphide mineralization along the northern margin of the belt; 5) cinnabar (mercury) at Monarch mine , and; 6) beryl and emerald mineralization whereapophyses of biotite schist on the southern margin of the belt are in contact with coarse-grained albitic (i.e. relatively sodic) pegmatoidal granitoid and finer-grained aplite rocks assigned by Vearncombe et al. (1992) to the Granville Granite Suite. A feature of the regional geology that is typically overlooked is the swarm of NE-trending dykes (Fig. 1) of diabase (older, altered mafic rocks dating to the 2.7 Ga Venterdorp event) and dolerite (fresher, more recent intrusive mafic rocks dating from the 180 Ma Karoo volcanic event) that affect the area (Uken & Watkeys, 1997).

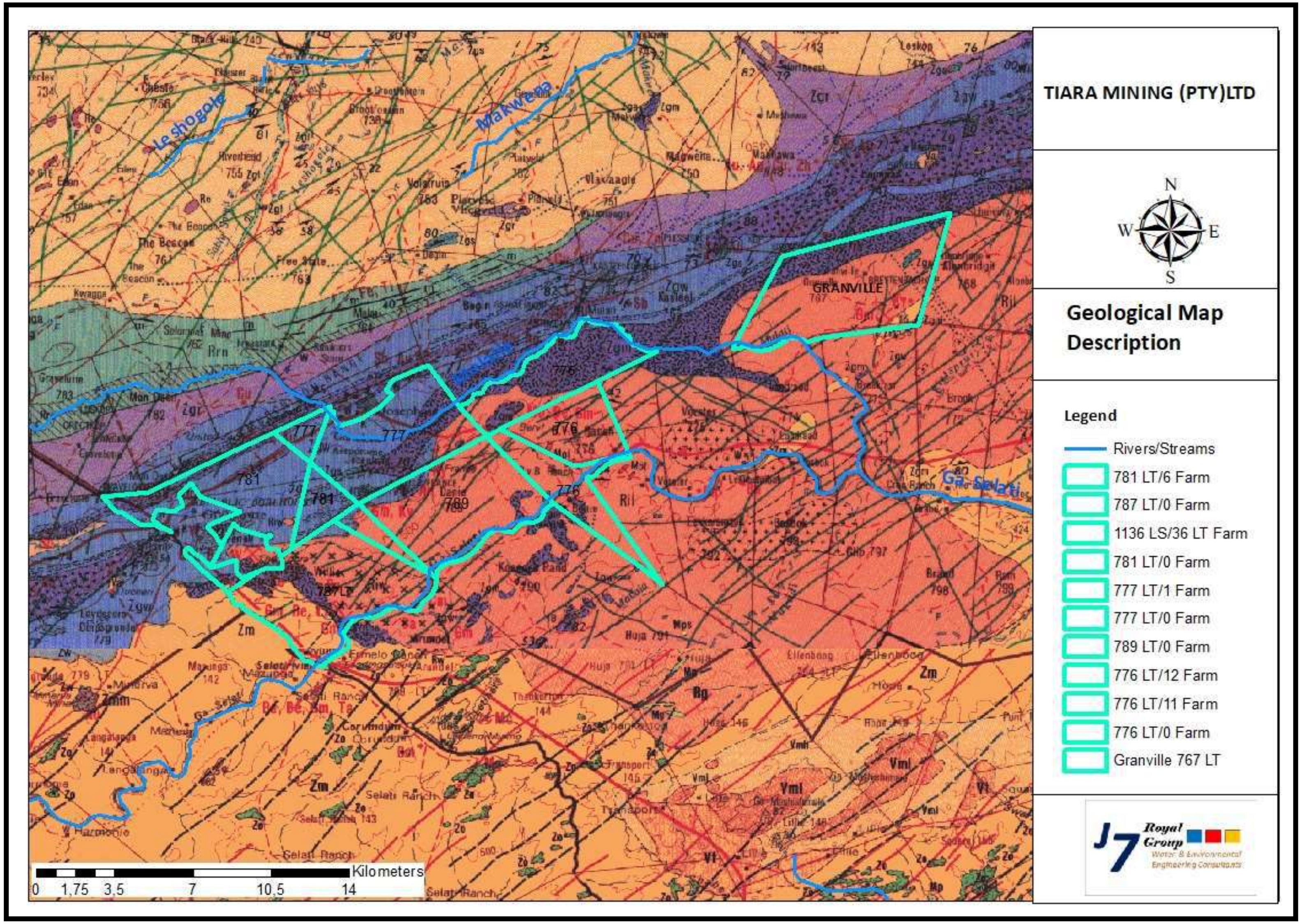


Figure 2-6: Geological Map of the Study Area

3 Conceptual Groundwater Model

The data gathered during the field investigation phases described in the preceding section of this report was used to develop the conceptual hydrogeological model of the area. The conceptual model forms the basis for the understanding of the groundwater occurrence and flow mechanisms in the area and is used as the starting point for the numerical modelling.

The regional climate in the area is defined by the South African Weather Bureau as moderate and can be locally described as warm in summer and cold in winter. The recharge values estimated 8.48 mm per year corresponding to 1-3 % of the annual precipitation (MAP) of 575 mm.

Based on the interpretation of the available and gathered geological and hydrogeological information of the area, a conceptual hydrogeological model was developed as an adequate description of the groundwater system. The basic components of a conceptual hydrogeological model are the primary hydrogeological units derived from the geological settings of the area and the groundwater flow in the area. The components then serve as an input and basis for the numerical model.

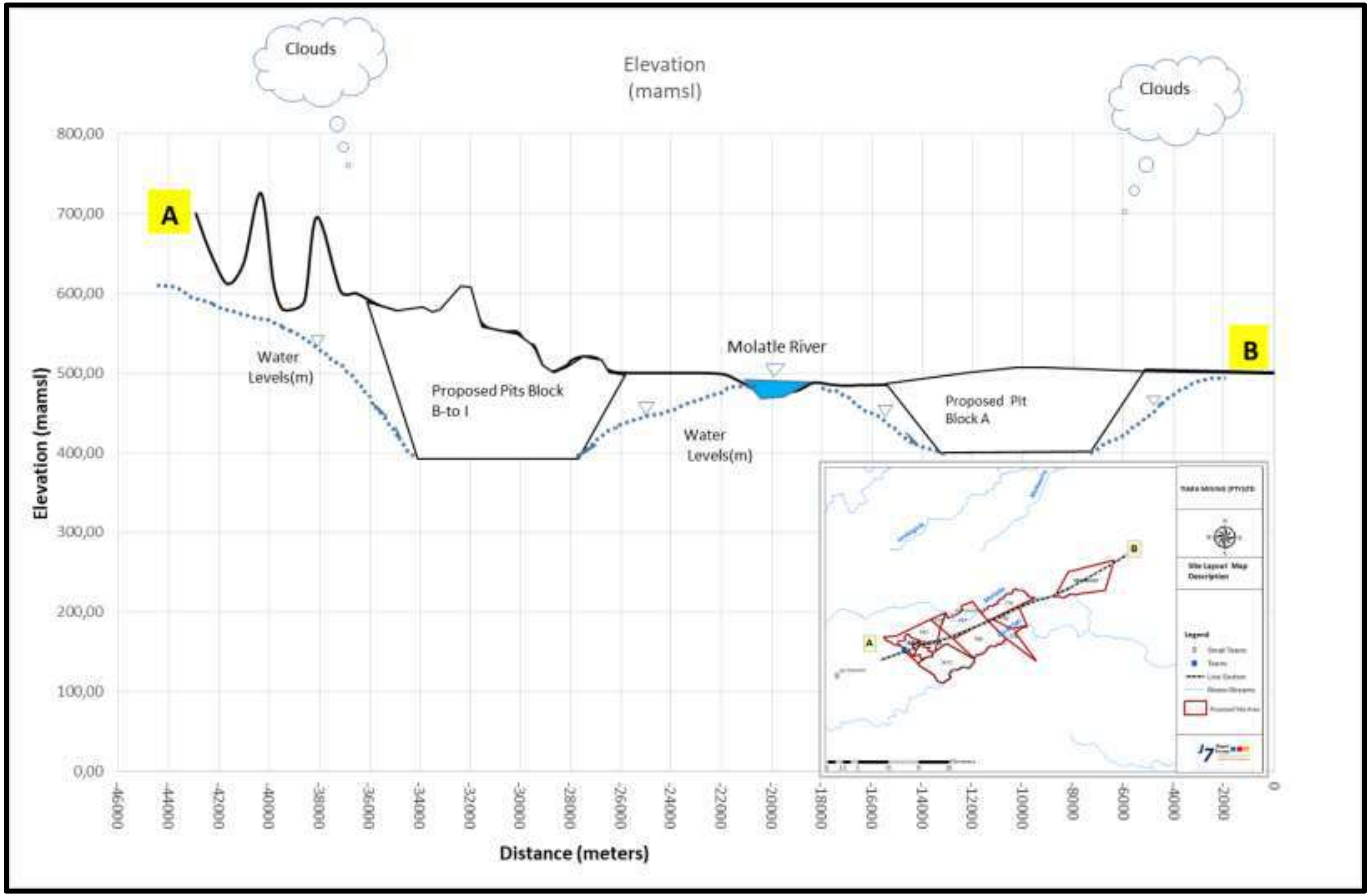


Figure 3-1: Conceptual Opencast Mine Model

3.1 Activity Life Description

The proposed Tiara Granville Quartz Mine Life of Mine (LoM) is estimated at 30 years ending in year 2051. Construction is expected to commence in the first quarter (Q1) of 2021, whilst the operational phase (production) is scheduled for the second quarter (Q2) of 2021. Mining will commence in the north-eastern parts of the project area (on the Granville 767 LT, BVB Ranch 776 LT and Buffalo Ranch 834 LT) moving towards the south-westerly direction into the farm Farrel 781 LT, Josephine 749 LT, Willie 787 LT as well as Danie 789 LT

3.2 Groundwater Numerical Modelling

A 3D numerical model was constructed to represent the conceptual groundwater system of the study area as presented in section 3 above. The purpose of the model is to develop a tool that can be used to assess the potential groundwater conditions during development, operation as well as post-closure.

3.3 Modelling Objectives

The main objectives of the numerical model are to determine the inflows into the proposed Tiara Granville Quartz and Emerald Mine over the operational phase and to simulate the re-bound of the water levels post mine closure. A further objective is to determine the potential impacts on the water levels in the aquifer in space over time with associated impacts on the baseflow to surface water systems.

3.4 Software Selection

Groundwater flow at the Tiara Grannville Quartz and Emerald Mine model was simulated with a finite difference model called MODFLOW that was developed by the United States Geological Survey. For the current model, the Block Centre Flow (BCF) flow package and the Preconditioned Conjugate Gradient 2 (PCG2) solver were used to solve the flow matrix (Hill, 1990).

A three (3) D numerical groundwater flow model was developed for the sub catchment using the modelling software MODFLOW.MOFLOW can also simulate the solute transport to simulate decant and concentration.

3.5 Model Construction

The groundwater flow modelling depends on the physical properties of the site. For a numerical model to be relevant as a predictive model tool, it is necessary to integrate the physical geometry and properties of the site into the model. Controlling factors are the topography and relief, surface hydrology and rainfall, geology as well as the properties of the aquifer system.

3.6 Conceptualisation of the Groundwater System for Numerical Model

The first step in the modelling procedure is the construction of a conceptual model of the problem and the relevant aquifer domain. The conceptual model consist of a set of assumptions that reduce the real problem and the real domain to simplified versions that are acceptable in view of the objectives of the modelling and of the associated management problem. The data gathered during the desk study and data evaluation phase of the study has been used to develop a hydrogeological conceptual model for the area, which forms the basis for the numerical modelling. A description of the conceptual model is provided in the preceding sections of this report.

Conceptual Model Delineated:

In a representative hydrogeological setting groundwater flow and aquifer development are closely linked to the geology and structural geology of an area. There is no intention to believe that the area under investigation will not conform to this assumption and therefore the geology forms the basis on which the conceptual hydrogeological model is based spatially. The nature and distribution of the geological units, and possibly geological structures control the hydrogeology of the study area.

Recharge to the aquifer is from precipitation during the rainy season. Groundwater flow is from areas of higher piezometric elevations to the lower elevations. Groundwater flow directions mimic topography in large parts of the model domain. This is confirmed by the general correlation between groundwater levels and the surface topography. It must be noted that some water levels do not correlate well especially in the deeper aquifer. This is attributed to the impact of abstraction for agricultural purposes. It must be noted that some water levels patterns do not follow topography.

As a result of local recharge and discharge, groundwater divides developed approximately beneath the major surface water divides. In the absence of evidence of physical subsurface no flow-boundaries, the modelling area was therefore selected based on topographical control i.e. along the surface catchment boundaries. According to standard modelling practice, this is a reasonable approach to follow since a fair correlation exists between the groundwater level elevation and the surface topography. Boundaries of the numerical model were therefore chosen to reflect the geometry of the surface water catchment systems Majority of the groundwater is towards Ga-Selati River which form the northern-eastern boundary but also forms a significant internal drain to the model. The southern boundary is considered a no flow boundary. The northern and eastern part of the study area drains at Ga-Selati River. To the south model the boundary coincide to groundwater divides present beneath the surface water divides.

3.7 Boundary Conditions

Boundary conditions express the way the considered domain interacts with its environment. In other words, they express the conditions of known water flux, or known variables, such as piezometric head. Different boundary conditions result in different solutions hence the importance of stating the correct boundary conditions. Boundary conditions in a groundwater flow model can be specified either as:

- Nueman Type (Specified flux) or;
- Dirichlet Type (or constant head) boundary; and
- Or a mixture of the above.

3.8 Model Perimeter Boundary Conditions

Groundwater flow directions largely follow topography, and the groundwater basin geometry can be approximated by the surface water drainage geometry. The boundary conditions of the numerical model are displaced .The model area perimeter coincides to the north and east where constant head boundary conditions (seepage faces) were specified. These boundary conditions are represented as a Type I boundary condition (Dirichlet condition).To the south the model perimeter coincides with a no-flow boundaries where no-flow boundary conditions were specified. These boundaries are represented as a "specified" boundary condition (zero specified flux or Neuman Type II boundary condition).To the west and east a Type I boundary condition (Dirichlet condition) were also specified along the Ga-Selati River.

3.9 Internal Model Boundaries

The groundwater system within the study area is recharged through infiltration of precipitation .It is thought that most of the groundwater recharge occurring within the study area discharges internally to the surface drainage systems via springs and discharge to the base of river drainage systems (base flow).Constant head boundary conditions were therefore specified along the surface drainages, which are known to receive base flow from groundwater. The constant head boundary condition allows the groundwater to discharge from the model area at a rate dependant on the hydraulic conductivity and hydraulic gradient across the boundary. Constant head boundary were constrained (seepage aspects) at the elevation of the ground surface so that water can only be simulated to leave the groundwater system.

3.10 Model Base Boundary Conditions

The model domain was assumed to extend vertically to the base of the geology of the area and the base of the model is assumed impermeable.

3.10.1 Model Surface Boundary Conditions

Boundary conditions applied to the top surface area of the model include the following. A defined quantity of the effective background recharge is assigned (1.84mm/a) to the entire surface area for the steady state simulation (calibration).This institutes about 0.5-3 % of MAP and is in line with the low hydraulic conductivity values of the area, which restricts vertical percolation of rainfall recharge into the subsurface.

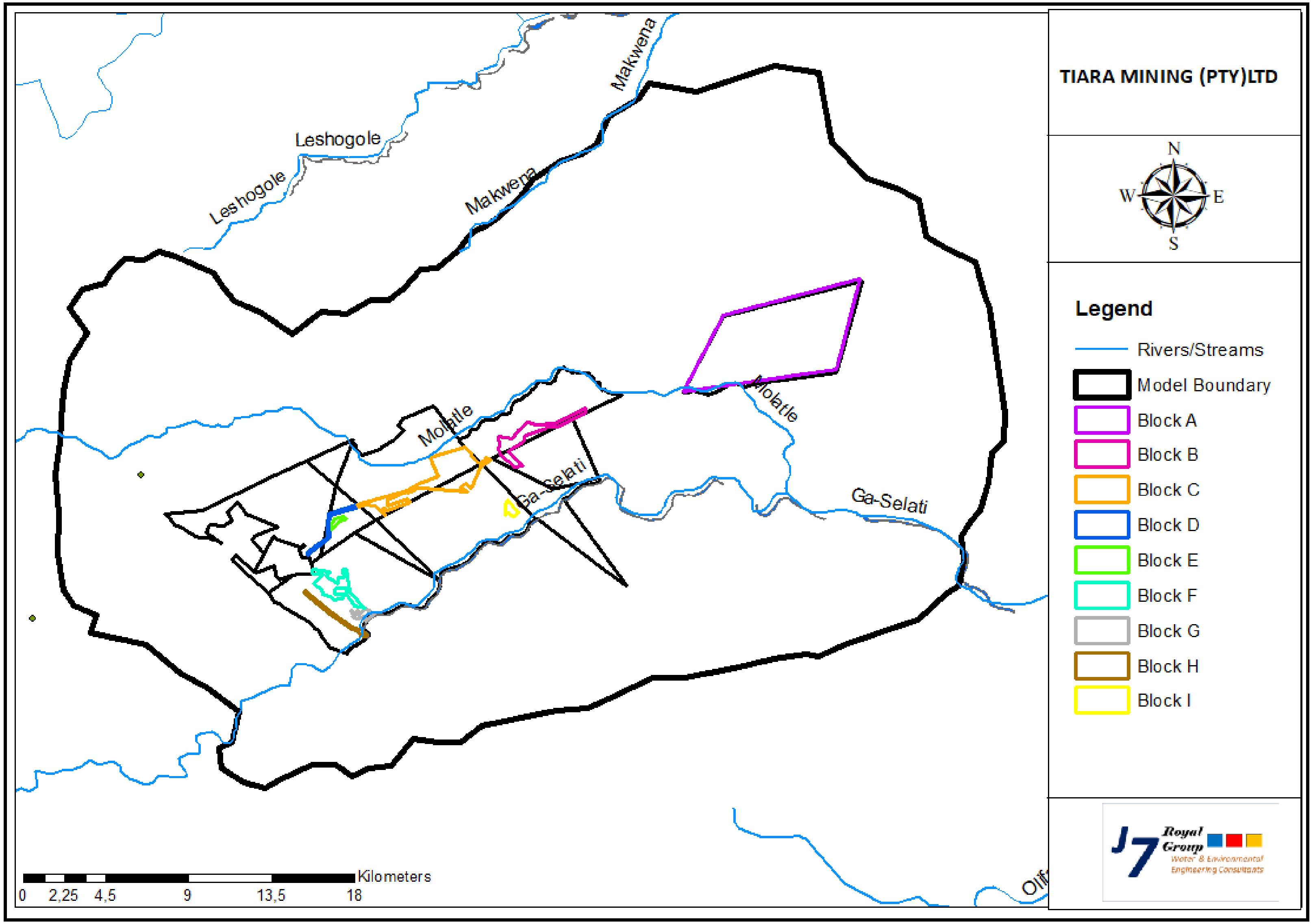


Figure 3-2: Extent of the Numerical Model Domain and Boundary Zones

3.10.2 Discretization or Hydrogeological Units and Model Structure

The following hydrogeological units were included in the model domain:

- Layer 1 : The alluvium and weathered horizon as unconfined(0-25 mbgl) ;and
- Later 2 : Fractured aquifer as semi-confined(25-70 mbgl)

SRTM elevation data was used to contour the surface elevation (top of Layer 1). The top of Layer 2 was offset by the thicknesses listed above. The bottom of Layer 2 was assigned a constant elevation of 230 m amsl.

In a finite difference numerical model the aquifer is represented by rectangular cell blocks and individual layers .Each cell is assigned hydraulic conductivity, specific yield, specific storage, thickness and recharge parameter. Hydraulic heads in each cell of each layer and the exchange of water between cells and across boundaries is calculated simultaneously using finite difference mathematics until a finite solution is reached within set convergence parameters. The model can be used to solve for heads under steady-state conditions, which are conditions that will occur when stability in water level and flow rates are reached, or transient.

State conditions, which are flow rates and hydraulic heads that will exist after specific time intervals from an initial starting condition. The regional aquifer was modelled as a two (2) layer, three (3) dimensional domains. Each layer was considered to be 25 m thick and 45m thick.

3.10.3 Hydraulic Stresses

The conceptualized water balance components that are considered were simulated in the numerical model using the available components of the MODFLOW software package. This included the "in-out flow from the surface" package to simulate natural groundwater recharge and the constant head boundary conditions Type I to simulate the outflow from the internal model boundaries and to simulate the underground mine.

3.10.4 Model Area and Finite Difference Grids

The numerical model covers an area of 1199,71 km^2. A finite difference (grid) was designed to provide a high resolution for the numerical solution .The finite difference was constructed using the MODFLOW software, which facilitated the construction of finite difference over the entire model. The groundwater model was developed using 47800 rows and 39300 columns to generate a mesh that discretizes the model domain into a finite difference mesh below. The positions of different geological units and mines are incorporated in the modelling grid including various surface catchments. The model consist of two (2) layers with variable thicknesses, with a depth of 70 m.A regular grid space of 100m is used for each column and row. The task is to assess the aquifer under the following conditions.

Steady State (with recharge rate):Steady refers to an equilibrium condition whereby over a long period of time, hydrogeological systems may achieve or approximate some non-changing conditions in which the heads or concentrations do not change with further passage of time. Such systems are said to have achieved a steady state. Models may deal with this in different ways. Some have "steady state" options, while others require the user to specify some long period of time and/or closure criterion beyond which changes in head are considered inconsequential

3.10.5 Recharge

The annual effective recharge is estimated to be in the order of 0.5-3 % of MAP and this low value relates directly to the low permeabilities of the aquifers(s).

3.10.6 Initial Hydraulic Heads Condition

The initial head conditions specified in the model were interpolated from the measured groundwater levels using the Kriging technique and extrapolated to the nodes in the model.

3.10.7 Numerical Groundwater Flow Model

A steady state groundwater flow model for the study area was constructed to simulate uninterrupted groundwater flow conditions. These conditions serve as starting heads for the transient simulations of the groundwater flow and mass transport where the effect of mining operations will be taken into considerations (refer to figure below).

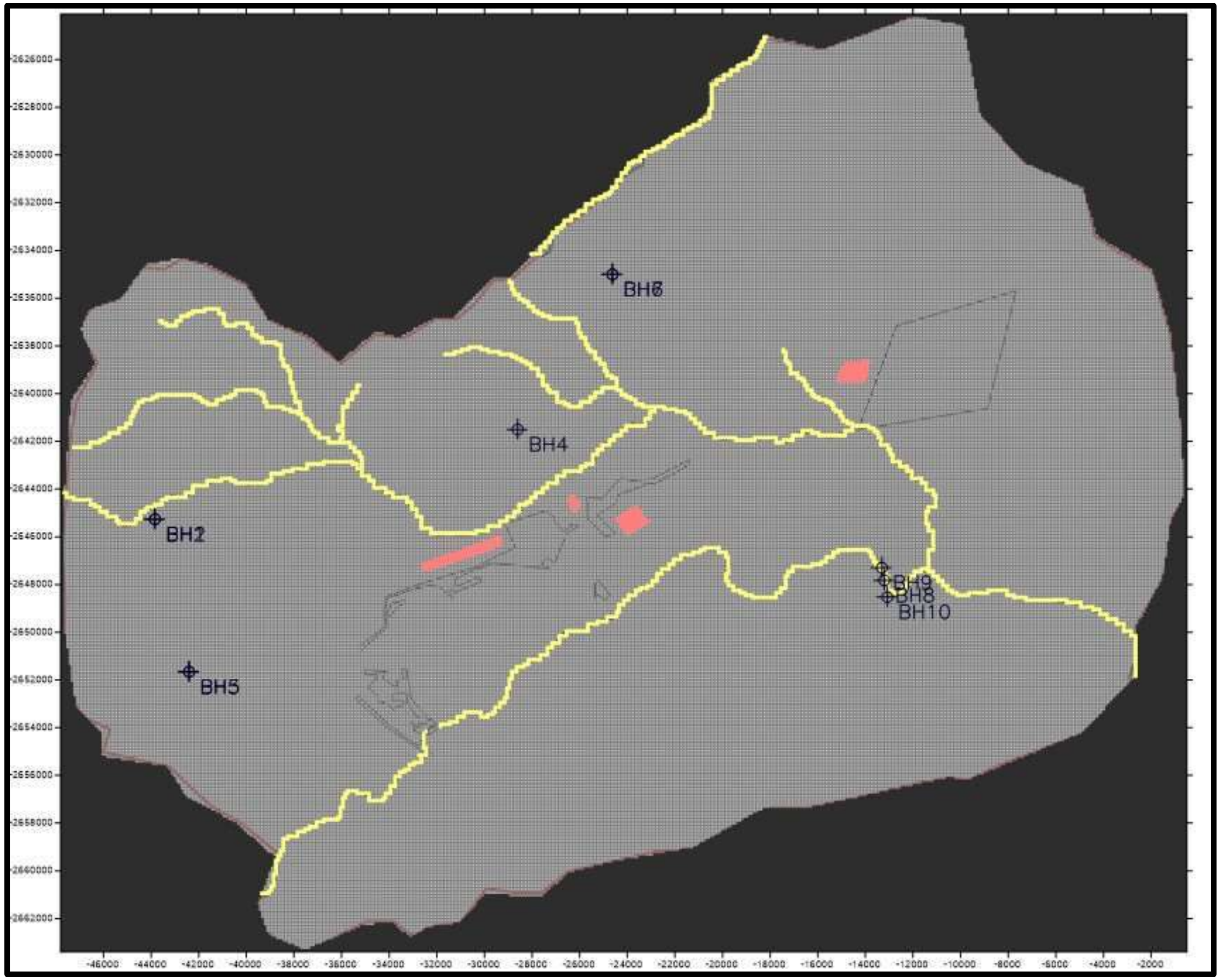


Figure 3-3: Finite Difference MODFLOW Grid applied over the Model

3.10.8 Model Limitations and Assumptions

The following assumptions were made with noted limitations:

1. The accuracy and scale of the assessment will result in deviations at specific points e.g. on the boundaries of mine layout areas however this effect is minimal and the selected mesh elements would represent the footprint of specific infrastructure.
2. The three (3) dimensional domain represent both aquifers in order to incorporate water strikes observed.
3. The base model developed for calibration purposes did not include any dewatering operations, thus no stresses to the aquifer system were included, and so the system was in equilibrium (steady state).
4. For lithological units different than that of the immediate study area hydraulic parameters from literature were used for specific types of geology.
5. Monitoring borehole data (water levels) was only available within the immediate mining area and the surrounding farms.
6. Sections of the model domain were therefore not thereby affecting the confidence level of the model.
7. Considering the spatial extent of the model domain and rainfall stations within the study area, rainfall data from a single station was used to represent entire study area. Once the model was calibrated, the mine proposed pits were incorporated into the model by applying drains to discharge water from the aquifer system.
8. The stream was constrained such that no water leaked from the streams to the groundwater system. By constraining infiltration
9. When the modelling assumptions were made or reference values used, a conservative approach was followed such that the trend was to overestimate groundwater discharges from dewatering .This gives a worst-case scenario for designing the dewatering system and impacts to the receiving environment .It should be noted that dewatering volumes should be less than those simulated by the model.

3.10.9 Model base boundary condition

The model domain was assigned to extend vertically to a depth of 70 m. It is assumed that the base of the model is impermeable.

The mine development stages were simulated as follows:

1. Scenario 1: Current steady state conditions and initial groundwater regime;
2. Scenario 2: Dewatering for a period of 30 years of mining period following mine schedule as indicated above;
3. Scenario 3: Mass transport from rehabilitated pit and tailings.

3.10.10 Scenario 1: Current Steady State Conditions and Initial Groundwater Regime

The model was calibrated in steady state based on the known geological and hydraulic head distribution data for the project site. Calibration was accomplished iteratively by adjusting recharge and hydraulic conductivity values until a reasonable fit between the measured and simulated heads were obtained. The measured data consists of head elevation data from 10 boreholes.

3.10.11 Model Calibration and Sensitivity Analysis

The objective of the model calibration process was to demonstrate that the model was capable of simulating hydraulic heads that match as close as possible the observed heads in Delmas proposed expansion open cast groundwater levels. The calibration process involved the continual adjustment of hydrogeological parameters including recharge, hydraulic conductivity and specific storage until the closest match between model predicted water levels and field measured water levels was obtained. Calibration was done into two (2) stages that is steady state calibration and transient state calibration. The aim of the steady state calibration was to represent the average (i.e. long term) groundwater conditions at the Tiara Mining aquifers. The resulting groundwater heads of the steady state model are used to initialise the transient groundwater models for transient calibration and predictions. The aquifer parameters and boundary conditions determined during steady sate calibration were applied to the transient state model for manual calibration. The transient state calibration satisfied an adequate match to observed groundwater levels affected by abstraction and any modifications to the model during transient calibration required a re-assessment of the steady state calibration.

The numerical model was calibrated and adjusted in steady state by keeping the model complexity to minimum. The quality of the fit between simulated and observed water levels was visually evaluated based on the elevations of the simulated hydraulic heads and by means of a statistical analysis.

The three (3) statistical analysis expressions were used to indicate the errors in calibration:

1) Mean Error (ME)

Mean difference between the measured and simulated water levels

2) Mean Absolute Error (MAE)

Mean of the absolute value of the differences between the measured and simulated heads

3) Root Mean Square Error (RMSE)

RMSE measures how much **error** there is between two data sets and in other words, it compares a simulated value and a measured/observed or known value. It's also known as **Root Mean Square** The Root Mean Squared Error (RMSE) is an important statistical calculation used to determine the difference between simulated values in a model and measured values from observations. If this difference is large the model is likely to be less accurate than if the difference is small; therefore, a modeller can calculate the RMSE and adjust other features until the RMSE is as small as possible to improve the model. The MAE addresses this problem by producing mean absolute values. However, the RMSE error is used most often by modellers in the industry to assess the adequacy of model calibration because the differences between observed and simulated water levels are normalized across the model domain. When the RMSE value is small, the errors are small relative to the overall water level and model response (Anderson and Woessner 1992).

For this study, RMSE was used to assess the calibration of Tiara mining proposed open pit and RMSE error was evaluated as a ratio to the total water level change across the model domain.

For this simulation, the calibration indicators for the aquifers were 5,7 for the ME, 11,65 for the MAE on average and 12,63 for the RMSE. The RMSE value for the calibrated model is greater than the typical range of **10%** used by most modellers as the threshold for a well calibrated model as depicted in the tabulation below.

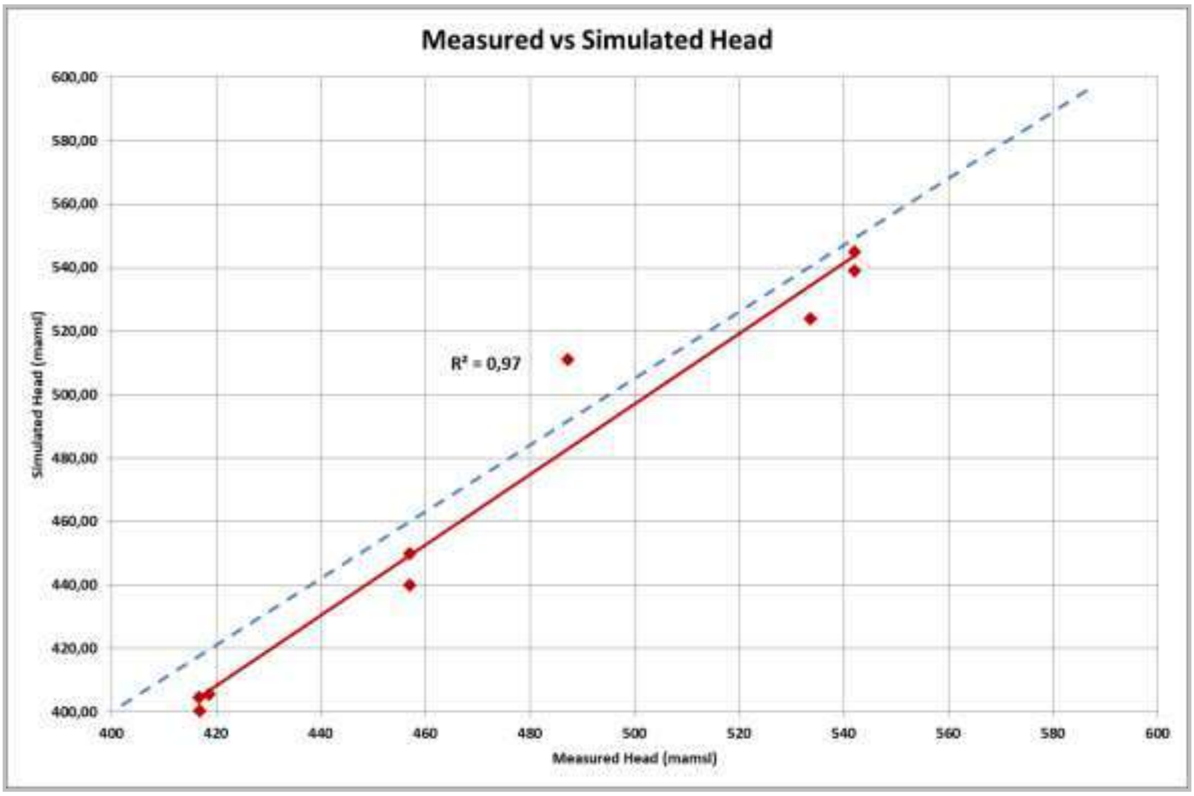
Based on this, the steady state model was determined to be adequately calibrated for use in adapting the model for predictive transient simulations to assess dewatering volumes and possible environmental impacts.

Table 3-1: Statistical Model Calibration –Simulated versus Measured Heads

No.	Component	Statistical Analysis	Observed Heads	Simulated Heads	Mean Error(m) ME	Mean ABS Error(m) MAE	Root Mean Square Error(m) RMS
1	Boreholes	**Max.**	545,00	542,00	16,95	23,75	563,97
2		**Min.**	400,50	416,72	-23,75	3,00	9,00
3		**Average**	468,83	474,53	5,70	11,65	177,26
4		**95th Percentile**	542,60	542,00	16,69	21,03	453,31
5		**5th Percentile**	402,10	416,75	-15,45	3,00	9,00
6		**Std.Dev**	60,78	53,81	12,76	6,84	177,13
7		**∑**			**51,32**	**104,81**	**1595,31**
8		**1/n**			**0,10**	**0,10**	**0,10**
10		**RMSE (Root Mean Square Error)**					**12,63**
11		**Correlation**	**0,98**				

In figure below, the difference between observed and simulated heads from the calibration process is shown. A negative value indicates that the observed head is lower than the head predicted by the simulation and vice versa.

The variances are due to known and/or unknown complexity in the geological environment that is not captured in the model. Once dewatering of the hydrogeological system start, then the model will be updated to reflect the major responses in hydraulic heads. The head elevation data from 21 observation boreholes were used to calibrate the steady-state flow model. The steady-state calibration of the measured and the simulated water levels resulted in an acceptable correlation of $\mathbf{R^2 = 0.97}$ for the boreholes. The model was calibrated in steady state with the parameters and the measured water levels were compared with simulated water levels to get an acceptable fit which would represent a realistic aquifer system as it might be in nature.



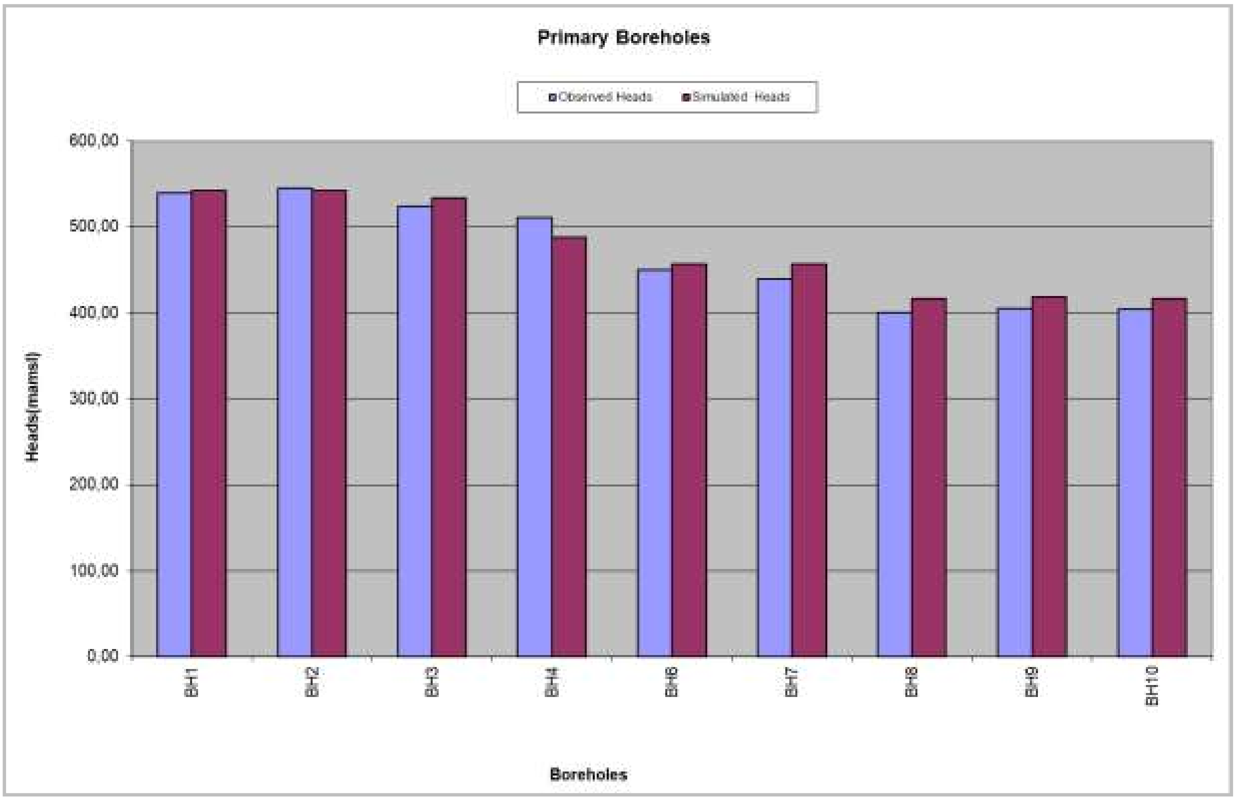


Figure 3-4: Simulated versus Measured Calibrated Heads

The groundwater balance indicates that approximately 16200 m^3/d coming into the system from precipitation and subsequent recharge with almost the same rate of outflow through the drainages as shown in the tabulation below. A preliminary regional groundwater balance is presented for the various scenarios discussed in the previous section.

The objective of the steady state model is to simulate the undisturbed groundwater status quo groundwater levels. The hydraulic head distribution of the steady state solution is then used as initial head distribution for the transient (time-dependant) model.

The transient model time steps were divided into a 1 year period with 12 time steps. Current groundwater flow directions are from west to east directions in the direction of Ga-Selati and in the middle of the model domain the localised depression on the head values indicates the dewatering impact of the proposed expansion existing pit.

A preliminary regional groundwater balance is presented for the various scenarios discussed in the previous section. There is an average of 300-400 m^3/d (3.5-4.6 ℓ/s) flowing into the proposed pit as defined as possible overall recharge.

The recharge per each proposed pit is described below. The groundwater balance is to be updated with DWA's registered groundwater abstraction and reserve data for the catchment.

Table 3-2: Initial Steady State Groundwater Budget

No	Component	Inflow (m^3/d)	Outflow (m^3/d)	Balance (m^3/d)
1	Recharge Overall	15887,00		15887,00
2	Opencast A(1-4 years)	82,00		82,00
3	Opencast B(5-10 years)	27,00		27,00
4	Opencast C(11-16 years)	123,00		123,00
5	Opencast D(17-20 years)	10,00		10,00
6	Opencast E(21-28 years)	5,00		5,00
7	Opencast F(21-28 years)	0,00		0,00
8	Opencast G(21-28 years)	47,00		47,00
9	Opencast H(21-28 years)	13,00		13,00
10	Opencast I(29-30 years)	6,00		6,00
11	Base flow streams-		-16200,00	-16200,00
12	**Total**	**16200,00**	**-16200,00**	**0,00**
13	**Imbalance (%)**			**0**

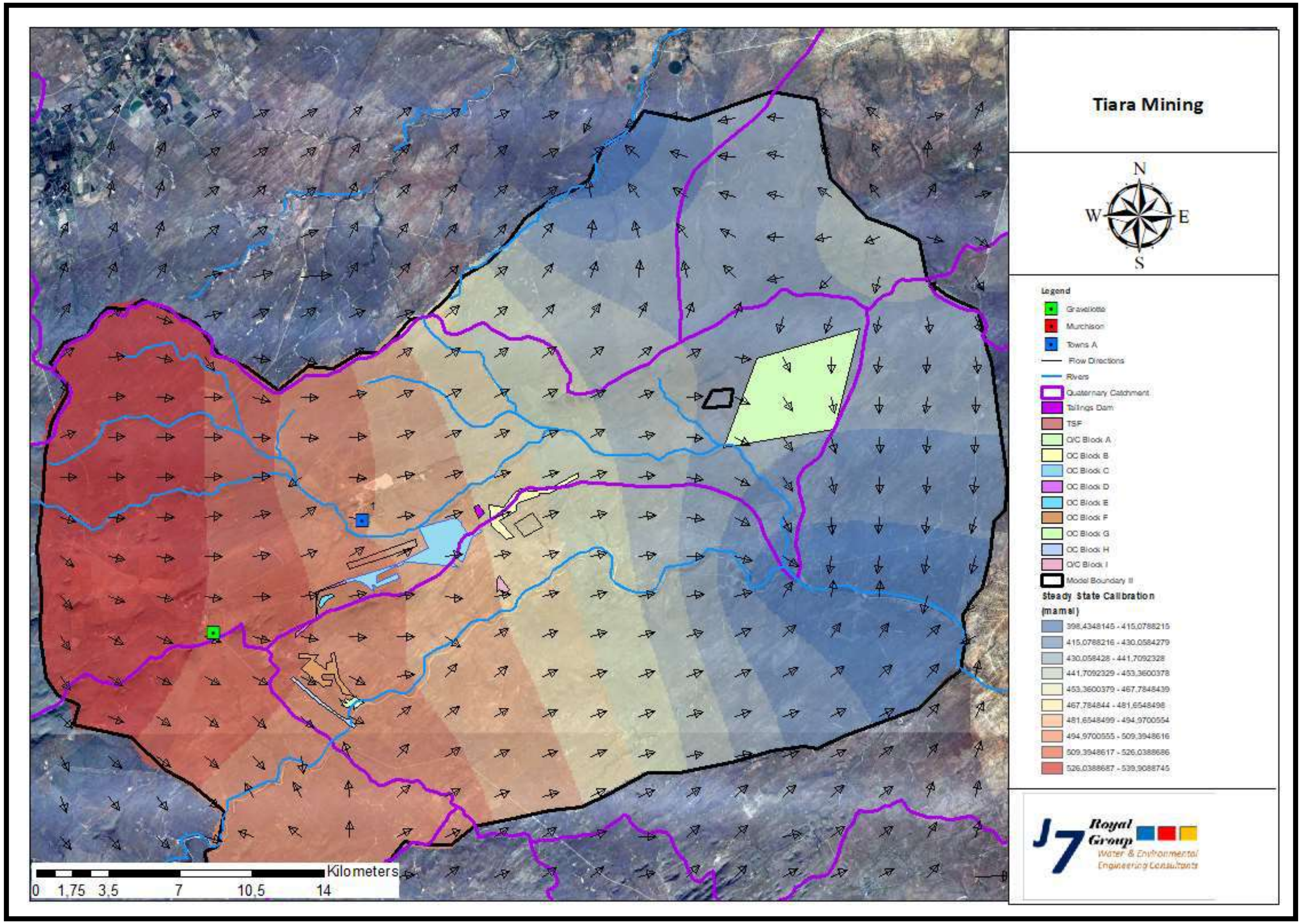


Figure 3-5: Simulated Steady-State Piezometric Heads and Flow Direction

3.10.12 Piezometric Heads and gradients

The piezometric heads and gradients for the calibrated model showed that the gradient and general flow follows the topography which is from west and south-east to the north, via the Ga-Selati River as base as shown in the figure above.

The general drainage direction is west to east in the study area and the groundwater drains in a eastern to south direction. The head constrained boundary conditions at both non-perennial and perennial streams including the Ga-Selati and Molatle River influences groundwater to drain down gradient towards drainages.

4 Transient Model

The transient state model calibration was conducted predominantly to estimate the aquifer storage values. The predictive model was setup according to the mine plan to estimate the inflow rates. The transient model is also applied to predict the cone of dewatering and contamination plume originating from potential sources. Aspects of the predictive model are discussed below.

The water balance of the aquifer during mining is altered due to inflows into the pits and has potential impacts on the water levels within and around the existing farms and subsequently on the aquifer water balance.

Scenario 2: Dewatering of Pits impacts 30 years

The level of detail provided in the mine plan was modelled as accurately as possible by dividing the model into stress periods, representing each mining strip per the mine plan.

Drain cells were used to model inflows due to mining and the modelled drain elevations were set to the final pit floors and progressed through yearly increments. The following mining approach has been adopted:

- Bock A proposed Mining Schedule (Year 1 to Year 4);
- Block B proposed Mining Schedule (Year 5 to Year 10);
- Block C proposed Mining Schedule (Year 11 to Year16);
- Block D proposed Mining Schedule (Year 17 to Year20);
- Block E,F,G,H proposed Mining Schedule (Year 21 to Year 28);

- Block I proposed Mining Schedule (Year 29 to Year30).

4.1 Groundwater Flow Patterns

The expected and anticipated inflow rates are not a cause for alarm and distress at the current moment as a maximum of roughly between 120 m^3/d and 250 m^3/d (2018) are predicted and in principle, in the absenteeism of rainfall, dry mining conditions will prevail at Tiara Granville mining operation. The groundwater seems to flow radially towards borehole pits.

The informed existing groundwater level dataset was contoured to visualise the groundwater table in the vicinity of the Tiara Mining operations. The figures below indicate a general decrease in groundwater levels around the project area.

The main and major impact due to mine dewatering is predicted to lie around proposed open pit (Block C) as it is almost within the Ga-Selati River.

The simulation indicated a maximum Zone of Influence (ZOI) depth located at the open pits approximately 70m in depth. The maximum lateral extent of the ZOI is approximately less than 1km from the centre positions of the pits.

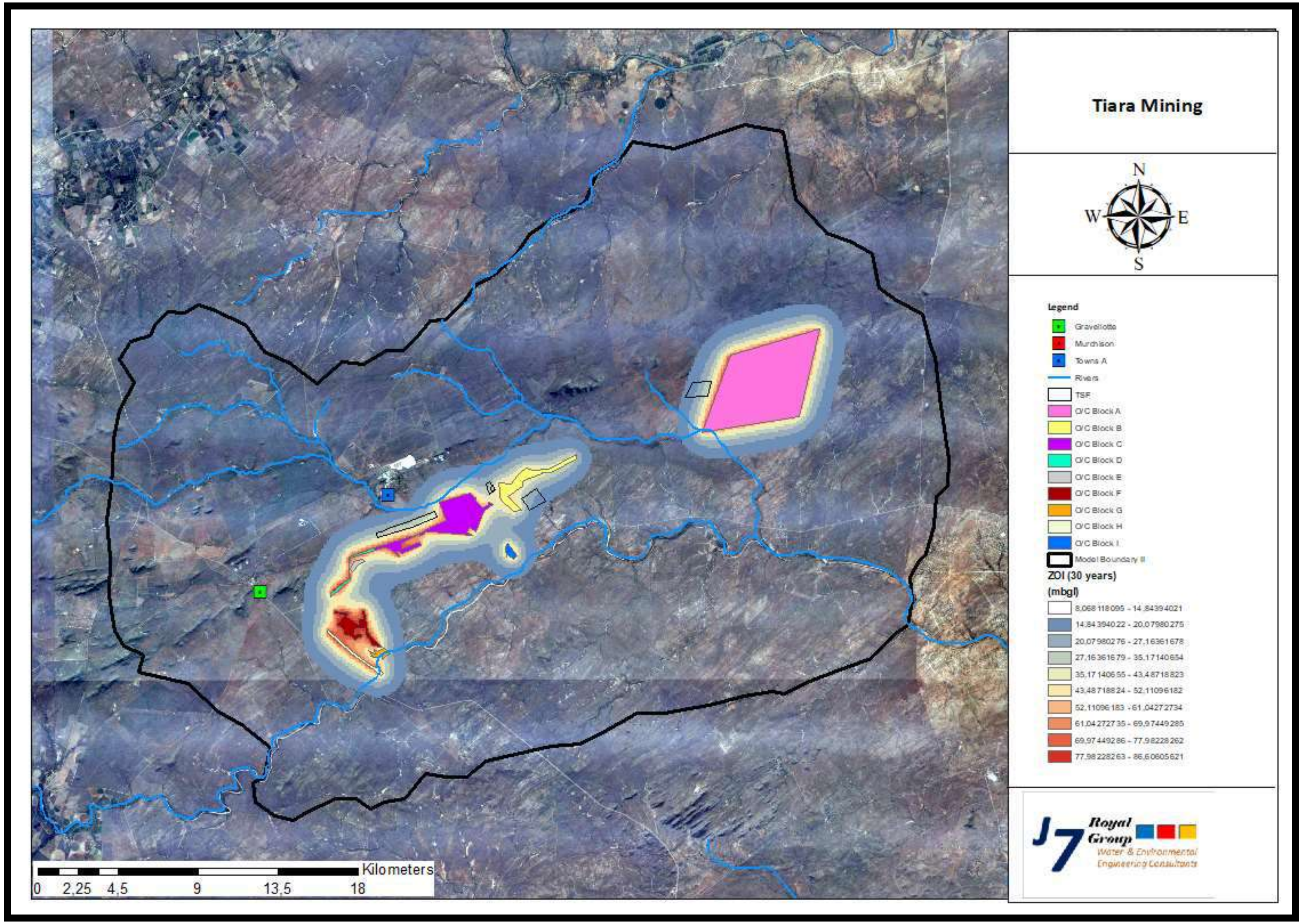


Figure 4-1: Cumulative Impacts Aquifer Zone of Influence (ZOI)

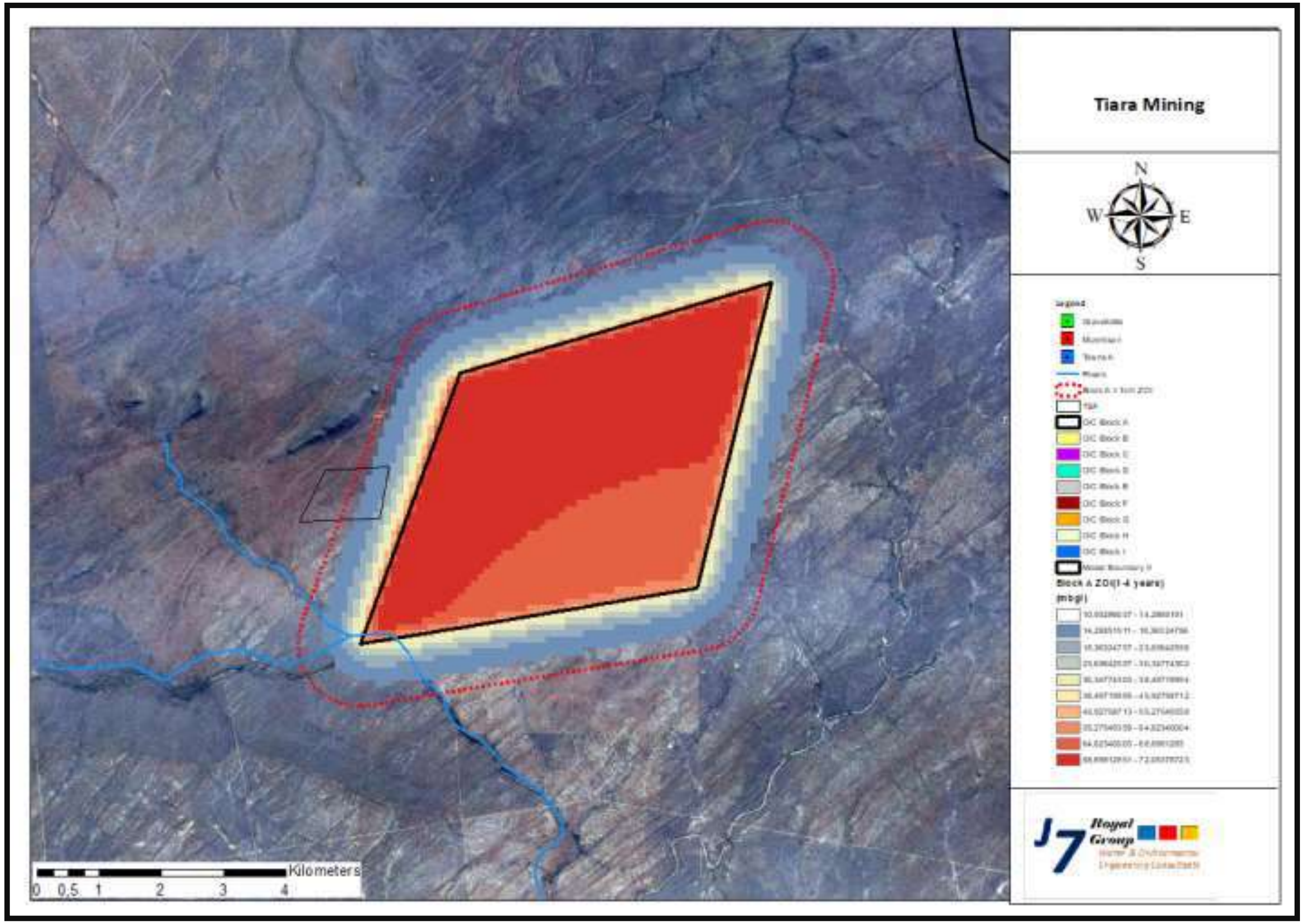


Figure 4-2: Block A (ZOI) impact (1-4 years)

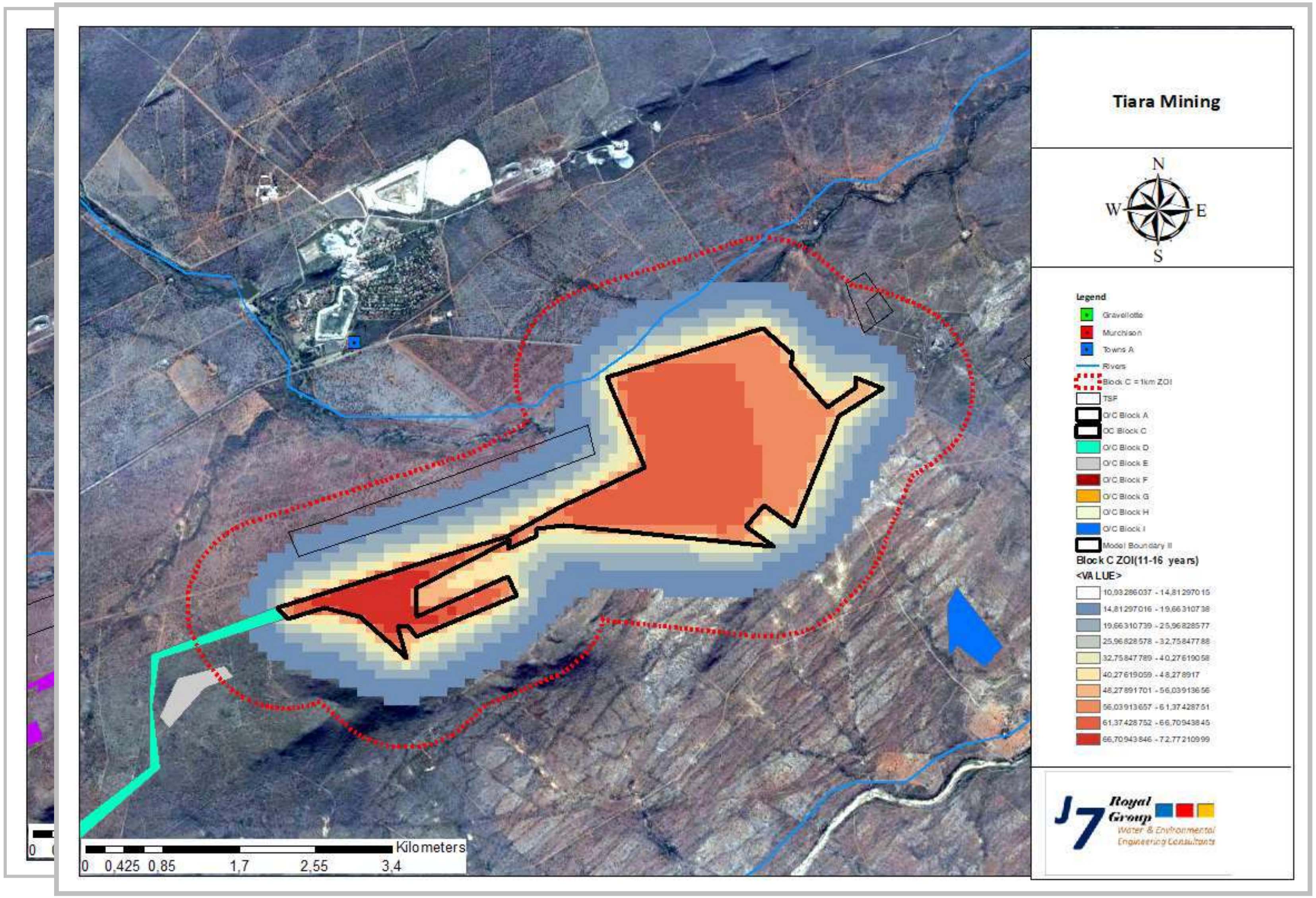


Figure 4-3: Block B (ZOI) impact (5-10 years)

Figure 4-4 Block C (ZOI) impact (11-16 years)

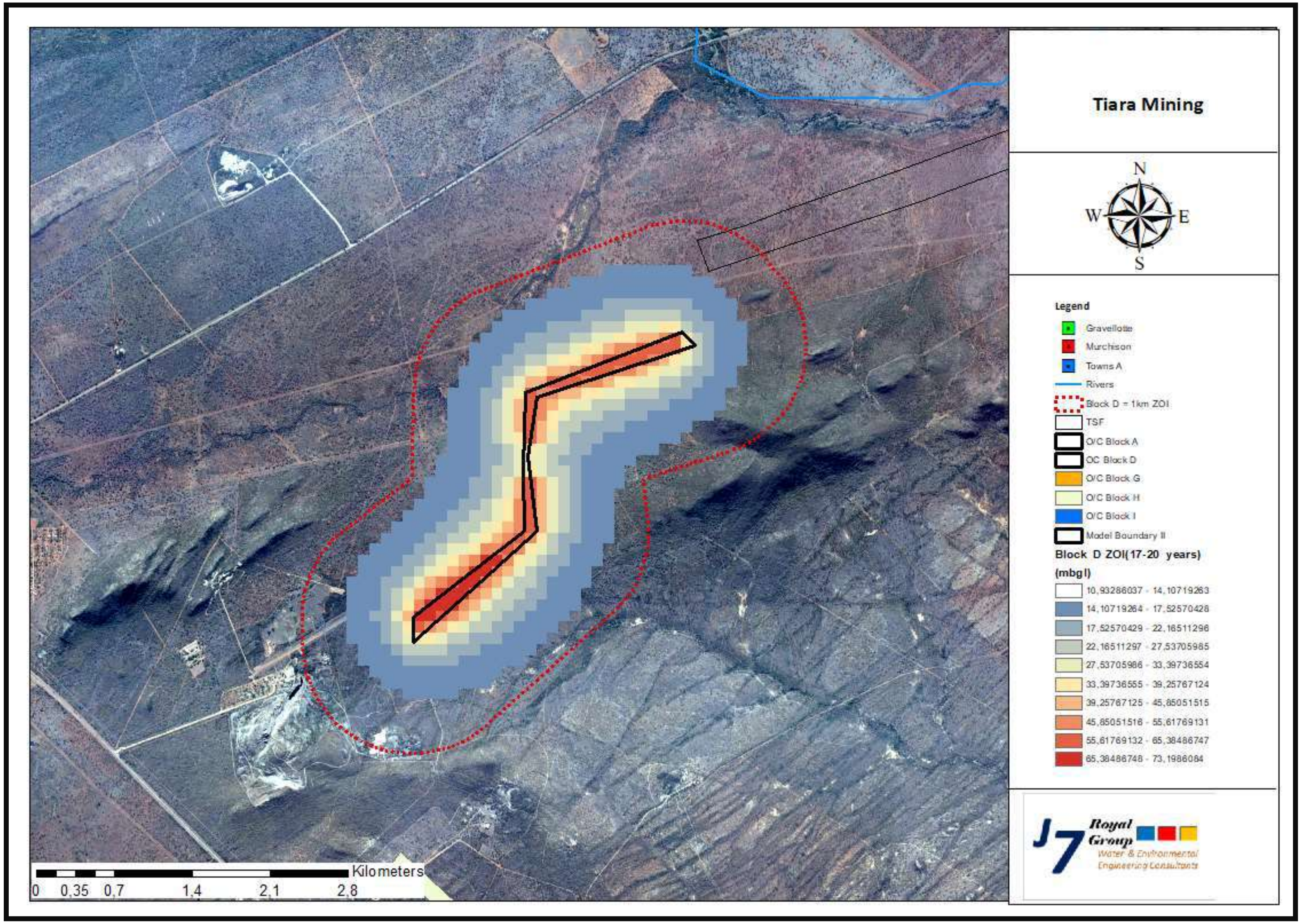


Figure 4-5: Block D (ZOI) impact (11-16 years)

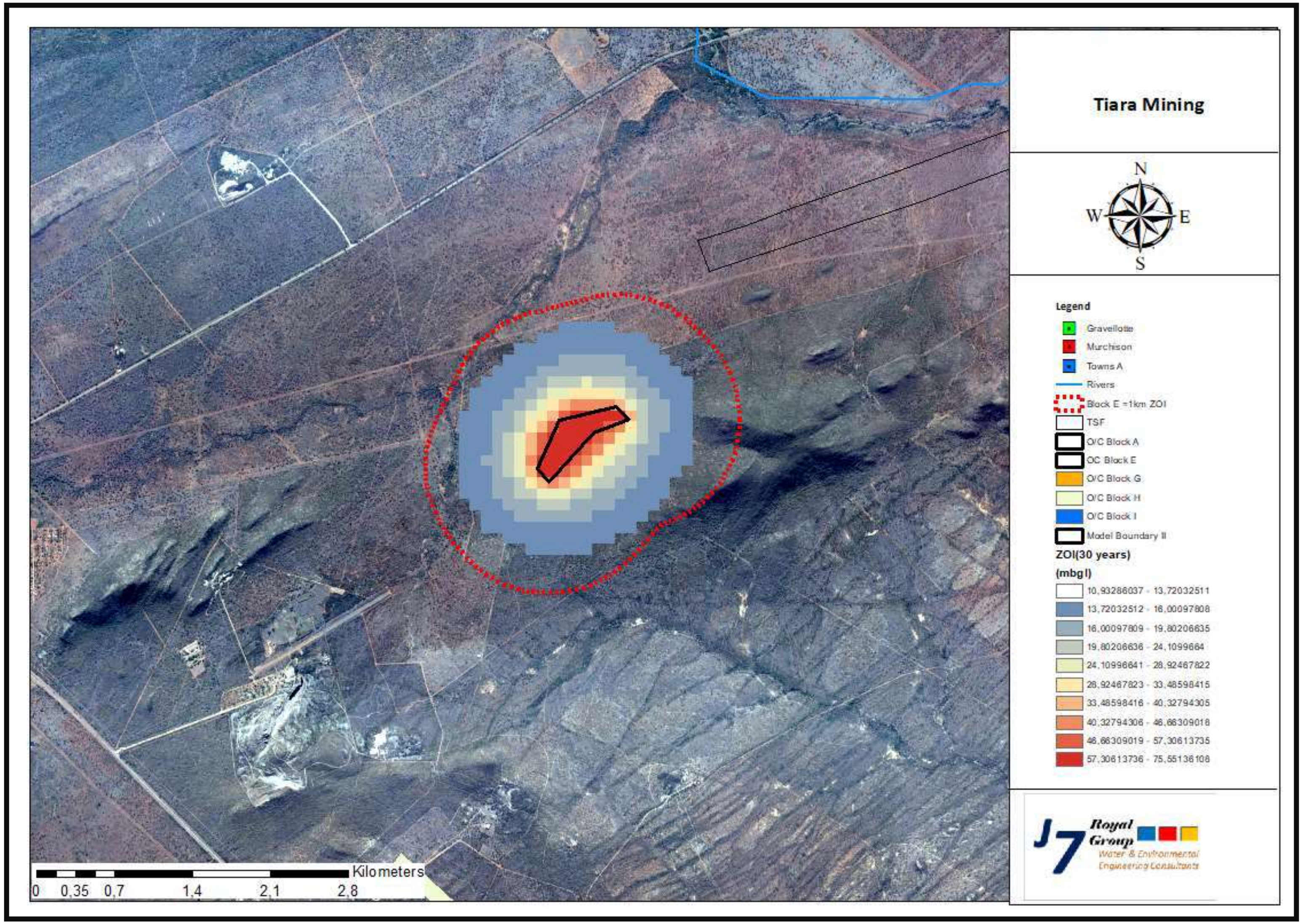


Figure 4-6: Block E (ZOI) impact (17-20 years)

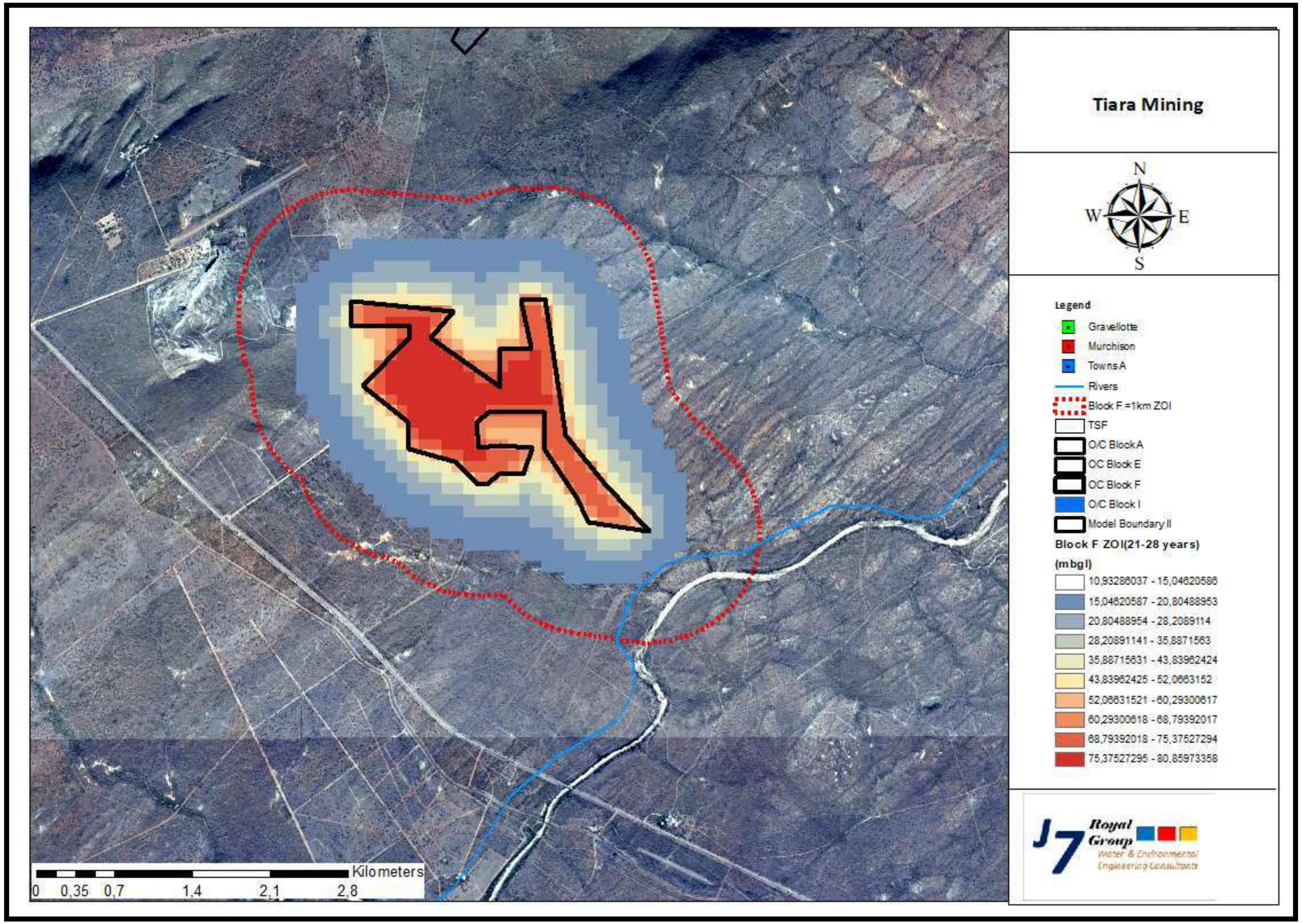


Figure 4-7: Block F (ZOI) impact (21-28 years)

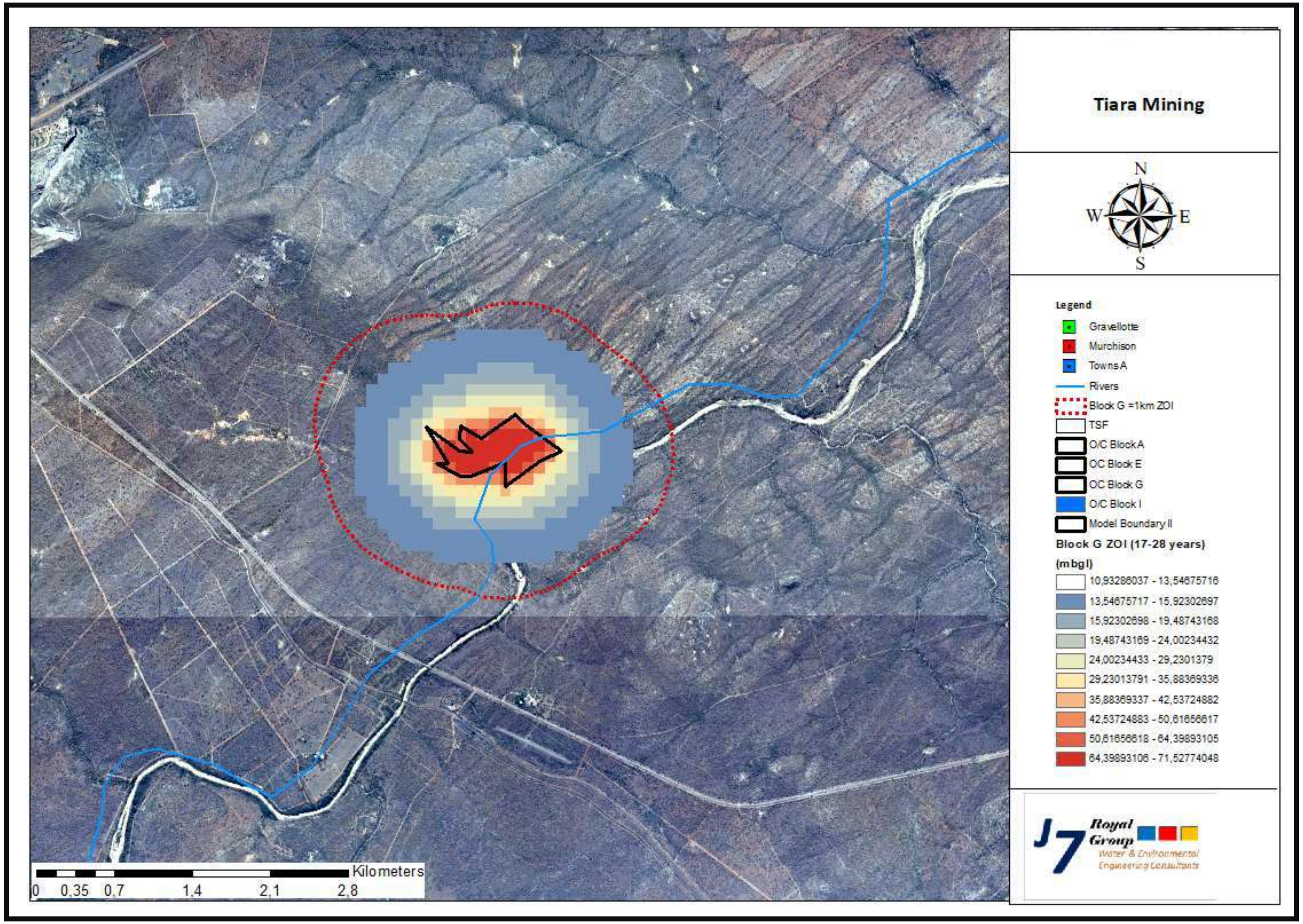


Figure 4-8: Block G (ZOI) impact (21-28 years)

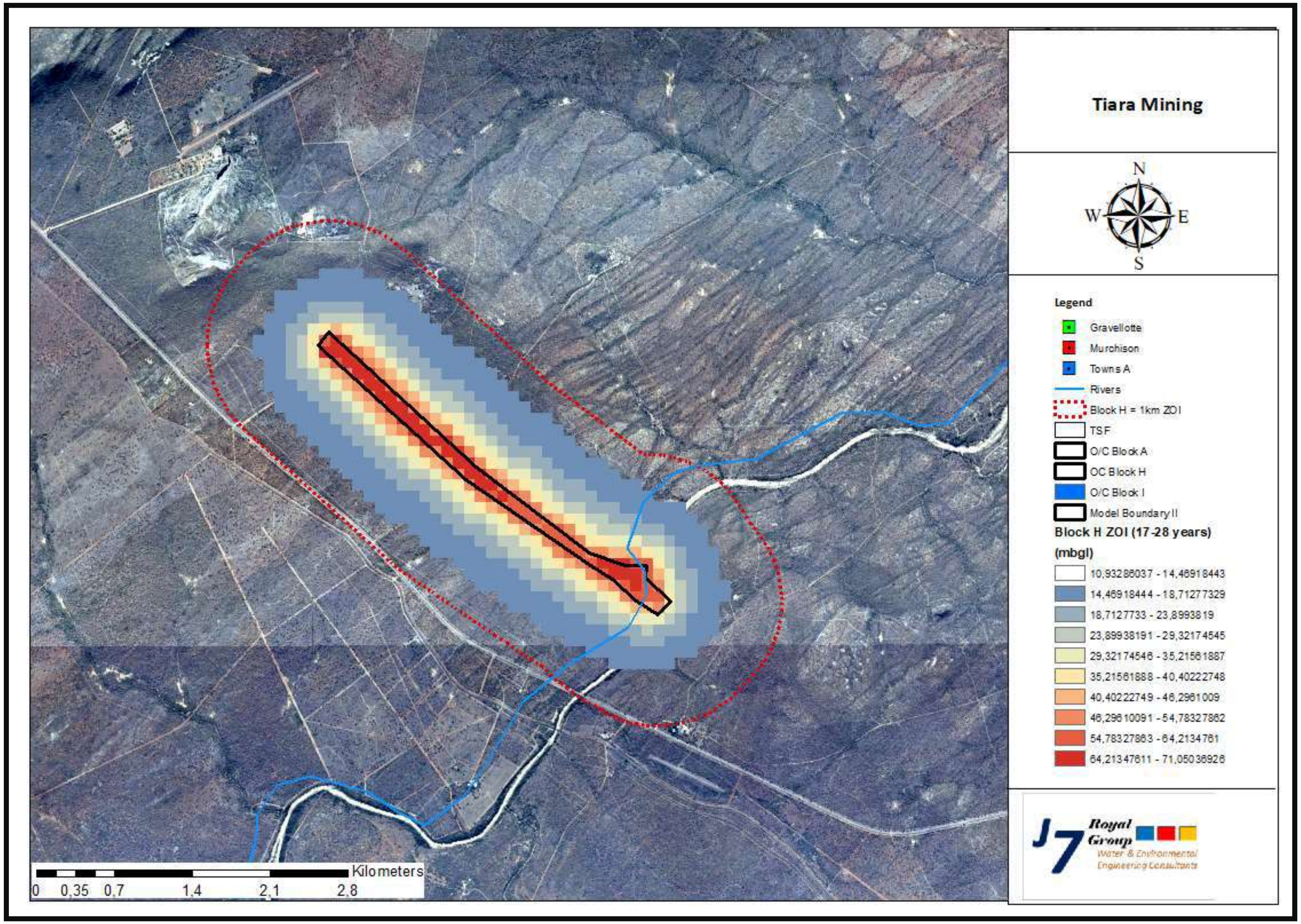


Figure 4-9: Block H (ZOI) impact (21-28 years)

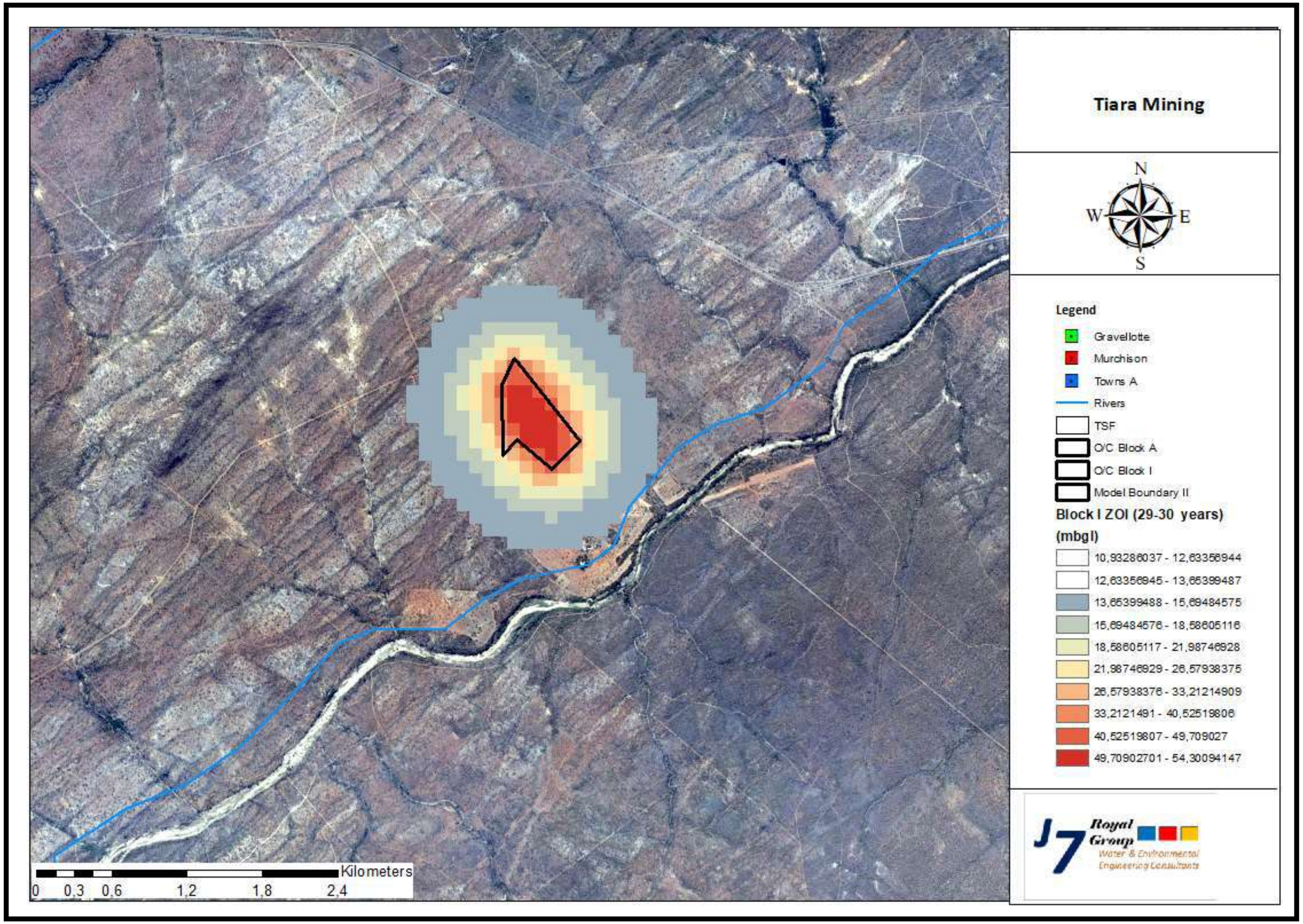


Figure 4-10: Block I (ZOI) impact (29-30 years)

4.2 Mass Transport with Simulated Dewatering

Following the potential post-operational water quality, the values quantified by NGDB data was adapted to various mean values and a conservative application of the data was applied with a TDS of 1000 mg/L and sulphate concentration of 500 mg/L.

Table 4-1 : Mine relative abundances of Acid and Buffer Capacity

No	Variable	TDS (mg/L)	SO4 (mg/L)
1	Adapted to Arithmetic mean TS %	2117	378
2	Adapted to harmonic Mean TS %	**861**	**34**
3	Values used in the Model	**1000**	**500**

It has been observed from Tailings Facility (TSF) and three (3) overburden that Sulphate and TDS were identified as the main seepage constituent from the waste material. The Sulphate and TDS were simulated to originate from the TSF and overburden stockpiles. Seepage concentration of 500mg/ℓ for SO4, and 1000mg/ℓ for TDS; were observed and used for numerical simulation as the final accumulation concentration.

The mass transport model was conservatively simulated using advective transport with a regional porosity value of 2-3 %. The background Sulphate (SO_4) and TDS concentration assigned to the regional area was 10 mg/ℓ.

The simulation results indicate a slow migration of mass from the TSF and three(3) overburden stockpiles and the following key observations:

- The TDS and Sulphate seepage from the TSF and overburden stockpiles is contained in the immediate facility of the rehabilitated pit as shown in figure below;
- There is a tendency for the TDS and Sulphate to migrate towards the eastern south probably because of the groundwater movement directions along the drainages from the pit;
- The total migration distance towards the from TSF and overburden stockpiles is approximately 300m during the LoM and post-closure simulation. This would imply a migration rate of 0.001245m a day, without any seepage capturing methods implemented; and
- Groundwater monitoring boreholes should be drilled up gradient and down-gradient of the pit both shallow and deep boreholes to monitor the shallow and deep aquifer.
- Once monitoring data is available, groundwater numerical model must be updated.

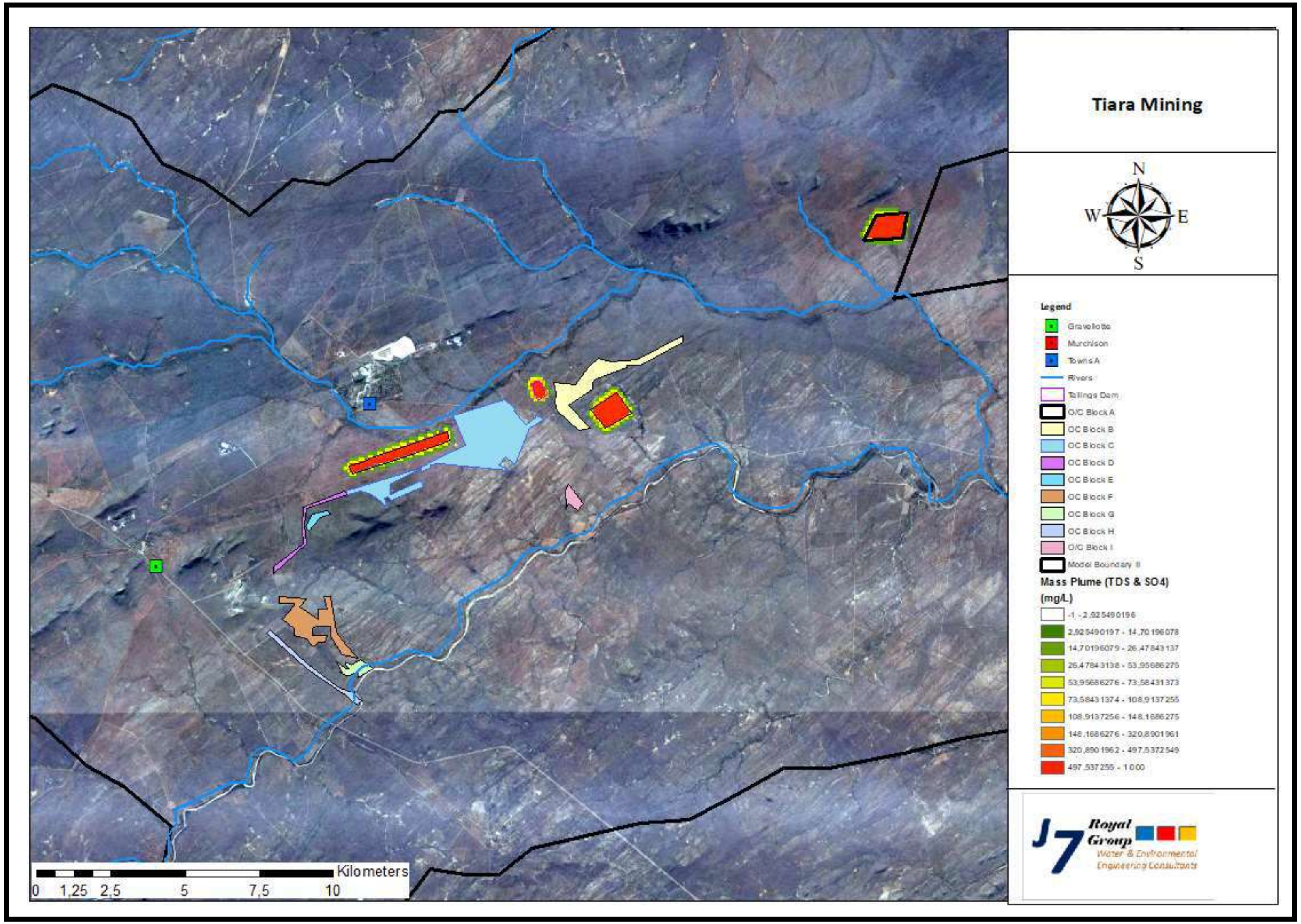


Figure 4-11: TDS and SO4 Simulation Impact during mine inception

5 Impact Assessment Methodology

The impact methodology will concentrate on addressing key issues. This methodology to be employed in the report thus results in a circular route, which allows for the evaluation of the efficiency of the process itself. The assessment of actions in each phase will be conducted in the following order:

- Assessment of key issues;
- Analysis of the activities relating to the proposed development;
- Assessment of the potential impacts arising from the activities, without mitigation, and
- Investigation of the relevant mitigation measures during Assessment.

5.1 Construction phase

This phase is concerned with all the construction and construction related activities on site, until the contractor leaves the site. Thus, the main activities will be the establishment of construction camp sites, access routes, clearance of servitude to facilitate access, digging the foundations, excavation of pits for transformer foundation, erection of transformer and associated structures, movement of construction workforce, equipment, construction vehicles and materials, etc. The above-mentioned activities result in different types of impacts and some contribute to cumulative impacts.

5.2 Operational phase

This phase involves activities that are post construction, i.e. the fully fledged functioning of the commercial facility. This phase requires a rehabilitation plan and monitoring system that will ensure the impacts of construction, such as vegetation pruning, erosion, colonisation of the study area by alien species, proliferation of disease, loss/reduction of economic sources, and preservation of heritage artefacts etc. are monitored and inspected as an on-going process. This involves the maintenance of the facilities to ensure continuous proper functioning of the equipment or resource.

The impact rating is only exposed when the impact is summarised in terms of its ratings. This approach enables analysis of the impact results, in terms of:

1. The number of severity criteria applicable as an indicator of influence/ severity;
2. The changes in number of low, moderate and high ratings before and after mitigation, and
3. The changes in quantitative/weighted magnitude before and after mitigation.

5.3 Assessment Criteria

An impact can be defined as any change in the physical-chemical, biological, cultural and/or socio-economic environmental system that can be attributed to human activities related to alternatives under study for meeting a project need.

The significance of the aspects/impacts of the process will be rated by using a matrix derived from Plomp (2004) and adapted to some extent to fit this process. These matrixes use the consequence and the likelihood of the different aspects and associated impacts to determine the significance of the impacts.

The significance of the impacts will be determined through a synthesis of the criteria below:

Probability: This describes the likelihood of the impact actually occurring

Improbable: The possibility of the impact occurring is very low, due to the circumstances, design or experience.

Probable: There is a probability that the impact will occur to the extent that provision must be made therefore.

Highly Probable: It is most likely that the impact will occur at some stage of the development.

Definite: The impact will take place regardless of any prevention plans and there can only be relied on mitigatory measures or contingency plans to contain the effect.

Duration: The lifetime of the impact

Short Term: The impact will either disappear with mitigation or will be mitigated through natural processes in a time span shorter than any of the phases.

Medium Term: The impact will last up to the end of the phases, where after it will be negated.

Long Term: The impact will last for the entire operational phase of the project but will be mitigated by direct human action or by natural processes thereafter.

Permanent: The impact is non-transitory. Mitigation either by man or natural processes will not occur in such a way or in such a time span that the impact can be considered transient.

Scale: The physical and spatial size of the impact

Local: The impacted area extends only as far as the activity, e.g. footprint

Site: The impact could affect the whole, or a measurable portion of the above mentioned properties.

Regional: The impact could affect the area including the neighbouring municipalities and hydrological catchments.

Magnitude/ Severity: The degree to which the impacts destroy the environment, or alter its function

Low: The impact alters the affected environment in such a way that natural processes are not affected.

Medium: The affected environment is altered, but functions and processes continue in a modified way.

High: The function or processes of the affected environment are disturbed to the extent where it temporarily or permanently ceases.

Significance: This is an indication of the importance of the impact in terms of both physical extent and time scale, and therefore indicates the level of mitigation required.

Negligible: The impact is non-existent or unsubstantial and is of no or little importance to any stakeholder and can be ignored.

Low: The impact is limited in extent, has low to medium intensity; whatever its probability of occurrence is, the impact will not have a material effect on the decision and is likely to require management intervention with increased costs.

Moderate: The impact is of importance to one or more stakeholders, and its intensity will be medium or high; therefore, the impact may materially affect the decision and management intervention will be required.

High: The impact could render development options controversial or the project unacceptable if it cannot be reduced to acceptable levels; and/or the cost of management intervention will be a significant factor in mitigation.

Table 5-1: The following weights were assigned to each attribute

Aspect	Description	Weight
Probability	Improbable	1
	Probable	2
	Highly Probable	4
	Definite	5
Duration	Short term	1
	Medium term	3
	Long term	4
	Permanent	5
Scale	Local	1
	Site	2
	Regional	3
Magnitude/Severity	Low	2
	Medium	6
	High	8
Significance	**Sum (Duration, Scale, Magnitude) x Probability**	
	Negligible	≤20
	Low	>20 ≤40
	Moderate	>40 ≤60
	High	>60

The significance of each activity should be rated without mitigation measures (WOM) and with mitigation (WM) measures for both construction, operational and closure phases of the proposed development.

Table 5-2: Impact Assessment and Mitigation Measures

Phase Details	Sources Activities	No	Potential Environmental Impact	Nature	M	D	S	P	Significance (WOM)	Significance (WM)
Opencast mine workings	Mining of the open Pits	1.1	Creation of pressure head, groundwater mounding and alteration of groundwater gradients	Negative	2	3	2	5	(35) Low	(24) Low
					2	3	2	5		
		1.2	Elevation of SO4 and TDS concentrations inside the TSF and Overburden stockpiles through contaminated water infiltration	Negative	6	4	2	5	(60) Moderate	(35) Low
					2	4	1	5		
		1.3	Contamination plume of elevated concentrations in TSF reaching clean water drainage system	Negative	2	4	3	5	(45) Moderate	(16) Negligible
					2	1	1	4		
Groundwater and Surface water monitoring	Alteration of natural topographical gradients and natural drainage lines	1.4	Prolonged contamination of groundwater and surface water as well as erosion	Positive	6	3	2	2	(22) Low	(4) Negligible
					2	1	1	1		
		1.5	No indication of how to manage seepage water from TSF and overburden stockyards into groundwater	Negative	6	1	3	4	(40) Moderate	(4) Negligible
					2	1	1	1		
All Phases	Storm water management	1.6	Flooding of the open pits	Negative	6	1	3	4	(40) Moderate	(4) Negligible
					4	1	1	1		

6 Mitigation Measures

6.1.1 Construction Phase

The following mitigation measures are recommended for the construction phase:

- Construction should preferably take place during the dry season;
- Adequate fuel containment facilities to be used during construction phase;
- All materials, fuels and chemicals must be stored in a specific and secured area to prevent pollution from spillage and leakages;
- Construction vehicles and machines must be maintained properly to ensure that oil spillages are kept to a minimum;
- Spill trays must be provided if refuelling of construction vehicles are done of site;
- Chemical sanitary facilities must be provided for construction workers. Construction workers should only be allowed to use temporary chemical toilets on site. Chemical toilets shall not be within close proximity to the drainage system. Frequent maintenance should include removal without spillages;
- No uncontrolled discharges from the construction camp shall be permitted;
- The removal/excavated soil and vegetation should be replaced once construction is complete and the pipeline cavities filled in and re-vegetated where possible;
- Real time monitoring should be installed in equipped boreholes and monthly monitoring should be conducted on water levels measurements and groundwater quality;

6.1.2 Operational Phase

The following mitigation measures are proposed to manage and reduce the impacts that may arise from the operational phase

- The radius of influence should be monitored with local and regional water level measurements monthly. Substitute water should be supplied if it's found and proven that neighbouring water levels and yields are affected;
- Drilling and long-term aquifer testing should be conducted as well as on-going monitoring to establish the source of the dewatered volumes;

- Packer testing should be conducted in boreholes drilled deep in the sub-surface to accurately determine the aquifer parameters for the different geological units. The groundwater flow model should be updated accordingly;
- Long duration aquifer tests should be conducted on any newly drilled water supply, monitoring and seepage capturing boreholes drilled during the LoM;
- The groundwater flow mode should be updated before operations start and then every two years from there on;
- Water seepage from the waste rock dumps and TSF should be intersected by a seepage capturing trench and directed into a PCD for reuse;
- The primary mitigation for the TSF should be ton enforce an adequate liner;
- Boreholes and related equipment should be in a fenced-off area for protection against theft and vandalism;
- Communities should be consulted in advance about the potential lowering of water levels in their boreholes;
- Groundwater levels and quality should be monitored in all pumping wells throughout;
- The monitoring programme must be implemented and honoured.

6.1.3 Operational Phase

- Numerical and geochemical model should be updated prior to the decommission phase to adequately determine the post closure impacts;
- Monitoring protocol to be implemented t strategically place monitoring locations to evaluate the potential zone of influence. Mining operation should provide alternative water supply to all affected groundwater users;
- Seepage must be captured around the TSF and WRD by making use of seepage capturing system such as development of cut-off trenches around the discard facilities;
- Rehabilitate the mine residue footprint to limit ingress and recharge to these facilities and minimise potential leaching into the groundwater;
- Monitoring of water quality in the neighbouring boreholes and monitoring boreholes drilled for that purpose should continue quarterly post closure for at least 12 months;
- Monitoring of surface water features upstream and downstream of the mine should be continued. Provision for this should be in the rehabilitation budget.

7 Conclusion

The following conclusions are drawn from the groundwater numerical model for Tiara Granville Quartz and Emerald Mine:

1. There is a general low decrease in groundwater levels around area due to high irrigation and mining in the surrounding area and other existing activities;
2. Inflow /recharge into the Tiara Mining proposed open pits throughout the mining duration ranges 300-400m^3/d;
3. Groundwater levels on average is around 11-36 mbgl;
4. Water quality in the area indicates CaMgHCO3 type (Hardness);
5. Boreholes Water TDS is around 762-948 mg/L, borehole water not good for consumptions;
6. Simulation of groundwater inflow to the pits indicated that the aquifers underlying the proposed Tiara Mining operation have a low hydraulic conductivity;
7. In general the aquifer in the immediate vicinity of the open pits is predicted to go dry;
8. Any potential leachate emanating from the TSF ,overburden stockpiles adjacent to the current mining pit will eventually seep to the pit;
9. Sulphates and TDS are frequently observed as the key outlining element in assessing probable mining impacts. The background sulphate concentration is currently very low in all boreholes. This is a clear indication that acid mine drainage (AMD) processes due to mining have not affected the groundwater system. Any future increase in sulphate concentration in the monitoring network can potentially be associated with mining impacts.

8 Recommendations

1. The paramount groundwater management practice of quarterly groundwater level and quality monitoring should stay and continue to be measured as this would serve as an early warning system in the event of the occurrence of hostile influences and impacts (DWA,2015);

2. If and when the groundwater quality monitoring and geochemical modelling assessment indicates possible contamination due to AMD, a shallow cut-off trench may be used and to capture any seepage towards the Bronkhorstspruit (DWA, 2015).

3. The groundwater model should be updated when monitoring data is available;

4. Drilling of new boreholes must be conducted before inception of mining begins to verify all findings covered in this study;

5. Water levels in the surrounding boreholes must be measured on a monthly basis before and after mining commenced;

6. Water levels in boreholes up to 2 km from the mine must be monitored on a monthly basis before and after mining activities commenced to determine the decrease in water level;

7. A detailed hydrocensus in the nearby farms is required. The hydrocensus should record the positions of the groundwater sources as well as the water level and depth of these sources;

8. The monitoring protocol and mitigation measures should be adhered to. The monitoring programme must include all the metal ions above total concentration threshold zero;

9. Flow meters should be installed to obtain legal water supply and water use information;

10. The paramount groundwater management practice of quarterly groundwater level and quality monitoring should stay and continue to be measured as this would serve as an early warning system in the event of the occurrence of hostile influences and impacts(DWA,2015);

Appendix 6 - Tiara Granville - Visual Impact Assessment

ENVIRONMENTAL & ENGINEERING

REPORT

TIARA MINING (PTY) LTD

VISUAL IMPACT ASSESSMENT (VIA)

REPORT REF: 20-1194

RE AND PORTION 12 OF THE FARM BVB RANCH 776 LT, RE OF THE FARM JOSEPHINE 749 LT, BUFFALO RANCH 834 LT, RE OF THE FARM DANIE 789 LT, GRANVILLE 767 LT, PORTION 6 AND RE OF THE FARM FARREL 781 LT AS WELL AS R/E OF THE FARM WILLIE 787 LT - LIMPOPO PROVINCE.)

2020-11-19

VERSION CC

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BB – draft	2020-11-18	Vernon Siemelink		Technical Review
CC– draft	2020-11-19	Leoni le Roux		Quality review
DD– draft				Client review
Approved for Distribution:				
0.1				Final report

Quality Control BY:

Nature of Signoff:	Responsible Person:	Role / Responsibility	Qualification
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Quality Reviewer	Leoni le Roux	Administrator	Professional Secretary and Personal Assistant
Reviewer	Vernon Siemelink	Senior Environmental Consultant ISO 14001:2004 Auditor	M(EnvMan) Environmental Management UP
Client			

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The findings, results, observations, conclusions and recommendations given in this report are based on the author's best scientific and professional knowledge, as well as available information. Information utilised and contained in this report is based on data/information supplied to Eco Elementum (Pty) Ltd by the client and other external sources (including previous site investigation data and external specialist studies).

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EXECUTIVE SUMMARY

Tiara Mining (Pty) Ltd appointed Archean Resources (Pty) Ltd to undertake environmental authorisations associated with the proposed Tiara Granville project. The applicant wants to conduct opencast mining on an area of 16 987 ha comprising of RE and portion 12 of the farm BVB Ranch 776 LT, RE of the farm Josephine 749 LT, Buffalo Ranch 834 LT, RE of the farm Danie 789 LT, Granville 767 LT, portion 6 and RE of the farm Farrel 781 LT as well as R/E of the farm Willie 787 LT in the Limpopo Province of South Africa.

Eco Elementum (Pty) Ltd is to undertake the Visual Impact Assessment for the Tiara Granville project.

Tiara wants to conduct opencast truck and shovel mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa).

It is estimated that the life of mine is 30 years, with peak ROM at 35 700 tonnes per month.

The following infrastructure will be required for the distribution of the coal, with Figure 2 showing the site layout.

- Screening and Crushing Plant;
- Processing Plant;
- ROM stockpiles;
- Office complex;
- Process water reservoir;
- Portable water tank;
- Ablution facility;
- Store house;
- Workshop;
- Security gate and fence.

The scope of work for this Visual Impact Assessment will include:

1. Describe the existing visual characteristics of the proposed sites and its environs;
2. Viewshed and viewing distance using GIS analysis up to 15 km from the proposed structures;
3. Visual Exposure Analysis;

SUMMARY OF FINDINGS

The construction and operation phase of the proposed Tiara Granville project related activities and its associated infrastructure will have a MODERATE visual impact on the natural scenic resources and the topography. However, with the correct mitigation measures the impact might decrease to a point where the visual impact can be seen as less significant. The moderating factors of the visual impact of the proposed mining operations in close range are the following:

- Number of human inhabitants located in the area;
- Natural topography and vegetation;
- Mitigation measures that will be implemented such as the establishment of barriers or screens;
- The size of the operation; and
- High absorption capacity of the landscape.

In light of the above mentioned factors that reduce the impact of the facility, the visual impact is assessed as MODERATE VISUAL IMPACT after mitigation measures have been implemented.

Table 1: The overall Assessment of the Visual Impact

Nature of impact: The overall Assessment of the Visual Impact of the area.		Unmitigated	Mitigated
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	2	2
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5 km to 50 km) (4); National (5)]	4	2
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	4	4
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	5	5
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	4	3
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	1	1
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	3	3
Consequence	Severity + Spatial Scale + Duration	10	8
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	13	12
Risk	Consequence * Likelihood	MODERATE (130)	MODERATE (96)
Mitigation:	The visual impact can be minimized by the creation of a visual barrier.		
Cumulative Impact:	Construction of proposed Tiara Granville structures with its associated infrastructure will increase the cumulative visual impact of the mining character within the region. In context of the existing character, added structures will contribute to a regional increase in small and heavy vehicles on the roads.		

The Visual Impact due to mining activities and associated infrastructure can be seen as having a MODERATE impact on the surrounding environment and inhabitants before mitigation measures are implemented. After mitigation, the visual impact can be seen as MODERATE. The visual impact from the mining activities can be sufficiently mitigated to a point where it can be seen as insignificant. Thus, mitigation measures are very important and one of the most significant mitigation measures are the rehabilitation of the area after mining has been concluded. If the rehabilitation of the impact is not done correctly and the final landform do not fit into the surrounding area then the visual impact will remain high and become a concern. However, with correct rehabilitation, the impact will be minimal and there should be no visual impact after the landform has been restored.

Cumulative Impacts

Cumulative landscape and visual effects (impacts) result from additional changes to the landscape or visual amenity caused by the proposed development in conjunction with other developments (associated with or separate to it), or actions that occurred in the past, present or are likely to occur in the foreseeable future. They may also affect the way in which the landscape is experienced. Cumulative effects may be positive or negative. Where they comprise of a range of benefits, they may be considered to form part of the mitigation measures.

Cumulative effects can also arise from the inter-visibility (visibility) of a range of developments and / or the combined effects of individual components of the proposed development occurring in different locations or over a period of time. The separate effects of such individual components or developments may not be significant, but together they may create an unacceptable degree of adverse effects on visual receptors within their combined visual envelopes. Inter-visibility depends upon general topography, aspect, tree cover or other visual obstruction, elevation and distance, as this affects visual acuity, which is also influenced by weather and light conditions. (Institute of Environmental Assessment and The Landscape Institute, 1996).

- The cumulative visual intrusion of the proposed Tiara Granville structures, will be MODERATE as it is a surface mining operation. The site location is also next to other mining operations which decreases the visual impact further. The visual impact and impact on sense of place of the proposed project will contribute to the cumulative negative effect on the aesthetics of the study area. It is recommended however, that the environmental authorities consider the overall cumulative impact on the agricultural and scattered mining character and the areas sense of place before a final decision is taken with regard to the optimal number of mining activities in the area.

Mitigation Measures

Mitigation measures may be considered in two categories:

- Primary measures that intrinsically comprise part of the development design through an iterative process. Mitigation measures are more effective if they are implemented from project inception when alternatives are being considered.
- Secondary measures designed to specifically address the remaining negative effects of the final development proposals.

Primary measures that will be implemented will mainly be measures that will minimise the visual impact by softening the visibility of the structures by "blending" with the surrounding areas. Such measures will include rehabilitation of the mining area by re-vegetation of the mining site and surrounding area.

Secondary measures will include final rehabilitation, after care and maintenance of the vegetation and to ensure that the final landform is maintained.

In addition, the following measures are recommended:

- Plant some indigenous trees to create a barrier between the neighbours and roads;
- Dust from Stockpile areas, roads and other activities must be managed by means of dust suppression to prevent excessive dust;
- A wind barrier system that encloses the stockpiles;
- Rehabilitation of the area must be done once mining is completed.
- Creating Berms around the opencast pits and planting indigenous vegetation on the berms.

CONTENTS

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Definition of Terms

Assessment	A systematic, independent and documented review of operations and practises to ensure that relevant requirements are met.
Construction	The time period that corresponds to any event, process, or activity that occurs during the Construction phase (e.g., building of site, buildings, and processing units) of the proposed project. This phase terminates when the project goes into full operation or use.
Critical viewpoints	Important points from where viewers will be able to view the proposed or actual development and from where the development may be significant.
Cumulative Impacts	The summation of the effects that result from changes caused by a development in conjunction with the other past, present or reasonably foreseen actions (The landscape Institute, Institute of Environmental Management & Assessment. 2002)
Decommissioning	to remove or retire (a mine, etc.) from active service.
Environmental Component	An attribute or constituent of the environment (i.e., air quality; marine water; waste management; geology, seismicity, soil, and groundwater; marine ecology; terrestrial ecology, noise, traffic, socio-economic) that may be impacted by the proposed project.
Environmental Impact	A positive or negative condition that occurs to an environmental component as a result of the activity of a project or facility. This impact can be directly or indirectly caused by the project's different phases (i.e., Construction, Operation, and Decommissioning).
Field of view:	The field of view is the angular extent of the observable world that is seen at any given moment. Humans have an almost 180º forward-facing field of view. Note that human stereoscopic (binocular) vision only covers 140º of the field of view in humans; the remaining peripheral 40º have no binocular vision due to the lack of overlap of the images of the eyes. The lower the focal length of a lens (see below), the wider the field of view.
Landscape Integrity	Landscape integrity is visual qualities represented by the following qualities, which enhance the visual and aesthetic experience of the area
Mitigation (in the context of Visual Impact Assessment):	Any action taken or not taken in order to avoid, minimise, rectify, reduce, eliminate, or compensate for actual or potential adverse visual impacts.
Operation	The time period that corresponds to any event, process, or activity that occurs during the Operation (i.e., fully functioning) phase of the proposed project or development. (The Operation phase follows the Construction phase, and then terminates when the project or development goes into the Decommissioning phase.)
Record of Decision	Is an environmental authorisation issued by a state department.
Scenic value	Degree of visual quality resulting from the level of variety, harmony and contrast among the basic visual elements.
Sense of place	the character of a place, whether natural, rural or urban, it is allocated to a place or area through cognitive experience by the user.
Visual absorption capacity (VAC):	The ability of elements of the landscape to "absorb" or mitigate the visibility of an element in the landscape. Visual absorption capacity is based on factors such as vegetation height (the greater the height of vegetation, the higher the absorption capacity), structures (the larger and higher the intervening structures, the higher the absorption capacity) and topographical variation (rolling topography presents opportunities to hide an element in the landscape and therefore increases the absorption capacity).
Visual character	the overall impression of a landscape created by the order of the patterns composing it; the visual elements of these patterns are the form, line, colour and texture of the landscape's components. Their interrelationships are described in terms of dominance, scale, diversity and continuity. This characteristic is also associated with land use.
Visual Exposure	Visual exposure is based on distance from the project to selected viewpoints. Visual exposure or visual impact tends to diminish exponentially with distance. The visibility or visual exposure of any structure or activity is the point of departure for the visual impact assessment. It stands to reason that if the proposed mine activities and associated infrastructure were not visible, no visual impact would occur. Visual exposure is determined by the Viewshed or the view catchment being the area within which the proposed development will be visible.
Visual Integrity	Visual sensitivity can be determined by a number of factors in combination, such as prominent topographic or other scenic features, including high points, steep slopes and axial vistas
Visually sensitive	Areas in the landscape from where the visual impact is readily or excessively encountered.

Abbreviations

CA:	Competent Authority
DEA:	Department of Environmental Affairs (The former Department of Environmental Affairs and Tourism)
DMR:	The Department of Mineral Resources (The former Department of Minerals and Energy)
DWA:	Department of Water Affairs (Is now referred to the Department of Water and Sanitation – DWS)
EIA:	Environmental Impact Assessment
EMP:	Environmental Management Plan
EMPr:	Environmental Management Programme
I&AP's:	Interested and Affected Parties
IWUL:	Integrated Water Use License
IWWMP:	Integrated Water and Water Management Plan
MPRDA:	Mineral and Petroleum Resources Development Act, 28 of 2002
NAAQS:	National Ambient Air Quality Standards
NEMA:	National Environmental Management Act, 107 of 1998
NEMAQA:	National Environmental Management: Air Quality Act, 39 of 2004
NEMBA:	National Environmental Management: Biodiversity Act, 10 of 2004
NEMWA:	National Environmental Management: Waste Act, 59 of 2008
NHRA:	National Heritage Resources Act, 25 of 1999
NWA:	National Water Act, 36 of 1998
ROD:	Record of Decision
VAC:	Visual Absorption Capability
VIA:	Visual Impact Assessment
WSA:	Water Services Act, 108 of 1997
WUL*:*	Water Use Licence

PROJECT INFORMATION

Table 2: Applicant Details

Name of Applicant:	Tiara Mining (Pty) Ltd
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File Reference Number DMR:	MP 30/5/1/1/2/394 PR

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Table 4: Specialist Details

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Contact Person:	Vernon Siemelink
Contact Number:	012 807 0383
Email:	vernon@ecoe.co.za info@ecoe.co.za
Website:	www.ecoe.co.za

SPECIALIST DECLARATION OF INDEPENDENCE

In support of an application in terms of the National Environmental Management Act 107 of 1998 (GNR983, GNR984 and GNR985, GG38282 of 4 December 2014 ("Listed Activities") that will require an environmental authorisation if triggered. As amended by GNR 327, GNR 325 and GNR 324.

I, **Neel Breitenbach** as specialist, has been appointed in terms of regulation 12(1) or 12(2), and can confirm that I shall —

a. be independent;
b. have expertise in undertaking specialist work as required, including knowledge of the Act, these Regulations and any guidelines that have relevance to the proposed activity;
c. ensure compliance with these Regulations;
d. perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the application'
e. take into account, to the extent possible, the matters referred to in regulation 18 when preparing the application and any report, plan or document relating to the application;
f. disclose to the proponent or applicant, registered interested and affected parties to the proponent or applicant, registered interested and affected parties and the competent authority all material information in the possession of the EAP and, where applicable, the specialist, that reasonably has or may have the potential of influencing –
g. any decision to be taken with respect to the application by the competent authority in terms of these Regulations; or
h. the objectivity of any report, plan or document to be prepared by the EAP or specialist, in terms of these Regulations for submission to the competent authority; and
i. unless access to that information is protected by law, in which case it must be indicated that such protected information exists and is only provided to the competent authority.

Neel Breitenbach	[signature]
Name and Surname	Signature
2020-11-18	**George**
Date	Signed at

1. INTRODUCTION

Tiara Mining (Pty) Ltd appointed Archean Resources (Pty) Ltd to undertake environmental authorisations associated with the proposed Tiara Granville project. The applicant wants to conduct opencast rollover mining on an area of 16 987 ha comprising of RE and portion 12 of the farm BVB Ranch 776 LT, RE of the farm Josephine 749 LT, Buffalo Ranch 834 LT, RE of the farm Danie 789 LT, Granville 767 LT, portion 6 and RE of the farm Farrel 781 LT as well as R/E of the farm Willie 787 LT in the Limpopo Province of South Africa.

Eco Elementum (Pty) Ltd is to undertake the Visual Impact Assessment for the Tiara Granville project.

Tiara wants to conduct opencast truck and shovel mining of Emerald (gemstone- Gem), all Gemstones except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa).

It is estimated that the life of mine is 30 years, with peak ROM at 35 700 tonnes per month.

The following infrastructure will be required for proposed Tiara project area, with Figure 2 showing the site layout.

- Screening and Crushing Plant;
- Processing Plant;
- ROM stockpiles;
- Office complex;
- Process water reservoir;
- Portable water tank;
- Ablution facility;
- Store house;
- Workshop;
- Security gate and fence.

Table 5: Project Locality

Farm Name:	RE and portion 12 of the farm BVB Ranch 776 LT, RE of the farm Josephine 749 LT, Buffalo Ranch 834 LT, RE of the farm Danie 789 LT, Granville 767 LT, portion 6 and RE of the farm Farrel 781 LT as well as R/E of the farm Willie 787 LT – Limpopo Province - South Africa
Application Area:	16 987 ha
Magisterial District:	Phalaborwa District Municipality, Limpopo Province South Africa
Distance and direction from nearest town:	The Project Area is ~ 13 km NE of . See Figure 1.

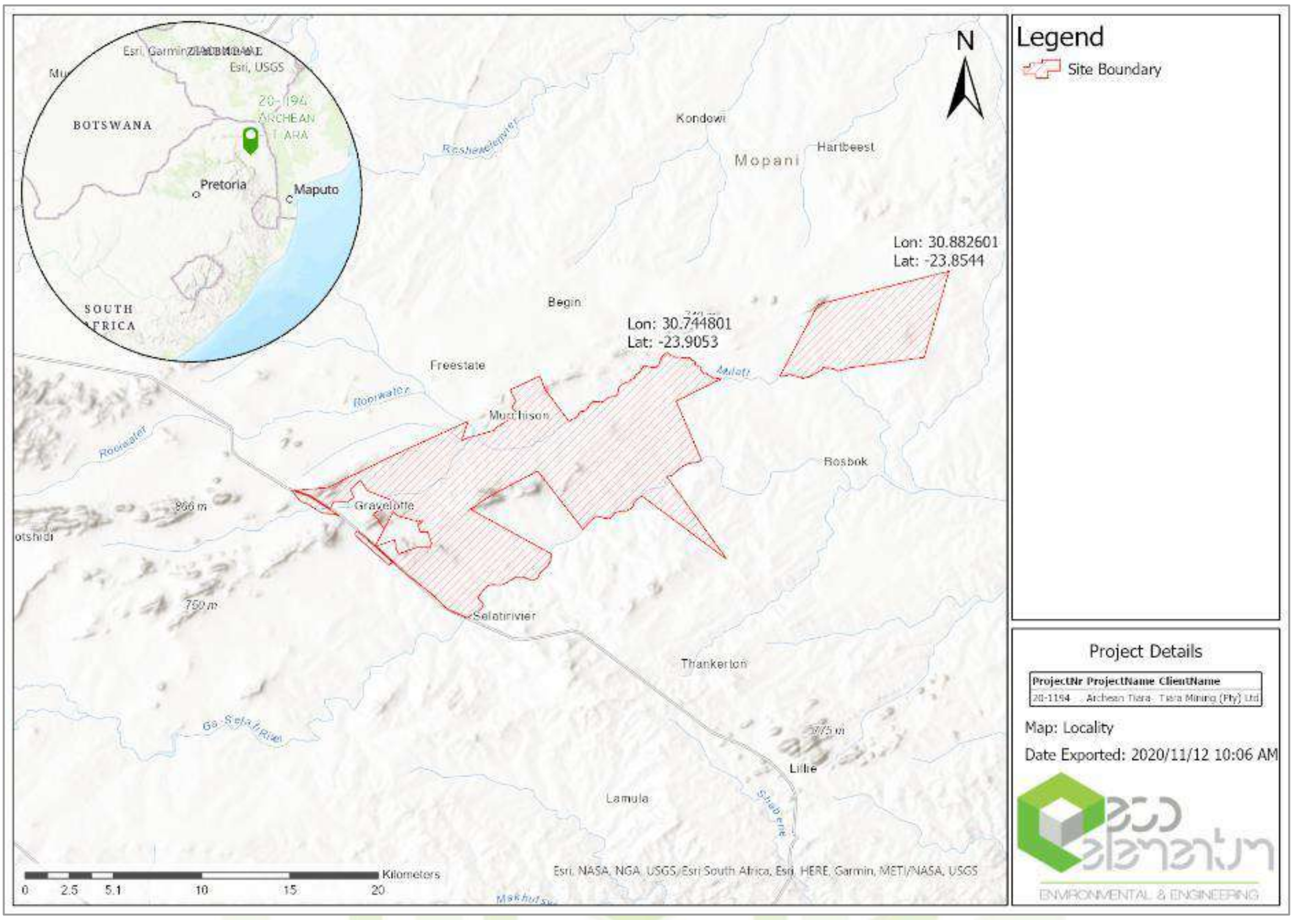

Figure 1: Locality map of the proposed Tiara Granville project.

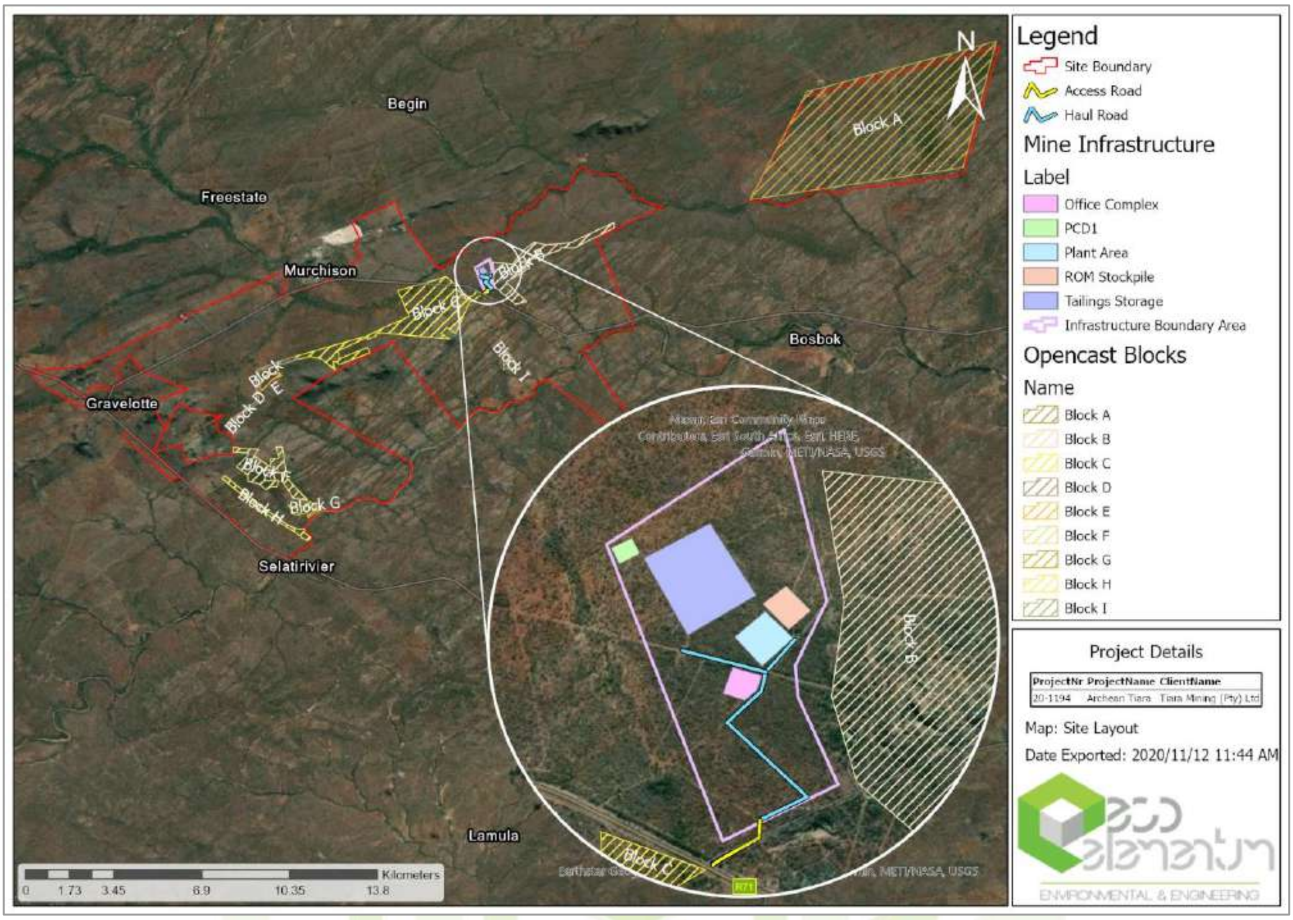

Figure 2: Proposed Site Layout for the proposed Tiara Granville project.

2. SCOPE OF WORK

The scope of work for this Visual Impact Assessment will include:

1. Describe the existing visual characteristics of the proposed sites and its environs;
2. Viewshed and viewing distance using GIS analysis up to 15 km from the proposed structures.
3. Visual Exposure Analysis comprising the following aspects:

- Terrain Slope;
  - Slope angle is determined from the Digital Terrain Model (DTM) and the location of the proposed structures given a ranking depending on the steepness of the slope.
- Aspect of structure location;
  - Aspect of the slope where the structures are to be built, are calculated from the DTM and given a ranking determined by the Sun angle.
- Landforms;
  - Landform of the location of the proposed structures are determined from the DTM and ranked according to the type of landform. Structures built on certain landforms, e.g. ridges, will be more visible than structures built in valleys.
- Slope Position of structure;
  - Using GIS analysis, the position of the proposed structure is determined and ranked according to the position on the slope the structure is to be built.
- Relative elevation of structure;
  - Using the DEM the elevation of the proposed structure relative to the surrounding elevation is determined and ranked according to the difference in height of the surrounding areas.
- Terrain Ruggedness;
  - The terrain ruggedness is determined from the DEM and given a ranking based on the homogeneousness of the terrain.
- Viewer Sensitivity;
  - The Viewer sensitivity ranking of the surrounding areas is determined using various land cover and land use datasets and ranked according to the sensitivity of the related structures to the environment.
- Overall Visual Impact;
  - Combing all the above dataset a final visual impact of the proposed structures is calculated.

3. DESCRIPTION OF AFFECTED AREA AND ENVIRONMENT

This section of the report provides a description of the current status of the environment. This provides a baseline context for assessment of the proposed structures.

3.1 Location

3.1.1 Population

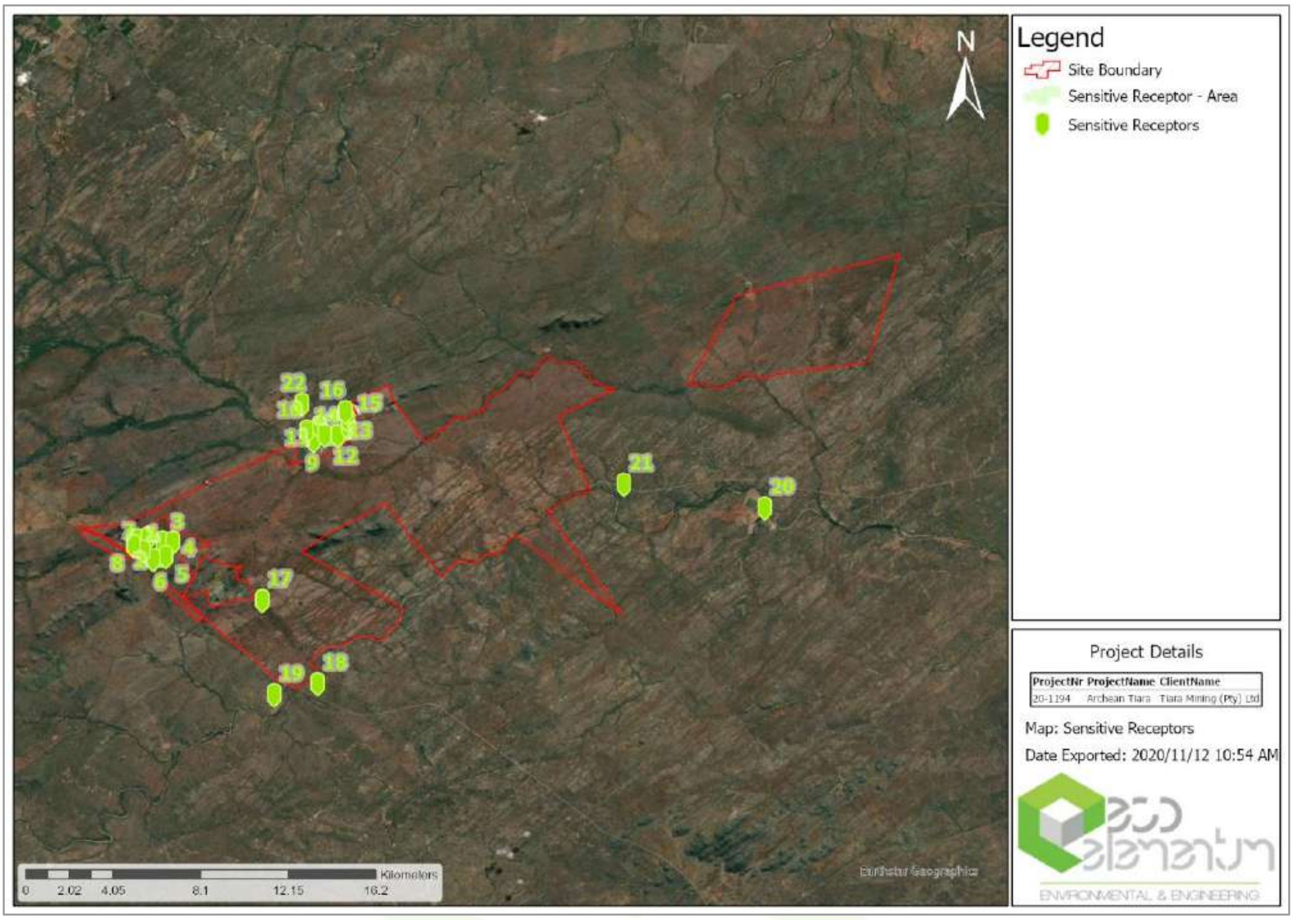

Figure 3: Population areas within close proximity of the proposed Tiara Granville project.

From a desktop study of satellite imagery various sensitive receptors in the form of human habitation areas, consisting of the small settlements of Murchinson and Gravelotte to the north and west, with various homesteads to the east and south of the proposed Tiara Granville project area can be seen in Figure 3. It should be noted that the sensitive receptors in the area may differ from those identified as not all areas may have been identified from the imagery successfully.

3.1.2 Topography

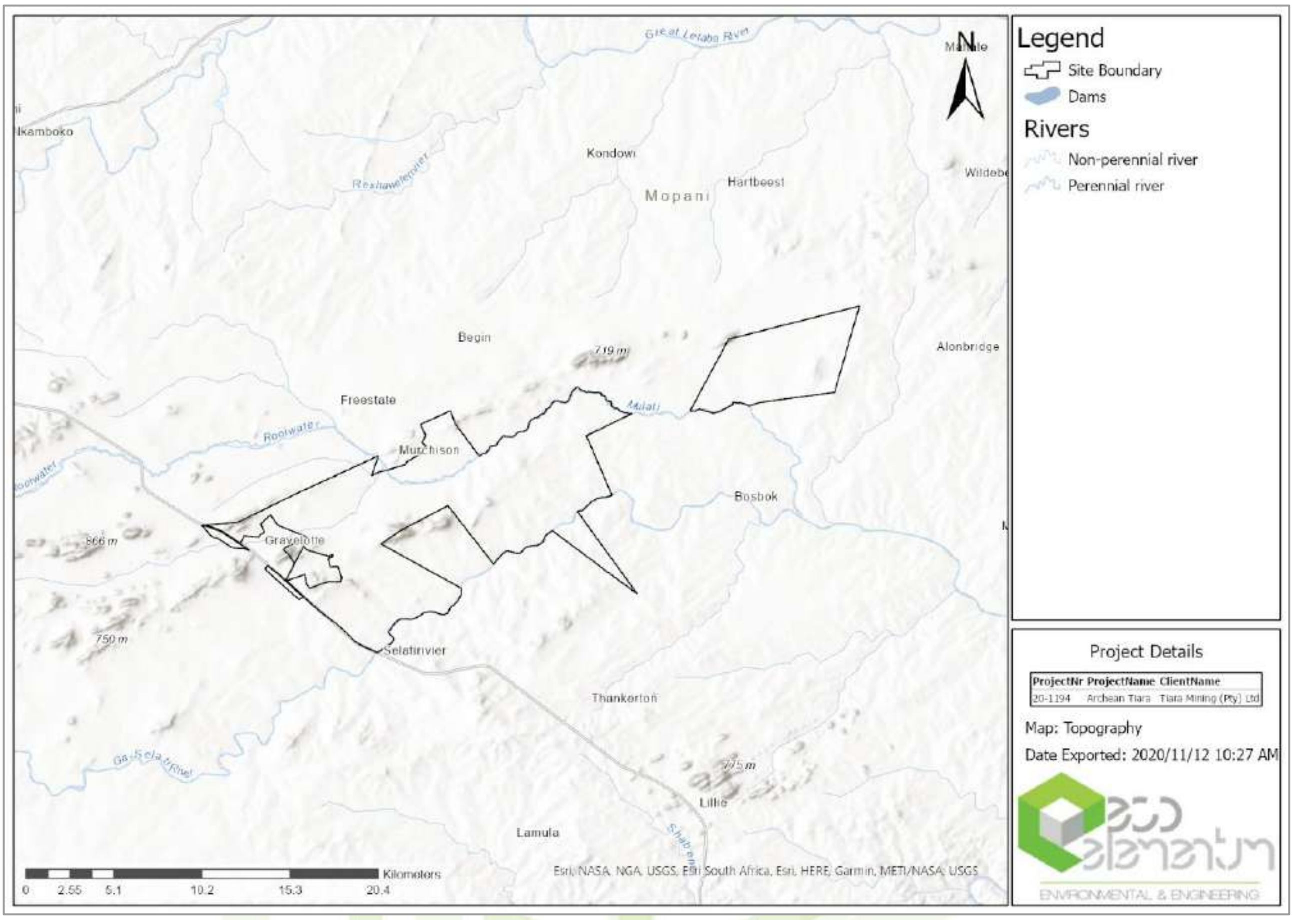

Figure 4: Map showing the Topography surrounding the proposed Tiara Granville project.

The proposed operation area is situated in fairly flat undulated terrain, with small hills running in an NE-SW direction. No major topographical features were found in the immediate vicinity as can be seen in Figure 4 above.

3.2 New Infrastructure

The proposed Tiara Granville project will comprise of various newly built structures. Some of the highest structures are included in this report as can been in Figure 5. It must be noted that no complete detail of the exact structures were available at the time of this report and general height and location assumptions were made where applicable.

Table 6: Maximum Height of the Relevant Proposed Structures.

Description	Height (m)
PCD	5
Tailings Storage	30
Office Complex	3
Plant Area	5
ROM Stockpile	5
Opencast Pits	3

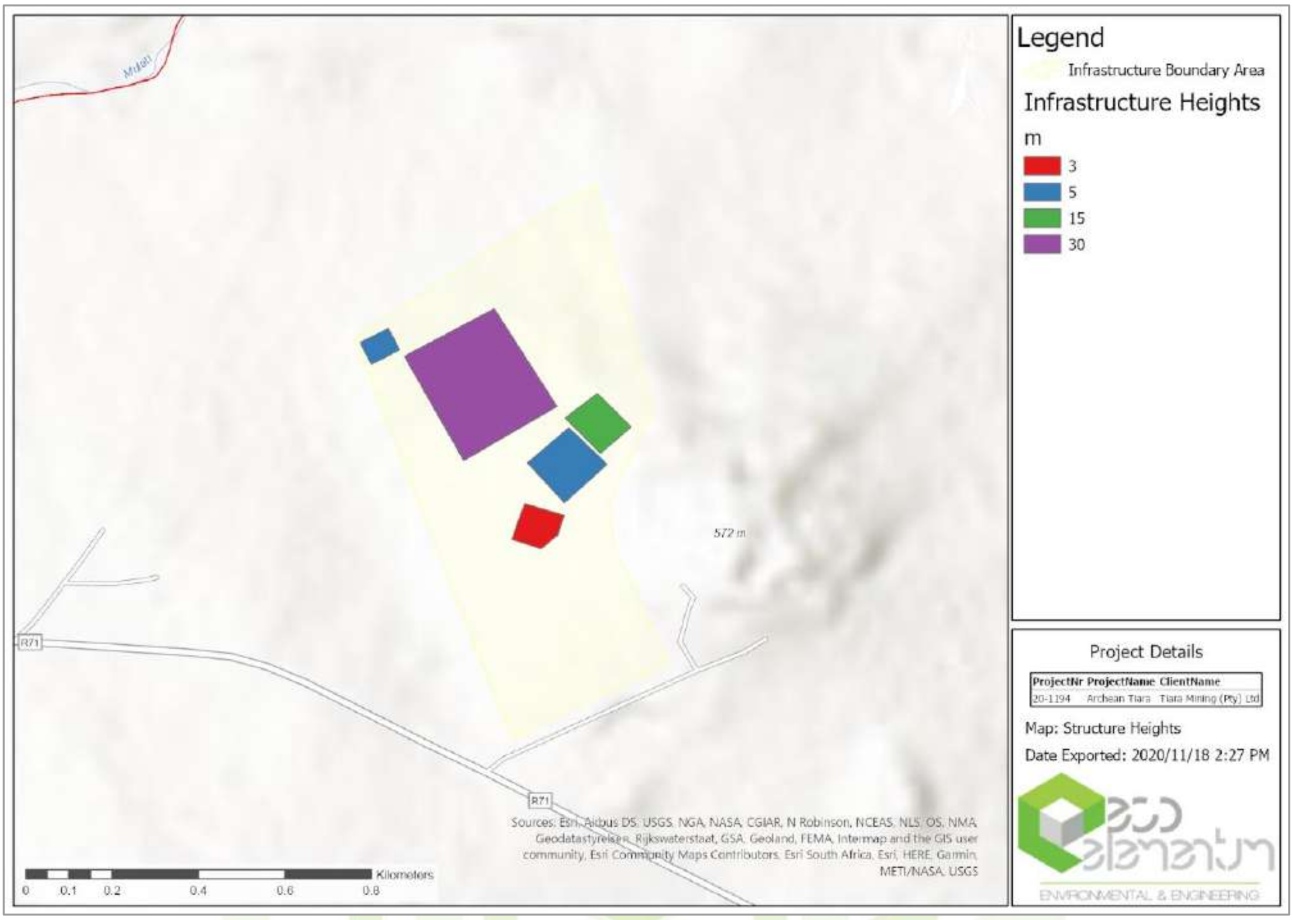

Figure 5: Infrastructure surface heights

3.3 Sense Of Place

The concept of "a Sense of Place" does not equate simply to the creation of picturesque landscapes or pretty buildings, but to recognize the importance of a sense of belonging. Embracing uniqueness as opposed to standardization attains quality of place. In terms of the natural environment, it requires the identification, a response to and the emphasis of the distinguishing features and characteristics of landscapes. Different natural landscapes suggest different responses. The sense of place is created by the predominant bushveld vegetation in the area, mixed with sparsely populated human habitation.

4. METHODOLOGY

The following sequence was employed in this Visual Assessment Report:

1. Viewshed and viewing distance using GIS analysis up to 15 km from the proposed structures utilizing ArcGIS Pro and Spatial Analyst extension.
2. In order to model the decreasing visual impact of the structures, concentric radii zones of 1 km to 15 km from the mine activities were superimposed on the viewshed to determine the level of visual exposure. The closest zone to the proposed structures indicates the area of most significant impact, and the zone further than 10 km from the structures indicates the area of least impact. The visual ratings of the zones have been defined as follows:
    - <1 km (very high);
    - 1 - 2 km (high);
    - 2 - 5 km (moderate);
    - 5 -10 km (low); and
    - > 15 km (insignificant).
3. A Visual Exposure Analysis were conducted that included the following parameters:
    - Terrain Slope
        - Slope angle is determined from the Digital Terrain Model (DTM) and the location of the proposed structures given a ranking depending on the steepness of the slope;
        - Structures built on steep slopes are assumed to be more visible and exposed than those on flat surfaces.
    - Aspect of structure location
        - Aspect of the slope where the structures are to be built, are calculated from the DTM and given a ranking determined by the Sun angle.
        - Structures on flat surface are illuminated by the sun the whole day and thus visible from all directions. In the southern hemisphere structures on North facing slopes are less visible from the south, structures on East and West facing slopes are only illuminated during half of the day thus less visible where structures on the southern slopes are mostly in the shade.
    - Landforms
        - Landform of the location of the proposed structures are determined from the DTM and ranked according to the type of landform. Structures built on certain landforms, e.g. ridges, will be more visible than structures built in valleys.
    - Slope Position of structure
        - Using GIS analysis, the position of the proposed structure is determined and ranked according to the position on the slope the structure is to be built.
    - Relative elevation of structure
        - Using the DEM the elevation of the proposed structure relative to the surrounding elevation is determined and ranked according to the difference in height of the surrounding areas. Structures built on higher ground are more visible than those built in low lying areas.
    - Terrain Ruggedness
        - The terrain ruggedness is determined from the DEM and given a ranking based on the homogeneousness of the terrain. Rugged terrain has a tendency to increase the visual absorption characteristics of the terrain.
    - Visual Absorption Capacity
        - To simulate the Visual Absorption Capacity (VAC) of the landscape, land cover data of the area were assigned a VAC ranking. The Visual Exposure results and VAC rankings of the landscape were use in an algorithm to determine a quantitative visual exposure for each sensitive receptor.
    - Overall Visual Impact
        - Combing all the above dataset a final visual exposure ranking was determined for each of the identified sensitive receptor areas.

4.1 Assumptions

- The core study area can be defined as an area with a radius of not more than 10 km from the structures and a total study area with a radius of 15 km from the structures. This is because the visual impact of structures beyond a distance of 10 km would be so reduced that it can be considered negligible even if there is direct line of sight.
- It is assumed that there are no alternative locations for the structures and that the visual assessment, therefore, assessed only the proposed site.
- The height of the VIA is based on the heights as stipulated in Table 6.
- Geographic location within the mining boundary of infrastructure.
- The assessment was undertaken during the planning stage of the project and is based on the information available at that time.

4.2 Limitations

- Visual perception is by nature a subjective experience, as it is influenced largely by personal values. For instance, what one-viewer experiences as an intrusion in the landscape, another may regard as positive. Such differences in perception are greatly influenced by culture, education and socio-economic background. A degree of subjectivity is therefore bound to influence the rating of visual impacts. In order to limit such subjectivity, a combination of quantitative and qualitative assessment methods were used. A high degree of reliance has been placed on GIS-based analysis viewshed, visibility analysis, and on making transparent assumptions and value judgements, where such assumptions or judgements are necessary.
- The viewshed generated in GIS cannot be guaranteed as 100% accurate. Some viewpoints, which are indicated on the viewshed as being inside of the viewshed, can be outside of the viewshed. This is due to the change of the natural environment by surrounding activities as well as natural vegetation that play a significant role and can have a positive or negative influence on the viewshed.

4.3 Legal Requirements

There are no specific legal requirements for visual impact assessment in South Africa. Visual impacts are, however required to be assessed by implication when the provisions of relevant acts governing environmental impacts management are considered.

5. CRITERIA USED IN THE ASSESSMENT OF VISUAL IMPACTS

5.1 View Points And View Corridors

Viewpoints have been selected based on prominent viewing positions in the area. The selected viewpoints and view corridors are used as a basis for determining potential visual ability and visual impacts of the proposed structures.

5.2 Visual Exposure

Visual exposure is based on distance from the project to selected viewpoints. Visual exposure or visual impact tends to diminish exponentially with distance. The visibility or visual exposure of any structure or activity is the point of departure for the visual impact assessment. It stands to reason that if the proposed structures were not visible, no visual impact would occur. Visual exposure is determined by the following variables:

- Slope angle (Figure 6);
- Aspect of slope (Figure 7);
- Landforms (Figure 10);
- Slope Position of structure (Figure 11);
- Relative Elevation of structure (Figure 9); and
- Terrain Ruggedness (Figure 8).

5.3 Landscape Integrity

Landscape integrity is visual qualities represented by the following qualities, which enhance the visual and aesthetic experience of the area:

- Intactness of the natural and cultural landscape;
- Lack of visual intrusions or incompatible structures; and
- Presence of a 'sense of place'.

5.4 Determine The Visual Absorption Capacity (VAC)

The VAC is the capacity of the receiving environment to absorb the potential visual impact of the proposed facility. The VAC is primarily a function of the vegetation, and will be high if the vegetation is tall, dense and continuous. Conversely, low growing, sparse and patchy vegetation will have a low VAC. Topography and built forms have the capacity to 'absorb' visual impact.

The digital terrain model utilised in the calculation of the visual exposure of the facility does not incorporate potential visual absorption capacity (VAC). It is therefore necessary to determine the VAC by means of the interpretation of the vegetation cover, topography and structures. Land cover is used in the ranking of the VAC.

6. VIEWSHED

6.1 Slope

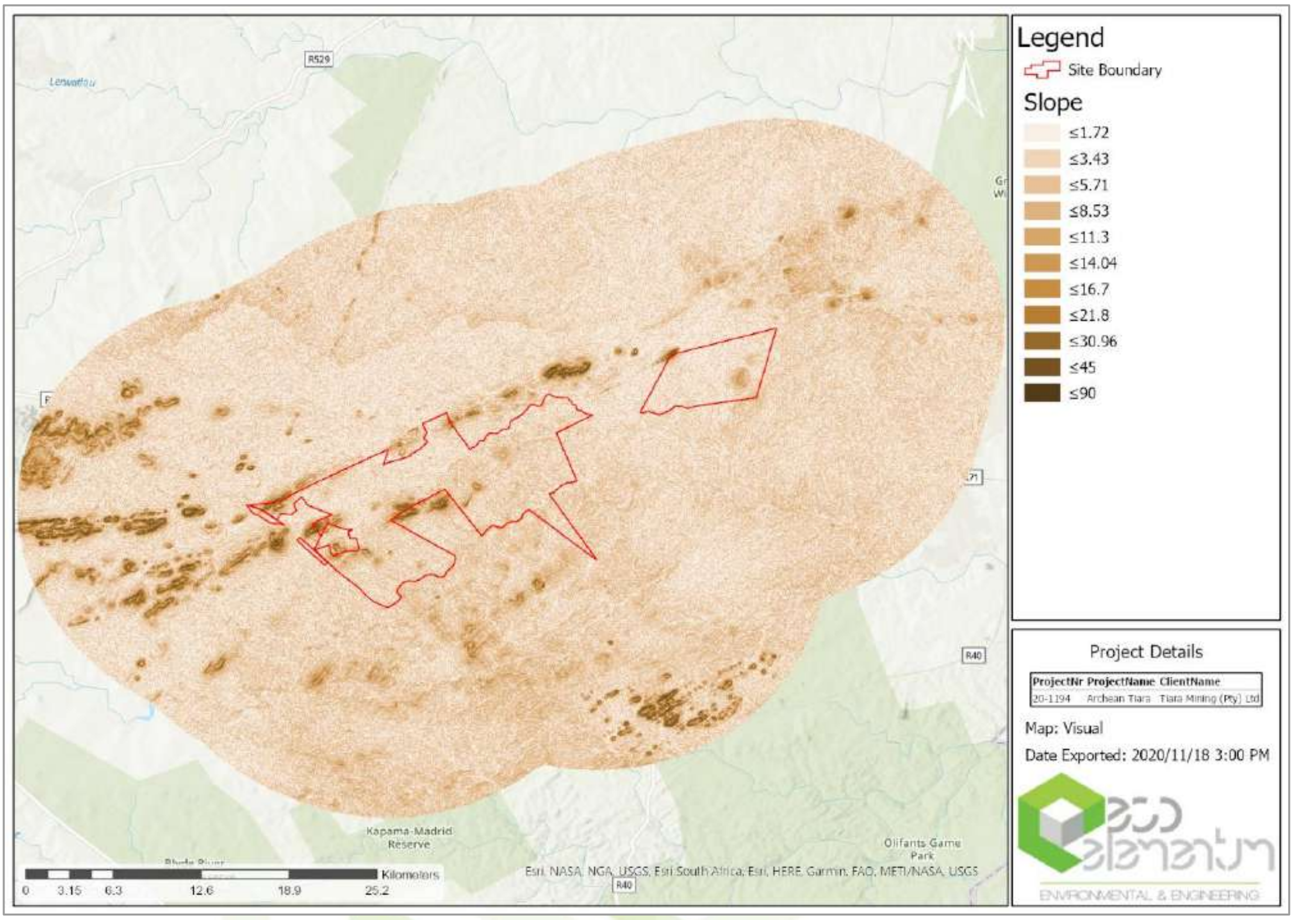

Figure 6: Slope angles of the terrain in the 15 km buffer area surrounding the proposed Tiara Granville project

6.2 Aspect

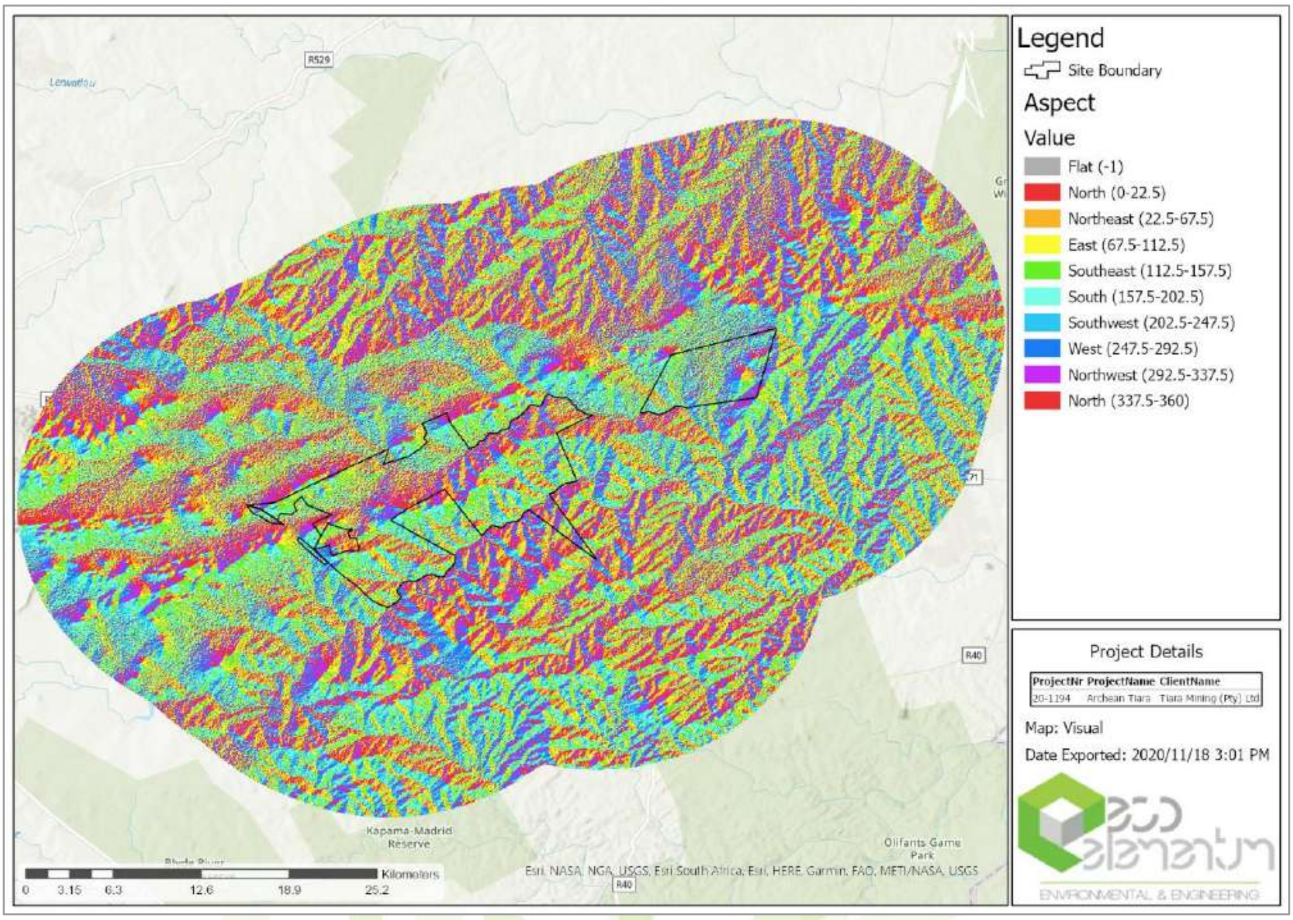

Figure 7: Aspect direction of the terrain in a 15 km buffer area surrounding the proposed Tiara Granville project

6.3 Terrain Ruggedness

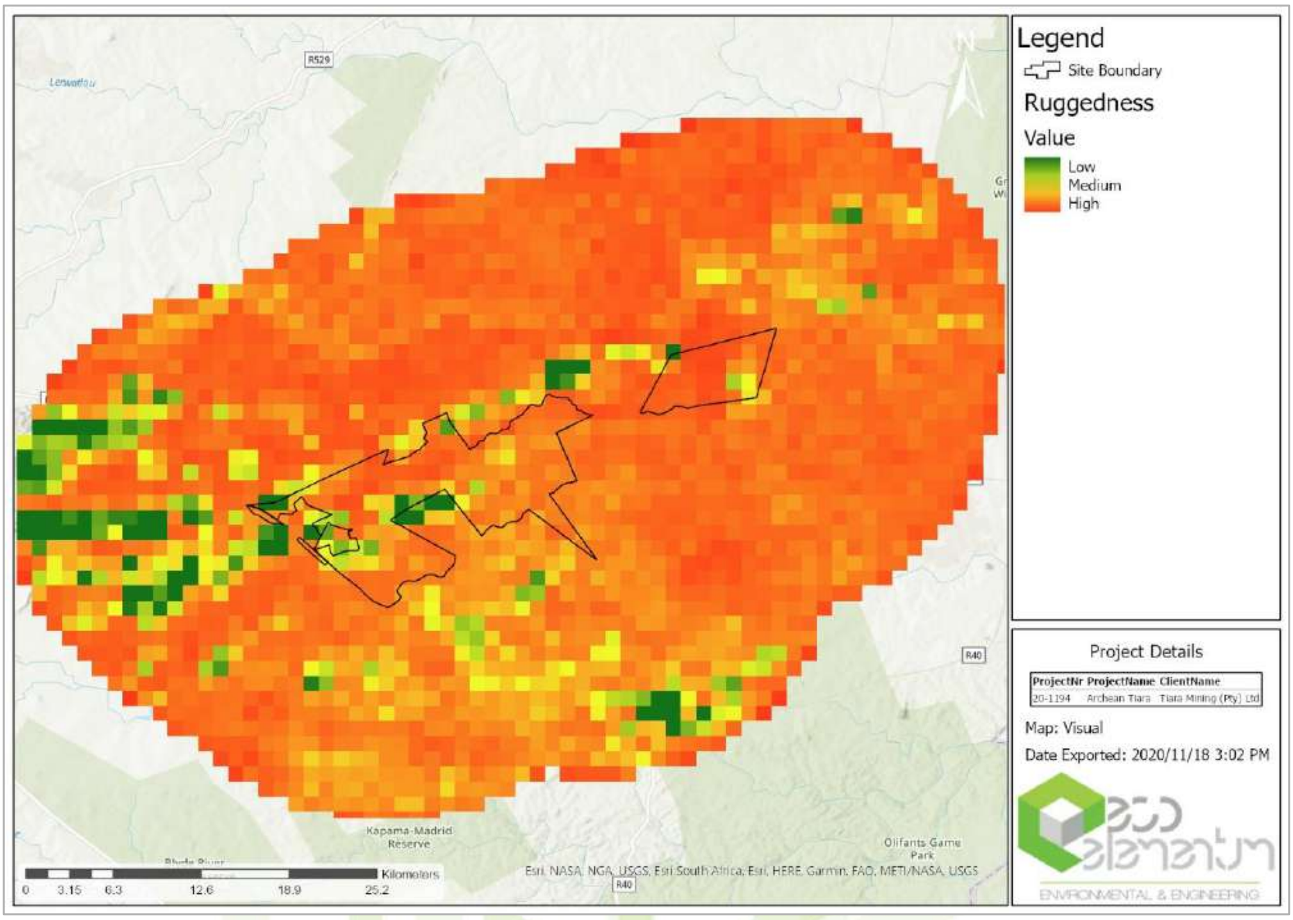

Figure 8: Terrain ruggedness in a 15 km buffer area surrounding the proposed Tiara Granville project

6.4 Relative Elevation

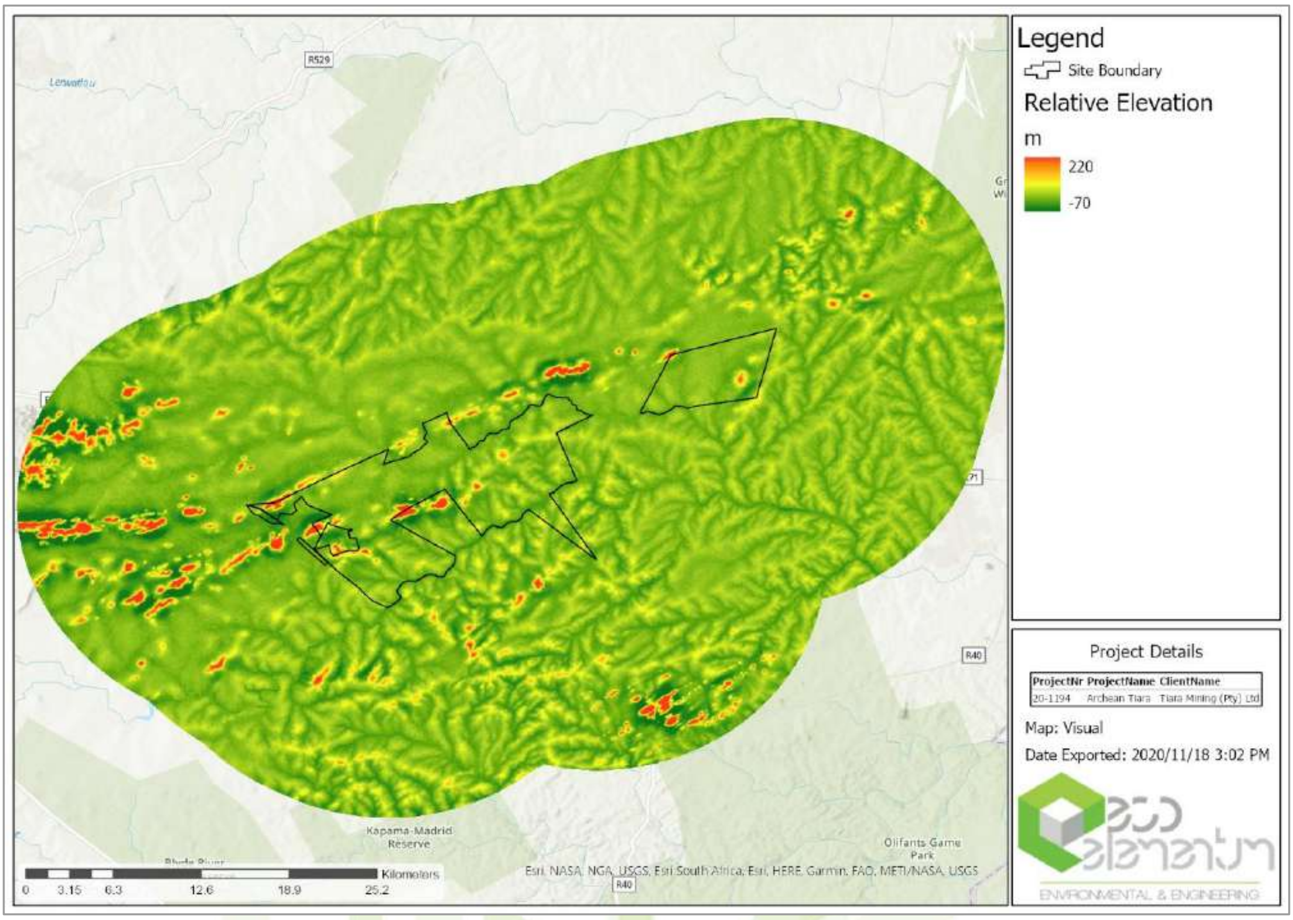

Figure 9: Relative Elevation of terrain in a 15 km buffer area surrounding the proposed Tiara Granville project

6.5 LANDFORMS

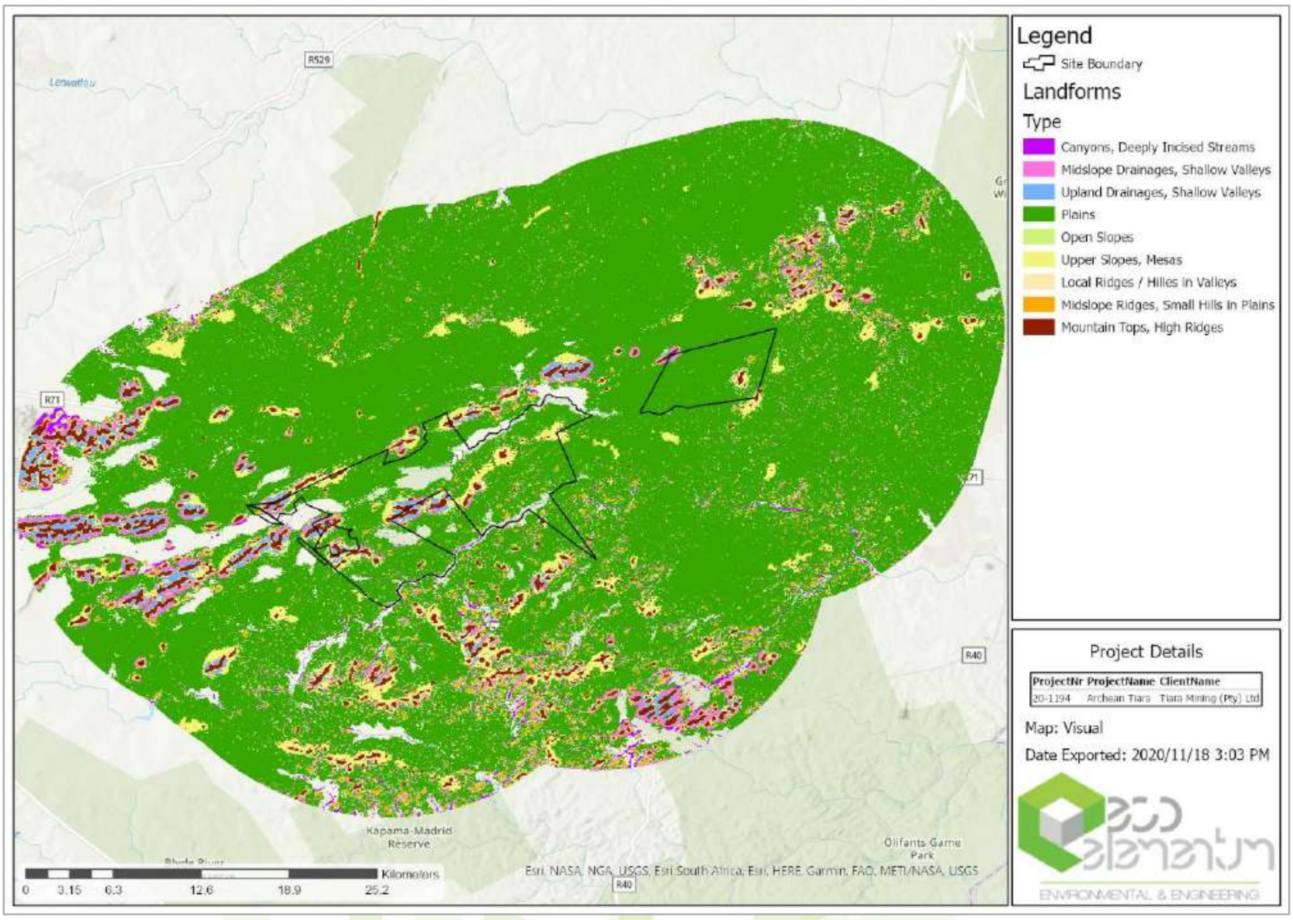

Figure 10: Landforms in a 15 km buffer area surrounding the proposed Tiara Granville project

6.6 Slope Position

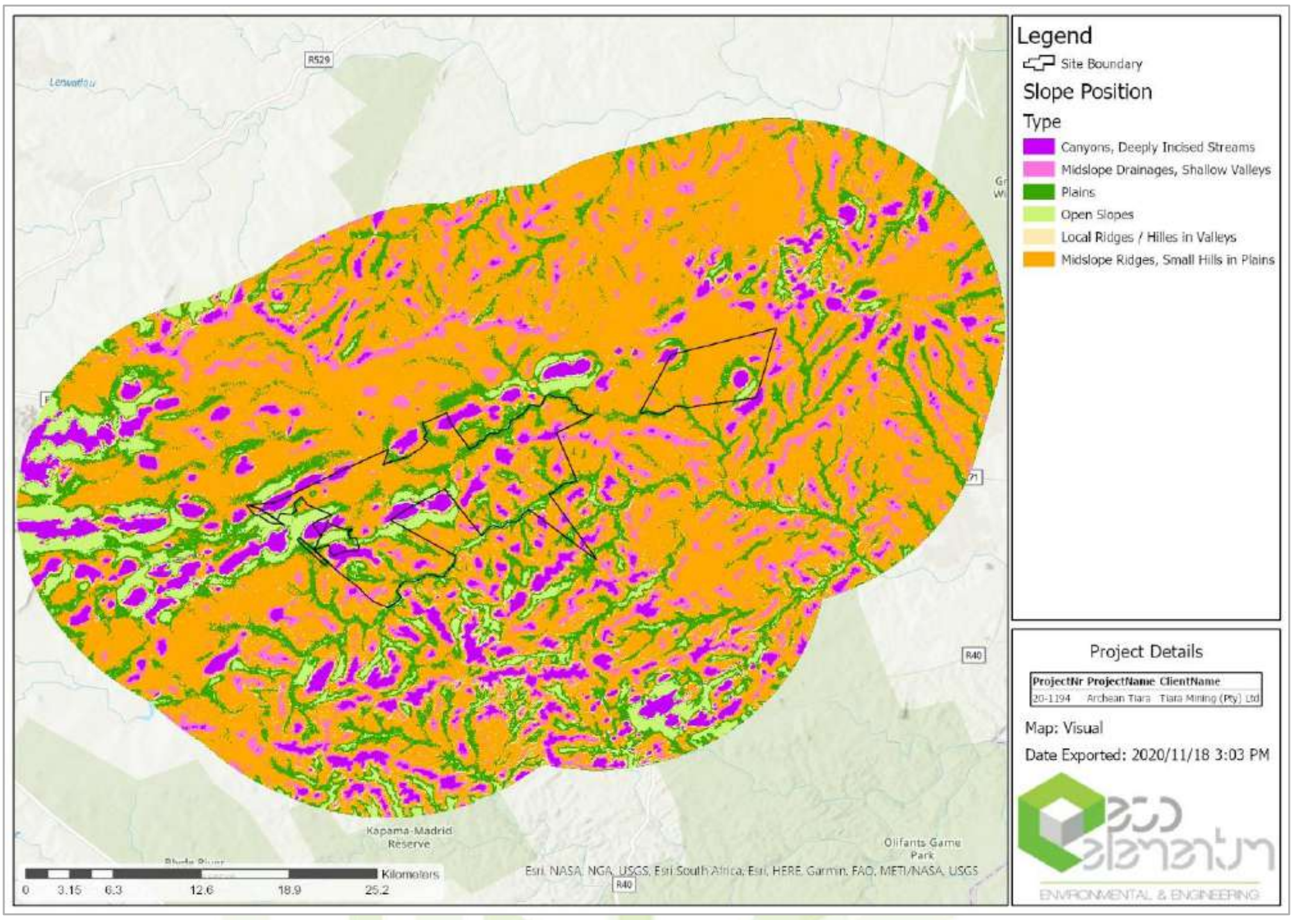

Figure 11: Slope Positions in a 15 km buffer area surrounding the proposed Tiara Granville project

6.7 LANDCOVER VAC

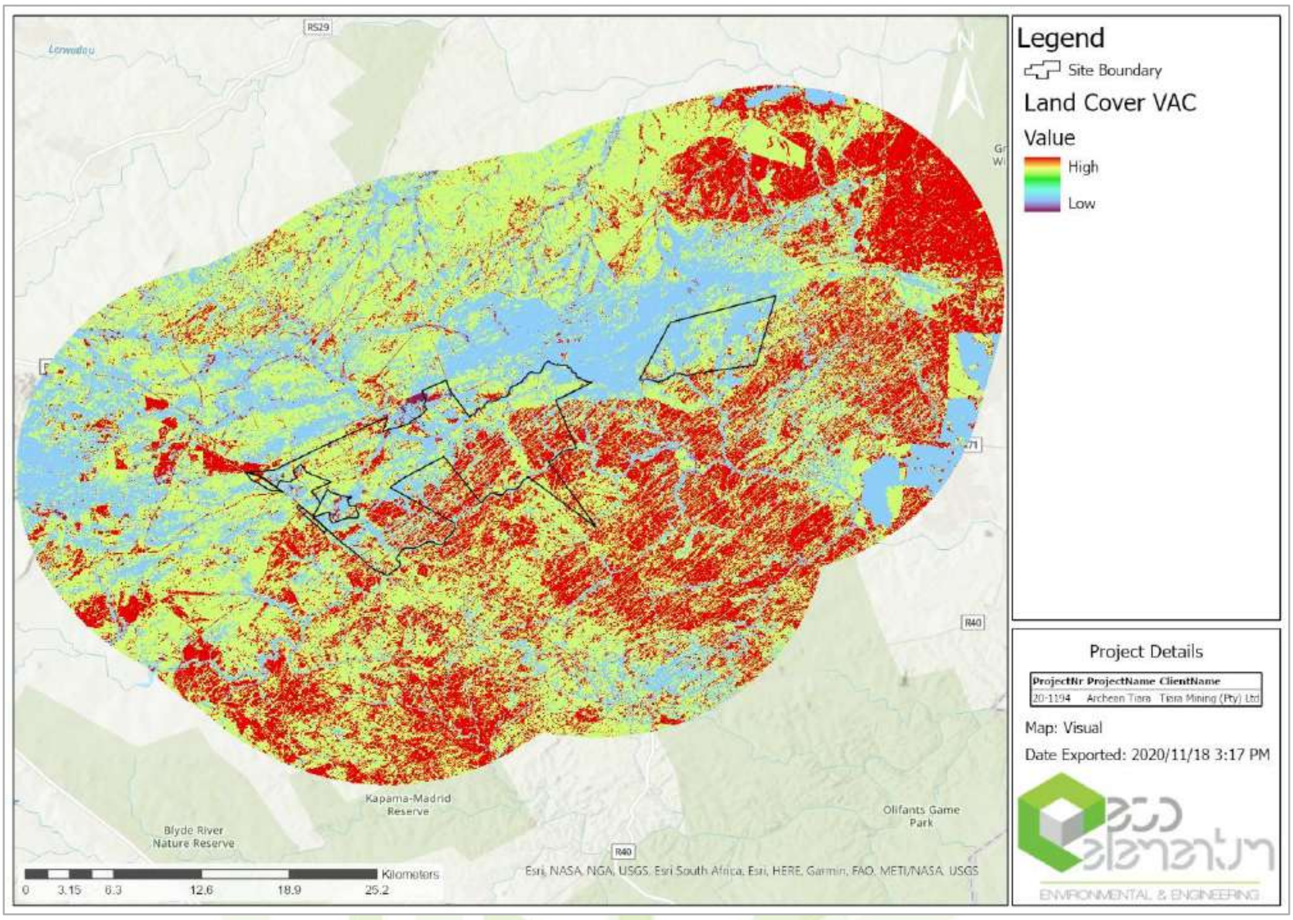

Figure 12: Possible VAC of the Landcover in a 15 km buffer area surrounding the proposed Tiara Granville project

6.8 VIEWSHED VISIBILITY

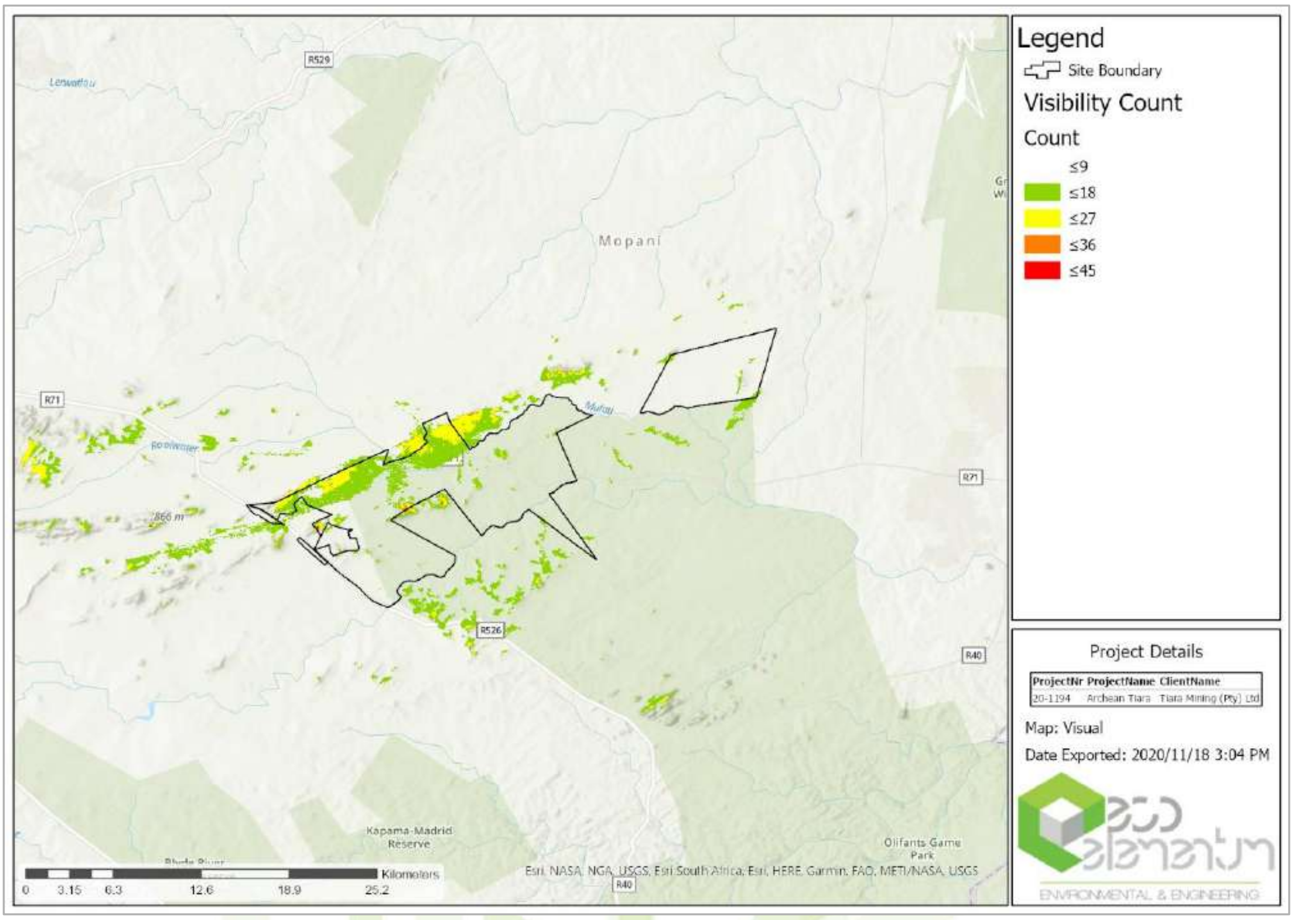

Figure 13: Viewshed of proposed Tiara Granville project – Visibility Count (How many surface infrastructure locations can be seen from any location on the map)

For the assessment of the visibility of the area, the viewshed has been calculated for the amount of surface infrastructure features that can be seen from any point on the map as seen in Figure 13.

Table 7: Visibility Rating – Count of infrastructure visible of the proposed development

0 - 2 Structures	Very Low
3 - 6 Structures	Low
7 - 11 Structures	Medium
12 - 17 Structures	High
18 - 23 Structures	Very High

6.9 Viewshed Visibility – Distance Ranking

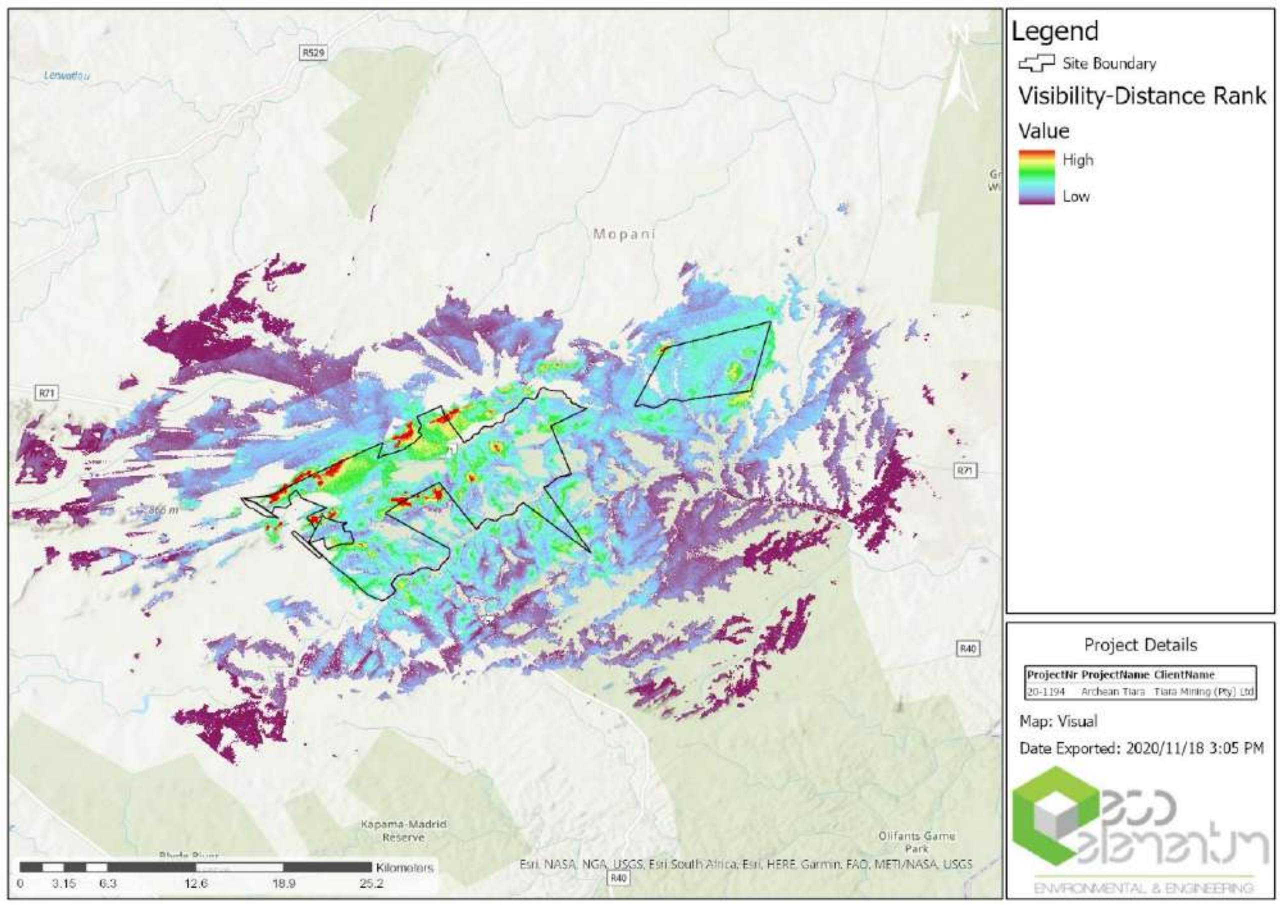

Figure 14: Viewshed of proposed Tiara Granville project – Visibility Count (How many surface infrastructure locations can be seen from any location on the map) ranked according to distance from source

The View Counts from the visibility section above is then further ranked based on distance from the centre of the proposed infrastructure site as seen in Figure 14. Distances are ranked according to the table below.

Table 8: Visibility rating – Distance from proposed infrastructure development

12 – 15 km	Very Low
9 – 12 km	Low
6 – 9 km	Medium
3 – 6 km	High
0 – 3 km	Very High

6.10 Visual Exposure Ranking

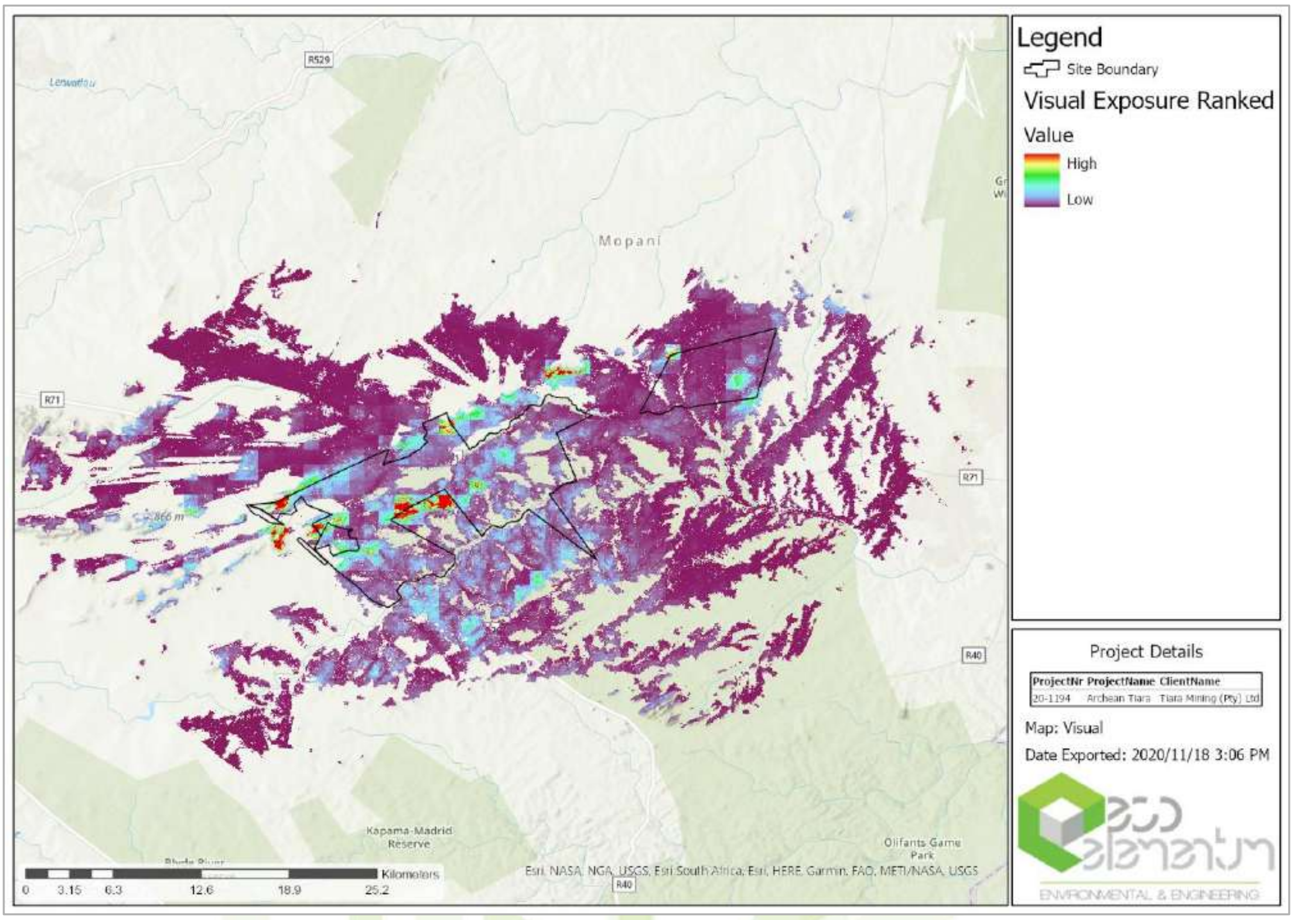

Figure 15: Visual Exposure ranking within a 15 km radius of the proposed Tiara Granville project

The visible infrastructure count is combined with the distance from the source ranking together with the VAC of the land cover types, the slope, aspect, ruggedness, relative elevation, landforms and slope position to get a quantitative Visual Exposure ranking of all the areas where it may be possible to see the proposed development as seen in Figure 15.

Table 9: Visual Exposure Ranking – Distance from Proposed Infrastructure Development

1	Very Low
2	Low
3	Medium
4	High
5	Very High

6.11 View Points

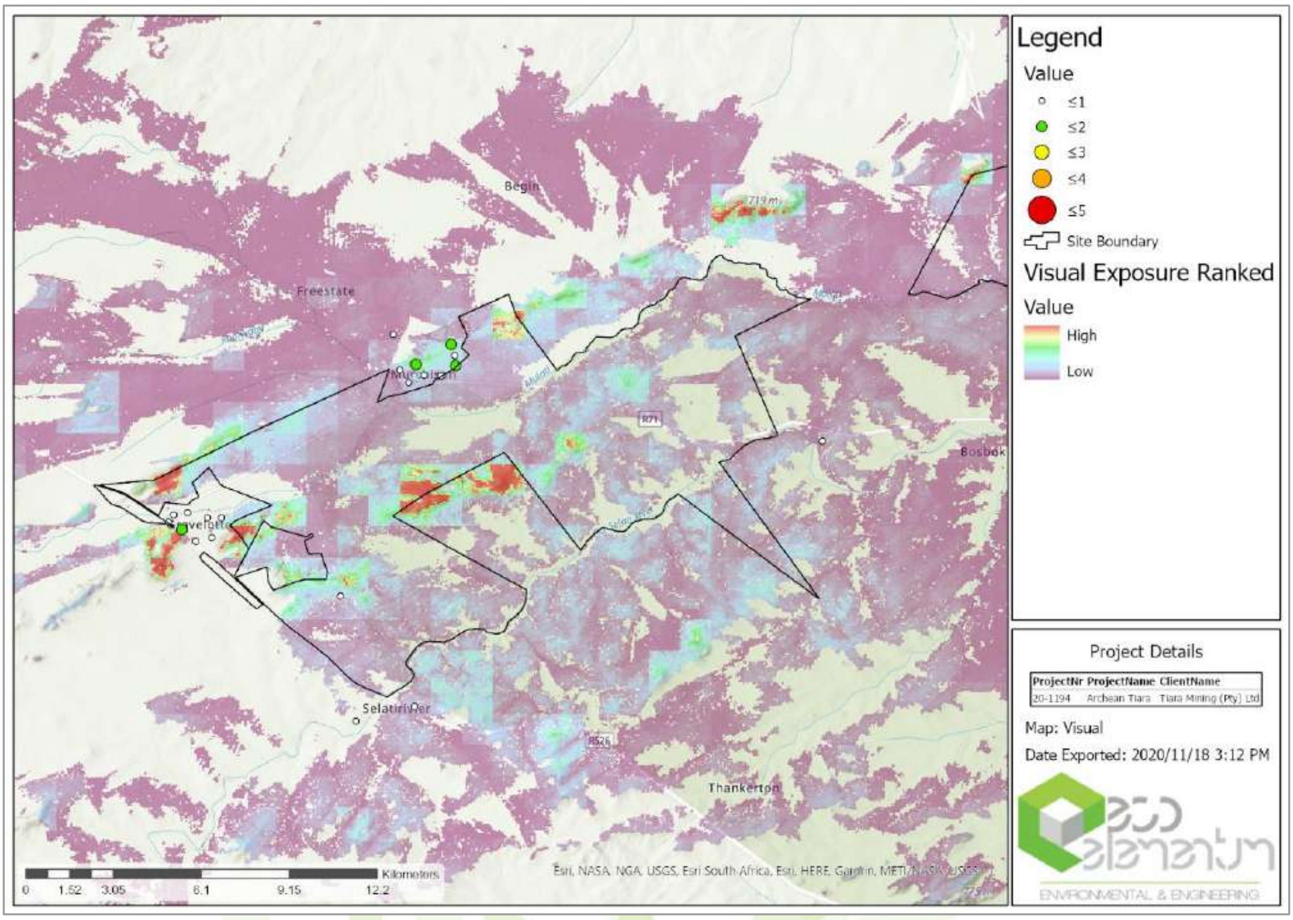

Figure 16: Viewpoint sensitive receptors overlaid on the Visual Exposure Ranking

Each identified sensitive receptor is then overlaid on the Visual Exposure Ranking and the value extracted to that pixel to give a quantitative ranking for each of the identified sensitive receptors as can be seen in Figure 16. Ranking is done from 1 to 10, 1 being very low and 10 very high.

Due to fact that topographic modification can take place by agricultural, vegetation and other activities in the area, the viewshed is only a theoretical study. The viewpoints have been identified based on the sensitivity of the areas to visual disturbance and areas that can be negatively impacted by the related structures.

Table 10: Quantified ranking of Visual Exposure each identified sensitive receptor may have due to proposed infrastructure

Visibility ratings	
ID	Rating
3	0.76
6	1.37
8	0.31
9	0.32
10	1.09
11	0.52
12	0.49
13	1.2
14	0.97
15	1.17
16	0.54
17	0.22
21	0.07

The above table display the results as calculated by the GIS. Only locations that did not receive a 0 are shown. Ratings are ranked 1 - 10, 1 being very low and 10 very high. The system only takes into account the variables as described in this report and the amount of infrastructure that would be visible. Factors like real time and micro scale vegetation are not taken into account, thus the actual rating may be lower or higher depending on the updated land use in the vicinity or latest vegetation growth or height on a micro and macro scale.

The table is by no means a rating of visual quality; it is rather used to determine the likelihood that the proposed infrastructure will be seen from the viewpoint receptors. It is also used to quantitively determine the best option in terms of visual impact.

6.12 Visual Impact Criteria

The level of detail as depicted in the EIA regulations were fine-tuned by assigning specific values to each impact. In order to establish a coherent framework within which all impacts could be objectively assessed, it was necessary to establish a rating system, which was applied consistently to all the criteria. For such purposes each aspect was assigned a value, ranging from one (1) to five (5), depending on its definition. This assessment is a relative evaluation within the context of all the activities and the other impacts within the framework of the project.

The impact assessment criteria used to determine the impact of the proposed development are as follows:

1. ***Severity*** of the impact;
2. **Spatial Scale** - The physical and spatial scale of the impact;
3. ***Duration*** - The lifetime of the impact, measured in relation to the lifetime of the proposed development;
4. ***Frequency of the Activity*** – How often do the activity take place;
5. ***Frequency of the incident/impact*** – How often does the activity impact on the environment;
6. ***Legal Issues*** – How is the activity governed by legislation; and
7. ***Detection*** – How quickly/easily the impacts/risks of the activity be detected on the environment, people and property.

To ensure uniformity, the assessment of potential impacts will be addressed in a standard manner so that a wide range of impacts is comparable. For this reason a clearly defined rating scale is provided for the specialist to assess impacts associated with the investigation.

Table 11: Assessment criteria

SEVERITY	
Insignificant / non-harmful	1
Small / potentially harmful	2
Significant / slightly harmful	3
Great / harmful	4
Disastrous / extremely harmful / within a regulated sensitive area	5
SPATIAL SCALE	
Area specific (at impact site)	1
Whole site (entire surface right)	2
Local (within 5 km)	3
Regional / neighboring areas (5 km to 50 km)	4
National	5
DURATION	
One day to one month (immediate)	1
One month to one year (Short term)	2
One year to 10 years (medium term)	3
Life of the activity (long term)	4
Beyond life of the activity (permanent)	5
FREQUENCY OF THE ACTIVITY	
Annually or less	1
6 monthly	2
Monthly	3
Weekly	4
Daily	5
FREQUENCY OF THE INCIDENT/IMPACT	
Almost never / almost impossible / >20%	1
Very seldom / highly unlikely / >40%	2
Infrequent / unlikely / seldom / >60%	3
Often / regularly / likely / possible / >80%	4
Daily / highly likely / definitely / >100%	5
LEGAL ISSUES	
No legislation	1
Fully covered by legislation	5
DETECTION	
Immediately	1

Without much effort	2
Need some effort	3
Remote and difficult to observe	4
Covered	5
Immediately	1

The impacts that are generated by the development can be minimised if measures are implemented in order to reduce the impacts. The mitigation measures ensure that the development considers the environment and the predicted impacts in order to minimise impacts and achieve sustainable development.

6.12.1 Consequence

Consequence is determined by the following equation after the assessment of each impact.

Consequence = Severity + Spatial Scale + Duration.

6.12.2 Likelihood

The Likelihood of the activity is then calculated based on frequency of the activity and impact, how easily it can be detected and whether the activity is governed by legislation. Thus:

Likelihood = Frequency of activity + frequency of impact + legal issues + detection.

6.12.3 Risk

The risk is then based on the consequence and likelihood.

Risk = Consequence x likelihood.

6.12.4 Impact Ratings

The impact is then rated according to the following table:

Table 12: Impact Rating Table

Rating	Class
1-55	(L) Low Risk
56-169	(M) Moderate Risk
170-600	(H) High Risk

7. VISUAL IMPACT ASSESSMENT

The previous section identified specific areas where, and likelihood of, the potential visual impact would occur as well as scenario with the least predicted visual impact on the sensitive receptors. This section will attempt to quantify these visual impacts in their respective geographic locations and in terms of the identified issues related to the visual impact.

7.1 Potential Construction Phase Visual Impact Of The Structures

Table 13: Summarizing the significance of visual impacts on the viewpoint with an Exposure rating for the Construction phase.

Nature of impact: Potential visual impact on the viewpoints that had a visual exposure rating for the construction phase.			
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5 km to 50 km) (4); National (5)]	**1**	**1**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**2**	**2**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**4**	**4**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**1**	**1**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**3**	**3**
Consequence	Severity + Spatial Scale + Duration	**5**	**5**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**12**	**11**
Risk	Consequence * Likelihood	**MODERATE (60)**	**LOW (55)**
Mitigation:	The visual impact can be minimized creating a visual barrier. The construction area will be cleared as soon as construction of the infrastructure is finished.		
Cumulative Impact:	The construction of the proposed Tiara Granville project with its associated infrastructure will increase the cumulative visual impact of mining type infrastructure within the region. In context of the existing bushveld, the construction phase of Tiara Granville structures will contribute to a regional increase in heavy vehicles on the roads in the region, with construction activity noticeable.		

The impact on the surrounding farmers and land users will be more significant but can still be seen as MODERATE because of the short time the proposed activity will be undertaken. Although the construction activities will be highly visible, the time of exposure is short and thus the impact on the users will be low after mitigation measures have been implemented.

7.2 Potential Permanent Visual Impact Of The Structures

Visibility is determined by a line of sight where nothing obscures the view of an object. Exposure is defined by the degree of visibility, in other words “how much” of it can be seen. This is influenced by topography and the incidence of objects such as trees and buildings that obscure the view partially or in total.

Potential permanent visual impact on the Viewpoints is expected to have a MODERATE impact before mitigation and MODERATE significance after mitigation, as indicated in the table below. The structures will be MODERATE visible from the Viewpoints, the time of exposure is permanent and thus the impact on the users will still remain MODERATE.

Table 14: Impact table summarising the significance of the structures on users of roads and land-users

Nature of impact: Potential visual impact on the viewpoints that had a visual exposure rating.			
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5 km to 50 km) (4); National (5)]	**4**	**2**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**4**	**4**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**5**	**5**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**1**	**1**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**3**	**3**
Consequence	Severity + Spatial Scale + Duration	**10**	**8**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**13**	**12**
Risk	Consequence * Likelihood	**MODERATE (130)**	**MODERATE (96)**

Mitigation:	The visual impact can be minimized by the creation of a visual barrier. Creating a Berm between the opencast pits if and Planting Indigenous vegetation.
Cumulative Impact:	The construction of the proposed Tiara Granville structures with its associated infrastructure will increase the cumulative visual impact of mining type infrastructure within the region. In context of the existing mine, agriculture and town border, the added structures will contribute to a regional increase in small and heavy vehicles on the roads.

The permanent impact on the surrounding land users will be increased due to the extra mining structures added to the area.

The modelling of visibility is merely conceptual. Being based on DEM and Land cover data, it does not take into account the real world effect of buildings, trees etc. that could shield the structures from being visible or could have changed over time.

The viewshed analysis therefore signifies a worst-case scenario. The immediate landscape surrounding the observer has a determining influence on long distance views. It is expected that different land cover may offer some degree of visual screening, especially where tall trees occur around farmsteads. This influence was quantified using the land cover data, it must however be noted that this can change on a micro scale or land cover may have changed over time.

The viewshed analysis was generated and refined to reflect the visual exposure of the development according to its actual position in the landscape, as per the general assumed mining related infrastructure.

7.3 Cumulative Impacts

Cumulative landscape and visual effects (impacts) result from additional changes to the landscape or visual amenity caused by the proposed development in conjunction with other developments (associated with or separate to it), or actions that occurred in the past, present or are likely to occur in the foreseeable future. They may also affect the way in which the landscape is experienced. Cumulative effects may be positive or negative. Where they comprise of a range of benefits, they may be considered to form part of the mitigation measures.

Cumulative effects can also arise from the inter-visibility (visibility) of a range of developments and / or the combined effects of individual components of the proposed development occurring in different locations or over a period of time. The separate effects of such individual components or developments may not be significant, but together they may create an unacceptable degree of adverse effects on visual receptors within their combined visual envelopes. Inter-visibility depends upon general topography, aspect, tree cover or other visual obstruction, elevation and distance, as this affects visual acuity, which is also influenced by weather and light conditions. (Institute of Environmental Assessment and The Landscape Institute, 1996).

- The cumulative visual intrusion of the proposed Tiara Granville structures, will be MODERATE as it is a surface mining operation. The site location is also next to other mining operations which decreases the visual impact further. The visual impact and impact on sense of place of the proposed project will contribute to the cumulative negative effect on the aesthetics of the study area. It is recommended however, that the environmental authorities consider the overall cumulative impact on the agricultural and scattered mining character and the areas sense of place before a final decision is taken with regard to the optimal number of mining activities in the area.

7.4 Mitigation Measures

Mitigation measures may be considered in two categories:

- Primary measures that intrinsically comprise part of the development design through an iterative process. Mitigation measures are more effective if they are implemented from project inception when alternatives are being considered.
- Secondary measures designed to specifically address the remaining negative effects of the final development proposals.

Primary measures that will be implemented will mainly be measures that will minimise the visual impact by softening the visibility of the structures by “blending” with the surrounding areas. Such measures will include rehabilitation of the mining area by re-vegetation of the mining site and surrounding area.

Secondary measures will include final rehabilitation, after care and maintenance of the vegetation and to ensure that the final landform is maintained.

In addition, the following measures are recommended:

- Plant some indigenous trees to create a barrier between the neighbours and roads;
- Dust from Stockpile areas, roads and other activities must be managed by means of dust suppression to prevent excessive dust;
- A wind barrier system that encloses the stockpiles;
- Rehabilitation of the area must be done once mining is completed.
- Creating Berms around the opencast pits and planting indigenous vegetation on the berms.

8. CONCLUSION

The construction and operation phase of the proposed Tiara Granville project related activities and its associated infrastructure will have a MODERATE visual impact on the natural scenic resources and the topography. However, with the correct mitigation measures the impact might decrease to a point where the visual impact can be seen as less significant. The moderating factors of the visual impact of the proposed mining operations in close range are the following:

- Number of human inhabitants located in the area;
- Natural topography and vegetation;
- Mitigation measures that will be implemented such as the establishment of barriers or screens;
- The size of the operation; and
- High absorption capacity of the landscape.

In light of the above mentioned factors that reduce the impact of the facility, the visual impact is assessed as MODERATE VISUAL IMPACT after mitigation measures have been implemented.

Table 15: The overall Assessment of the Visual Impact

Nature of impact: The overall Assessment of the Visual Impact of the area.			
		Unmitigated	**Mitigated**
Assessment Criteria	**Severity** [Insignificant / non-harmful (1); Small / potentially harmful (2); Significant / slightly harmful (3); Great / harmful (4); Disastrous / extremely harmful / within a regulated sensitive area (5)]	**2**	**2**
	Spatial Scale [Area specific (at impact site) (1); Whole site (entire surface right) (2); Local (within 5km) (3); Regional / neighbouring areas (5 km to 50 km) (4); National (5)]	**4**	**2**
	Duration [One day to one month (immediate) (1); One month to one year (Short term) (2); One year to 10 years (medium term) (3); Life of the activity (long term) (4); Beyond life of the activity (permanent) (5)]	**4**	**4**
	Frequency of Activity [Annually or less (1); 6 monthly (2); Monthly (3); Weekly (4); Daily (5)]	**5**	**5**
	Frequency of Incident/Impact [Almost never / almost impossible / >20% (1); Very seldom / highly unlikely / >40% (2); Infrequent / unlikely / seldom / >60% (3); Often / regularly / likely / possible / >80% (4); Daily / highly likely / definitely / >100% (5)	**4**	**3**
	Legal Issues [No legislation(1); Fully covered by legislation (5)]	**1**	**1**
	Detection [Immediately(1); Without much effort (2); Need some effort (3); Remote and difficult to observe (4); Covered (5)]	**3**	**3**
Consequence	Severity + Spatial Scale + Duration	**10**	**8**
Likelihood	Frequency of Activity + Frequency of impact + Legal issues + Detection	**13**	**12**
Risk	Consequence * Likelihood	**MODERATE (130)**	**MODERATE (96)**
Mitigation:	The visual impact can be minimized by the creation of a visual barrier.		
Cumulative Impact:	Construction of proposed Tiara Granville structures with its associated infrastructure will increase the cumulative visual impact of the mining character within the region. In context of the existing character, added structures will contribute to a regional increase in small and heavy vehicles on the roads.		

The Visual Impact due to mining activities and associated infrastructure can be seen as having a MODERATE impact on the surrounding environment and inhabitants before mitigation measures are implemented. After mitigation, the visual impact can be seen as MODERATE. The visual impact from the mining activities can be sufficiently mitigated to a point where it can be seen as insignificant. Thus, mitigation measures are very important and one of the most significant mitigation measures are the rehabilitation of the area after mining has been concluded. If the rehabilitation of the impact is not done correctly and the final landform do not fit into the surrounding area then the visual impact will remain high and become a concern. However, with correct rehabilitation, the impact will be minimal and there should be no visual impact after the landform has been restored.

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Appendix 7 - Archaeological Scoping Report

ARCHAEOLOGICAL SCOPING REPORT

for the Proposed Tiara Mining Project on the demarcated portions of the RE of the Farm B.V.B Ranch 776 LT and the Farm Granville 767 LT, Phalaborwa, Limpopo

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October 2020

Archaeological scoping report for the proposed Tiara Mining Project on the demarcated portions of the RE of the Farm B.V.B Ranch 776 LT and the Farm Granville 767 LT, Phalaborwa, Limpopo

For: Archean Resources (Pty) Ltd

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Version: 1

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- I, Tobias Coetzee, declare that –
- I act as the independent specialist;
- I am conducting any work and activity relating to the proposed Tiara Mining Project in an objective manner, even if this results in views and findings that are not favourable to the client;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have the required expertise in conducting the specialist report and I will comply with legislation, regulations and any guidelines that have relevance to the proposed activity;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this declaration are true and correct.

Date: 30 October 2020

Executive Summary

The author was appointed by Archean Resources (Pty) Ltd to undertake an Archaeological Scoping study for Tiara Mining (Pty) Ltd on the listed Farm Portions (**Table 1)** within the Ba-Phalaborwa Local Municipality in the Limpopo Province. The proposed project consists of two study areas: One portion on B.V.B. Ranch 776 LT and one portion on the Farm Granville 767 LT. The B.V.B. Ranch 776 LT portion is located roughly 15 km east-northeast of Gravelotte, 44 km west of Phalaborwa and 66 km south of Giyani. The Granville 767 LT portion is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani. The aim of this report is to contextualise the general study area in terms of heritage resources and will provide the developers with general information regarding potentially sensitive areas. This will also shed light on what is to be expected during a Phase 1 Archaeological Impact Assessment and aid in interpreting finds.

Based on historical topographical maps and historical aerial photographs, no buildings, structures or cemeteries exist on the demarcated portions. Single graves and cultural heritage remains dating to the Stone Ages and Iron Age/Farmer Period, however, are not likely to be visible on such historical datasets. Such sites are generally associated with water sources and hills. These potentially sensitive areas are indicated on **Figures 14 & 15**. Research into archaeological sites associated with the general area revealed an area rich in Stone Age, Iron Age/Farmer and Historical Period remains. Typical sites may include ESA/MSA/LSA remains, Iron Age/Farmer settlements and its associated material culture, as well as historical buildings and structures. A full Phase 1 AIA, however, must be done prior to any development.

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1. Project Background

1.1 Introduction

Archean Resources (Pty) Ltd appointed the author to undertake an Archaeological Scoping study for Tiara Mining (Pty) Ltd on the following parent farms: B.V.B. Ranch 776 LT and Granville 767 LT within the Ba-Phalaborwa Local Municipality and the Mopani District Municipality in the Limpopo Province. The affected farm portions are listed in **Table 1,** while **Table 2** lists the farm portions pertaining to the larger long-term mining project. The proposed project consists of two study areas: One portion on B.V.B. Ranch 776 LT and a portion on the Farm Granville 767 LT. The B.V.B. Ranch 776 LT section is located roughly 15 km east-northeast of Gravelotte, 44 km west of Phalaborwa and 66 km south of Giyani. The Granville 767 LT portion is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani (**Figure 1**). The purpose of this study is to contextualise the demarcated study area in order to determine the scope of heritage resources that might be encountered during the proposed mining project and Phase 1 AIA. The aim of this report is to provide the developer with information regarding heritage resources in the vicinity of the study area based on results from previous studies, written historical information and historical topographical maps and aerial photographs.

In the following report, I provide a broad overview of the proposed Tiara Mining project and contextualise the study area in terms of heritage resources. The mining right application is for all Emerald (gemstone- Gem), except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa). The legislation section included serves as a guide towards the effective identification and protection of heritage resources and will apply to any such material unearthed during the proposed mining project.

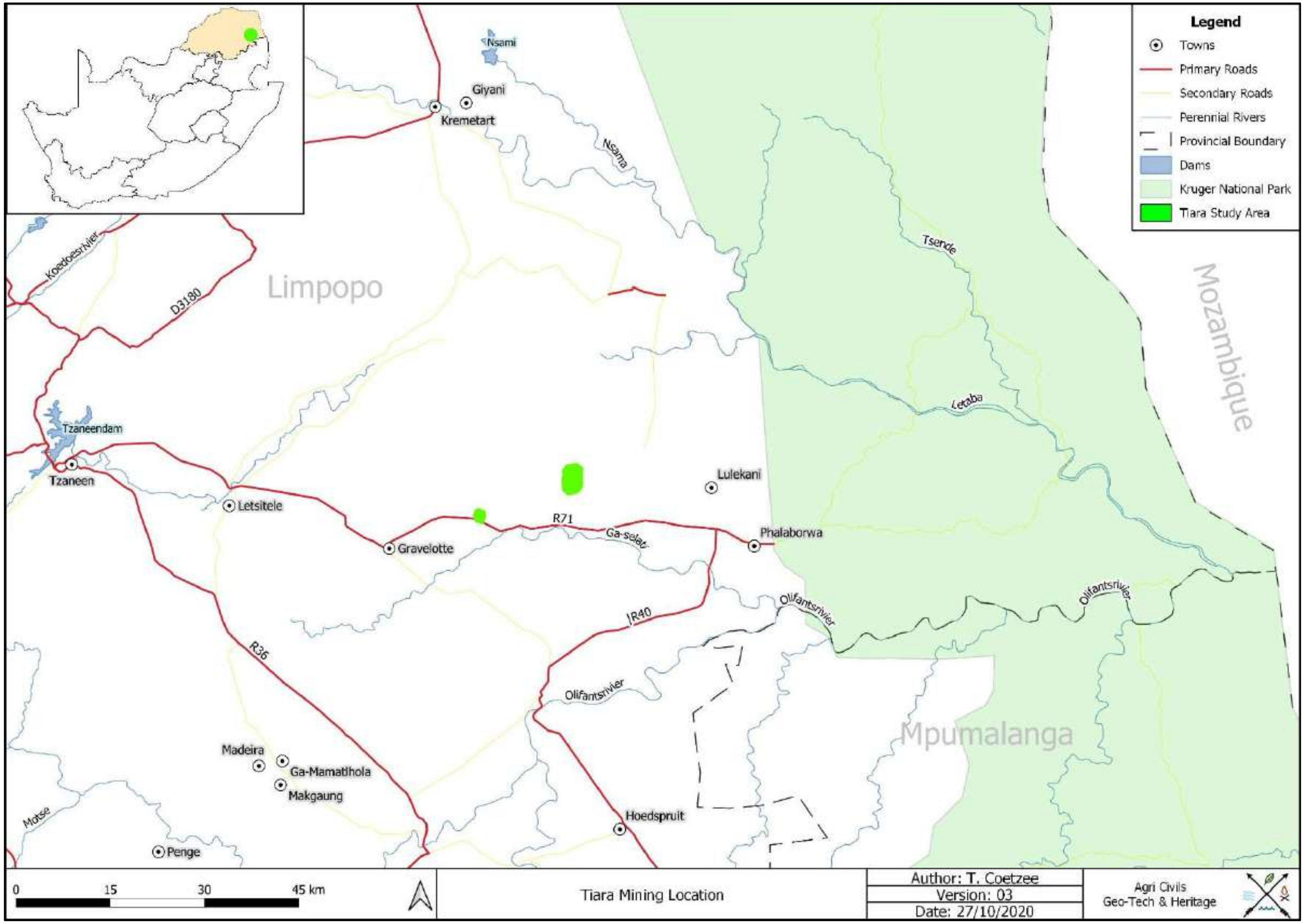

Figure 1: Regional and Provincial location of the study area.

1.2 Legislation

The South African Heritage Resources Agency (SAHRA) aims to conserve and control the management, research, alteration and destruction of cultural resources of South Africa and to prosecute if necessary. It is therefore crucially important to adhere to heritage resource legislation contained in the Government Gazette of the Republic of South Africa (Act No.25 of 1999), as many heritage sites are threatened daily by development. Conservation legislation requires an impact assessment report to be submitted for development authorisation that must include an AIA if triggered.

AIAs should be done by qualified professionals with adequate knowledge to (a) identify all heritage resources that might occur in areas of development and (b) make recommendations for protection or mitigation of the impact of the sites.

1.2.1 The EIA and AIA processes

Phase 1 Archaeological Impact Assessments generally involve the identification of sites during a field survey with assessment of their significance, the possible impact that the development might have, and relevant recommendations.

All Archaeological Impact Assessment reports should include:

a. Location of the sites that are found;

b. Short descriptions of the characteristics of each site;

c. Short assessments of how important each site is, indicating which should be conserved and which mitigated;

d. Assessments of the potential impact of the development on the site(s);

e. In some cases a shovel test, to establish the extent of a site, or collection of material, to identify the associations of the site, may be necessary (a pre-arranged SAHRA permit is required); and

f. Recommendations for conservation or mitigation.

This AIA report is intended to inform the client about the legislative protection of heritage resources and their significance and make appropriate recommendations. It is essential to also provide the heritage authority with sufficient information about the sites to enable the authority to assess with confidence:

a. Whether or not it has objections to a development;

b. What the conditions are upon which such development might proceed;

c. Which sites require permits for mitigation or destruction;

d. Which sites require mitigation and what this should comprise;

e. Whether sites must be conserved and what alternatives can be proposed to relocate the development in such a way as to conserve other sites; and

f. What measures should or could be put in place to protect the sites which should be conserved.

When a Phase 1 AIA is part of an EIA, wider issues such as public consultation and assessment of the spatial and visual impacts of the development may be undertaken as part of the general study and may not be required from the archaeologist. If, however, the Phase 1 project forms a major component of an AIA it will be necessary to ensure that the study addresses such issues and complies with Section 38 of the National Heritage Resources Act.

1.2.2 Legislation regarding archaeology and heritage sites

National Heritage Resource Act No.25 of April 1999

Buildings are among the most enduring features of human occupation, and this definition therefore includes all buildings older than 60 years, modern architecture as well as ruins, fortifications and Farming Community settlements. The Act identifies heritage objects as:

- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects, meteorites and rare geological specimens;
- visual art objects;
- military objects;
- numismatic objects;
- objects of cultural and historical significance;
- objects to which oral traditions are attached and which are associated with living heritage;
- objects of scientific or technological interest;
- books, records, documents, photographic positives and negatives, graphic material, film or video or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No. 43 of 1996), or in a provincial law pertaining to records or archives;

- any other prescribed category.

With regards to activities and work on archaeological and heritage sites this Act states that:

"No person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority." (34. [1] 1999:58)

and

"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."(35. [4] 1999:58)

and

"No person may, without a permit issued by SAHRA or a provincial heritage resources authority:

(a) destroy, damage, alter, exhume or remove from its original position or otherwise disturb the grave of a victim of conflict, or any burial ground or part thereof which contains such graves;

(b) destroy, damage, alter, exhume, remove from its original position or otherwise disturb any grave or burial ground older than 60 years which is situated outside a formal cemetery administered by a local authority;

(c) bring onto or use at a burial ground or grave referred to in paragraph (a) or (b) and excavation equipment, or any equipment which assists in the detection or recovery of metals." (36. [3] 1999:60)

On the development of any area the gazette states that:

"…any person who intends to undertake a development categorised as:

(a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;

(b) *the construction of a bridge or similar structure exceeding 50m in length;*

(c) *any development or other activity which will change the character of a site-*

i. *exceeding 5000m² in extent; or*

ii. *involving three or more existing erven or subdivisions thereof; or*

iii. *involving three or more erven or divisions thereof which have been consolidated within the past five years; or*

iv. *the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;*

(d) *the re-zoning of a site exceeding 10000m² in extent; or*

(e) *any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority, must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development."* (38. [1] 1999:62-64)

and

"The responsible heritage resources authority must specify the information to be provided in a report required in terms of subsection (2)(a): Provided that the following must be included:

(a) *The identification and mapping of all heritage resources in the area affected;*

(b) *an assessment of the significance of such resources in terms of the heritage assessment criteria set out in section 6(2) or prescribed under section 7;*

(c) *an assessment of the impact of the development on such heritage resources;*

(d) *an evaluation of the impact of the development on heritage resources relative to the sustainable social and economic benefits to be derived from the development;*

(e) *the results of consultation with communities affected by the proposed development and other interested parties regarding the impact of the development on heritage resources;*

(f) *if heritage resources will be adversely affected by the proposed development, the consideration of alternatives; and*

(g) plans for mitigation of any adverse effects during and after the completion of the proposed development." (38. [3] 1999:64)

Human Tissue Act and Ordinance 7 of 1925

The Human Tissues Act (65 of 1983) and Ordinance on the Removal of Graves and Dead Bodies (Ordinance 7 of 1925) protects graves younger than 60 years. These fall under the jurisdiction of the National Department of Health and the Provincial Health Departments. Approval for the exhumation and re-burial must be obtained from the relevant Provincial MEC as well as the relevant Local Authorities. Graves 60 years or older fall under the jurisdiction of the National Heritage Resources Act as well as the Human Tissues Act, 1983.

2. Study Area and Project Description

2.1 Location & Physical Environment

Table 1 lists the demarcated project areas and intersecting land parcels for the first phase of the project, while **Table 2** lists the land parcels of the larger project as obtained form the Mine Work Programme.

Table 1: Property name & coordinates of the proposed study areas.

Property	Portion	Map Reference (1:50 000)	Lat (y)	Lon (x)	Parcel extent (ha)	Development Extent (ha)
B.V.B Ranch 776 LT	RE/776	2330 DC	-23.903867	30.743935	1547.8	48
Granville 767 LT	0	2330 DD	-23.857985	30.877454	3110.3	582

Table 2: Land parcels part of the larger project.

No	Parent Farm	Farm Portion
1	B.V.B Ranch 776 LT	12/776
2	Josephine 749 LT	Full extent
3	Buffalo Ranch 834 LT	Full extent
4	Danie 789 LT	RE
5	Farrel 781 LT	RE
6	Farrel 781 LT	6/781
7	Willie 787 LT	RE

Gravelotte is located about 15 km west-southwest of the proposed mine infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT, while Phalaborwa is located 44 km to the east and Giyani 66 km to the north. The proposed opencast mining block A1 on the Farm Granville 767 LT is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani. The study area falls within the Ba-Phalaborwa Local Municipality and the Mopani District Municipality in the Limpopo Province. The R71 primary road runs east-west between Gravelotte and Phalaborwa and borders the demarcated mining infrastructure section on the Farm B.V.B. Ranch 776 LT on the southern border, while the R71 is located roughly 6 km to the south of the proposed opencast mining block A1.

In terms of vegetation, the study area falls within the Savanna Biome and Lowveld Bioregion. On a local scale, Granite Lowveld covers the majority of both study areas, while the south-eastern section of both areas fall on Phalaborwa-Timbavati Mopaneveld (Mucina & Rutherfords 2006).

The distribution of Granite Lowveld is described by Mucina & Rutherfords (2006) as:

"Limpopo and Mpumalanga Provinces, Swaziland and marginally also KwaZulu-Natal: A north-south belt on the plains east of the escarpment from Thohoyandou in the north, interrupted in the Bolobedu area, continued in the Bitavi area, with an eastward extension on the plains around the Murchison Range and southwards to Abel Erasmus Pass, Mica and Hoedspruit areas to the area east of Bushbuckridge. Substantial parts are found in the Kruger National Park spanning areas east of Orpen Camp southwards through Skukuza and Mkuhlu, including undulating terrain west of Skukuza to the basin of the Mbyamiti River. It continues further southward to the Hectorspruit area with a narrow westward extension up the Crocodile River Valley past Malelane, Kaapmuiden and the Kaap River Valley, entering Swaziland between Jeppe's Reef in the west and the Komati River in the east, through to the area between Manzini and Siphofaneni, including the Grand Valley, narrowing irregularly and marginally entering KwaZulu-Natal near Pongola"

Granite Lowveld is considered vulnerable with a conservation target of 19%. About 17% is statutorily conserved in the Kruger National Park and roughly the same amount in private reserves. More than 20% has already been transformed, mainly by cultivation and settlement development. Erosion is considered very low to moderate (Mucina & Rutherfords 2006).

Phalaborwa-Timbavati Mopaneveld is associated with the Limpopo and Mpumalanga Provinces and is distributed in a band about 40 km west and east of Phalaborwa. This vegetation unit also occurs in the area south of the Olifants River on the boundary between the Timbavati Game Reserve and the Kruger National Park. Parts of the Umbabat and Klaserie Nature Reserves are included as well. In terms of conservation, Phalaborwa-Timbavati Mopaneveld is considered least threatened with a conservation target of 19%. About 38% is statutorily conserved in the Kruger National Park with roughly the same amount in private nature reserves. About 5% has been transformed mostly by development, human settlement and mining (Mucina & Rutherfords 2006).

The average elevation for Granite Lowveld varies between 250 and 700 MASL, while Phalaborwa-Timbavati Mopaneveld varies between 300 and 600 MASL (Mucina & Rutherfords 2006). The elevation for the proposed mining infrastructure area on the Farm B.V.B Ranch 776 LT is 520 MASL and slopes from the more elevated south-eastern section towards the lower north-western area. The elevation of the demarcated portion on the Farm Granville 767 LT varies between 450 and 470 MASL and slopes form the more elevated northern section towards the lower southern section.

The study area falls within the summer rainfall region and the average annual rainfall is roughly 543 mm per year. The average maximum temperature for the study area is recorded during January when an average of 26.1 ºC is reached. The average minimum temperature is recorded during June when an average of 17 ºC is reached (Climate-data.org 27/10/2020).

The majority of the study area falls within the B72J Quaternary Catchment of the Ga-Selati River Catchment , while a small section of the southern portion of the proposed mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 767 LT falls within B72K of the Molatle River Catchment. The closest perennial river to the study area is the Ga-Selati River that flows 4 km to the south of the proposed area on the Farm B.V.B. Ranch 776 LT and 6 km south of the Granville 767 LT portion. A non-perennial stream is located along the western border of the B.V.B. Ranch 776 LT section and one on eastern, as well western side of the Granville 767 LT portion.

2.2 Project description

The proposed Tiara Granville Emerald and Quartz Mine proposes to mine all emerald (gemstone- Gem), except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa) on the demarcated portions as indicated on **Figure 2**. It should be noted, however, that the entire project includes a significantly larger study area (listed in **Table 2**) with mining operations planned until 2051, but for the first phase the focus will only be on the demarcated portions as indicated by **Figure 2.**

The main reason for this particular Mining Right application is for the supply of quartz (gemstones) to various markets including the electronics and semiconductors industry, solar, building and construction industry, optical fibre and telecommunication, automotive industry and other end-user industries. The main products that are envisaged to be sold are silicon metal, quartz crystal, high purity quartz (quartz surface and tiles, fused quartz crucible and quartz glass). Roughly 60% of the products will be distributed within the Middle-East and Africa (South Africa and Saudi Arabia) while the remaining 40% is destined for the export market (South America- Brazil and Argentina; Europe-Germany, United Kingdom, Italy, France, and Russia; North-America- United States of America, Canada, Mexico and lastly Asia Pacific- China, India, Japan and South Korea).

The proposed mining will be based on the following principles:

- Mining will take place by opencast drilling, blasting, truck and shovel bench mining;
- Bench sets will be mined at approximately 300 m in length, with a width of 200 m and each cut will have a depth of 70 m;
- It is estimated that a mine cut measuring 40m x 40 m x 6m along a bench set will be mined in less than a month;
- Annual production will be about 428 400 tonnes of RoM material;
- Mining will take place to a maximum depth of 70 m;
- Overburden stripping will be required. Only 50-100 mm of topsoil might be removed for each box-cut;
- Topsoil will be stockpiled for future rehabilitation purposes;
- The processed material will be stockpiled in the product stockpile areas located close to the mine office complex.

The proposed Tiara Granville Quartz Mine Life of Mine (LoM) is estimated at 30 years ending in year 2051. Construction is expected to commence in the first quarter (Q1) of 2021, whilst the operational phase (production) is scheduled for the second quarter (Q2) of 2021. Mining will commence in the north-eastern parts of the project area (on the Granville 767 LT, BVB Ranch 776 LT and Buffalo Ranch 834 LT) moving towards the south-westerly direction into the farm Farrel 781 LT, Josephine 749 LT, Willie 787 LT as well as Danie 789 LT.

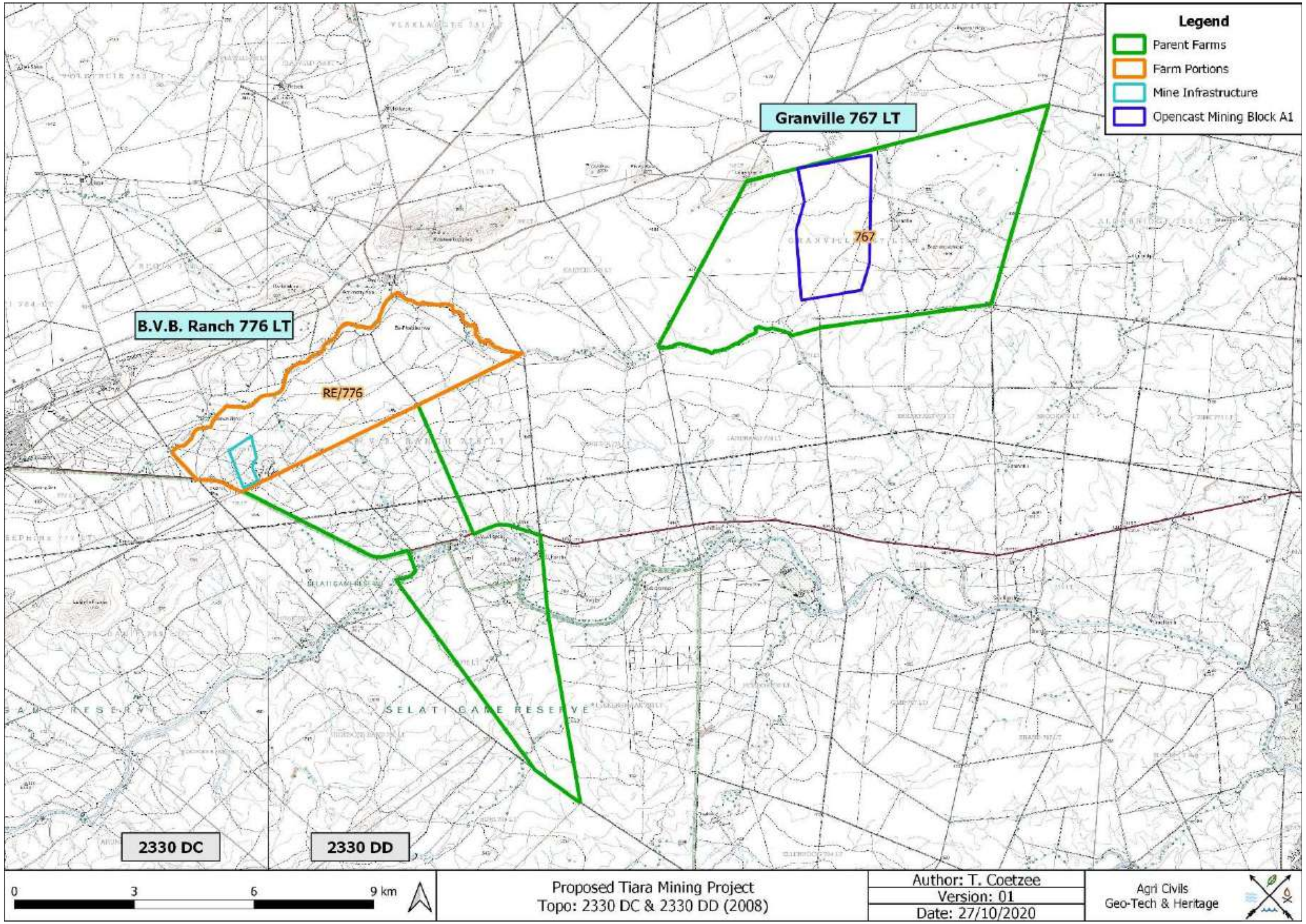

Figure 2: Segments of SA 1: 50 000 2330 DC & DD indicating the study area.

3. Archaeological Background

Southern African archaeology is broadly divided into the Early, Middle and Later Stone Ages; Early, Middle and Later Iron Ages; and Historical or Colonial Periods. This section of the report provides a general background to archaeology in South Africa.

3.1 The Stone Age

The earliest stone tool industry, the Oldowan, was developed by early human ancestors which were the earliest members of the genus *Homo,* such as *Homo habilis*, around 2.6 million years ago. It comprises tools such as cobble cores and pebble choppers (Toth & Schick 2007). Archaeologists suggest these stone tools are the earliest direct evidence for culture in southern Africa (Clarke & Kuman 2000). The advent of culture indicates the advent of more cognitively modern hominins (Mitchell 2002: 56, 57).

The Acheulean industry completely replaced the Oldowan industry. The Acheulian industry was first developed by *Homo ergaster* between 1.8 to 1.65 million years ago and lasted until around 300 000 years ago. Archaeological evidence from this period is also found at Swartkrans, Kromdraai and Sterkfontein. The most typical tools of the ESA are handaxes, cleavers, choppers and spheroids. Although hominins seemingly used handaxes often, scholars disagree about their use. There are no indications of hafting, and some artefacts are far too large for it. Hominins likely used choppers and scrapers for skinning and butchering scavenged animals and often obtained sharp ended sticks for digging up edible roots. Presumably, early humans used wooden spears as early as 5 million years ago to hunt small animals.

Middle Stone Age artefacts started appearing about 250 000 years ago and replaced the larger Early Stone Age bifaces, handaxes and cleavers with smaller flake industries consisting of scrapers, points and blades. These artefacts roughly fall in the 40-100 mm size range and were, in some cases, attached to handles, indicating a significant technical advance. The first *Homo sapiens* species also emerged during this period. Associated sites are Klasies River Mouth, Blombos Cave and Border Cave (Deacon & Deacon 1999).

Although the transition from the Middle Stone Age to the Later Stone Age did not occur simultaneously across the whole of southern Africa, the Later Stone Age ranges from about 20 000 to 2000 years ago. Stone tools from this period are generally smaller, but were used to do the same job as those from previous periods; only in a different, more efficient way. The Later Stone Age is associated with: rock art, smaller stone tools (microliths), bows and arrows, bored stones, grooved stones, polished bone tools, earthenware pottery and beads. Examples of Later Stone Age sites are Nelson Bay Cave, Rose Cottage Cave and Boomplaas Cave (Deacon & Deacon 1999). These artefacts are often associated with rocky outcrops or water sources. **Figures 7 – 9** below shows examples of stone tools often associated with the ESA, MSA and LSA of southern Africa. The LSA site, Fort Troje, is located just north of Cullinan and approximately 35 km northwest of the proposed National Treasure Minerals Prospecting project (Korsman et al. 1998: 95).

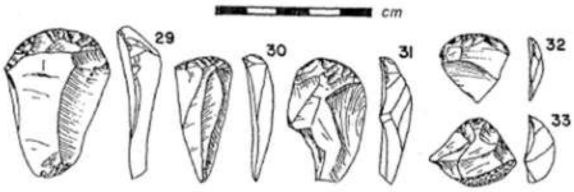

Figure 3: LSA scrapers (Klein 1984).

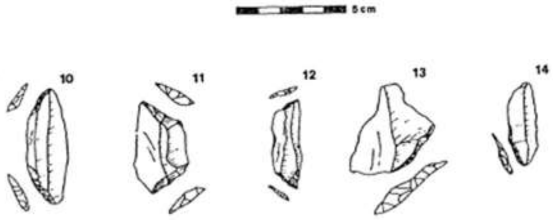

Figure 4: MSA artefacts from Howiesons Poort (Volman 1984).

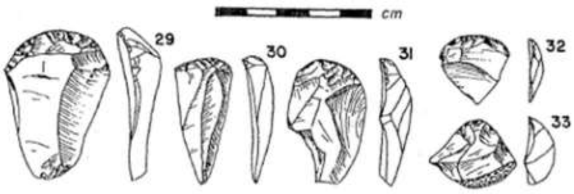

Figure 5: LSA scrapers (Klein 1984).

3.2 The Iron Age & Historical Period

The Early Iron Age marks the movement of farming communities into South Africa in the first millennium AD, or around 2500 years ago (Mitchell 2002:259, 260). These groups were agro-pastoralist communities that settled in the vicinity of water in order to provide subsistence for their cattle and crops. Archaeological evidence from Early Iron Age sites is mostly artefacts in the form of ceramic assemblages. The origins and archaeological identities of this period are largely based upon ceramic typologies. Some scholars classify Early Iron Age ceramic traditions into different “streams” or “trends” in pot types and decoration, which emerged over time in southern Africa. These “streams” are identified as the Kwale Branch (east), the Nkope Branch (central) and the Kalundu Branch (west). Early Iron Age ceramics typically display features such as large and prominent inverted rims, large neck areas and fine elaborate decorations. This period continued until the end of the first millennium AD (Mitchell 2002; Huffman 2007). Some well-known Early Iron Age sites include the Lydenburg Heads in Mpumalanga, Happy Rest in the Limpopo Province and Mzonjani in Kwa-Zulu Natal.

The Middle Iron Age roughly stretches from AD 900 to 1300 and marks the origins of the Zimbabwe culture. During this period cattle herding appeared to play an increasingly important role in society. However, it was proved that cattle remained an important source of wealth throughout the Iron Age. An important shift in the Iron Age of southern Africa took place in the Shashe-Limpopo basin during this period, namely the development of class distinction and sacred leadership. The Zimbabwe culture can be divided into three periods based on certain capitals. Mapungubwe, the first period, dates from AD 1220 to 1300, Great Zimbabwe from AD 1300 to 1450, and Khami from AD 1450 to 1820 (Huffman 2007: 361, 362).

The Late Iron Age roughly dates from AD 1300 to 1840. It is generally accepted that Great Zimbabwe replaced Mapungubwe. Some characteristics include a greater focus on economic growth and the increased importance of trade. Specialisation in terms of natural resources also started to play a role, as can be seen from the distribution of iron slag which tend to occur only in certain localities compared to a wide distribution during earlier times. It was also during the Late Iron Age that different areas of South Africa were populated, such as the interior of KwaZulu Natal, the Free State, the Gauteng Highveld and the Transkei. Another characteristic is the increased use of stone as building material. Some artefacts associated with this period are knife-blades, hoes, adzes, awls, other metal objects as well as bone tools and grinding stones.

The Historical period mainly deals with Europe's discovery, settlement and impact on southern Africa. Some topics covered by the Historical period include Dutch settlement in the Western Cape, early mission stations, Voortrekker routes and the Anglo Boer War. This time period also saw the compilation of early maps by missionaries, explorers, military personnel, etc.

Figures 6 – 13 are examples of some heritage sites likely to be encountered – such areas should be avoided.

Figure 6: Example of undecorated potsherds.

Figure 7: Example of a decorated potsherd.

Figure 8: Example of a potential granary base.

Figure 9: Example of a stone-walled site.

Figure 10: Example of a broken lower grinding stone.

Figure 11: Example of a dilapidated stone-walled site.

Figure 12: Example of a historical building.

Figure 13: Example of a potential informal grave.

3.3 Previous Heritage Studies

Mahale Quartzite Mine, Phalaborwa

A phase 1 HIA was done for the Mahale Quartzite Mine located on portions of the farms Mahale 718 LT, Silwana's Location 719 LT & Wildebeest 745 LT near Phalaborwa. The study area for the Mahale Quartzite Mine is located about 12 km northeast of the proposed Tiara Mining Project study area. The HIA recorded ceremonial remains on a hilltop within the study area and a Phase 2 assessment was recommended (Roodt 2008).

400kV Powerline from Foskor Substation to Spencer Substation

The Phase 1 AIA for the construction of a 400kV powerline from Foskor Substation to Spencer Substation was done by Vhubvo Archaeo-Heritage Consultant cc (Magoma & Muroyi 2018). The proposed powerline spans a distance of 110 km just south of Phalaborwa to approximately 40 km southwest of Giyani. The study recorded two cemeteries, an abandoned settlement and the Muti wa Vatsonga Open Museum, but notes the possibility of Stone Age/Iron Age sites in the vicinity. The closest section of the powerline project to the proposed Tiara Mining Project is approximately 15 km to the southwest of the demarcated portion on the Farm B.V.B. Ranch 776 LT.

BaPhalaborwa Waste Disposal Landfill Site

Roodt (2002) conducted an Archaeological Impact Assessment for the BaPhalaborwa Waste Disposal Landfill Site. The study recorded an Iron Age site at the base of a hill that consisted of middens and terraces. The middens were rich pottery fragments, bone and metal slag. Other material culture found include an ostrich eggshell bead and tuyere pieces. According to Roodt (2002), the site is typical of a pre-colonial BaPhalaborwa settlement but also notes that some of the pottery fragments might date to the 10^{th} – 12^{th} Century and belong to the Kgopolwe cultural tradition. It is also noted that the possibility exists that the hilltop might have been used in rainmaking rituals. The BaPhalaborwa Waste Disposal Landfill Site is located approximately 21 km southeast of the proposed Granville 767 LT area.

4. Evaluation

The significance of an archaeological site is based on the amount of deposit, the integrity of the context, the kind of deposit and the potential to help answer present research questions. Historical structures are defined by Section 34 of the National Heritage Resources Act, 1999, while other historical and cultural significant sites, places and features, are generally determined by community preferences.

A fundamental aspect in the conservation of a heritage resource relates to whether the sustainable social and economic benefits of a proposed development outweigh the conservation issues at stake. There are many aspects that must be taken into consideration when determining significance, such as rarity, national significance, scientific importance, cultural and religious significance, and not least, community preferences. When, for whatever reason the protection of a heritage site is not deemed necessary or practical, its research potential must be assessed and if appropriate mitigated in order to gain data / information which would otherwise be lost. Such sites must be adequately recorded and sampled before being destroyed.

5. Statement of Significance & Recommendations

5.1 Statement of significance

The study area: A portion of the Remaining Extent of the Farm B.V.B. Ranch 776 LT and a portion of the Farm Granville 767 LT, Phalaborwa, Limpopo

According to historical imagery, topographical maps and previous heritage studies done in the general area, the general region is significant from a heritage perspective. Heritage sites are likely to include Stone Age material, cemeteries/graves, Iron Age/Farmer Period and historical sites. Stone Age and Iron Age/Farmer Period sites are generally associated with water sources and hills. Therefore, sensitivity maps based on inland water areas, drainage lines and areas characterised by steep gradients were created (**Figures 14 & 15**). Except for two buildings along the southern boundary of the demarcated portion on the Remaining Extent of the Farm B.V.B. Ranch 767 LT, no buildings or structures, however, were identified on historical aerial photographs or topographical maps (**Appendix A: Figures 16 – 29**). The two buildings are visible on the 1974 topographical map (**Appendix A: Figure 26**), but appear to relate to the mining activity to the east of the study area that dates to between 1965 and 1968. The drainage lines and inland water features (based on digital 1: 50 000 topographical data) were buffered by 200 m, while a gradient buffer was established around areas with closely spaced contour lines falling within the study area. These areas are considered potentially sensitive from a heritage perspective and extra attention should be paid when impacting on these areas. This, however, does not mean that the remaining area might not be sensitive, only that it is more likely to encounter heritage remains within the demarcated zones.

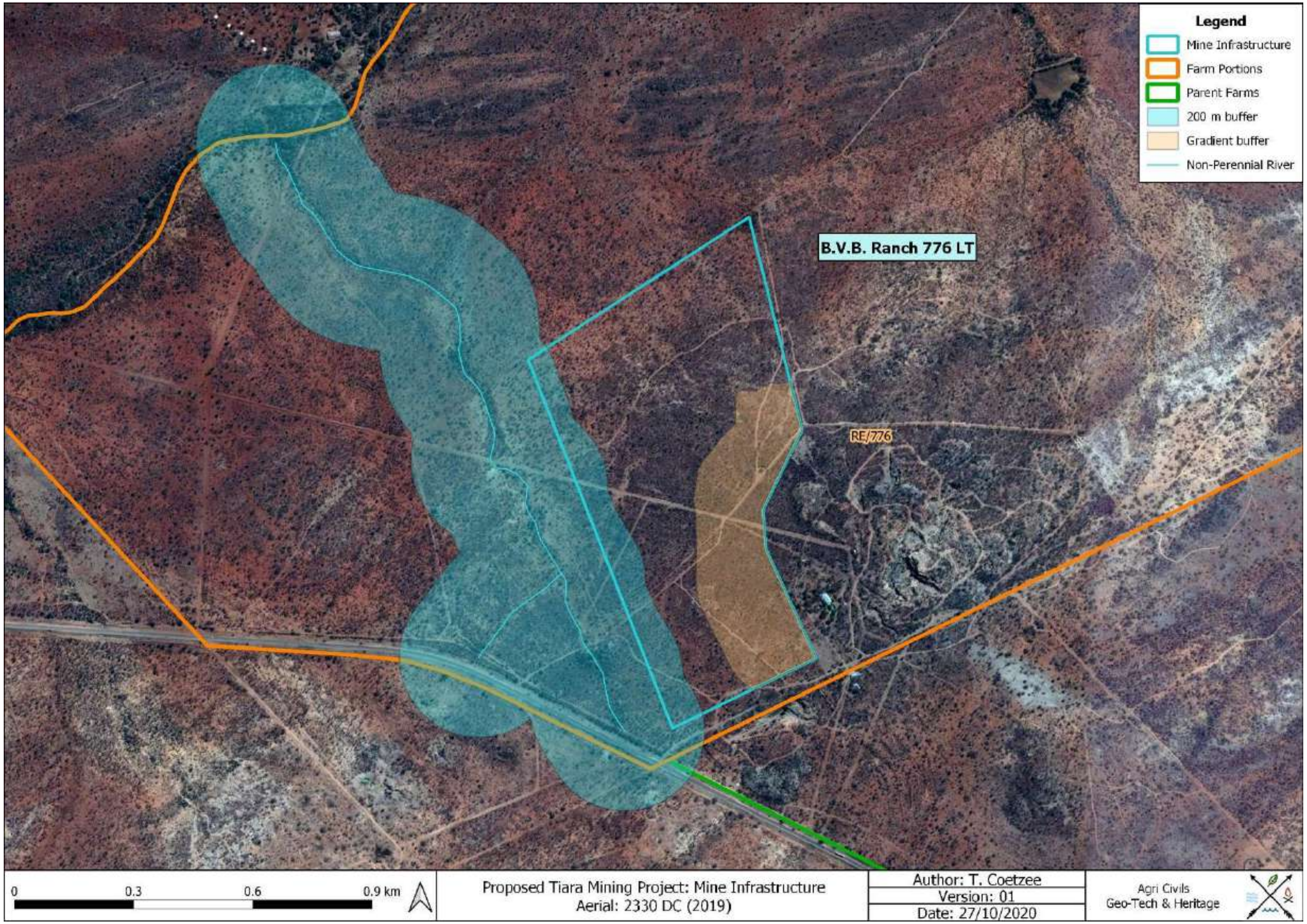

Figure 14: Heritage Sensitivity Map – Mine Infrastructure.

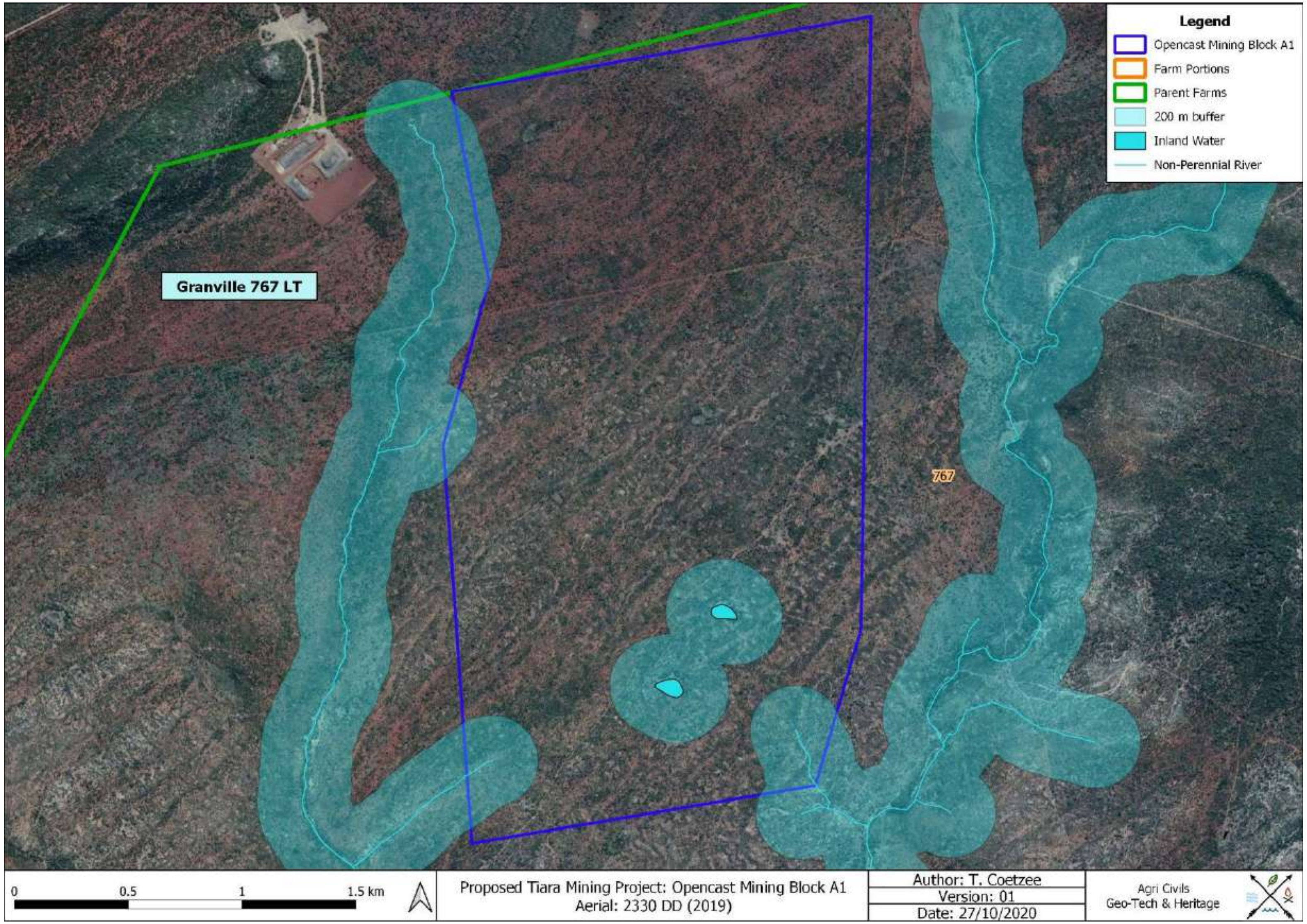

Figure 15: Heritage Sensitivity Map – Opencast Mining Block A1.

5.2 Recommendations

- Pending Phase 1 AIA Fieldwork.

6. Addendum: Terminology

Archaeology:

The study of the human past through its material remains.

Artefact:

Any portable object used, modified, or made by humans; e.g. pottery and metal objects.

Assemblage:

A group of artefacts occurring together at a particular time and place, and representing the sum of human activities.

Context:

An artefact's context usually consist of its immediate *matrix* (the material surrounding it e.g. gravel, clay or sand), its *provenience* (horizontal and vertical position within the matrix), and its *association* with other artefacts (occurrence together with other archaeological remains, usually in the same matrix).

Cultural Resource Management (CRM):

The safeguarding of the archaeological heritage through the protection of sites and through selvage archaeology (rescue archaeology), generally within the framework of legislation designed to safeguard the past.

Excavation:

The principal method of data acquisition in archaeology, involving the systematic uncovering of archaeological remains through the removal of the deposits of soil and other material covering and accompanying it.

Feature:

An irremovable artefact; e.g. hearths or architectural elements.

Ground Reconnaissance:

A collective name for a wide variety of methods for identifying individual archaeological sites, including consultation of documentary sources, place-name evidence, local folklore, and legend, but primarily actual fieldwork.

Matrix:

The physical material within which artefacts is embedded or supported, i.e. the material surrounding it e.g. gravel, clay or sand.

Phase 1 Assessments:

Scoping surveys to establish the presence of and to evaluate heritage resources in a given area.

Phase 2 Assessments:

In-depth culture resources management studies which could include major archaeological excavations, detailed site surveys and mapping / plans of sites, including historical / architectural structures and features. Alternatively, the sampling of sites by collecting material, small test pit excavations or auger sampling is required.

Sensitive:

Often refers to graves and burial sites although not necessarily a heritage place, as well as ideologically significant sites such as ritual / religious places. *Sensitive* may also refer to an entire landscape / area known for its significant heritage remains.

Site:

A distinct spatial clustering of artefacts, features, structures, and organic and environmental remains, as the residue of human activity.

Surface survey:

There are two kinds: (1) unsystematic and (2) systematic. The former involves field walking, i.e. scanning the ground along one's path and recording the location of artefacts and surface features. Systematic survey by comparison is less subjective and involves a grid system, such that the survey area is divided into sectors and these are walked ally, thus making the recording of finds more accurate.

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National Heritage Resource Act No.25 of 1999, Government Gazette, Cape Town

Removal of Graves and Dead Bodies Ordinance No. 7 of 1925, Government Gazette, Cape Town

Appendix A: Historical Aerial Imagery & Topographical Maps

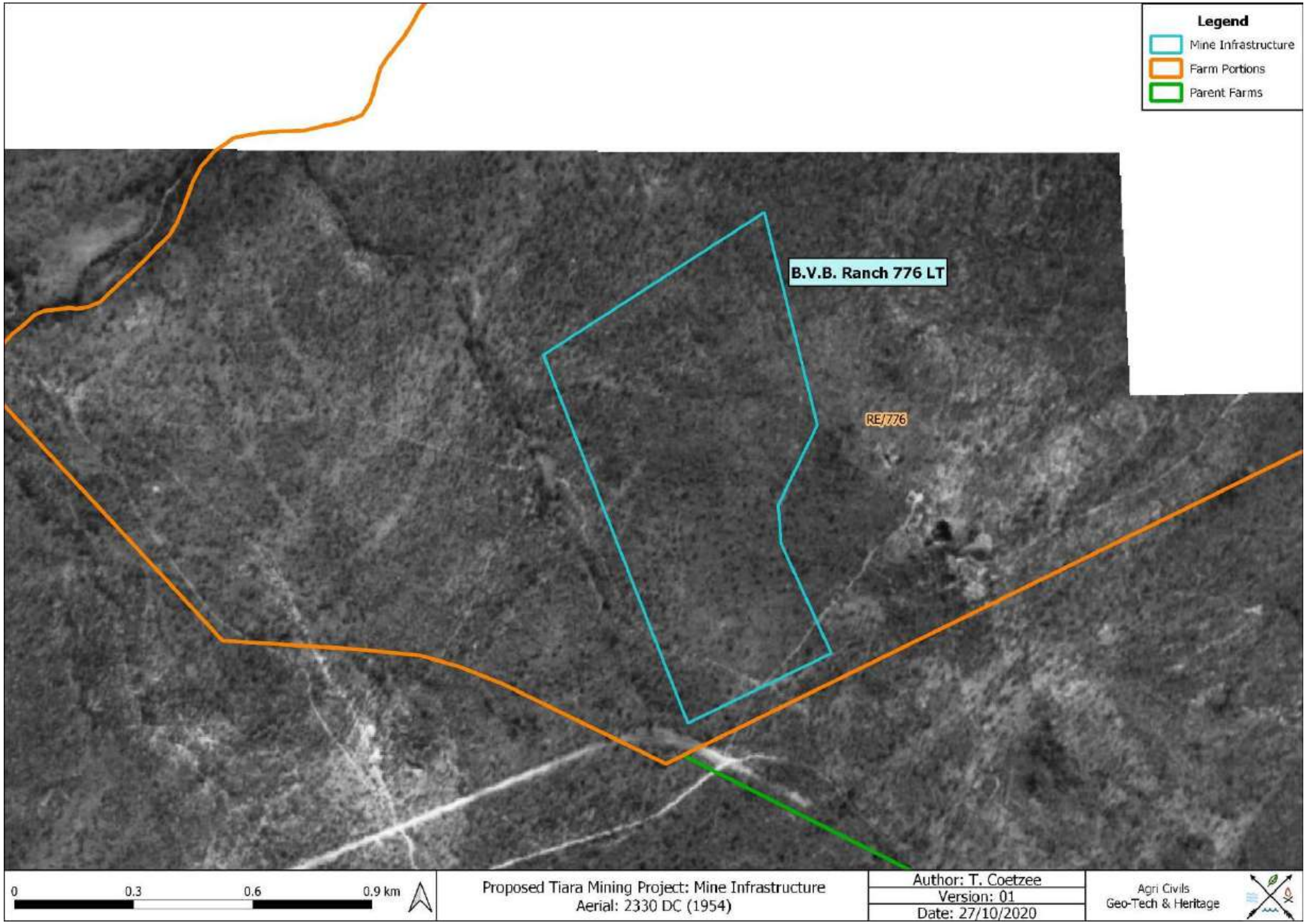

Figure 16: Proposed mining infrastructure on a 1954 aerial backdrop.

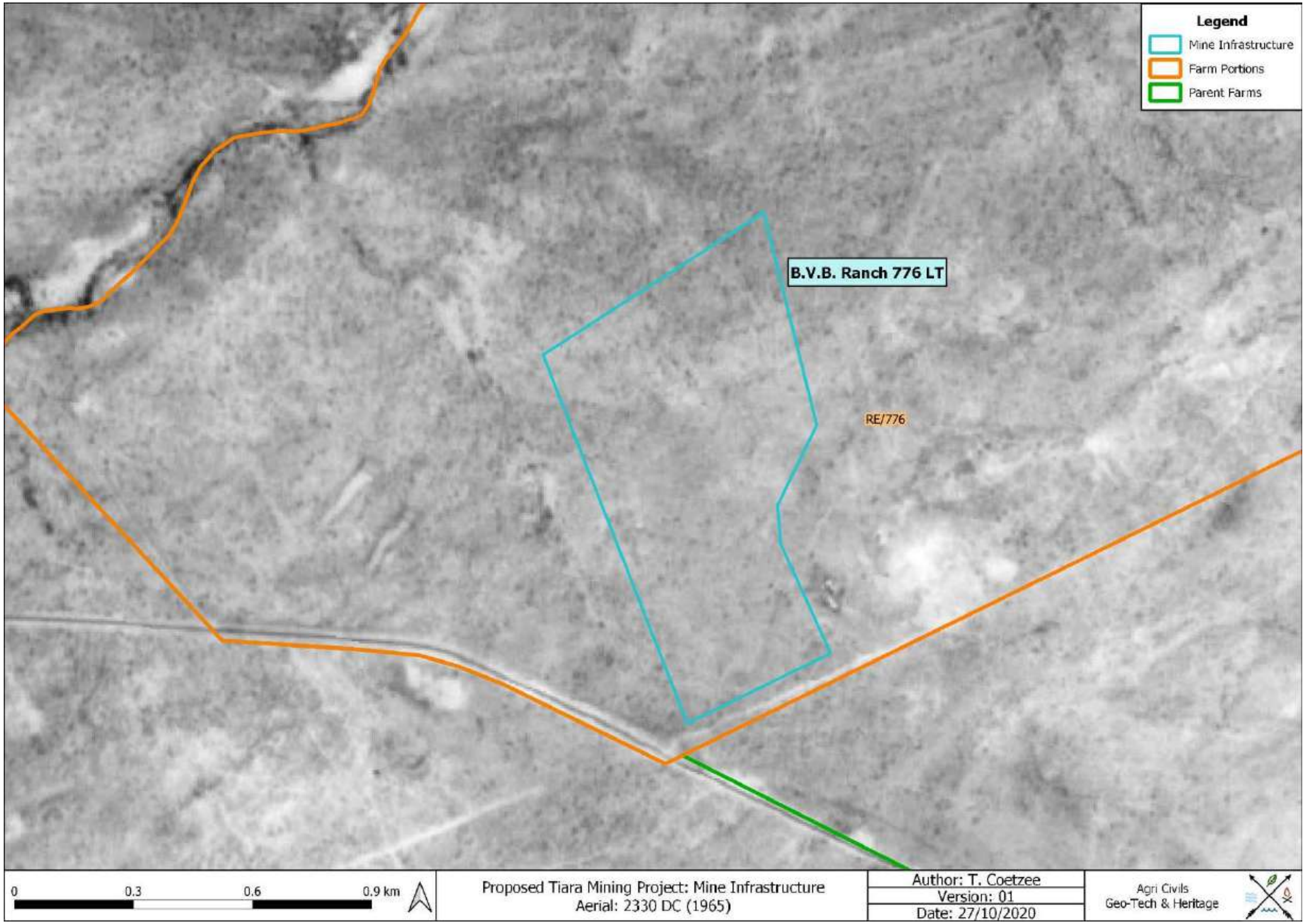

Figure 17: Proposed mining infrastructure on a 1965 aerial backdrop.

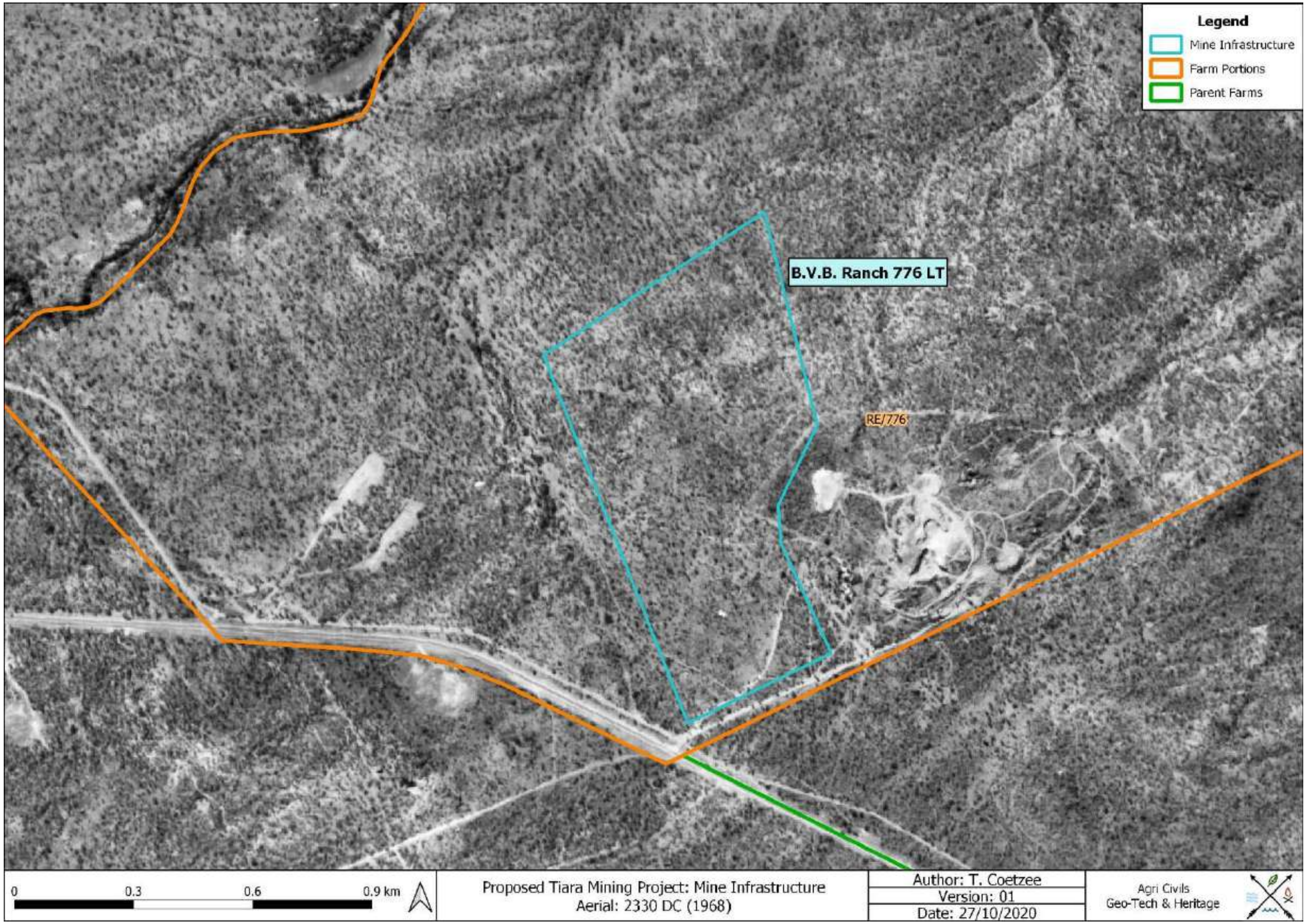

Figure 18: Proposed mining infrastructure on a 1968 aerial backdrop.

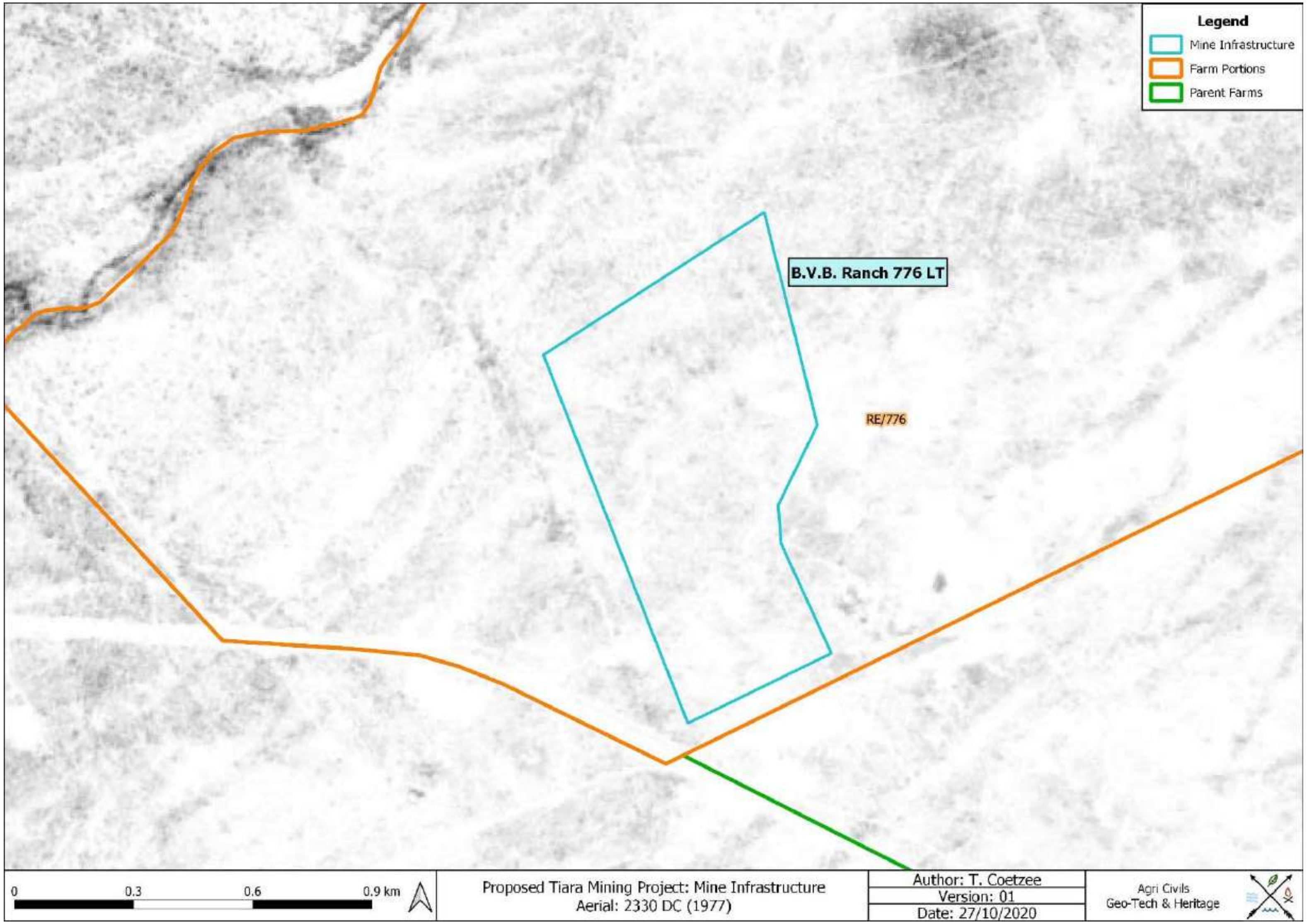

Figure 19: Proposed mining infrastructure on a 1977 aerial backdrop.

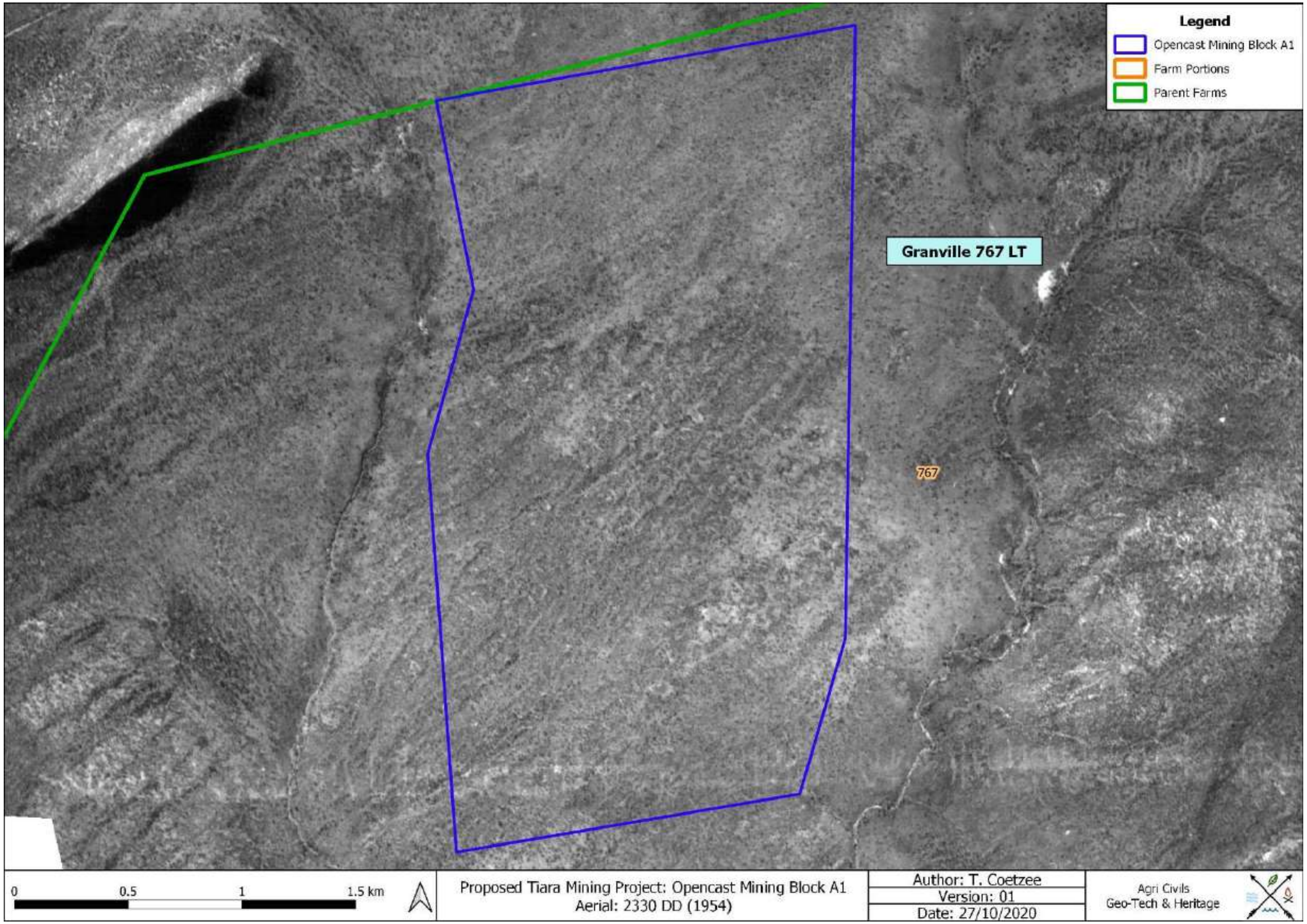

Figure 20: Proposed opencast mining block A1 on a 1954 aerial backdrop.

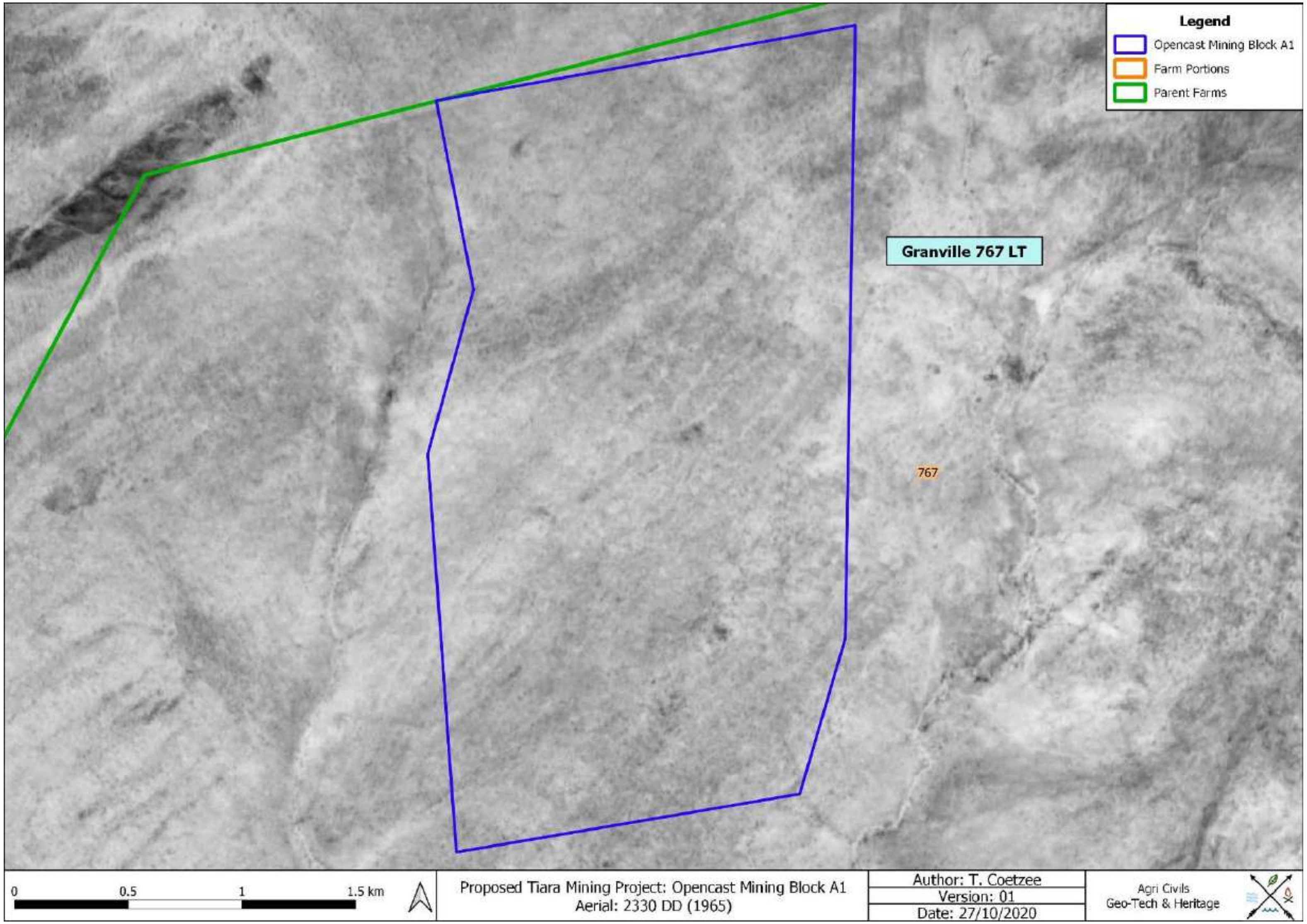

Figure 21: Proposed opencast mining block A1 on a 1965 aerial backdrop.

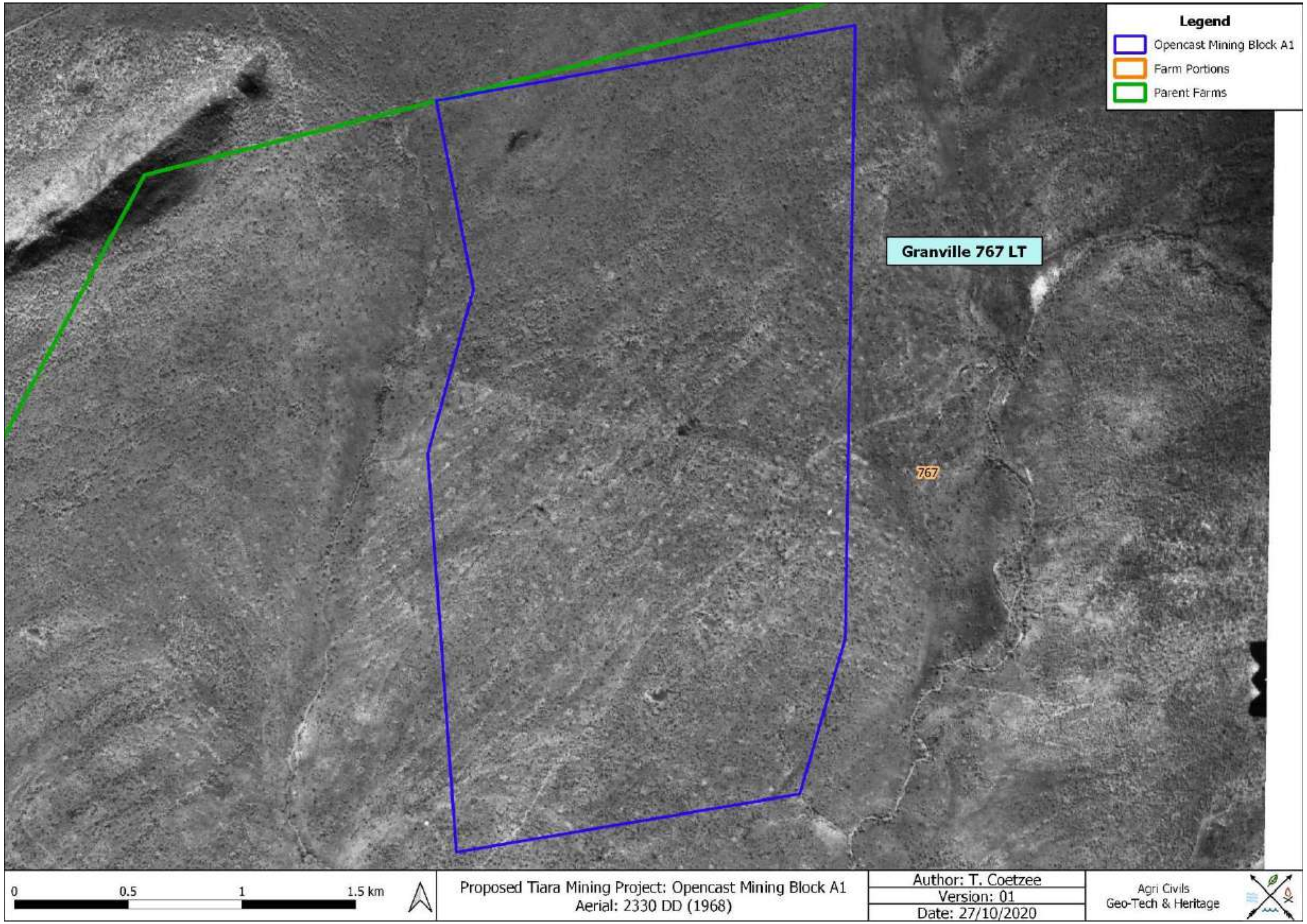

Figure 22: Proposed opencast mining block A1 on a 1968 aerial backdrop.

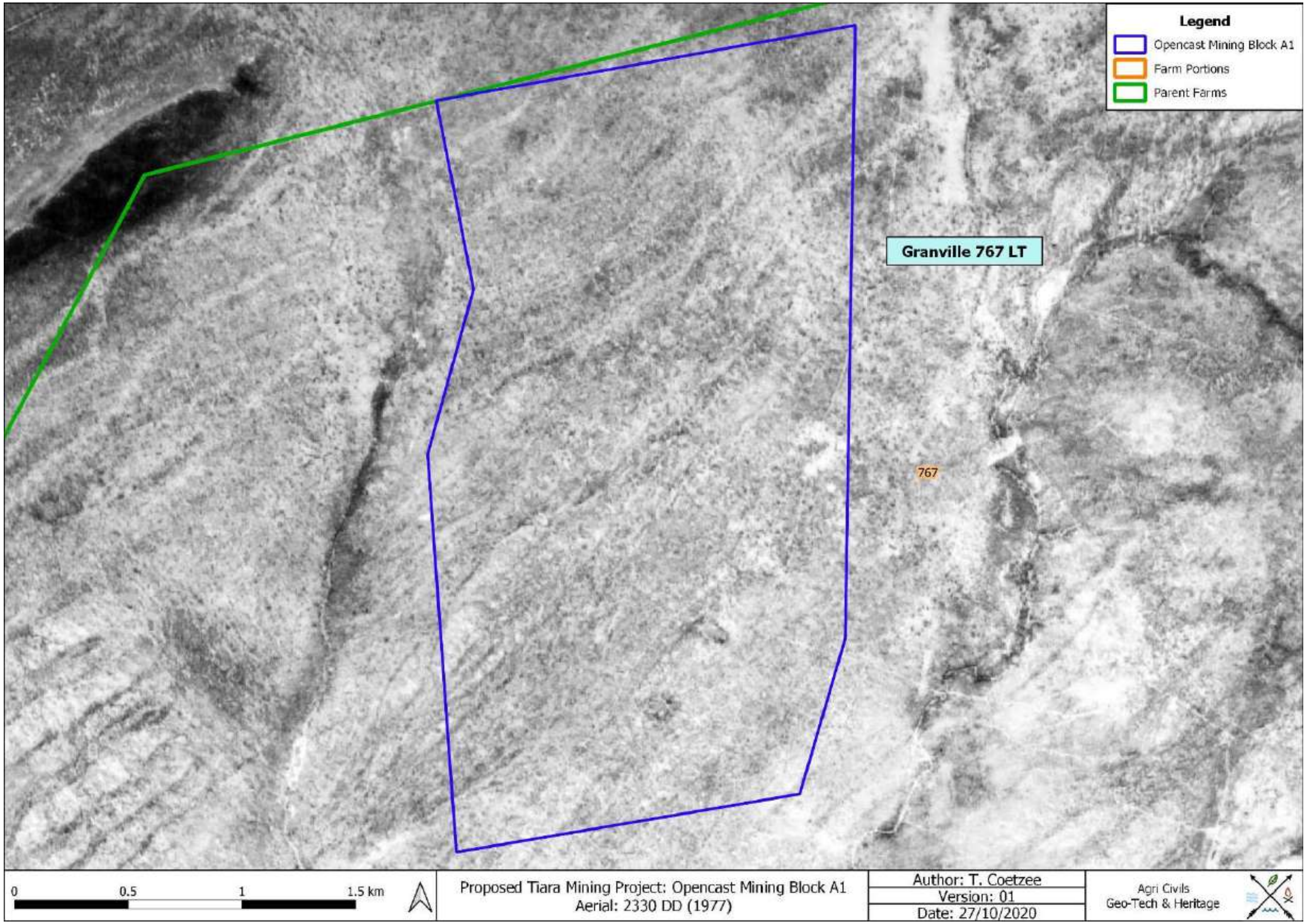

Figure 23: Proposed opencast mining block A1 on a 1977 aerial backdrop.

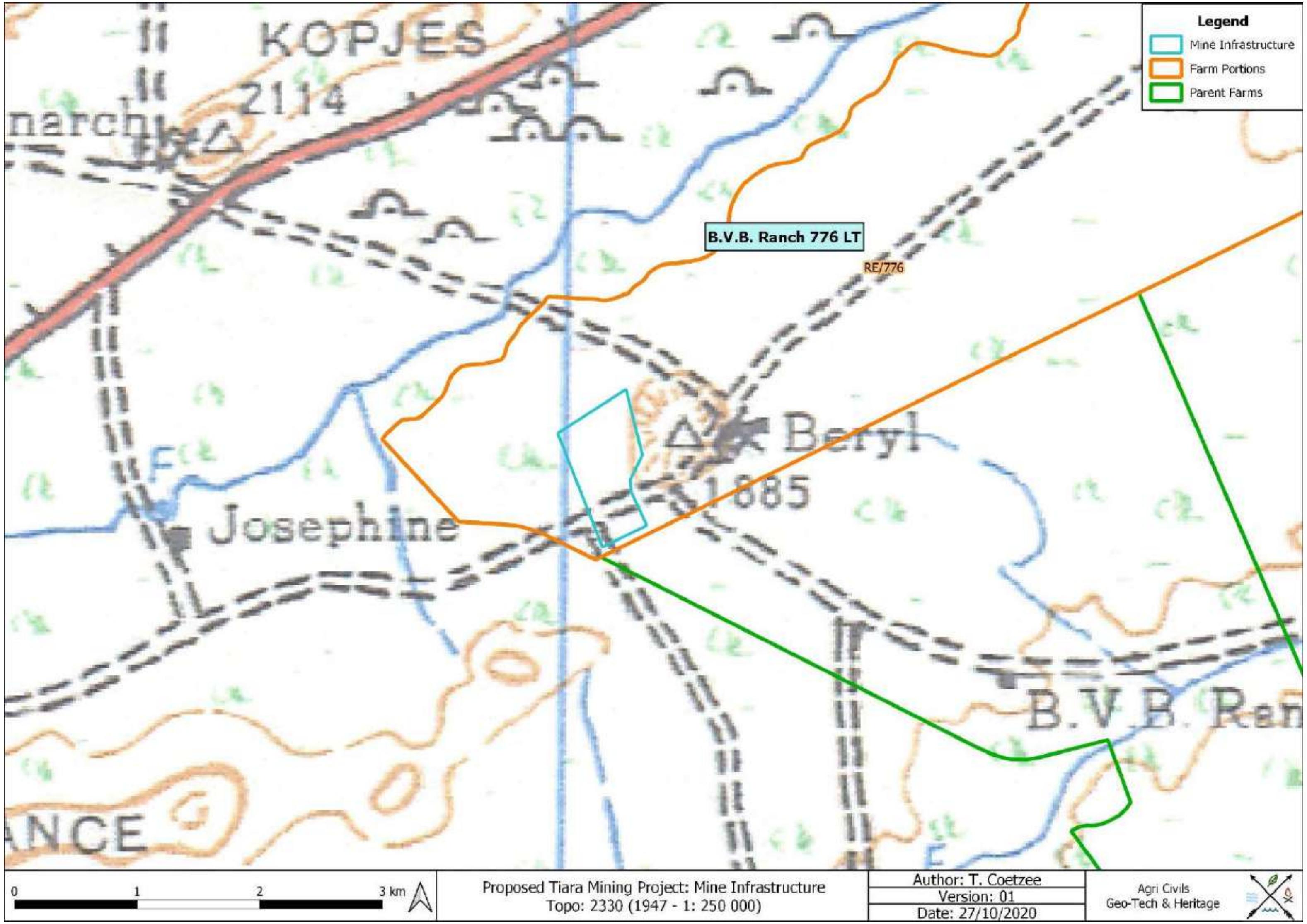

Figure 24: Segment of 1947 SA 1: 250 000 2330 indicating the area demarcated for mining infrastructure.

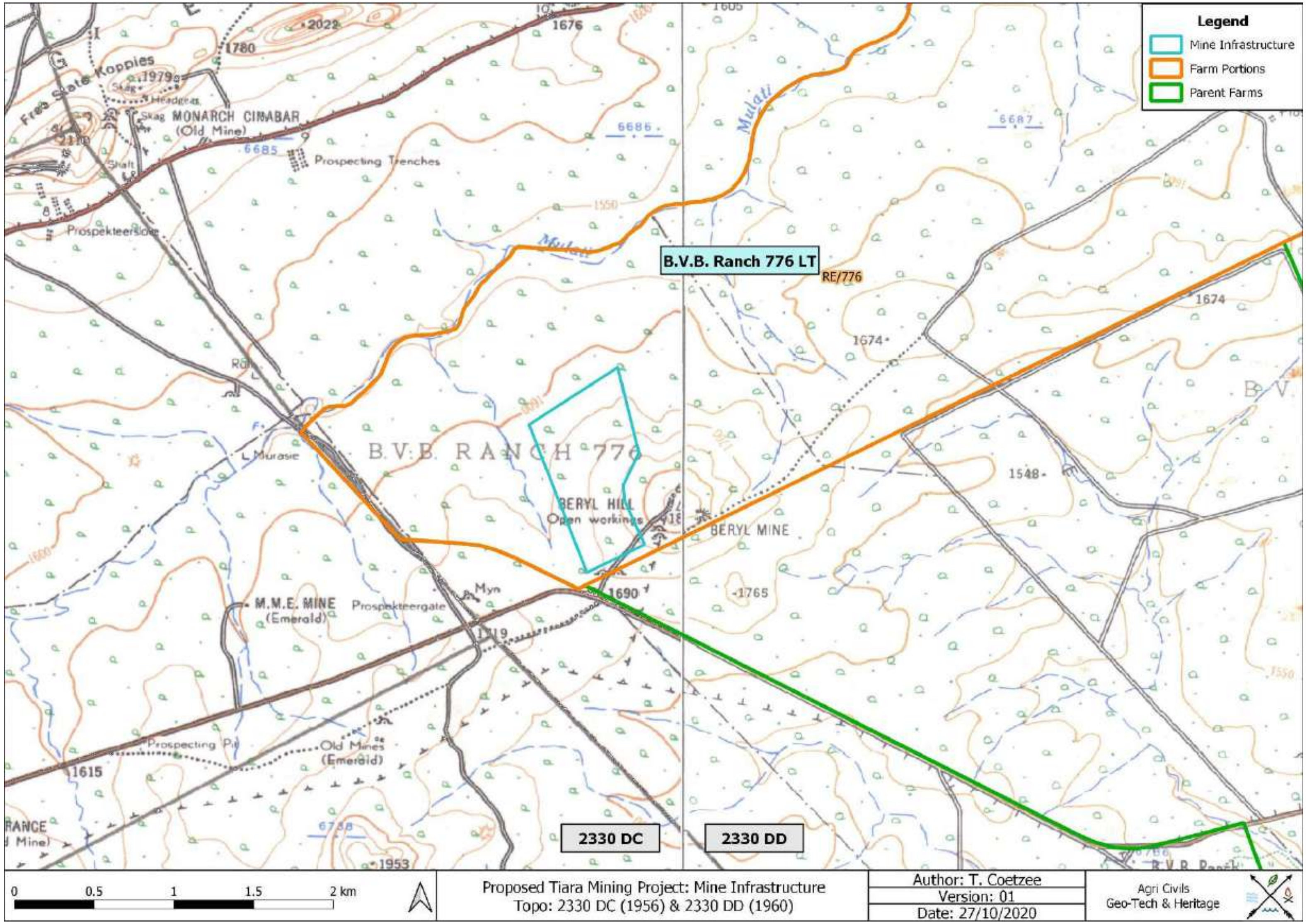

Figure 25: Segments of 1956 & 1960 SA 1: 50 000 2330 DC & DD indicating the area demarcated for mining infrastructure.

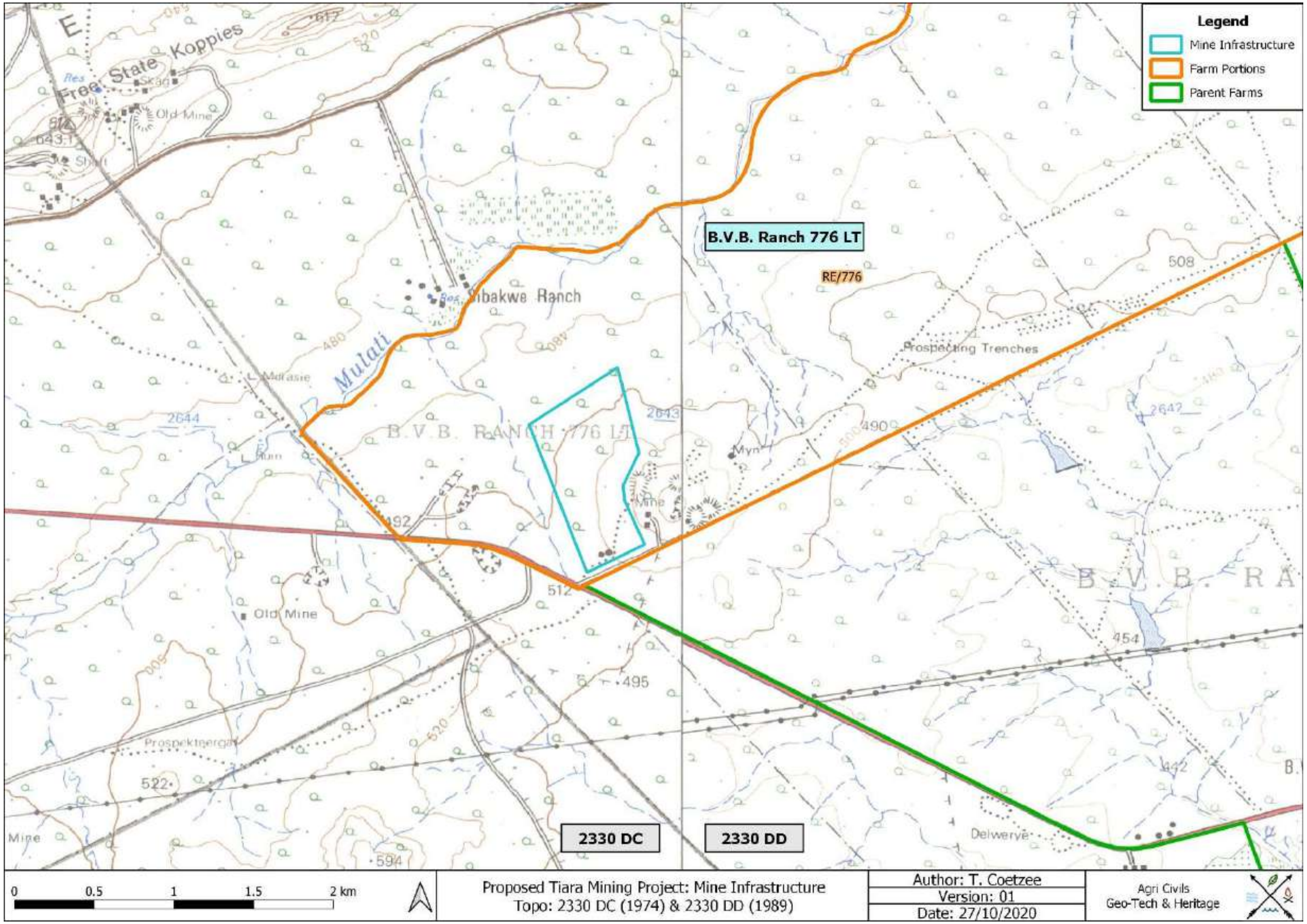

Figure 26: Segments of 1974 & 1989 SA 1: 50 000 2330 DC & DD indicating the area demarcated for mining infrastructure.

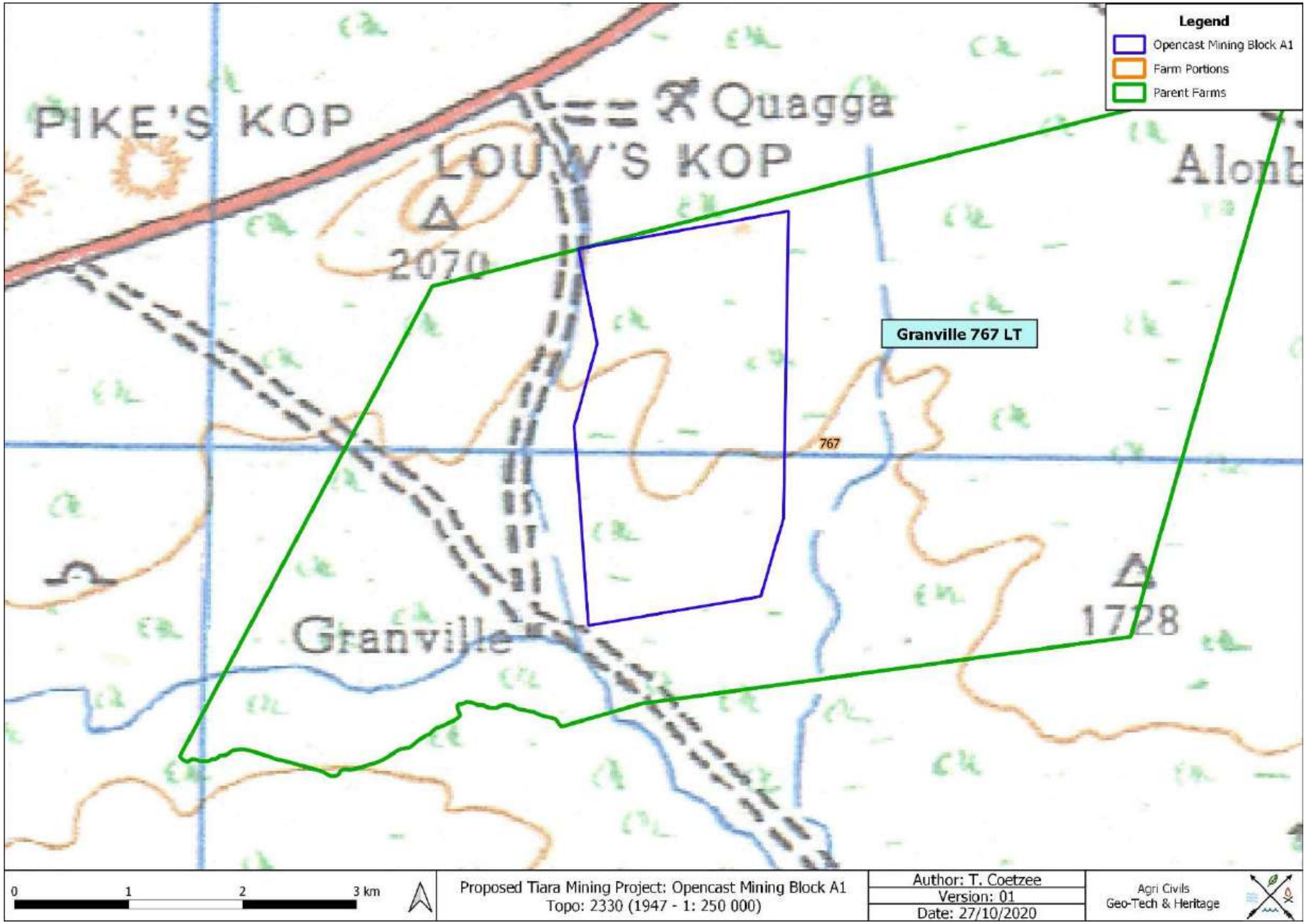

Figure 27: Segment of 1947 SA 1: 250 000 2330 indicating Opencast Mining Block A1.

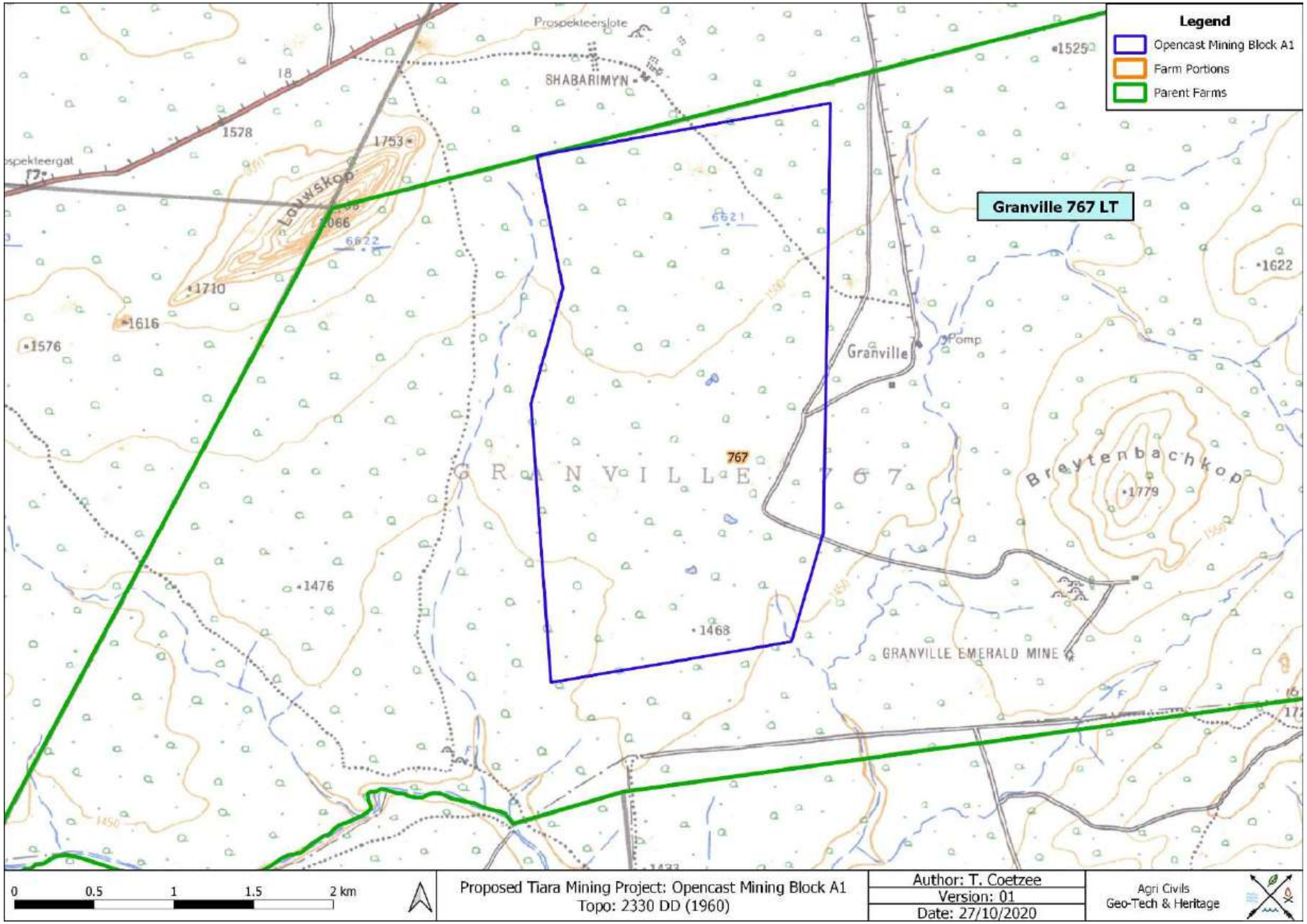

Figure 28: Segment of 1960 SA 1: 50 000 2330 DD indicating Opencast Mining Block A1.

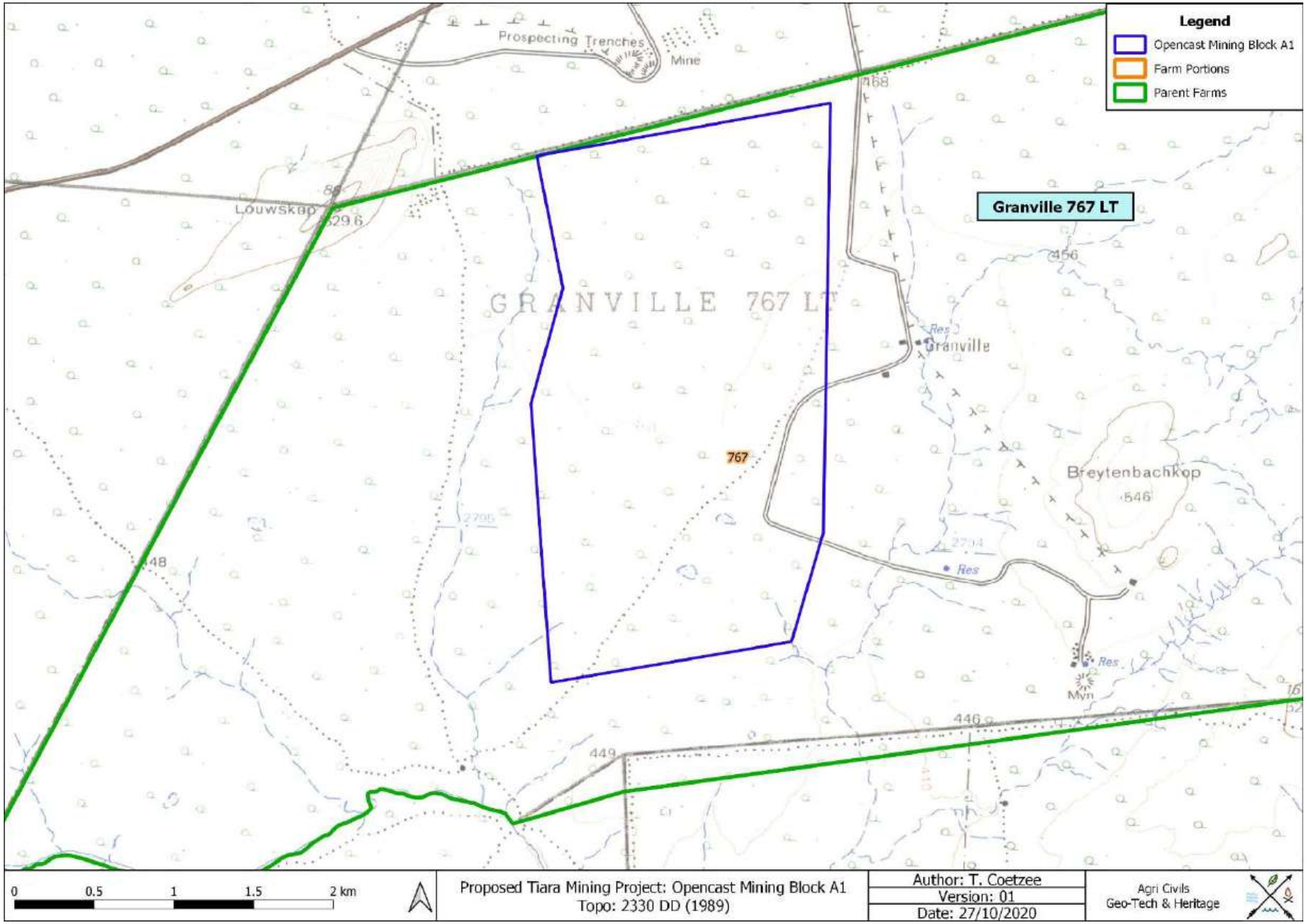

Figure 29: Segment of 1989 SA 1: 50 000 2330 DD indicating Opencast Mining Block A1.

Appendix 8 - Phase 1 Archaeological Impact Assessment

PHASE 1 ARCHAEOLOGICAL IMPACT ASSESSMENT

For

the Proposed Tiara Mining Project on the demarcated portions of the Remaining Extents of the Farms B.V.B Ranch 776 LT, Josephine 749 LT and the Farm Granville 767 LT, Phalaborwa, Limpopo

Author ©:

Tobias Coetzee, MA (Archaeology) (UP)

November 2020

A Phase 1 Archaeological Impact Assessment for the Proposed Tiara Mining Project on the demarcated portions of the Remaining Extents of the Farms B.V.B Ranch 776 LT, Josephine 749 LT and the Farm Granville 767 LT, Phalaborwa, Limpopo

For: Archean Resources (Pty) Ltd

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0081

Report No: 2011201_Tiara

Version: 1

Email: tobias.coetzee@gmail.com

I, Tobias Coetzee, declare that –

- I act as the independent specialist;
- I am conducting any work and activity relating to the proposed Tiara Mining Project in an objective manner, even if this results in views and findings that are not favourable to the client;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have the required expertise in conducting the specialist report and I will comply with legislation, regulations and any guidelines that have relevance to the proposed activity;
- I have not, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this declaration are true and correct.

Coetzee

Date: 20 November 2020

Executive Summary

The author was appointed by Archean Resources (Pty) Ltd to undertake a Phase 1 Archaeological Impact Assessment for the proposed Tiara Mining Project on the listed Farm Portions (**Table 1**) within the Ba-Phalaborwa Local Municipality in the Limpopo Province. The larger project consists of the full extent of the Farm Granville 767 LT, Buffalo Ranch 834 LT and Josephine 749 LT, Portion 12 and the Remaining Extent of the Farm B.V.B. Ranch 776 LT, the Remaining Extents of the Farms Willie 787 LT and Danie 789 LT, as well as Portion 6 and the Remaining Extent of the Farm Farrel 781 LT. The total proposed area is approximately 16 988 ha. For the first phase of the project two areas were identified: One portion on B.V.B. Ranch 776 LT and one portion on the Farm Granville 767 LT. The B.V.B. Ranch 776 LT portion is located roughly 15 km east-northeast of Gravelotte, 44 km west of Phalaborwa and 66 km south of Giyani. The Granville 767 LT portion is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani. Three areas demarcated for overburden stockpiles were identified at a later stage. One of the areas is located on the Farm Granville 767 LT, one on Portion 12 of the Farm B.V.B. Ranch 776 LT and one on the Remaining Extent of the Farm Josephine 749 LT. The aim of the study is to determine the scope of archaeological resources that could be impacted on by the proposed Tiara Mining Project.

It should also be noted that the boundaries for the three additional areas demarcated for overburden stockpiles were received close to the final stages of the report and limited time to arrange access. Two of these areas were briefly inspected. The third proposed overburden stockpile area is located within the Selati Nature Reserve and guided access will be required as the Big Five are found within the reserve.

In terms of limitations, the demarcated study areas are all characterised by extremely dense vegetation that severely restricted access, free movement and visibility during the time of surveying. The type of vegetation consisted of thick mopane tree cover, thorn bushes and grass cover. This can be ascribed to the fact that the larger area received approximately 200mm of rain in the weeks preceding the survey.

Two contemporary buildings, an area where a building might have existed, a contemporary building ruin, a cattle drinking trough and a water reservoir were located within the area demarcated for mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 776 LT (Sites TA01, TA02, TF01, TF07). These sites are of recent origin, not of heritage significance, was adequately recorded and require no further action.

Three stone cairns (Sites TF03, TF04 and TF08), also located within the area demarcated for mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 776 LT, indicate the position of mining claims and are therefore not significant from a heritage perspective. The recording done is regarded as sufficient and no further action is required. Not all stone cairns, however, might indicate mining claims as stone cairns often indicate the location of a burial sites. In such cases where the mine manger is uncertain regarding the origin of a stone cairn, it is recommended that such sites be regarded as graves.

Another stone cairn or possible section of a wall located on the same portion, however, might date to the Iron Age and would therefore be significant from a heritage perspective as the site would be protected under the NHRA 25 of 1999 (Site TF06). The site is poorly preserved and dense vegetation hampered inspecting the surrounding area. Recording of the site for this phase of the project is deemed sufficient as the site is located a significant distance from the nearest proposed development and should therefore not be impacted. Should impact be unavoidable, a destruction permit might be required pending site verification after vegetation is cleared.

Sites TA03 and TA04 are located within the boundary of the proposed Opencast Mining Boundary A1 on the Farm Granville 767 LT. These sites consist of natural pans/dams and are therefore not significant from a heritage perspective and no further action is required.

One historical rectangular enclosure exceeding 60 years of age was identified along the western boundary of the area demarcated for mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 776 LT (Site TF01). The site is located a significant distance from the nearest proposed surface development and should therefore not be impacted by the proposed mining development. However, it is recommended that the mine's ECO inspect the site on a quarterly basis. Should any impact be observed, or if impact cannot be avoided, the vegetation must be cleared and the structure adequately recorded by a qualified archaeologist. A destruction permit will have to be obtained from the relevant heritage authority as the site is protected under the NHRA 25 of 1999.

The general area is considered significant from a heritage perspective, but dense vegetation and tree cover significantly hampered free movement and site observation, thereby preventing obtaining a true representation and indication of the cultural resources within the demarcated development areas. Therefore, is recommended that a qualified archaeologist be present on site when vegetation is cleared in order to prevent the accidental damage and destruction of heritage resources.

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1. Project Background

1.1 Introduction

Archean Resources (Pty) Ltd appointed the author to undertake a Phase 1 Archaeological Impact Assessment for Tiara Mining (Pty) Ltd on portions of the following parent farms: B.V.B. Ranch 776 LT and Granville 767 LT within the Ba-Phalaborwa Local Municipality and the Mopani District Municipality in the Limpopo Province. The affected farm portions are listed in **Table 1**, while **Table 2** lists the farm portions pertaining to the larger long-term mining project. The proposed project consists of two study areas: One portion on B.V.B. Ranch 776 LT and a portion on the Farm Granville 767 LT. The B.V.B. Ranch 776 LT section is located roughly 15 km east-northeast of Gravelotte, 44 km west of Phalaborwa and 66 km south of Giyani. The Granville 767 LT portion is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani (**Figure 1**). Three additional demarcated areas, one on the Remaining Extent of the Farm Josephine 749 LT, one on Portion 12 of the Farm B.V.B. Ranch 776 LT and one the Farm Granville 767 LT were received at a later stage and were briefly inspected where access was obtained. The purpose of this study is to examine the demarcated portions in order to determine if any archaeological resources of heritage value will be impacted on by the proposed Tiara Mining Project, as well as to archaeologically contextualise the general study area. The aim of this report is to provide the developer with information regarding the location of heritage resources on the demarcated portions.

In the following report, the implication for the proposed mining activities on the demarcated portions with regard to heritage resources are discussed: A Portion of the Farm Granville 767 LT and a Portion of the Remaining Extent of the Farm B.V.B. Ranch 776 LT. Two of the three additional portions, one on Portion 12 of the Farm B.V.B. Ranch 776 LT and one on the Farm Granville 767 LT, were inspected as well. The development will consist of opencast mining methods and surface infrastructure. The legislation section included serves as a guide towards the effective identification and protection of heritage resources and will apply to any such material unearthed during development and construction phases within the demarcated study areas.

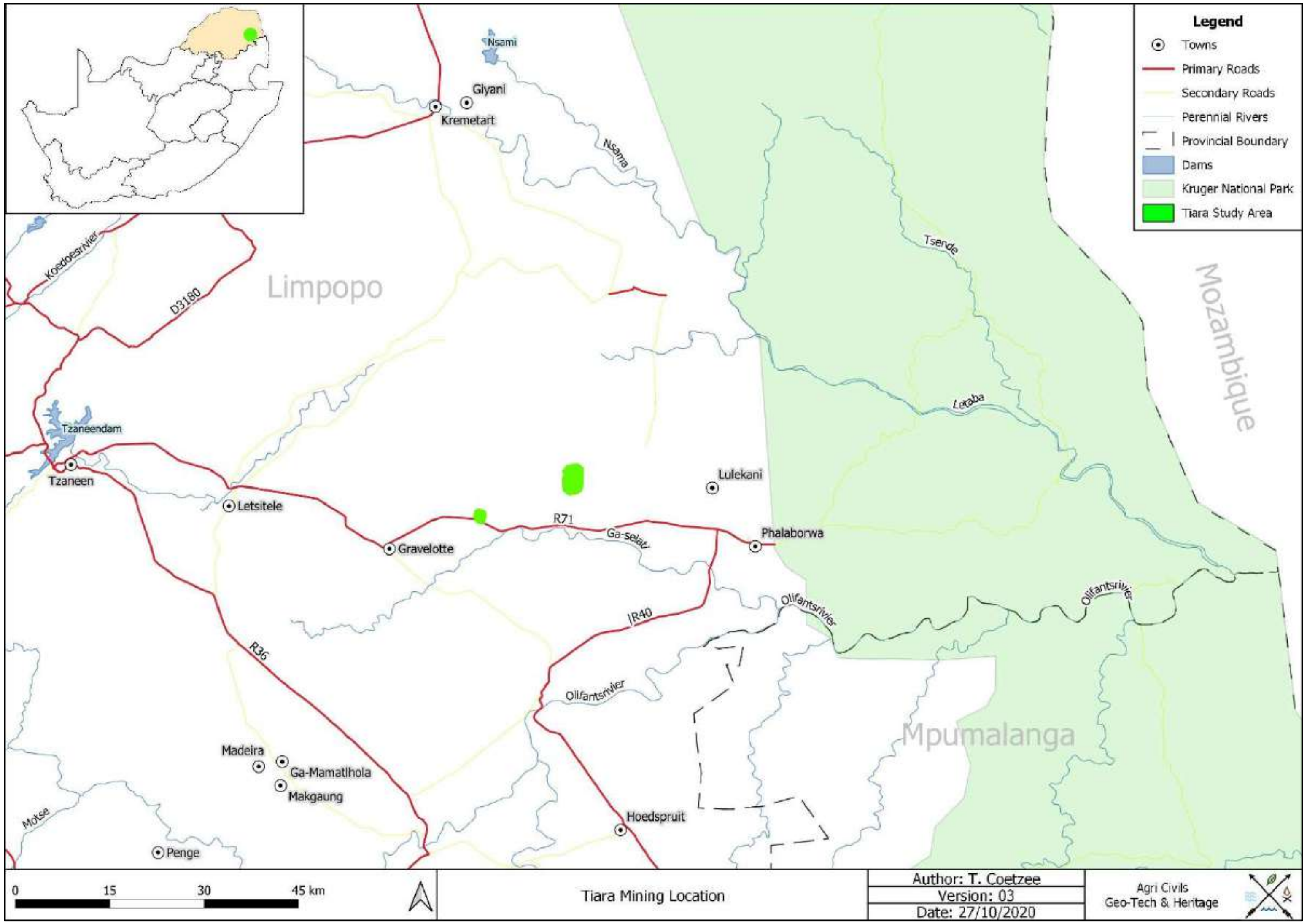

Figure 1: Regional and Provincial location of the study area.

1.2 Legislation

The South African Heritage Resources Agency (SAHRA) aims to conserve and control the management, research, alteration and destruction of cultural resources of South Africa and to prosecute if necessary. It is therefore crucially important to adhere to heritage resource legislation contained in the Government Gazette of the Republic of South Africa (Act No.25 of 1999), as many heritage sites are threatened daily by development. Conservation legislation requires an impact assessment report to be submitted for development authorisation that must include an AIA if triggered.

AIAs should be done by qualified professionals with adequate knowledge to (a) identify all heritage resources that might occur in areas of development and (b) make recommendations for protection or mitigation of the impact of the sites.

1.2.1 The EIA and AIA processes

Phase 1 Archaeological Impact Assessments generally involve the identification of sites during a field survey with assessment of their significance, the possible impact that the development might have, and relevant recommendations.

All Archaeological Impact Assessment reports should include:

a. Location of the sites that are found;

b. Short descriptions of the characteristics of each site;

c. Short assessments of how important each site is, indicating which should be conserved and which mitigated;

d. Assessments of the potential impact of the development on the site(s);

e. In some cases a shovel test, to establish the extent of a site, or collection of material, to identify the associations of the site, may be necessary (a pre-arranged SAHRA permit is required); and

f. Recommendations for conservation or mitigation.

This AIA report is intended to inform the client about the legislative protection of heritage resources and their significance and make appropriate recommendations. It is essential to also provide the heritage authority with sufficient information about the sites to enable the authority to assess with confidence:

a. Whether or not it has objections to a development;

b. What the conditions are upon which such development might proceed;

c. Which sites require permits for mitigation or destruction;

d. Which sites require mitigation and what this should comprise;

e. Whether sites must be conserved and what alternatives can be proposed to relocate the development in such a way as to conserve other sites; and

f. What measures should or could be put in place to protect the sites which should be conserved.

When a Phase 1 AIA is part of an EIA, wider issues such as public consultation and assessment of the spatial and visual impacts of the development may be undertaken as part of the general study and may not be required from the archaeologist. If, however, the Phase 1 project forms a major component of an AIA it will be necessary to ensure that the study addresses such issues and complies with Section 38 of the National Heritage Resources Act.

1.2.2 Legislation regarding archaeology and heritage sites

National Heritage Resource Act No.25 of April 1999

Buildings are among the most enduring features of human occupation, and this definition therefore includes all buildings older than 60 years, modern architecture as well as ruins, fortifications and Farming Community settlements. The Act identifies heritage objects as:

- objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects, meteorites and rare geological specimens;
- visual art objects;
- military objects;
- numismatic objects;
- objects of cultural and historical significance;
- objects to which oral traditions are attached and which are associated with living heritage;
- objects of scientific or technological interest;
- books, records, documents, photographic positives and negatives, graphic material, film or video or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No. 43 of 1996), or in a provincial law pertaining to records or archives;
- any other prescribed category.

With regards to activities and work on archaeological and heritage sites this Act states that:

"No person may alter or demolish any structure or part of a structure which is older than 60 years without a permit issued by the relevant provincial heritage resources authority." (34. [1] 1999:58)

and

"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.'(35. [4] 1999:58)

and

"No person may, without a permit issued by SAHRA or a provincial heritage resources authority:

(a) destroy, damage, alter, exhume or remove from its original position or otherwise disturb the grave of a victim of conflict, or any burial ground or part thereof which contains such graves;

(b) destroy, damage, alter, exhume, remove from its original position or otherwise disturb any grave or burial ground older than 60 years which is situated outside a formal cemetery administered by a local authority;

(c) bring onto or use at a burial ground or grave referred to in paragraph (a) or (b) and excavation equipment, or any equipment which assists in the detection or recovery of metals." (36. [3] 1999:60)

On the development of any area the gazette states that:

"…any person who intends to undertake a development categorised as:

(a) the construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;

(b) the construction of a bridge or similar structure exceeding 50m in length;

(c) any development or other activity which will change the character of a site-

i. *exceeding 5000m² in extent; or*

ii. *involving three or more existing erven or subdivisions thereof; or*

iii. *involving three or more erven or divisions thereof which have been consolidated within the past five years; or*

iv. *the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;*

(d) *the re-zoning of a site exceeding 10000m² in extent; or*

(e) *any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority, must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development."* (38. [1] 1999:62-64)

and

"The responsible heritage resources authority must specify the information to be provided in a report required in terms of subsection (2)(a): Provided that the following must be included:

(a) *The identification and mapping of all heritage resources in the area affected;*

(b) *an assessment of the significance of such resources in terms of the heritage assessment criteria set out in section 6(2) or prescribed under section 7;*

(c) *an assessment of the impact of the development on such heritage resources;*

(d) *an evaluation of the impact of the development on heritage resources relative to the sustainable social and economic benefits to be derived from the development;*

(e) *the results of consultation with communities affected by the proposed development and other interested parties regarding the impact of the development on heritage resources;*

(f) *if heritage resources will be adversely affected by the proposed development, the consideration of alternatives; and*

(g) *plans for mitigation of any adverse effects during and after the completion of the proposed development."* (38. [3] 1999:64)

Human Tissue Act and Ordinance 7 of 1925

The Human Tissues Act (65 of 1983) and Ordinance on the Removal of Graves and Dead Bodies (Ordinance 7 of 1925) protects graves younger than 60 years. These fall under the jurisdiction of the National Department of Health and the Provincial Health Departments. Approval for the exhumation and re-burial must be obtained from the relevant Provincial MEC as well as the relevant Local Authorities. Graves 60 years or older fall under the jurisdiction of the National Heritage Resources Act as well as the Human Tissues Act, 1983.

2. Study Area and Project Description

2.1 Location & Physical Environment

The proposed Tiara Mining Project study area is situated between Phalaborwa and Gravelotte. **Table 1** lists the demarcated project areas and intersecting land parcels for the first phase of the project, while **Table 2** lists the land parcels of the larger project as obtained from the Mine Work Programme.

Table 1: Property name & coordinates

Property	Portion	Map Reference (1:50 000)	Lat (y)	Lon (x)	Parcel extent (ha)	Development Extent (ha)
B.V.B Ranch 776 LT	RE/776	2330 DC	-23.903867	30.743935	1547.8	53
B.V.B Ranch 776 LT	12/776	2330 DD	-23.910641	30.762206	1064.7	100
Granville 767 LT	0	2330 DD	-23.857985	30.877454	3110.3	686
Josephine 749 LT	RE	2330 DC	-23.923015	30.701328	1707.9	163

Table 2: Land parcels part of the larger project.

No	Parent Farm	Farm Portion
1	B.V.B Ranch 776 LT	12/776
2	Josephine 749 LT	Full extent
3	Buffalo Ranch 834 LT	Full extent
4	Danie 789 LT	RE
5	Farrel 781 LT	RE
6	Farrel 781 LT	6/781
7	Willie 787 LT	RE

Gravelotte is located about 15 km west-southwest of the proposed mine infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT, while Phalaborwa is located 44 km to the east and Giyani 66 km to the north (**Figures 1 & 2**). The proposed opencast mining block A1 on the Farm Granville 767 LT is located approximately 31 km northeast of Gravelotte, 30 km northwest of Phalaborwa and 61 km south-southeast of Giyani. The study area falls within the Ba-Phalaborwa Local Municipality and the Mopani District Municipality in the Limpopo Province. The R71 primary road runs east-west between Gravelotte and Phalaborwa and borders the proposed mining infrastructure section of the Farm B.V.B. Ranch 776 LT to the south, while the R71 is located roughly 6 km to the south of the proposed opencast mining block A1. The area proposed for overburden stockpile

1 is located just to the west of the proposed Mining Block A1, while the area demarcated for the 2nd overburden stockpile is located just to the east of the proposed mining infrastructure. The 3rd proposed overburden stockpile is located to the southwest of the proposed mining infrastructure and on the southern side of the R71.

In terms of vegetation, the study area falls within the Savanna Biome and Lowveld Bioregion. On a local scale, Granite Lowveld covers the majority of the study, while the south-eastern section of the proposed mining infrastructure and Mining Block A1, as well as the overburden stockpile no. 2 areas fall on Phalaborwa-Timbavati Mopaneveld (Mucina & Rutherfords 2006).

The distribution of Granite Lowveld is described by Mucina & Rutherfords (2006) as:

"Limpopo and Mpumalanga Provinces, Swaziland and marginally also KwaZulu-Natal: A north-south belt on the plains east of the escarpment from Thohoyandou in the north, interrupted in the Bolobedu area, continued in the Bitavi area, with an eastward extension on the plains around the Murchison Range and southwards to Abel Erasmus Pass, Mica and Hoedspruit areas to the area east of Bushbuckridge. Substantial parts are found in the Kruger National Park spanning areas east of Orpen Camp southwards through Skukuza and Mkuhlu, including undulating terrain west of Skukuza to the basin of the Mbyamiti River. It continues further southward to the Hectorspruit area with a narrow westward extension up the Crocodile River Valley past Malelane, Kaapmuiden and the Kaap River Valley, entering Swaziland between Jeppe's Reef in the west and the Komati River in the east, through to the area between Manzini and Siphofaneni, including the Grand Valley, narrowing irregularly and marginally entering KwaZulu-Natal near Pongola"

Granite Lowveld is considered vulnerable with a conservation target of 19%. About 17% is statutorily conserved in the Kruger National Park and roughly the same amount in private reserves. More than 20% has already been transformed, mainly by cultivation and settlement development. Erosion is considered very low to moderate (Mucina & Rutherfords 2006).

Phalaborwa-Timbavati Mopaneveld is associated with the Limpopo and Mpumalanga Provinces and is distributed in a band about 40 km west and east of Phalaborwa. This vegetation unit also occurs in the area south of the Olifants River on the boundary between the Timbavati Game Reserve and the Kruger National Park. Parts of the Umbabat and Klaserie Nature Reserves are included as well. In terms of conservation, Phalaborwa-Timbavati Mopaneveld is considered least threatened with a conservation target of 19%. About 38% is statutorily conserved in the Kruger National Park with roughly the same amount in private nature reserves. About 5% has been transformed mostly by development, human settlement and mining (Mucina & Rutherfords 2006).

The average elevation for Granite Lowveld varies between 250 and 700 MASL, while Phalaborwa-Timbavati

Mopaneveld varies between 300 and 600 MASL (Mucina & Rutherfords 2006). The elevation for the proposed mining infrastructure area on the Farm B.V.B Ranch 776 LT is 520 MASL and slopes from the more elevated south-eastern section towards the lower north-western area. The elevation of the demarcated portions on the Farm Granville 767 LT varies between 450 and 470 MASL and slopes form the more elevated northern section towards the lower southern section. The elevation of the proposed overburden stockpile area on portion 12 of the Farm B.V.B. Ranch 776 LT slopes from the more elevated western side at 530 MASL to the lower eastern border at 480 MASL, while the proposed stockpile no. 3 area on the Remaining Extent of the Farm Josephine 749 LT slopes from an elevation of 530 MASL in the southwest to about 490 MASL in the northeast.

The study area falls within the summer rainfall region and the average annual rainfall is roughly 543 mm per year. The average maximum temperature for the study area is recorded during January when an average of 26.1 ºC is reached. The average minimum temperature is recorded during June when an average of 17 ºC is reached (Climate-data.org 27/10/2020).

The majority of the study area falls within the B72J Quaternary Catchment of the Ga-Selati River Catchment, while a small section of the southern portion of the proposed mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 767 LT, as well as the area demarcated for overburden stockpile no. 2 fall within B72K of the Molatle River Catchment. The closest perennial river to the study area is the Ga-Selati River that flows 3 km to the south of the proposed area on the Farm B.V.B. Ranch 776 LT and 6 km south of the Granville 767 LT portion. A non-perennial stream is located along the western border of the B.V.B. Ranch 776 LT section, as well as on the eastern and western side of the Granville 767 LT portion. Several non-perennial streams are also intersecting the overburden stockpile no. 2 area.

There appears to be no primary utilisation for the demarcated mine infrastructure and overburden stockpile no. 2 areas as these areas are to some extent associated with mining activities that took place during the 1970's. The demarcated sections on the Farm Granville are associated with cattle grazing, mining activity and local tree logging. The area associated with overburden stockpile no.3 is located within the Selati Nature Reserve.

Access to the study areas (**Figures 1 & 2**) is mostly via tertiary and jeep tracks and farm roads turning from the R71 primary road.

Historical topographical maps (**Appendix A**) show that several huts and old mines are located in the general area, the oldest of which are likely to be M.M.E. Mine on the northern side of the R71. According to Mr Van Der Westhuizen, this mine dates to the late 1800's (Wessie van der Westhuizen, pers comm. 2020). Some open workings are also indicated on Beryl Hill directly east of the proposed mining infrastructure area and a few huts directly to the south. The only buildings within the demarcated study areas, however, appear on the 1974 topographical map.

2.2 Project description

The proposed Tiara Granville Emerald and Quartz Mine proposes to mine all emerald (gemstone- Gem), except diamonds (GS), Quartz (gemstones-GQ), Nickel ore (Ni), Antimony ore (SB), Gold ore (Au), Molybdenum ore (Mo), Silicon ore (Si), Beryl (GB), Beryllium ore (Be), Chalcedony (GCh), Chrysoberyl (GCb), Citrine (GCi), Corundum (GCm), Epidole (GEp), Feldspar (GFs), Garnet (GGa), Jade (GJd), Zircon (GZr), Tourmaline (GTm), Jasper (GJ), Platinum Group Metals (PGMs), Cobalt (Co), Topaz (GT), Copper ore (Cu), Rose Quartz (GRq), Ruby (GRb), and Sapphire (GSa) on the demarcated portions as indicated on **Figure 2**. It should be noted, however, that the entire project includes a significantly larger study area (**Table 2 & Figure 3**) with mining operations planned until 2051, but for the first phase the focus will only be on the demarcated portions as indicated by **Figure 2.**

The main reason for this particular Mining Right application is for the supply of quartz (gemstones) to various markets including the electronics and semiconductors industry, solar, building and construction industry, optical fibre and telecommunication, automotive industry and other end-user industries. The main products that are envisaged to be sold are silicon metal, quartz crystal, high purity quartz (quartz surface and tiles, fused quartz crucible and quartz glass). Roughly 60% of the products will be distributed within the Middle-East and Africa (South Africa and Saudi Arabia) while the remaining 40% is destined for the export market (South America- Brazil and Argentina; Europe-Germany, United Kingdom, Italy, France, and Russia; North-America- United States of America, Canada, Mexico and lastly Asia Pacific- China, India, Japan and South Korea).

The proposed mining will be based on the following principles:

- Mining will take place by opencast drilling, blasting, truck and shovel bench mining;
- Bench sets will be mined at approximately 300 m in length, with a width of 200 m and each cut will have a depth of 70 m;
- It is estimated that a mine cut measuring 40m x 40 m x 6m along a bench set will be mined in less than a month;
- Annual production will be about 428 400 tonnes of RoM material;
- Mining will take place to a maximum depth of 70 m;
- Overburden stripping will be required. Only 50-100 mm of topsoil might be removed for each box-cut;
- Topsoil will be stockpiled for future rehabilitation purposes;
- The processed material will be stockpiled in the product stockpile areas located close to the mine office complex.

The proposed Tiara Granville Quartz Mine Life of Mine (LoM) is estimated at 30 years ending in year 2051. Construction is expected to commence in the first quarter (Q1) of 2021, whilst the operational phase (production) is scheduled for the second quarter (Q2) of 2021. Mining will commence in the north-eastern parts of the project area (on the Granville 767 LT, BVB Ranch 776 LT and Buffalo Ranch 834 LT) moving towards the south-westerly direction into the farm Farrel 781 LT, Josephine 749 LT, Willie 787 LT as well as Danie 789 LT.

Table 3: Proposed surface development.

Development	Portion	Farm	Approximate surface impact (ha)	Lat	Lon
Mining Block A1	0	Granville 767 LT	582	-26.118961	29.647206
Mine Infrastructure	RE	B.V.B. Ranch 776 LT	53	-26.152162	29.658789
Overburden Stockpile 1	0	Granville 767 LT	104	-26.155843	29.673130
Overburden Stockpile 2	12	B.V.B. Ranch 776 LT	100	-26.154878	29.687603
Overburden Stockpile 3	RE	Josephine 749 LT	163	-26.142753	29.662940

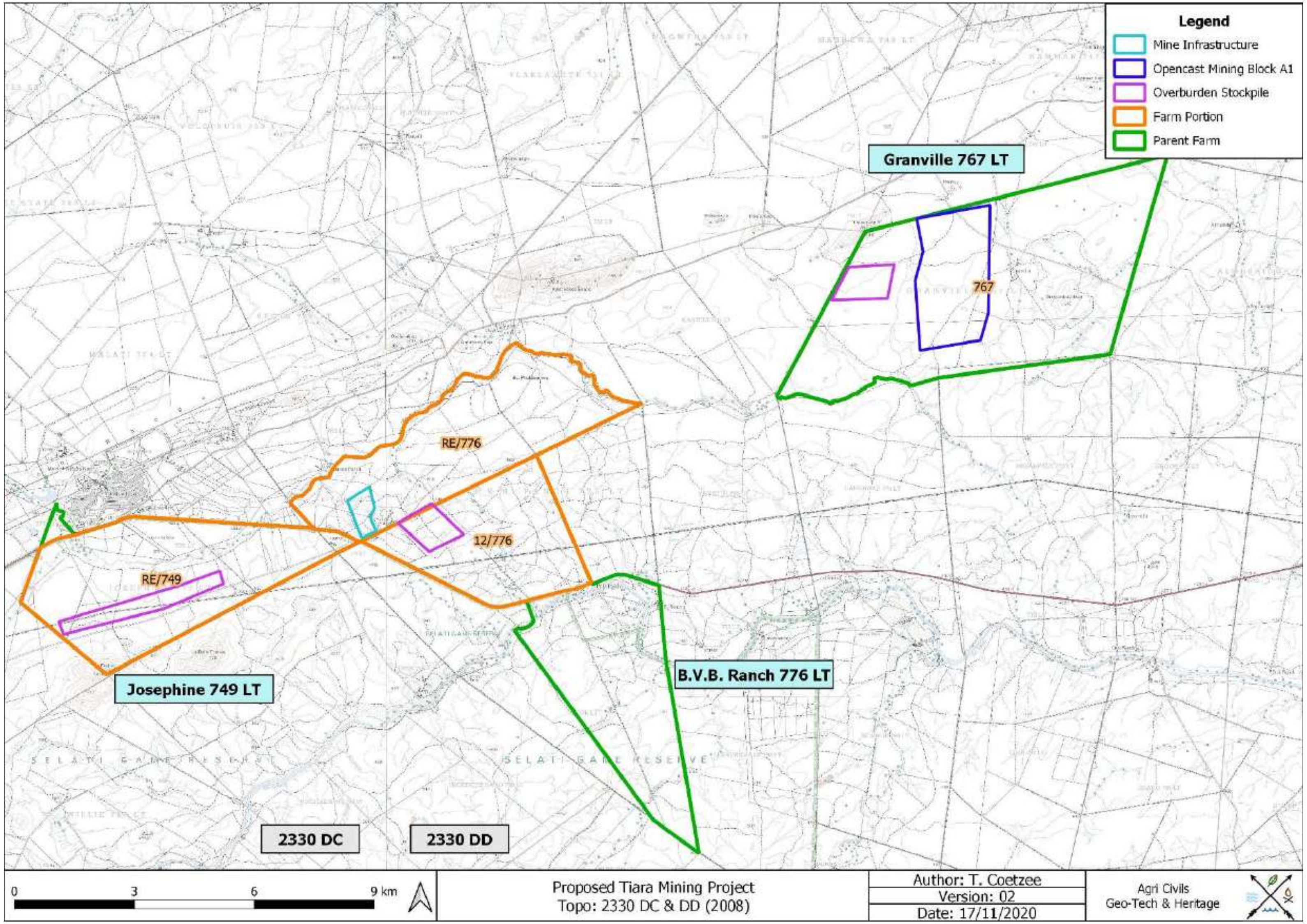

Figure 2: Segment of SA 1: 50 000 2330 DC & DD indicating the study area.

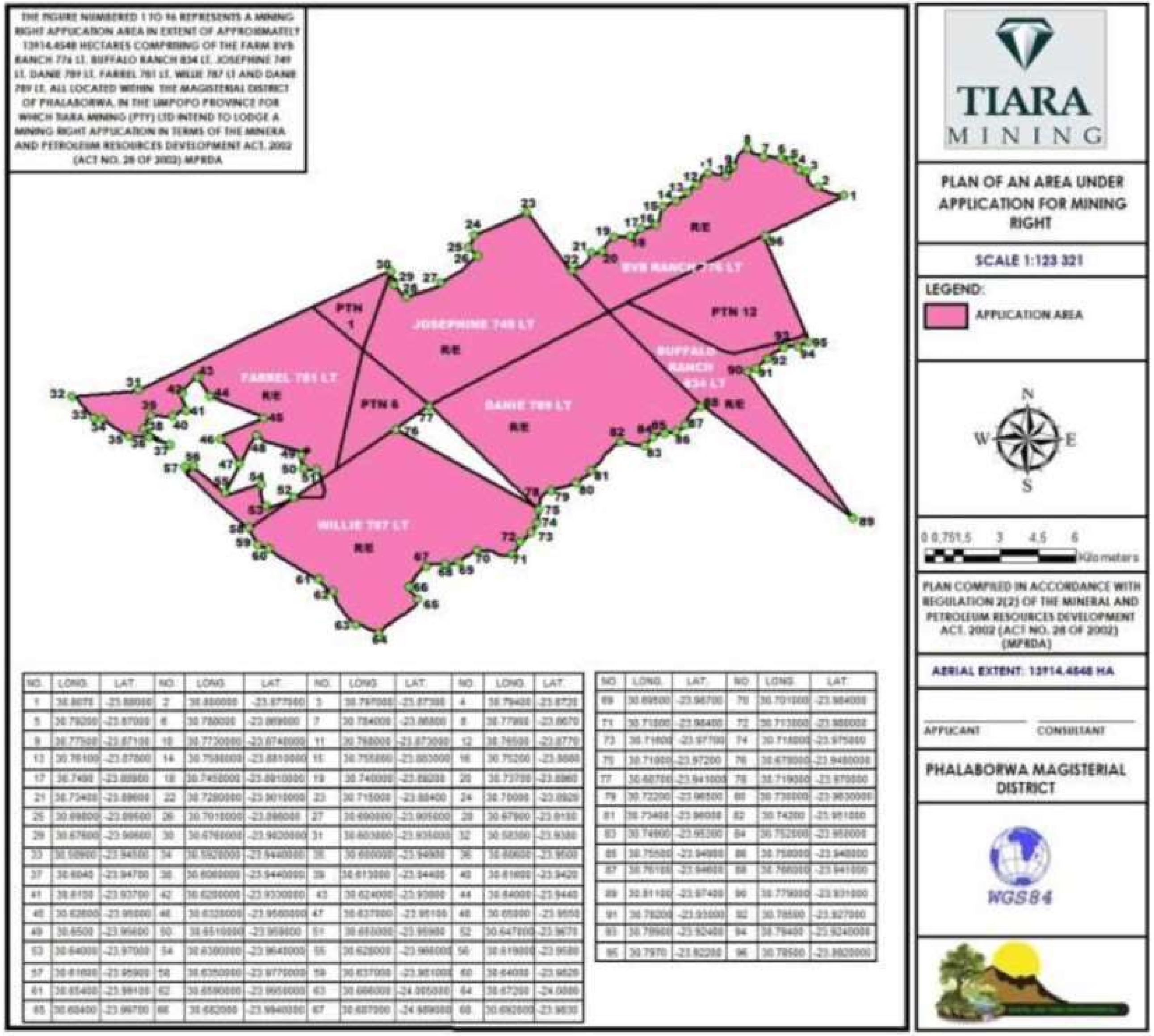

Figure 3: Regulation 2(2) plan of the greater study area (Mine Work Programme 2020).

3. Archaeological Background

Southern African archaeology is broadly divided into the Early, Middle and Later Stone Ages; Early, Middle and Later Iron Ages; and Historical or Colonial Periods. This section of the report provides a general background to archaeology in South Africa and focuses on more site-specific elements where relevant.

3.1 The Stone Ages

The earliest stone tool industry, the Oldowan, was developed by early human ancestors which were the earliest members of the genus *Homo,* such as *Homo habilis*, around 2.6 million years ago. It comprises tools such as cobble cores and pebble choppers (Toth & Schick 2007). Archaeologists suggest these stone tools are the earliest direct evidence for culture in southern Africa (Clarke & Kuman 2000). The advent of culture indicates the advent of more cognitively modern hominins (Mitchell 2002: 56, 57)

The Acheulean industry completely replaced the Oldowan industry. The Acheulian industry was first developed by *Homo ergaster* between 1.8 to 1.65 million years ago and lasted until around 300 000 years ago. Archaeological evidence from this period is also found at Swartkrans, Kromdraai and Sterkfontein. The most typical tools of the ESA are handaxes, cleavers, choppers and spheroids. Although hominins seemingly used handaxes often, scholars disagree about their use. There are no indications of hafting, and some artefacts are far too large for it. Hominins likely used choppers and scrapers for skinning and butchering scavenged animals and often obtained sharp ended sticks for digging up edible roots. Presumably, early humans used wooden spears as early as 5 million years ago to hunt small animals.

Middle Stone Age artefacts started appearing about 250 000 years ago and replaced the larger Early Stone Age bifaces, handaxes and cleavers with smaller flake industries consisting of scrapers, points and blades. These artefacts roughly fall in the 40-100 mm size range and were, in some cases, attached to handles, indicating a significant technical advance. The first *Homo sapiens* species also emerged during this period. Associated sites are Klasies River Mouth, Blombos Cave and Border Cave (Deacon & Deacon 1999).

Although the transition from the Middle Stone Age to the Later Stone Age did not occur simultaneously across the whole of southern Africa, the Later Stone Age ranges from about 20 000 to 2000 years ago. Stone tools from this period are generally smaller, but were used to do the same job as those from previous periods; only in a different, more efficient way. The Later Stone Age is associated with: rock art, smaller stone tools (microliths), bows and arrows, bored stones, grooved stones, polished bone tools, earthenware pottery and beads. Examples of Later Stone Age sites are Nelson Bay Cave, Rose Cottage Cave and Boomplaas Cave (Deacon & Deacon 1999).

3.2 The Iron Age & Historical Period

The Early Iron Age marks the movement of farming communities into South Africa in the first millennium AD, or around 2500 years ago (Mitchell 2002:259, 260). These groups were agro-pastoralist communities that settled in the vicinity of water in order to provide subsistence for their cattle and crops. Archaeological evidence from Early Iron Age sites is mostly artefacts in the form of ceramic assemblages. The origins and archaeological identities of this period are largely based upon ceramic typologies. Some scholars classify Early Iron Age ceramic traditions into different "streams" or "trends" in pot types and decoration, which emerged over time in southern Africa. These "streams" are identified as the Kwale Branch (east), the Nkope Branch (central) and the Kalundu Branch (west). Early Iron Age ceramics typically display features such as large and prominent inverted rims, large neck areas and fine elaborate decorations. This period continued until the end of the first millennium AD (Mitchell 2002; Huffman 2007). Some well-known Early Iron Age sites include the Lydenburg Heads in Mpumalanga, Happy Rest in the Limpopo Province and Mzonjani in Kwa-Zulu Natal.

The Middle Iron Age roughly stretches from AD 900 to 1300 and marks the origins of the Zimbabwe culture. During this period cattle herding appeared to play an increasingly important role in society. However, it was proved that cattle remained an important source of wealth throughout the Iron Age. An important shift in the Iron Age of southern Africa took place in the Shashe-Limpopo basin during this period, namely the development of class distinction and sacred leadership. The Zimbabwe culture can be divided into three periods based on certain capitals. Mapungubwe, the first period, dates from AD 1220 to 1300, Great Zimbabwe from AD 1300 to 1450, and Khami from AD 1450 to 1820 (Huffman 2007: 361, 362).

The Late Iron Age roughly dates from AD 1300 to 1840. It is generally accepted that Great Zimbabwe replaced Mapungubwe. Some characteristics include a greater focus on economic growth and the increased importance of trade. Specialisation in terms of natural resources also started to play a role, as can be seen from the distribution of iron slag which tend to occur only in certain localities compared to a wide distribution during earlier times. It was also during the Late Iron Age that different areas of South Africa were populated, such as the interior of KwaZulu Natal, the Free State, the Gauteng Highveld and the Transkei. Another characteristic is the increased use of stone as building material. Some artefacts associated with this period are knife-blades, hoes, adzes, awls, other metal objects as well as bone tools and grinding stones.

The area between Gravelotte and Phalaborwa is characterised by numerous settlements associated with metal working as the general area is rich in iron and copper ores. The past 1200 years saw the discontinuous working of these copper ores by a succession of people representing different archaeological complexes. The metal production sites mostly date to the Late Iron Age and excavations indicate that animal husbandry was not of primary importance. Since the soils and climate of the area are not particularly suitable for herding and agriculture, the communities predominantly focussed on metal production. The subsequent production of metal objects, such as hoes, were used as replacement for cattle in bride wealth (Plug & Pistorius 1999).

Historically known groups of the areas include Makusane and Maseke-Malatji, the Majaji-Malatji, and the Bashai. Iron production was dominant in the influence spheres of the Makusane, Majaji-Malatji and the Bashai, while copper production was dominant in the influence sphere of the Maseke-Malatji. Worthy to note is that geological reports first made the earliest mention of archaeological remains at Phalaborwa and referred to ancient mining activities on Loole Hill and the Old Guide Mine. Mention is made of iron and copper smelting at Serotwe Hill in Phalaborwa, while valuable ethnographic studies were done among the Baphalaborwa (Bamalatji) people who are associated with the metal working remains at Phalaborwa (Plug & Pistorius 1999).

The Historical period mainly deals with Europe's discovery, settlement and impact on southern Africa. Some topics covered by the Historical period include Dutch settlement in the Western Cape, early mission stations, Voortrekker routes and the Anglo Boer War. This time period also saw the compilation of early maps by missionaries, explorers, military personnel, etc.

3.2.3 Phalaborwa & Gravelotte general history

According to Bulpin (1986: 675) Karanga metal workers form Zimbabwe ventured south, but after finding themselves in a fever area, they retraced their steps and settled to the north. Accordingly, they named the area Phalaborwa (better than the south). At the beginning of the 20th Century, European miners re-discovered the rich metal deposits in the area and people such as William Valentine, Tucker, Cleveland and Scannell started mining copper in the area. In 1935 the Merensky Trust amalgamated Vermiculite (Pty) Ltd and the Phalaborwa Phosphate Co and in 1938 the Transvaal Ore Company commenced mining vermiculite. The government financed Foskor through the Industrial Development Corporation for the purpose of making the country self-sufficient in phosphate concentrate used in agricultural fertilizers.

Gravelotte was named after the battle fought on 18 August 1970 in the Franco-German War and was established as a railway and trading centre for mining activity in the Murchison Range. Gold, cinnabar, mica, feldspar, silica and emeralds are produced in the vicinity and Alpha shaft of the Consolidated Murchison Mine, the largest and richest antimony mine at that stage, was the deepest sunk mine for the recovery of a base metal (Bulpin 1986:674)

4. Methodology

Archaeological reconnaissance of the study area was conducted during November 2020 through a combination of unsystematic vehicular and pedestrian surveys of the proposed surface infrastructure areas. Two initial areas demarcated for surface development were identified, with an additional three areas were later added (**Figure 4**). General site conditions were recorded via photographic record (**Figures 5 – 15**). Also, the project area was inspected beforehand on Google Earth, historical aerial imagery and topographical maps in order to identify possible heritage remains (**Appendix A**). Twelve sites (**Table 4**) were identified during the study through a combination of inspecting historical topographical maps, aerial images, surveying and through personal communication with the manager at Tiara Mining. Four sites were pre-identified, visited and recorded (TA01 –

TA04), while an additional eight sites (TF01 – TF08) were identified and recorded during the survey **(Tables 5 – 7 & Figure 4**). It should be noted that the prefixes '2330DC' and '2330DD' are not used when referring to the official site names due to the length of the name, but are recorded as such in **Table 4**. The historical topographical datasets dating to 1947, 1956, 1960, 1974, 1989 and 2002, as well as the historical aerial photographs dating to 1954, 1965 and 1968 proved useful in terms of providing an indication of the location and age of some of the structures and features associated with the study area. The total area inspected was roughly 1002 ha. Dense vegetation significantly hampered free movement and visibility, resulting in mainly inspections along roads. Pedestrian surveys were limited to areas where clearings were observed (further discussed in the 'limitations' section).

The reconnaissance of the area under investigation served a twofold purpose:

- To obtain an indication of heritage material found in the general area as well as to identify or locate archaeological sites on the areas demarcated for development. This was done in order to establish a heritage context and to supplement background information that would benefit developers through identifying areas that are sensitive from a heritage perspective.

- All archaeological and historical events have spatial definitions in addition to their cultural and chronological context. Where applicable, spatial recording of these definitions were done by means of a handheld GPS during the site visit, as well as by plotting the boundaries from aerial imagery and topographical maps.

Table 4: Site coordinates & description.

Abbreviated name	Site / Survey Point Name	Longitude	Latitude	Description	Current Status	Identification Source
TA01	2330DC-TA01	30.745321	-23.910242	Building	Unknown	Topo 1974
TA02	2330DC-TA02	30.745805	-23.910174	Building	Intact	Topo 1974
TA03	2330DD-TA03	30.877649	-23.862744	Natural	N/A	Aerial
TA04	2330DD-TA04	30.880031	-23.859627	Natural	N/A	Aerial
TF01	2330DC-TF01	30.743306	-23.907301	Building	Ruin	Survey
TF02	2330DC-TF02	30.74644	-23.905505	Reservoir	Intact	Survey
TF03	2330DC-TF03	30.746818	-23.903102	Stone Cairn	Intact	Survey
TF04	2330DC-TF04	30.744627	-23.901703	Stone Cairn	Intact	Survey
TF05	2330DC-TF05	30.746189	-23.899721	Reservoir	Intact	Survey
TF06	2330DC-TF06	30.744206	-23.908282	Stone Cairn	Intact	Survey
TF07	2330DC-TF07	30.745198	-23.908446	Building	Ruin	Survey
TF08	2330DC-TF08	30.746715	-23.909845	Stone Cairn	Intact	Survey

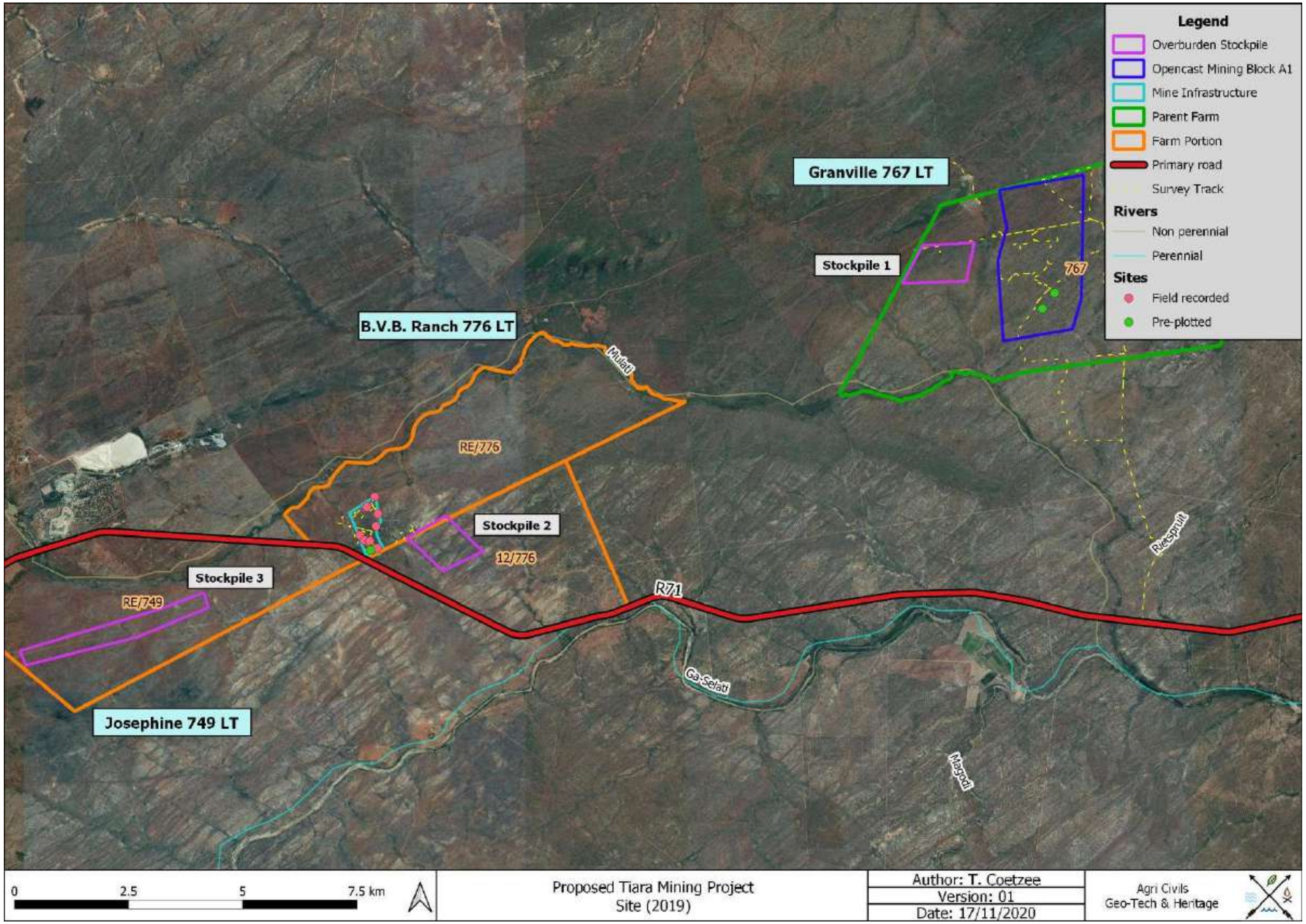

Figure 4: Study area with pre-plotted and field-recorded sites on a 2019 aerial backdrop.

Figure 5: Cattle track – north-eastern corner of proposed mining infrastructure area.

Figure 6: Dense vegetation – northern section of proposed mining infrastructure area.

Figure 7: Access road – eastern border of proposed mining infrastructure area.

Figure 8: Access road & dense vegetation – centre of proposed mining infrastructure area.

Figure 9: Dense vegetation – southern section of proposed mining infrastructure area.

Figure 10: Dense vegetation – southern section of Opencast Mining Block A1.

Figure 11: Dense vegetation – western section of Opencast Mining Block A1.

Figure 12: Dense vegetation – eastern section of Opencast Mining Block A1.

Figure 13: Dense vegetation – northern section of Opencast Mining Block A1.

Figure 14: General environment associated with Overburden Stockpile 1.

Figure 15: General environment associated with Overburden Stockpile 2.

4.1 Sources of information

At all times during the survey, standard archaeological procedures for the observation of heritage resources were followed. As most archaeological material occur in single or multiple stratified layers beneath the soil surface, special attention was paid to disturbances; both man-made such as roads and clearings, and those made by natural agents such as burrowing animals and erosion. Locations of archaeological material remains were recorded by means of a Garmin Oregon 750 GPS and photographed these sites as well as general conditions on the terrain with a Sony Cyber-shot camera.

A literature study, which incorporated previous work done in the region, was conducted in order to place the study area into context from a heritage perspective.

Personal communication with the following managers proved useful in locating potential heritage sites:

- Mr Wessie vd Westhuizen (B.V.B. Rach & Granville sections) – Manager at Tiara Mining
- Mr Bryan Havemann (Josephine section) – General Manager at Selati Game Reserve.

4.1.1 Previous Heritage Studies

Mahale Quartzite Mine, Phalaborwa

A phase 1 HIA was done for the Mahale Quartzite Mine located on portions of the farms Mahale 718 LT, Silwana's Location 719 LT & Wildebeest 745 LT near Phalaborwa. The study area for the Mahale Quartzite Mine is located about 12 km northeast of the proposed Tiara Mining Project study area. The HIA recorded ceremonial remains on a hilltop within the study area and a Phase 2 assessment was recommended (Roodt 2008).

400kV Powerline from Foskor Substation to Spencer Substation

The Phase 1 AIA for the construction of a 400kV powerline from Foskor Substation to Spencer Substation was done by Vhubvo Archaeo-Heritage Consultant cc (Magoma & Muroyi 2018). The proposed powerline spans a distance of 110 km just south of Phalaborwa to approximately 40 km southwest of Giyani. The study recorded two cemeteries, an abandoned settlement and the Muti wa Vatsonga Open Museum, but notes the possibility of Stone Age/Iron Age sites in the vicinity. The closest section of the powerline project to the proposed Tiara Mining Project is approximately 15 km to the southwest of the demarcated portion on the Farm B.V.B. Ranch 776 LT.

BaPhalaborwa Waste Disposal Landfill Site

Roodt (2002) conducted an Archaeological Impact Assessment for the BaPhalaborwa Waste Disposal Landfill Site. The study recorded an Iron Age site at the base of a hill that consisted of middens and terraces. The middens were rich pottery fragments, bone and metal slag. Other material culture found include an ostrich eggshell bead and tuyere pieces. According to Roodt (2002), the site is typical of a pre-colonial BaPhalaborwa settlement but also notes that some of the pottery fragments might date to the 10th – 12th Century and belong to the Kgopolwe cultural tradition. It is also noted that the possibility exists that the hilltop might have been used in rainmaking rituals. The BaPhalaborwa Waste Disposal Landfill Site is located approximately 21 km southeast of the proposed Granville 767 LT area.

4.2 Limitations

The demarcated study areas are all characterised by extremely dense vegetation that severely restricted access, free movement and visibility during the time of surveying (November 2020). The type of vegetation consisted of thick mopane tree cover, thorn bushes and grass cover (**Figures 16 – 19**). This can be ascribed to the fact that the larger area received approximately 200mm of rain in the weeks preceding the survey. Several jeep tracks exist within the areas demarcated for the construction of mine infrastructure and Opencast Mining Block A1. These roads were followed as far as possible and clearings in the dense vegetation were inspected via a pedestrian survey where possible. In a few instances, cattle tracks were followed as well. Few or no roads were observed at the proposed overburden stockpile no. 1 and 2 areas. The proposed overburden stockpile no. 3 area is located within the Selati Nature Reserve. Personal Communication with the General Manager, Mr Havemann, revealed that access to the area is strictly controlled due to the fact that the Big Five are found within the nature reserve. It would therefore be compulsory to be accompanied by a guide. Given the late acquisition of the overburden stockpile boundaries, access could not be arranged in time.

Figure 16: Dense vegetation associated with the area demarcated for mining infrastructure.

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Figure 17: Dense vegetation associated with demarcated Mining Block A1.

Figure 18: Dense vegetation – proposed Overburden Stockpile 1.

Figure 19: Dense vegetation – proposed Overburden Stockpile 2.

5. Archaeological and Historical Remains

5.1 Stone Age Remains

No Stone Age archaeological remains were located within the demarcated study area.

Although no Stone Age archaeological remains were located, such artefacts are likely to occur in the area. These artefacts are often associated with rocky outcrops or water sources. **Figures 20 – 22** below are examples of stone tools often associated with the Early, Middle and Later Stone Age of southern Africa.

Archaeological studies done on the surrounding areas also did not locate material pertaining to the Stone Age.

According to Bergh (1999: 5), no major Stone Age archaeological sites are located in the direct vicinity of the study area.

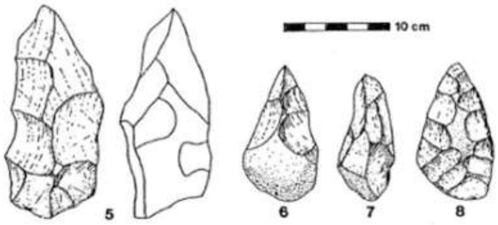

Figure 20: ESA artefacts from Sterkfontein (Volman 1984).

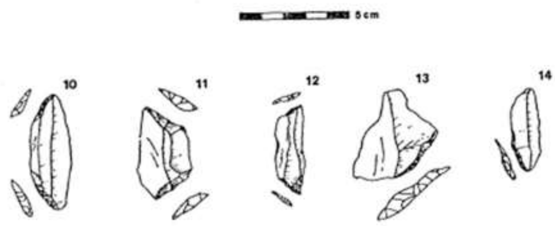

Figure 21: MSA artefacts from Howiesons Poort (Volman 1984).

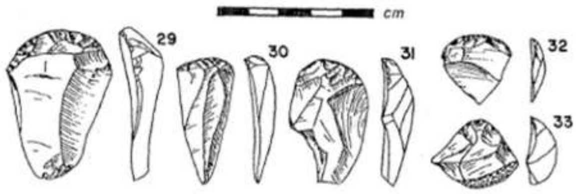

Figure 22: LSA scrapers (Klein 1984).

5.2 Iron Age Farmer Remains

One site that might possibly date to the Iron Age was observed (TF06). The site, located within the proposed boundary of the demarcated mine infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT and approximately 60 m from the closest infrastructure in the south-western section, consists of what appears to be a stone cairn, but might be a short section of stone-walling as well (**Table 5**). Although several other stone cairns were observed, this particular stone cairn differs in style as it is partially located below the surface and are associated with few loose stones. No material culture were observed in the direct vicinity of the site.

The heritage study done for the Mahale Quartzite Mine recorded ceremonial remains on a hilltop (Roodt 2008), while the HIA done for the BaPhalaborwa Waste Disposal Landfill recorded middens rich in pottery fragments, bone and metal slag. Tuyere pieces and an eggshell bead were found as well, and according to Roodt (2002), the site is typical of a pre-colonial BaPhalaborwa settlement. Roodt (2002) also notes that some of the pottery fragments might date to the 10th – 12th Century and might belong to the Kgopolwe cultural tradition. As in the case of the Mahale Quartzite Mine, the hilltop might have been associated with ceremonial practices.
According to Mr Havemann, several objects dating to the Iron Age have in the past been discovered within the Selati Nature Reserve, located directly southwest of the proposed mining infrastructure area and where the 3rd overburden stockpile is proposed. Accordingly, material culture include complete pots, pottery fragments and iron objects (Bryan Havemann, pers comm. 2020).

Table 5: Iron Age sites.

Name	Type	Source	Year	Status	Age	Estimated extent (m^2)	Parcel
TF06	Stone cairn	Survey	Unknown	Intact	LIA	3	RE/776

Figure 23: Potential stone cairn/walling.

5.3 Historical

One Historical sites was identified within the boundary of the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 776 LT (**Table 6**). Site TF01 is located next to a road near the western boundary of the demarcated area and approximately 130 m west of the nearest proposed development. The site consists of a rectangular enclosure built using stone and mud and is heavily overgrown (**Figure 24**). The walls are approximately 0.6 m high and occupies about 6 m². One angular opening in the wall suggests a window. In terms of material culture, one lower grinding stone was observed along to the jeep track running next to the enclosure (**Figure 25**). The use of the structure and whether this structure was part of a larger complex is not known. It should also be noted that site TF01 is not visible on historical aerial imagery and is not indicated on historical topographical maps (**Appendix A**).

Table 6: Historical sites.

Name	Type	Source	Year	Status	Age	Estimated extent (m²)	Parcel
TF01	Building	Survey	Unknown	Ruin	Historical	6	RE/776

Only the study done by Vhubvo Archaeo-Heritage Consultant cc (Magoma & Muroyi 2018) for the 400kV Powerline from Foskor Substation to Spencer Substation mentions an abandoned settlement that might date to historical times.

Figure 24: Rectangular enclosure.

Figure 25: Lower grinding stone associated with TF01.

5.4 Contemporary Remains

Table 7 lists the four pre-plotted sites, as well as six sites identified during the survey (**Figures 26 – 35**).

Sites TA01 & TA02 were identified on the 1974/1989 topographical map as buildings (**Appendix A: Figure 46**) and were visited during the survey. No evidence of site TA01, however, could be located, but a possibility exists that the associated building are located closer to site TA02, where two buildings constructure form bricks and cement were observed. As such, site TA02 consists of two small buildings 20 m apart with an approximate extent of 4 m² each. The structures respectively have 1 m and 1.9 m high walls on three sides, one open side and a flat roof (**Figures 26 & 27**). The buildings are located within the demarcated mining infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT near the southern boundary and in close proximity of a jeep track. No material culture were observed at the site. According to Mr Van Der Westhuizen, who has been with Tiara Mining on B.V.B. Ranch 776 LT for 18 years, these building were built to house explosives during previous mining operations in the 1970's (Wessie van der Westhuizen, pers comm. 2020).

Sites TA03 & TA04, identified on the 1956/1960 topographical map (**Appendix A: Figure 45**), are natural dams/pans of approximately 4000 m² each (**Figures 28 & 29**). These sites are located within the southern half of the area demarcated for the Opencast Mining Block A1 area on the Farm Granville 767 LT.

Sites TF02 and TF05 were identified as cement constructed water reservoirs on the demarcated mine infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT. Site TF02 (**Figure 30**) is located near the eastern boundary of the demarcated area and next to a jeep track and measures approximately 80 m², while site TF05 (**Figure 33**) is located in the north-eastern corner and appears to be used as a cattle drinking trough. Site TF05 measures approximately 40 m². Only site TF02 is located within close proximity of the planned development.

Sites TF03, TF04 and TF08 were identified as stone cairns within the boundary of the demarcated mining infrastructure area on the Remaining Extent of the Farm B.V.B. Ranch 776 LT. Site TF03 is located along the eastern boundary of the demarcated area, site TF04 near the northern boundary and site TF08 near the southern boundary. The stone cairn closest to a proposed development boundary is site TF04 and is located 85 m away. Sites TF03 and TF04 (**Figures 31 & 32**) consist of relatively small stone cairns of mediums sized stones, while site TF08 (**Figure 35**) is characterised by a slightly elongated stone cairn consisting of small stones oriented in an east-west direction. According to Mr Van Der Westhuizen, the stone cairns associated with the area demarcated for the construction of mining infrastructure indicate the location of mining claims. Accordingly, the elongated stone cairns indicate the direction of the claim (Wessie van der Westhuizen, pers comm. 2020).

Site TF07 (**Figure 34**), a building ruin located next to a jeep track and proposed access road on the southern half of the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B.

Ranch 776 LT, consists of a dugout foundation of approximately 20 m². A pile of bricks with cement are located next to the foundation. According to Mr Van Der Westhuizen, the building was built to house mining machinery during previous mining operations in the 1970's and was subsequently demolished. No other material culture were observed at the site.

Table 7: Contemporary Remains.

Name	Type	Source	Year	Status	Age	Estimated extent (m^2)	Land Parcel
TA01	Building	Topo	1974	Unknown	Contemporary	unknown	RE/776
TA02	Building	Topo	1974	Intact	Contemporary	4	RE/776
TA03	Dam/pan	Topo	1960	Intact	N/A	4000	787
TA04	Dam/pan	Topo	1960	Intact	N/A	4000	787
TF02	Reservoir	Survey	Unknown	Intact	Contemporary	80	RE/776
TF03	Stone cairn	Survey	Unknown	Intact	Contemporary	1	RE/776
TF04	Stone cairn	Survey	Unknown	Intact	Contemporary	1	RE/776
TF05	Reservoir	Survey	Unknown	Intact	Contemporary	40	RE/776
TF07	Building	Survey	±1978	Ruin	Contemporary	20	RE/776
TF08	Stone cairn	Survey	Unknown	Intact	Contemporary	2	RE/776

Figure 26: Small explosives building at site TA02.

Figure 27: Larger explosives building at site TA02.

Figure 28: Natural dam/pan at site TA03.

Figure 29: Natural dam/pan at site TA04.

Figure 30: Site TF02 – water reservoir.

Figure 31: Site TF03 – Stone cairn.

Figure 32: Site TF04 – Stone cairn.

Figure 33: Cattle drinking trough at site TF05.

Figure 34: Demolished building at site TF07.

Figure 35: TF08 – Elongated stone cairn.

Heritage studies done in the surrounding area did not record buildings or structures dating to contemporary times See Magoma & Muroyi (2018); Roodt (2002 & 2008).

5.5 Graves

No graves or burial sites were located within the demarcated study areas. However, due to limited accessibility and visibility, the possibility exists that graves or burial sites might be located within the demarcated study areas.

Only the study for the 400kV Powerline from Foskor Substation to Spencer Substation done by Vhubvo Archaeo-Heritage Consultant cc recorded two cemeteries (Magoma & Muroyi 2018).

6. Evaluation

The significance of an archaeological site is based on the amount of deposit, the integrity of the context, the kind of deposit and the potential to help answer present research questions. Historical structures are defined by Section 34 of the National Heritage Resources Act, 1999, while other historical and cultural significant sites, places and features, are generally determined by community preferences.

A fundamental aspect in the conservation of a heritage resource relates to whether the sustainable social and economic benefits of a proposed development outweigh the conservation issues at stake. There are many aspects that must be taken into consideration when determining significance, such as rarity, national significance, scientific importance, cultural and religious significance, and not least, community preferences. When, for whatever reason the protection of a heritage site is not deemed necessary or practical, its research potential must be assessed and if appropriate mitigated in order to gain data / information which would otherwise be lost. Such sites must be adequately recorded and sampled before being destroyed.

6.1 Field Ratings

All sites should include a field rating in order to comply with section 38 of the National Heritage Resources Act (Act No. 25 of 1999). The field rating and classification in this report are prescribed by SAHRA.

Table 8: Field Ratings

Rating	Field Rating/Grade	Significance	Recommendation
National	Grade 1		National site
Provincial	Grade 2		Provincial site
Local	Grade 3 A	High	Mitigation not advised
Local	Grade 3 B	High	Part of site should be retained
General protection A	4 A	High/Medium	Mitigate site
General Protection B	4 B	Medium	Record site
General Protection C	4 C	Low	No recording necessary

Table 9: Individual site ratings

Site / Survey Point Name	Type	Rating	Field Rating/Grade	Significance	Recommendation
2330DC-TA01	Building-unknown	General Protection C	4 C	Low	No recording necessary
2330DC-TA02	Building-intact	General Protection B	4 B	Medium	Record site
2330DD-TA03	Natural	General Protection C	4 C	Low	No recording necessary
2330DD-TA04	Natural	General Protection C	4 C	Low	No recording necessary
2330DC-TF01	Building-ruin	General Protection B	4 B	Medium	Record site
2330DC-TF02	Reservoir-intact	General Protection B	4 B	Medium	Record site
2330DC-TF03	Stone cairn	General Protection B	4 B	Medium	Record site
2330DC-TF04	Stone cairn	General Protection B	4 B	Medium	Record site
2330DC-TF05	Reservoir-intact	General Protection B	4 B	Medium	Record site
2330DC-TF06	Stone cairn	General Protection B	4 B	Medium	Record site
2330DC-TF07	Building-ruin	General Protection B	4 B	Medium	Record site
2330DC-TF08	Stone cairn	General Protection B	4 B	Medium	Record site

7. Statement of Significance & Recommendations

7.1 Statement of significance

The study area: Demarcated portions of the Remaining Extents of the Farms B.V.B Ranch 776 LT, Josephine 749 LT and the Farm Granville 767 LT, Phalaborwa, Limpopo

Given the significance of the larger cultural landscape, as well as cultural material remains from the Selati Nature Reserve and heritage sites located during previous heritage studies, the demarcated study areas are considered sensitive from a heritage perspective. However, due to extremely dense vegetation cover as a result of recent rainfall, the identification of culturally significant heritage sites was significantly hampered. It is therefore likely that more culturally significant sites are located within the demarcated study areas. The located sites and potentially sensitive areas are indicated on **Figures 36 & 37**.

According to the manager at Tiara Mining, Mr Van Der Westhuizen, the two explosives buildings and the building used to house mining equipment (now a ruin) on the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B Ranch 776 LT date to the 1970's, do not exceed 60 years of age and are therefore not considered significant from a heritage perspective (Sites TA02 & TF07). Also, site TA02 and the area associated with TA01 are located approximately 20 m from the proposed haul road and impact is therefore unlikely. Site TF07, however, is located in close proximity of the proposed haul road, but is not considered significant from a heritage perspective due to its relative recent construction and dilapidated state.

Sites TA03 and TA04 are natural pans/dams on the proposed Opencast Mining Block A1 area on the Farm Granville 767 LT. The sites are not considered significant from a heritage perspective. Due to the presence of water, however, the general surroundings might mean that the areas were more like to be settled during historical times and might therefore be potentially sensitive from a heritage perspective.

Sites TF02 and TF05 are respectively a water reservoir and cattle drinking trough located on the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B Ranch 776 LT. The sites appear to be of recent origin and are not significant from a heritage perspective. Also worthy to note is that only site TF02 is located in close proximity of the planned development.

According to Mr Van Der Westhuizen, the stone cairns identified on the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B Ranch 776 LT relate to mining claims and are not burial sites (Sites TF03, TF04 and TF08). Only stone cairn TF08 is located in close proximity of the proposed development. These sites are therefore not considered significant form a heritage perspective, but might not apply to all stone cairns within the study area.

Site TF06, a potential stone cairn or section of stone-walling located on the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B Ranch 776 LT, might date to the Iron Age, but could not be verified due to dense vegetation cover in the general vicinity. Also, no supportive material culture were observed. Site TF06 is not located within close proximity of the proposed infrastructure and are therefore not likely to be impacted.

Site TF01 consists of a historical building ruin on the area demarcated for the construction of mining infrastructure on the Remaining Extent of the Farm B.V.B Ranch 776 LT and is considered significant from a heritage perspective. Because this structure is likely to exceed 60 years of age, it is protected under the NHRA act 25 of 1999. The closest development is planned approximately 130 m east of the site, therefore no impact is envisaged.

The area demarcated for overburden stockpile no.3 on the Farm Josephine 749 LT is located within the Selati Nature Reserve and could not be accessed. No buildings or infrastructure were observed on historical topographical maps, but the Selati Nature Reserve General Manager, Mr Havemann, did confirm the presence of complete pots, pottery fragments and iron artefacts within the reserve, attesting to cultural significance of the area.

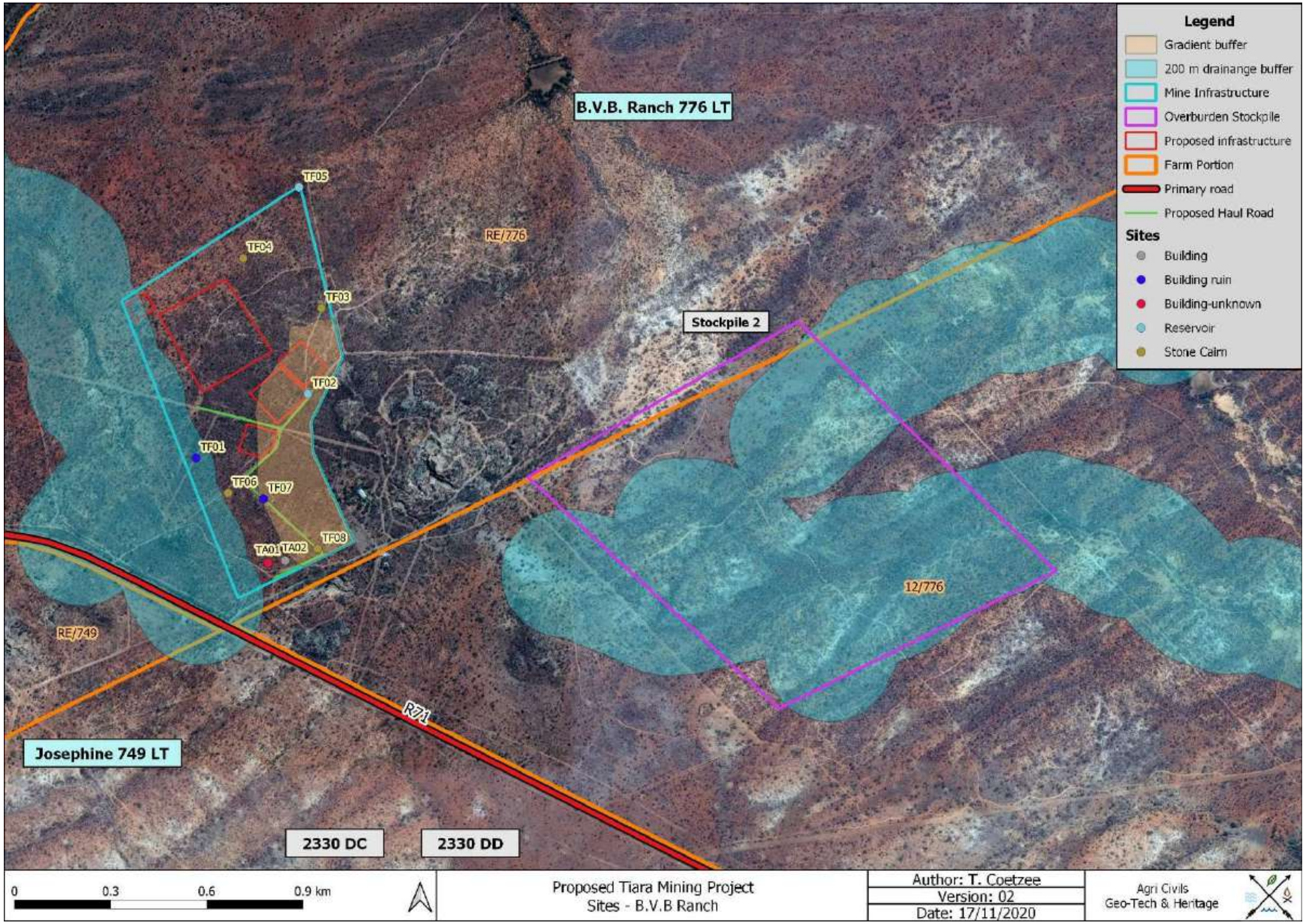

Figure 36: Sites and buffer zones indicated on a 2019 aerial backdrop – B.V.B Ranch section.

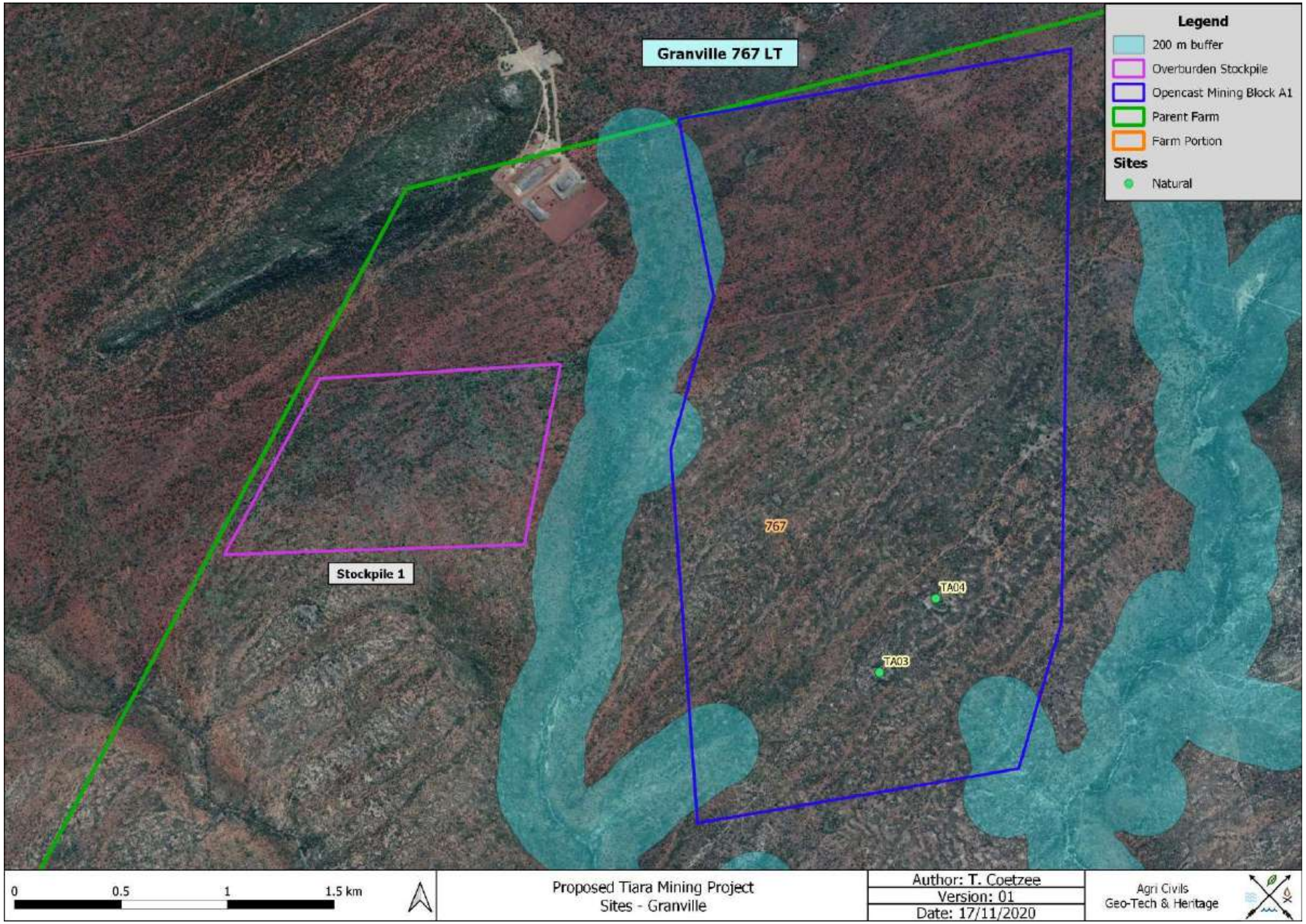

Figure 37: Sites and buffer zones indicated on a 2019 aerial backdrop – Granville section.

7.2 Recommendations

The following recommendations are made in terms with the National Heritage Resources Act (25 of 1999) in order to avoid the destruction of heritage remains associated with the areas demarcated for development:

Demarcated surface infrastructure areas & conveyor belt

- Sites TA01, TA02 and TF07 are buildings or building remains relating to previous mining operations, are of recent origin and are not regarded as significant from a heritage perspective. The recording done during the Phase 1 AIA is considered sufficient – no further action is required.

- Sites TA03 and TA04 are natural features – no further action is required.

- Site TF02 is a circular water reservoir and site TF05 a cattle water trough. These sites appear to be of recent origin and are not regarded as significant from a heritage perspective. The recording done during the Phase 1 AIA is considered sufficient – no further action is required.

- The historical building, site TF01, is significant from a heritage perspective. The site exceeds 60 years of age and are therefore protected under the NHRA act 25 of 1999. Although impact is not likely on account of the site begin located a significant distance from the proposed infrastructure, it is recommended that the mine's ECO inspect the structure on a quarterly basis . Should any impact be observed, or if impact cannot be avoided, the vegetation must be cleared and the structure adequately recorded by a qualified archaeologist. A destruction permit will have to be obtained from the relevant heritage authority as well.

- According to the Tiara Mine manger, Mr Van Der Westhuizen, the stone cairns associated with the area demarcated for the development of mining infrastructure on the Remaining Extent of the Farm B.V.B. Ranch 776 LT are mining claims and not potential graves (Sites TF03, TF04 and TF08). However, it is recommended should the mine manger be uncertain about the origin of a stone cairn, the stone cairn be considered a grave, in which case a 30 m fenced-off conservation buffer with explanatory signage must be erected around the stone cairn. Also, access to the potential graves must not be refused. Alternatively, the potential graves may be relocated by a qualified graves relocation unit to a premises earmarked by the local municipality, but will set in motion a substantial process as new legislation will be triggered. These processes, however, must be performed in accordance with the involvement of community leaders. Another possibility would be to make use of Ground Penetrating Radar operated by a suitably qualified professional to determine the presence of human remains at stone cairn localities of which the origin is uncertain.

- Site TF06, a stone cairn or possible section of a stone wall, might date to the Iron Age and would therefore be protected under the NHRA 25 of 1999. Due to the dilapidated state and poor level of preservation, the extent could not be determined, but the site is located a significant distance from the proposed mining infrastructure and should therefore not be impacted. Should impact be unavoidable, it is recommended that a qualified archaeologist inspect the site after the removal of vegetation to determine the extent of the site. Should the site be verified, a destruction permit from the South African Heritage Resources Agency will be required.

- The general area is considered significant from a heritage perspective, but dense vegetation and tree covered significantly hampered free movement and site observation, thereby preventing obtaining a true representation and indication of the cultural resources within the demarcated development areas. Therefore, is recommended that a qualified archaeologist be present on site when vegetation is cleared in order to prevent the accidental damage and destruction of heritage resources.

- Also, the area demarcated for overburden stockpile no.3 on the Farm Josephine 749 LT could not be accessed. It is assumed that at the time of reporting, vegetation and tree cover will be as restrictive as in the remaining areas. Therefore, the same recommendation regarding the presence of an on-site archaeologist is recommended once vegetation clearing is started in order to prevent the accidental damage and destruction of heritage resources.

General Recommendations

- The above recommendations are based on the specific project activities, as well as surface boundaries as indicated in this report. Should the proposed surface impact areas be changed, a qualified archaeologist must conduct a Phase 1 AIA on the new areas and amend the report accordingly.

- Because archaeological artefacts generally occur below surface, the possibility exists that culturally significant material may be exposed during the development and construction phases, in which case all activities must be suspended pending further archaeological investigations by a qualified archaeologist. Also, should skeletal remains be exposed during development and construction phases, all activities must be suspended and the relevant heritage resources authority contacted (See National Heritage Resources Act, 25 of 1999 section 36 (6)).

- From a heritage point of view, development may proceed on the demarcated areas, subject to the abovementioned conditions, recommendations and approval by the South African Heritage Resources Agency.

8. Addendum: Terminology

Archaeology:

The study of the human past through its material remains.

Artefact:

Any portable object used, modified, or made by humans; e.g. pottery and metal objects.

Assemblage:

A group of artefacts occurring together at a particular time and place, and representing the sum of human activities.

Context:

An artefact's context usually consist of its immediate *matrix* (the material surrounding it e.g. gravel, clay or sand), its *provenience* (horizontal and vertical position within the matrix), and its *association* with other artefacts (occurrence together with other archaeological remains, usually in the same matrix).

Cultural Resource Management (CRM):

The safeguarding of the archaeological heritage through the protection of sites and through selvage archaeology (rescue archaeology), generally within the framework of legislation designed to safeguard the past.

Excavation:

The principal method of data acquisition in archaeology, involving the systematic uncovering of archaeological remains through the removal of the deposits of soil and other material covering and accompanying it.

Feature:

An irremovable artefact; e.g. hearths or architectural elements.

Ground Reconnaissance:

A collective name for a wide variety of methods for identifying individual archaeological sites, including consultation of documentary sources, place-name evidence, local folklore, and legend, but primarily actual fieldwork.

Matrix:

The physical material within which artefacts is embedded or supported, i.e. the material surrounding it e.g. gravel, clay or sand.

Phase 1 Assessments:

Scoping surveys to establish the presence of and to evaluate heritage resources in a given area.

Phase 2 Assessments:

In-depth culture resources management studies which could include major archaeological excavations, detailed site surveys and mapping / plans of sites, including historical / architectural structures and features. Alternatively, the sampling of sites by collecting material, small test pit excavations or auger sampling is required.

Sensitive:

Often refers to graves and burial sites although not necessarily a heritage place, as well as ideologically significant sites such as ritual / religious places. *Sensitive* may also refer to an entire landscape / area known for its significant heritage remains.

Site:

A distinct spatial clustering of artefacts, features, structures, and organic and environmental remains, as the residue of human activity.

Surface survey:

There are two kinds: (1) unsystematic and (2) systematic. The former involves field walking, i.e. scanning the ground along one's path and recording the location of artefacts and surface features. Systematic survey by comparison is less subjective and involves a grid system, such that the survey area is divided into sectors and these are walked ally, thus making the recording of finds more accurate.

9. References

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National Heritage Resource Act No.25 of 1999, Government Gazette, Cape Town

Removal of Graves and Dead Bodies Ordinance No. 7 of 1925, Government Gazette, Cape Town

Appendix A: Historical Aerial Photographs and Topographical Maps

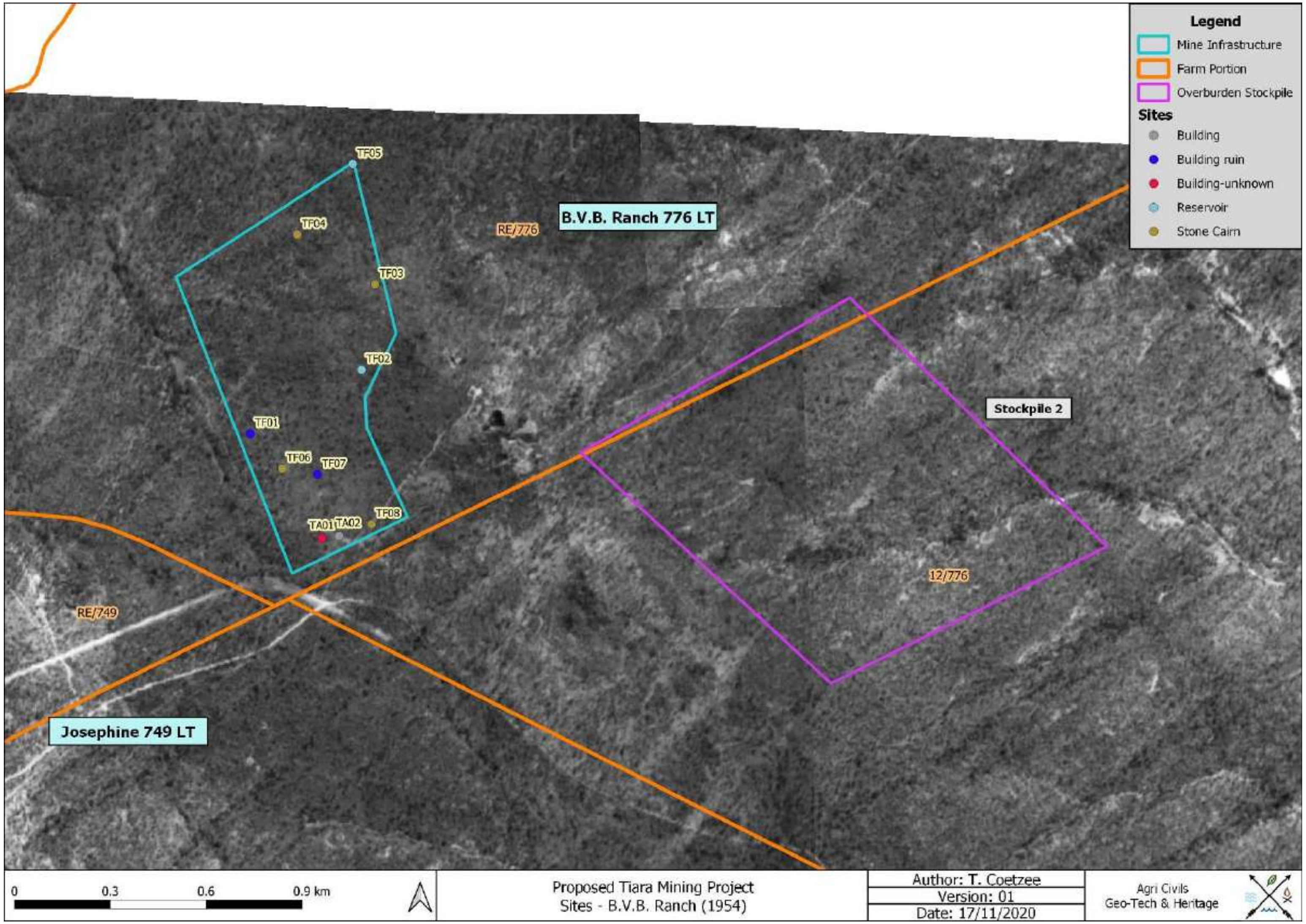

Figure 38: Study area superimposed on a 1954 aerial photograph – B.V.B. Ranch section**.**

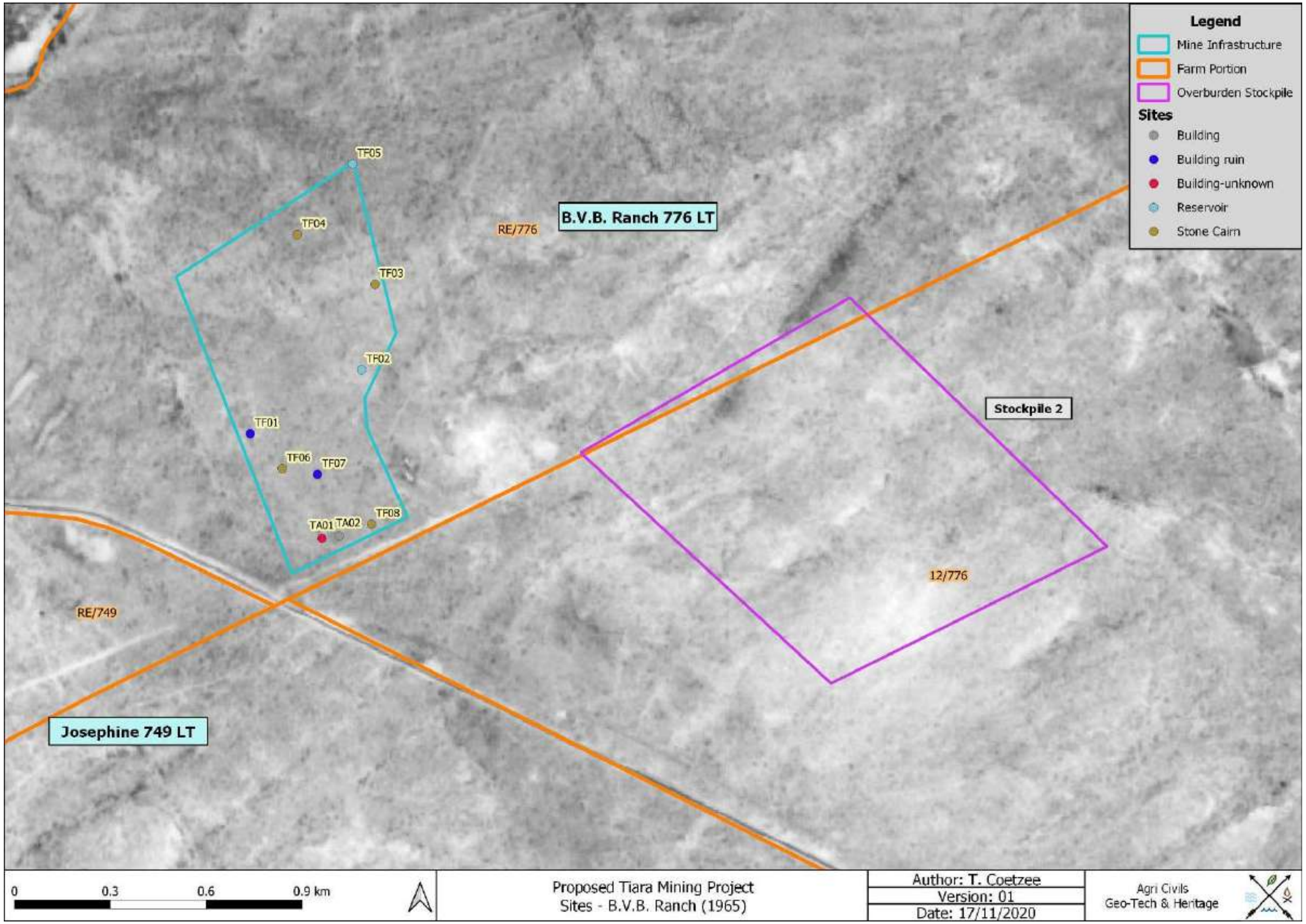

Figure 39: Study area superimposed on a 1965 aerial photograph – B.V.B. Ranch section.

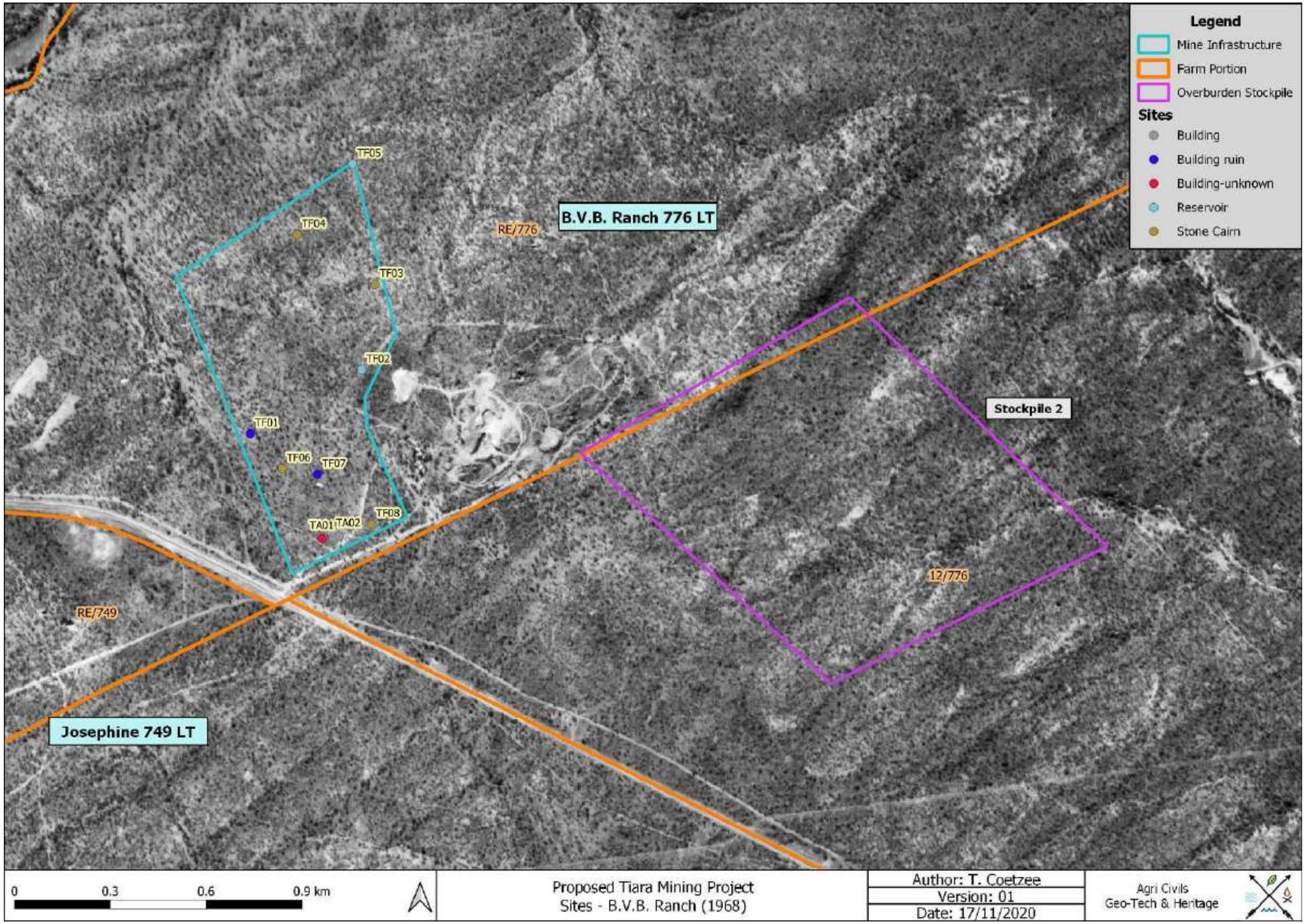

Figure 40: Study area superimposed on a 1968 aerial photograph – B.V.B. Ranch section.

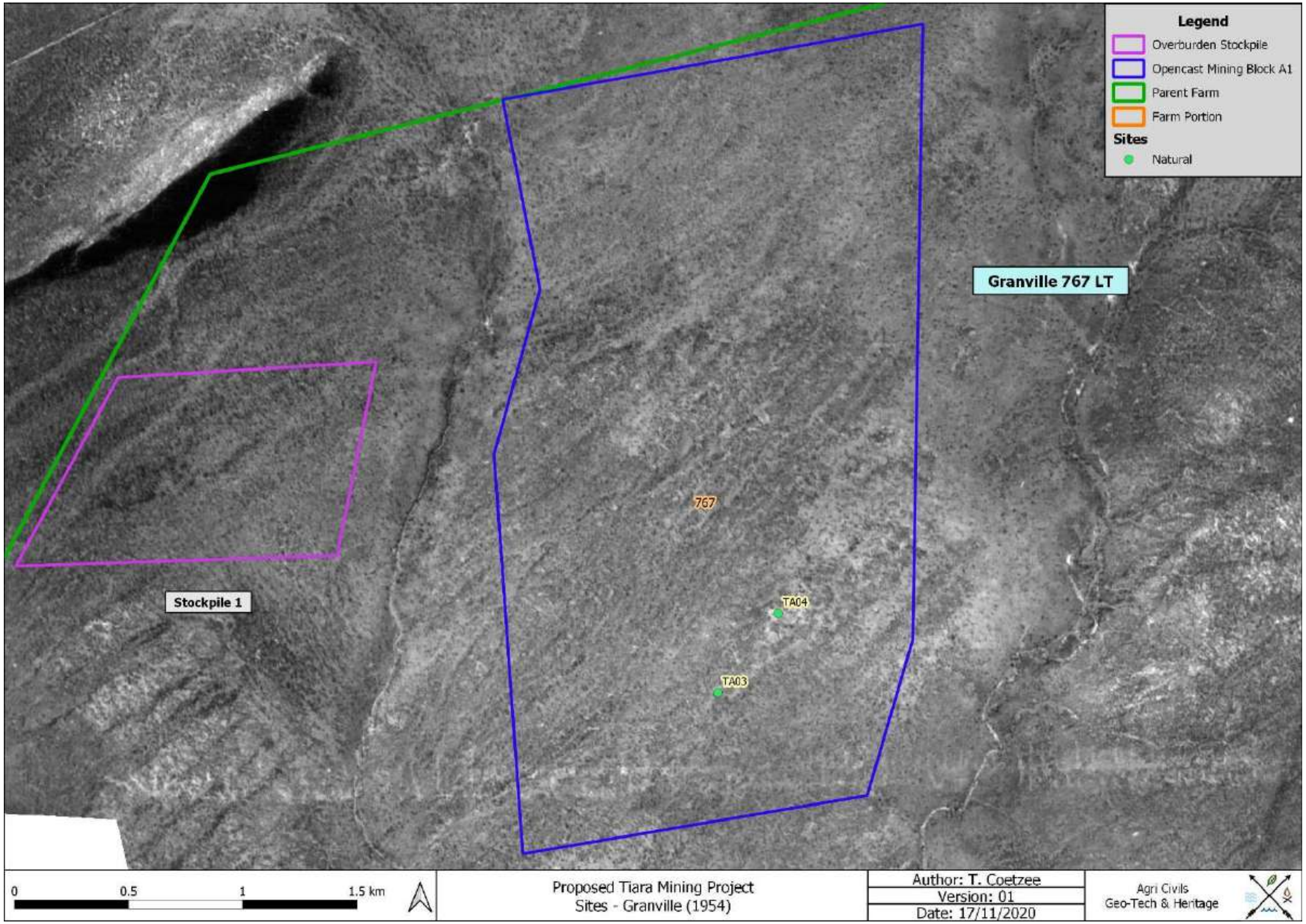

Figure 41: Study area superimposed on a 1954 aerial photograph – Granville section**.**

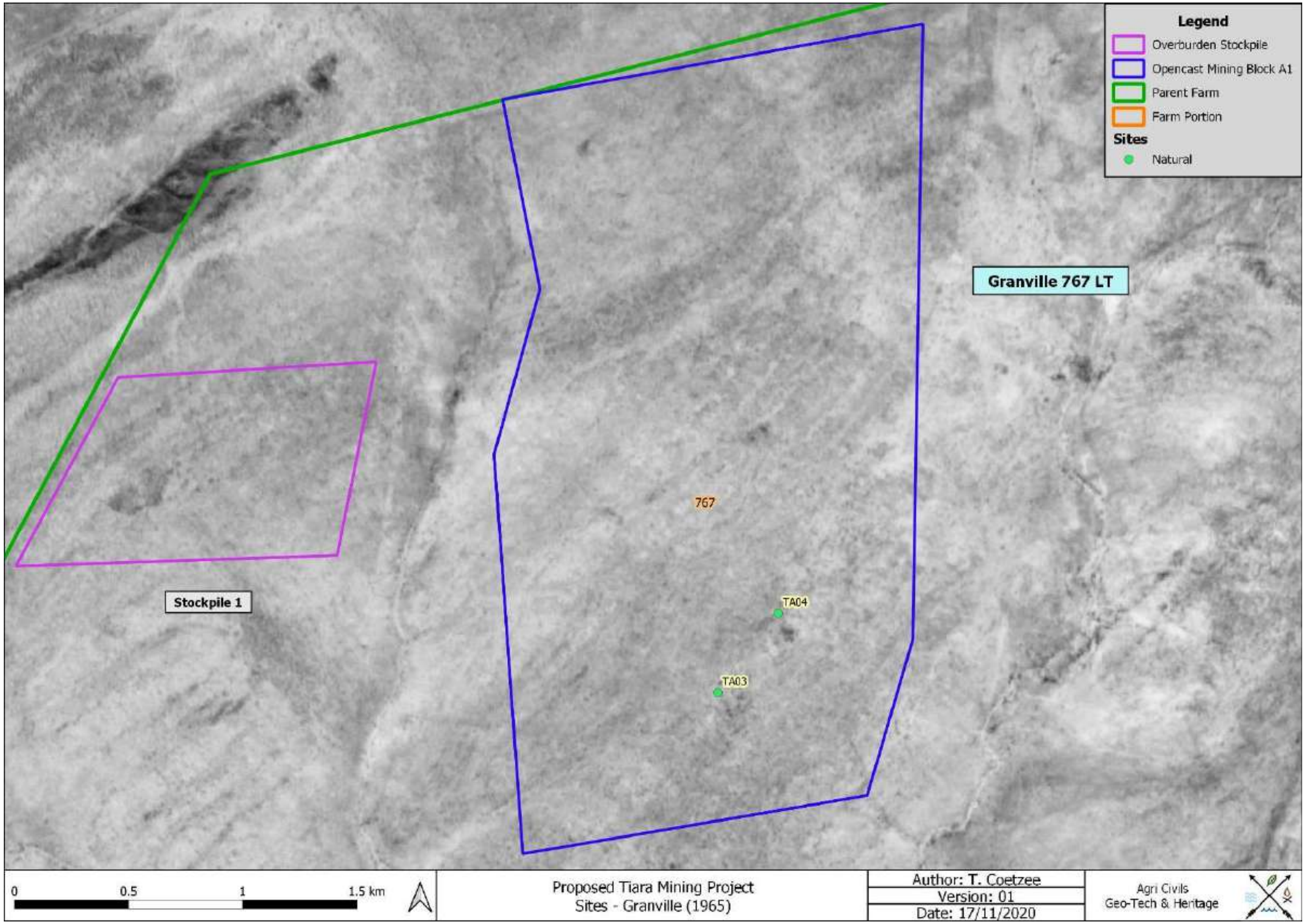

Figure 42: Study area superimposed on a 1965 aerial photograph – Granville section**.**