8. SELECTION OF PREFERRED ACTIVITY, SITE AND LOCATION

This section has as an objective of the determination of the specific site layout having taken into consideration:

- the comparison of the originally proposed site plan,
- the comparison of this plan with the plan of environmental features and current land uses,
- the issues raised by interested and affected parties, and
- the consideration of alternatives to the initially proposed site layout as a result.

8.1. DETAILS OF ALTERNATIVES CONSIDERED

In terms of the different alternatives to be considered, reference is made to the definition for *alternatives* as contained in the Environmental Impact Assessment Regulations – GNR 982 of 04 December 2014.

"*alternatives*" in relation to a proposed activity, means different means of meeting the general purpose and requirements of the activity, which may include alternatives to the -

(a) property on which or location where the activity is proposed to be undertaken
(b) type of activity to be undertaken
(c) design or layout of the activity
(d) technology to be used in the activity
(e) operational aspects of the activity
(f) the option of not implementing the activity

All HERNIC Current Activity Infrastructure and Processes are situated on the Farm De Kroon 444 JQ and Farm Elandsfontein 440 JQ. No Alternatives can be considered with regards to the current activity infrastructure and processes as they have already been constructed and have been operational since 1996. Several new activities discussed below have however been considered in order to upgrade/optimise the current operations on site.

8.1.1. Alternatives Associated with Proposed New Activities

The following proposed activities at HERNIC were identified for Environmental Authorization and have therefore been considered as far as possible alternatives are concerned:

- Decommissioning of two Historic Slimes Dams
- Decommissioning of Phase 1 of the H:H Slimes Dam
- Development and Expansion of the Site Storm Water and Process Water Management Facilities:
    - Development and Expansion of the Process Water and Storm Water Canal System including Silt Traps
    - Development of the Morula PCD
    - Expansion of Storm Water PCD No.1
    - Development of Storm Water PCD No.2
    - Development of Storm Water PCD No.3
    - Expansion of the OB Plant Process Water Dam
    - Expansion of the Plant Process Water Dam
    - Expansion of the CRP Process Water Dam
- Decommissioning of the Morula Dewatering Dam
- Development of a New Salvage Yard

- Expansion of the Tap Hole Fume Extraction System
- Expansion of the Finished Product Plant Dust Abatement System
- Expansion of the HERNIC Tailings Storage Facility (TSF)
- Re-Use (Screening, Stockpiling, Internal Use and /or Selling) of Slag Sand at the Fine Slag Processing Plant
- Re-Use (Screening, Stockpiling, Internal Use and /or Selling) of Coarse Slag at the Chrome Recovery Plant
- Re-Use (Screening, Stockpiling, Internal Use and /or Selling) of Mine Waste Rock at the Mine Waste Rock Stockpile

An Alternative Identification and Motivation Table has been compiled and which provides a summary of the outcome of the Alternatives Assessment. The assessment was conducted with reference to the Site Layout and Environmental Features Map attached as **APPENDIX 8(A)** to this report.

Table 8.1.1(a): Alternatives Identification and Motivation

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Decommissioning of two Historic Slimes Dams	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of the two Historic Slimes Dams is a legal requirement.	No design or layout is required to decommission the two Historic Slimes Dams. A procedure will be documented by a qualified civil engineer.	The decommissioning of the two Historic Slimes Dams will be done through standard civil construction technologies as determined by site and material conditions.	Alternative 1. Mechanical removal of the Slimes from the two Historic Slimes Dams followed by transport of the material on trucks via road for depositing on the H:H Slimes Dam. Alternative 2. Hydro-mining of the slimes from the two Historic Slimes Dams, followed by slurrying and pumping of the slurried slimes for depositing on the H:H Slimes Dam. Alternative 3. Mechanical mining of the slimes from the two Historic Slimes Dams, followed by on-site pelletizing and recycling through the Furnaces to extract residual chrome.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	**Preferred Alternative to be determined after further research and to be finalized during the EIA Phase.**	The no-go option is not feasible.
Decommissioning of Phase 1 of the H:H Slimes Dam	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of Phase 1 of the H:H Slimes Dam is a legal requirement.	A formal civil engineering design, giving full compliance with DWS and DEA standard procedure requirements as relating to the closure of Waste Disposal Facilities, is currently being performed to rehabilitate and close the H:H facility.	The decommissioning of the H:H Slimes Dam will be done through standard civil construction technologies as determined by site and material conditions.	Alternative 1: Deposition of the slimes from the two Historic Slimes Dams onto the H:H Slimes Dam, followed by final shaping, capping and closure of the H:H Slimes Dam. Alternative 2: No additional deposition but only final shaping, capping and closure of the H:H Slimes Dam.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	**The outcome of the operational aspects alternative assessment for the two Historic Slimes Dams will determine which one of the two alternatives will be implemented.**	The no-go option is not feasible.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Development and Expansion of the Site Storm Water and Process Water Management Measures	Existing Activity on the Farm De Kroon 444 JQ	The site locations for the process water and storm water management systems are dictated by the location of the current mining and smelting activities, as well as by surface topographical and footprint availability considerations.	The upgrading of the Storm and Process Water Management Systems is required in order to comply with GNR 704 as well as with DWS Best Practice Guidelines on Water Management at Mines.	The design and layout of these facilities need to comply with rigorous DWS Best Practice Guidelines and need to conform the GNR 704. Designs are done in strict compliance with these requirements.	The upgrading of the Storm and Process Water Management Systems will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The actual upgrading and operation of the Storm Water and Process Water management systems will be done in strict compliance with DWS approved designs as well as DWS Best Practice Guidelines for process water and storm water management at mines.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternatives Existing locations will be used as far as possible. Alternatives are excluded due to the fact that placement of drains, silt traps and dams are dictated by topographical and footprint availability considerations.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Decommissioning of the Morula Dewatering Dam	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of the Morula Dewatering Dam is a legal requirement.	A civil engineering design and closure protocol is currently being performed to decommissioning the Morula Dewatering Dam according to DWS Best Practice.	The decommissioning of the Morula Dewatering Dam will be done through standard civil construction technologies as determined by site and material conditions.	The decommissioning will be done in strict compliance with DWS Best Practice and according to a documented closure work protocol.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternatives	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Development of New Salvage Yard	Activity Required on the Farm De Kroon 444 JQ	Two Site Alternatives were considered. Site Alternative 1: Upgrading and Expansion of the Existing Salvage Yard. Site Alternative 2: Development of a New Salvage Yard in proximity to the redundant Old Civil Workshop Area.	The Hernic Mining and Smelting Operations generate a large volume of salvageable materials and a Salvage Yard is therefore a basic requirement.	The design and layout of the new Salvage Yard is dictated by logistical considerations, none of which have any environmental implication.	The development of the new Salvage Yard will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The construction of the new Salvage Yard will be done in strict compliance with the DEA approved designs and the operation will be done in compliance with DEA Norms and Standards.	The option of not implementing the activity will compromise the entire Hernic mining and smelting operation.
Motivation for Preferred Alternative	No Property Alternative	Site Alternative 1 was discarded as the site is too small. **Site Alternative 2** is the preferred alternative site as it is big enough, it is located along favourable access route, it does not interfere with existing plant activities and is located optimally from a salvage logistical perspective.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Expansion of the Tap Hole Fume Extraction System	Existing Activity on the Farm De Kroon 444 JQ	The fume extraction system is required at the existing furnace tap holes.	Air quality control, and in this instance particulate emission abatement at the furnaces, is a legal requirement.	The design and layout of these measures are dictated by the existing site specific conditions. No new stacks are required as cleaned gas will be vented through existing stacks.	Alternative 1: Cyclones Alternative 2: Electrostatic Precipitators Alternative 3: Fabric/Bag Filters	Alternative 1: Vent the cleaned gas through current active stacks. Alternative 2: Vent the cleaned gas through existing but currently in-active stacks.	The option of not implementing the activity will result in a legal non-compliance.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
					Alternative 4: Wet Scrubbers Alternative 5: Combinations of the above		
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	Furnaces 1 and 2 – **Existing** Wet Scrubbers. Furnaces 3 and 4 – **Existing** Bag Filters.	**Preferred Alternative to be determined after further research and to be finalized during the EIA Phase.**	The no-go option is not feasible.
Expansion of the Finished Product Plant Dust Abatement System	Existing Activity on the Farm De Kroon 444 JQ	The dust abatement system is required at the existing crushing and screening plant.	Air quality control, and in this instance dust abatement at the finished product plant, is a legal requirement.	The existing bag plant just needs to be enlarged to increase its capacity and efficiency.	None. Existing bag plant.	The plant will be operated as per the instructions in the design report.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Expansion of the HERNIC Tailings Storage Facility	Existing Activity on the Farm De Kroon 444 JQ	The expansion of the OB Plant TSF can only be done in a southerly direction. The footprint expansion size is limited due to the proximity of the underground and opencast mining.	The expansion of the OB Plant TSF is a basic requirement to cater for the disposal of the Smelting Plant Fine Waste. The waste is deposited as a slurry.	The design and layout for the TSF Expansion is governed by the design and layout of the current facility, the available footprint for expansion as well as the current disposal method and infrastructure.	The expansion of the OB Plant TSF will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The expansion of the OB Plant TSF will be done in strict compliance with the DWS approved designs and the operation will be done in accordance with Standard Best Practices and the Operational Plan for the TSF Slimes Dam.	The option of not implementing the activity will compromise the entire Hernic mining and smelting operation.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Re-use of Fine Slag from the Fine Slag Processing Plant	Existing Activity on the Farm De Kroon 444	The fine slag is one of the two final products from the Fine Chrome Recovery Plant It	The fine slag is one of the two final products from the Fine Chrome	The manufacturing of the Fine Slag represents a current activity. No design or	The manufacturing of the Fine Slag represents a current activity. No	The Fine Slag is manufactured in an existing activity. Selling of the fine slag entails the placement of orders, payment and then loading onto trucks	The option of not implementing the activity will result in the requirement

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
	JQ	therefore represents an existing activity.	Recovery Process.	layout is applicable.	technology is required.	with a front end loader and transport from the site by road.	for Disposal of the Fine Slag.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.
Re-use of Coarse Slag (Slag Chips) from the Chrome Recovery Plant.	Existing Activity on the Farm De Kroon 444 JQ	The Slag Chips is one of the two final products from the Chrome Recovery Plant It therefore represents an existing activity.	The Slag Chips is one of the two final products from the Chrome Recovery Process.	The manufacturing of the Slag Chips is a current activity. No design/layout applicable.	The manufacturing of the Slag Chips represents a current activity. No technology is required for the selling of the Slag Chips.	The Slag Chips are manufactured in an existing activity. Selling of the Slag Chips entails the placement of orders, payment and then loading onto trucks with a front end loader and transport from the site by road.	The option of not implementing the activity will result in the requirement for Disposal of the Slag Chips.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.
Re-use of Mine Waste Rock from the Mine Waste Rock Dump.	Existing Activity on the Farm De Kroon 444 JQ	The manufacturing of the aggregate represents a crushing and screening operation of mine waste rock currently contained on the Morula Mine Waste Rock Dump. There is ample space for the aggregate plant, transport routes are favourable and the required storm water management measures will be in place.	The manufacturing of aggregate from the Mine Waste Rock represents a crushing and screening process.	The infrastructure required to support the crushing and screening of the Mine Waste Rock comprises a small and standardized crushing and screening plant whilst the actual site layout is governed by the existing infrastructure and access roads.	The crushing and screening of the Mine Waste Rock comprises a small and standardized crushing and screening operation. Neither this, nor the selling of the Aggregate requires any technology.	The Aggregate is manufactured through a standard crushing and screening operation. Selling of the aggregate entails the placement of orders, payment and then loading onto trucks with a front end loader and transport from the site by road.	The option of not implementing the activity will result in the requirement for Disposal of the Mine Waste Rock.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.

8.2. DETAILS OF PUBLIC PARTICIPATION FOLLOWED

8.2.1. The I&AP Data Base

At the start of any public participation process a formal I&AP Data Base has to be compiled and which need to be updated/expanded as the process continues. The relevant regulations define I&AP's as:

- Any person, group of persons or organisation interested in, or affected by an activity
- Any organ of state that may have jurisdiction over any aspect of the activity

In the DMR Guidelines for Scoping, I&AP's are defined as:

- Host Communities
- Traditional Land Owners
- Title Deed Land Owners
- Traditional Authority
- Land Claimants
- Lawful Land Occupier
- Any other person on adjacent or even non-adjacent land whose socio-economic conditions may be directly affected by the proposed project
- The Local Municipality
- The Regional Municipality
- The Department of Rural Development and Land Reform
- The Department of Economic Development, Environment and Tourism
- The Department of Water Affairs
- The Department of Mineral Resources
- The Department of Environmental Affairs
- The relevant Government Agencies and Institutions responsible for the various aspects of the environment and for infrastructure

Having full regard for the above, a formal I&AP Data Base was compiled for the HERNIC project. This data base was continually updated throughout the process. A copy of the current I&AP data base is attached as **APPENDIX 8(B)** to this report**.**

8.2.2. Specific Parties Consulted

- Landowners
- Land Occupiers and Adjacent Land Occupiers
- Competent Authority
- Local Government (including Ward Councillors)
- National Authorities/Agencies (E.g. SAHRA)

8.2.3. Proof of Notifications to Land Owners, Land Occupiers and I&AP's

Copies of notifications sent to the relevant parties are attached as **APPENDIX 8(C)** to this report.

8.2.4. Information provided to I&AP's

A Background Information Document (BID) for distribution to I&AP's, notification letters to I&AP's, newspaper advertisements as well as site notices were compiled by JMA Consulting. Copies of the BID, the notifications letters, the newspaper advertisements as placed in the newspapers, as well as the site notices are attached as **APPENDIX 8(D)**.

BID documents, comment pages and notification letters were e-mailed, faxed and posted to I&AP's in cases where relevant details were available. Notifications were sent via sms'e and BID documents were distributed to I&AP's during the public meeting. Proof of Scoping Phase e-mails & sms's can be found in **APPENDIX 8(E).**

During the Scoping Phase, advertisements were placed two weeks prior to the Scoping Phase Public meeting to appear on 13 January 2017 in both the Brits Pos and the Platinum Weekly. These advertisements notified I&AP's of the first Public Meeting to be held on 27 January 2017 at the HERNIC Ferrochrome Admin Lapa. Proof of the placement of the advertisement in the newspaper is attached as **APPENDIX 8(D)**.

Site Notices were put up two weeks in advance of the Scoping Phase Public meeting at the following sites:

- HERNIC Ferrochrome Site Entrance as well as within the Site
- Madibeng Local Municipality Offices
- Madibeng Local Library (Brits Library)
- RAS Community School

Proof of the site notices at the localities where they were placed is attached as **APPENDIX 8(D)**.

Using all available information generated during the Scoping Phase, which included base line studies for a number of environmental aspects, as well as the comments received from the I&AP's, a Draft Scoping Report and Plan of Study was compiled. This report was compiled in strict compliance with the EIA Regulations, as well as Guidelines provided by DMR.

During the various authority and public meetings that were conducted it was ensured that I&AP's knew when and where draft documents/reports would be made available for review. Electronic copies of the reports on CD disk were also available and distributed to I&AP's on request. Notifications were e-mailed, faxed and sms'ed to all Registered I&AP's after distribution of reports in cases where relevant details were available. Timeframe for commenting was clearly indicated to I&AP's and was set for a minimum 30 days period as required by the NEMA regulations.

The report was made available for comment on 27 January 2017 to I&AP's for a 30 day period until 28 February 2017.

The Draft Scoping Report was available for I&AP review at the following public sites:

- HERNIC Ferrochrome Site Entrance
- Madibeng Local Municipality Offices
- Madibeng Local Library (Brits Library)

Additional copies were also provided on request. Proof of placement of reports is attached as **APPENDIX 8(D)**.

8.2.5. Public and other Meetings

Focus Group Meetings are meetings that are held with I&AP's that have more or less similar issues pertaining to the proposed project. Such meetings are usually on a smaller scale than the I&AP Public Meeting and has the function of providing additional opportunities for communication between the applicant and I&APs in order to prevent any misunderstanding and/or to address sensitive issues that may arise during the formal public participation process.

No focus group meetings were held during the Scoping Phase.

The Scoping Phase Public Meeting was held on 27 January 2017 at the HERNIC Admin Lapa.

JMA addressed the full agenda in the format of a slide show and explained what was proposed by HERNIC. Opportunity was provided to I&AP's to ask questions and to raise concerns regarding the proposed project. The contents of the Draft Scoping Report and Plan of Study were discussed with the I&AP's and the opportunity to comment on aspects related to the Project Alternatives, Current status of the Environment and Potential Impacts of the Project and the Plan of Study was explained.

I&AP's were informed that the Draft Scoping Report and Plan of Study would be available for public review as from 27 January 2017 for a time period of at least 30 days. The closure date for comments was agreed as 28 February 2017. After consultation, it was agreed by the meeting that hard copies of the reports would be made available at the following localities:

- HERNIC Ferrochrome Site Entrance
- Madibeng Local Municipality Offices
- Madibeng Local Library (Brits Library)

I&AP's were also informed that Electronic Copies would be provided on request. The report can also be downloaded from the JMA website: www.jmaconsult.co.za.

The minutes of the Public Meeting, attached in **APPENDIX 8(E)** were circulated to all registered I&AP's

8.2.6. The Public Participation Programme Report

This Report comprises the Public Participation Programme (PPP) Report compiled in support of the Scoping and EIA Process followed for the relevant Applications for Environmental Authorisation in terms of the provisions of the MPRDA, NEMA, NEW:WA, NWA and NEMAQA Regulations as relevant to HERNIC.

The MPRDA Regulations together with NEMA Regulations and NEM: WA Regulations contain a list of requirements specifically relating to the Public Participation Process. These regulations were strictly adhered to during the public participation conducted for this project.

Several guideline documents are currently available to assist persons when conducting a public participation process and all of these documents were extensively studied and incorporated into the planning for this report.

However, JMA consulted the EIA Regulation GNR 807 of 10 October 2012 – Publication of Public Participation Guideline as the primary guidance.

The Guidelines describe the public participation process as follows:

- Provides an opportunity for interested and affected parties (I&AP's), EAPs and the Competent Authority (CA) to obtain clear, accurate and understandable information about the environmental impacts of the proposed activity or implications of a decision;
- Provides I&AP's with an opportunity to voice their support, concerns and questions regarding the project, application or decision;
- Provides I&AP's with the opportunity of suggesting ways of reducing or mitigating any negative impacts of the project and for enhancing its positive impacts;
- Enables an applicant to incorporate the needs, preferences and values of affected parties into its application;
- Provides opportunities for clearing up misunderstandings about technical issues, resolving disputes and reconciling conflicting interests;
- It is an important aspect of securing transparency and accountability in decision-making;
- It contributes towards maintaining a healthy, vibrant democracy.

This report will continually be updated during the HERNIC EIA process to reflect and address all comments that are received during the I&AP Review periods. The final PPP Report will be submitted to the relevant authorities as an APPENDIX to the Final Environmental Impact Assessment Report.

8.3. SUMMARY OF ISSUES RAISED BY I&APS

A summary of the Issues raised by I&APS is relayed in Table 8.3(a) and is provided below. A concise description of the views on the preferred alternatives, views on the existing environment, views on potential impacts and mitigation is relayed in the sections below.

8.3.1. Views on Preferred Alternatives

Will be completed after the Public Review Period

8.3.2. Views on Existing Environment

Will be completed after the Public Review Period

8.3.3. Views on Impacts and Mitigation

Will be completed after the Public Review Period

8.3.4. Issues and Concerns Register

A formal Issues and Concerns Register was compiled for this Project and which will be attached as an APPENDIX to the Public Participation Programme Report at the conclusion of the EIA Phase. However, for the purposes of this Scoping Report, the current version of the Issues and Concerns Register relating to this Scoping Phase is shown in Table 8.3(a).

8.3.5. Objections

Will be completed after the Public Review Period

Table 8.3(a): Summary of the Issues Raised by I & AP's during the Scoping Phase

Interested and Affected Parties		Date of Comments Received	Issues Raised	EAP's response to issues as mandated by the Applicant	Consultation Status (e.g. Consensus, Dispute, Not Finalised etc.)
Name of Individual	Consulted				

Will be completed after the Public Review Period

8.4. ENVIRONMENTAL BASE LINE – TYPE OF ENVIRONMENT AFFECTED

A full set of Environmental Base Line Studies, were conducted in support of this Environmental Authorisation Process.

Extracts of the current environmental conditions (baseline descriptions) relevant to the proposed project activities have been compiled from the Specialist Reports for presentation in this Scoping Report and will be documented below.

The Specialist Reports will only be finalized during the EIA/EMP Phase and are therefore not attached to this report but are fully referenced in each section and will be available in hard copy and electronic format from the EAP on request once they are completed during the EIA/EMP Phase.

Baseline (Current Status) descriptions are provided for the following environmental components:

- Socio-Cultural/ Socio-Economic Environment
- Archaeological and Heritage Environment
- Palaeontological Environment
- Land Use
- Current Status of Infrastructure (Roads)
- Blasting and Vibration Environment
- Traffic Aspects
- Climate/Meteorology
- Topography
- Soils and Land Capability
- Geology and Geochemistry
- Groundwater Environment
- Surface Water Environment
- Plant Life Environment
- Animal Life Environment
- Wetland Environment
- Aquatic Ecosystems Environment
- Air Quality Environment
- Noise Environment
- Visual Aspects

The information contained in this section provides a concise description of the environment on site relative to the surrounding area which may require management or rehabilitation.

8.4.1. Socio-Cultural and Socio-Economic Environment

The relevant Specialist Report is:

Socio-Economic Scoping Report for the Hernic Ferrochrome Complex, May 2016. An Kritzinger (Economic Specialist) and Johan Oosthuizen (Social Specialist).

HERNIC Ferrochrome Complex is mainly surrounded by other mining areas (Elandskraal Chrome and Krokodil mines), agricultural areas including a small number of houses and small settlements, including the De Kroon informal settlement directly across the R 511.

The population and households in the local municipal area grow at rates higher than the national average due to high levels of urbanisation within North West province as well as in-migration due to the attraction of mining activities. De Kroon informal settlement adjacent to the Project area formed approximately eight years ago as a result of migrants being drawn to various employment opportunities in agricultural and mining activities in the area. Currently the settlement hosts approximately 2000 households including a large number of single backyard dwellers. Population growth in the settlement is slowly declining as people leave the settlement for other informal settlements in the municipal area.

While there is a number of clinics providing primary healthcare services to the rural population in the local area, clinics are seriously under-staffed. The local area is also characterised by HIV/AIDS levels that is higher than the national average. Various HIV/AIDS support organisations exist in the local area but experience capacity constraints.

While basic education levels (literacy rates, primary enrolment rates and matric completion rates) in the municipal area improved the past decade, the percentage of the adult population without schooling is however still higher than the national average. The skilled portion of the labour force (with tertiary qualifications) is also lower than the national average.

Due to the high levels of in-migration into the local area and as a result of farm evictions, more than a third of the households in the municipal area lives in informal settlements. The majority of informal settlements (including De Kroon settlement) is ear-marked for relocation. The relocation of informal settlements in the local area is constrained by a mixture of governance issues, lack of funds and the lack of available land. De Kroon informal settlement is situated on the property of HERNIC Ferrochrome (Pty) Ltd and the latter is in consultation with the local community to mitigate further growth of the settlement. While bulk water services and a school bus are among the basic municipal services provided to the settlement, the local municipality have decided not to formalise the settlement which also makes it less popular among migrants.

The local municipal area face serious issues related to water supply and a large percentage of households do not have access to an improved water source or sanitation within their houses.

The local area recorded very high crime rates compared to the national average. Violent crimes and property-related crimes are furthermore on the increase. Service delivery protests in the local area are also more prevalent than nationally and are mostly related to water-issues.

Madibeng Local Municipality received qualified audits up to the latest audited year. Main concerns raised include the lack of basic financial controls and inadequate human resource management. Limited skills amongst staff and a limited development budget are however listed as capacity constraints in Madibeng Local Municipality related to long term development planning.

The mining and agricultural sectors (both exposed to external factors) employ close to 45% of the local labour force. The local economy experienced a slump in recent years due to falling commodity prices, resulting in higher unemployment and poverty rates in the local area. Mining and agriculture still are the major drivers in the local economy and also contribute towards the high energy and water intensity of the local economy.

Job creation and economic growth are high local development priorities. In terms of the mining sector, mineral beneficiation is regarded a priority as well as mining companies' obligation to facilitate local enterprise development.

The HERNIC Project is in line with development priorities to enhance downstream mineral processing in the North West Province. The HERNIC Project is expected to have both positive and negative socio-economic impacts on the local environment.

Potential negative socio-economic impacts include negative impacts associated with increase population influx into the local area, negative perceptions of the impact on health and safety, potential draw-down of labour from adjacent sectors, external costs related to other environmental impacts (e.g. impacts on groundwater, air quality, biodiversity, traffic, road infrastructure), unfulfilled community expectations and the increased concentration of the local economy in the resource intensive mining sector.

Potential positive impacts mainly related to opportunities provided to local employment and suppliers and increased public funds (tax and corporate social funds) directed at lower income groups.

8.4.2. Archaeological and Heritage Environment

The relevant Specialist Report is:

A Phase I Heritage Study for the Upgrading of Base Line Information and for the Amendment of the Environmental Management Program Report for HERNIC Ferrochrome near Madibeng in the North-West Province, May 2016. Dr Julius CC Pistorius (Archaeologist and Heritage Consultant).

Archaeological surveys and heritage studies have indicated that the North West Province is rich in archaeological remains and in heritage resources. The National Heritage Resources Act (Act 25 of 1999, Section 3) outlines the following types and ranges of heritage resources that qualify as part of the national estate:

- Places, buildings structures and equipment of cultural significance;
- Places to which oral traditions are attached or which are associated with living heritage;
- Historical settlements and townscapes;
- Landscapes and natural features of cultural significance;
- Geological sites of scientific or cultural importance;
- Archaeological and palaeontological sites;
- Graves and burial grounds including -:
    - Ancestral graves;
    - Royal graves and graves of traditional leaders;
    - Graves of victims of conflict;
    - Graves of individuals designated by the Minister by notice in the Gazette;
    - Historical graves and cemeteries; and
    - Other human remains which are not covered in terms of the Human Tissue Act (Act 65 of 1983);
- Sites of significance relating to the history of slavery in South Africa;
- Moveable objects, including -:
    - Objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects, material, meteorites and rare geological specimens;
    - Objects to which oral traditions are attached or which are associated with living heritage;
    - Ethnographic art and objects;
    - Military objects;
    - Objects of decorative or fine art;
    - Objects of scientific or technological interest; and
    - Books, records, documents, photographs, positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act (Act 43 of 1996).

The National Heritage Resources Act (Act 25 of 1999, Sec 3) also distinguishes nine criteria for a place and/or object to qualify as 'part of the national estate if they have cultural significance or other special value …'. These criteria are the following:

- Its importance in the community, or pattern of South Africa's history;
- Its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
- Its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
- Its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;

- Its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
- Its importance in demonstrating a high degree of creative or technical achievement at a particular period;
- Its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
- Its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and/or
- Its significance relating to the history of slavery in South Africa.

Most of the types and ranges of heritage resources which are outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999) do occur across the North-West Province. Refer to Table 8.4.2(a) below for a description of these types and ranges of heritage resources. Several heritage studies for developers have been conducted in the larger Project Area. These studies have indicated that the most common heritage resources which occur in the region are the following:

- Stone walled sites which date from the Late Iron Age are relatively common in the region and can be associated with various pre-historical and historical Tswana spheres of influence.
- Second or third generation farmstead complexes which date from the first half of the twentieth century.

Heritage resources which are scarce in the larger Project Area include the following:

- Stone Age sites with dense concentrations of stone tools on the surface of the land although it is expected that such sites do exist but that they have not been discovered and/or adequately recorded.
- Historical platinum and chrome mining activities which sometimes are associated with limited infrastructure.

A Phase I Heritage Impact Assessment (HIA) study for HERNIC Ferrochrome was done according to Section 38 of the National Heritage Resources Act (No 25 of 1999). The aims of the Phase I HIA study were the following, namely:

- To establish whether any of the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999) (Table 8.4.2(a)) do occur in the Project Area and, if so, to determine the nature and the extent of these remains.
- To establish whether any of the types and ranges of heritage resources which have been identified in the Project Area will be affected by HERNIC's operations and, if so, to establish appropriate mitigation and management measures for these heritage resources.

Following the types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999), the Phase I HIA in the Project Area **revealed two graveyards**. All graveyards and graves can be considered to be of high significance and are protected by various laws. Legislation with regard to graves includes Section 36 of the National Heritage Resources Act (No 25 of 1999) whenever graves are older than sixty years. The act also distinguishes various categories of graves and burial grounds. Other legislation with regard to graves includes those which apply when graves are exhumed and relocated, namely the Ordinance on Exhumations (No 12 of 1980) and the Human Tissues Act (No 65 of 1983 as amended). The graveyards will not be affected by HERNIC's operations. Consequently, the graveyards require no mitigation measures.

Table 8.4.2(a): Types and ranges of heritage resources as outlined in Section 3 of the National Heritage Resources Act (No 25 of 1999).

The National Heritage Resources Act (Act 25 of 1999, Section 3) outlines the following types and ranges of heritage resources that qualify as part of the national estate:

a. Places, buildings structures and equipment of cultural significance;
b. Places to which oral traditions are attached or which are associated with living heritage;
c. Historical settlements and townscapes;
d. Landscapes and natural features of cultural significance;
e. Geological sites of scientific or cultural importance;
f. Archaeological and palaeontological sites;
g. Graves and burial grounds including-
    i. Ancestral graves;
    ii. Royal graves and graves of traditional leaders;
    iii. Graves of victims of conflict;
    iv. Graves of individuals designated by the Minister by notice in the Gazette;
    v. Historical graves and cemeteries; and
    vi. Other human remains which are not covered in terms of the Human Tissue Act (Act 65 of 1983);
h. Sites of significance relating to the history of slavery in South Africa;
i. Moveable objects, including -
    i. Objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects, material, meteorites and rare geological specimens;
    ii. Objects to which oral traditions are attached or which are associated with living heritage;
    iii. Ethnographic art and objects;
    iv. Military objects;
    v. Objects of decorative or fine art;
    vi. Objects of scientific or technological interest; and
    vii. Books, records, documents, photographs, positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act (Act 43 of 1996).

The National Heritage Resources Act (Act 25 of 1999, Sec 3) also distinguishes nine criteria for a place and/or object to qualify as 'part of the national estate if they have cultural significance or other special value …'. These criteria are the following:

a. Its importance in the community, or pattern of South Africa's history;
b. Its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
c. Its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
d. Its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
e. Its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
f. Its importance in demonstrating a high degree of creative or technical achievement at a particular period;
g. Its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
j. Its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and/or
k. Its significance relating to the history of slavery in South Africa.

8.4.3. Palaeontological Environment

The regional palaeontological setting is determined by the surrounding geological environment and is therefore addressed in section 8.4.11. The entire study area is underlain by rocks of the Precambrian Bushveld Igneous Complex. As the rocks of the Bushveld Complex are of igneous origin there is no possibility of fossils being present. There is a slight, but very unlikely, possibility that fossils could be present in Quaternary alluvial deposits present in low-lying areas.

If fossils are however exposed in Quaternary alluvial deposits during the development of the proposed activities it will create a unique opportunity to explore the area for fossils. Additionally, if in the extremely unlikely event that fossils are exposed in Quaternary alluvial deposits during the proposed developments are HERNIC, a qualified palaeontologist must be contacted to assess the exposure for fossils before further development takes place so that the necessary rescue operations are implemented.

8.4.4. Current Land Use

The relevant Specialist Report is:

Baseline Description of the Environment: Soils, Land Capability and Land Use of HERNIC Ferrochrome (Pty) Ltd, Brits Operations and Surrounds, September 2016. B.B. McLeroth, Red Earth cc.

Given the complexity of the numerous man-made features in the survey area on the one hand, and the fact that the vegetated areas also displayed numerous features, it was necessary to present the Current Land Use as two different mapping themes. Firstly, in terms of the man-made features (Figure 8.4.4(a)) and then secondly as the broad vegetation communities features (Figure 8.4.4(b)).

The corresponding summary tables include Table 8.4.4(a), which is a summary of the man-made features and Table 8.4.4(b) which is a summary of the broad vegetation communities.

Tables 8.4.4(a) and 8.4.4(b) indicate that man-made features comprise 299.94 *ha* (48.32%); while vegetated areas (although degraded or transformed in sections) comprise 320.82 *ha* (51.68%); of the total survey area of 620.75 *ha* (100%).

8.4.4.1. Man-Made Features

The 526 individual Mapping Polygons have been grouped into 127 individual Map Notations; which have in turn been grouped into 58 Sub-Groups; which have in turn been grouped into 12 Groups (refer to Table 8.4.4(a)).

8.4.4.2. Broad Vegetation Communities

The vegetated areas are presented on Figure 8.4.4(b). The corresponding summary Table 8.4.4 (b) indicates vegetated areas (although degraded or transformed in sections) comprise 320.82 *ha* (51.68%); of the total survey area of 620.75 *ha* (100%).

The 323 individual Mapping Polygons have been grouped into 50 individual Map Notations (that describe the vegetation); which have in turn been grouped into 7 Vegetation Communities; which have in turn been grouped into 2 classes ('Terrestrial' or Wetland) [refer to Table 8.4.4 (b)].

The methodology utilised for mapping the state of degradation of a site was developed by the soil specialist during the course of previous soil survey fieldwork exercises.

The broad vegetation community units have been mapped primarily in order to produce a baseline of the entire survey area. However, they were also mapped in order to identify and indicate the location of degraded (slightly, moderately, or highly) areas (of vegetation and soils) associated with pollution (sub-surface plumes, or occasionally wind-blown 'waste' dust); overburden/under-burden 'wastes' or 'non-wastes' (usually due to spreading); and mechanical disturbance of the surface.

Table 8.4.4(a): Summary of Current Land Use - Man-Made Features

Man-Made Features Summary								
Group	**Sub-Group**	**Map Notation**	**Further Explanation**	**Count**	**Area**			
					ha	**%**	**ha**	**%**
Infrastructure (note - buildings/concrete pads are displayed on the map set as a visual background without areas, in locations where they lie within a larger mapping polygon)	Electrical	IE	Electricity related (sub-stations)	3	0.88	0.14	23.96	3.86
	Farming	IF	Farming related buildings	12	0.38	0.06		
	Human	IH	Undifferentiated buildings	20	0.31	0.05		
		IH hostel	Hostel buildings	4	0.52	0.08		
		IH school	School buildings	2	0.08	0.01		
		IH sewerage	Sewerage works	2	0.48	0.08		
	Industrial (light)	II	Light industrial buildings / structures	43	1.28	0.21		
	Smelter	IS	Smelter buildings / structures	25	13.12	2.11		
		IS/Sof	Smelter buildings / structures; and Prepared Surface (ore fines) in-between	1	1.45	0.23		
		IS bunker	Smelter bunker containing ore fines (Concentrator Plants A and B)	2	0.57	0.09		
	Mining	IM	Undifferentiated buildings / structures	7	0.13	0.02		
		IM fan	Fan	1	0.02	0.00		
		IM magazine	Magazine	1	0.10	0.02		
		IM Morula/of,gc	Morula Shaft buildings / structures; and Prepared Surface (ore fines, slag coarse) in-between	1	4.46	0.72		
		IM pumps	Pumps	1	0.01	0.00		
		Conveyor	Conveyor	5	0.17	0.03		
Railway	Railway	Railway	Railway line	1	0.47	0.08	0.47	0.08
Ruins	Farming	FR	Farm related ruins	5	0.27	0.04	0.78	0.13
	Industrial	IR	Industrial related ruins	2	0.51	0.08		
Roads - major roads only (minor dirt tracks not mapped)	Concrete	Rc	Concrete road or traffic area	2	0.22	0.04	37.33	6.01
	Dirt or Soil	Rd	Dirt or Soil road	32	10.30	1.66		
	Haul	Rh	Haul road (various materials)	8	14.53	2.34		
	Tar	Rtar	Tar road	5	7.98	1.29		
	Verge	Rv	Road verge (waste land)	8	4.30	0.69		
Dumps	Undifferentiated	D	Dump (undifferentiated)	9	2.58	0.42	88.11	14.19
		D/P	Dump (undifferentiated) / Piles (undifferentiated)	1	0.68	0.11		
	Ash	Da	Dump (ash)	1	0.06	0.01		
		Da clad	Dump (ash) clad	3	1.77	0.29		
		Da,i	Dump (ash, rock crushed to sand grade)	1	0.25	0.04		
		Da,i,t level	Dump (ash, sand grade, stone) levelled	1	1.72	0.28		
	Pellets	De	Dump (pellets)	4	0.85	0.14		
	Slag	Dg	Dump (slag)	5	1.21	0.19		
		Dg,(m)	Dump (slag) and (occasional chrome)	2	9.24	1.49		
	Sand grade and Silica	Di	Dump (sand grade)	1	2.82	0.45		
		Di,(m)	Dump (sand grade) and (occasional chrome)	1	0.09	0.01		
		Di,of	Dump (sand grade, ore fines)	1	0.16	0.03		
	Rock (majority waste rock)	Dk	Dump (waste rock)	13	9.45	1.52		
		Dk / Sk	Dump (waste rock) and Prepared Surface (rock)	1	0.47	0.08		
		Dk,ok,(of)	Dump (waste rock, ore rock) and (occasional ore fines)	1	0.91	0.15		
		Dk/Ds	Dump (waste rock) and Dump (soil)	1	0.47	0.08		
	Ore	Do	Dump (ore)	2	1.38	0.22		
		Do high	Dump (ore) high	1	0.80	0.13		
		Do level	Dump (ore) levelled	1	0.38	0.06		
		Do low	Dump (ore) low (i.e. lower height)	1	0.48	0.08		
		Doc	Dump (ore coarse)	1	0.21	0.03		
		Dof	Dump (ore fines)	7	6.42	1.03		
		Dof level	Dump (ore fine) levelled	2	1.57	0.25		
		Dof, Dc	Dump (ore fines) and Dump (concrete)	1	1.54	0.25		
		Dof,(os)	Dump (ore fines) and (occasional ore stones)	1	4.29	0.69		
		Dof,ok	Dump (ore fines, ore rock)	2	2.07	0.33		
		Dof,ok,(a)	Dump (ore fines, ore rock) and (occasional ash)	1	1.81	0.29		
		Dof/Sof	Dump (ore fines) and Prepared Surface (ore fines)	1	1.17	0.19		
	Spoil (mostly waste rock)	Dp	Dump (spoil - i.e. waste rock/weathering rock/fines)	13	17.68	2.85		
		Dp level	Dump (spoil) levelled	2	8.36	1.35		
		Dp,of level	Dump (spoil, ore fines) levelled	1	5.47	0.88		
	Stone	Dt,i	Dump (stone, rock crushed to sand grade)	1	1.48	0.24		
	Slurry	Du	Dump (slurry)	1	0.27	0.04		
Piles of Materials (dumped close together by truck)	Raw Materials Stockpiles	RMS	Raw Materials Stockpile Areas (various - includes coke, anthracite, chromite concentrate, quartzite, and dolomite)	3	7.39	1.19	16.82	2.71
	Undifferentiated	P	Piles of materials (undifferentiated)	2	0.53	0.09		
	Ash	Pa	Piles (ash)	1	0.09	0.01		
	Rubble	Pb	Piles (rubble)	2	0.33	0.05		
		Pb,Sg	Piles (rubble) and Prepared Surface (slag)	1	0.32	0.05		
	Concrete	Pc	Piles (concrete)	2	0.36	0.06		
		Pc,k	Piles (concrete, rock)	1	0.11	0.02		
	Slag	Pg	Piles (slag)	2	0.07	0.01		
	Rock	Pk	Piles (rock)	7	0.84	0.14		
	Chrome	Pm	Piles (chrome)	1	0.51	0.08		
		Pm/Sc	Piles (chrome) and Prepared Surface (concrete)	1	1.80	0.29		
	Ore	Pof	Piles (ore fines)	2	0.14	0.02		
	Scrap	Pscrap	Piles (scrap)	1	0.02	0.00		
	Stone	Pt,s	Piles (stone, soil)	1	0.06	0.01		
	Slurry	Pu	Piles (slurry)	3	2.03	0.33		
		Pu,a	Piles (slurry, ash)	1	2.22	0.36		

Table 8.4.4(a): Summary of Current Land Use - Man-Made Features (continued)

Man-Made Features Summary								
Group	Sub-Group	Map Notation	Further Explanation	Count	Area			
					ha	%	ha	%
Banks (adjacent to railway or drains; majority adjacent to drains not mapped since narrow)	Undifferentiated	B	Bank (undifferentiated)	11	2.03	0.33	3.03	0.49
	Slag	Bg,t	Bank (slag, stone)	4	0.34	0.05		
	Rock	Bk	Bank (rock)	2	0.22	0.04		
	Ore	Bof	Bank (ore fines)	2	0.44	0.07		
Prepared Surface (to facilitate trafficing of machinery)	Undifferentiated	S	Surface (undifferentiated)	1	2.94	0.47	59.71	9.62
	Concrete	Sc	Surface (concrete)	8	2.88	0.46		
	Pellets	Se	Surface (pellets)	1	1.03	0.17		
	Slag	Sg	Surface (slag)	20	12.95	2.09		
		Sg, (c)	Surface (slag) and (occasional concrete)	1	5.72	0.92		
		Sg,of	Surface (slag, ore fines)	1	0.50	0.08		
		Sg/B	Surface (slag) and Bank (undifferentiated)	1	3.61	0.58		
		Sg/Pg	Surface (slag) and Piles (slag)	1	2.66	0.43		
	Sand grade and Silica	Si	Surface (rock crushed to sand grade)	2	0.70	0.11		
		Si,of	Surface (sand grade, ore fines)	1	4.18	0.67		
		Si,t	Surface (sand grade, stone)	2	1.17	0.19		
	Rock	Sk	Surface (rock)	2	0.60	0.10		
	Chrome	Smf	Surface (chrome fines)	1	0.26	0.04		
	Ore	So level	Surface (ore) levelled	1	1.04	0.17		
		Sof	Surface (ore fines)	9	5.36	0.86		
		Sof,(B)	Surface (ore fines) and (occasional Banks)	1	4.41	0.71		
		Sof,e	Surface (ore fines, pellets)	2	1.62	0.26		
		Sof,t	Surface (ore fines, stone)	2	0.91	0.15		
		Sof,t level	Surface (ore fines, stone) levelled	1	2.22	0.36		
	Stone	St	Surface (stone)	5	1.76	0.28		
		St,i	Surface (stone, sand grade)	1	1.15	0.19		
		St,of	Surface (stone, ore fines)	1	0.32	0.05		
		St,k	Surface (stone, rock)	1	1.72	0.28		
Soil Stockpiles	Dumps	Ds	Dump (soil)	21	8.84	1.42	16.87	2.72
		Ds,k	Dump (soil, rock)	1	1.71	0.28		
		Ds/Ps	Dump (soil) and Piles (soil)	1	0.63	0.10		
	Piles	Ps	Piles (soil)	15	2.30	0.37		
		Ps,k	Piles (soil, rock)	1	0.10	0.02		
	Banks	Bs	Bank (soil)	11	3.29	0.53		
Excavations	Excavations	X1	Excavation (shallow)	1	0.01	0.00	5.40	0.87
		X2	Excavation (moderately deep)	2	0.83	0.13		
		X3	Excavation (deep)	3	0.57	0.09		
		Opencast	Excavation (very deep) - final void	2	3.99	0.64		
Pollution Control	TSF	TSF	Tailings Storage Facility (current)	1	13.37	2.15	44.83	7.22
		TSF old	Tailings Storage Facility (old - out of use)	1	7.32	1.18		
	Paddock	Paddock	Paddocks surrounding TSF and Da clad (Dump-boiler ash-clad)	14	3.26	0.53		
	Pollution Control, Return Water, Process Water, Storm Water, and Drinking Water Dams/Ponds	PCD	Pollution Control Dam	2	0.76	0.12		
		PCD clad	Pollution Control Dam - clad	5	3.54	0.57		
		PCD silted	Pollution Control Dam - silted	3	2.92	0.47		
		Dam slurry	Dam - slurry	2	0.38	0.06		
		Pond	Pond	6	1.62	0.26		
	Walls around PCD's, Ponds, Dams	W	Wall (undifferentiated)	1	0.17	0.03		
		Wi,of	Wall (sand, ore fines)	1	0.15	0.02		
		Ws	Wall (soil)	18	8.03	1.29		
		Ws,of	Wall (soil, ore fines)	1	3.31	0.53		
Water Attenuation	Various	Canal	Canal (western boundary)	1	1.11	0.18	2.63	0.42
		Drain	Drain (majority not mapped as polygons - visual only - displayed on map set)	5	0.71	0.11		
		Drainage	Drainage (run-off water flow pathway)	4	0.26	0.04		
		Reservoir	Reservoir	4	0.04	0.01		
		Dam	Dam other	5	0.51	0.08		
SUB-TOTAL (MAN-MADE FEATURES)				**217**	**132.47**	**21.34**	**132.47**	**21.34**
TOTALS (MAN-MADE FEATURES and SOILS)				**834**	**620.75**	**100.00**	**620.75**	**100.00**

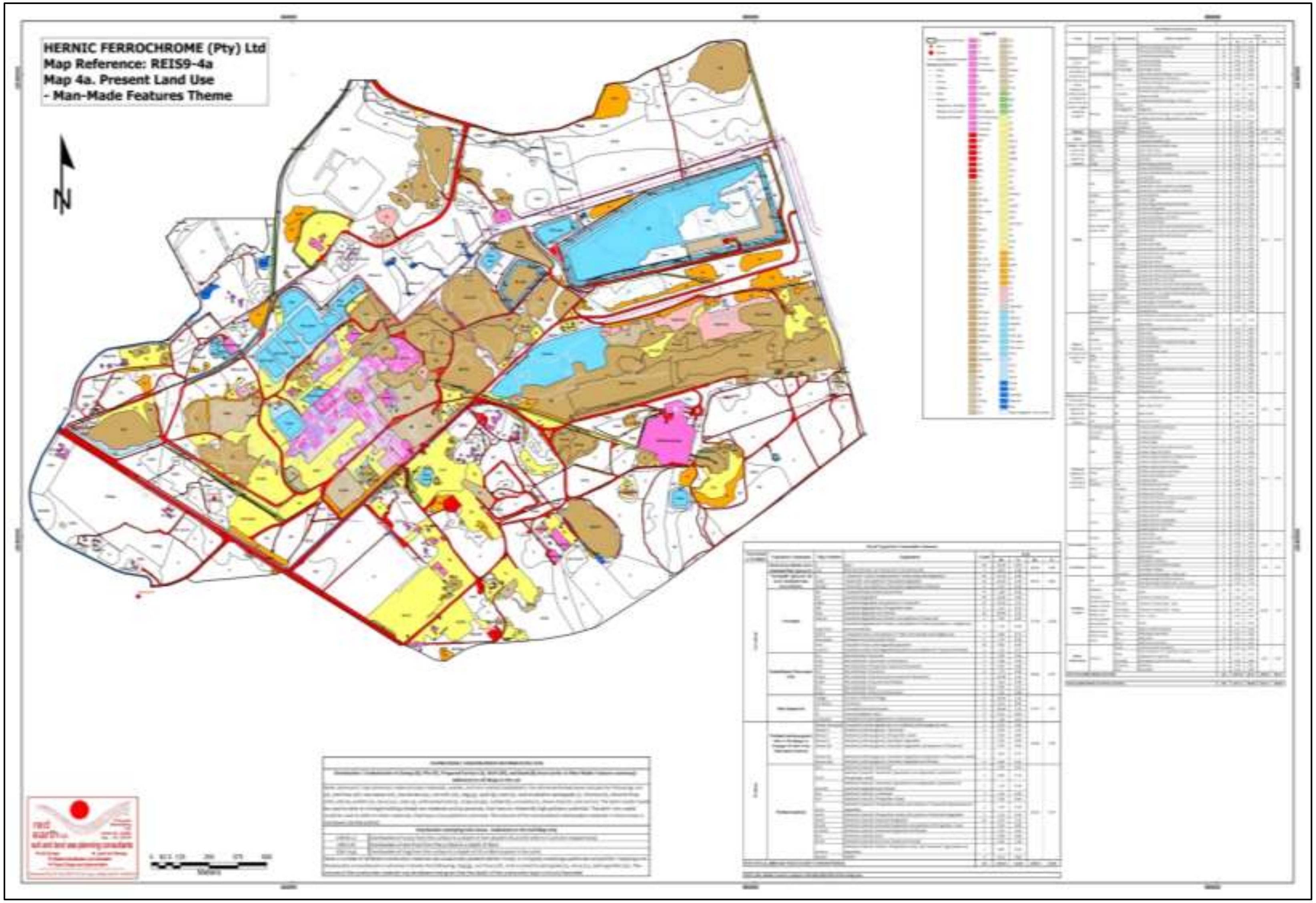


Figure 8.4.4(a): Current Land Use – Man-Made Features

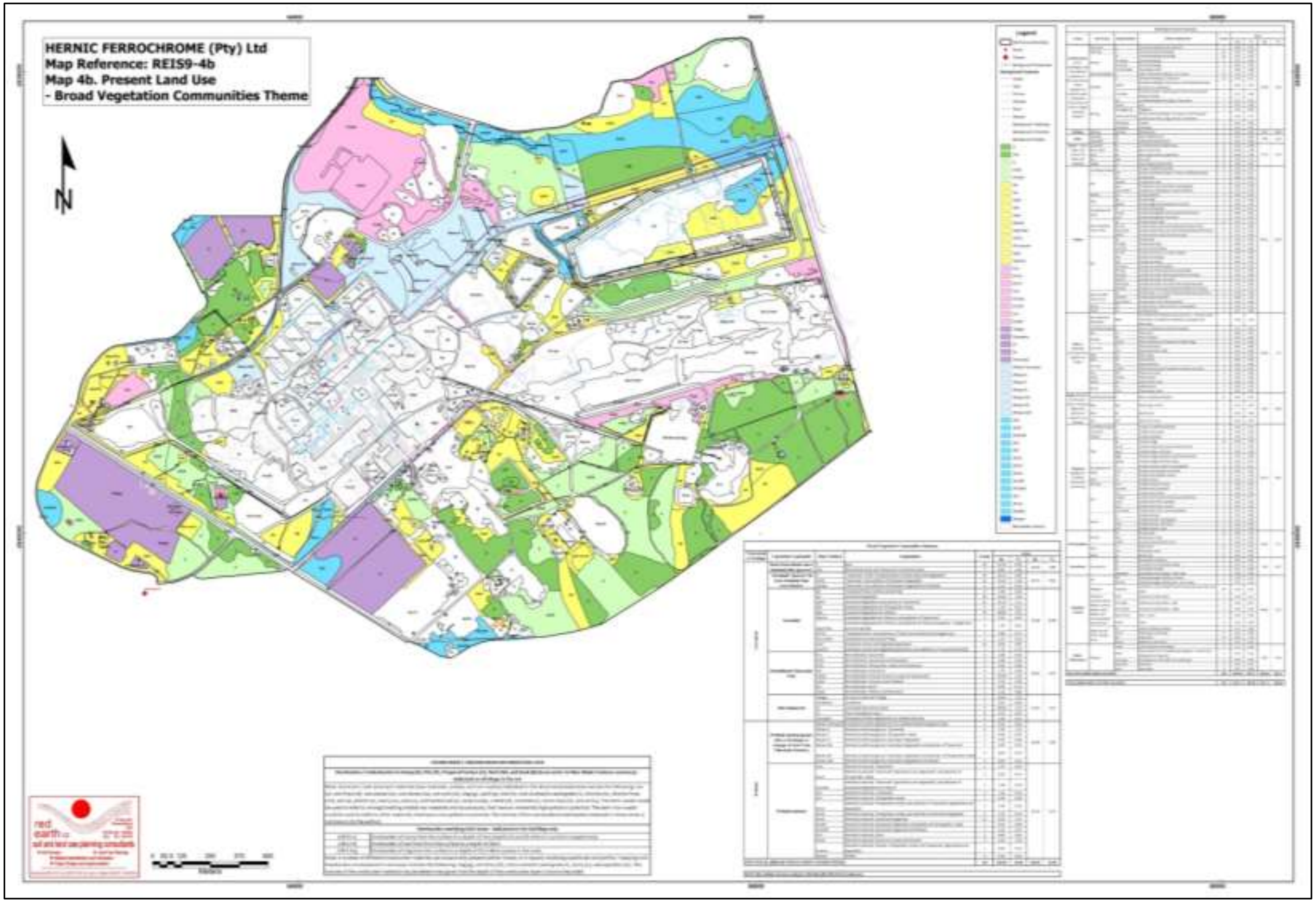


Figure 8.4.4(b): Current Land Use – Broad Vegetation Communities Theme

Table 8.4.4(b): Summary of Current Land Use - Broad Vegetation Communities

Broad Vegetation Communities Summary								
'Terrestrial' or Wetland	Vegetation Community	Map Notation	Explanation	Count	Area			
					ha	%	ha	%
Terrestrial	Bush (trees/shrubs more dominant than 'grasses')	U	Bush	54	53.16	8.56	61.83	9.96
		U/A	Bush (dominant); and 'Savannah' (sub-dominant)	7	8.67	1.40		
	'Savannah' ('grasses' far more dominant than trees/shrubs)	A	' Savannah' (note: the grasslands in these areas are degraded)	40	43.32	6.98	59.71	9.62
		A/Gd	'Savannah'; and patches of Grassland degraded	11	14.22	2.29		
		A/Gdw	'Savannah'; and patches of Grassland degraded and Weeds	4	2.17	0.35		
	Grassland	Gb	'Grassland' bare surface (presently)	4	1.60	0.26	73.38	11.82
		Gd	Grassland degraded	36	23.61	3.80		
		Gd/A	Grassland degraded; and patches of 'Savannah'	11	13.23	2.13		
		Gdf	Grassland degraded and *Phragmites* reeds	3	1.15	0.19		
		Gdw	Grassland degraded and Weeds	29	18.09	2.91		
		Gdw/A	Grassland degraded and Weeds; and patches of 'Savannah'	5	2.92	0.47		
		Gdw/Teio	Grassland degraded and Weeds; and patches of Trees (*Eucalyptus*, indigenous, and ornimental)	2	1.79	0.29		
		Gl/Toi	'Grassland' lawn; and patches of Trees (ornimental and indigenous)	7	4.40	0.71		
		Gm soccer	Grassland mowed (soccer field)	2	1.37	0.22		
		Gwd	Grassland weeds and degraded grassland	14	4.01	0.65		
		Gwd/To	Grassland weeds and degraded grassland; and patches of Trees (ornimental)	2	1.21	0.19		
	Rehabilitated Man-made Soils	R.A	Rehabilitated. Savannah	3	2.60	0.42	30.83	4.97
		R.AG	Rehabilitated. Savannah and Grassland	3	2.68	0.43		
		R.FG	Rehabilitated. *Phragmites* reeds and Grassland	2	0.52	0.08		
		R.G	Rehabilitated. Grassland	4	1.75	0.28		
		R.G(A)	Rehabilitated. Grassland (and occasional 'Savannah')	1	14.98	2.41		
		R.GW	Rehabilitated. Grassland and Weeds	2	3.13	0.50		
		R.U	Rehabilitated. Bush	3	0.95	0.15		
		R.WG	Rehabilitated. Weeds and Grassland	2	4.22	0.68		
	Man (Impacted)	Village	De Kroon Informal Village	2	14.65	2.36	37.07	5.97
		Cemetery	Cemetery	2	0.53	0.09		
		Ct	Cultivated terrestrial areas	9	20.68	3.33		
		Te	Trees (*Eucalyptus spp.*)	6	0.21	0.03		
		Farmyard	Farmyard (mixed vegetation) in a terrestrial area	3	1.00	0.16		
Wetland	Wetland (anthropogenic) [due to discharge or seepage of water from Man-made features]	Wman.Farmyard	Farmyard (mixed vegetation) in a wetland (anthropogenic) area	1	0.12	0.02	24.68	3.98
		Wman.A	Wetland (anthropogenic). 'Savannah'	4	9.35	1.51		
		Wman.F	Wetland (anthropogenic). *Phragmites* reeds	2	0.41	0.07		
		Wman.G	Wetland (anthropogenic). Grassland degraded	1	0.20	0.03		
		Wman.GA	Wetland (anthropogenic). Grassland degraded; and patches of 'Savannah'	1	5.87	0.95		
		Wman.GF	Wetland (anthropogenic). Grassland degraded; and patches of *Phragmites* reeds	2	4.67	0.75		
		Wman.GW	Wetland (anthropogenic). Grassland degraded and Weeds	4	4.06	0.65		
	Wetland (natural)	W.A	Wetland (natural). 'Savannah'	1	1.97	0.32	33.32	5.37
		W.AF	Wetland (natural). 'Savannah' (grasslands are degraded); and patches of *Phragmites* reeds	2	0.62	0.10		
		W.AGW	Wetland (natural). 'Savannah' (grasslands are degraded); and patches of Grassland degraded and Weeds	1	1.19	0.19		
		W.C	Wetland (natural). Cultivated	2	1.81	0.29		
		W.F	Wetland (natural). *Phragmites* reeds	1	0.58	0.09		
		W.FA	Wetland (natural). *Phragmites* reeds; and patches of 'Savannah' (grasslands are degraded)	2	1.01	0.16		
		W.FG	Wetland (natural). *Phragmites* reeds; and patches of Grassland degraded	2	2.12	0.34		
		W.Gd	Wetland (natural). Grassland degraded	12	8.14	1.31		
		W.GdF	Wetland (natural). Grassland degraded; and patches of *Phragmites* reeds	1	0.55	0.09		
		W.GdW	Wetland (natural). Grassland degraded and Weeds	2	2.15	0.35		
		W.U	Wetland (natural). Bush	2	4.06	0.65		
		W.UA	Wetland (natural). Bush and 'Savannah'(mixed)	2	8.30	1.34		
		W.WFA	Wetland (natural). Weeds, *Phragmites* reeds, and 'Savannah' (grasslands are degraded)	1	0.63	0.10		
		Stream	Stream	4	0.19	0.03		
SUB-TOTAL (BROAD VEGETATION COMMUNITIES)				**323**	**320.82**	**51.68**	**320.82**	**51.68**

NOTE: Man-Made Features comprise 299.94ha (48.32%) of the study area.

Degraded areas (associated with a pollution plume, or spread 'waste') include those that exhibit the following 'Visual Indicators of Salinity and Wetness':

- Precipitated surface (surface efflorescence) / sub-surface salts (not observed in the current survey area due to recent rain);
- Man-made perched soil water-tables;
- Surface/sub-surface 'waste' deposits; and
- Degraded 'terrestrial' (natural indigenous bush/'savannah', or 'grasslands') or wetland vegetation (inevitable consequence of the aforementioned points).

The initial signs of vegetation degradation in the current survey area are as follows:

- Reduction in the stand density of the indigenous *Acacia* species. Hence the formation of the 'savannah' (where 'grasses' are far more dominant than trees/shrubs) or 'grassland' areas.
- Increasing density of *Cynodon dactylon* (opportunistic pioneer species).
- In extreme cases, where an anthropogenic soil water-table (plume) is close to the soil surface, *Phragmites* species (reeds - hydrophytic) begin to grow. In other areas (not observed in current survey area) *Schoenoplectus* species (also hydrophytic species) begin to grow before the reeds do.

Another cause of vegetation degradation is bush clearing or as a result of past machinery/vehicle activity/traffic. Augmented planting may be considered in such areas. The location of degraded areas is more difficult to identify when the saturated zone of a plume is deeper below the surface, since the 'Visual Indicators of Salinity and Wetness' may not be observed. Hence the necessity of analysing and interpreting soil analytical data.

Degraded areas (associated with a pollution plume, or spread 'waste') include those that are indicated by the following 'Analytical Indicators of Pollution, Salinity and Wetness' (although samples have been collected, this exercise has not been conducted for the current survey area):

- Raised (relative to the 'relatively undisturbed' surrounding areas) EC; and levels of Cl, SO_4, NO_3, and Cr(VI) to name a few. XRF analysis of the soils / 'wastes' / 'non-wastes' would provide far more data on raised concentrations of metals and other elements.

Quantification (concentrations and distribution patterns) of the aforementioned would be obtained by analysing the soil / 'waste' / 'non-waste' samples that were collected from each auger point during the course of the soil survey, thereby providing the fifth 'indicator', namely 'Analytical Indicators of Pollution, Salinity and Wetness'. The aforementioned samples are currently stored in a deep freeze on site at HERNIC.

8.4.4.3. Human Settlement

Human settlement is indicated on Figure 8.4.4(b) and is summarized in Table 8.4.4(b). Human settlement within the survey area is dominated by the De Kroon informal village that displays hundreds of dwellings and a school.

Other settlement is limited to five sites that display farm houses (and associated buildings/structures) [three of which display a clearly discernible farmyard], two that display the ruins of the same, two mine hostels, and one old site displaying kraal ruins (stone hut ruins - informal settlement). The two graveyards within the survey area are also indicative of human settlement.

8.4.4.4. Historical Agricultural Production

Farming related activities within the survey area are indicated on Figure 8.4.4(a) and (b) and summarized in Tables 8.4.4(a) and (b).

Agriculture

Previous/present cultivation was identified in five distinct patches within the survey area, these being comprised of nine terrestrial mapping polygons (20.68 *ha*), and two wetland mapping polygons (1.81 *ha*). The patch (two separate lands or mapping polygons) to the west of the railway line is cultivated to lucerne by a small scale farmer, while the two small patches to the west of the De Kroon village are cultivated to a variety of vegetable crops by the local community. The remaining 'cultivated' areas were cultivated previously (in the last few years), and the crop that was planted in these areas is not known to the author. Possible previous cultivation in sections of the smelter and mining areas has been obliterated by the development of these areas.

Five sites were identified that display farmhouses and associated buildings/structures, three of which have a clearly discernible 'farmyard'. These farmyards as well as the associated cultivated areas all lie in proximity to the irrigation canal along the western extent of the survey area. Two sites displaying farmhouse (and associated buildings/structures) ruins were also encountered; one in the same area in proximity to the canal, and the other away from the canal to the south-east of the smelter. It is logical that the cultivated areas and farm houses (majority) are located in the vicinity of the canal, the aforementioned since water derived from the canal is utilised for the irrigation of crops.

The altitude within the survey surveyed area ranges from approximately 1128 *mamsl* (unnamed non-perennial stream on one short section of the north-western boundary) to approximately 1197 *mamsl* (towards the south of the eastern boundary). These altitudes exclude the man-made features; in particular the TSF's and rock / spoil dumps.

The Department of Agriculture stipulates that conservation measures should be implemented on slopes of over 2.0% percentage grade (1.1 degrees) on disturbed (where the original grass cover has been removed) sites. These measures involve practices such as building contour banks, re-grassing and cultivating on the contour, etc. The maximum allowable slope for annual cropping is 12% (6.8 degrees). Vertic broad soil group will display unacceptable levels of soil erosion on slopes that exceed a percentage grade of 11.2% (6.4 degrees). Furthermore, given that the natural slope in the survey area varies between 1 and 6 degrees (and 1 and 4 degrees in the arable areas); soil erosion is not likely to be an issue in the cultivated areas.

The arable soils within the survey area occur in the deeper less-rocky sections of the vertic broad soil group that dominates in the area.

Dryland

Given the low mean annual precipitation (617 *mm* for the Hartebeespoort weather station), the short growing season (approximately only five months for maize), as well as the unpredictable rainfall in the area; dryland production is not recommended due to the low yields obtained as well as the high associated risk.

Generalized dryland yields in the region are presented for the vertic broad soil group. These yields are according to those presented in the South African Atlas of Agrohydrology and -Climatology (R.E. Schulze *et-al*, 1997).

All of the yields mentioned by Schultze *et-al* refer to dry mass.

- Maize
  Schulze: 3 - 4 *tonnes/ha*, with an inter-seasonal coefficient of variation of approximately 40 - 50%.
- Dry Beans
  Schulze: boundary of 0.75 - 1.00 *tonnes/ha* (north), and 1.00 - 1.25 *tonnes/ha* (south). National average is 1.2 *tonnes/ha.* Given poorly drained soils (due to the slow permeability of vertic soils), a MAP of <775 *mm*, a rooting depth 75 – 100 *cm*, and clay content (clay >35%); the indicated yields must be multiplied by a factor of 0.9.
- Soybeans
  Schulze: boundary of 1.00 - 1.50 *tonnes/ha* (north), and 1.50 - 2.00 *tonnes/ha* (south). Given poorly drained soils (due to the slow permeability of vertic soils), a MAP of <775 *mm*, a rooting depth 75 – 100 *cm*, and clay content (clay >35%); the indicated yields must be multiplied by a factor of 0.9.
- Sorghum
  Schulze: 4.0 - 5.0 *tonnes/ha*. Given vertic soils, a MAP of <775 *mm*, a rooting depth 75 – 100 *cm,* and clay content (clay >35%); the indicated yields must be multiplied by a factor of 0.7.
- Sunflowers
  Schulze: 1.00 - 1.50 *tonnes/ha*. Given poorly drained soils (due to the slow permeability of vertic soils), a MAP of <775 *mm*, a rooting depth 75 – 100 *cm*, and clay content (clay >35%); the indicated yields must be multiplied by a factor of 0.9. Lategan Boerdery (refer to irrigated) indicated that the maximum yield (dryland or irrigated) for sunflowers was 2 tonnes/ha which was not economic, and so was not planted by the farmers in the area.
- Cotton
  Schulze: 1.00 - 1.50 *tonnes/ha*. For arable soil depths of 0.7 *m*, 0.8 *m*, 0.9 *m*, and 1.0 *m*; the indicated yields must be multiplied by factors of 0.8, 0.9, 1.0.and 1.1 respectively in the different areas. The crop is not planted by the local farmers.
- Groundnuts
  Schulze: 2.00 - 2.50 *tonnes/ha*. For soil depths of 0.5 *m*, 0.6 *m*, 0.7 *m*, 0.8 *m*, and 0.9 *m*; the indicated yields must be multiplied by factors of 0.6, 0.7, 0.8, 0.9, and 1.0 respectively in the different areas. The crop is not planted by the local farmers on the vertic soils and the aforementioned yields will not be realized, given that the vertic soils display too much clay and are not well aerated. Thus the vertic soils are not suited to this crop.
- Kikuyu (Pennisetum clandistinum), Coast Cross II (more drought resistant than Kikuyu), Eragrostis curvula, and Smuts Finger Grass (Digitaria eriantha)
  Schulze: 6 - 8 *tonnes/ha*. Given that the soils are eutrophic in the area, the indicated yields must be multiplied by a factor of 0.8.

The aforementioned yields assume that the pH and nutrient status of the soils are optimum (ameliorated) for a particular crop. The yield variations are primarily rainfall dependant.

Cultivated fields should ideally be located on soils of the arable capability class. The yields obtained on grazing capability class soils would be considerably lower than those obtained on the deeper arable soils. However, shallow patches inevitably occur within a land. Scotney *et al*. (Soil Capability Classification, March 1987) defines many such areas as arable, albeit with decreased production possibilities, an increased hazard of use, and an increased intensity of conservation techniques required.

Previous/present cultivation was identified in five distinct patches within the survey area, these being comprised of nine terrestrial mapping polygons (20.68 *ha*), and two wetland mapping polygons (1.81 *ha*).

The patch (two separate lands or mapping polygons) to the west of the railway line is cultivated to lucerne by a small scale farmer, while the two small patches to the west of the village are cultivated to a variety of vegetable crops by the local community. The remaining 'cultivated' areas were cultivated previously (in the last few years), and the crop that was planted in these areas is not known to the author. Possible previous cultivation in sections of the smelter and mining areas has been obliterated by the development of these areas.

Five sites were identified that display farmhouses and associated buildings/structures, three of which have a clearly discernible 'farmyard'. These farmyards as well as the associated cultivated areas all lie in proximity to the irrigation canal along the western extent of the survey area. Two sites displaying farmhouse (and associated buildings/structures) ruins were also encountered, one in the same area in proximity to the canal, and the other away from the canal to the south-east of the smelter.

The indigenous 'grasslands' and wetlands that are interspersed between the bush and 'savannah' areas would in the past have been utilised for the grazing of cattle.

Irrigated

Irrigation is feasible in the current soil survey area, due to the canal from the Hartebeespoort dam that forms the western boundary of the survey area. However, the water quality would need to be evaluated.

High irrigated yields will only be achieved with high levels of expertise and management. The irrigated yields that follow are as personal communication (March 2016) with Jannie Lategan who is the joint owner/manager (with his father) of 'Lategan Boerdery' that lies immediately to the north and west of the survey area.

- Soybeans
  Lategan: 3.5 *tonnes/ha*. Plant in November, harvest at end of April. Lategan Boerdery practice is to work the harvested (Soybean) land for two weeks and then plant wheat immediately thereafter; or alternatively to 'rest' the land until maize is planted at the end of September.
- Maize
  Lategan: 13 - 15 *tonnes/ha*. Yeild drops to 13 *tonnes/ha* when the heat units are too high. Plant at the end of September, and harvest at the end of February to the beginning of March. These fast growing varieties are bred specifically for irrigation and mature in 5 months. Note that dryland maize takes 8 months to mature in the area, and is planted in mid-October or mid-November, and is harvested in mid-July.
- Wheat
  Lategan: 6.5 - 7.5 *tonnes/ha*. Plant in May, and harvest at the end of October or the beginning of November.
- Onions
  Lategan: 40 - 80 *tonnes/ha* (harvest into 10 *kg* bags). Yield is largely weather related. Plant in February, and harvest over a three month period from July to September inclusive.
- Lucerne
  Lategan: 2420 - 3300 *tonnes/ha* (110 - 150 bales/ha x 22 *kg* bale). Yield is largely weather related. The lucerne is harvested on a particular day, raked the next day, and baled the next. If it rains after harvesting (before baling), the lucerne looses grade and cannot easily be sold.

Lategan Boerdery indicated that most farmers in the area plant the same range of crops as indicated.

However, the farm Langplaas (owned by Gert [father] and Piet [son] van Rensburg) to the west of the Crocodile River plants a much broader range of crops including those mentioned previously, as well as sweet potatoes and vegetables (onions particularly, as well as beetroot, carrots, spinach, and cabbage).

Lategan Boerdery also indicated that approximately 40 years ago the region was almost exclusively planted to tobacco, as indicated by the old tobacco barns. However, the crop was discontinued as a result of the grade dropping. The irrigated yields that follow are as personal communication (October 2005) with Christoff van der Merwe of 'Nick van der Merwe & Seuns Boerdery Bk' who farms approximately 2.5km east of Bethanie (north-west of Brits) in an area with similar altitude, temperature, rainfall and thus soils.

In the aforementioned agri-business, only the soils of the vertic broad soil group are cultivated since the core business is vegetable growing and these soils can easily be washed off the vegetables after harvesting, while vegetables grown on the red soils ('red' pedocutanic, red apedal and red structured broad soil groups) are stained red after harvesting and cannot easily be washed clean. However, cabbage and onions (both can be washed successfully) as well as wheat, maize and tobacco can also be grown on the 'red' soils in the Bethanie area.

The aforementioned agri-business cultivates approximately 197 *ha*, frequently on a double cropping basis and at the time of the discussion produced the following:

- Maize: 13 - 15 *tonnes/ha.*
  14.8 *tonnes/ha* (2000 year), 12.0 *tonnes/ha* (2001 year), 13.0 *tonnes/ha* (2002 year), and 13.8 *tonnes/ha* (2004). Plant 70 - 80 *ha/year.*
- Beetroot: 26.2 *tonnes/ha* (2004 year).
  Plant 115 *ha/year*.
- Carrots: 30.85 *tonnes/ha* (2004 year).
  Plant 85 *ha/year.*
- Swiss chard (spinach): 7.3 *tonnes/ha* (2004 year).
  Plant 25 *ha/year.*

Other crops which have been planted by the agri-business in the past include the following:

- Wheat: 6.5 - 7.5 tonnes/ha.
- Cabbage: 135.0 tonnes/ha (30 000 plants/ha x 4.5 kg/head).
- Onions: 85.0 - 95.0 tonnes/ha (8 500 - 9 500 bags/ha x 10 kg/bag).

According to the same source, other farmers in the Brits area have also planted the following irrigated crops:

- Sunflowers: 3.8 - 4.0 tonnes/ha.
- Soybeans: 3.0 - 3.5 tonnes/ha.
- Lucerne: 3600 tonnes/ha (200 bales/ha x 18 kg bale average).
- Tobacco: Discontinued since the soils have too much clay, while the tobacco would also not cure properly.

Grazing

The indigenous 'grasslands' and wetlands that are interspersed between the bush and 'savannah' areas would in the past have been utilised for the grazing of cattle by the local farmers and communities.

Subsistence agriculture and livestock rearing that was part of the traditional way of life of the early indigenous settlers in the area, as evidenced by the one old kraal ruin (stone hut ruin - informal settlement site).

8.4.4.5. Existing Structures

The man-made features (including structures) within the survey area are presented on Figure 8.4.4(a) and the corresponding summary Table 8.4.4(a) indicates that man-made features / structures comprise 299.94 *ha* (48.32%), of the total survey area of 620.75 *ha* (100%).

The complexity and number of man-made features / structures in the survey area is indicated by the number of mapping polygons (526 mapping polygons). Within the main smelter infrastructure area, the individual buildings were not presented as separate polygons on our maps, but were rather grouped into a number of larger polygons. However, our map set still displays these buildings in a background grey colour, and our mapping Shapefiles also includes a layer for the individual buildings.

The only man-made features that are not indicated on Figure 8.4.4(a) are the De Kroon informal village (divided into two polygons by the main dirt track), two cemeteries, and three farmyards, the aforementioned being indicated on Figure 8.4.4(a) and the corresponding summary Table 8.4.4(a). Within the De Kroon informal village, the hundreds of individual dwellings have not been mapped either, only the village boundary.

All of the existing structures/features are smelting, mining, light industry, human, and agriculture related.

Industrial / mining activities (and therefore structures / features) are dominated by the HERNIC operations (smelting and Morula Mine). Other Industrial activities within the survey area include the following: a workshop (north of HERNIC), Silverstone Crushers (north-west), Gravmax (south), workshops (south-east of Gravmax), RASA (further south), and a concrete producer (south-east). The other mining operation within the survey area is the Crocodile Mine (to the north).

8.4.4.6. Evidence of Misuse

<u>Agriculture</u>

There is little evidence of misuse from the agricultural perspective. Overgrazing and soil erosion are not evident in the vast majority of the surveyed area.

Annual burning is not recommended in the vegetated areas, since the loss of organic matter will result in an increase in soil erosion, disrupt the nutrient cycle and reduce the moisture holding capacity of the topsoil.

Given the complete absence of grazing animals (cattle, sheep, and wildlife) in the area, the grasslands are not being utilised in the way that they are adapted to be utilised. This will over time lead to a change in the natural species composition of these ‘grasslands’, thereby jeopardising the bio-diversity of the area. Thus, a burning policy must be implemented, whereby the entirety of the vegetated areas must be burned at least once every two to three years (burning interval to be recommended by a ‘grasslands’ specialist), with fire thereby fulfilling the ‘role’ of grazers. Certain limited areas displaying anthropogenic organic matter build-up to the east of the railway line must not be burned.

Smelting

The majority of these issues are historical due to the design and layout of the past. One reason for our current study is in order to look for potential solutions to the problems that may exist.

Infiltration of 'Dirty' Water

The infiltration / seepage / runoff of 'dirty' water are taking place in certain sections of the smelter / raw materials / processing / dumping / containment areas. The aforementioned is evidenced in certain natural areas in downslope positions (mainly immediately to the north of the smelter / dumping / containment areas) by the following 'Visual Indicators of Salinity and Wetness': perched soil water-tables (indicated by the terms: moist depth, moist, wet, or very wet) as indicated on Figure 8.4.4(b).

Infiltration of 'dirty' water will be taking place from a number of the features / facilities indicated below.

- Smelter Plant, Raw Materials, and Processing Areas. This is probably due to insufficient concrete pads, and/or insufficient dirty water drains.
- Old Tailings Storage Facility. This facility is probably not sealed (on the walls or at the base), and without under drainage. However, the current (new) TSF appears to be well constructed and probably includes an underlying soil 'seal' layer and under drainage (although unknown to the author).
- Pollution Control / Return water / Process Water Dams. A number of the older dams are unclad (without an underlying soil 'seal' layer and impermeable membrane). However, all of the more recent dams are well constructed and include cladding.
- 'Dirty' Water Intercept Drains and Canals. The dirty water canal/drain downslope (north) of the complex of pollution control/return water/process water dams (that lie to the immediate north of the plant) does not appear to be functioning effectively due to the following: unclad, silted, reed growth, poor gradient, and does not itself lead into a return water dam or well-field. Much of the water in this drain is finding its way (by direct drainage and seepage) into the area to the east of the railway line, immediately to the north. The soils in this area are wet to very wet as a result, and Phragmites reeds are present in patches.
- 'Waste' (Potentially Polluting) Areas. These include dumps, piles, and prepared surfaces (levelled surfaces facilitate the trafficking of machinery). Sufficient dirty water intercept drains must be constructed on the downslope sides of these features, and potentially polluting 'waste' dumps must be identified and clad (as three already have been).
- 'Clean' Water Diversion Drains/Canals/Berms. Such additional features must only be constructed where they are found to be both lacking and necessary. These are necessary in order to re-direct 'clean' water away from the upslope boundaries of potential pollution sources, this water being released to the environment at a suitable location, either downslope or away from the feature (as the landscape dictates).

Perched Anthropogenic Water-Table and Pollution Plume

The inevitable combined effect/consequence of the first point, third point and fourth point is that a proportion of polluted water is currently infiltrating into the underlying/surrounding soils (as evidenced by the 'Visual Indicators of Salinity and Wetness' mentioned in Point i); as well as into the perched 'ground' water-table and 'deeper' groundwater-table in certain areas. A proportion of this water will ultimately find its way into the surrounding non-perennial streams.

Redundant Features/Materials - Remove and Consolidate

Redundant features, the material from which is not required in the smelter process in the future, must be removed from where it is no longer required, and transported to a designated facility or dumping area, which must in turn be ‘rehabilitated’. Redundant features/materials will be contributing to soil/water pollution since rainwater will currently be percolating through these materials (dissolving pollutants), and thereafter into the underlying/surrounding soils and water-tables.

Redundant features (‘wastes’ and ‘non-wastes’) in the HERNIC (not including opencast) area appear to include a number of the following:

- ‘Wastes’: slag (numerous dumps, piles, and prepared surfaces); ash (two unclad dumps, and one pile); slurry (one dump, four piles, and two small dams); and scrap. These materials must be removed from their current locations. The surplus slag may be sold to one of the two private companies (Silverstone Crushers and RASA) that sell crushed slag in the vicinity. The ash must be added to one of the three existing clad ash dumps. The slurry must be placed in the current TSF.
- ‘Non-Wastes’: concrete (three piles, and eight prepared surfaces - actually just spread out on the surface and disposed of in this manner); and rubble (three piles). The footprint of the discarded concrete from the private company appears to be spreading in an unplanned manner. This must be removed to a designated dumping area.
- Ore: A number of dumps / piles / prepared surfaces of ore (rock grade, stone grade, coarse grade, and fines). Many of these features appear not to be required, perhaps in certain instances due to a low mineral content in the ore. The material in many of these locations (if no longer required) must be scraped up and removed; to either be processed in the plant (those materials that have a high enough ore grade), dumped in a designated dumping area (those materials that are potentially polluting), or alternatively dumped in the opencast area (those materials that are potentially non-polluting).
- Rock: Numerous dumps / piles / prepared surfaces of rock, rock crushed to sand grade, and stone chips; in the broader smelter area. Many of these features appear to be redundant and must be removed to the opencast area if no longer required.

Unnecessary Spreading of ‘Waste’ and ‘Non-Waste’ in the Past

‘Waste’ materials (particularly slag) were spread over the in-situ soils in certain areas in the past, and particularly so in a number of areas to the south of the internal tar road to the smelter. Such locations include the sites of previous dumps that have now been removed, ‘prepared surfaces’, as well as on roads. A number of the private businesses in the survey area are presently doing the same thing, and with an apparent absence of planning or control (e.g. spreading of ‘waste’ slag, concrete, and rubble).

The footprint of crushed ‘ore fines’ and ‘rock crushed to sand grade’ prepared surfaces must also be minimized. Such areas of ‘waste’ and ‘non-waste’ must be scraped up and transported to a designated ‘waste’ facility or dumping area.

Rehabilitate Existing Permanent Redundant Features

Permanent features that will remain in perpetuity must be ‘rehabilitated’. Potentially non-polluting dumps must be re-graded to an acceptable slope, ‘topsoiled’, ameliorated (fertilised), and re-vegetated.

Potentially polluting facilities or dumps must be completed as per legislation for the various materials (slope grade, cladding, and drainage).

Non-rehabilitated features will be contributing to soil/water pollution since rainwater will currently be percolating through these materials (dissolving pollutants), and thereafter into the underlying/surrounding soils and water-tables.

One rehabilitated area lies within the Alloys Smelting Plant operational area, the aforementioned being a rehabilitated (back-filled and 'topsoiled') borrow pit.

The reason for the lack of completed rehabilitation operations in the majority of the Alloys Smelting Plant area is described. This is because most of the surface materials are still required (either now or in the future) in the various smelter processes, and these areas will be rehabilitated in the future during the closure phase.

The objectives of the above mentioned are collectively to:

- Limit soil and water pollution;
- Consolidate 'waste' and 'non-waste' materials;
- Reduce the size (surface area) of the footprint of smelter related activities and private companies (in cases where the size of the footprint is not warranted), and thus the extent of the impact on the environment; and
- Expose the underlying in-situ soils which can then be ameliorated and re-vegetated.

Mining

The mining related issues must be dealt with by the Morula Mine.

Non-Rehabilitated Areas: Morula Mine (opencast and underground)

Apart from the surface levelling of an extensive area of spoils (but not 'topsoiled'), almost none (bar one small area – north-eastern edge of opencast) of the Morula Mining Opencast Operation area has been rehabilitated and two opencast sections (final voids) remain to be filled with spoil. The same goes for the Morula Mining Shaft Complex area, where only one small fragmented area (band to the south of the internal tar road that divides the opencast area from the underground area) has been rehabilitated.

The reason for the lack of completed rehabilitation operations in the majority of the Morula Mining Opencast Operation and Morula Mining Shaft Complex areas are described. In the former area, rehabilitation operations are ongoing (mostly filling voids and re-grading uneven surfaces at this stage) and will be completed over time. In the latter area, although the underground mine is temporarily closed the various facilities and features will still be required when the mine re-opens, and these areas will be rehabilitated in the future during the closure phase.

However, the completion of rehabilitation operations should have been ongoing (wherever possible) during the operational phase of the mine. Apart from the re-grading (re-levelling) of spoil areas to an acceptable slope (from the erosion point of view), rehabilitation operations should have included the 'topsoiling' and re-vegetation of these areas as well.

Generally speaking, the following operations need to be conducted in the broader opencast area:

- Final voids must be filled with potentially non-polluting rock
- Re-grade (re-slope) the area to an acceptable grade from the soil erosion point of view. The maximum determined slope for the vertic broad soil group in rehabilitated ‘topsoiled’ areas, is a percentage grade of 11.2% (6.4 degrees).
- ‘Topsoil’ the re-graded surface to at least the grazing capability class depth standard, meaning at least 25 *cm* of suitable ‘topsoil’. Vertic A-horizon material (‘topsoil’) must be utilised, given that it surrounds the area;
- Ameliorate (sample, analyse, and fertilise) the ‘topsoil’; and
- Re-vegetate the ‘topsoiled’ areas with indigenous (to the area) ‘grasses’. Indigenous trees will naturally re-colonise the rehabilitated areas over time.

The other scattered features to the south of the opencast area (in the underground area) must ideally be removed from their current locations; and disposed of.

8.4.5. Current Status of Infrastructure (Roads)

The relevant Specialist Report is:

Traffic Impact Study Base Line Report: HERNIC Ferrochrome Mine, Brits, May 2016. Koleko Solutions - Transport Engineering and Planning.

The site locality in relation to the main access roads is shown on Figure 8.4.5(a). Direct access to the site is gained from the R 511 (Pretoria-Brits road) which runs in a north-westerly direction along the western boundary of HERNIC. This road intersects the N4 Pretoria-Rustenburg freeway which essentially forms the southern boundary of the site. The R 566 Rosslyn-Brits road runs some 2 *km* to the north of the site in an east by west direction.

The R 511 Road is an existing one lane per direction, surfaced road and forms part of the major road Brits network as well as the road network in the North West Province. The R 566 Road is an existing one lane per direction, surfaced road which links the R 104 Road with Lavender Road in the Pretoria North area. Both these main access roads (R 511 and R 566) are in acceptable condition with minor maintenance requirements. The N4 Freeway is an existing duel carriage way, two lanes per direction with grade separations at cross roads with the N4. The N4 connects Komatipoort border post with Lobatsi border post.

The main access road to the HERNIC's Brits operations is from the R 511 Road. Photographs of the access roads to the HERNIC site are provided below (Figure 8.4.5(a)).

Access Road to HERNIC Operations	Access Road to HERNIC Operations
	
R511 Road eastbound	**R511 Road**
	
N4 Freeway westbound	**N4 Freeway**
	

Figure 8.4.5(a): Photo Collage of Main Access Roads showing current Road Condition

8.4.6. Blasting and Vibration

Open-cast mining at the Morula Mine was concluded in 2014/2015. The underground section is currently in care and maintenance and therefore no blasting is currently conducted on site.

The current base line for blasting and vibration is therefore stable with no blasting related vibration.

8.4.7. Traffic

The relevant Specialist Report is:

Traffic Impact Study Base Line Report: HERNIC Ferrochrome Mine, Brits, May 2016. Koleko Solutions - Transport Engineering and Planning.

8.4.7.1. Current Traffic Volumes

Classified Traffic counts were carried out on Thursday, 17th March 2016 for 12 hours (6:00 - 18:00) at the R 511 Road, the R 566 Road and the N4 Bakwena Toll Route Freeway. Light vehicles, heavy vehicles (1 – 4 axles) and very heavy vehicles (>5 axles), were counted at the intersections.

The AM and PM Peak hour was determined based on the highest traffic volumes registered during the morning and afternoon periods respectively. The AM Peak was found to be from 07:45 to 08:45 and the PM Peak hour was recorded at 17:00 to 18:00. Approximately 11% of the counted AM and PM peak hour traffic volumes were heavy vehicles. The existing AM and PM peak hour total traffic volumes are indicated in Figure 8.4.7(a) and Figure 8.4.7(b).

8.4.7.2. Intersection and Roadway Performance

The analysis indicate that some of the intersections are currently operating over capacity with high Level Of Service (LOS) ranging between E and F during the morning AM and afternoon PM peak hour as indicated in Table 8.4.7(a). In most urban areas overall rating of A to D are normally considered acceptable. Levels of service D or better are considered desirable and levels of service E and F are normally undesirable (Table 8.4.7(b)).

LOS definitions are based on vehicle delay. Delay is a measure of intersection or roadway performance which is measured based on the driver discomfort, frustration, fuel consumption and lost travel time. Delay at intersections depends on various factors such as type of signal control, volume of traffic and volume/capacity ratio of each approach at an intersection.

The intersection performance has been rated based on the average delay, i.e. the LOS of the intersections under investigation (including the access to the Mine) will be measured based on the intersection average delay.

Volume / capacity ratio (v/c) is a measure of intersection or roadway performance. It is the ratio of number of vehicles on the road to the available capacity of the roadway. The road link capacity in the study area was rated based on the volume/capacity ratio, i.e. the LOS of the link roads will be measured based on the volume/capacity of the roads.

8.4.7.3. Access to the Site

Security controlled access is provided at the existing access road via the R 511 Road. The R 511, R 566 Road and the N4 Freeway are currently used as the major access roads in the region as well as for the operational purposes of the HERNIC's operations.

The R 511 Road is an existing one lane per direction, surfaced road and forms part of the major road Brits network as well as the road network in the North West Province. The traffic volumes on the R 511 Road consist mainly of traffic from Brits travelling to the N4 Freeway and to the surrounding mining and farm areas.

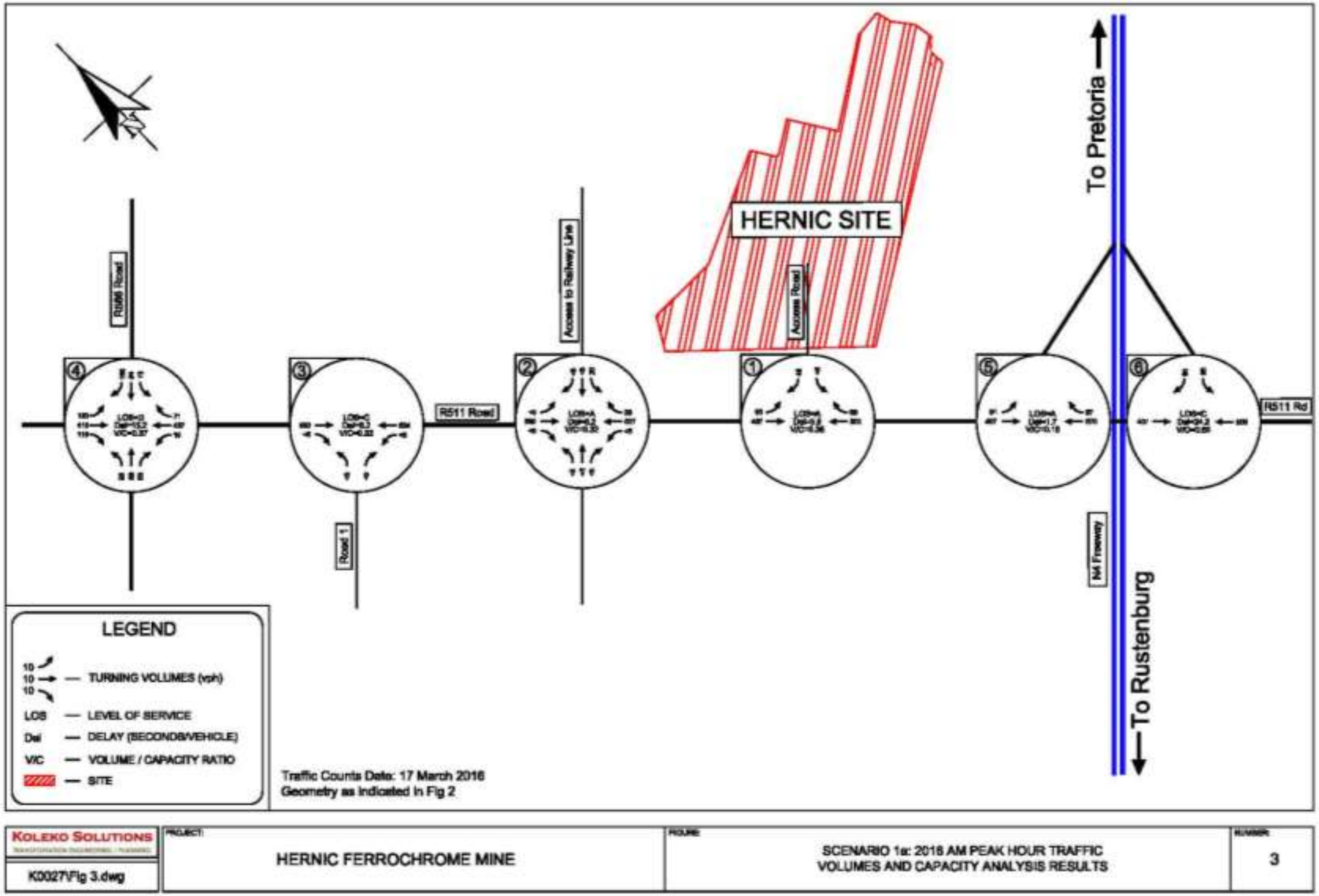


Figure 8.4.7(a): 2016 AM Peak Hour Traffic Volumes and Capacity Analysis Results

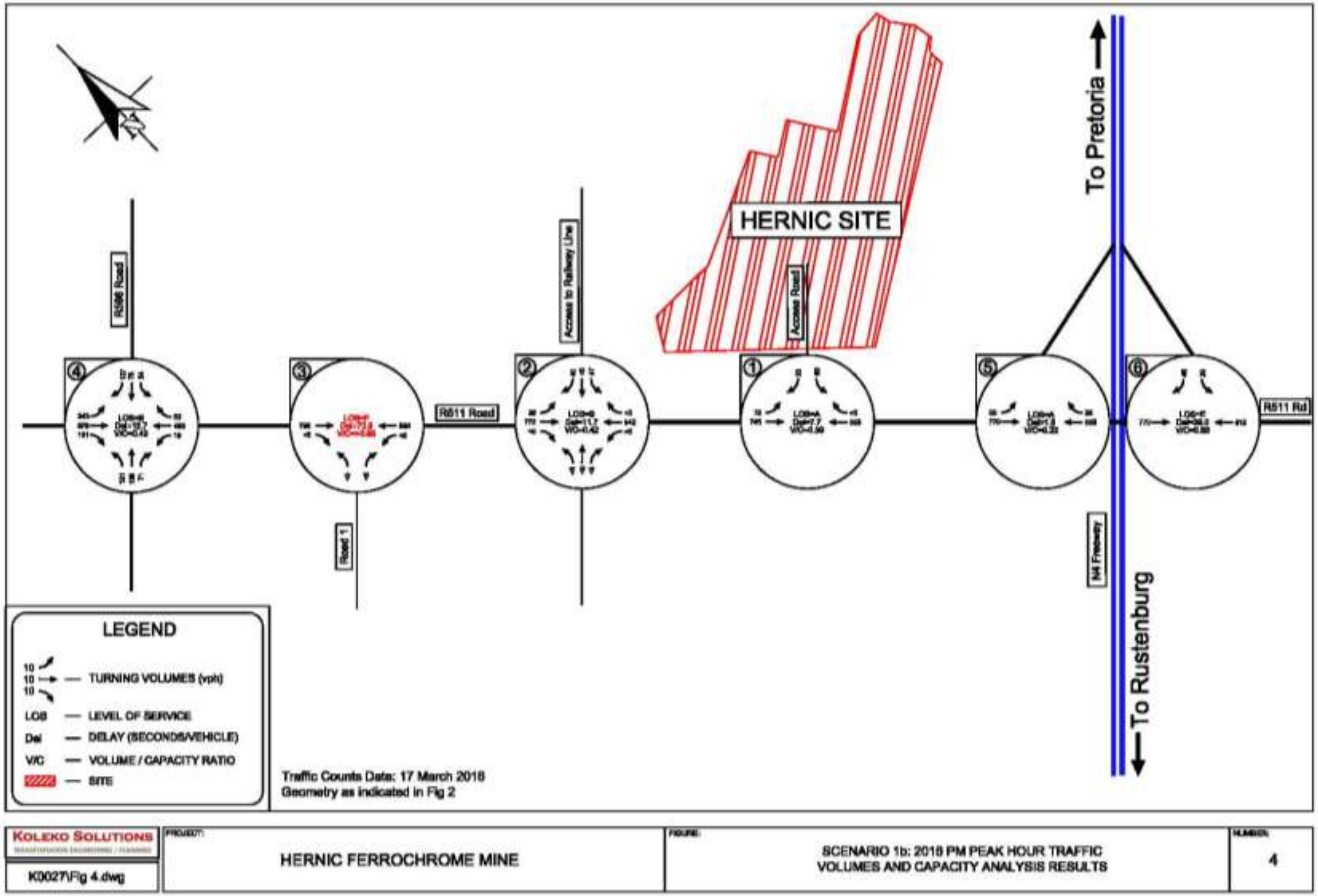


Figure 8.4.7(b): 2016 PM Peak Hour Traffic Volumes and Capacity Analysis Results

Table 8.4.7(a): Summary of Capacity Analysis Results

Intersection / Approach		2016 Existing Traffic Volumes						2021 Future Traffic Volumes					
		Sc 1a: AM PEAK HOUR			Sc 1b: PM PEAK HOUR			Sc 2a:AM PEAK HOUR			Sc 2b: PM PEAK HOUR		
		V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS
R511 Rd / Access Rd	R511 Rd WB	0.36	4.3	A	0.44	4.7	A	0.41	4.6	A	0.51	5.0	A
	Access Rd SB	0.35	46.2	D	0.55	37.3	D	0.41	46.4	D	0.64	38.2	D
	R511 Rd **EB**	0.35	4.0	A	0.59	5.7	A	0.40	4.2	A	0.69	6.3	A
	Overall	**0.36**	**5.9**	**A**	**0.59**	**7.7**	**A**	**0.41**	**6.1**	**A**	**0.69**	**8.3**	**A**
R511 Rd / Rail Access / Road A	Road B NB	0.01	19.0	C	0.01	27.6	C	0.02	22.8	C	0.04	39.6	E
	R511 Rd WB	0.32	6.4	A	0.32	12.8	B	0.37	9.3	A	0.48	20.5	C
	Rail Access SB	0.03	16.7	C	0.03	34.6	D	0.04	18.9	C	0.78	75.8	F
	R511 Rd EB	0.31	5.6	A	0.30	8.2	A	0.35	8.1	A	0.49	13.2	B
	Overall	**0.31**	**6.2**	**A**	**0.32**	**11.7**	**B**	**0.37**	**8.9**	**A**	**0.78**	**19.9**	**C**
R511 Rd / Road B	Road B NB	0.02	28.7	D	0.04	28.8	D	0.02	28.7	D	0.04	28.8	D
	R511 Rd WB	0.68	22.7	C	0.82	32.6	D	0.79	28.7	D	0.82	32.6	D
	R511 Rd EB	0.73	24.6	C	>0.95	104.5	F	0.84	33.3	D	>0.95	104.5	F
	Overall	**0.73**	**23.7**	**C**	>0.95	**73.8**	**F**	**0.84**	**31.1**	**D**	>0.95	**73.8**	**F**

v/c : Volume /capacity
delay: in seconds (s)
LOS: Level of Service (based on delay)

Table 8.4.7(a): Summary of Capacity Analysis Results (continued)

Intersection / Approach		2016 Existing Traffic Volumes						2021 Future Traffic Volumes					
		Sc 1a: AM PEAK HOUR			Sc 1b: PM PEAK HOUR			Sc 2a:AM PEAK HOUR			Sc 2b: PM PEAK HOUR		
		V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS	V/C	Delay (sec)	LOS
R511 Rd / R566 Rd	R566 Rd NB	0.17	12.7	B	0.27	16.3	B	0.21	13.2	B	0.29	16.1	B
	R511 Rd WB	0.32	16.1	B	0.25	10.4	B	0.36	15.7	B	0.32	11.4	B
	R566 Rd EB	0.37	15.9	B	0.43	21.8	C	0.46	16.8	B	0.50	21.4	C
	R511 Rd EB	0.37	15.0	B	0.43	10.9	B	0.44	14.6	B	0.57	11.9	B
	Overall	**0.37**	**15.2**	**B**	**0.43**	**12.7**	**B**	**0.46**	**15.2**	**B**	**0.57**	**13.4**	**B**
N4 On-Ramp / R511 Rd	R511 Rd WB	0.18	2.0	A	0.18	3.5	A	0.21	2.3	A	0.18	3.5	A
	R511 Rd EB	0.13	1.4	A	0.22	0.6	A	0.15	1.4	A	0.22	0.6	A
	Overall	**0.18**	**1.7**	**A**	0.22	**1.8**	**A**	**0.21**	**1.9**	**A**	0.22	**1.8**	**A**
N4 Off-Ramp / R511 Rd	R511 Rd WB	0.60	26.0	D	0.60	26.2	D	0.69	31.3	D	0.70	32.0	D
	N4 Off-Ramp SB	0.26	21.8	C	0.20	21.7	C	0.30	22.6	C	0.23	22.3	C
	R511 Rd EB	0.50	22.5	C	0.85	49.1	E	0.58	25.4	D	>0.95	91.8	F
	Overall	**0.60**	**24.2**	**C**	0.85	**39.0**	**E**	**0.69**	**28.1**	**D**	>0.95	**65.6**	**F**

v/c : Volume /capacity
delay: in seconds (s)
LOS: Level of Service (based on delay)

Table 8.4.7(b): Level of Service Classes and Definitions

LEVEL-OF-SERVICE DEFINITIONS BASED ON VEHICLES DELAY		
Level of Service	**Control Delay per vehicle in seconds**	**Level of Acceptability**
A	d≤14.5	Acceptable
B	14.5 < d ≤ 28.5	Acceptable
C	28.5 < d ≤ 42.5	Acceptable
D	42.5 < d ≤ 56.5	Acceptable
E	56.5 < d ≤ 70.5	Not Acceptable
F	70.5 < d	Not Acceptable

The R 511 Road carries relatively high volumes of traffic during the morning and afternoon peak hours. The R 511 Road carriers approximately 1 130 *vehicles per hour (vph)* in both directions during the morning peak hours and ±1 400 *vph* in both directions during the afternoon peak hours. The eastbound direction (towards the N4 Freeway) experiences higher traffic flows in the morning and afternoon peak hours.

The R 566 Road is an existing one lane per direction, surfaced road which links the R 104 Road with Lavender Road in the Pretoria North area. The traffic volumes on the R 566 Road are mainly traffic from Brits to the Pretoria North area. The R 566 Road carriers approximately 680 *vph* in both directions during the morning peak hours with the main direction eastbound towards Pretoria North. During the afternoon peak hours the main direction on the R 566 is eastbound similar as the morning peak hour with approximately 720 *vph* in both directions with ± 460 *vph* in an easterly direction towards Pretoria North area.

The N4 Freeway is an existing duel carriage way, two lanes per direction with grade separations at cross roads with the N4. The N4 connects Komatipoort border post with Lobatsi border post. SARAL's Comprehensive Traffic Observations (CTO Year 2013) Data from counting stations "1617 Bakwena K3", "1719 Bakwena R511 Brits" and "2560 Brits Plaza" *(between Pretoria and Brits), were used to determine traffic volumes on the N4 Freeway.

The R 511 / Road A Road (Access to the mine) intersection is currently a traffic signal controlled intersection with turning lanes on the approaches of the R 511 Road. The R 511 / Road B Road intersection is currently a priority controlled intersection with priority on the R 511 Road. The R 511 / R 566 Road intersection is currently a traffic signal controlled intersection. The N4 Freeway Off-Ramp / R 511 Road intersection is currently a three way stop controlled intersection.

The results of the capacity analysis for the baseline traffic are shown in Figure 8.4.7(a) and (b), and Table 8.4.7(a). All the intersections analysed are currently operating at acceptable levels of service and delay

8.4.8. Climate and Meteorology

The Climate and Meteorology description was compiled from two Specialist Reports:

HERNIC Ferrochrome (Pty) Ltd - Surface Water Specialist Study Report, April 2016. Inprocon Consultants cc – Consulting Environmental & Civil Engineers.

and

Atmospheric Impact Report / Air Quality Impact Assessment for HERNIC Ferrochrome, July 2016. G D Fourie and J G Potgieter – EnviroNgaka CC.

The climate of the region is typical of the middleveld climate zone. During the summer, the day time temperatures are in the upper twenties to early thirties but cools down slightly during the evening to mid-teens.

Summer (mid-October to mid-February) is characterised by hot, sunny weather often with afternoon thunderstorms of short duration.

In winter (May to July) day time temperatures are in the mid-teens to early twenties dropping the Celsius scale to single figures during the night. Frost occurrence during winter occurs but is not common. The rainfall occurs mostly in summer – some 85% of the annual rainfall being recorded during this period. There is a distinct seasonal variation in rainfall and the evaporation follows the same seasonal trend during the year for this region.

8.4.8.1. Ambient Temperature

Air temperature is important, both for determining the effect of plume buoyancy (the larger the temperature difference between the plume and the ambient air, the higher the plume is able to rise), and determining the development of the mixing and inversion layers. Figures 8.4.8.1(a) and 8.4.8.1(b) will provide an average monthly & average quarterly diurnal ambient temperature respectively for 2013 to 2015.

From the Figure 8.4.8.1(a) it is evident how the average ambient air temperature decreases by approximately 10˚C to 15˚C from March till July after which it increases again.

From Figure 8.4.8.1(b) it is evident how the ambient air temperature increases by approximately 10˚C to 15˚C from around 07h00 till 15:00 after which it decreases. The highest quarterly temperatures are expected from January to March and October to December.

An increase in wind speed and ambient temperature improves the dispersion of air pollutants in the air. As a norm, unfortunately wind speeds in excess of 5.4 m/s potentially has sufficient energy to pick-up and transport loose and/or disturbed particulate matter, which gives rise to visible nuisance dust and clouds of dust at ground level.

The extent, to which this occurs / can occur, depends on several parameters, such as the properties and characteristics of the particulate matter, moisture content, etc.

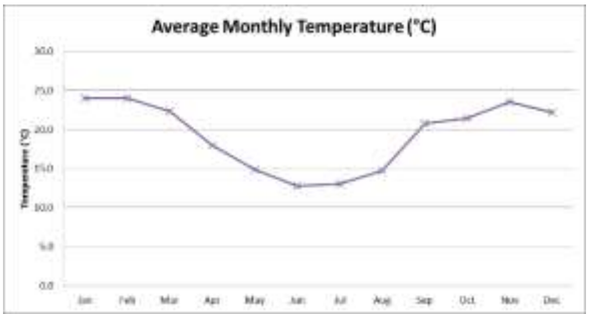
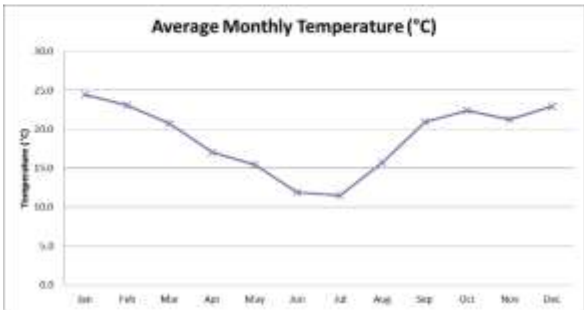
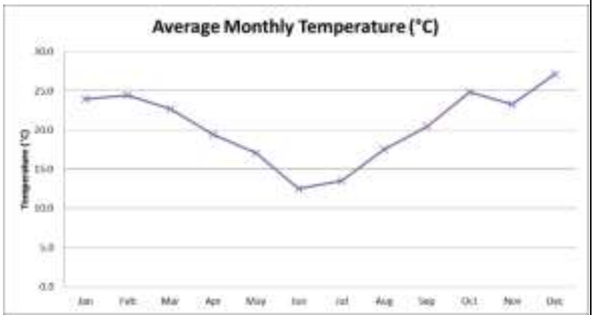
Average Monthly Diurnal Ambient Temperature for 2013 to 2015	
2013	2014
	
2015	
	

Figure 8.4.8.1(a): Average Monthly Diurnal Ambient Temperature for 2013 to 2015

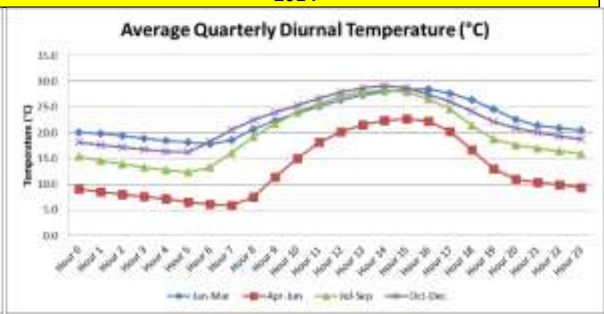
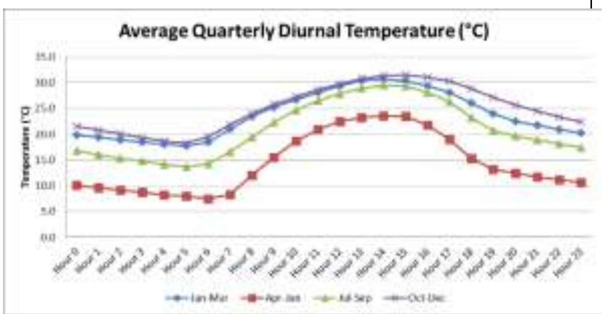
Average Monthly & Average Quarterly Diurnal Ambient Temperature for 2013 to 2015	
2013	2014
	
2015	
	

Figure 8.4.8.1(b): Average Quarterly Diurnal Ambient Temperature for 2013 to 2015

8.4.8.2. Mean Monthly and Annual Rainfall

Three Weather Bureau rainfall stations closest to the site with accompanying detail are listed in Table 8.4.8.2(a). Sandfontein and De Kroon represents two locations closest to the site with Sandfontein to the southwest of the site and De Kroon more north of the site. Sandfontein is approximately 6 km and De Kroon 1.5 km from the site. These two stations include most recent rainfall data and also the stations with the longest rainfall records closest to the site (79 years and 95 years respectively).

There is not a considerable variation in Mean Annual Precipitation (MAP) for rainfall stations closest to the site. Although the record lengths differ it appears that the MAPs are closely grouped. The Hartebeespoort Dam also close to the site, is situated in the mountainous Magalies mountain range where the rainfall isohyets is more steep than at the study area. Therefore the rainfall at the site will be more representative by the former two rainfall gauges.

Table 8.4.8.2(a): Rainfall Stations in the vicinity of the site.

Weather Bureau Gauge No.	Station Name	Latitude		Longitude		Record Used	No. of Years	MAP (mm)
		D	M	D	M			
1) 512 552	Sandfontein	25	42	27	49	1926-2004	79	669
2) 512 580	De Kroon	25	40	27	50	1920-2004	85	661
3) 512 613	Hartebeespoort Dam	25	43	27	51	1932-2004	73	726
Adopted MAP for Hernic Site 665								

The site lies close the southern internal watershed of the quaternary catchment A21J. In the recently published Water Resources 2005 Report (an update of WR90) the MAP for the quaternary catchment is given as 637 *mm*.

Due to HERNIC being close to the Sandfontein and De Kroon rainfall gauges the average of these two stations has been adopted as the MAP for the site (**665 *mm***). The MAP for Hernic site is slightly higher than for the quaternary catchment which is acceptable as the rainfall isohyets further north have a flatter gradient.

Refer to Figure 8.4.8.2(a) indicating the rainfall spread according to WRC WR005 study report. The figure focuses on the A21J and adjacent quaternaries.

The monthly distribution at the site has been assumed to be like the closest rainfall station that is De Kroon #512 580 and is indicated in the table below.

Table 8.4.8.2(b): Mean Monthly Rainfall for HERNIC Site (*mm*).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total
%	9.6	15.5	16.4	18	13.8	12.2	6.7	2.8	1.0	0.7	0.8	2.5	100
Mean	**64.1**	**102.9**	**108.9**	**119.9**	**91.71**	**81.09**	**44.6**	**18.4**	**6.6**	**4.72**	**5.56**	**16.5**	**665**

As indicated in Table 8.4.8.2(b), about 85% of the total annual rainfall occurs during the wet six months of October to March while only about 5% occurs during the driest 4 months (May to August).

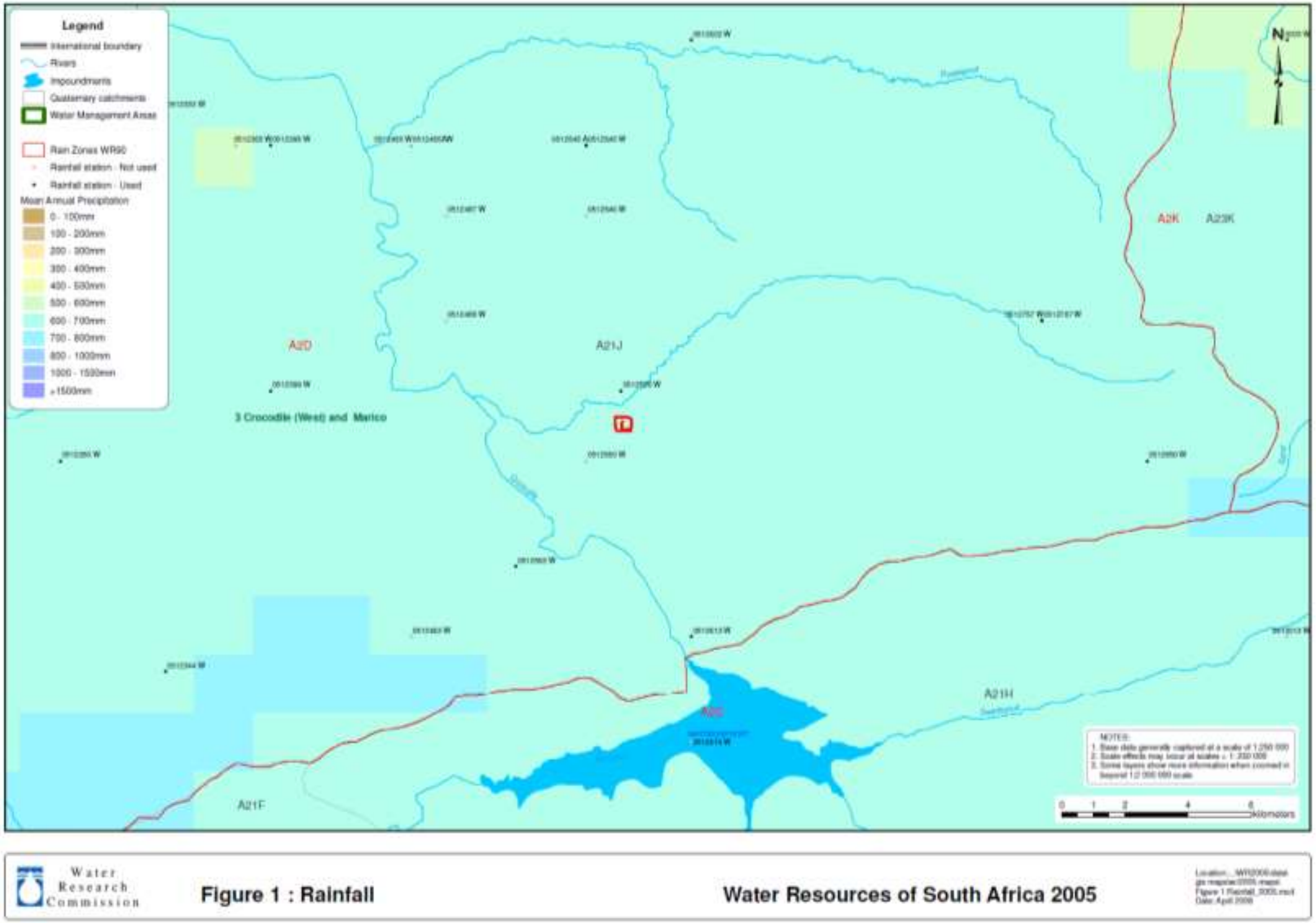


Figure 8.4.8.2(a): Rainfall of the A21J Quaternary Catchment

8.4.8.3. Maximum Rainfall Intensities

Storm rainfall intensities are required in estimating potential flood peaks and flood volumes. These intensities are dependent on the duration of the storm and the storm frequency or return period. There are few autographic rain gauges in use and thus statistical analyses are limited. The following storm precipitation values for the De Kroon Weather Bureau Number 512580 were extracted from TR102 published by the DWS.

Table 8.4.8.3(a): Rainfall for given duration and return period in *mm*.

Duration (days)	Return Period (years)				
	5	10	20	50	100
1	77	93	110	135	156
2	95	115	136	166	191
3	105	126	148	180	205
7	134	159	184	219	248

As the catchment areas in this project are relatively small, critical storm durations will be considerably less than the one day reflected in the above. An alternate method of obtaining storm precipitation values for shorter durations is the formulation developed by Op ten Oord which is an analytical version of the well-known monograph C2 from the HRU 1/72 Report. The results are provided in the table below.

Table 8.4.8.3(b): Storm Rainfall as per Op ten Oord formulation (*mm*)

Duration (hrs)	Return Period (years)				
	5	10	20	50	100
0.5	31.9	39.3	48.3	63.6	78.4
1	40.3	49.6	61.1	80.4	99.0
2	47.6	58.6	72.2	95.0	117.0
6	57.4	70.7	87.0	114.5	141.0
12	63.0	77.6	95.5	125.7	154.8
24	68.6	84.5	104.0	136.9	168.5

From Table 8.4.8.3(a) and Table 8.4.8.3(b), it is clear that, for the same storm duration of 1 day (24 hrs), the TR102 values gives considerably higher results than the Op ten Oord formula. The Op ten Oord formulation will be used in calculating storm rainfall for the various points of interest on the site based on critical storm duration for the given point. This well accepted in Civil Engineering practice.

8.4.8.4. Mean Monthly Evaporation

The Mean Annual Evaporation (MAE) for the area is given in WR2005 as 1700 *mm*. Evaporation, in terms of spatial variation, is fairly constant over the area. The average MAE for the Evaporation Zone 3B is 1700 *mm* (See Figure 8.4.8.4(a)). The Hartebeespoortdam gauge A2E001 average from 1926 till 2014 indicate the S-pan MAE as 1699 *mm*. The MAE (S-Pan) is 1700 *mm* (see Table 8.4.8.4(a)) for the site.

Table 8.4.8.4(a): Monthly average S Pan evaporation (*mm*).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Total
Ave	185.6	176.3	191.8	181.9	151.8	147.2	116.1	98.8	81.3	90.1	119.3	159.8	1700
%	**10.92**	**10.37**	**11.28**	**10.7**	**8.93**	**8.66**	**6.83**	**5.81**	**4.78**	**5.3**	**7.02**	**9.4**	**100.0**

The Monthly Lake Evaporation is calculated and indicated in Table 8.4.8.4(b). This represents a monthly average for clear chemical unaffected water.

Table 8.4.8.4(b): Monthly average lake evaporation (*mm*).

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
mm	186	176	192	182	152	147	116	99	81	90	119	160	1700
Lake Convert	0.81	0.82	0.83	0.84	0.88	0.88	0.88	0.87	0.85	0.83	0.81	0.81	
Lake Evap mm	151	144	159	153	134	129	102	86	69	75	96	130	1428

8.4.8.5. Wind Speed and Directions

The Site of Works falls within the Highveld Climatic Zone. The meteorological characteristics present at a specific site, from an air quality perspective, impact on the rate of emissions from fugitive sources, govern the dispersion, chemical transformation and the eventual removal of pollutants from the atmosphere (Pasquill and Smith, 1983; Godish, 1990). The extent to which pollution will accumulate or disperse in the atmosphere is dependent on the degree of thermal and mechanical turbulence within the earth's boundary layer. Dispersion comprises vertical and horizontal components of motion. The vertical component is defined by the stability of the atmosphere and the depth of the surface mixing layer, whereas the horizontal dispersion of pollution in the boundary layer is primarily a function of the wind field.

The wind speed will determine both the distance of downwind transport and the rate of dilution as a result of plume 'stretching'. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. The wind direction and the variability in wind direction, will determine the general path pollutants follow, as well as the extent of crosswind spreading (Shaw and Munn, 1971; Pasquill and Smith, 1983; Oke, 1990). Therefore pollution concentration levels fluctuate in response to changes in atmospheric stability, concurrent variations in the mixing depth and to shifts in the wind field.

Spatial variations, and diurnal and seasonal changes, in the wind field and stability regime are functions of atmospheric processes operating at various temporal and spatial scales (Goldreich and Tyson, 1988). Atmospheric processes at macro- and meso-scales have to be taken into account in order to accurately parameterise the atmospheric dispersion potential of a particular area.

The analysis of hourly average meteorological data is necessary to facilitate a comprehensive understanding of the ventilation potential of the site and to provide the input requirements for the dispersion simulation. A comprehensive data set for a duration of at least one year of detailed hourly average wind speed, wind direction and temperature data are needed for the dispersion simulations.

Site specific meteorological data was simulated for a period from January 2013 to December 2015, and utilised for the impact assessment and data interpretation. The location for the simulated meteorological monitoring data is located approximately 1.5 km south of the Enterprise (25.675°S, 27.841°E) at an elevation of approximately 1171 mamsl, with the wind monitored at a height of 10m and the other parameters at 2m above ground level. This specific data set was assessed and discussed below.

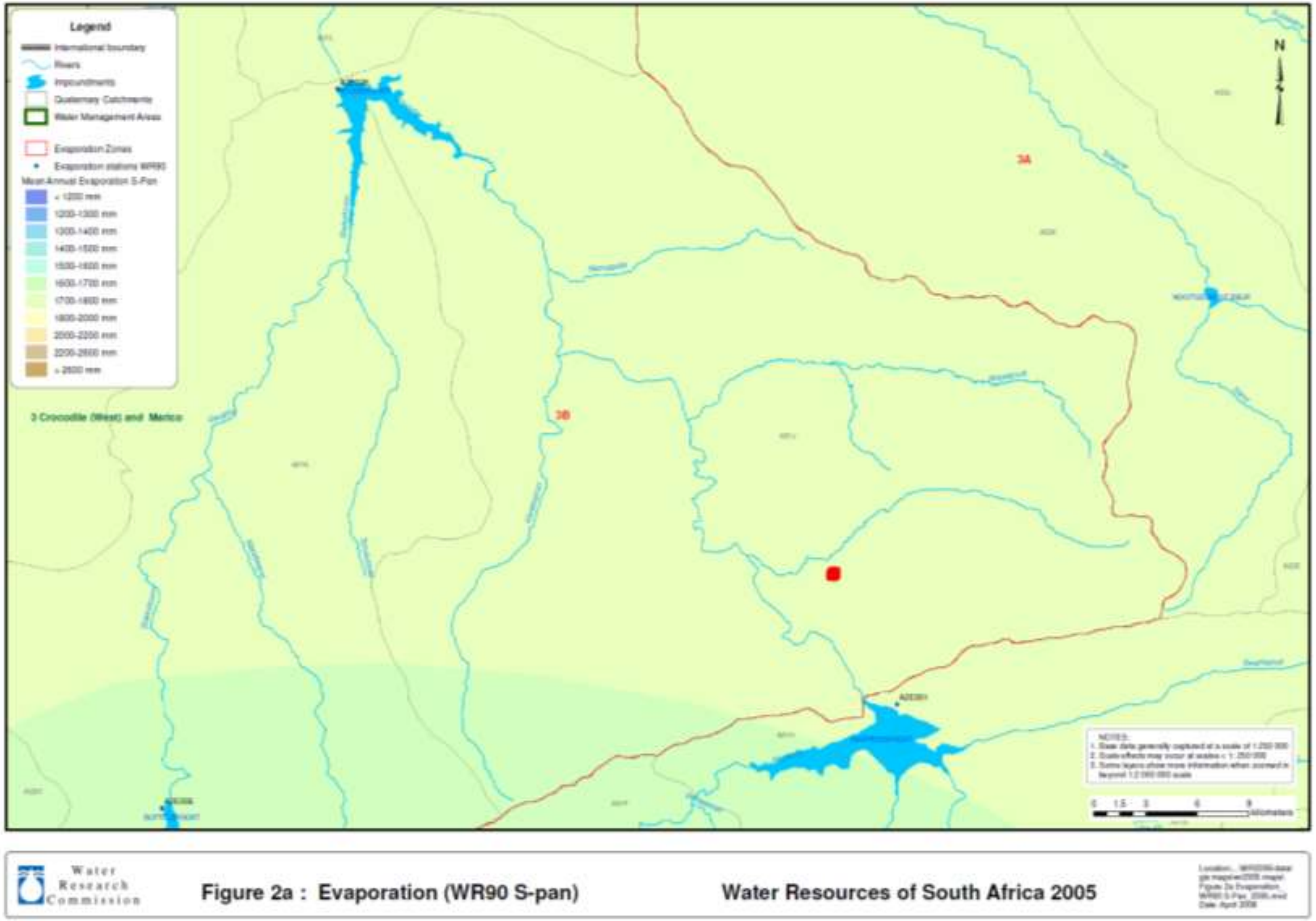


Figure 8.4.8.4(a): Average MAE for the Evaporation Zone 3B

Throughout 2013 to 2015, winds are predominantly from North Northeast and South Southeast (predominantly from the Northeast) relative to the site/Enterprise as illustrated by Figures 8.4.8.5(a) and 8.4.8.5(b).

Figure 8.4.8.5(b) also indicates that high wind speeds are predominantly from the North North-easterly and South South-easterly directions. Higher wind speeds were also recorded during winter and spring months.

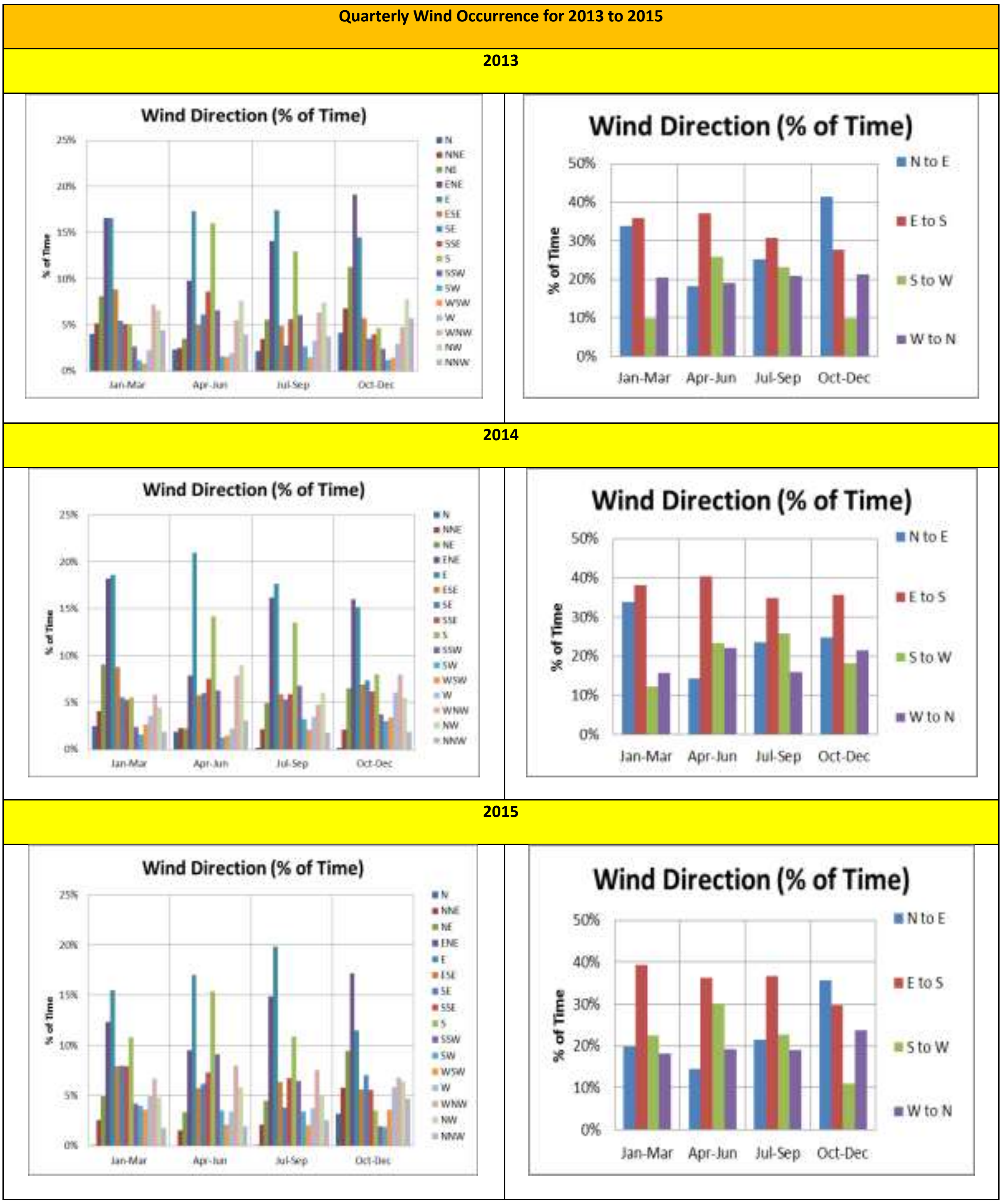
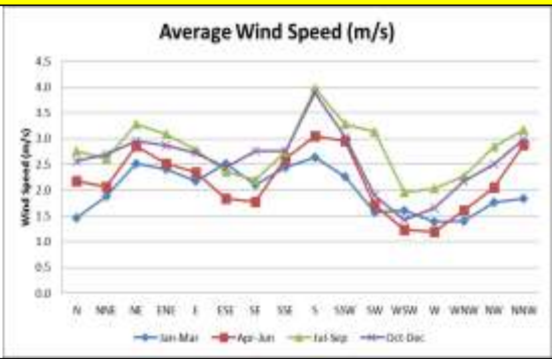
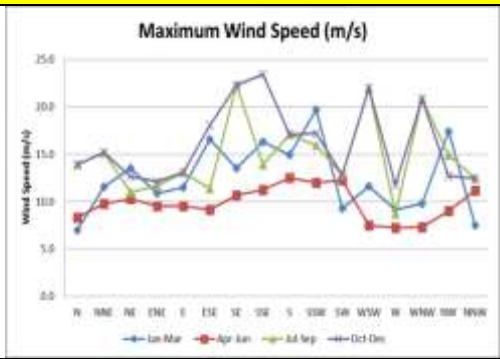


Figure 8.4.8.5(a): Quarterly Wind Occurrence for 2013 to 2015

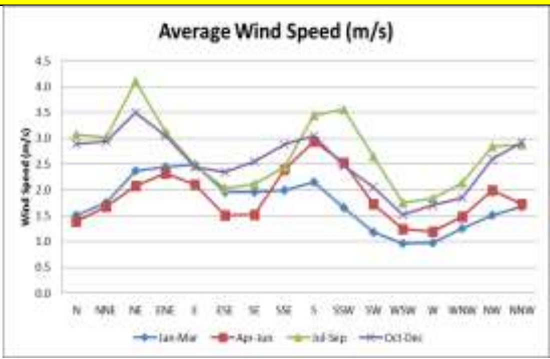
Average and Maximum quarterly wind speeds for 2013 to 2015

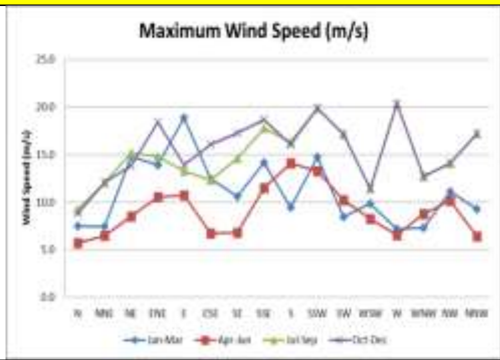
2013



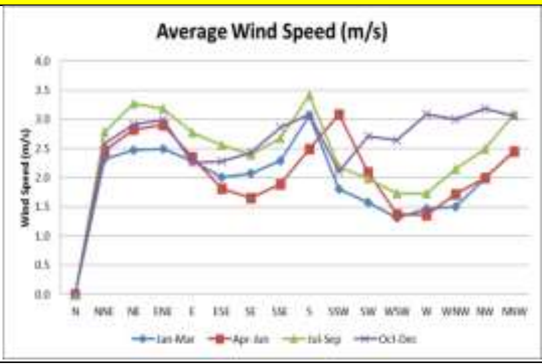


2014





2015



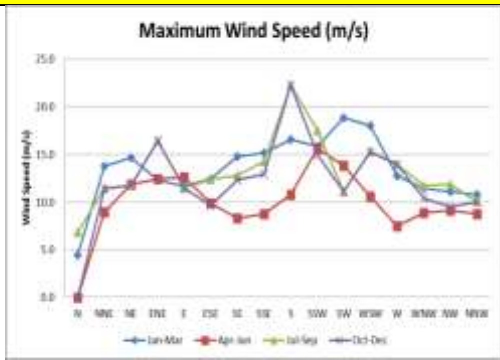


Figure 8.4.8.5(b): Average Quarterly Wind Speeds for 2013 to 2015

From Figure 8.4.8.5(c) it is evident how the wind speed increases after 06h00 and reduces from around 16h00, with maximums around 12:00. From 20h00 to 00h00 it increases again, but decreases again after 00h00.

Figure 8.4.8.5(d) illustrates the site specific annual wind-roses, as well as the annual day/night wind-roses. The North-easterly and southerly winds are prominent during day and night time, whilst a strong North Westerly is only observed during the day-time.

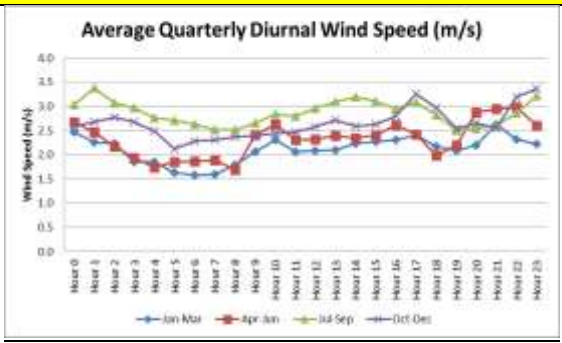
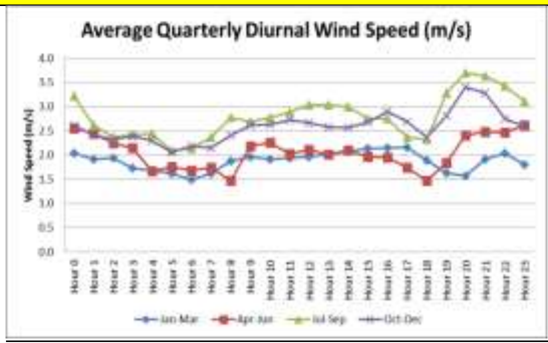
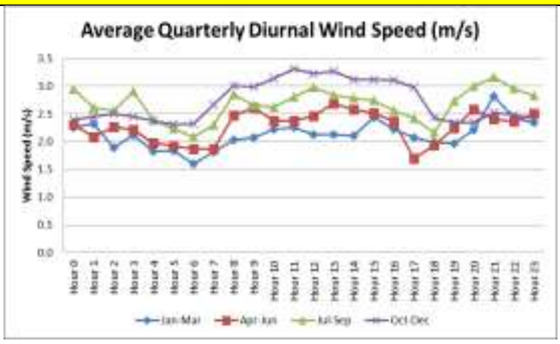
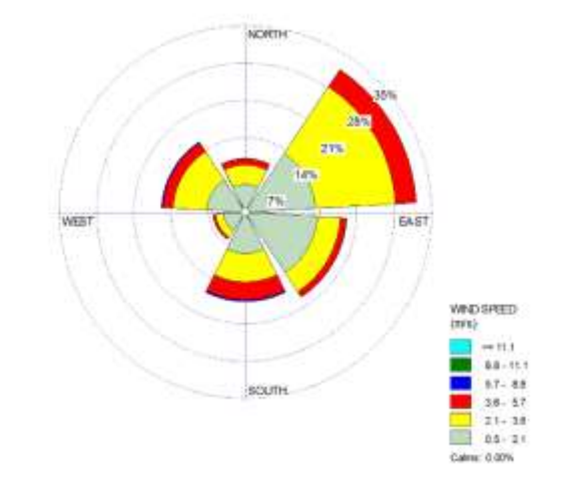
Average Quarterly Diurnal Wind Speed for 2013 to 2015	
2013	2014
	
2015	
	

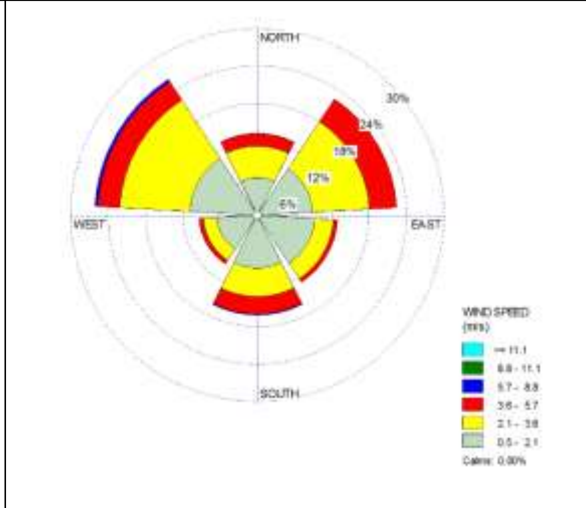
Figure 8.4.8.5(c): Average Quarterly Diurnal Wind Speed for 2013 to 2015

Wind roses for 2013 to 2015

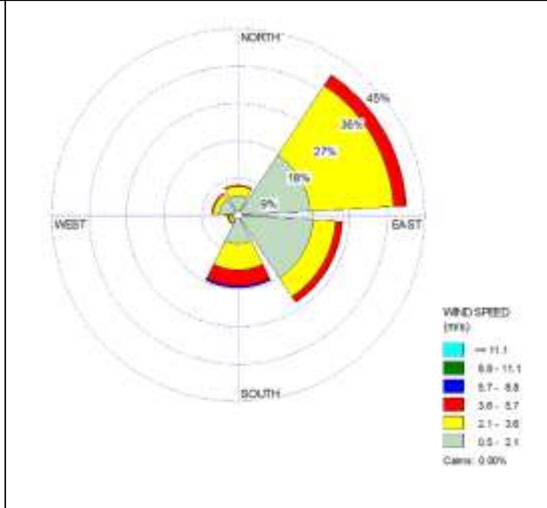
2013 Annual



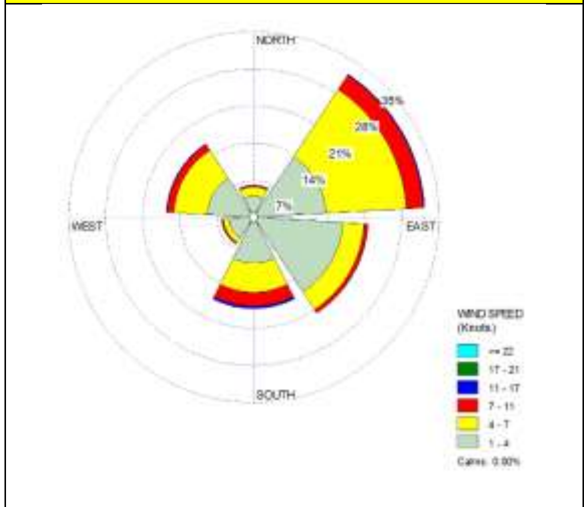
2013 Day-time



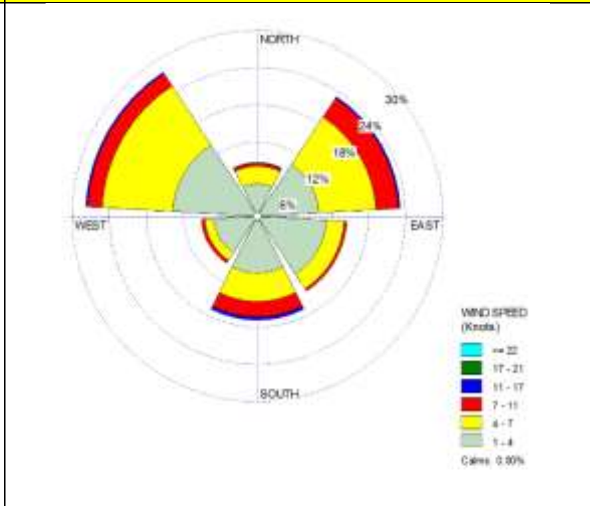
2013 Night-time



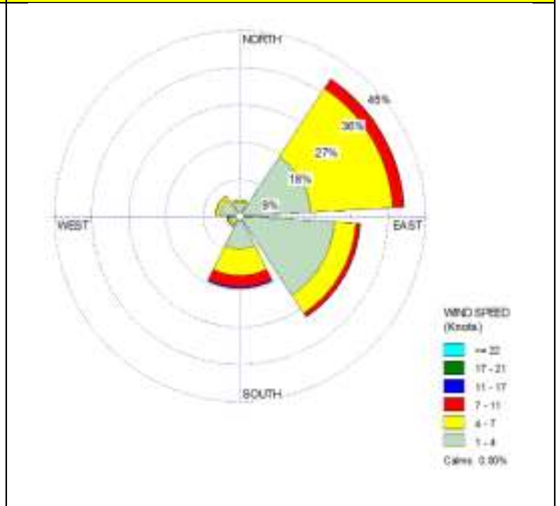
2014 Annual



2014 Day-time



2014 Night-time



2015 Annual

2015 Day-time

2015 Night-time

Wind roses for 2013 to 2015

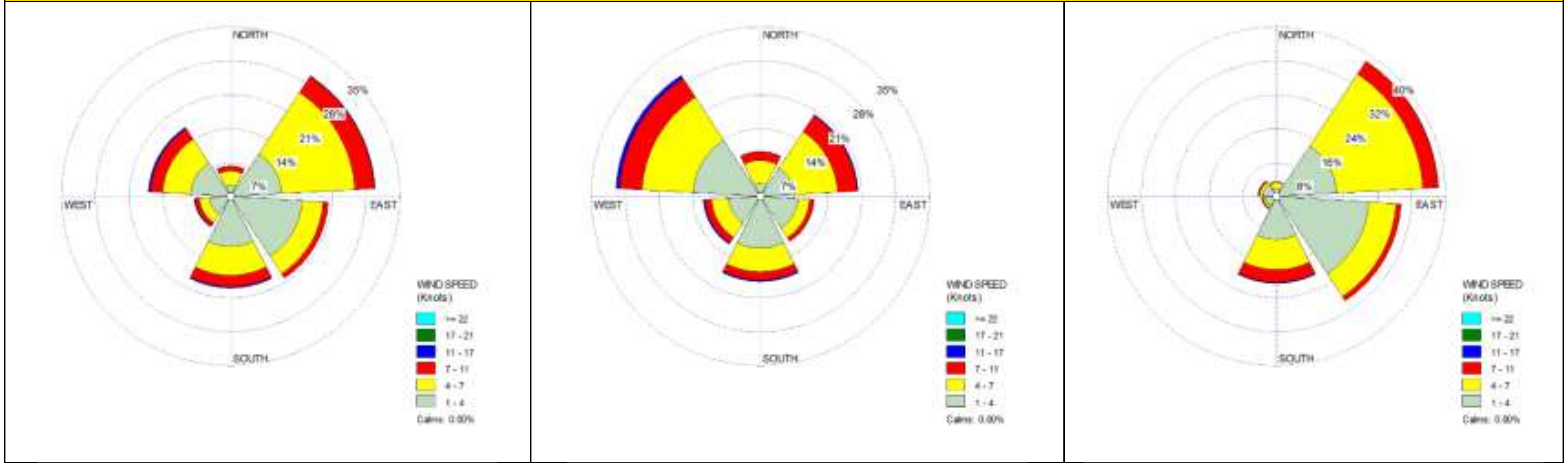


Figure 8.4.8.5(d): Site Specific Wind Roses for 2013 to 2015

8.4.9. Topography

The relevant Specialist Report is:

Topography Specialist Report for HERNIC Ferrochrome (Pty) Ltd, April 2016. JMA Consulting (Pty) Ltd.

8.4.9.1. Introduction

In order to support the Environmental Master Plan compiled for HERNIC, topographical inputs were required. The topography of an area refers to the physical structure, shape, elevation and features (natural or manmade) of the surface environment. This includes the land forms or surface configuration of a region. The topography of the study area influences the surface water, soils and vegetation components of the biophysical environment as well as aspects such as the visual, noise and air quality assessments. A description of the regional topography will therefore assist in the assessments of each of the abovementioned specialist investigations.

8.4.9.2. Regional Topography

HERNIC is flanked by the Magaliesberg Mountain Range to the south and the smaller Kareepoortberg and the Langberg to the north-west of the site. The land use adjacent to HERNIC is dominated by agricultural and mining related activities (Figure 8.4.9.1(a)).

8.4.9.3. Site Topography

The HERNIC study area stretches for some 3.5 *km* from west to east and 3.2 *km* from north to south. The surface elevation ranges from 1145 *mamsl* in the north-west perimeter to 1200 *mamsl* on the south-east perimeter of the site. The ground surface is gently sloping toward an unnamed non-perennial tributary in the north, north-west which drains towards the Crocodile River (Figure 8.4.9(a)).

The surface topography of the HERNIC study area is considered to be relatively flat, with a slight topographical gradient evident in a north-westerly direction. This supports the surface water drainage towards the Crocodile River.

8.4.9.4. HERNIC View Shed Analyses

The topography adjacent to the site is also considered to be relative flat, and therefore the site will most likely only be visible on a localised scale in all directions as well as from higher lying areas surrounding the site. Figure 8.4.9.4(a) depicts a topographical view shed analyses. The site is visible from all green areas and not visible from all red areas on Figure 8.4.9.4(a).

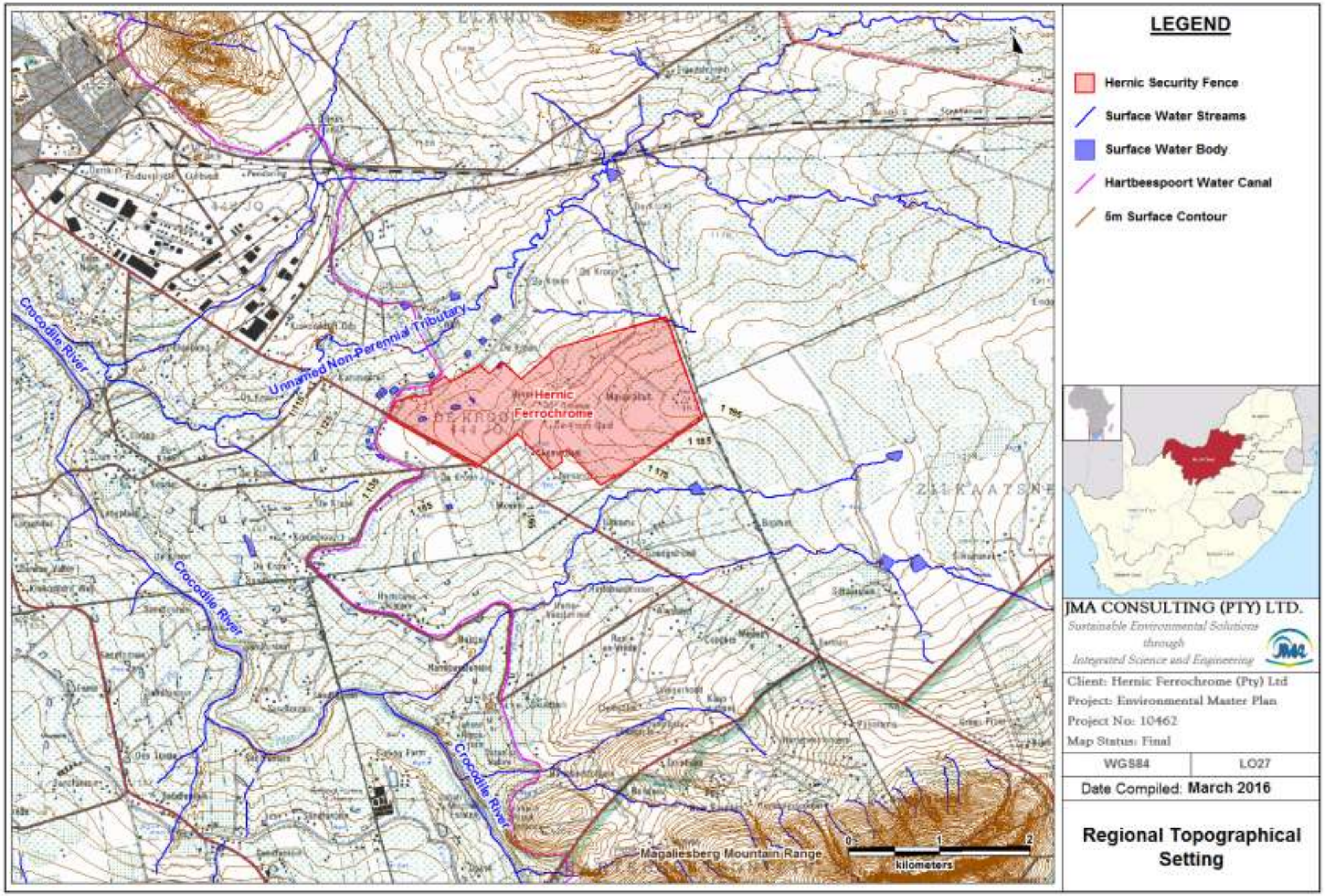


Figure 8.4.9.1(a): Regional Topography (Topographical Map 2527 DB).

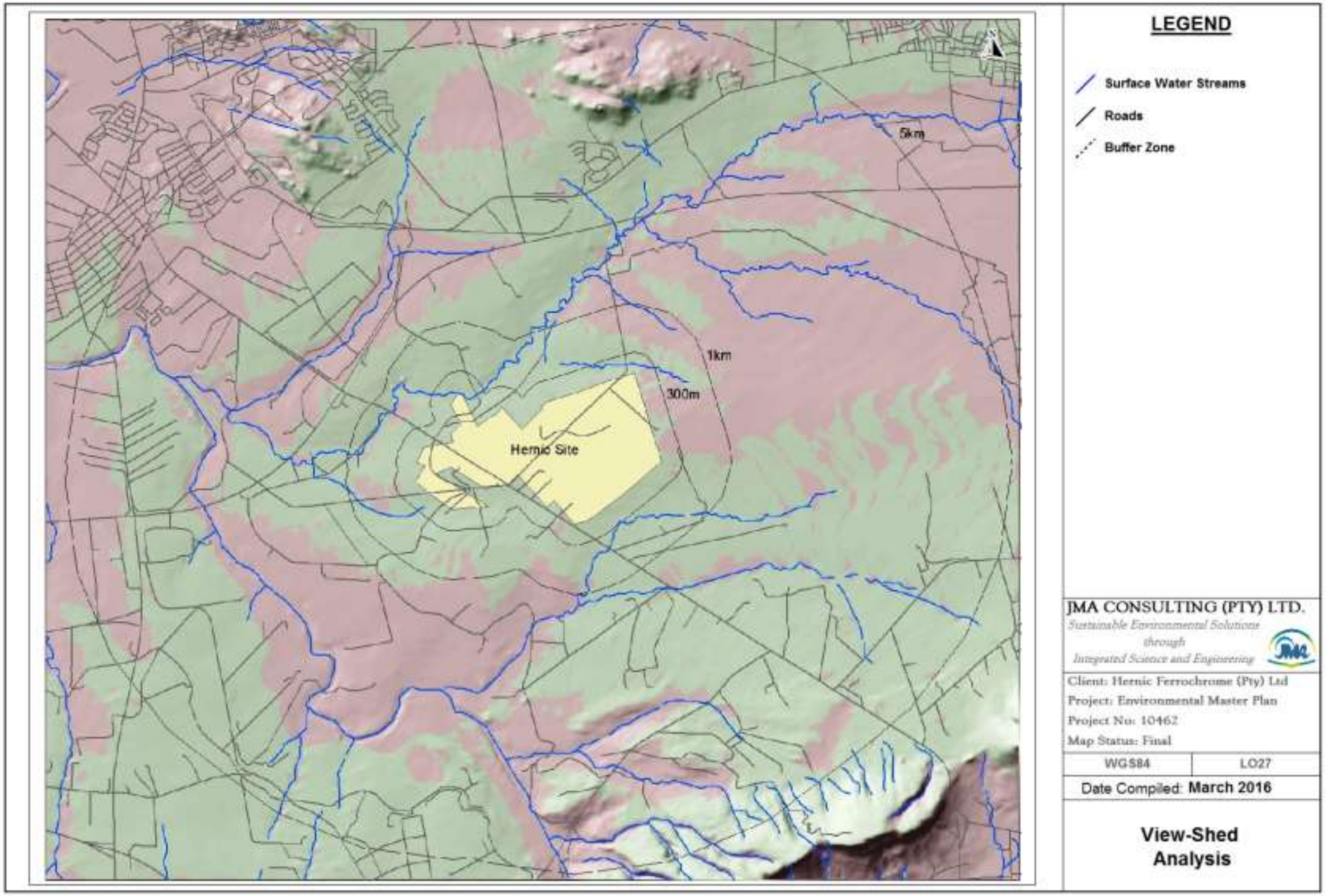


Figure 8.4.9.4(a): View-Shed Analysis of HERNIC Topographical Setting.

8.4.10. Soils and Land Capability

The relevant Specialist Report is:

Baseline Description of the Environment: Soils, Land Capability and Land Use of HERNIC Ferrochrome (Pty) Ltd, Brits Operations and Surrounds, September 2016. B.B. McLeroth, Red Earth cc.

8.4.10.1. Soils

Soil-mapping units are indicated on Figure 8.4.10.1(a) and are summarized in terms of soil form in Table 8.4.10.1(a).

The different soil types identified were grouped together into soil-mapping units on the basis of soil form, effective soil depth (ESD) for rehabilitation (stripping depth) and cropping (effective rooting depth - ERD), surface features, parent material, perched soil water-table depth, location of precipitated surface (day-lighting surface efflorescence) or sub-surface salts associated with pollution plumes (not observed in the current survey area due to recent rain), and overburden/underburden 'waste' (large variety of materials) or 'non-waste' type/depth/location (where present).

The soils encountered in the survey area were divided into five broad groups.

Vertic soils (Arcadia and Rensburg forms) [266.62 *ha*; 42.95 %]

These relatively poorly drained (slowly draining) soils display 'dark' colours including black and very-dark-grey [hue 10YR] in the topsoil, and are highly dominant in the survey area, occurring in all slope positions.

These strongly structured clay (majority) to clay-loam (occasionally), or sandy-clay-loam (rarely - shallow examples) textured vertic topsoils are collectively shallow to deep (0.2 - 1.5 *m*). These soils are derived from the most base rich parent material types in the area, namely norite (and anorthosite). The Arcadia form is the most dominant form in the survey area (crest and midslope positions) and generally overlies saprolite (weathering rock) or hard rock; and very rarely a non-diagnostic soft carbonate horizon.

The Rensburg form is the second most dominant naturally occurring soil form in the survey area, the vertic topsoil overlying a clay-textured calcareous (generally) G-horizon (synonymous with gley or gleyed) at depth. This underlying gleyed (intense reduction as a result of prolonged saturation with water) horizon is generally thin (0.2 - 0.4 *m*) in the lower-midslope positions, but may be (not always) thick (>0.5 *m*) in the valley-bottom positions. In the latter slope positions, the areas of the Rensburg form are clearly classifiable as permanent wetlands, and have been mapped as "Wp" (Wetland Permanent).

However, in the former lower-midslope positions, the thin G-horizon is hereafter (in this report) referred to as a 'pseudo' G-horizon since it in turn overlies weathering/hard rock or very rarely a soft carbonate horizon. This narrow band of 'pseudo' G-horizon has probably formed at the bottom of the vertic A-horizon due to the increasingly poor aeration of the soil with depth, as well as temporary waterlogging (during the rainy season only) above the relatively impermeable weathering/hard rock layer. Areas of the Rensburg form which occur in lower-midslope positions and which display a 'pseudo' G-horizon; have in this report been mapped as "Wp-A" (Wetland Permanent transitional Arable) or "Wp-G" (Wetland Permanent transitional Grazing) [depth dependent].

Table 8.4.10.1(a): Summary of Soil Form

Soils Summary								
Broad Soil Group	Map Notation	Soil Form (South African Taxonomic System)	Soil Horizons	Count	Area			
					ha	%	ha	%
Red apedal	Hu	Hutton	orthic A/red apedal B	11	4.59	0.74	4.59	0.74
Pedocutanic	Sw	Swartland	orthic A/pedocutanic B/saprolite (occasionally	11	9.82	1.58	12.04	1.94
	Va	Valsrivier	orthic A/pedocutanic B/unconsolidated material without signs of wetness	3	0.44	0.07		
	Bo	Bonheim	melanic A/pedocutanic B/unspecified	3	1.78	0.29		
Shallow	Ms	Mispah	orthic A/hard rock	8	3.46	0.56	6.45	1.04
	My	Mayo	melanic A/lithocutanic B	4	1.99	0.32		
	Mw	Milkwood	melanic A/hard rock	3	1.00	0.16		
Vertic	Ar	Arcadia	vertic A (overlying weathering rock, hard rock, or rarely calcrete in this area)	198	206.89	33.33	266.62	42.95
	Ar/Wb	Arcadia and Witbank		2	1.60	0.26		
	Ar-Rg	Arcadia transitional Rensburg		4	1.76	0.28		
	Rg-Ar	Rensburg transitional Arcadia		13	27.91	4.50		
	Rg	Rensburg	vertic A/ G-horizon	27	28.46	4.58		
Man-made	Wb/Rg	Witbank and Rensburg		1	1.26	0.20	30.92	4.98
	Wb	Witbank	orthic A/man-made 'soil' deposit (frequently vertic A topsoil in this area)	15	29.66	4.78		
	Stream	'Stream' (natural)		4	0.19	0.03	0.19	0.03
SUB-TOTAL (SOILS)				**307**	**320.81**	**51.68**	**320.81**	**51.68**

NOTE: Man-Made Features comprise 299.94ha (48.32%) of the study area.

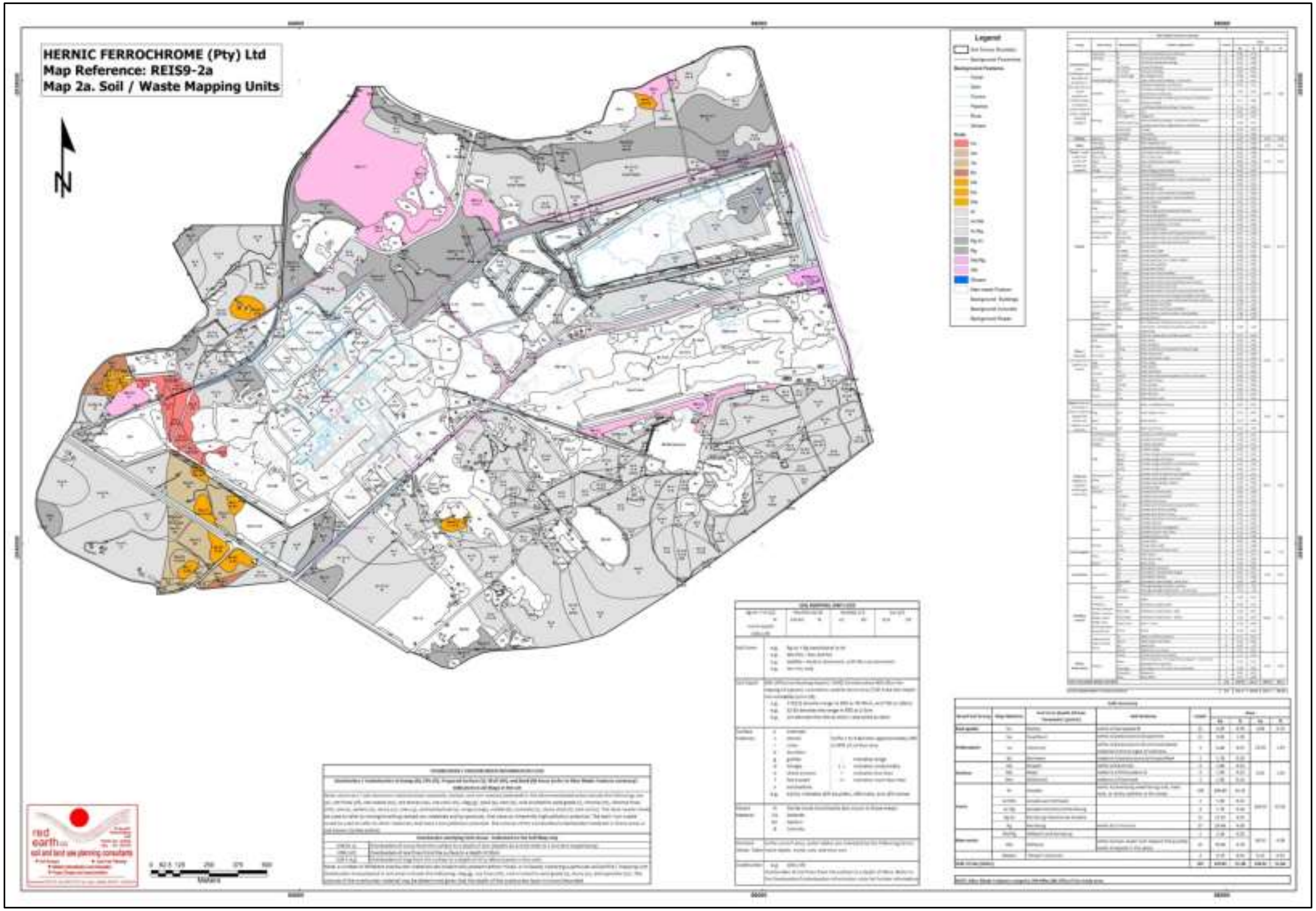


Figure 8.4.10.1(a): Soil Mapping Units

A number of areas displaying anthropogenic (as a result of the activities of man) moisture of the Rensburg transitional Arcadia soil forms have been mapped as “W man” (Wetland – ‘man-made’ anthropogenic wetlands). Runoff or seepage derived from the man-made features has infiltrated the affected areas over an extended period of time, resulting in a certain amount of wetness, mottling and gleying in a ‘pseudo’ G-horizon (at depth) as a result. However, these areas also display sections of naturally occurring Rensburg soil forms, the boundary between the naturally occurring and anthropogenic examples being difficult to differentiate as a result of surface disturbance as well.

Many of the “Wp-A”, “Wp-G”, and “W man” mapping units do not appear to be wetland areas based on the surface vegetation, the classification as wetland being entirely based on the soil form (Rensburg). However, other of the aforementioned units clearly display wetland vegetation (hydrophytes), and particularly so in a number of the “W man” areas.

Topsoil (A-horizon) S-values (cmol (+) kg^{-1} clay = leaching status) are all eutrophic (S-value >15 = high base status = very poor leached).

Approximately half of the vertic A-horizons in the survey area are slightly calcareous (effervesces visibly when treated with cold 10 % hydrochloric acid) at depth (and also in the underlying G-horizon).

The vertic soils are very poorly leached, given both the high base reserve of the norite (and anorthosite) parent material from which they are derived, as well as the low effective rainfall (interaction of the low mean annual precipitation, the high mean annual evaporation, and the moderate mean annual temperature) in the area, whereby the leaching potential is insufficient to remove base cations (calcium and/or calcium-magnesium carbonates) from the soil profile.

Due to their high clay content and the predominance of smectitic clay minerals, vertic soils possess the capacity to swell and shrink markedly in response to moisture changes. Such expansive materials have a characteristic appearance: structure is strongly developed, ped faces are shiny, and consistence is highly plastic when moist and sticky when wet. Swell-shrink potential is manifested typically by the presence of conspicuous vertical cracks (dry state), the presence of slickensides (polished or grooved glide planes produced by internal movement), and either a self-mulching (crumbly) or crusting soil surface. Once the soils are moist and the surface cracks have closed, the permeability becomes slow to very slow, and rainfall runs off laterally on the surface.

The shrinking/swelling properties of these soils results in a narrower moisture range for cultivation than most other agricultural soils. When wet, the pores saturate easily and drain slowly, resulting in anaerobic conditions in the rooting zone. When dry, these soils crack thereby damaging roots. Vertic soils thus require complex irrigation scheduling.

The moderate to poor quality vertic A-horizons have an unfavourable structure (strong blocky), consistence (very firm to firm) and permeability (slow to very slow once moist). These soils should nevertheless be utilized for cultivation and rehabilitation ‘topsoiling’ purposes since they are highly dominant in the areas that may possibly be disturbed in the future (as well as in those areas which have already been disturbed). The vertic soils are also the basis of the agriculture (cultivation) in the adjacent areas, and are being successfully irrigated. The utilization of the vertic soils for rehabilitation ‘topsoiling’ purposes will ensure soil, and consequently vegetative continuity in the area.

This material is also the most suitable of all of the broad soil groups for sealing purposes, since it naturally displays at least a slow permeability once moist, and possibly a very slow permeability once compacted.

Pedocutanic soils (Swartland, Bonheim and Valsrivier forms) [12.04 *ha*; 1.94 %]

A narrow band of the pedocutanic (all occurrences), red apedal (all occurrences), and shallow (approximately half of occurrences) broad soil groups occur in a north - south trending dyke (or fault) area to the west of the smelter plant. The naturally occurring indigenous bush is thicker and more diverse in these areas, as compared with the surrounding vertic broad soil group areas.

The one band/patch of pedocutanic soils is fragmented into seven patches by man-made features.

These soils are relatively well drained; dark-reddish-brown, dusky-red or reddish-brown) [hue 5YR and 2.5YR] in colour; mostly shallow to intermediate (0.3 - 0.5 *m*), and rarely deep (0.7 - 1.0 *m*) in depth; and overlie weathering or hard rock.

Textures are generally sandy-clay-loam to loam in the topsoil, and clay to clay-loam in the subsoil, while structure varies from coarse-granular to moderate blocky in the topsoil, and strong-very-thick-platy to strong blocky in the subsoil.

These soils are also very poorly leached (eutrophic) and rarely become calcareous at depth.

The pedocutanic subsoils are non-uniform in colour due to the presence of cutans (clay skins) on most ped surfaces, and both the presence of 2: 1 clays and the generally high clay contents have given rise to the pedality (structure) of the soils.

These soils have formed on a parent material type/phase that has a moderate to high content of weatherable minerals, similar to that of the red apedal soils. However, these soils have a slightly higher proportion of swelling 2: 1 clay types than the red apedal soils. The iron mineral hematite imparts the red pigment to the pedocutanic soils and is indicative of oxidizing conditions.

The moderate quality orthic A and pedocutanic B horizons are highly suitable materials for annual cropping (good rooting medium) where depth allows (rarely), and use as 'topsoil'. However, these soils must not be disturbed due to the relatively high bio-diversity (generally thick bush when not cut down) in this area.

Red apedal soils (Hutton form) [4.59 *ha*; 0.74 %]

These soils exclusively occur in one band/patch (fragmented into six patches by man-made features) in the narrow north - south trending dyke (or fault) area to the west of the smelter plant.

These soils are well drained, dark-reddish-brown [hue 5YR or 2.5YR] in colour, shallow to intermediate [depth] (0.3 - 0.5 *m*) in depth, are frequently rocky (none - 50 % surface cover of boulders and rocks) and overlie weathering or hard rock.

Textures are generally clay in both horizons, while structure is weak blocky or moderate blocky in the topsoil and weak-fine-crumb in the subsoil.

These soils are also very poorly leached (eutrophic).

These soils have formed on a parent material type/phase that has a moderate to high content of weatherable minerals, similar to that of the pedocutanic soils.

The clay mineral suites of the red apedal soils display slightly greater proportions of non-swelling 1: 1 types than swelling 2: 1 types, the relative proportions varying slightly between the different auger points and horizons (hence the variability in structural development). The iron mineral hematite imparts the red pigment to the red apedal soils and is indicative of oxidizing conditions.

The high quality orthic A and red apedal B horizons are highly suitable materials for annual cropping (good rooting medium) and use as 'topsoil' in the non-rocky sections. However, this is not the case in the rocky sections. These soils have favourable texture (clay), structure (weak blocky, moderate blocky or weak-fine-crumb) and consistence (friable to firm). However, these soils must not be disturbed due to the high bio-diversity (generally thick bush when not cut down) in this area.

Shallow soils (Mispah, Mayo and Milkwood forms) [6.45 *ha*; 1.04 %]

These soils occur in eight distinct patches (fragmented into fifteen patches by man-made features) associated with dykes (or faults) in midslope positions. Approximately half of these occurrences are four distinct patches in the narrow north - south trending dyke (or fault) area to the west of the smelter plant.

These soils are shallow (0.05 - 0.3 *m*) in depth, and rocky (generally 10 - 60% surface cover of boulders, rocks or stones).

The norite derived melanic topsoils are very poorly leached (eutrophic); and display a brown, dark-brown or very-dark-grey [hue 10YR] colour; clay texture; and a crumb, weak blocky or strong blocky structure. The gabbro (possibly) derived orthic topsoils in the dyke (or fault) area are also very poorly leached (eutrophic); and display a dark-brown [hue 7.5YR] or occasionally dark-reddish-brown [hue 5YR - Hutton form in patches] colour; sandy-clay-loam texture; and a weak blocky to moderate blocky structure.

The melanic and orthic A-horizons are unsuitable for annual cropping or forage plants. These stony topsoils constitute a poor rooting medium, displaying very low total available moisture (drought prone). These wilderness and grazing capability class areas must be preserved as repositories of bio-diversity, which is presently high (thick bush) in these areas.

Man-made soils (Witbank form) [30.92 *ha*; 4.98 %]

Six areas of the Witbank soil form occur in the survey area. These areas have been fragmented into sixteen patches by man-made features.

In terms of the Hernic Operational Areas three of these rehabilitated areas of man-made soils lie within Hernic Operational Areas and three within the Adjacent Areas. The three that lie within the Hernic Operational Areas include the following: one area within the Alloys Smelting Plant area (back-filled and 'topsoiled' borrow pit), one within the Morula Mining Opencast Operation area (north-eastern edge of opencast), and one within the Morula Mining Shaft Complex area (band to the south of the internal tar road that divides the opencast area from the underground area). The three rehabilitated areas that lie within the Adjacent Areas all lie within the Crocodile Mine Area (one large back-filled and 'topsoiled' opencast area, and two 'topsoiled' low peripheral 'rock dump' areas).

All of these man-made soils are comprised of vertic 'topsoil' material overlying waste rock or spoil derived from opencast mining areas, with the exception of the one borrow-pit area which was not an opencast mining area. However, this area too is comprised of vertic 'topsoil' material (overlying rocky fill material).

The 'topsoiling' depth within the rehabilitated areas varies from 20 (rehabilitated grazing transitional wilderness capability class) – 60 *cm* (rehabilitated grazing transitional arable capability class). The characteristics of the vertic broad soil group have already been described previously (refer to Point i).

Apart from those rehabilitated areas mentioned in the second paragraph, almost none of the Alloys Smelting Plant, Morula Mining Opencast Operation, and Morula Mining Shaft Complex areas display any other areas where rehabilitation operations are completed. However, in the Morula Mining Opencast Operation area there are a number of fairly extensive opencast sections which have been back-filled and levelled, but not 'topsoiled'. In the same opencast area there are also many sections where the spoil has not been levelled, while two final voids also remain to be filled with spoil.

The reason for the lack of completed rehabilitation operations in the majority of the Hernic Operational areas are described. Within the Alloys Smelting Plant area, most of the surface materials are still required (either now or in the future) in the various smelter processes, and these areas will be rehabilitated in the future during the closure phase. In the Morula Mining Opencast Operation area, rehabilitation operations are ongoing (mostly filling voids and re-grading uneven surfaces at this stage) and will be completed over time. In the Morula Mining Shaft Complex area, although the mine is temporarily closed the various facilities and features will still be required when the mine re-opens, and these areas will be rehabilitated in the future during the closure phase.

Within the Crocodile Mine Area there are still a number of low rock dumps, two excavations, and one pile of rubble that remain to be consolidated and rehabilitated. The rubble pile could be utilised to fill the two excavations (thereafter 'topsoiled', ameliorated, and re-vegetated), while the material in the low rock dumps could be consolidated at the site of the feature that is next described. There is also a large (high) spoil dump that will remain in perpetuity as a hill, but which must still be re-graded, 'topsoiled' and re-vegetated (if feasible). This dump is presently too steep and rocky for vegetation to colonise.

The standard of the rehabilitation operations in the various areas are described:

- Alloys Smelting Plant area (back-filled and 'topsoiled' borrow pit) – rehabilitated to a high standard (rehabilitated grazing capability class 'topsoiling' depth of 50 – 60 *cm*, 2 degree slope, 10 % small surface stones in some areas acceptable);
- Morula Mining Opencast Operation area (north-eastern edge of opencast) – rehabilitated to an acceptable standard (rehabilitated grazing capability class 'topsoiling' depth of 30 – 50 *cm*, 2 degree slope, 5 % surface rocks must be removed);
- Morula Mining Shaft Complex area (band to the south of the internal tar road that divides the opencast area from the underground area) – rehabilitated to a relatively low to moderate standard (rehabilitated grazing capability class 'topsoiling' depth of 20 – 30 *cm*, 2 - 8 degree slope, 5 - 10 % surface rocks must be removed); and
- Crocodile Mine Area (one large back-filled and 'topsoiled' opencast area, and two 'topsoiled' low peripheral 'rock dump' areas). Former area rehabilitated to a high standard (north - rehabilitated grazing capability class 'topsoiling' depth of 20 – 30 *cm*, average 2 degrees evenly sloping, no surface rocks); and a low standard (south - rehabilitated wilderness capability class 'topsoiling' depth of 20 *cm*, 2 degree slope, 30 - 40 % surface rocks must be removed). Latter areas rehabilitated to a low standard (rehabilitated grazing capability class 'topsoiling' depth of 20 – 30 *cm*, uneven surface, 2 - 4 degree slope, 5 - 20 % surface rocks must be removed).

Streams (0.19 *ha*; 0.03 %) and Man-Made features (299.94 *ha*; 48.32 %) comprise the balance of the total survey area (620.75 ha; 100.00 %); the aforementioned being indicated in Table 8.4.10.1(a) and Table 8.4.4(a) respectively.

8.4.10.2. Land Capability

Land capability classes were determined using the guidelines outlined in the following document produced by The Chamber of Mines of South Africa / CoalTech: Guidelines for the Rehabilitation of Mined Land (November 2007).

The aforementioned guidelines were extracted (unchanged) from the following document produced by The Chamber of Mines of South Africa: Handbook of Guidelines for Environmental Protection - The Rehabilitation of Land Disturbed by Surface Coal Mining in South Africa (volume 3, 1981).

A summary of the land capability classes is presented in Table 8.4.10.2(a).

Table 8.4.10.2(a): Land Capability Requirements

Criteria for Wetland

- Land with organic soils or
- A horizon that is gleyed throughout more than 50 % of its volume and is significantly thick, occurring within 750mm of the surface.

{*Note: The DWAF definition (DWAF. Edition 1, September 2005) has now superseded this definition, and instead considers a wetland to occur if the soil wetness indicator occurs within 500mm of the surface. Exceptions are the Champagne, Rensburg, Katspruit and Willowbrook forms, which may be of any depth. The topsoils of the former two forms are frequently deeper than 500mm*}

Criteria for Arable Land

- Land, which does not qualify as a wetland
- The soil is readily permeable to the roots of common cultivated plants to a depth of 750mm
- The soil has a pH value of between 4.0 and 8.4
- The soil has a low salinity and SAR
- The soil has a permeability of at least 1.5mm per hour in the upper 500 mm of soil
- The soil has less than 10 % (by volume) rocks or pedocrete fragments larger than 100mm in diameter in the upper 750mm
- Has a slope (in %) and erodibility factor (K) such that their product is <2.0
- Occurs under a climatic regime, which facilitates crop yields that are at least equal to the current national average for these crops, or is currently being irrigated successfully

Criteria for Grazing Land

- Land, which does not qualify as wetland or arable land
- Has soil, or soil-like material, permeable to roots of native plants, that is more than 250mm thick and contains less than 50 % by volume of rocks or pedocrete fragments larger than 100mm
- Supports, or is capable of supporting, a stand of native or introduced grass species, or other forage plants, utilizable by domesticated livestock or game animals on a commercial basis

Criteria for Non-Grazing (Wilderness)* Land

- Land, which does not qualify as wetland, arable land or grazing land.

***Note that the term "Wilderness", which was in common usage in South Africa due to its erroneous definition in the 1981 Chamber of Mines guidelines, is no longer used. The definition of "wilderness" is globally accepted to be land which has not been impacted upon by human development or settled agricultural or industrial activities. The aforementioned is not the case in areas overlaid by 'wastes', or underlain by a pollution plume (as indicated by degraded vegetation)**

A further document was utilised in order to subdivide the wetlands into three classes (permanent/semi-permanent, seasonal and temporary), as well as to identify riparian areas. The aforementioned document is entitled 'A Practical Field Procedure for Identification and Delineation of Wetlands and Riparian Areas', and is published by the Department of Water Affairs and Forestry (Edition 1, September 2005). Table 8.4.10.2(b) is extracted from Figure 8.4.10.2(a) and summarizes the information for the survey area.

Table 8.4.10.2(a): Summary of Land Capability and Wetlands

Land Capability and Wetlands Summary							
Land Capability	Map Notation	Description	Count	Area			
				ha	%	ha	%
Arable	A	Arable [Arcadia form; Effective Rooting Depth (ERD) 80-160cm, majority <120cm]	58	78.86	12.70	91.26	14.70
	A-Wp	Arable transitional Wetland (permanent). [Arcadia transitional Rensburg form; ERD 70-100cm]. Slight mottling at depth	4	1.76	0.28		
	A-G	Arable transitional Grazing. [Arcadia form; ERD 70cm]	10	10.64	1.71		
Grazing	G-A	Grazing transitional Arable. [majority Arcadia form, one Bonheim form; ERD 60-70cm]	10	14.70	2.37	115.61	18.62
	G	Grazing. [majority Arcadia form; also Bonheim, Hutton, Mayo, Swartland forms; ERD 30-70cm]	125	100.91	16.26		
'Non-Grazing'	L	'Non-Grazing' ('Wilderness'). [Arcadia, Hutton, Mispah, Milkwood, Mayo forms; ERD 10-20cm, or 40-70cm if very rocky]	38	25.08	4.04	25.08	4.04
Wetland	Wp	Wetland (permanent). [Rensburg form; ERD 20-150cm, majority >50cm]	23	24.88	4.01	57.94	9.33
	Wp-A	Wetland (permanent) transitional Arable. [Rensburg transitional Arcadia form; ERD 80-90cm]. Narrow (20-40cm thick) natural 'pseudo' G-horizon overlying saprolite	5	2.69	0.43		
	Wp-G	Wetland (permanent) transitional Grazing. [Rensburg transitional Arcadia form; ERD 50-70cm]. Narrow (20-40cm thick) natural 'pseudo' G-horizon overlying saprolite	1	5.51	0.89		
	W man	Wetland ('man-made' anthropogenic wetlands - due to water runoff and seepage from man-made features; wetness, mottling and gleying developing at depth as a result). [Rensburg transitional Arcadia, Rensburg, and Arcadia forms; ERD 40-140cm, majority >60cm]	13	24.67	3.97		
	Stream	'Stream' (natural). Thus defined as a Permanent Wetland	4	0.19	0.03		
Rehabilitated Grazing and 'Non-Grazing'	RG	Rehabilitated (Grazing). [Witbank form; ERD 20-30cm, and slightly rocky]	15	28.54	4.60	30.92	4.98
	RL	Rehabilitated ('Non-Grazing' 'Wilderness'). [Witbank form; ERD 20cm, and more rocky]	1	2.38	0.38		
SUB-TOTAL (LAND CAPABILITY and WETLANDS)			**307**	**320.81**	**51.68**	**320.81**	**51.68**

NOTE: Man-Made Features comprise 299.94ha (48.32%) of the study area.

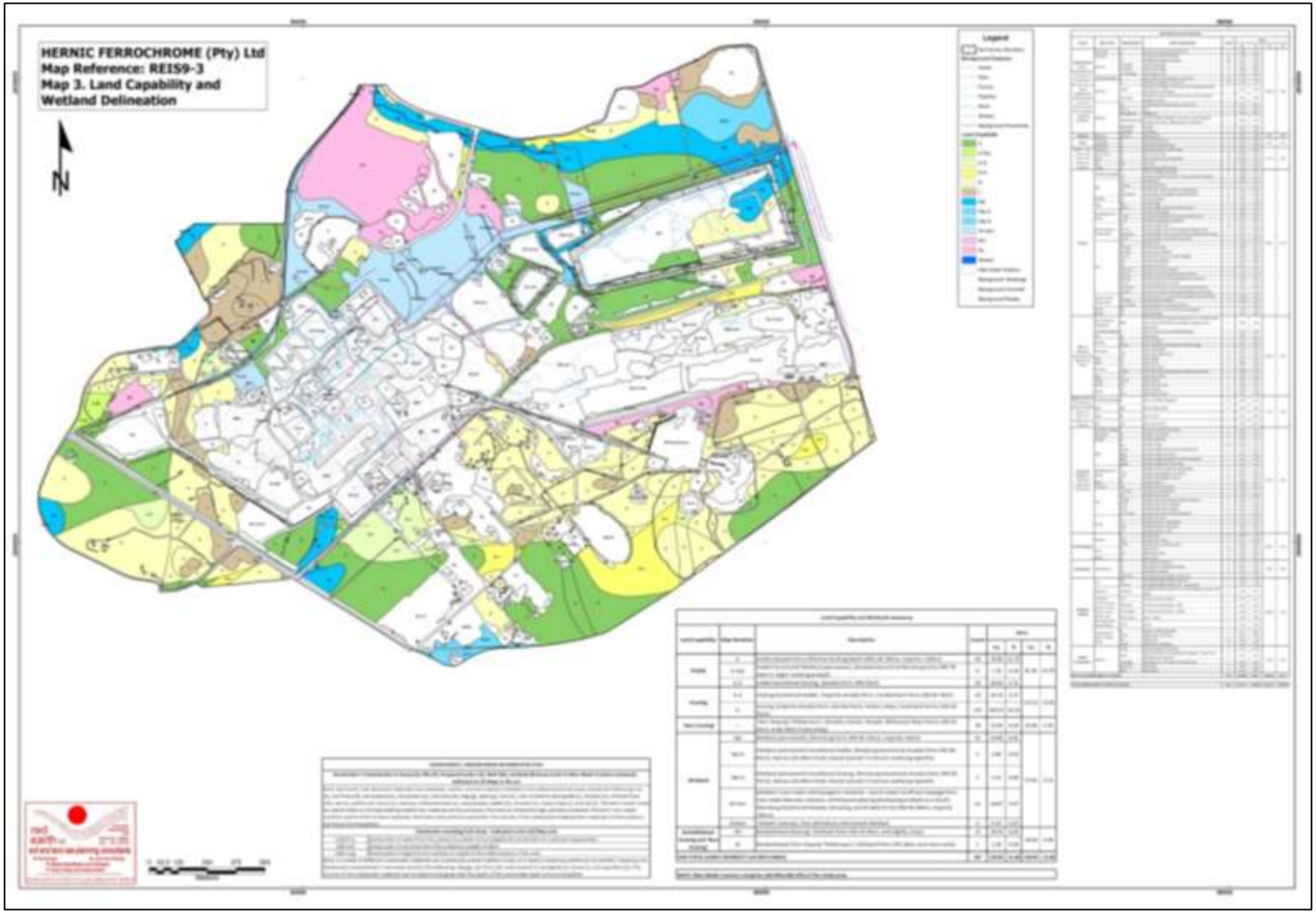


Figure 8.4.10.2(a): Land Capability Delineation

8.4.11. Geology

The relevant Specialist Report is:

Geology Baseline Report for HERNIC Ferrochrome (Pty) Ltd, May 2016. JMA Consulting (Pty) Ltd.

8.4.11.1. Introduction

The geology of the study area forms the basis for the topography, soils, vegetation, groundwater and surface water components of the biophysical environment. The current underground and previous opencast mining operations at HERNIC as well as the extensive mining operations adjacent to HERNIC are dependent on the nature of the underlying geology as well. The geology and nature thereof therefore represent a crucially important component of the overall biophysical environment within the study area. A fundamental understanding of the regional geology as well as a site specific quantitative description of the geology at and adjacent to HERNIC is thus a prerequisite on which to base impact assessments for the geophysical as well biophysical environments and from which to design and implement effective environmental management measures related to these environmental components.

8.4.11.2. Fieldwork and Research

The geological investigation conducted at HERNIC entailed a quantitative site specific investigation using data obtained in the field during the drilling of 8 geological / geohydrological investigative boreholes, in addition to the information documented during previous studies and in published articles and reports (Figure 8.4.11.2(a)). The geological / geohydrological investigative boreholes were drilled to depths that fully intersected the shallow weathered zone aquifers and were drilled to an average depth of 27.01 *mbgl*. The lithology that was penetrated, its weathering and fracturing status as well as its water yielding capacity was recorded for each borehole during the drilling operations to confirm / verify the geological conditions within the study area.

8.4.11.3. Regional Geological Setting

The HERNIC study area is located within the western limb of the Precambrian Bushveld Igneous Complex (BIC) and is underlain by the Rustenburg Layered Suite lithologies of the BIC which dip at an angle of around 17° to the north/north-west (Figure 8.4.11.3(a)). These lithologies typically range from norites and anorthosites through to gabbros, harzburgites, magnetites and pyroxenites.

The BIC contains the world's largest reserves of PGE's; namely platinum, palladium, osmium, iridium, rhodium and ruthenium along with vast quantities of iron, tin, chromium, titanium and vanadium. The western limb of the BIC has been and is still currently being extensively mined for chromium and platinum group elements (PGE's) by both opencast and underground mining methods.

The BIC is best known for its intimately interrelated mafic intrusive bodies and is the thickest and most extensive structure of its kind in the world. Partial differentiation of the crystals from the melt (due to the slow cooling of the magma) formed the indicative differentiated or layered property of the BIC. During partial differentiation, the heaviest minerals such as olivine and pyroxene as well as the sulphide minerals (including the PGE's) and oxide minerals (magnetite, chromite) concentrate towards the base of each layer. The lighter minerals such as feldspar and quartz thus tend to form at the top of the respective layers.

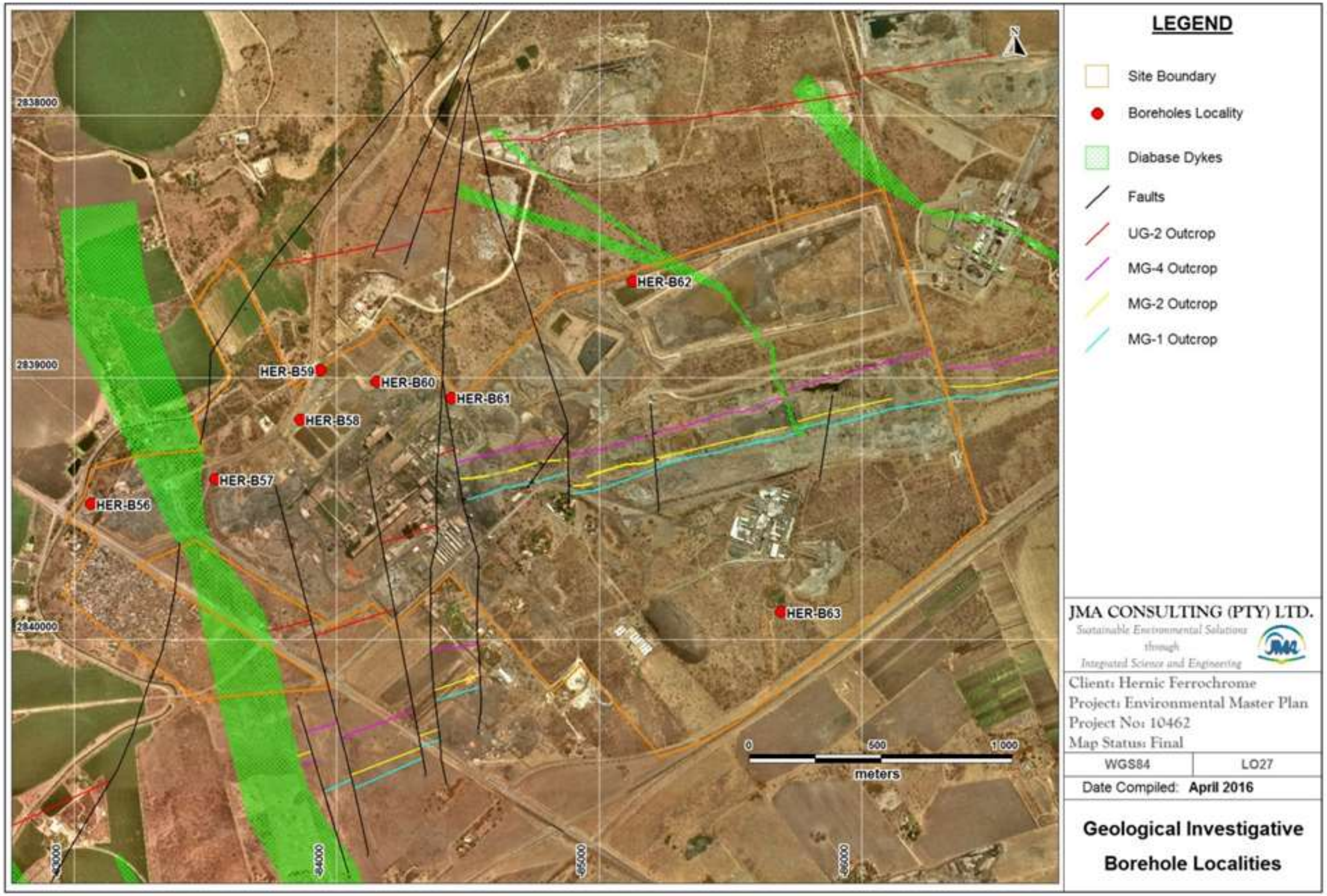


Figure 8.4.11.2(a): Geological Investigative Borehole Localities

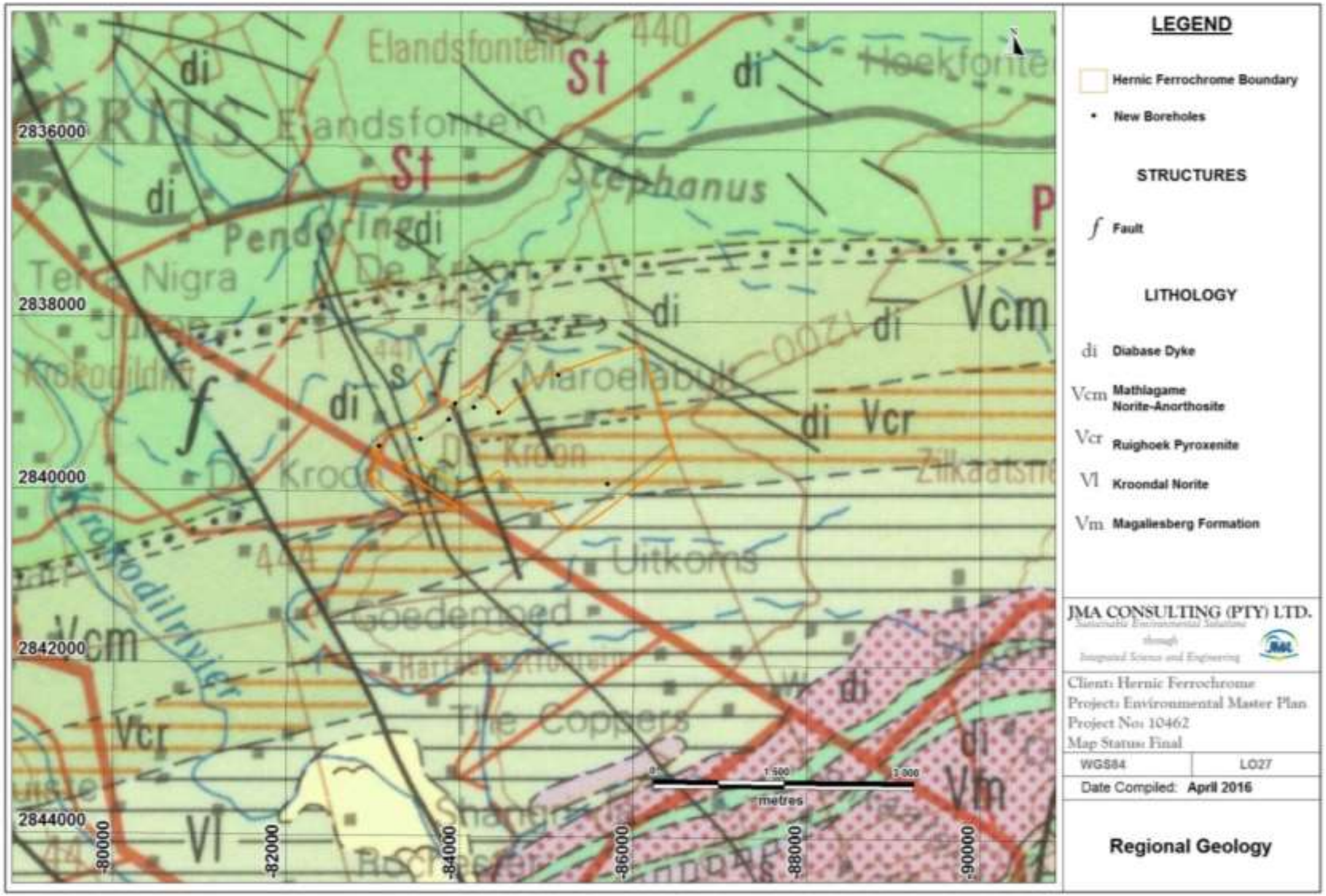


Figure 8.4.11.3(a): Regional Geological Setting

The BIC is subdivided into a felsic suite namely the Rooiberg Group and three mafic suites, namely the Lebowa Granite Suite, the Rashoop Granophyre Suite and the Rustenburg Layered Suite. Most of the mineralization in the BIC occurs within the Rustenburg Layered Suite. The Rustenburg Layered Suite is economically the most important suite in the Bushveld Igneous Complex and some of the more important and economically exploitable horizons include the LG-6, MG-1, MG-2, MG-3, MG-4, UG-1 and UG-2 chromitite layers as well as the Merensky Reef.

8.4.11.4. Site Surface Geology

The surface geology to the far south and south-east of the study area consists predominantly of lithologies of the Magaliesberg Formation. The sandstones and quartzites of the Magaliesberg Formation are highly resistant to weathering and as a result give rise to the Magaliesberg Mountain Range. The surface geology to the north of the Magaliesberg Formation and within the southern extent of the study area (to the south of HERNIC) consists of Kroondal Norites of the BIC which intruded into and above the lithological units of the Magaliesberg Formation and Silverton Formation of the Pretoria Group.

The Kroondal Norites are overlain to the north by the Ruighoek Pyroxenites of the BIC. The Ruighoek Pyroxenites make up the largest part of surface geology underlying HERNIC, specifically within the mining operational areas. A large scale fault, associated with the regional graben structure to the west of HERNIC, has displaced the Ruighoek Pyroxenites further to the south within the western sections of the HERNIC site boundary.

The Ruighoek Pyroxenites are further overlain by the Mathlagame Norites and Anorthosites of the BIC. These norites and anorthosites make up most of the northern area of the HERNIC site boundary. Pyramid Gabbro-Norites overly the Mathlagame Norites and Anorthosites and outcrop to the north of the HERNIC site boundary.

The Kolobeng Norites, Ruighoek Pyroxenites, Mathlagame Norites, and Pyramid Gabbro-Norites all form part of the Rustenburg Layered Suite of the Bushveld Igneous Complex. The Mathlagame Norites and Anorthosite and Pyramid Gabbro-Norites which underlie the HERNIC site area are confined to the economically important Upper, Critical and Main zones of the Rustenburg Layered Suite.

The host rock matrix at Hernic Ferrochrome (down to an average depth of 27 *mbgl*) comprises predominantly of weathered, fractured and fresh norites (Mathlagame Norites-Anorthosites) which are extensively covered by soil and / or overburden material at the surface. The soil comprises of a dark brown to greyish brown structured fine grained and clayey “turf” soil derived from the predominantly noritic parent material. The thickness of the soil penetrated during the drilling of the 8 investigative boreholes varies between 1.0 *m* and 4.0 *m*, with an average of 1.6 *m*.

The depth of weathering and weathering related fracturing is relatively deep and varies between 13.0 *m* and 22.5 *m*, with an average depth of 17.6 *m*. The norites weather down to a soft gritty matrix, which is unevenly distributed across the study area. The weathering / fracturing profile depth is combination of the primary weathering profile and the transitional fracturing zone which occurs immediately above the fresh bedrock interface.

The norite penetrated is predominantly grey to light grey in colour and is fine-medium grained in texture. The norite comprises predominantly of pyroxenes and plagioclase feldspars, with biotite and hornblende and mica’s observed in several of the samples. A typical profile of the geology penetrated at HERNIC is indicated on Figure 8.4.11.4(a), which is the geological profile for borehole HER-B56.

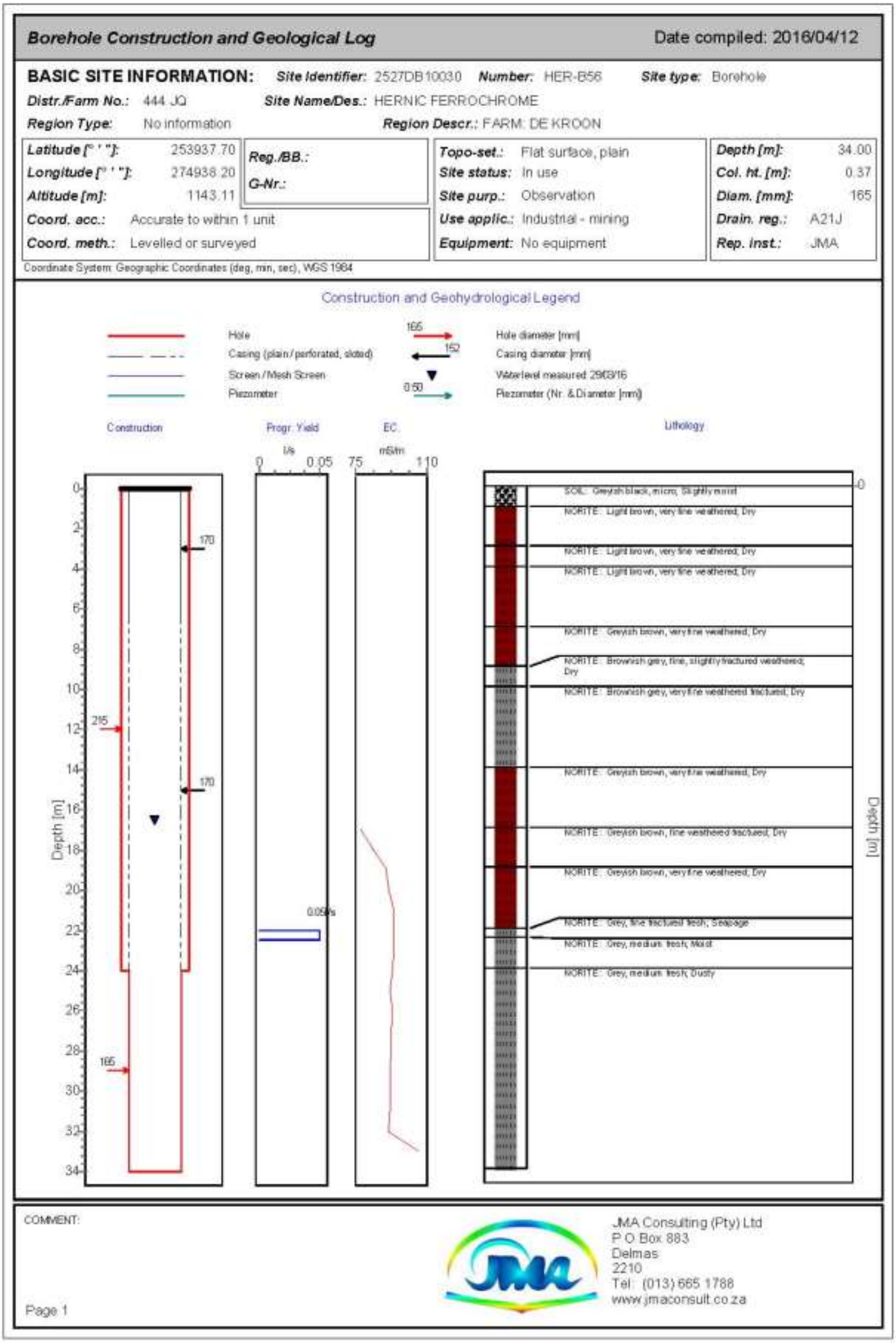


Figure 8.4.11.4(a): Typical Geological Profile at HERNIC (Borehole HER-B56)

The lithologies penetrated during the drilling operations (norites and anorthosites) comprise entirely of ino- and phylo- silicates. No sulphide and sulphate mineral phases were identified in the geology samples analysed. The geological units of the BIC are predominantly mafic to ultramafic in and it is therefore not expected that that the lithological units within the study area will generate acidic conditions.

This indicates that there is no potential for the underlying geology at HERNIC to generate acidic conditions. There is there is no possibility of fossils being present.

The mineralogical composition of the geology samples collected were however determined by means of XRD and the elemental composition was determined by means of XRF analytical methods. The Norite-Anorthosite samples collected consist predominantly of Plagioclase (87.5%), (92.9%) and (91.2%) respectively. These high plagioclase concentrations are typical of Anorthosite, which characteristically has more than 90% plagioclase feldspar in its mineralogical composition.

The gabbro-norite sample collected from borehole HER-B57 consists predominantly of Plagioclase (65.2%), whilst the sample collected from borehole HER-B59 consists mostly of Actinolite (27.32%). Actinolite is a silicate mineral which forms at contact metamorphism commonly associated with intrusive diabase dykes in proximity of gabbro-norite. Small amounts of diabase were observed in borehole HER-B59 during the drilling thereof, which could have provided the metamorphic conditions favourable for the formation of Actinolite. The high mineralogical concentrations of plagioclase (5.46%), diopside (11.33%) and enstatite (8.23%) are indicative of gabbros.

Although not penetrated in any of the boreholes (due to the restricted depth of drilling as well as the extent of the current mining operations), several chromitite layers are present within the study area. The MG-1, MG-2 and MG-4 chromite ore layers outcrop at HERNIC and are specifically mined for their chromium content. The extents of the MG-1, MG-2 and MG-4 chromitite layers (sub-outcrops) are delineated on Figure 8.4.11(a).

The mining operations at HERNIC are directly dependent on the nature of the underlying geology and associated chromite ore layers. The MG-1, MG-2 and MG-4 chromitite layers have historically been mined by opencast mining operations and are currently still being mined by underground mining operations within the eastern extent of the site.

Opencast mining operations historically took place at 4 separate pits on the Farms De Kroon 444 JQ and Elandsfontein 440 JQ. The extents of the 4 historic pits, namely the Western (7.3 *ha*), Central (24.7 *ha*), Eastern (7.4 *ha*) and Far Eastern (6.8 *ha*) Pits are delineated on Figure 4. From the layout plans provided by HERNIC it appears that the 4 pits were mined separately and they are not linked to each other. These pits have been / will be backfilled and rehabilitated. Once backfilled, the rehabilitated surface will be shaped to be free-draining and will be re-vegetated.

Mining is however currently taking place by means of underground mining operations at HERNIC. The underground mining operations are taking place below the Farms De Kroon 444 JQ and Elandsfontein 440 JQ and are accessed via the Morula Shaft Complex, delineated on Figure 8.4.11.4(b). The underground mining operations commenced in 2005 and although currently under care and maintenance, are planned to continue in the future.

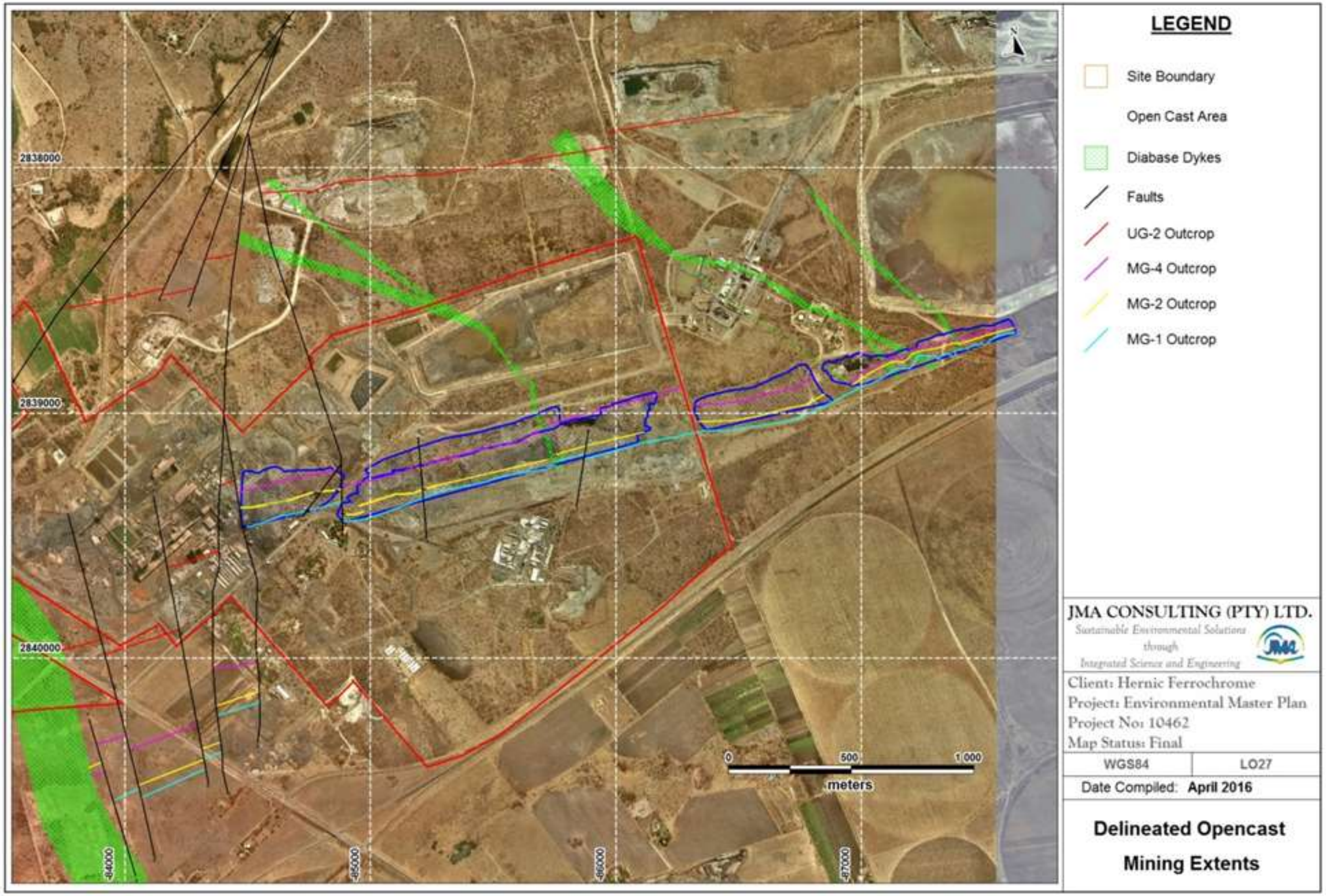


Figure 8.4.11.4(b): Delineated Opencast Mining Extents

The underground mining operations currently extract chromite ore from the MG-1 and MG-2 chromite seams, although mining of the MG-4 chromite seam is also authorised. The extents of the underground workings on the MG-1 and MG-2 Chromitite ores at HERNIC are delineated on Figure 8.4.11.4(c). There is a 15 *m* parting between the underground workings on the MG-1 (bottom) and MG-2 (top) Chromitite Ores.

The UG-2 is also a significantly important layer within the study area and is also being mined by underground mining operations, although not by HERNIC. Transgressive dykes, rolls, potholes and fault structures are indicated to often influence and negatively impact continuity of the chromitite layers exploited. The extent of the inferred dykes and faults are delineated on Figure 8.4.11.2(a).

There are three major diabase dykes at HERNIC which strike in a north-westerly to north-north-westerly direction (Figure 8.4.11.2(a)). They are younger in age than the RLS and have therefore intruded into and in some places displaced the chromitite seams within the RLS. Two of the three major diabase intrusions have sterilized some of the ore as is evident by the extent of the underground workings.

These faults significantly influence the continuity of the chromitite seams and thus the extent of the mining operations as well.

Several large scale (regional) faults have been identified and delineated within the study area as well (Figure 8.4.11.2(a)). The most predominant faults are the normal faults that trend in a northerly direction within the western and central regions of the HERNIC operations. These normal faults form part of the eastern side of a regional graben structure situated to the west of HERNIC. A Reverse fault is also identified trending in a northerly to north-westerly direction to the east of the normal faults where the chromitite layers are displaced to the north.

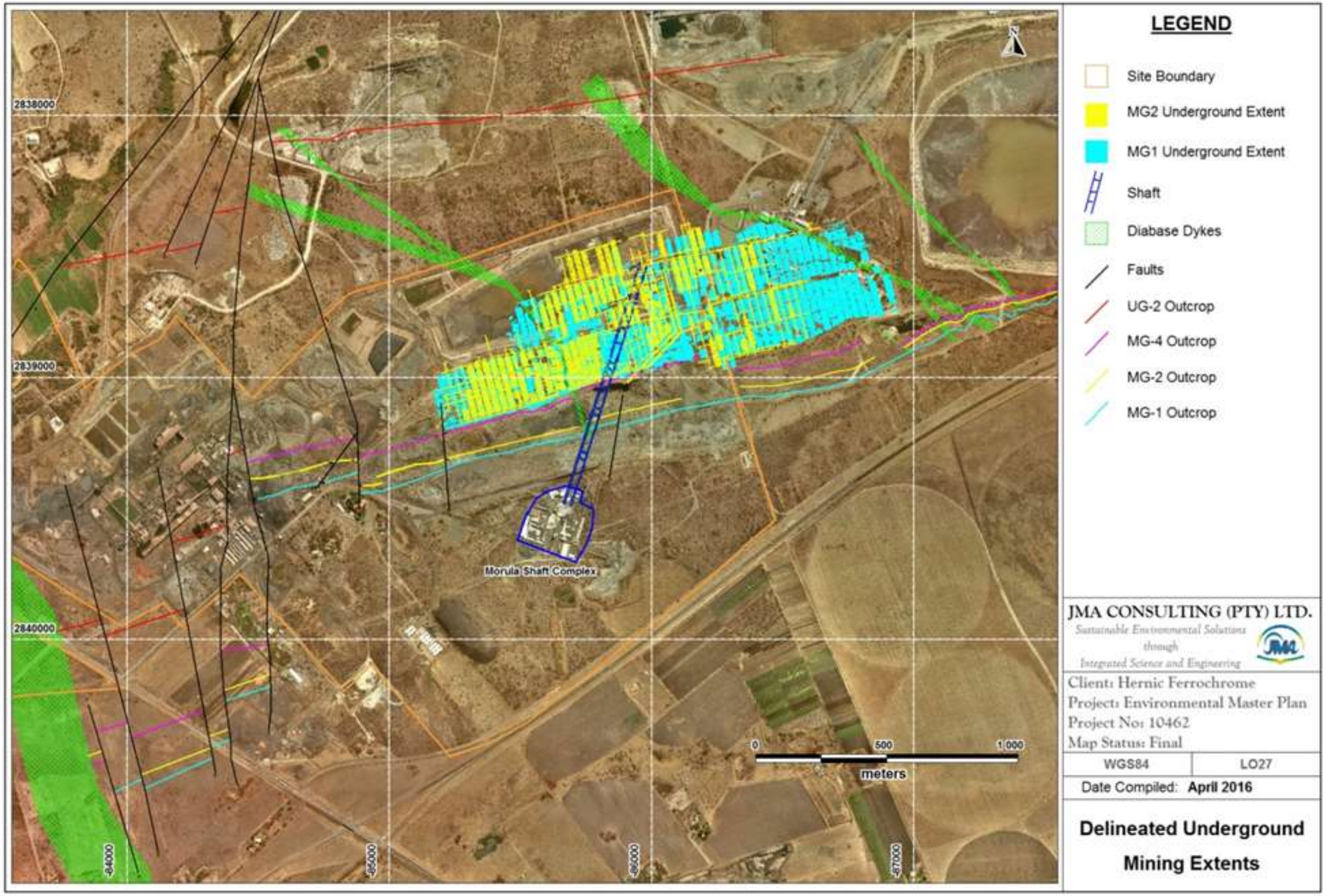


Figure 8.4.11.4(c): Delineated Underground Mining Extents'

8.4.12. Groundwater

The relevant Specialist Report is:

Groundwater Baseline Report for HERNIC Ferrochrome (Pty) Ltd, June 2016. JMA Consulting (Pty) Ltd.

8.4.12.1. Introduction

The geohydrological investigation conducted for the HERNIC project entailed a quantitative site specific investigation using data obtained in the field as well as information documented during previous studies, in accordance with the various guidelines and documents obtained from the regulating authorities. A detailed quantitative and site-specific fieldwork investigation was undertaken at HERNIC during February and March 2016 as part of the groundwater study.

8.4.12.2. Regional Geohydrology

The regional hydrogeological conditions are naturally influenced by the associated geological formations and properties thereof. The natural hydrogeological conditions within the study area have been significantly altered as a result of the historic opencast and current underground mining operations as addressed within this Groundwater Specialist Study Report.

The regional geohydrology at HERNIC is discussed with reference to the available information relevant to the clipped region of the published 1:500 000 Hydrogeological Map Series of the Republic of South Africa – Sheet 2526 Johannesburg, 1999, depicted as Figure 8.4.12.2(a).

There are two distinctly separate stratigraphic sequences within the larger study area, each with their own geohydrological manifestations, summaries of which are given below.

<u>Geohydrological Zone 1: Pretoria Group Meta-Sediments</u>

The area to the south of HERNIC is underlain by predominantly meta-argillaceous and meta-arenaceous rocks of the Pretoria Group - denoted by *Vp* on Figure 8.4.12.2(a).

Within this zone the groundwater primarily occurs within the joints and fractures of the competent argillaceous (mudstones, siltstones, shales) and arenaceous rocks (sandstones and quartzites), related to tensional or compressional stresses and offloading.

The borehole yielding potential within this geohydrological zone is classified as *b3*, which implies a median yield which varies between 0.5 *l/s* to 2.0 *l/s*. No large scale groundwater abstraction is indicated to occur from these fractured aquifers within the bounds of the study area. The groundwater potential for this area to the far south of HERNIC is given as between 40 and 60%, which indicates the probability of drilling a successful borehole (yield > 0.1 *l/s*) whilst the probability of obtaining a yield in excess of 2 *l/s* is given as between 20% and 30% (DWAF (1995) Sheet 1).

The mean annual recharge (MAR) to the groundwater system in the southern parts of the study area is estimated to be between 25 *mm* and 37 *mm* per annum, which relates to between 4% and 6% of the MAP. The groundwater contribution to surface stream base flow is relatively low, indicated at less than 10 *mm/annum* (DWAF (1995) Sheet 2).

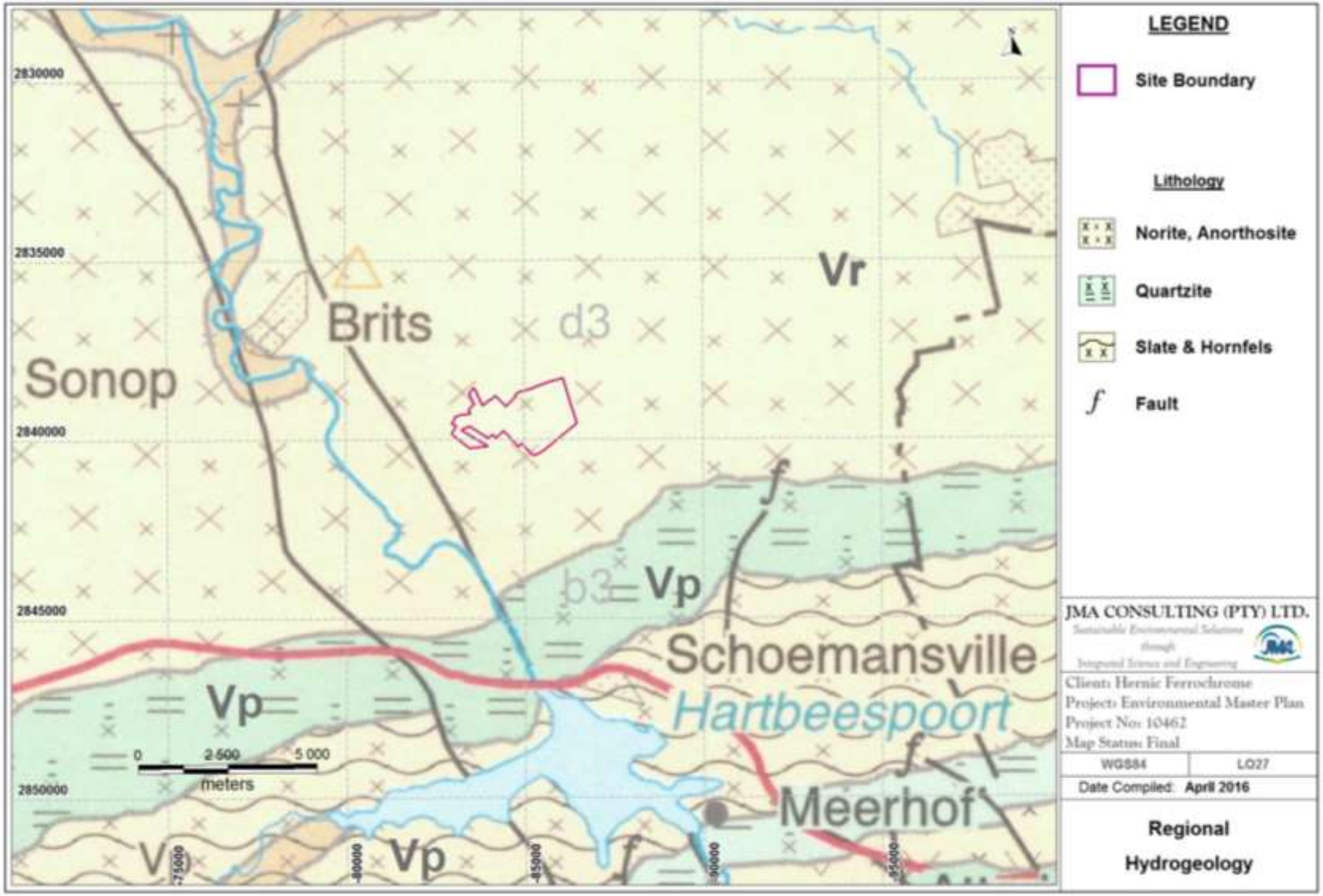


Figure 8.4.12.2(a): **Regional Hydrogeology of the Larger Study Area**

The depths to groundwater levels are estimated to range between 10 *m* and 20 *m* below the surface. The aquifer storativity (S) for the fractured aquifers in this part of the study area is indicated to be less than 0.001. The saturated interstice types (storage medium) are fractures which are restricted principally to the zone directly below the groundwater level. The pristine groundwater quality is good with an expected TDS range of between 300 *mg/l* to 500 *mg/l* (DWAF (1995) Sheet 2).

<u>Geohydrological Zone 2: Rustenburg Layered Suite</u>

The groundwater study area at HERNIC is underlain by ultramafic/mafic intrusive rocks of the Rustenburg Layered Suite - denoted by *Vr* on Figure 8.4.12.2(a). The geohydrological properties of this zone are therefore of utmost importance and will be addressed in detail in the sections that follow.

The primary groundwater occurrences within this zone are in the joints and fractures occurring within the contact zones related to the heating and cooling of the country rocks as well as in fractures in the transitional zones between the weathered and un-weathered rocks. Numerous faults are recorded within the Rustenburg Layered Suite within the study area and potentially act as additional preferential groundwater flow zones.

The borehole yielding potential within this geohydrological zone within the study area is classified as *d3*, which implies an average yield which varies between 0.5 *l/s* and 2.0 *l/s*. A large number of adjacent land users abstract groundwater from within these inter-granular and fractured aquifers for domestic and agricultural purposes. The groundwater potential for these aquifers area is given as < 40%, which indicates the probability of drilling a successful borehole (yield > 0.1 *l/s*) whilst the probability of obtaining a yield in excess of 2 *l/s* is given as between 20 and 30% (DWAF (1995) Sheet 2).

The MAR to the groundwater system in the central and northern parts of the study area is estimated to be between 25 *mm* and 37 *mm* per annum, which relates to between 4% and 6% of the MAP. The groundwater contribution to surface stream base flow is relatively low, indicated at less than 10 *mm/annum* (DWAF (1995) Sheet 2).

The depths to groundwater levels are also estimated to range between 10 *m* and 20 *m* below the surface. The aquifer storativity (S) for the fractured aquifers in this part of the study area is indicated to be less than 0.001. The saturated interstice types (storage medium) are fractures which are restricted principally to the zone directly below the groundwater level. The pristine groundwater quality is also good with the TDS expected to range between 300 *mg/l* and 500 *mg/l* (DWAF (1995) Sheet 2).

8.4.12.3. HERNIC Site Geohydrology

The physical delineation and description of the aquifers within the study area is discussed with reference to the geological and hydrogeological information generated during the quantitative site specific field investigation at HERNIC. The geology underlying the study area was verified and assessed during the drilling of 8 geological / geohydrological investigative boreholes in addition to the information contained within HERNIC's Amended Mining Work Programme (March 2013).

The geohydrological investigative boreholes were drilled to depths that fully intersected the shallow weathered zone aquifers and were drilled to an average depth of 28.14 *mbgl*. The lithology that was penetrated, its weathering and fracturing status as well as its water yielding capacity was recorded for each borehole during the drilling operations

Aquifer Matrix (Soil and Geological Matrix)

The host rock matrix at Hernic Ferrochrome (down to an average depth of 28 *mbgl*) comprises predominantly of weathered, fractured and fresh norites (Mathlagame Norites-Anorthosites) which are extensively covered by soil and / or overburden material at the surface. The soil comprises of a dark brown to greyish brown structured fine grained and clayey "turf" soil derived from the predominantly noritic parent material. The thickness of the soil penetrated during the drilling of the 8 investigative boreholes varies between 1.0 *m* and 4.0 *m*, with an average of 1.6 *m*.

The norite penetrated is predominantly grey to light grey in colour and is fine-medium grained in texture. The norite comprises predominantly of pyroxenes and plagioclase feldspars, with biotite and hornblende and mica's observed in several of the samples.

Although not penetrated in any of the boreholes (due to the restricted depth of drilling as well as the extent of the current mining operations), several chromitite layers are present within the study area. The MG-1, MG-2 and MG-4 chromitite layers are of economic importance at HERNIC. The layers have historically been mined by opencast mining operations and are currently still being mined by underground mining operations within the eastern extent of the site. The UG-2 is also a significantly important layer within the study area and is also being mined by underground mining operations, although not by HERNIC.

The lithological units of the RLS at HERNIC, including the respective chromitite layers, dip at an angle of 17° to the north / north-west. The interpolated depth distribution lines of the MG-1 Chromitite Layer (southern-most / deepest of the chromitite layers at HERNIC) are depicted on Figure 8.4.12.3(a). These depth distribution contour lines are important as they provide an indication of the depth of the underground workings on the specific (MG-1) chromitite layer.

The information obtained from the Amended Mining Work Programme (March 2013) indicates that the MG-1 chromitite layer has approximate thickness of 1.3 *m* with an outcrop thickness of approximately 1.0 *m*. Transgressive dykes, rolls, potholes and fault structures are indicated to often influence and negatively impact continuity of the chromitite layers exploited.

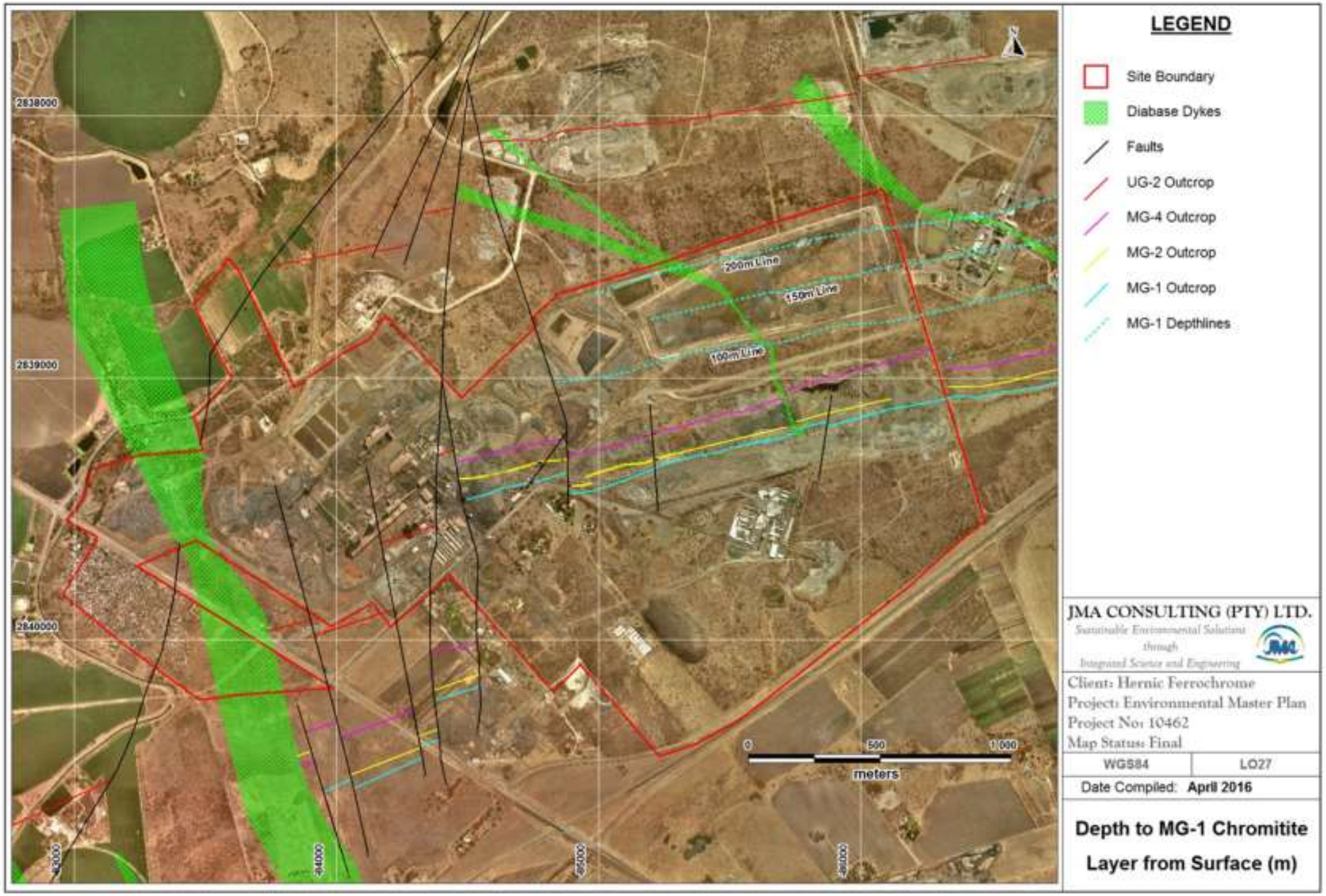


Figure 8.4.12.3(a): Depth of MG-1 Chromitite Layer from Surface

The occurrence and distribution of dykes, faults and ore reefs (linear geological features) also play a significant role in that they could potentially influence and control the groundwater occurrences and flow. The areas adjacent to the contact zones between dykes and the norite host rock are generally highly fractured, usually resulting in higher transmissivity and yields and may represent preferential groundwater flow zones.

The depth of weathering and weathering related fracturing, is an important attribute from a geohydrological perspective. This zone essentially represents the bulk of what is commonly referred to as the weathered zone aquifer. Within the HERNIC geological setting, weathered zone aquifers will constitute the most important groundwater zones, from both a recharge and storage perspective. The weathered zone aquifers are also the most susceptible to surface induced impacts and will therefore be assessed in detail. The fractures and voids related to weathering form the interstices through which the groundwater flows.

The depth of weathering and weathering related fracturing is relatively deep and varies between 13.0 *m* and 22.5 m, with an average weathering depth of ***17.6 m*** within the study area. This weathering / fracture profile is unevenly distributed across the study area. The norite weathers down to a soft gritty matrix. The weathering fracture profile depth is combination of the primary weathering profile and the transitional fracturing zone which occurs immediately above the fresh bedrock interface.

Aquifer Types (Primary, Weathered, Fractured, Karst)

With reference to the local geology of the site, it is regarded that two major aquifer types occur within the study area, namely: 1) a laterally extensive shallow weathered zone aquifer system and 2) more localized fractured aquifer systems.

The predominant aquifer type present within the study area is a laterally extensive shallow weathered zone aquifer which occurs within the weathered and weathering related fractured zone, within the predominantly norite host rock matrix. This aquifer extends across the entire study area and has an average vertical thickness of ***17.6 m***. This aquifer zone will store and transport the bulk of the groundwater in the study area and will display unconfined to semi-unconfined piezometric conditions. This shallow weathered zone aquifer will therefore as a result, be highly susceptible to surface induced anthropogenic influences on site.

The localized fractured aquifers present within the study area are restricted to the contact zones between the intrusive diabase bodies and the host rocks as well as along the major fault zones. Although these aquifers may potentially have high yields, high transmissivity values and represent preferential flow paths; they have a limited storage capacity as well as restricted recharge characteristics.

The bulk of the water supplied by the fractured aquifers will be drained laterally from storage within the shallow weathered zone aquifers neighbouring onto them. These aquifers can transmit surface induced contaminants over great distances, and as such have been identified as potential fatal flaws if their lateral continuation extends beyond the delineated lateral aquifer boundaries.

With regards to the two aquifer types present within the study area and subject to the site specific host matrix physical properties, it is assumed that the bulk of the groundwater zone within the study area will display porous groundwater flow conditions. The "fractured conditions" encountered along the linear geological features, may, due to their scale and interconnectivity, also be regarded as porous groundwater flow zones within the delineated lateral aquifer boundaries.

Aquifer Zones (Unsaturated, Saturated)

Previous hydrogeological investigations as well as the information obtained during the drilling operations indicate that there are no extensive perched aquifer systems within the study area. This simplifies the geohydrology and indicates that the conceptual geohydrological model can be comprehensively described in terms of unconfined to semi-unconfined unsaturated and saturated zones within the weathered zone.

Unsaturated Zone:

Due to the nature of the shallow weathered zone aquifers at HERNIC, the top of the unsaturated zone is defined by the land surface, whilst the bottom of the unsaturated zone is defined by the groundwater table/level. The thickness of the unsaturated zone is therefore determined according to the natural groundwater levels recorded.

The natural thickness of the unsaturated zone has been affected by the mining operations and local groundwater abstraction at and adjacent to HERNIC. The average thickness of the natural unsaturated zone at HERNIC is recorded to range between 3.37 m and 18.76 m with an average thickness of $\mathbf{10.66}\ \boldsymbol{m}$. This excludes the areas that have been affected by aquifer dewatering associated with abstraction of the groundwater for domestic, agricultural and mining related uses and operations.

Saturated Zone:

The saturated zone of the shallow weathered zone aquifer at HERNIC is defined at the top by the groundwater table/level and at the bottom by the weathered/fractured and fresh bedrock interface. The saturated aquifer thickness of the shallow weathered zone aquifer at HERNIC is calculated by subtracting the measured natural groundwater level depth from the weathered or weathering related fractured depth as recorded at the groundwater monitoring boreholes.

The average thickness of the natural saturated zone at HERNIC varies between 6.35 m and 13.85 m with an average thickness $\mathbf{9.27}\ \boldsymbol{m}$. This also excludes the areas that have been affected by aquifer dewatering associated with abstraction of the groundwater for domestic, agricultural and mining related uses and operations.

Preferential Groundwater Flow Zones

Preferential groundwater flow zones are associated with the highly fractured zones along faults as well as within contact zones associated with intrusive igneous bodies. The zones adjacent to the contact zones between dykes and the norite host rock are generally highly fractured due to their intrusive nature and are often associated with the regional faults in the area.

These highly fractured contact zones have potentially higher transmissivity values and represent zones through which the groundwater can potentially move more freely as opposed to the adjacent host rock and could thus affect the natural local groundwater flow characteristics of the shallow weathered zone aquifer as well.

Several large scale faults have been identified and delineated within the study area. The most predominant faults are the normal faults that trend in a northerly direction across the western regions of the study area. The normal faults form part of the eastern side of the graben structure situated in a western direction of HERNIC.

Three relatively large diabase dykes, as delineated from the Mining Work Programme also transect the HERNIC property boundary. These diabase dykes strike in a north-westerly to south-easterly direction and are delineated on the figures above. The diabase dykes are younger in age than the lithological units of the RLS and have thus displaced some of the chromitite layers within the study area as well.

The most significant of the diabase dykes is the western of the 3 dykes delineated at HERNIC, which strikes in a northerly direction to the west of Fine Fraction Slag reworking / recovering area. Although the contact zones along the dyke are deemed to be highly permeable, the dyke itself is generally more impermeable.

The nature and extent of the associated highly fractured and permeable zones are defined by the geometry and extent of the delineated faults and dykes. Whilst these preferential flow zones may potentially have high yields and high transmissivity values they have a limited storage capacity as well as restricted recharge characteristics. The bulk of the water supplied by the fractured aquifers will be drained laterally from storage within the shallow weathered zone aquifers neighbouring onto them. The preferential groundwater flow conditions encountered along the linear geological features within the extent of the study area, may due to their scale and interconnectivity, be regarded as porous groundwater flow zones within the delineated lateral aquifer boundaries.

<u>Artificial Groundwater Zones (Mining Voids/Spoils)</u>

Artificial groundwater zones result when the underlying geological and hydrogeological conditions are altered or changed as a result of human activities. Artificial groundwater zones are generally created within the study area as a result of the mining operations. The areas that have been mined as well as the areas that have been fully or partially rehabilitated create artificial voids within the geological and geohydrological environment which increases the porosity and storativity of these geohydrological zones. During the operation of the mining activities groundwater flowing into the active mine workings is pumped out, which lowers the natural groundwater levels adjacent to the aquifers and alters the natural local flow characteristics thereof as well.

The study area has been extensively mined for both chromium and platinum as well as the associated PGE's, by both opencast and underground mining methods. The voids created during these mining operations have a permanent impact on the storage and regional groundwater flow characteristics within the groundwater management area, as well as the chemistry and availability thereof. The layers of significant economic importance that occur within the study area are the MG-1, MG-2, MG-4 and the UG-2 chromitite layers.

The MG-1, MG-2 and MG-4 chromite ore layers outcrop at HERNIC and are specifically mined for their chromium content. The UG-2 chromite ore layer outcrops to the north of HERNIC and is mined for its platinum and PGE contents. These ores generally have an east-west strike and dip at an angle of 17° to the north. HERNIC historically mined the chromite ore layers by opencast mining methods (4 separate pits) and are currently mining the ore layers by means of underground mining methods. No opencast mining operations are currently taking place at HERNIC and the pits have been / are being backfilled and rehabilitated.

The layout plan of the historic opencast mining operations at HERNIC are delineated on Figure 8.4.12.3(b), whilst the layout of the current underground mining operations are delineated on Figure 8.4.12.3(c). The details of both the historic opencast and current underground mining operations at HERNIC are addressed below.

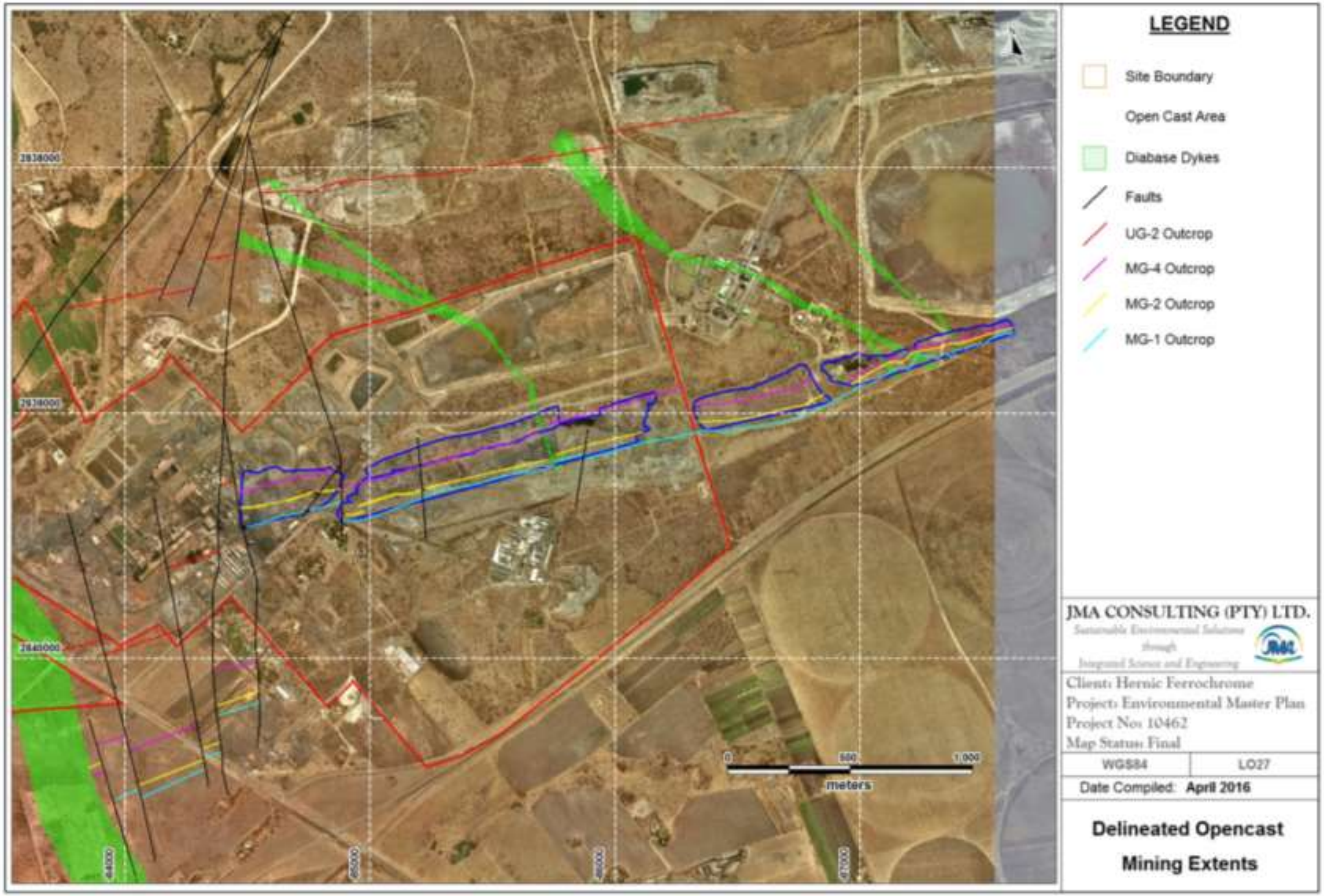


Figure 8.4.12.3(b): **Delineated Extents of the Historic Opencast Mining Operations at HERNIC**

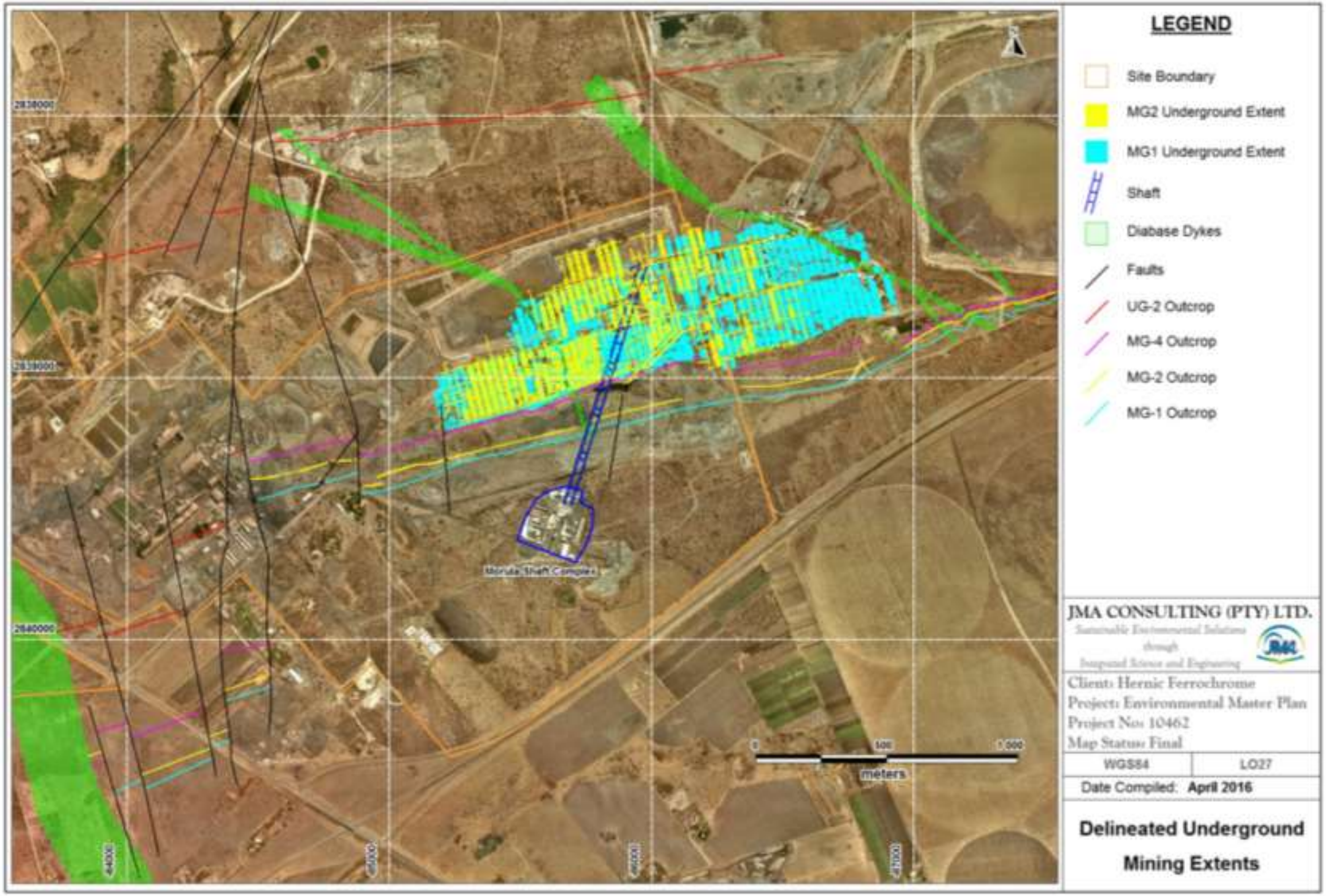


Figure 8.4.12.3(c): Delineated Extents of the Current Underground Mining Operations at HERNIC

Opencast Mining Operations

Opencast mining operations historically took place at 4 separate pits on the Farms De Kroon 444 JQ and Elandsfontein 440 JQ, as delineated on Figure 8.4.12.3(b). From the layout plans provided by HERNIC it appears that the 4 pits were mined separately and that they are not connected / linked to each other. No opencast mining is currently taking place at HERNIC and the pits have been / will be backfilled and rehabilitated. Once backfilled, the rehabilitated surface will be shaped to be free-draining and will be re-vegetated.

The *Western Pit*, located on the Farm De Kroon 444 JQ, extended across a surface area of 7.3 *ha*. The MG-1, MG-2 and MG-4 Chromitite seams were historically mined at this pit. This pit has been backfilled will mixed material from the OB and Smelter Plant, the surface area of which is currently being used as footprint areas for raw materials, mixed waste and current slag arising.

The *Central Pit,* located on the Farm De Kroon 444 JQ, is by the far the largest of the four pits and extended across a surface area of 24.7 *ha*. The MG-1, MG-2 and a small portion of the MG-4 Chromitite seams were historically mined at this pit. There is still a void in this pit which is being backfilled with overburden material. The western extent of the pit was historically backfilled with mixed fine waste material. Investigations are currently underway to assess the feasibility of removing / reworking this fine material for its PGM content. Irrespective of whether the fine material will be re-worked or not, the pit will be backfilled, shaped to be free-draining and will be re-vegetated. All material stockpiles and processing plants will be removed from the surface before rehabilitation of the pit is completed.

The *Eastern Pit,* located on the Farm Elandsfontein 440 JQ, extended across a surface area of 7.4 *ha*. The MG-1, MG-2 and MG-4 Chromitite seams were historically mined at this pit. This pit has been backfilled and rehabilitated (sloped and re-vegetated). The *Far Eastern Pit,* located on the Farm Elandsfontein 440 JQ, extended across a surface area of 6.8 *ha*. The MG-1, MG-2 and MG-4 Chromitite seams were historically mined at this pit. A void has been left open in this pit, which is currently being used as a water containment facility for the adjacent platinum mining operations at Eland Platinum. No future mining is planned at the pit and it is proposed that the pit also be backfilled and fully rehabilitated to ensure that the surface is free draining and re-vegetated.

Underground Mining Operations

Mining is currently taking place by means of underground mining methods at HERNIC. The underground mining operations are taking place below the Farms De Kroon 444 JQ and Elandsfontein 440 JQ and are accessed via the Morula Shaft Complex, delineated on Figure 8.4.12.3(c). The underground mining operations commenced in 2005 and although currently under care and maintenance, are planned to continue in the future.

The underground mining operations currently extract chromite ore from the MG-1 and MG-2 chromite seams, although mining of the MG-4 chromite seam is also authorised. The extents of the underground workings on the MG-1 and MG-2 chromitite ores at HERNIC are delineated on Figure 8.4.12.3(c). There is a 15 m parting between the underground workings on the MG-1 (bottom) and MG-2 (top) Chromitite Ores. The Mining Work Programme indicates that the total height of the MG-1 chromitite ore body is 1.4 m, which is ideal for the conventional mining methods. The MG-2 chromitite ore body is indicated to have a height 2.8 m, which is ideal for the operation of trackless equipment.

The Mining Work Programme also states that the technology used in the underground workings is conventional mining methods with an average ore extraction rate of 80%.

All development and stoping will be undertaken on reef and the planned production rate is 120 000 tons/month (1 440 00 tons/annum). At the planned production rates, the underground workings still have a LOM of 60 *years*.

Lateral Aquifer Boundaries (Physical, Hydraulic, Arbitrary)

The groundwater zone of influence may be defined and delineated by three principle types of aquifer boundaries, namely physical, hydraulic and arbitrary boundaries.

- Physical boundaries are defined by linear geological intrusions (dykes) or geological contacts between rocks with different geohydrological attributes.
- Hydraulic boundaries are defined by dams, rivers and streams, or alternatively by surface water and groundwater divides.
- Arbitrary boundaries are selected in terms of groundwater flow directions and are usually chosen parallel to the groundwater flow direction.

It is important to note that the HERNIC surface operations are situated above and to the west (down-gradient) of well-developed mining areas and internal artificial aquifer boundaries and voids therefore exist as well. The delineated lateral aquifer boundaries for the HERNIC study area define the extent of the groundwater zone that could potentially be affected by the surface activities and underground mining operations at HERNIC. The groundwater influence zone is therefore delineated with reference to the lateral aquifer boundaries as mentioned above. The extent of delineated lateral aquifer boundaries for the HERNIC operations is delineated on Figure 8.4.12.3(d).

A summary of the delineated boundaries is given below:

- The north-eastern aquifer boundary (1) is defined as a groundwater discharge boundary which has been selected along an unnamed non-perennial tributary which drains in a north-westerly direction to the north-east (up-gradient of HERNIC).
- The eastern boundary (2) is defined as a groundwater no-flow boundary, which has been selected parallel to the natural groundwater flow directions, up-gradient from HERNIC.
- The south-eastern boundary (3) is defined as a constant head hydraulic boundary and has been selected along the 1 200 *mamsl* surface elevation contour up-gradient from HERNIC.
- The southern aquifer boundary (4) is defined as a groundwater discharge boundary which has been selected along an unnamed non-perennial tributary, which drains in a westerly direction to the south of HERNIC.
- The south-western boundary (5) is defined as a constant head hydraulic boundary and has been selected along the 1 130 *mamsl* surface elevation contour.
- The western boundary (6) is defined as a groundwater discharge boundary which has been selected along an unnamed non-perennial tributary, which drains in a north-westerly direction to the west of HERNIC.
- The northern boundary (10) is defined as a groundwater no-flow boundary and has been selected along the surface water divide (watershed) to the north of HERNIC.
- The HERNIC operations are also located on a topographical crest (surface water divide) which gives rise to an internal no-flow groundwater boundary as well.

There are two internal groundwater discharge boundaries at HERNIC (7 and 9) selected along two unnamed non-perennial drainage bodies. Although these two boundaries define the extent of the potential groundwater impact zone as a result of the HERNIC operations, they have been selected as internal boundaries so that accurate baseflow calculations can be made for them as part of the groundwater impact assessment.

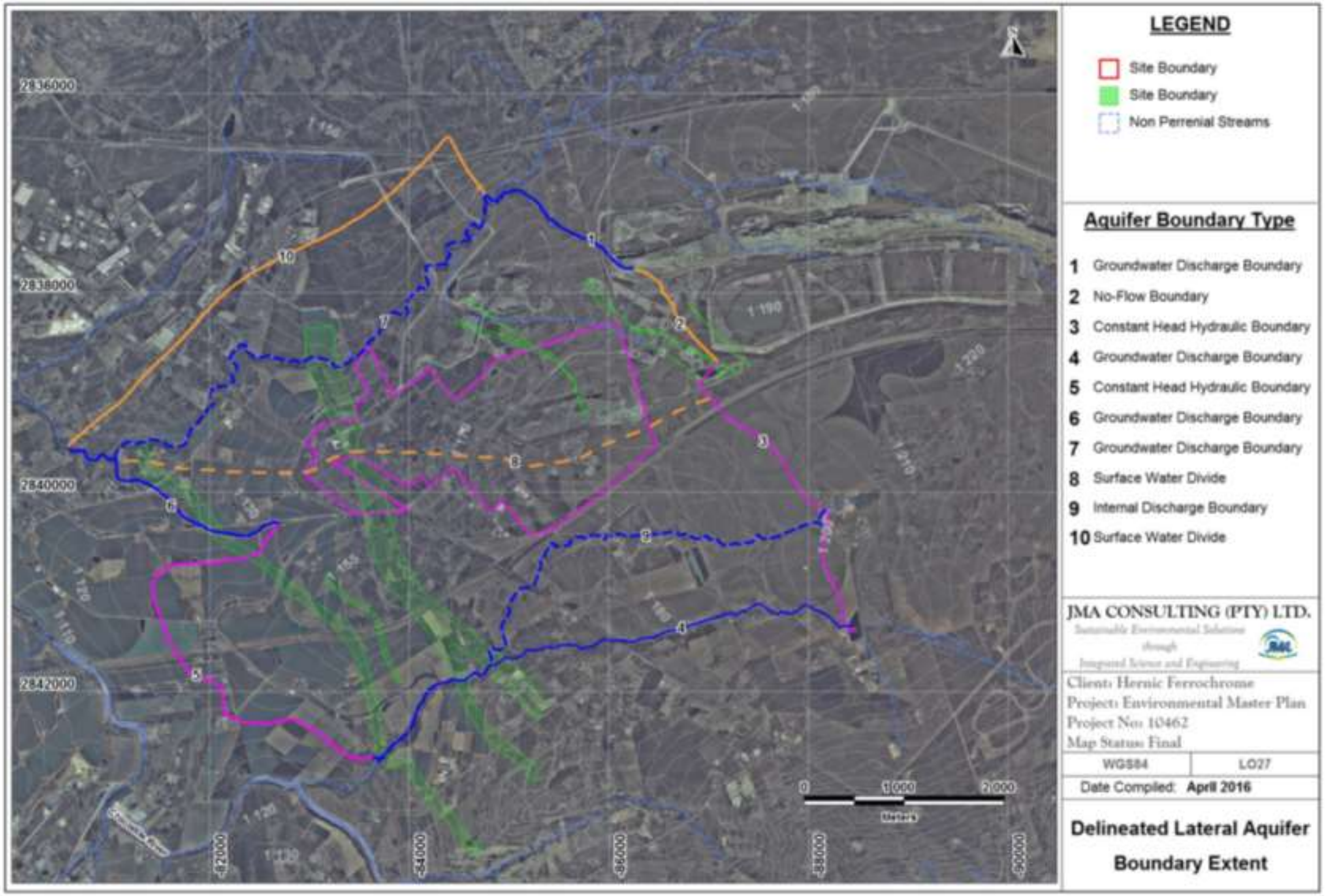


Figure 8.4.12.3(d): Groundwater Influence Zone for the HERNIC Operations

Borehole Yields

The blow yields recorded during drilling were obtained from the shallow weathered zone aquifers present within the study area. The borehole blow yield distribution is indicated in Table 8.4.12.3(a) below.

Table 8.4.12.3(a): Recorded blow yield information for each of the 8 investigative boreholes.

BH No.	Intersection Depths (mbgl)	Total Blow Yield (*l/s*)
HER-B56	22-22.5	0.05
HER-B57	16-17	0.20
HER-B58	12-13	2.00
HER-B59	19-21	1.50
HER-B60	13-14	0.30
HER-B61	9-10.5 & 14-15	0.35
HER-B62	-	-
HER-B63	10-11 & 13-14	3.30

With regards to the borehole blow yield distribution the following is important:

- No information regarding the blow yields of the existing groundwater boreholes at HERNIC was available.
- Only borehole HER-B62 was dry and did not yield any water during drilling.
- The borehole blow yields recorded at the other 7 geological / geohydrological investigative boreholes are heterogeneously distributed and vary between 0.05 l/s and 3.3 l/s, with an average blow yield of 0.96 l/s. The geometric mean of the recorded blow yield is calculated as 0.52 l/s and the harmonic mean is calculated as 0.21 l/s.
- The water strikes typically occur within the fractured to slightly weathered zones of the aquifers at depths between 9 mbgl and 22.5 mbgl.
- Borehole HER-B63 (adjacent to the Morula Dewatering Dam) had the highest recorded blow yield (3.3 l/s) followed by boreholes HER-B58 (adjacent to the Process Water Dam) and HER-B59 (adjacent to the Emergency Dam) which had blow yields of 2.0 l/s and 1.5 l/s respectively.
- The borehole blow yields within the Alloys Smelting Plant Management Area range between 0.05 l/s and 2.0 l/s with an average blow yield of 0.63 l/s.

Aquifer Permeability/Transmissivity

The hydraulic conductivity or permeability (k) of an aquifer is a measure of the ease with which groundwater can pass through the aquifer system. The permeability is defined as the volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured at perpendicular to the flow direction and is expressed in *m/day*.

The permeability of the shallow weathered zone aquifers were calculated using the data obtained from the aquifer permeability (slug) tests conducted at the 8 geological / geohydrological investigative boreholes.

The average hydraulic conductivity of the shallow weathered zone aquifers adjacent to the boreholes is taken as the arithmetic mean of the permeability's calculated using the Hvorslev and Bouwer & Rice analysis methods, both of which are applicable to weathered zone aquifers. The distribution of the calculated aquifer permeabilities are indicated in Table 8.4,12.3(b) below.

Table 8.4.12.3(b): Calculated Aquifer Permeability Values

Borehole Number	Permeability (Hvorslev) (m/day)	Permeability (Bouwer & Rice) (m/day)	Average Permeability (m/day)
HER-B56	0.49	0.32	**0.40**
HER-B57	0.65	0.24	**0.44**
HER-B58	0.96	0.71	**0.83**
HER-B59	1.87	1.40	**1.64**
HER-B60	0.52	0.41	**0.47**
HER-B61	0.65	0.48	**0.56**
HER-B62	-	-	**-**
HER-B63	5.06	3.89	**4.47**
Harmonic Mean	0.79	0.49	**0.66**
Geometric Mean	1.00	0.67	**0.84**
Arithmetic Mean	1.46	1.06	**1.26**

With reference to the calculated permeabilities of the shallow weathered zones aquifers present within the study area, the following is important:

- There is a large variation in the calculated permeability values and distribution across the site. The variation in permeability is related to the differing degrees to which the underlying norites have been weathered and fractured.
- The average calculated aquifer permeabilities varied between 0.4 m/day and 4.47 m/day with an average calculated permeability of 1.26 m/day.
- Due to the heterogeneities inherent to weathered zone aquifers, statistical assessments indicate that the hydraulic parameter distribution will be log-normally distributed and that the actual permeability (k-value) for the aquifer is bound by the calculated geometric and the harmonic means.
- Based on the analyses of the slug tests conducted at HERNIC a bulk hydraulic conductivity of 0.7 m/day is assigned to the shallow weathered zone aquifers within the study area.

The transmissivity (T) of an aquifer represents the groundwater flow potential through the entire saturated zone. The transmissivity is defined as the rate at which water is passed through a unit width of an aquifer under a unit hydraulic gradient. It is expressed as the product of the average permeability and the thickness of the saturated portion of the aquifer (D). The transmissivity of the aquifers is thus calculated as T=k*D (*m^2/day*).

The distribution of the calculated aquifer transmissivities are indicated in Table 8.4.12.3(c) below.

Table 8.4.12.3(c): Calculated Aquifer Transmissivity Values

Borehole Number	Saturated Aquifer Thickness (m)	Aquifer Permeability (m/day)	Aquifer Transmissivity (m^2/day)
HER-B56	6.35	0.40	**2.54**
HER-B57	7.64	0.44	**3.36**
HER-B58	9.35	0.83	**7.76**
HER-B59	13.85	1.64	**22.71**
HER-B60	11.04	0.47	**5.19**
HER-B61	7.96	0.56	**4.46**
HER-B62	-	-	**-**
HER-B63	8.73	4.47	**39.02**
Harmonic Mean	8.77	0.66	**5.39**
Geometric Mean	9.01	0.84	**7.54**
Arithmetic Mean	9.27	1.26	**12.15**

With reference to the calculated transmissivity values of the shallow weathered aquifers present in the study area, the following is important:

- The calculated aquifer transmissivities vary significantly between 2.54 m^2/day and 39.02 m^2/day with an average calculated transmissivity of 12.15 m^2/day. The calculated aquifer transmissivities are heterogeneously distributed within the study area.
- A bulk transmissivity value of 6.00 m^2/day is assigned for the shallow weathered zone aquifers within the study area.

Aquifer Storativity

The storativity (**S**) of an aquifer is defined as the volume of water that an aquifer releases from, or takes into, storage per unit surface area of the aquifer per unit hydraulic gradient. The storativity of the shallow weathered zone aquifers at HERNIC is taken to be approximately **0.002**. The saturated interstice types or storage medium of the aquifer are the interstices and fractures present below the groundwater level, as a result of weathering and the weathering related fracturing of the host rock.

Aquifer Porosity

The porosity of an aquifer is the ratio of the void space to the total volume of the aquifer. The porosity gives is an indication of the amount of water in the subsurface, but does not represent the volume that can be released from or taken into storage. The ratio between the volume of water that can be drained from the aquifer and the total volume of the aquifer is referred to as the effective porosity. The effective porosity is related to the connectivity of the pores and is an important factor in that it governs the specific groundwater flow velocities through the aquifer.

In the shallow weathered zone aquifers at HERNIC, the effective porosity will play the most significant role as it will determine the groundwater flow velocity. The groundwater flow velocity represents the velocity at which advective contaminant transport will take place. Areas of smaller effective porosities will result in greater effective flow velocities through the aquifer. The effective porosity in the weathered zone aquifers at HERNIC is indicated to vary between 0.01 and 0.07, with a bulk effective porosity value of **0.05 (5%)**.

Rainfall Recharge

The recharge to the shallow weathered zone aquifers within the study area will occur primarily through the infiltration of the rain water and surface water bodies from the surface. The MAP assigned to the study area is 617 *mm/annum*. The mean annual recharge to the groundwater system is estimated to range between **30 *mm*** and **55 *mm* per annum** which calculates to between 5*%* and 9*%* of the MAP.

Due to the nature of certain anthropogenic surface features, such as unlined surface water containment facilities and the historic slimes dams as well as rehabilitated and un-rehabilitated pits, larger recharge volumes within the extents of their surface footprints may occur. Areas that have been covered at the surface with infrastructure, buildings and paving etc. will deplete the natural recharge volumes to the underlying groundwater resource.

The recharge through the respective surface water containment facilities, waste disposal facilities and into / from the opencast and underground working s will be calculated as part of the groundwater impact assessments.

Groundwater Level Depths and Fluctuations

Groundwater levels were recorded in all the accessible boreholes within the study area (1 km radius from delineated HERNIC properties). A total of 81 boreholes were identified within the study area, comprising of 29 existing monitoring boreholes, 8 new geohydrological / groundwater monitoring boreholes and 44 external user boreholes (Figure 8.4.12.3(e)).

Of the 81 boreholes identified within the study area, only 34 were accessible for the measuring of groundwater levels. The majority of the external user boreholes are fitted with pump equipment, prohibiting access down the boreholes. The groundwater levels recorded during February and March 2016 are depicted on Figure 8.4.12.3(f) and are listed in Table 8.4.12.3(d) below.

Table 8.4.12.3(d): Recorded Groundwater Level Depths

Number	Date	Time	Water Level (mbgl)	Number	Date	Time	Water Level (mbgl)
EUB-3	2016/03/04	09:20	**7.29**	**HER-B41D**	2016/02/29	09:43	**10.50**
EUB-4	2016/03/04	09:01	**10.41**	**HER-B52**	2016/02/29	09:07	**6.97**
EUB-14	2016/03/11	15:37	**6.61**	**HER-B56**	2016/03/29	11:56	**16.13**
EUB-15	2016/03/11	1528	**8.98**	**HER-B57**	2016/03/29	13:27	**10.81**
EUB-20	2016/03/09	11:35	**8.02**	**HER-B58**	2016/03/29	15:14	**8.06**
EUB-24	2016/03/09	13:35	**16.49**	**HER-B59**	2016/03/30	12:12	**7.33**
EUB-31	2016/03/11	09:44	**5.17**	**HER-B60**	2016/03/30	11:03	**4.13**
HER-B1	2016/03/01	11:59	**13.07**	**HER-B61**	2016/03/30	09:31	**6.43**
HER-B2D	2016/02/29	13:57	**13.40**	**HER-B62**	2016/03/30	08:48	**26.35**
HER-B3	2016/03/01	04:19	**15.18**	**HER-B63**	2016/03/29	16:43	**5.66**
HER-B7	2016/02/29	12:43	**9.34**	**HER-MC 1**	2016/02/29	15:54	**14.50**
HER-B23	2016/02/29	14:37	**11.70**	**HER-MC 2**	2016/02/29	16:18	**14.62**
HER-B35	2016/02/29	14:25	**12.27**	**HER-MD**	2016/03/01	10:50	**13.79**
HER-B37	2016/02/29	15:03	**9.18**	**HER-ME**	2016/03/01	13:00	**11.91**
HER-B38 D	2016/02/29	10:43	**9.90**	**HER-UN**	2016/03/01	13:17	**30.14**
HER-B39 D	2016/02/29	10:14	**9.66**	**HF 1**	2016/02/29	12:11	**4.30**
HER-B40 D	2016/02/29	10:01	**7.46**	**HF 4**	2016/02/29	11:35	**5.75**

The groundwater levels recorded within the study area varied between 4.13 *m* and 30.14 *m* with an average depth of 10.92 *m*. The groundwater levels recorded at several of the boreholes do however not reflect the natural groundwater levels as they are being used as groundwater abstraction points. The boreholes that are currently used as groundwater abstraction points are depicted on Figure 8.4.12.3(g). Any groundwater levels recorded at these boreholes were therefore omitted during the calculation of the natural groundwater levels.

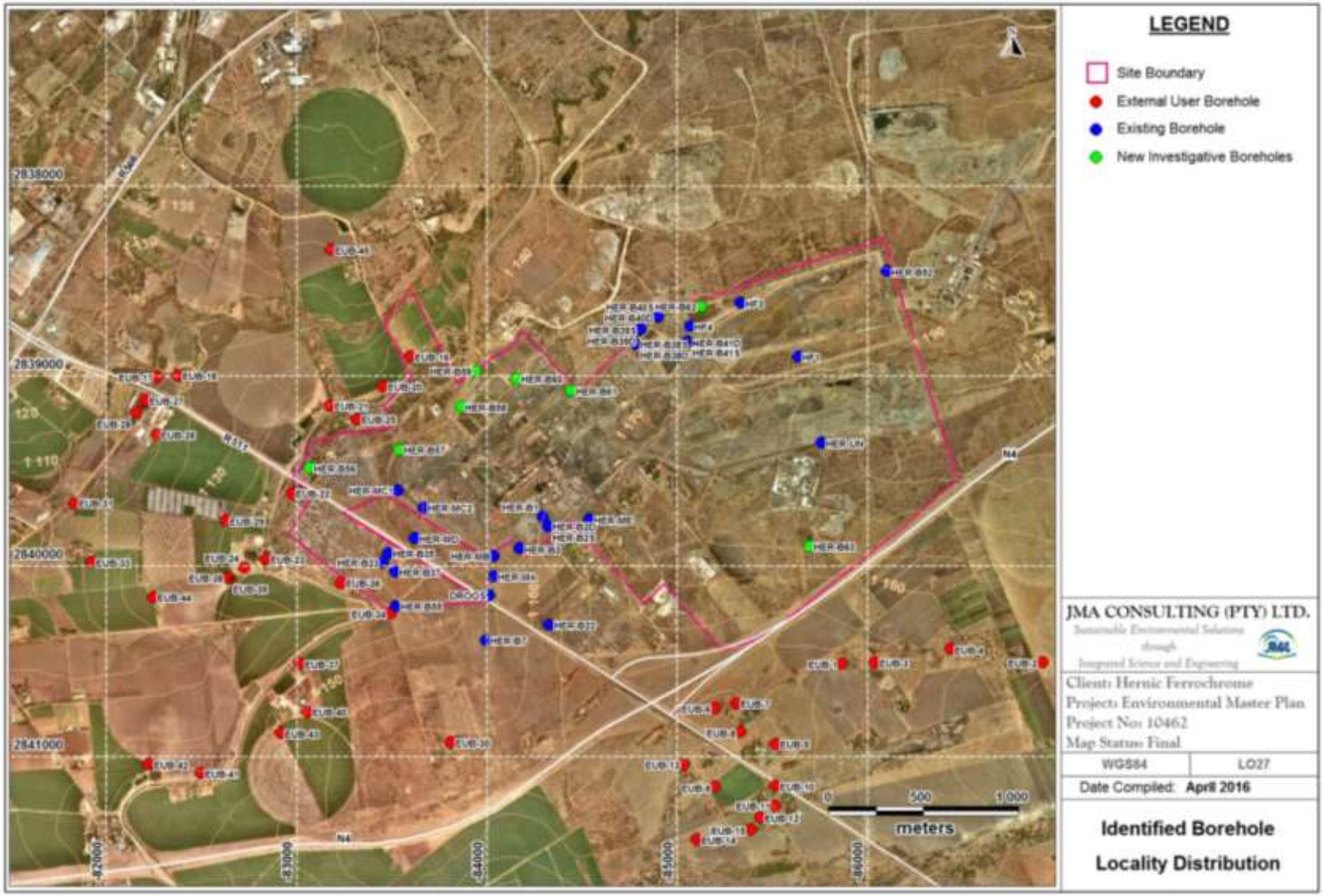


Figure 8.4.12.3(e): Boreholes identified within the HERNIC Study Area (81 Boreholes)

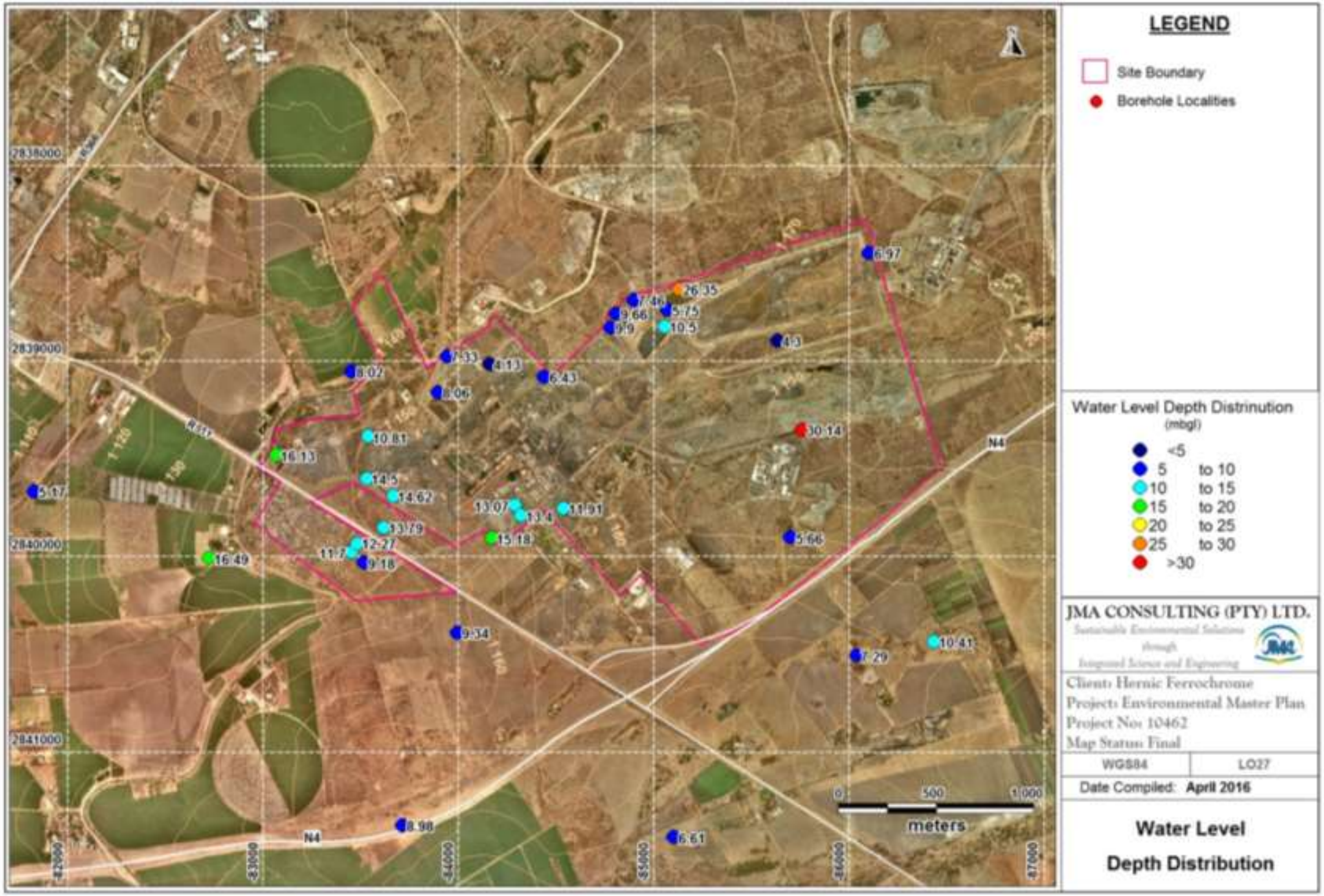


Figure 8.4.12.3(f): Recorded Groundwater Level Depth Distribution (34 Boreholes)

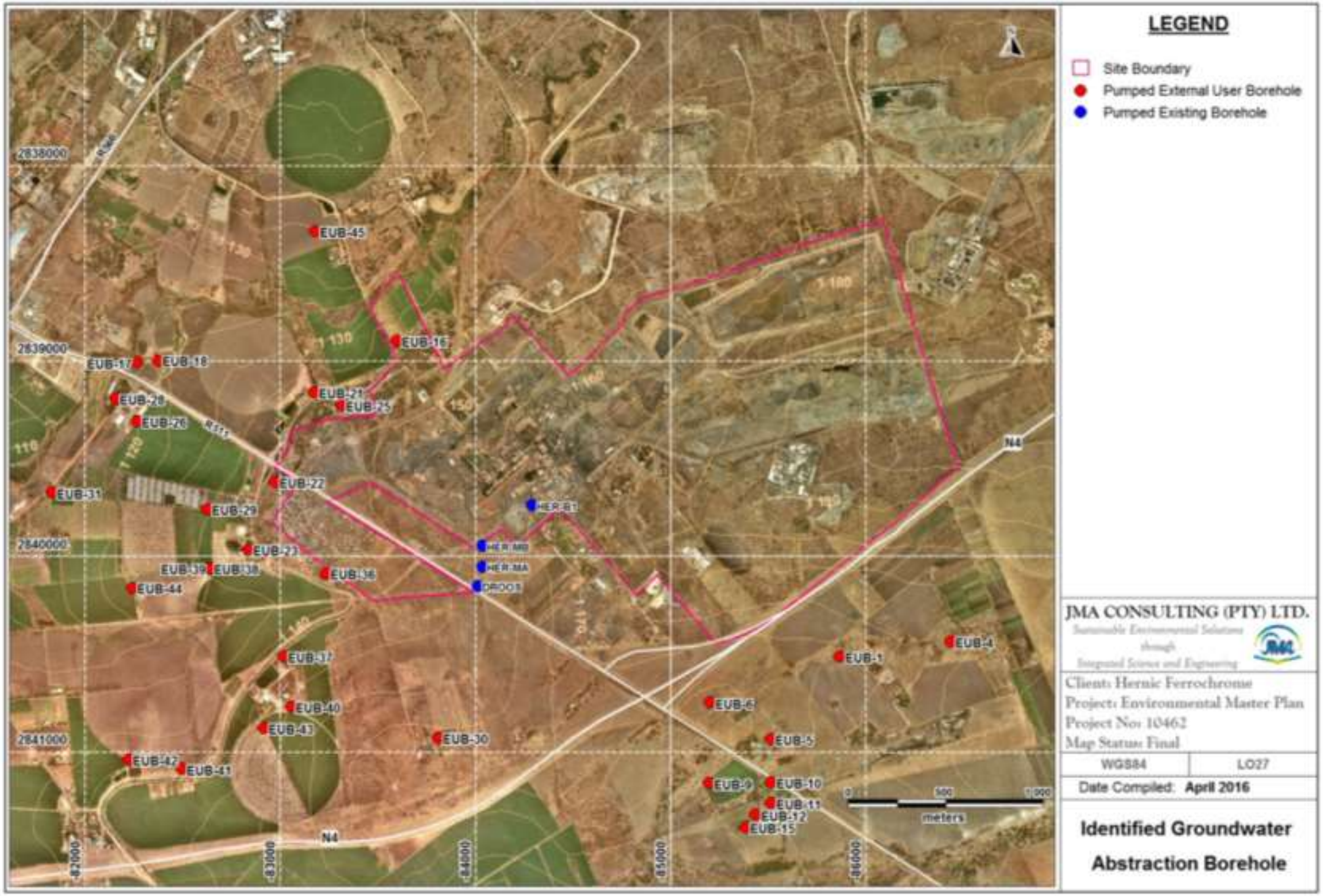


Figure 8.4.12.3(g): Boreholes currently used as Groundwater Abstraction Points (35 Boreholes)

The natural groundwater levels within the study area are expected to range between 4.13 *m* and 16.49 *m* with an average groundwater level depth of around **9.87 *m*** assigned to the shallow weathered zone aquifers. With reference to the recorded groundwater levels within the shallow weathered zone aquifers at HERNIC, the following is important:

- No groundwater level data was obtained or provided for the properties to the east of HERNIC (Eland Platinum).
- The groundwater levels recorded from 21 monitoring boreholes with established water levels adjacent to the beneficiation plant operations range between 4.13 mbgl (HF1) and 16.13 mbgl (HER-B3) with an average groundwater level depth of 10.15 mbgl.
- The groundwater levels recorded from 2 boreholes within the Mining Management Area range significantly between 5.66 mbgl (HER-B63) and 30.14 mbgl (HER-UN). Borehole HER-UN is located between the Historic Opencast Pit and the Morula Shaft Complex, whilst borehole HER-B63 is located further south, to the south of the Morula Dewatering Dam.
- Borehole HER-UN is situated alongside the incline shaft to the current underground workings. The deep water level recorded in this borehole could be as a result of the previous aquifer dewatering associated with the underground workings.
- The Morula Dewatering Dam is an unlined facility and the shallow water level recorded at borehole HER-B63 could be attributed to an increase in the groundwater recharge below the Morula Dewatering Dam.
- It is interesting to note that the groundwater level recorded at Borehole HF-1, which is situated between Historic Opencast Pit and the Tailings Storage Facility (TSF) is also very shallow, with a recorded groundwater level of 4.30 mbgl.
- The opencast pit is approximately 40 m deep at its deepest point. Groundwater flow is therefore still currently from the aquifer towards the pit.
- No significant / large scale dewatering of the aquifers, as a result of the mining operations at HERNIC, is observed based on the groundwater levels recorded.
- Most of the privately owned boreholes (EUB) adjacent to the HERNIC operations were being used as groundwater abstraction points. The groundwater levels recorded at these boreholes do therefore not necessarily reflect the natural groundwater levels as the water levels in the boreholes have been affected as a result of the abstraction from the boreholes.

At a storage value (storativity) of 0.002 the groundwater level response to 1 mm of rainfall will be 0.5 m. This indicates that for every 2 mm of rainfall recharge the change in groundwater storage would manifest as a rise in the water level of 1 m. In view of the fact that not all the recharge will take place at the same time but rather spread out over the summer months, natural groundwater level fluctuations in excess of 4 *m* to 6 *m* per annum is not expected.

Groundwater Elevations and Gradients

The groundwater elevations within the study area were calculated by subtracting the measured groundwater level depths from the surface elevations The calculated groundwater elevation distribution is listed in Table 8.4.12.3(e).

It is evident that the groundwater elevations are the highest in the east and generally get lower towards the west. The natural groundwater gradient within the shallow weathered zone aquifer at HERNIC is calculated by as **0.027** to the west / north-west.

The calculated groundwater elevations will furthermore be used to calibrate the steady state groundwater model, which will be developed for HERNIC. The simulated steady state groundwater elevations will be incorporated into the Groundwater Specialist Study Report.

Table 8.4.12.3(e): Calculated Groundwater Elevations

Number	Surface Elevation (mamsl)	Groundwater Elevation (mamsl)	Number	Surface Elevation (mamsl)	Groundwater Elevation (mamsl)
EUB-3	1168	**1160.71**	**HER-B41D**	1153	**1142.50**
EUB-4	1173	**1162.59**	**HER-B52**	1175	**1168.03**
EUB-14	1159	**1152.39**	**HER-B56**	1142.73	**1126.61**
EUB-15	1155	**1146.02**	**HER-B57**	1149.2	**1138.39**
EUB-20	1135	**1126.98**	**HER-B58**	1147.85	**1139.79**
EUB-24	1128	**1111.51**	**HER-B59**	1144.65	**1137.32**
EUB-31	1112	**1106.83**	**HER-B60**	1148.01	**1143.88**
HER-B1	1157	**1143.93**	**HER-B61**	1157.52	**1151.09**
HER-B2D	1157	**1143.60**	**HER-B62**	1162.56	**1136.21**
HER-B3	1151	**1135.82**	**HER-B63**	1184.96	**1179.30**
HER-B7	1152	**1142.66**	**HER-MC 1**	1143	**1128.50**
HER-B23	1138	**1126.30**	**HER-MC 2**	1147	**1132.38**
HER-B35	1137	**1124.73**	**HER-MD**	1142	**1128.21**
HER-B37	1136	**1126.82**	**HER-ME**	1161	**1149.09**
HER-B38 D	1147	**1137.10**	**HER-UN**	1186	**1155.86**
HER-B39 D	1146	**1136.34**	**HF 1**	1174	**1169.70**
HER-B40 D	1146	**1138.54**	**HF 4**	1153	**1147.25**

Groundwater Flow Directions and Flow Velocities

The groundwater flow directions were interpolated using the calculated groundwater elevations and are depicted on Figure 8.4.12.3(h). The groundwater flow directions depicted in Figure 8.4.12.3(h) provide a regional first order indication of the natural regional groundwater flow directions within the study area and indicate that the groundwater flows in a predominantly north-westerly direction within the study area.

The groundwater flow directions will be more accurately quantified and depicted within the numerical groundwater flow model. The steady state groundwater flow directions will be incorporated in the Groundwater Specialist Study Report.

The groundwater flow/seepage velocity (**Vs**) represents the most realistic expression of the actual groundwater flow velocity. The specific seepage velocity will be influenced by the hydraulic gradient (**i**), effective porosity (**n_e**) and permeability (**k**) of the shallow weathered zone aquifer and will therefore continuously vary across the extent of the study area. The average / bulk effective porosity across the site will therefore be used to determine the average seepage velocity, which is expressed as: $v_s = \frac{k\,i}{n_e}$ where k, i and n_e are all bulk average values for the site.

The average seepage velocity calculated for the majority of the study area is calculated as follows:

$$v_s: \quad = \frac{0.70 \times 0.027}{0.05}$$

$$= 0.378 \text{ m/day (138 m/year), towards the west / north-west.}$$

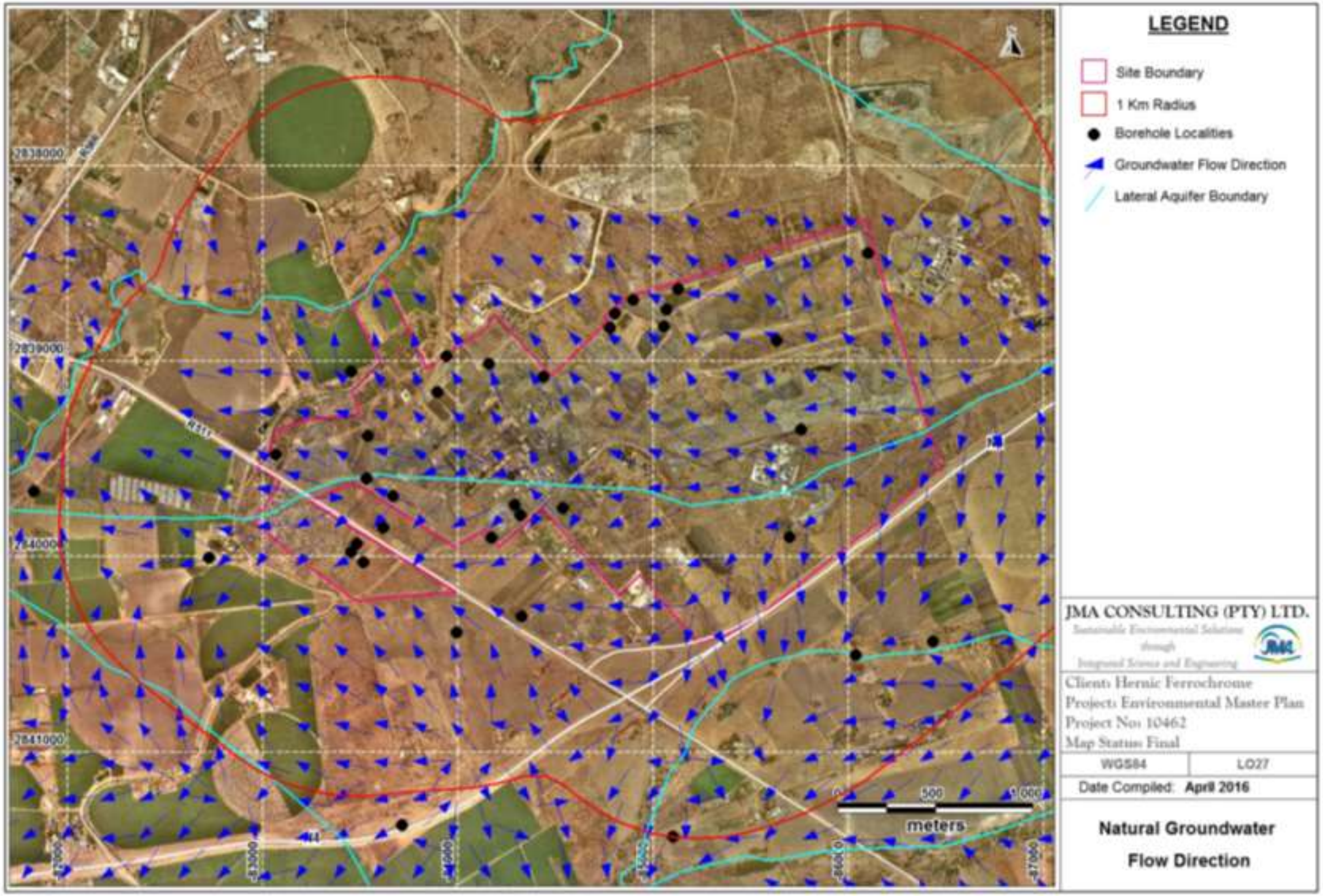


Figure 8.4.12.3(h): Interpolated Regional Groundwater Flow Directions

The Groundwater Reserve

The Groundwater Reserve is defined in the National Water Act (Act No. 36 of 1998) as "*the quantity and quality of water required to satisfy the basic human needs by securing a basic water supply, as prescribed under the Water Services Act (Act 108 of 1997) for people to be supplied with water from that resource, and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources*".

The HERNIC study area is located in the southern regions of the **A21J** Quaternary Catchment within the Limpopo River Primary Catchment Area and within the Crocodile (West) and Marico Water Management Area. In order to manage the groundwater resources within South Africa a groundwater quality and quantity reserve is required to be determined for each of the individual quaternary catchments.

These Reserves are calculated and issued by the Department of Water and Sanitation (DWS) during the processing of any new Water Use Licence applications. The Groundwater Reserve for each quaternary catchment is therefore updated every time a new Water Use Licence application within that specific quaternary catchment.

Although HERNIC was issued with a Water Use Licence in December 2015, no Reserve has been made available by the DWS. Upon request of the latest groundwater reserve from the DWS, JMA was informed that the groundwater reserve is now an internal DWS document which is not distributed externally. The details of the Groundwater Reserve calculated during the processing of HERNIC's WUL are therefore unknown. Reference is made therefore made to a previous Reserve (Ref: 26/8/3/3/54) which was issued in July 2010.

Groundwater Quantity Reserve

This previous (2010) Groundwater Reserve indicates that the A21J quaternary catchment receives an estimated average annual groundwater recharge of **29.97 Mm³/annum** across the catchment area of 1150.20 km² of which only **3.24 Mm³/annum** (10.81% of recharge) is required for the Reserve. The Ecological Water Requirements (EWR) and Basic Human Needs (BHN) requirements for the A21J quaternary catchment are 2.02 Mm³/annum (6.74% of recharge) and 1.22 Mm³/annum (4.07% of recharge) respectively.

A summary of the Groundwater Quantity Reserve for the A21J quaternary catchment is indicated in Table 8.4.12.3(f).

Table 8.4.12.3(f): Summary of the Groundwater Quantity Reserve (Ref: 26/8/3/3/54)

Catchment	Area (km²)	Recharge (Mm³/a)	Population	Baseflow (Mm³/a)	EWR (Mm³/a)	BHN Reserve (Mm³/a)	Reserve as % of Recharge
A21J	1150.20	29.97*	133 750	4.31**	2.02	1.22	10.81

* **Estimated using the GRAII dataset.** Recharge is calculated at 2.61% of MAP of 604 *mm/annum*. Bredenkamp et. al. 1995.
** **Estimated using the Herold Method (GRDM Version 3.3).** Herold, 1980.

The HERNIC WUL authorises the abstraction of 436,175 m³/annum of groundwater for aquifer dewatering purposes (to be re-used in the mining operations) and 47,450 m³/annum of contaminated groundwater from 3 groundwater abstraction boreholes (HER-B1, HER-MA and HER-MB) for remediation purposes and dust suppression.

HERNIC is therefore currently authorised to abstract a total volume of 483,625 m³ of groundwater per annum, which calculates to 1.6% of the groundwater recharge within the A21J quaternary catchment.

Groundwater Quality Reserve

The groundwater quality component of the Reserve for the A21J quaternary catchment (Ref: 26/8/3/3/54) is based on data obtained from the National Groundwater Database (NGDB). The stipulated ambient groundwater quality was determined from the statistical analysis of between 141 and 150 datasets from the catchment. The Reserve indicates that the ambient groundwater quality in quaternary catchment A21J falls within Class II of the previous DWAF water quality classification. Class II is indicated to represent water suitable for short term domestic use.

The preliminary determination of the Reserve for water quality in terms of Section 17(1) of the National Water Act (Act No. 36 of 1998) is summarized in Table 8.4.12.3(g), Table 8.4.12.3(h) and Table 8.4.12.3(i) for the General Chemistry, Physical Water Quality and Toxic Substances and Complex Mixtures respectively.

Table 8.4.12.3(g): General Chemistry

Parameter	Ambient Groundwater Quality[1)]	Basic Human Needs Reserve[2)]	Groundwater Quality Reserve[3)]
EC (mS/m)	58.05	<150	63.86
Sodium (*mg/l*)	28.27	<200	31.10
Magnesium (*mg/l*)	20.74	<70	22.81
Calcium (*mg/l*)	43.75	<150	48.13
Chloride (*mg/l*)	18.63	<200	20.49
Sulphate (*mg/l*)	25.99	<400	28.59
Nitrate (*mg/l*)	0.24	<10	0.26
Fluoride (*mg/l*)	0.48	<1.5	0.53

[1)] Based on data obtained from the National Groundwater Database. Values reported at statistical median of each parameter.
[2)] Ref: *Quality of Domestic Water Supplies, Volume 1: Assessment Guide, 2nd Ed.1998*. Water Research Commission Report No: TT 101/98. Pretoria, South Africa (Set for a Class 1).
[3)] Ref. Where a difference in the water quality values for the ambient groundwater quality and basic human needs was found, the lesser or more protective value was selected for the groundwater quality Reserve. Where the ambient groundwater quality was selected as the groundwater quality Reserve, the value was scaled up by 10 per cent.

Table 8.4.12.3(h): Physical Water Quality

Parameter	Ambient Groundwater Quality[1)]	Basic Human Needs Reserve[2)]	Groundwater Quality Reserve
pH	7.88	5.0 – 9.5	6 – 9.5

[1)] Based on data obtained from the National Groundwater Database. Values reported at statistical median of each parameter.
[2)] Ref: *Quality of Domestic Water Supplies, Volume 1: Assessment Guide, 2nd Ed.1998*. Water Research Commission Report No: TT 101/98. Pretoria, South Africa.

Table 8.4.12.3(i): Toxic Substances and Complex Mixtures

Parameter	Ambient Groundwater Quality	Basic Human Needs Reserve[1)]	Groundwater Quality Reserve
Toxics	Not Provided	< TWQR	

TWQR denotes Target Water Quality Range
[1)] Ref: South African Water Quality Guidelines, Volume 1: Domestic Water Use, 2nd Ed. 1996. Department of Water Affairs and Forestry. Pretoria, South Africa.

Aquifer Hydrochemistry

The operations at HERNIC comprise of both an existing active industrial site as well as existing mining operations and therefore represents a brown field's scenario, in that impacts on the underlying groundwater resource already exist. It is therefore important to describe both the background groundwater quality as well as the current (baseline) groundwater quality within the study area to provide a meaningful assessment of the current situation.

Groundwater samples were collected from 64 boreholes during February and March 2016 as part of this Groundwater Specialist Study. These included groundwater samples taken from 36 external user boreholes and 28 groundwater monitoring boreholes at HERNIC. The localities of the 64 groundwater sampling points / boreholes are depicted on Figure 8.4.12.3(i).

Expected Groundwater Quality within the Rustenburg Layered Suite

Research done on the groundwater qualities recorded from within the Rustenburg Layered Suite "indicate a marginally questionable quality, associated in particular with the average EC value of 105 *mS/m*" (Barnard, H.C. (2000)). Barnard, H.C. (2000) states that significant coefficients of variation are observed for potassium (222%), sulphate (186%), and nitrate (151%) (Table 8.4.12.3(j)) and further states that salinity is an important factor in the classification of this water for irrigation purposes.

Table 8.4.12.3(j): Groundwater Chemistry sampled within the RLS (Barnard, H.C (2000))

Element/ Parameter	STATISTICS FROM A POPULATION OF 73 SAMPLES					
	Min Value	Mean Value	Max Value	Standard Deviation	Coefficient of Variation	*Max Value +1 Std Dev*
pH	6.2	7.7	9.7	0.5	6%	-
EC (*mS/m*)	7.9	105	384	75	71%	*459*
TDS (*mg/l*)	52	760	2828	535	70%	*3363*
Ca (*mg/l*)	5	99	428	88	89%	*516*
Mg (*mg/l*)	2	56	231	44	79%	*275*
Na (*mg/l*)	3	45	179	37	82%	*216*
K (*mg/l*)	0.1	2.7	33	6	222%	*39*
Cl (*mg/l*)	2	94	570	117.7	125%	*687.7*
SO_4 (*mg/l*)	1	184	1850	343	186%	*2193*
T.Alk (*mg/l*)	9	219	532	102	47%	*634*
NO_3 (*mg/l*)	0.1	10.6	81	16	151%	*97*
F (*mg/l*)	0.1	0.3	2.2	0.4	133%	*2.6*

*** Elemental Concentrations assessed with regards to the SANS 241:2011 Drinking Water Standard**

As indicated in Table 8.4.12.3(j), certain elemental concentrations within groundwater sampled from the Rustenburg Layered Suite are generally very high due to the nature of the host rock geology, which potentially decrease the background groundwater quality within these regions. The classification of the elemental concentrations with regards to SANS 241:2011 indicates that the expected quality of the groundwater sampled from within the aquifers of the Rustenburg Layered Suite could potentially exceed the concentrations stipulated within the SANS 241:2011 Standard.

It is therefore of significant importance to determine the quality of the estimated "background" groundwater quality within the study area, before any groundwater quality and impact risk assessments are made and assigned to the groundwater resource within the study area.

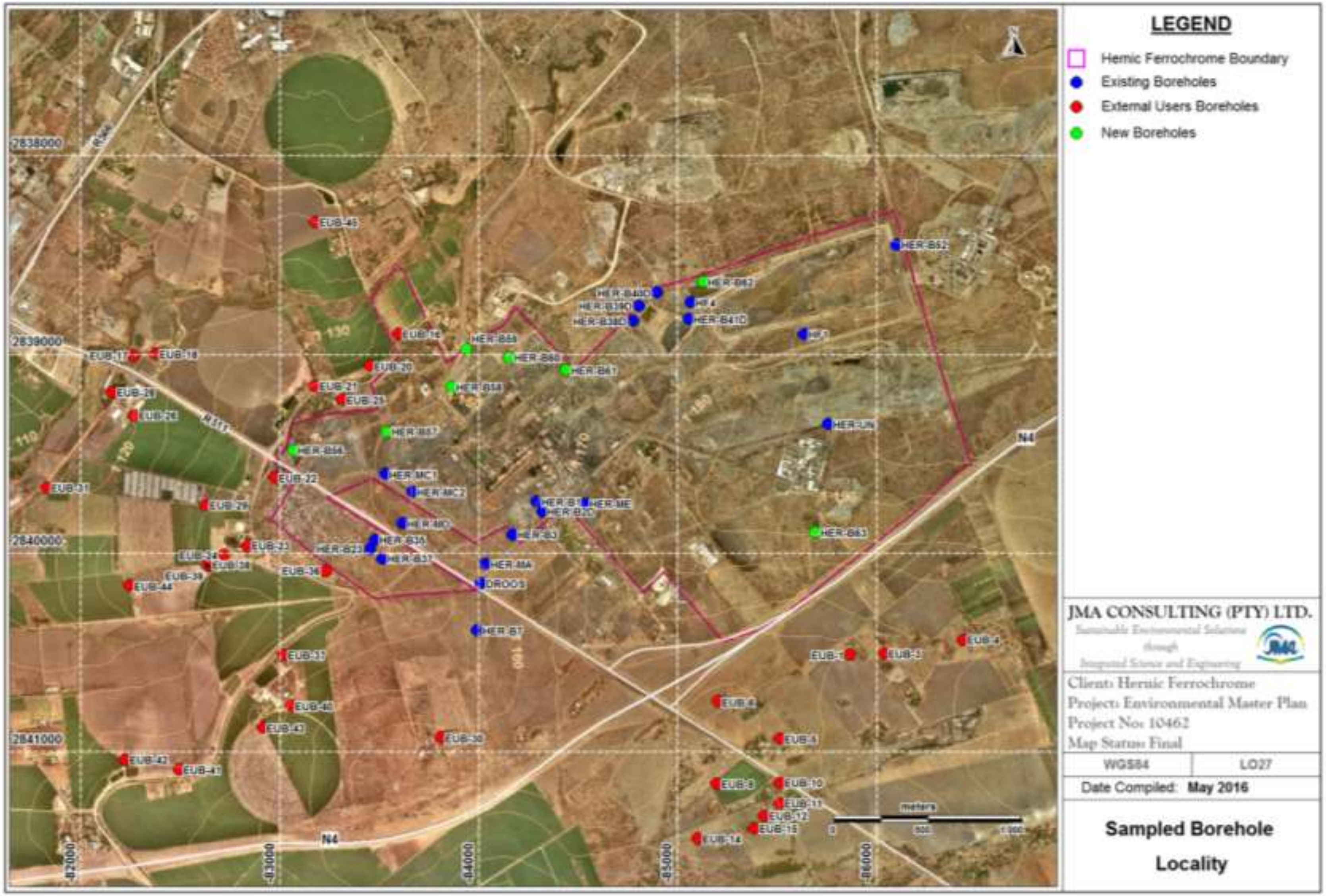


Figure 8.4.12.3(i): Groundwater Sampling Localities (64 Boreholes)

Background Groundwater Quality

The expected background groundwater quality assigned to the study area was determined using selected groundwater qualities sampled during the groundwater hydrocensus assessment and geohydrological field investigations conducted within the study area during February and March 2016.

The 64 groundwater samples collected were scrutinized and samples that were identified to represent background groundwater qualities were selected according to the following criteria:

- Locality - The boreholes are not to be located immediately adjacent to any surface activities that are deemed to have already had an impact on the quality of the groundwater sampled at the borehole.
- TDS - The groundwater samples have TDS concentrations of less than 1,000 mg/l,
- SO4. - The groundwater samples have SO4 concentrations of less than 250 mg/l.
- Na. - The groundwater samples have Na concentrations of less than 100 mg/l.

The groundwater samples collected from the following 32 boreholes adhere to the abovementioned requirements and are deemed to have qualities that represent that of the natural background groundwater qualities: EUB-1. EUB-3, EUB-4, EUB-5, EUB-6, EUB-9, EUB-10, EUB-11, EUB-12, EUB-14, EUB-15, EUB-17, EUB-20, EUB-21, EUB-22, EUB-23, EUB-24, EUB-26, EUB-28, EUB-29, EUB-31, EUB-36, EUB-38, EUB-39, EUB-42, EUB-43, EUB-44, EUB-46, HER-B52, HER-B56 , HER-B63 and HF-1,

The assessment of the background groundwater qualities for each of the elements analysed for, is made with reference to the SANS 241:2011 Drinking Water Standard, and is indicated in Table 8.4.12.3(k).

The SANS 241:2011 Standard (Drinking Water) was published in June 2011 and supersedes the SANS 241:2006 (Edition 6) Standard. The SANS 241:2011 Standard has been approved by the National Committee StanSA in accordance with procedures of Standards South Africa and specifies the quality of "*acceptable drinking water*", defined in terms of the microbiological, physical, aesthetic and chemical determinants, at the point of delivery. Water quality that complies with Part 1 of SANS 241:2011 is deemed to present an *acceptable health risk for lifetime consumption* (this implies an average consumption of 2 *l* of water per day for 70 years by a person that weighs 70 kg). Reference is made to the SANS 241:2011 Standard due to the fact that groundwater abstracted from several of the external user boreholes is used for domestic and drinking purposes.

Elemental concentrations that exceed the SANS 241:2011 Standard are indicated in red and elemental concentrations that adhere to the SANS 241:2011 Standard are indicated in green. The SANS 241:2011 Standard does not define concentrations for all the elements and these elemental concentrations in the groundwater samples are therefore indicated in black. Reference is also made to the SANS 241:2006 for certain elemental concentrations not specified in the SANS 241:2011 Standard.

Table 8.4.12.3(k): Expected Background Groundwater Quality

Analyses in mg/ℓ	Unit	Minimum	Average	Maximum	Standard Deviation	Max + 1 SD	SANS 241: 2011	SANS 241: 2006
pH	-	7.3	7.7	8.0	0.2	8.2	≥ 5 to ≤ 9.7	-
EC	mS/m	57.6	108.0	150.0	24.5	174.5	≤ 170	-
TDS	mg/l	332.0	678.6	988.0	186.6	1174.6	≤ 1200	-
Ca	mg/l	11.0	53.9	88.0	18.7	106.7	-	≤ 150
Mg	mg/l	21.0	89.4	154.0	36.8	190.8	-	≤ 70
Na	mg/l	22.0	48.5	92.0	17.9	109.9	≤ 200	-
K	mg/l	0.6	1.8	8.5	1.9	10.4	-	≤ 50
T.Alk	mg/l	152.0	377.5	564.0	80.6	644.6	-	-
Cl	mg/l	17.0	68.7	152.0	33.6	185.6	≤ 300	-
SO_4	mg/l	29.0	132.0	240.0	51.2	291.2	≤ 250, ≤ 500	-
Si	mg/l	4.0	21.2	35.0	9.3	44.3	-	-
NO_3	mg/l	0.5	9.7	25.0	8.1	33.1	≤ 11	-
NO_2	mg/l	<0.05	0.1	0.1	0.0	0.1	≤ 0.9	-
Al	mg/l	<0.1	0.1	0.1	0.0	0.1	≤ 0.3	-
F	mg/l	<0.2	0.2	0.2	0.0	0.2	≤ 1.5	-
Fe	mg/l	<0.025	0.1	0.3	0.1	0.5	≤ 0.3, ≤ 2	-
Mn	mg/l	<0.025	0.2	0.5	0.2	0.6	≤ 0.1, ≤ 0.5	-
NH_3	mg/l	0.1	0.4	7.1	1.3	8.4	≤ 1.5	-
Zn	mg/l	<0.025	0.22	1.51	0.46	1.97	≤ 5	-
Cr	mg/l	<0.025	0.03	0.03	0.00	0.03	≤ 0.05	-
Cr^{6+}	mg/l	<0.01	0.01	0.03	0.00	0.03	-	-
Ag	mg/l	<0.025	<0.025	<0.025	0.00	0.03	-	-
As	mg/l	<0.01	<0.01	<0.01	0.00	0.01	≤ 0.01	-
Co	mg/l	<0.025	<0.025	<0.025	0.00	0.03	≤ 0.5	-
P	mg/l	0.10	0.78	1.70	0.67	2.37	-	-
B	mg/l	0.03	0.04	0.09	0.02	0.11	-	-
Ba	mg/l	0.03	0.05	0.10	0.02	0.12	-	-
Bi	mg/l	<0.025	<0.025	<0.025	0.00	0.03	-	-
Cd	mg/l	<0.003	<0.003	<0.003	0.00	0.00	≤ 0.003	-
Cu	mg/l	0.01	0.01	0.03	0.00	0.03	≤ 2	-
Li	mg/l	<0.025	<0.025	<0.025	0.00	0.03	-	-
Mo	mg/l	<0.025	<0.025	<0.025	0.00	0.03	-	-
Ni	mg/l	<0.025	<0.025	<0.025	0.00	0.03	≤ 0.07	-
P	mg/l	0.03	0.15	1.72	0.32	2.04	-	-
Pb	mg/l	<0.01	<0.01	<0.01	0.00	0.01	≤ 0.01	-
S	mg/l	1.70	42.14	118.00	29.92	147.92	-	-
Sb	mg/l	<0.02	<0.02	<0.02	0.00	0.02	≤ 0.02	-
Se	mg/l	<0.01	<0.01	<0.01	0.00	0.01	≤ 0.01	-
Sr	mg/l	0.06	0.28	0.50	0.10	0.60	-	-
Ti	mg/l	<0.025	<0.025	<0.025	0.00	0.03	-	-
V	mg/l	0.03	0.04	0.07	0.01	0.08	≤ 0.2	-

It is important to note that the groundwater qualities may fluctuate between the seasons and between respective groundwater sampling runs. Representative groundwater qualities can therefore not be assigned to an aquifer or area of investigation based on only 1 sampling run. Statistical analyses of the chemistry of the groundwater sampled at the 32 boreholes between February 2016 and March 2016 was performed during which the minimum, average, maximum and standard deviations of the elemental concentrations were calculated

The assessment of the expected background groundwater quality of the study area with regards to the limits set in SANS 241:2011 indicates that the quality of the background groundwater samples collected predominantly, but not entirely, complies with the SANS 241:2011 limits. The major elements that have total (unfiltered) concentrations in at least one of the background groundwater samples collected that exceeds the SANS 241:2011 limits are Mg, NO_3 and NH_3, with Fe and Mn only slightly elevated.

It is evident that the background groundwater quality expected for the study area is significantly better than the quality of the groundwater generally expected within aquifers of the Rustenburg Layered Suite.

With the exception of Mg and NO_3, the elemental concentrations of the expected background groundwater quality for the study area also falls within the "Baseline Groundwater Quality" limits specified in the WUL issued to HERNIC.

The expected background groundwater quality determined for the study area is deemed relevant and should be used and referred to with regards to formal groundwater impact and risk assessments for the study area at HERNIC as well as during future groundwater quality reserve determinations.

Hydrochemical imaging of expected background groundwater samples collected from within the study area was performed during which Piper and Durov Diagrams were compiled. The resulting Piper and Durov Diagrams of the expected background groundwater quality are depicted as Figure 8.4.12.3(j) and Figure 8.4.12.3(k) respectively.

It is evident from the Piper Diagram that the background groundwater quality is classified as having a distinctly characteristic **Type-B** hydrochemical facies signature, with the dominant cation evidently being **Mg^{2+}** and the dominant anion being **HCO_3^-**(T.Alk).

The groundwater sampled from borehole EUB-3 has more Na^+ & K^+ and less Ca^{2+} and Mg^{2+} equivalent cations, with almost no Cl^-(12%) than the rest of the background groundwater samples. The groundwater sample collected from borehole EUB-3 is subsequently classified as having a Type-C hydrochemical signature.

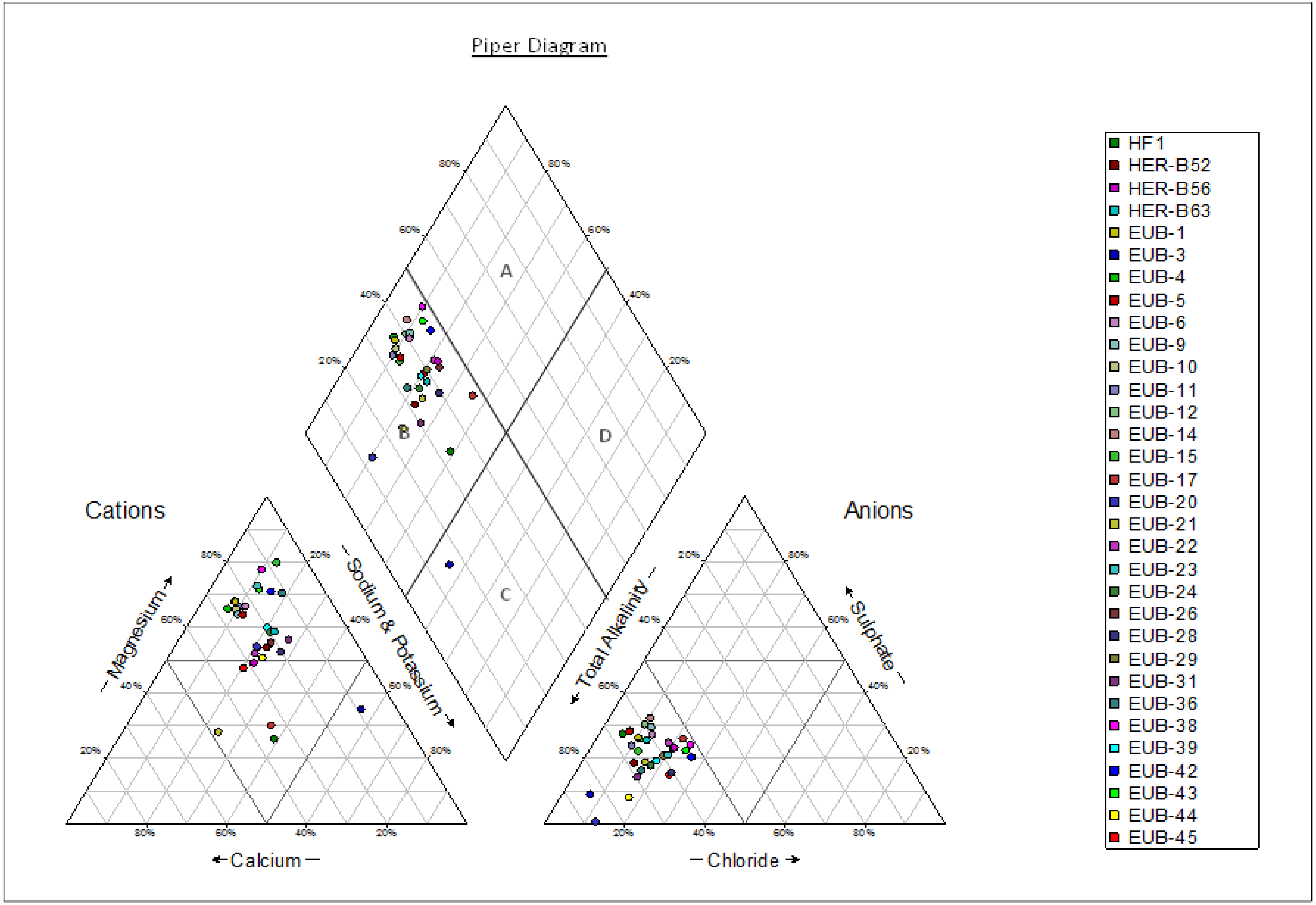


Figure 8.4.12.3(j): Background Groundwater Quality – Piper Diagram

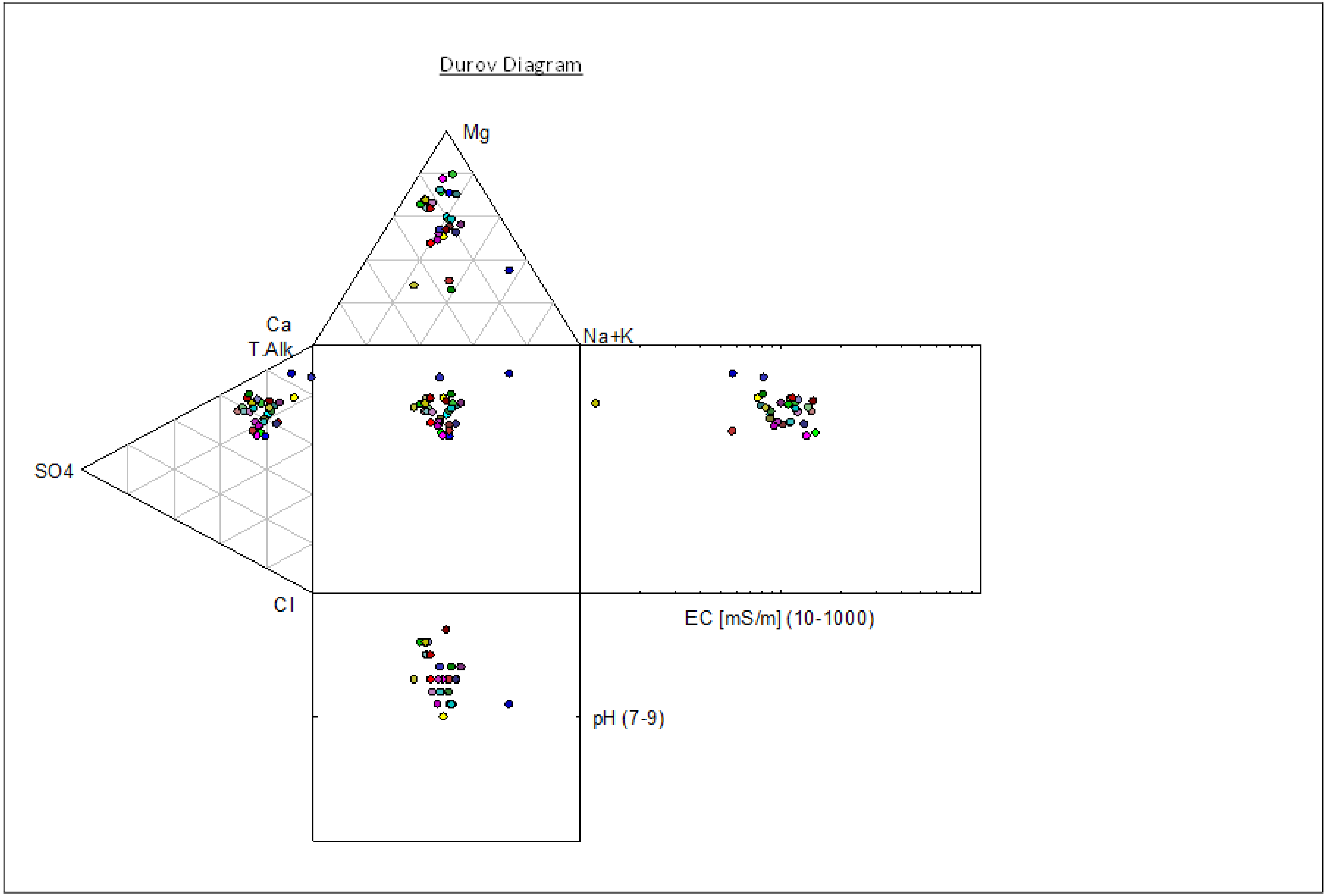


Figure 8.4.12.3(k): Background Groundwater Quality – Durov Diagram

Current Groundwater Quality

The current groundwater quality is assessed with regards to **all** the groundwater samples collected within the study area during February and March 2016. A total of 64 groundwater samples were collected..

Groundwater samples were collected from 35 of the privately owned external user boreholes (EUB) identified during the groundwater hydrocensus, 21 of the existing groundwater monitoring boreholes (HER-B-, HER-MA, HER-ME and HF-) and at each of the 8 geohydrological investigative / groundwater monitoring boreholes (HER-B) drilled at HERNIC.

The elemental concentrations analysed for in each of each of the groundwater samples collected are listed in Table 8.4.12.3(l) (7 tables) and have also been assessed with regards to the SANS 241:2011 Standard. It is evident from the Table and specifically the TDS and SO_4 concentrations that the groundwater sampled from the HERNIC monitoring boreholes have elemental concentrations which are higher than those observed in the background groundwater quality. This is indicative of surface induced impacts on the groundwater resource quality, specifically within the Alloys Plant Management Area.

The following has relevance with regards to the major elemental concentrations of the groundwater sampled within the study area:

- The pH is neutral and ranges between 7.2 and 8.0 with an average pH of 7.6.
- EC ranges between 57.6 mS/m and 547 mS/m with an average of 167.1 mS/m.
- TDS ranges significantly between 332 mg/l and 3714 mg/l with an average of 1145 mg/l.
- Ca ranges between 11 mg/l and 791 mg/l with an average of 93.8 mg/l.
- Mg ranges between 20 mg/l and 317 mg/l with an average of 134.2 mg/l.
- Na ranges between 15 mg/l and 300 mg/l with an average of 83 mg/l.
- K ranges between 0.6 mg/l and 68 mg/l with an average of 3.7 mg/l.
- T.Alk ranges between 80 mg/l and 952 mg/l with an average of 428.5 mg/l.
- Cl ranges between 17 mg/l and 1694 mg/l with an average of 155.3 mg/l.
- SO4 ranges between 16 mg/l and 899 mg/l with an average of 292.5 mg/l.
- NO3 ranges significantly between 0.5 mg/l and 74 mg/l with an average of 19 mg/l.
- Cr(T) ranges between < 0.025 mg/l (below the detection limit) and 12 mg/l as recorded at borehole HER-MC2.
- Cr(T) was detected in 2 of the 35 external user boreholes (EUB-23 and EUB-25) and in 11 of the 29 groundwater monitoring boreholes at HERNIC.
- Cr(VI) ranges between < 0.010 mg/l (below the detection limit) and 11 mg/l as recorded at borehole HER-MC2.
- Cr(VI) was detected in 4 of the 35 external user boreholes (EUB-6, EUB-23, EUB-25 and EUB-38) and in 11 of the 29 groundwater monitoring boreholes at HERNIC.

Concentration distribution maps have been compiled for TDS, SO_4, Cl, Cr(VI) and NO_3, depicted as Figures 8.4.12.3(l) to 8.4.12.3(p) respectively. The TDS as well as SO_4^{2-} and Cl^- are deemed conservative elements and an increase in these concentrations indicate potential surface induced impacts on the groundwater samples collected. The Cr(VI) concentration distribution is also depicted for reference purposes and will be discussed below due to the history of and sensitivity regarding elevated Cr(VI) concentrations recorded at HERNIC.

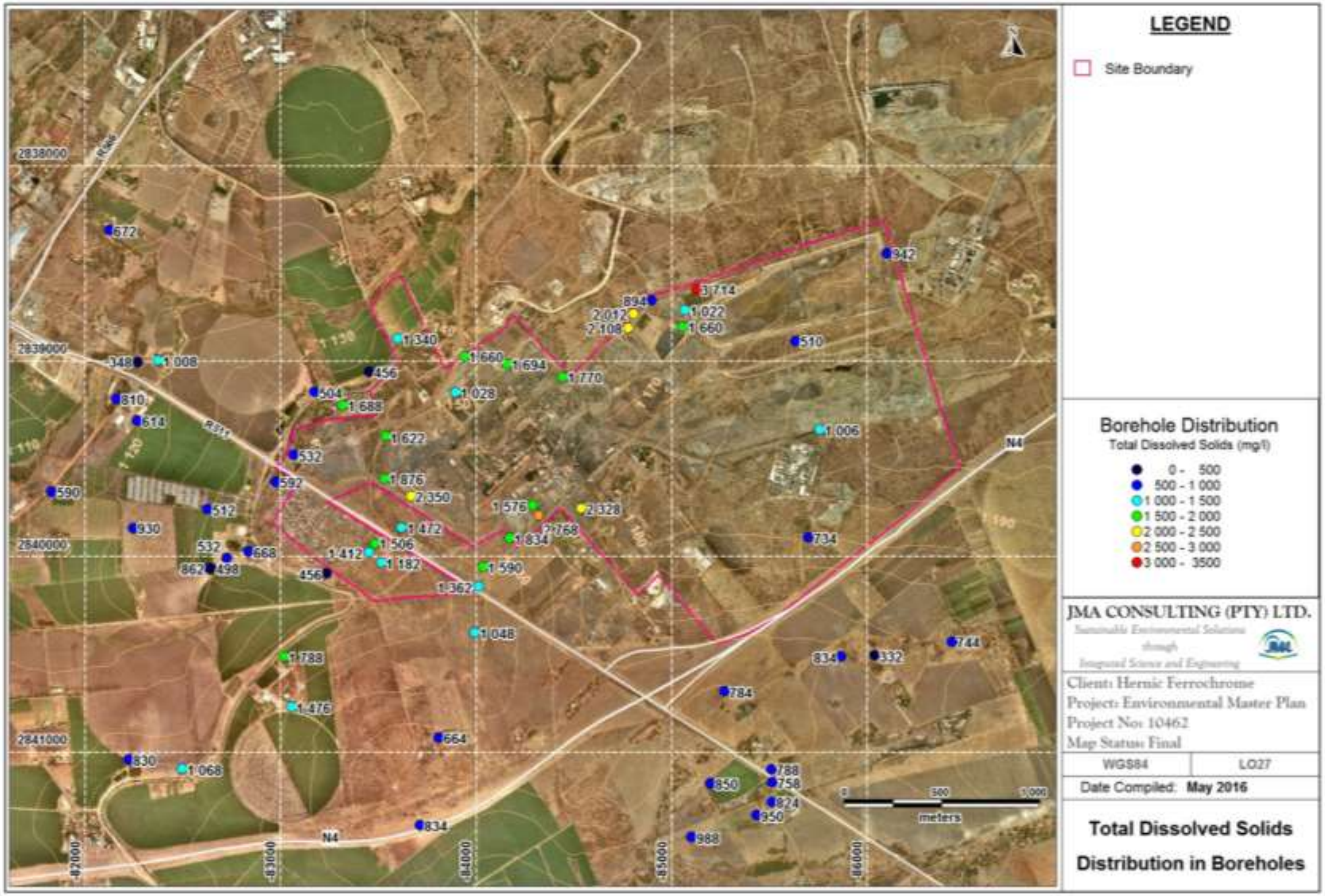


Figure 8.4.12.3(l): Total Dissolved Solids (TDS) Concentration Distribution Map

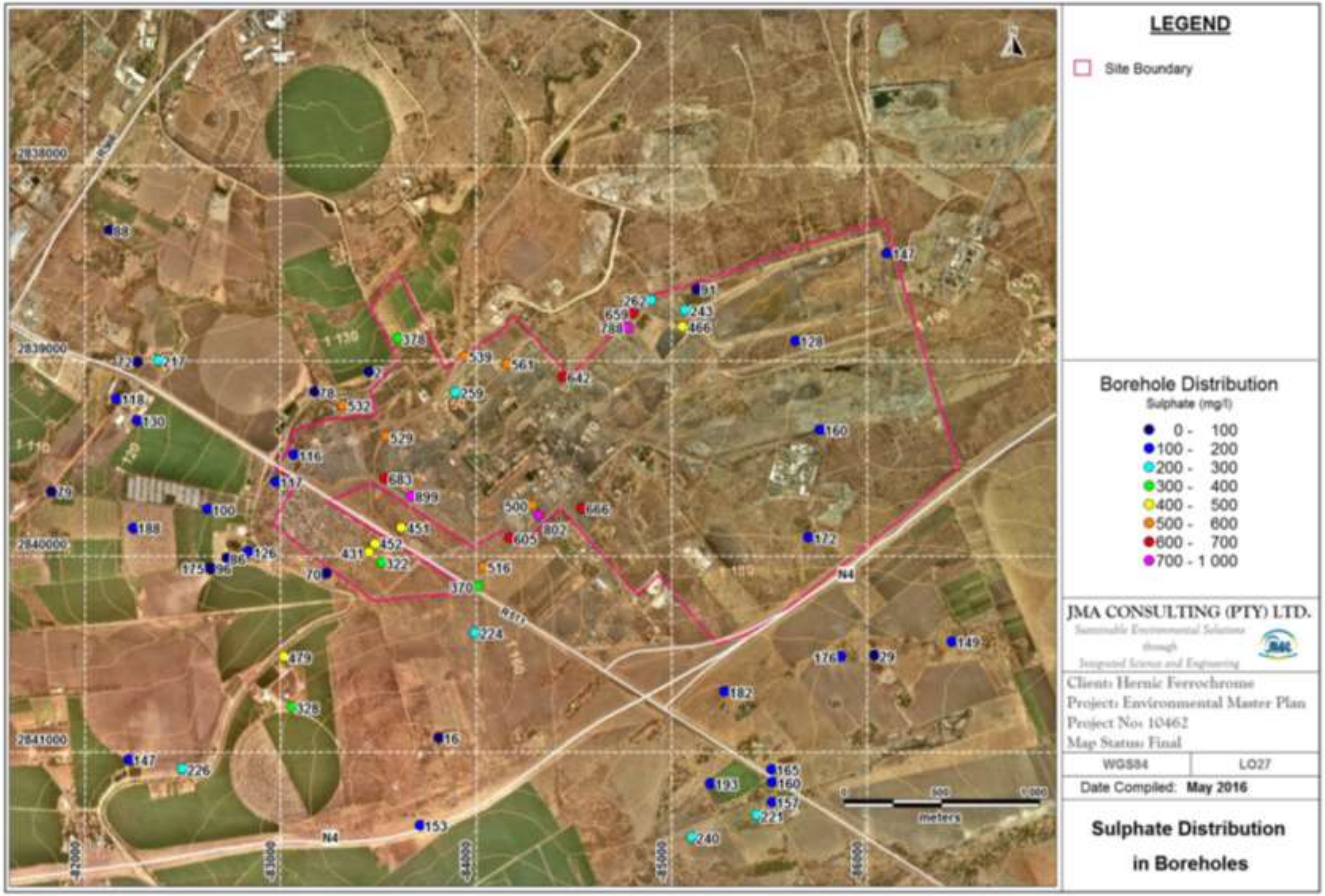


Figure 8.4.12.3(m): Sulphate Concentration Distribution Map

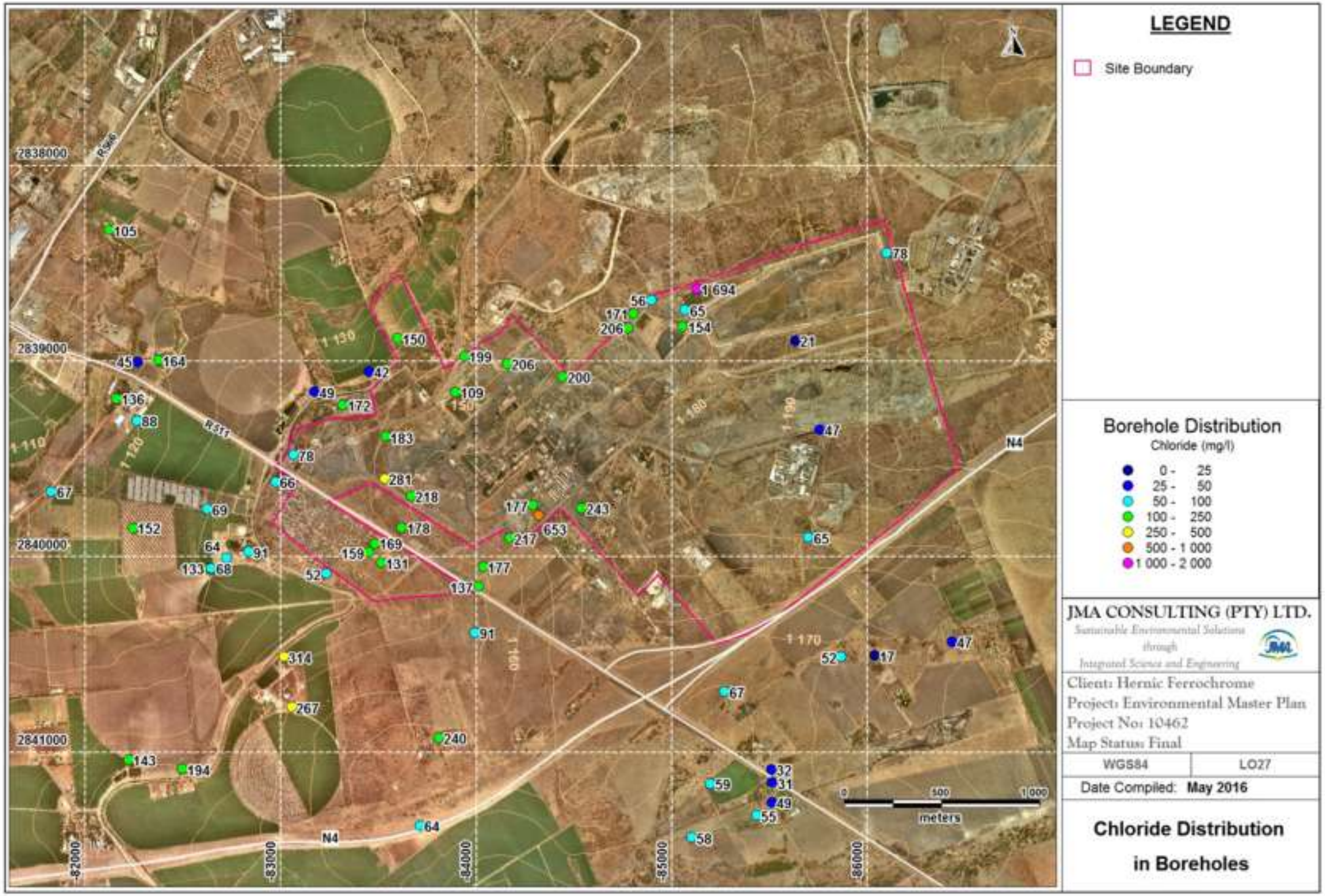


Figure 8.4.12.3(n): Chloride Concentration Distribution Map

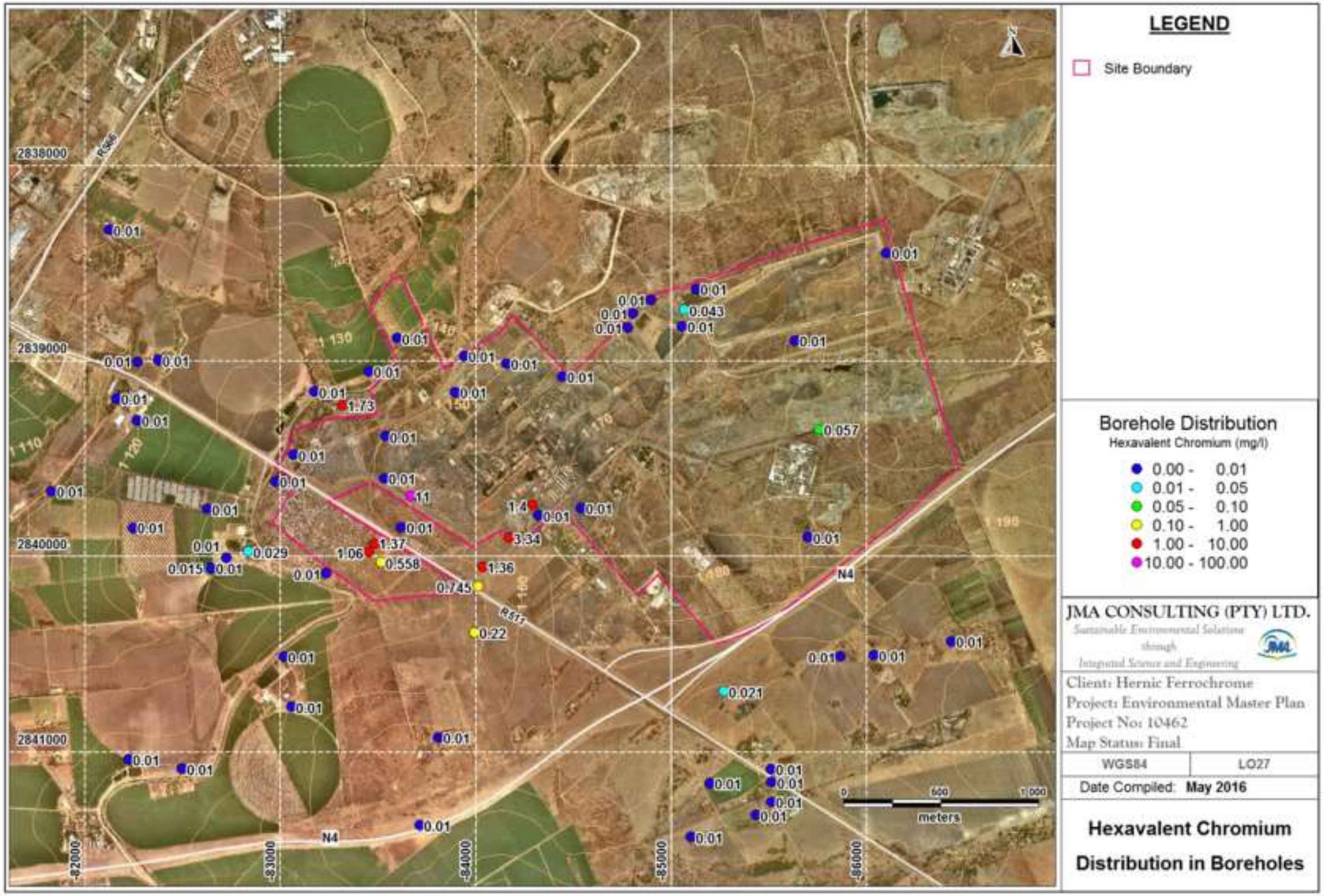


Figure 8.4.12.3(o): **Hexavalent Chromium Concentration Distribution Map**

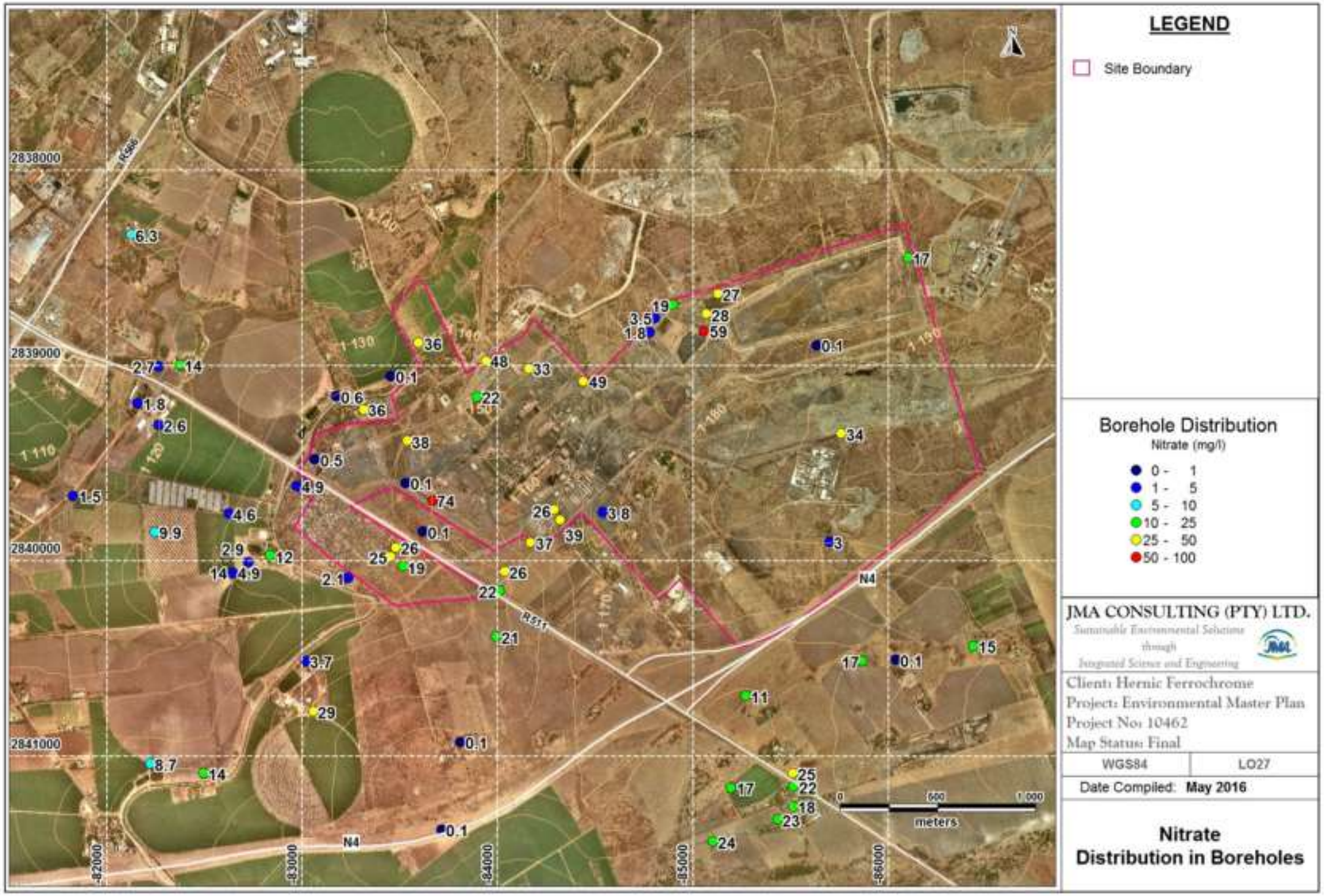


Figure 8.4.12.3(p): Nitrate Concentration Distribution Map

Table 8.4.12.3(l): Current Groundwater Quality (1 of 7)

Borehole No.	Sampling Date	pH	EC	TDS	Ca	Mg	Na
EUB-1	2016/03/04	7.4	124	834	70	121	28
EUB-3	2016/03/04	7.9	58	332	11	26	78
EUB-4	2016/03/04	7.4	110	744	69	102	22
EUB-5	2016/03/10	7.5	115	788	64	103	37
EUB-6	2016/03/04	7.8	122	784	60	109	36
EUB-9	2016/03/04	7.5	123	850	73	112	36
EUB-10	2016/03/04	7.5	112	758	63	101	28
EUB-11	2016/03/04	7.4	123	824	67	113	32
EUB-12	2016/03/04	7.4	138	950	78	131	37
EUB-14	2016/03/11	7.4	143	988	81	139	31
EUB-15	2016/03/11	7.9	118	834	22	138	41
EUB-16	2016/03/08	7.6	191	1 340	77	179	82
EUB-17	2016/03/09	7.7	58	348	39	21	43
EUB-18	2016/03/09	7.7	154	1 008	81	126	72
EUB-20	2016/03/09	7.6	83	456	45	58	40
EUB-21	2016/03/09	7.7	85	504	88	31	47
EUB-22	2016/03/09	7.7	97	592	58	68	52
EUB-23	2016/03/09	7.8	113	668	42	115	34
EUB-24	2016/03/09	7.8	90	532	39	70	49
EUB-25	2016/03/09	7.5	219	1 688	164	193	78
EUB-26	2016/03/09	7.7	103	614	48	76	61
EUB-28	2016/03/09	7.7	132	810	59	93	92
EUB-29	2016/03/10	7.8	89	512	49	63	46
EUB-30	2016/03/10	7.6	123	664	41	25	147
EUB-31	2016/03/11	7.6	101	590	37	77	71
EUB-36	2016/03/11	7.7	80	456	20	78	39
EUB-37	2016/03/11	7.5	271	1 788	92	317	52
EUB-38	2016/03/11	7.7	135	862	39	148	36
EUB-39	2016/03/11	7.7	90	498	39	71	44
EUB-40	2016/03/11	7.8	222	1 476	88	242	53
EUB-41	2016/03/11	7.9	173	1 068	61	168	74
EUB-42	2016/03/11	7.9	135	830	41	131	55
EUB-43	2016/03/11	7.8	150	930	57	154	50
EUB-44	2016/03/11	8.0	77	438	41	49	43
EUB-45	2016/03/11	7.7	112	672	79	71	58
D. Roos	2016/03/01	7.4	193	1 362	82	195	88
HER-B1	2016/03/01	7.6	218	1 576	85	208	117
HER-B3	2016/03/01	7.5	241	1 834	83	158	229
HER-B7	2016/02/29	7.4	160	1 048	58	178	42
HER-B2D	2016/02/26	7.5	383	2 768	229	197	300
HER-B23	2016/02/29	7.5	196	1 412	60	253	26
HER-B35	2016/02/29	7.3	201	1 506	93	236	33
HER-B37	2016/02/29	7.4	177	1 182	72	211	31
HER-B38D	2016/02/29	7.2	280	2 108	122	285	175
HER-B39D	2016/02/29	7.3	268	2 012	114	305	119
HER-B40D	2016/02/29	7.5	130	894	70	90	76
HER-B41D	2016/02/29	7.3	226	1 660	136	150	160
HER-B52	2016/02/29	7.3	146	942	78	110	89
HER-B56	2016/03/29	7.9	93	532	57	59	50
HER-B57	2016/03/29	7.5	215	1 622	204	160	63
HER-B58	2016/03/29	7.6	152	1 028	92	79	116
HER-B59	2016/03/30	7.6	227	1 660	116	167	170
HER-B60	2016/03/30	7.6	241	1 694	111	136	254
HER-B61	2016/03/30	7.9	238	1 770	92	255	83
HER-B62	2016/03/30	7.4	547	3 714	791	20	201
HER-B63	2016/03/29	7.9	119	734	50	95	69
HER-MA	2016/03/01	7.7	218	1 590	91	209	125
HER-MC1	2016/02/29	7.3	250	1 876	254	116	154
HER-MC2	2016/02/29	7.3	284	2 350	289	139	188
HER-MD	2016/03/01	7.4	205	1 472	128	202	56
HER-ME	2016/03/01	7.3	314	2 328	113	308	212
HER-UN	2016/03/01	7.4	153	1 006	89	162	15
HF1	2016/02/29	7.6	82	510	63	28	78
HF-4	2016/02/29	8.0	152	1 022	63	106	122
SANS 2011		≥ 5 to ≤ 9.7	≤ 170	≤ 1200	-	-	≤ 200
SANS 2006					≤ 150	≤ 70	

Table 8.4.12.3(l): Current Groundwater Quality (2 of 7)

Borehole No.	Sampling Date	K	NH_4	T.Alk	Cl	SO_4	NO_3
EUB-1	2016/03/04	0.7	<0.1	444	52	176	17
EUB-3	2016/03/04	2.3	0.1	284	17	29	<0.1
EUB-4	2016/03/04	0.8	0.1	380	47	149	15
EUB-5	2016/03/10	0.9	0.1	396	32	165	25
EUB-6	2016/03/04	0.6	<0.1	416	67	182	11
EUB-9	2016/03/04	0.7	0.1	400	59	193	17
EUB-10	2016/03/04	1.1	0.1	380	31	160	22
EUB-11	2016/03/04	1.4	0.1	456	49	157	18
EUB-12	2016/03/04	1.1	0.1	456	55	221	23
EUB-14	2016/03/11	1.3	<0.1	444	58	240	24
EUB-15	2016/03/11	1.2	1.1	472	64	153	<0.1
EUB-16	2016/03/08	0.7	0.1	460	150	378	36
EUB-17	2016/03/09	8.5	0.1	152	45	72	2.7
EUB-18	2016/03/09	<0.5	0.1	400	164	217	14
EUB-20	2016/03/09	3.4	7.1	404	42	<2	<0.1
EUB-21	2016/03/09	6	0.1	284	49	78	0.6
EUB-22	2016/03/09	1.1	0.1	280	66	117	4.9
EUB-23	2016/03/09	0.6	0.1	368	91	126	12
EUB-24	2016/03/09	<0.5	0.1	328	64	86	2.9
EUB-25	2016/03/09	<0.5	0.1	468	172	532	36
EUB-26	2016/03/09	<0.5	0.1	336	88	130	2.6
EUB-28	2016/03/09	<0.5	0.3	480	136	118	1.8
EUB-29	2016/03/10	<0.5	0.1	300	69	100	4.6
EUB-30	2016/03/10	3.3	13	212	240	16	<0.1
EUB-31	2016/03/11	<0.5	0.1	404	67	79	1.5
EUB-36	2016/03/11	<0.5	0.1	304	52	70	2.1
EUB-37	2016/03/11	1	0.1	648	314	479	3.7
EUB-38	2016/03/11	0.6	0.1	392	133	175	14
EUB-39	2016/03/11	2.9	0.1	324	68	96	4.9
EUB-40	2016/03/11	1	0.1	556	267	328	29
EUB-41	2016/03/11	1.3	0.1	492	194	226	14
EUB-42	2016/03/11	0.6	0.1	400	143	147	8.7
EUB-43	2016/03/11	0.8	0.1	472	152	188	9.9
EUB-44	2016/03/11	0.7	0.1	328	54	33	0.9
EUB-45	2016/03/11	<0.5	0.1	380	105	88	6.3
D. Roos	2016/03/01	1.8	<0.1	560	137	370	22
HER-B1	2016/03/01	1.3	<0.1	500	177	500	26
HER-B3	2016/03/01	1.5	<0.1	340	217	605	37
HER-B7	2016/02/29	1	0.1	568	91	224	21
HER-B2D	2016/02/26	68	0.1	328	653	802	39
HER-B23	2016/02/29	<0.5	<0.1	504	159	431	25
HER-B35	2016/02/29	1	<0.1	476	169	452	26
HER-B37	2016/02/29	0.9	<0.1	524	131	322	19
HER-B38D	2016/02/29	2.3	<0.1	780	206	788	1.8
HER-B39D	2016/02/29	2.4	<0.1	820	171	659	3.5
HER-B40D	2016/02/29	16.4	<0.1	340	56	262	19
HER-B41D	2016/02/29	2.9	<0.1	480	154	466	59
HER-B52	2016/02/29	1.6	0.1	564	78	147	17
HER-B56	2016/03/29	1.7	1.6	292	78	116	0.5
HER-B57	2016/03/29	0.7	0.5	420	183	529	38
HER-B58	2016/03/29	2.2	0.2	380	109	259	22
HER-B59	2016/03/30	1.1	1.7	408	199	539	48
HER-B60	2016/03/30	10.9	1.1	480	206	561	33
HER-B61	2016/03/30	2.2	1	456	200	642	49
HER-B62	2016/03/30	7.9	0.2	80	1 694	91	27
HER-B63	2016/03/29	1.4	0.1	436	65	172	3
HER-MA	2016/03/01	1.3	0.1	520	177	516	26
HER-MC1	2016/02/29	1.4	0.2	380	281	683	<0.1
HER-MC2	2016/02/29	1.6	0.1	276	218	899	74
HER-MD	2016/03/01	2.1	4	620	178	451	<0.1
HER-ME	2016/03/01	7.5	0.1	952	243	666	3.8
HER-UN	2016/03/01	2.6	0.1	604	47	160	34
HF1	2016/02/29	4	0.5	324	21	128	<0.1
HF-4	2016/02/29	1.5	<0.1	460	65	243	28
SANS 2011		-	≤ 1.5	-	≤ 300	≤ 250, ≤ 500	≤ 11
SANS 2006		≤ 50					

Table 8.4.12.3(l): Current Groundwater Quality (3 of 7)

Borehole No.	Sampling Date	NO_2	PO_4	F	Fe	Cr(T)	Cr(VI)
EUB-1	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-3	2016/03/04	<0.05	<0.1	0.2	0.181	<0.025	<0.010
EUB-4	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-5	2016/03/10	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-6	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	0.021
EUB-9	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-10	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-11	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-12	2016/03/04	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-14	2016/03/11	<0.05	<0.1	<0.2	0.027	<0.025	<0.010
EUB-15	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-16	2016/03/08	<0.05	<0.1	<0.2	0.034	<0.025	<0.010
EUB-17	2016/03/09	<0.05	0.7	<0.2	<0.025	<0.025	<0.010
EUB-18	2016/03/09	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-20	2016/03/09	<0.05	1.7	0.2	0.331	<0.025	<0.010
EUB-21	2016/03/09	<0.05	<0.1	0.2	<0.025	<0.025	<0.010
EUB-22	2016/03/09	<0.05	<0.1	0.2	<0.025	<0.025	<0.010
EUB-23	2016/03/09	<0.05	<0.1	<0.2	0.042	0.029	0.029
EUB-24	2016/03/09	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-25	2016/03/09	<0.05	<0.1	<0.2	<0.025	1.81	1.73
EUB-26	2016/03/09	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-28	2016/03/09	<0.05	0.6	<0.2	<0.025	<0.025	<0.010
EUB-29	2016/03/10	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-30	2016/03/10	<0.05	0.6	1.4	0.03	<0.025	<0.010
EUB-31	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-36	2016/03/11	<0.05	<0.1	0.2	<0.025	<0.025	<0.010
EUB-37	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-38	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	0.015
EUB-39	2016/03/11	<0.05	0.1	0.2	0.05	<0.025	<0.010
EUB-40	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-41	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-42	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-43	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
EUB-44	2016/03/11	<0.05	<0.1	0.2	<0.025	<0.025	<0.010
EUB-45	2016/03/11	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
D. Roos	2016/03/01	<0.05	<0.1	<0.2	0.033	0.758	0.745
HER-B1	2016/03/01	<0.05	<0.1	<0.2	<0.025	1.42	1.4
HER-B3	2016/03/01	<0.05	<0.1	<0.2	<0.025	3.47	3.34
HER-B7	2016/02/29	<0.05	<0.1	<0.2	<0.025	0.249	0.22
HER-B2D	2016/02/26	0.4	<0.1	0.3	<0.025	<0.025	<0.010
HER-B23	2016/02/29	<0.05	<0.1	<0.2	<0.025	1.07	1.06
HER-B35	2016/02/29	0.1	<0.1	<0.2	0.052	1.37	1.37
HER-B37	2016/02/29	0.05	<0.1	<0.2	<0.025	0.558	0.558
HER-B38D	2016/02/29	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
HER-B39D	2016/02/29	<0.05	<0.1	0.2	<0.025	<0.025	<0.010
HER-B40D	2016/02/29	0.1	<0.1	0.2	<0.025	<0.025	<0.010
HER-B41D	2016/02/29	0.5	<0.1	0.4	<0.025	<0.025	<0.010
HER-B52	2016/02/29	0.1	<0.1	0.2	<0.025	<0.025	<0.010
HER-B56	2016/03/29	0.08	<0.1	<0.2	0.026	<0.025	<0.010
HER-B57	2016/03/29	0.2	<0.1	<0.2	<0.025	<0.025	<0.010
HER-B58	2016/03/29	0.1	<0.1	0.3	0.095	<0.025	<0.010
HER-B59	2016/03/30	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
HER-B60	2016/03/30	0.6	<0.1	0.4	<0.025	<0.025	<0.010
HER-B61	2016/03/30	0.05	<0.1	0.2	<0.025	<0.025	<0.010
HER-B62	2016/03/30	0.09	<0.1	<0.2	<0.025	<0.025	<0.010
HER-B63	2016/03/29	0.07	<0.1	<0.2	<0.025	<0.025	<0.010
HER-MA	2016/03/01	<0.05	<0.1	<0.2	<0.025	1.36	1.36
HER-MC1	2016/02/29	<0.05	<0.1	0.4	0.046	<0.025	<0.010
HER-MC2	2016/02/29	0.05	<0.1	<0.2	<0.025	12	11
HER-MD	2016/03/01	<0.05	0.1	<0.2	<0.025	<0.025	<0.010
HER-ME	2016/03/01	0.4	<0.1	0.3	0.025	<0.025	<0.010
HER-UN	2016/03/01	<0.05	<0.1	<0.2	<0.025	0.057	0.057
HF1	2016/02/29	<0.05	<0.1	<0.2	<0.025	<0.025	<0.010
HF-4	2016/02/29	<0.05	<0.1	0.2	<0.025	0.043	0.043
SANS 2011		≤ 0.9	-	≤ 1.5	≤ 0.3, ≤ 2	≤ 0.05	-
SANS 2006							

Table 8.4.12.3(l): Current Groundwater Quality (4 of 7)

Borehole No.	Sampling Date	Ag	Al	As	B	Ba	Bi
EUB-1	2016/03/04	<0.025	<0.100	<0.010	<0.025	0.06	<0.025
EUB-3	2016/03/04	<0.025	<0.100	<0.010	<0.025	<0.025	<0.025
EUB-4	2016/03/04	<0.025	<0.100	<0.010	<0.025	0.084	<0.025
EUB-5	2016/03/10	<0.025	<0.100	<0.010	<0.025	0.06	<0.025
EUB-6	2016/03/04	<0.025	<0.100	<0.010	<0.025	0.045	<0.025
EUB-9	2016/03/04	<0.025	<0.100	<0.010	<0.025	0.063	<0.025
EUB-10	2016/03/04	<0.025	<0.100	<0.010	<0.025	0.081	<0.025
EUB-11	2016/03/04	<0.025	<0.100	<0.010	0.029	0.089	<0.025
EUB-12	2016/03/04	<0.025	<0.100	<0.010	0.026	0.099	<0.025
EUB-14	2016/03/11	<0.025	<0.100	<0.010	<0.025	0.089	<0.025
EUB-15	2016/03/11	<0.025	<0.100	<0.010	0.044	0.026	<0.025
EUB-16	2016/03/08	<0.025	<0.100	<0.010	0.095	0.08	<0.025
EUB-17	2016/03/09	<0.025	<0.100	<0.010	0.04	<0.025	<0.025
EUB-18	2016/03/09	<0.025	<0.100	<0.010	0.064	0.041	<0.025
EUB-20	2016/03/09	<0.025	<0.100	<0.010	0.055	0.049	<0.025
EUB-21	2016/03/09	<0.025	<0.100	<0.010	0.046	0.092	<0.025
EUB-22	2016/03/09	<0.025	<0.100	<0.010	0.058	0.034	<0.025
EUB-23	2016/03/09	<0.025	<0.100	<0.010	0.038	0.037	<0.025
EUB-24	2016/03/09	<0.025	<0.100	<0.010	0.056	0.03	<0.025
EUB-25	2016/03/09	<0.025	<0.100	0.024	<0.025	0.075	<0.025
EUB-26	2016/03/09	<0.025	<0.100	<0.010	0.029	0.033	<0.025
EUB-28	2016/03/09	<0.025	<0.100	<0.010	0.025	0.037	<0.025
EUB-29	2016/03/10	<0.025	<0.100	<0.010	0.046	0.029	<0.025
EUB-30	2016/03/10	<0.025	<0.100	<0.010	0.586	<0.025	<0.025
EUB-31	2016/03/11	<0.025	<0.100	<0.010	0.045	<0.025	<0.025
EUB-36	2016/03/11	<0.025	<0.100	<0.010	0.074	<0.025	<0.025
EUB-37	2016/03/11	<0.025	<0.100	<0.010	0.048	0.063	<0.025
EUB-38	2016/03/11	<0.025	<0.100	<0.010	0.047	0.031	<0.025
EUB-39	2016/03/11	<0.025	<0.100	<0.010	0.049	0.042	<0.025
EUB-40	2016/03/11	<0.025	<0.100	<0.010	0.026	0.06	<0.025
EUB-41	2016/03/11	<0.025	<0.100	<0.010	0.053	0.035	<0.025
EUB-42	2016/03/11	<0.025	<0.100	<0.010	0.025	0.033	<0.025
EUB-43	2016/03/11	<0.025	<0.100	<0.010	0.068	0.046	<0.025
EUB-44	2016/03/11	<0.025	<0.100	<0.010	0.053	0.029	<0.025
EUB-45	2016/03/11	<0.025	<0.100	<0.010	0.092	0.06	<0.025
D. Roos	2016/03/01	<0.025	<0.100	0.015	<0.025	0.088	<0.025
HER-B1	2016/03/01	<0.025	<0.100	0.011	<0.025	0.041	<0.025
HER-B3	2016/03/01	<0.025	<0.100	0.038	0.055	0.067	<0.025
HER-B7	2016/02/29	<0.025	<0.100	<0.010	<0.025	0.059	<0.025
HER-B2D	2016/02/26	<0.025	<0.100	<0.010	0.118	0.077	<0.025
HER-B23	2016/02/29	<0.025	<0.100	0.017	<0.025	0.069	<0.025
HER-B35	2016/02/29	<0.025	<0.100	0.018	<0.025	0.029	<0.025
HER-B37	2016/02/29	<0.025	<0.100	<0.010	<0.025	0.035	<0.025
HER-B38D	2016/02/29	<0.025	<0.100	<0.010	0.18	0.134	<0.025
HER-B39D	2016/02/29	<0.025	<0.100	<0.010	0.117	0.164	<0.025
HER-B40D	2016/02/29	<0.025	<0.100	<0.010	0.056	0.095	<0.025
HER-B41D	2016/02/29	<0.025	<0.100	0.013	0.096	0.095	<0.025
HER-B52	2016/02/29	<0.025	<0.100	<0.010	0.029	0.077	<0.025
HER-B56	2016/03/29	<0.025	<0.100	<0.010	0.056	<0.025	<0.025
HER-B57	2016/03/29	<0.025	<0.100	0.026	<0.025	<0.025	<0.025
HER-B58	2016/03/29	<0.025	<0.100	<0.010	0.16	0.039	<0.025
HER-B59	2016/03/30	<0.025	<0.100	0.013	<0.025	0.056	<0.025
HER-B60	2016/03/30	<0.025	<0.100	<0.010	0.074	0.06	<0.025
HER-B61	2016/03/30	<0.025	<0.100	0.013	<0.025	0.081	<0.025
HER-B62	2016/03/30	<0.025	0.3	<0.010	<0.025	0.039	<0.025
HER-B63	2016/03/29	<0.025	<0.100	<0.010	0.086	0.043	<0.025
HER-MA	2016/03/01	<0.025	<0.100	0.031	<0.025	0.042	<0.025
HER-MC1	2016/02/29	<0.025	<0.100	0.012	<0.025	0.036	<0.025
HER-MC2	2016/02/29	<0.025	<0.100	0.028	0.043	0.115	<0.025
HER-MD	2016/03/01	<0.025	<0.100	0.029	<0.025	0.029	<0.025
HER-ME	2016/03/01	<0.025	<0.100	0.013	0.104	0.101	<0.025
HER-UN	2016/03/01	<0.025	<0.100	<0.010	<0.025	0.068	<0.025
HF1	2016/02/29	<0.025	<0.100	<0.010	0.035	<0.025	<0.025
HF-4	2016/02/29	<0.025	<0.100	<0.010	0.066	0.048	<0.025
SANS 2011		-	≤ 0.3	≤ 0.01	-	-	-
SANS 2006							

Table 8.4.12.3(l): Current Groundwater Quality (5 of 7)

Borehole No.	Sampling Date	Cd	Co	Cu	Li	Mn	Mo
EUB-1	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-3	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-4	2016/03/04	<0.003	<0.025	0.016	<0.025	<0.025	<0.025
EUB-5	2016/03/10	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-6	2016/03/04	<0.003	<0.025	0.01	<0.025	<0.025	<0.025
EUB-9	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-10	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-11	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-12	2016/03/04	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-14	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-15	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-16	2016/03/08	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-17	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-18	2016/03/09	<0.003	<0.025	0.065	<0.025	<0.025	<0.025
EUB-20	2016/03/09	<0.003	<0.025	<0.010	<0.025	0.451	<0.025
EUB-21	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-22	2016/03/09	<0.003	<0.025	0.029	<0.025	<0.025	<0.025
EUB-23	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-24	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-25	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-26	2016/03/09	<0.003	<0.025	0.015	<0.025	<0.025	<0.025
EUB-28	2016/03/09	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-29	2016/03/10	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-30	2016/03/10	<0.003	<0.025	<0.010	<0.025	0.151	<0.025
EUB-31	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-36	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-37	2016/03/11	0.004	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-38	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-39	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-40	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-41	2016/03/11	<0.003	<0.025	0.038	<0.025	<0.025	<0.025
EUB-42	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-43	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-44	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
EUB-45	2016/03/11	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
D. Roos	2016/03/01	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B1	2016/03/01	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B3	2016/03/01	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B7	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B2D	2016/02/26	<0.003	<0.025	<0.010	<0.025	0.226	<0.025
HER-B23	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B35	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B37	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.029	<0.025
HER-B38D	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.504	<0.025
HER-B39D	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B40D	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.102	<0.025
HER-B41D	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.059	<0.025
HER-B52	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B56	2016/03/29	<0.003	<0.025	<0.010	<0.025	0.277	<0.025
HER-B57	2016/03/29	0.004	<0.025	<0.010	<0.025	0.119	<0.025
HER-B58	2016/03/29	<0.003	<0.025	<0.010	<0.025	0.195	0.045
HER-B59	2016/03/30	<0.003	<0.025	<0.010	<0.025	0.487	<0.025
HER-B60	2016/03/30	<0.003	<0.025	<0.010	<0.025	0.499	<0.025
HER-B61	2016/03/30	0.004	<0.025	<0.010	<0.025	0.328	<0.025
HER-B62	2016/03/30	0.005	<0.025	<0.010	<0.025	<0.025	<0.025
HER-B63	2016/03/29	<0.003	<0.025	<0.010	<0.025	0.051	<0.025
HER-MA	2016/03/01	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-MC1	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.821	<0.025
HER-MC2	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HER-MD	2016/03/01	<0.003	<0.025	<0.010	<0.025	0.135	<0.025
HER-ME	2016/03/01	<0.003	<0.025	<0.010	<0.025	0.372	<0.025
HER-UN	2016/03/01	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
HF1	2016/02/29	<0.003	<0.025	<0.010	<0.025	0.044	<0.025
HF-4	2016/02/29	<0.003	<0.025	<0.010	<0.025	<0.025	<0.025
SANS 2011		**≤ 0.003**	**≤ 0.5**	**≤ 2**	-	**≤ 0.1, ≤ 0.5**	-
SANS 2006							

Table 8.4.12.3(l): Current Groundwater Quality (6 of 7)

Borehole No.	Sampling Date	Ni	Pb	S	Sb	Se
EUB-1	2016/03/04	<0.025	<0.010	71	<0.020	<0.010
EUB-3	2016/03/04	<0.025	<0.010	8.86	<0.020	<0.010
EUB-4	2016/03/04	<0.025	<0.010	55	<0.020	<0.010
EUB-5	2016/03/10	<0.025	<0.010	59	<0.020	<0.010
EUB-6	2016/03/04	<0.025	<0.010	64	<0.020	<0.010
EUB-9	2016/03/04	<0.025	<0.010	64	<0.020	<0.010
EUB-10	2016/03/04	<0.025	<0.010	51	<0.020	<0.010
EUB-11	2016/03/04	<0.025	<0.010	46	<0.020	<0.010
EUB-12	2016/03/04	<0.025	<0.010	84	<0.020	<0.010
EUB-14	2016/03/11	<0.025	<0.010	101	<0.020	<0.010
EUB-15	2016/03/11	<0.025	<0.010	81	<0.020	<0.010
EUB-16	2016/03/08	<0.025	<0.010	85	<0.020	<0.010
EUB-17	2016/03/09	<0.025	<0.010	15	<0.020	<0.010
EUB-18	2016/03/09	<0.025	<0.010	37	<0.020	<0.010
EUB-20	2016/03/09	<0.025	<0.010	1.7	<0.020	<0.010
EUB-21	2016/03/09	<0.025	<0.010	12	<0.020	<0.010
EUB-22	2016/03/09	<0.025	<0.010	14	<0.020	0.01
EUB-23	2016/03/09	<0.025	<0.010	13	<0.020	<0.010
EUB-24	2016/03/09	<0.025	<0.010	13	<0.020	<0.010
EUB-25	2016/03/09	<0.025	<0.010	112	<0.020	0.027
EUB-26	2016/03/09	<0.025	<0.010	16	<0.020	<0.010
EUB-28	2016/03/09	<0.025	<0.010	19	<0.020	<0.010
EUB-29	2016/03/10	<0.025	<0.010	18	<0.020	<0.010
EUB-30	2016/03/10	<0.025	<0.010	4.51	<0.020	<0.010
EUB-31	2016/03/11	<0.025	<0.010	10	<0.020	<0.010
EUB-36	2016/03/11	<0.025	<0.010	9.9	<0.020	<0.010
EUB-37	2016/03/11	<0.025	<0.010	284	<0.020	0.11
EUB-38	2016/03/11	<0.025	<0.010	118	<0.020	<0.010
EUB-39	2016/03/11	<0.025	<0.010	47	<0.020	<0.010
EUB-40	2016/03/11	<0.025	<0.010	142	<0.020	<0.010
EUB-41	2016/03/11	<0.025	<0.010	76	<0.020	<0.010
EUB-42	2016/03/11	<0.025	<0.010	59	<0.020	<0.010
EUB-43	2016/03/11	<0.025	<0.010	58	<0.020	<0.010
EUB-44	2016/03/11	<0.025	<0.010	12	<0.020	<0.010
EUB-45	2016/03/11	<0.025	<0.010	29	<0.020	<0.010
D. Roos	2016/03/01	<0.025	<0.010	70	<0.020	<0.010
HER-B1	2016/03/01	<0.025	<0.010	135	<0.020	<0.010
HER-B3	2016/03/01	<0.025	0.01	197	<0.020	0.031
HER-B7	2016/02/29	<0.025	<0.010	89	<0.020	<0.010
HER-B2D	2016/02/26	<0.025	0.011	289	<0.020	<0.010
HER-B23	2016/02/29	<0.025	<0.010	107	<0.020	0.03
HER-B35	2016/02/29	<0.025	<0.010	252	<0.020	<0.010
HER-B37	2016/02/29	<0.025	0.01	109	<0.020	<0.010
HER-B38D	2016/02/29	<0.025	<0.010	310	<0.020	0.052
HER-B39D	2016/02/29	<0.025	<0.010	265	<0.020	0.017
HER-B40D	2016/02/29	<0.025	<0.010	98	<0.020	0.01
HER-B41D	2016/02/29	<0.025	<0.010	170	<0.020	0.024
HER-B52	2016/02/29	<0.025	<0.010	50	<0.020	<0.010
HER-B56	2016/03/29	<0.025	<0.010	40	<0.020	<0.010
HER-B57	2016/03/29	<0.025	0.019	186	<0.020	<0.010
HER-B58	2016/03/29	<0.025	<0.010	103	<0.020	<0.010
HER-B59	2016/03/30	<0.025	<0.010	214	<0.020	<0.010
HER-B60	2016/03/30	<0.025	<0.010	213	<0.020	<0.010
HER-B61	2016/03/30	<0.025	0.013	235	<0.020	0.011
HER-B62	2016/03/30	<0.025	0.019	30	<0.020	0.02
HER-B63	2016/03/29	<0.025	<0.010	64	<0.020	<0.010
HER-MA	2016/03/01	<0.025	<0.010	201	<0.020	0.018
HER-MC1	2016/02/29	<0.025	<0.010	324	<0.020	<0.010
HER-MC2	2016/02/29	<0.025	<0.010	397	<0.020	0.05
HER-MD	2016/03/01	<0.025	0.01	166	<0.020	0.038
HER-ME	2016/03/01	0.106	<0.010	249	<0.020	0.021
HER-UN	2016/03/01	<0.025	<0.010	52	<0.020	<0.010
HF1	2016/02/29	<0.025	<0.010	45	<0.020	<0.010
HF-4	2016/02/29	<0.025	<0.010	92	<0020	<0.010
SANS 2011		**≤ 0.07**	**≤ 0.01**	-	**≤ 0.02**	**≤ 0.01**
SANS 2006						

Table 8.4.12.3(l): Current Groundwater Quality (7 of 7)

Borehole No.	Sampling Date	Si	Sr	Ti	V	Zn
EUB-1	2016/03/04	32	0.331	<0.025	0.029	0.174
EUB-3	2016/03/04	4	0.059	<0.025	<0.025	<0.025
EUB-4	2016/03/04	32	0.265	<0.025	<0.025	0.052
EUB-5	2016/03/10	31	0.252	<0.025	0.033	<0.025
EUB-6	2016/03/04	35	0.289	<0.025	0.043	<0.025
EUB-9	2016/03/04	33	0.316	<0.025	0.026	<0.025
EUB-10	2016/03/04	32	0.25	<0.025	0.026	0.094
EUB-11	2016/03/04	32	0.262	<0.025	0.031	<0.025
EUB-12	2016/03/04	31	0.325	<0.025	0.028	0.078
EUB-14	2016/03/11	28	0.309	<0.025	<0.025	<0.025
EUB-15	2016/03/11	33	0.063	<0.025	<0.025	<0.025
EUB-16	2016/03/08	24	0.539	<0.025	0.036	0.258
EUB-17	2016/03/09	5.6	0.148	<0.025	<0.025	<0.025
EUB-18	2016/03/09	24	0.537	<0.025	0.039	0.1
EUB-20	2016/03/09	15.2	0.222	<0.025	<0.025	<0.025
EUB-21	2016/03/09	9.2	0.262	<0.025	<0.025	0.051
EUB-22	2016/03/09	13.6	0.349	<0.025	0.028	<0.025
EUB-23	2016/03/09	20	0.259	<0.025	0.049	<0.025
EUB-24	2016/03/09	15.4	0.362	<0.025	0.032	<0.025
EUB-25	2016/03/09	29	0.861	<0.025	0.047	0.038
EUB-26	2016/03/09	20	0.386	<0.025	0.055	0.164
EUB-28	2016/03/09	23	0.495	<0.025	0.061	<0.025
EUB-29	2016/03/10	15.8	0.334	<0.025	0.035	0.03
EUB-30	2016/03/10	16.2	0.221	<0.025	<0.025	<0.025
EUB-31	2016/03/11	22	0.321	<0.025	0.067	<0.025
EUB-36	2016/03/11	25	0.136	<0.025	0.04	<0.025
EUB-37	2016/03/11	24	0.733	<0.025	0.074	<0.025
EUB-38	2016/03/11	24	0.312	<0.025	0.067	0.03
EUB-39	2016/03/11	15.4	0.236	<0.025	0.035	0.046
EUB-40	2016/03/11	19.8	0.75	<0.025	0.047	0.247
EUB-41	2016/03/11	13.6	0.684	<0.025	0.043	<0.025
EUB-42	2016/03/11	14.6	0.358	<0.025	0.056	1.51
EUB-43	2016/03/11	18.1	0.476	<0.025	0.06	<0.025
EUB-44	2016/03/11	14.6	0.243	<0.025	0.033	<0.025
EUB-45	2016/03/11	16.6	0.44	<0.025	0.052	<0.025
D. Roos	2016/03/01	26	0.613	<0.025	0.051	<0.025
HER-B1	2016/03/01	29	0.568	<0.025	0.043	<0.025
HER-B3	2016/03/01	24	0.805	<0.025	0.049	<0.025
HER-B7	2016/02/29	25	0.483	<0.025	0.067	<0.025
HER-B2D	2016/02/26	11.9	1.44	<0.025	0.051	<0.025
HER-B23	2016/02/29	33	0.343	<0.025	0.048	<0.025
HER-B35	2016/02/29	29	0.532	<0.025	0.051	<0.025
HER-B37	2016/02/29	29	0.426	<0.025	0.046	<0.025
HER-B38D	2016/02/29	27	0.787	<0.025	0.044	<0.025
HER-B39D	2016/02/29	28	0.612	<0.025	0.052	<0.025
HER-B40D	2016/02/29	17.3	0.397	<0.025	0.048	0.055
HER-B41D	2016/02/29	23	1.11	<0.025	0.048	<0.025
HER-B52	2016/02/29	28	0.355	<0.025	0.053	<0.025
HER-B56	2016/03/29	5.7	0.297	<0.025	0.03	<0.025
HER-B57	2016/03/29	29	1.37	<0.025	0.248	<0.025
HER-B58	2016/03/29	21	0.697	<0.025	0.025	<0.025
HER-B59	2016/03/30	16.4	0.848	<0.025	0.251	<0.025
HER-B60	2016/03/30	12.5	0.913	<0.025	0.23	0.097
HER-B61	2016/03/30	21	0.513	<0.025	0.25	<0.025
HER-B62	2016/03/30	3.1	1.03	<0.025	0.24	<0.025
HER-B63	2016/03/29	27	0.218	<0.025	<0.025	<0.025
HER-MA	2016/03/01	29	0.582	<0.025	0.049	<0.025
HER-MC1	2016/02/29	7.6	0.862	<0.025	0.047	<0.025
HER-MC2	2016/02/29	29	2.07	<0.025	0.053	<0.025
HER-MD	2016/03/01	23	0.541	<0.025	0.048	<0.025
HER-ME	2016/03/01	18.7	0.489	<0.025	0.051	<0.025
HER-UN	2016/03/01	31	0.336	<0.025	<0.025	<0.025
HF1	2016/02/29	7.8	0.157	<0.025	<0.025	<0.025
HF-4	2016/02/29	29	0.437	<0.025	0.04	<0.025
SANS 2011		-	-	-	≤ 0.2	≤ 5
SANS 2006						

It is evident from Figure 8.4.12.3(l) that the TDS concentrations are elevated to concentrations above 1,000 *mg/l* within the Alloys Plant and Tailings Storage Facility (TSF) Management Areas. Most of the groundwater samples which had elevated TDS concentrations were sampled at boreholes situated adjacent to or down-gradient from surface water containment facilities (*Chrome Recovery Plant Pollution Control Dam, Process Water Dam, Emergency Dam, OB Plant Return Water Dam, New Slimes Dam Return Water Dam and the TSF Return Water Dam*) or fine grained waste disposal / stockpile facilities (*Historic Slimes Dams, Fine Fraction Slag Stockpiles, Western Sediment Trap Stockpiles, Mixed Waste Stockpiles and New Slimes Dam*) at HERNIC. The groundwater sampled from borehole HER-UN, which is situated adjacent to the Morula Incline Shaft also had a TDS concentration elevated above 1,000 *mg/l*.

The elevated SO_4 concentrations correlate very well to the elevated TDS concentrations, as is evident on Figure 8.4.12.3(m). The groundwater samples with SO_4 concentrations elevated above 250 mg/l were all sampled from boreholes adjacent to the surface water containment facilities and fine grained waste stockpile / disposal facilities within the Alloys Plant and Tailings Storage Facility Management Areas at HERNIC. All the groundwater samples within the Alloys Plant Management Area (excluding borehole HER-B56 (116 *mg/l*) which is situated along the western perimeter and HER-B58 (259 *mg/l*) adjacent to the Process Water Dam) have SO_4 concentrations above 500 *mg/l*.

The groundwater samples within the Alloys Plant Management Area all have Cl concentrations (Figure 8.4.12.3(n), with almost all the groundwater samples in this area having concentrations above 170 *mg/l*. The Cl concentration of 1,694 *mg/l* recorded at borehole HER-B62 is somewhat of an outlier and may be an analytical error. This value will need to be confirmed during future groundwater monitoring at HERNIC. The elevated Cl concentrations also correlate with the elevated SO_4 and TDS concentrations, indicating that the groundwater within the Alloys Plant and Tailings Storage Facility Management Areas has been impacted on by the surface operations at HERNIC. These impacts most probably originate from the infiltration of soluble contaminants from the unlined fine grained waste disposal / stockpile facilities and unlined dirty water containment facilities at HERNIC. The quantification of these impacts will be assessed as part of the Groundwater Impact Assessment for this Groundwater Specialist Study.

An assessment of the Cr(VI) concentration distribution was also made and is depicted as Figure 8.6.3(d). It is evident from Figure 8.4.12.3(o) that the Cr(VI) concentrations are consistently elevated to the west (down-gradient) of the historic slimes disposal facilities. Two of the external user boreholes down-gradient from HERNIC (EUB-23 and EUB-38) have elevated Cr(VI) concentrations within this area. The Cr(VI) concentration of 11 *mg/l* recorded at borehole HER-MC2 is also an outlier and will need to be confirmed during future groundwater monitoring at HERNIC. Elevated Cr(VI) concentrations are also observed at borehole HER-UN (adjacent to the Morula Incline Shaft) and to the south-west of the TSF Return Water Dam. An elevated Cr(VI) concentration is also observed to the west (down-gradient) of the Silverstone Crushers operations, although not observed up-gradient from these operations.

From the assessment of the nitrate concentration distribution (Figure 8.4.12.3(p), it is evident that the NO_3 concentrations within the Alloys Plant and Tailings Storage Facility Management Areas are typically elevated to concentrations above 25 *mg/l*, specifically adjacent to the fine grained waste disposal / stockpile facilities and unlined dirty water containment facilities at HERNIC. Elevated NO_3 concentrations are sporadically observed in some of the external user boreholes as well.

Hydrochemical imaging of groundwater samples collected within the study area was performed during which Piper and Durov Diagrams were compiled. The resulting Piper Diagrams of the HERNIC Groundwater Monitoring Boreholes and External User Boreholes are depicted as Figure 8.4.12.3(q) and Figure 8.4.12.3(r) respectively. The Durov Diagrams of the HERNIC Groundwater Monitoring Boreholes and External User Boreholes are depicted as Figure 8.4.12.3(s) and Figure 8.4.12.3(t) respectively.

The Piper Diagrams clearly indicate that the geochemistry of the groundwater sampled from the HERNIC monitoring boreholes differs from the geochemistry of the groundwater sampled from the external user boreholes and that deemed representative of the background groundwater quality. The groundwater sampled from the HERNIC monitoring boreholes is classified as having a predominantly *Type-A* hydrochemical facies signature, compared to the *Type-B* signature of the groundwater sampled from the external user boreholes and that of the background groundwater quality.

The major cation in the groundwater samples is predominantly Mg^{2+} with some of the HERNIC monitoring boreholes also having increased Na^{+} and K^{+} equivalent concentrations. The major anions in the external user boreholes and background groundwater quality is typically HCO_3^- (generally more than 50%), whilst the HCO_3^- equivalent concentrations in the HERNIC groundwater monitoring boreholes is generally less than 50%, as they are replaced by Cl^- and specifically SO_4^{2-} as the major anions.

The groundwater samples taken from the external user boreholes EUB-3, EUB- 12, EUB-16, EUB-18, EUB-22 and EUB-41 have a Type-A hydrochemical facies signature, which is different to that of the background groundwater samples collected. The groundwater samples taken from EUB-30 and EUB-37 are unique in that they have Type-D and Type-C hydrochemical facies signatures respectively.

The groundwater samples taken from boreholes HER-B7, HER-B35, HER-B38D, HER-B52, HER-B56, HER-B63 and HER-UN have distinct type B hydrochemical signatures, similar to that of and indicative of background groundwater qualities.

The Durov Diagrams indicate that the EC of the groundwater sampled from the HERNIC groundwater monitoring boreholes is generally higher than the EC of the groundwater sampled from the external user boreholes and that of the background groundwater quality. The pH of the groundwater sampled from the HERNIC groundwater monitoring boreholes is generally also lower (more acidic) (7.0 – 7.5) than the pH of the groundwater sampled from the external user boreholes and that of the background groundwater quality (7.5 – 8.0), although these pH values are all still very neutral.

Based on the chemistry of the groundwater sampled from 29 groundwater monitoring boreholes at HERNIC and 35 external user boreholes, it is evident that the groundwater within the western extent of the HERNIC site (below the Alloys Plant and Tailings Storage Facility Management Areas) has a different signature to that of the groundwater sampled from the external user boreholes and that of the expected background groundwater quality. The elemental concentrations of the groundwater samples collected also implies that the groundwater within these management areas has been impacted on by certain surface activities (dirty water containment facilities and fine grained waste disposal / stockpile facilities).

The level of legal compliance from a groundwater quality perspective is governed by the water quality limits stipulated by the DWS. Groundwater quality limits, which are not allowed to be exceeded have been included in the HERNIC WUL and are addressed in the following Section.

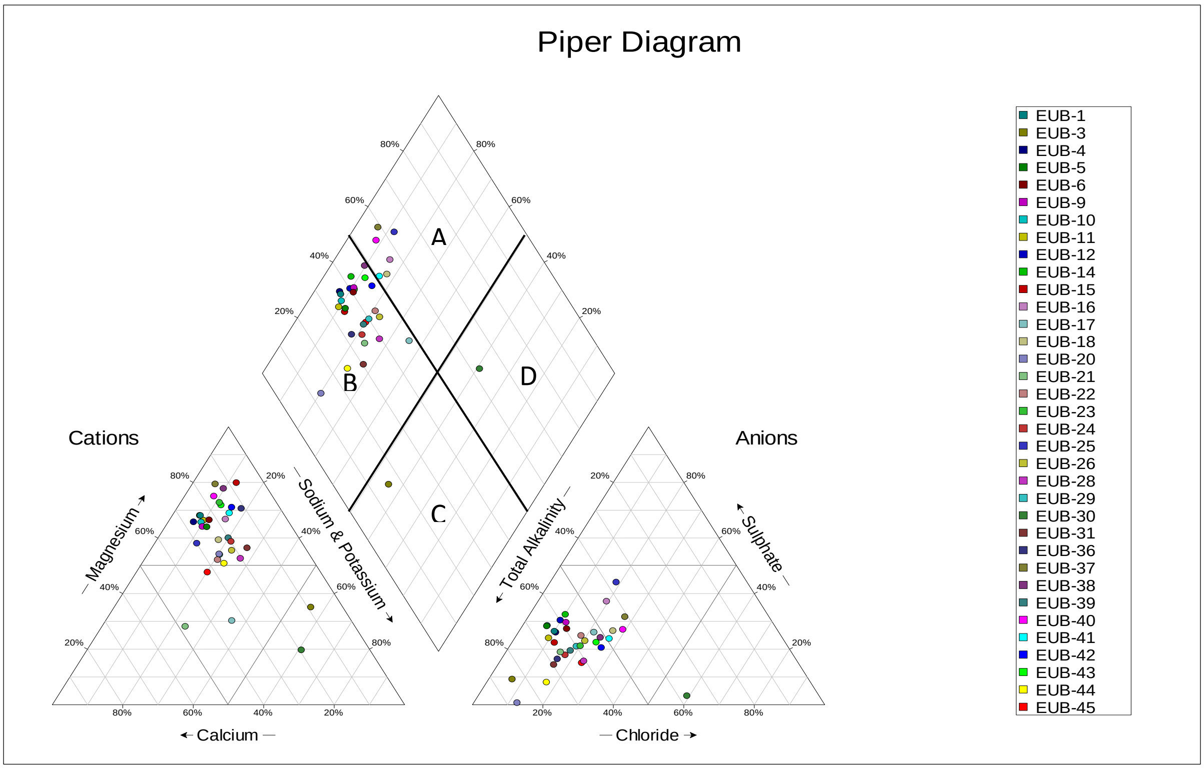


Figure 8.4.12.3(q): **Current Groundwater Quality – Piper Diagram (HERNIC Monitoring Boreholes)**

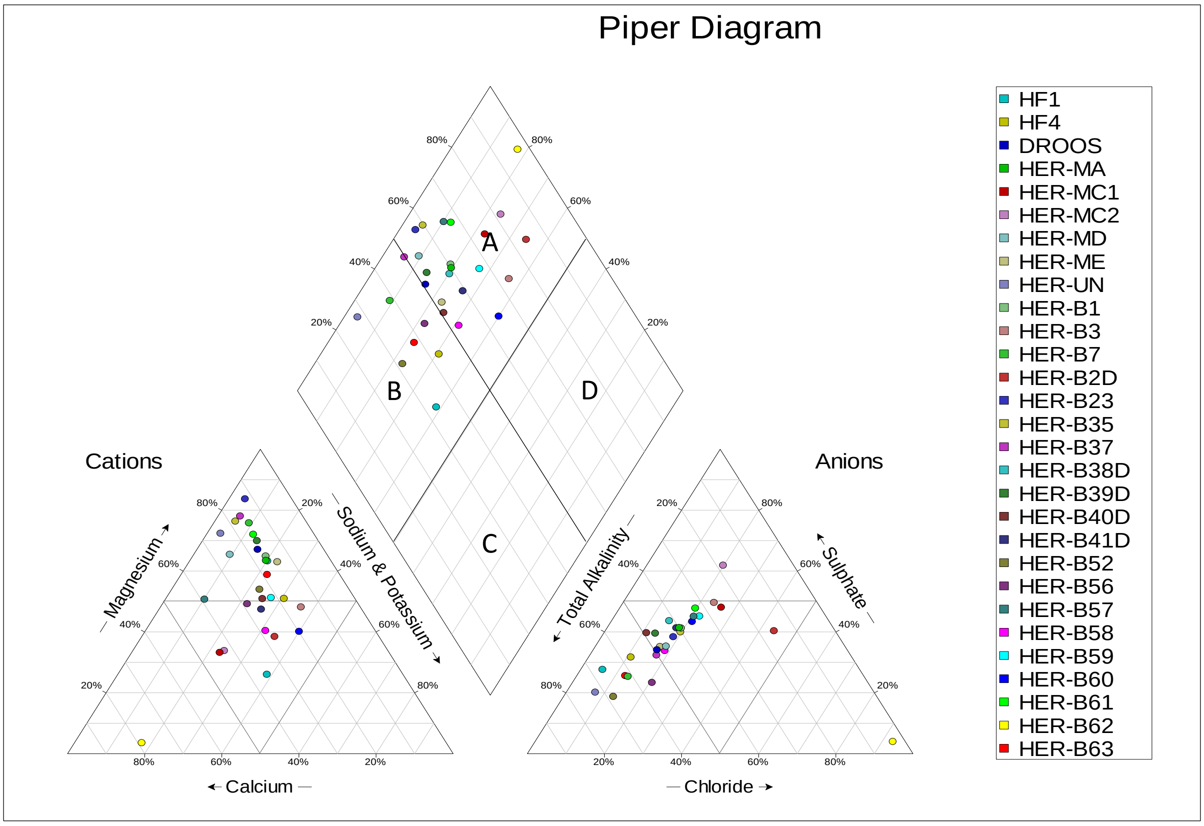


Figure 8.4.12.3(r): **Current Groundwater Quality – Piper Diagram (External User Boreholes)**

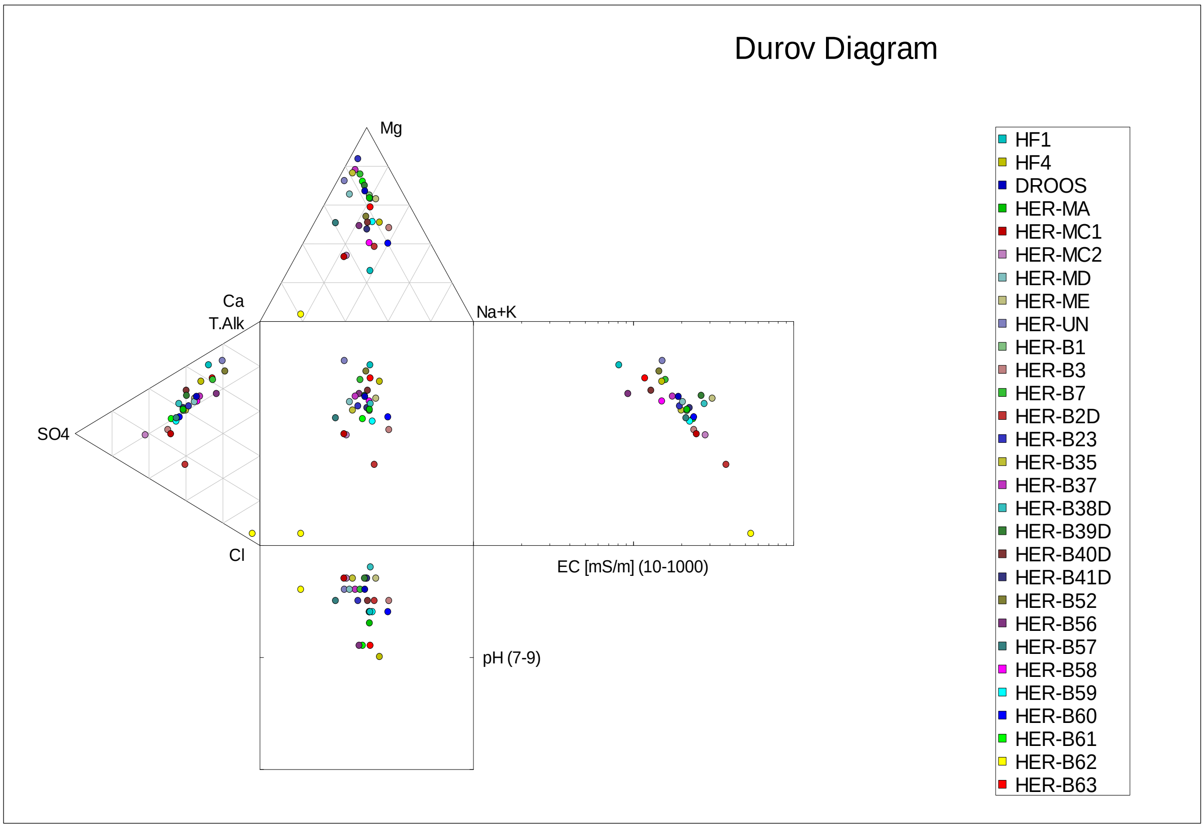


Figure 8.4.12.3(s): Current Groundwater Quality – Durov Diagram (HERNIC Monitoring Boreholes)

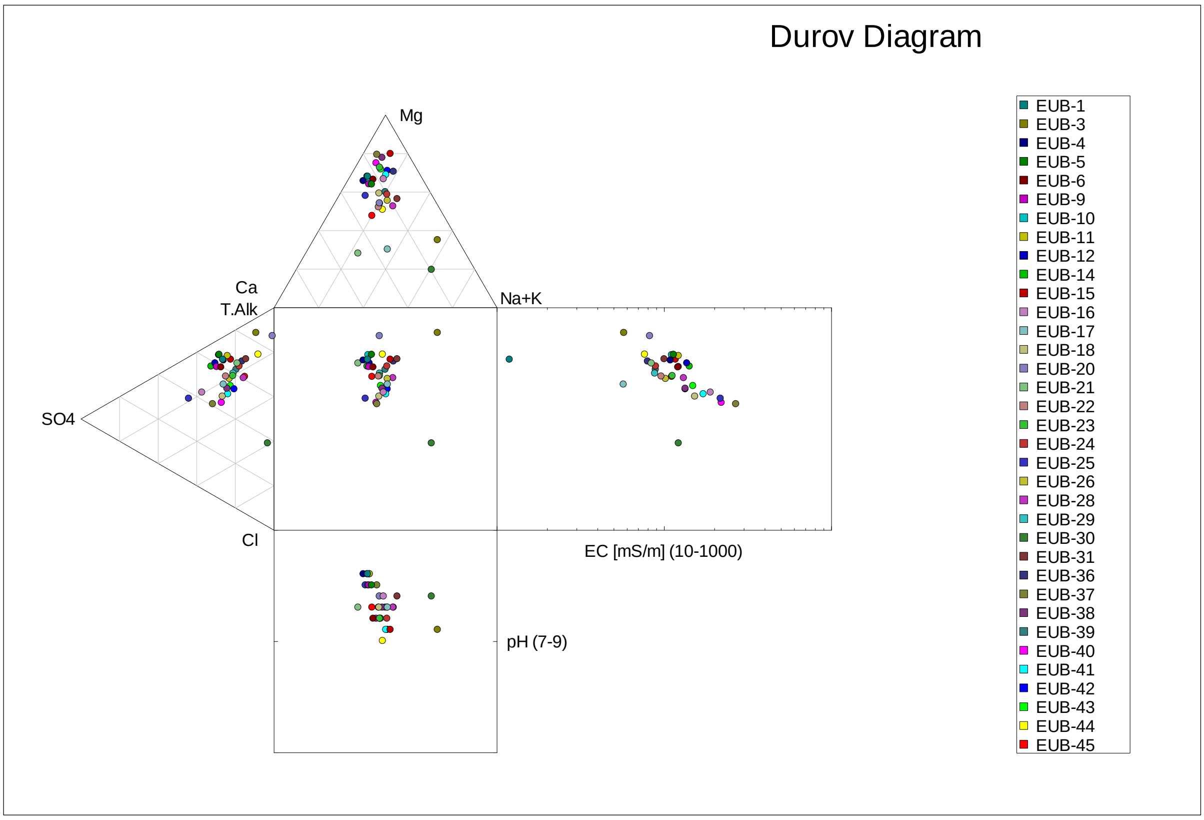


Figure 8.4.12.3(t): Current Groundwater Quality – Durov Diagram (External User Boreholes)

Groundwater Quality Limits and Compliance

HERNIC was issued with a Water Use Licence on 18 December 2015, in which certain "Baseline Groundwater Quality" limits have been stipulated. These groundwater quality limits are specified in Table 8 of the Water Use Licence and are not allowed to be exceeded. Any exceedance of these water quality limits results in non-compliance in terms of the requirements of the National Water Act (Act No. 36 of 1998).

The quality of the groundwater sampled at HERNIC in comparison to the water quality limits stipulated in the Water Use Licence issued to HERNIC is given in Table 8.4.12.3(m). No units are indicated in Table 8 of the WUL and it is therefore assumed that the Fe and $Cr^{(Total)}$ concentrations are indicated in *ppb* (*µg/l*) and not *ppm* (*mg/l)* as for the others.

It is evident from Table 8.4.12.3(m) that the quality of the groundwater sampled / monitored at HERNIC is non-compliant with the water quality limits stipulated within the WUL. The TDS, Mg, SO_4, NO_3 and $Cr^{(Total)}$ concentrations are all elevated to concentrations above those stipulated in the WUL in at least 6 of the sampling localities. The Cl and Mn concentrations are also marginally to non-compliant with the specified limits.

The groundwater samples which are non-compliant with the stipulated water quality limits are sampled from boreholes which are predominantly located within the Alloys Plant and Tailings Storage Facility Management Areas. The groundwater within this area has been impacted on by certain activities / infrastructure at the surface to a degree where the water quality is currently in non-compliance with groundwater quality limits specified for HERNIC.

Table 8.4.12.3(m): Compliance of Current Groundwater Quality with regards to HERNIC WUL Water Quality Limits

Borehole Number	Sampling Date	pH	EC *mS/m*	TDS *mg/l*	Ca *mg/l*	Mg *mg/l*	Na *mg/l*	K *mg/l*	Cl *mg/l*	SO_4 *mg/l*	NO_3 *mg/l*	F *mg/l*	Al *mg/l*	Fe *mg/l*	Mn *mg/l*	Cr(T) *mg/l*
D. Roos	2016/03/01	7.4	193	1 362	82	195	88	1.8	137	370	22	<0.2	<0.100	0.033	<0.025	0.758
HER-B1	2016/03/01	7.6	218	1 576	85	208	117	1.3	177	500	26	<0.2	<0.100	<0.025	<0.025	1.42
HER-B2D	2016/02/26	7.5	383	2 768	229	197	300	68	653	802	39	0.3	<0.100	<0.025	0.226	<0.025
HER-B3	2016/03/01	7.5	241	1 834	83	158	229	1.5	217	605	37	<0.2	<0.100	<0.025	<0.025	3.47
HER-B7	2016/02/29	7.4	160	1 048	58	178	42	1	91	224	21	<0.2	<0.100	<0.025	<0.025	0.249
HER-B23	2016/02/29	7.5	196	1 412	60	253	26	<0.5	159	431	25	<0.2	<0.100	<0.025	<0.025	1.07
HER-B35	2016/02/29	7.3	201	1 506	93	236	33	1	169	452	26	<0.2	<0.100	0.052	<0.025	1.37
HER-B37	2016/02/29	7.4	177	1 182	72	211	31	0.9	131	322	19	<0.2	<0.100	<0.025	0.029	0.558
HER-B38D	2016/02/29	7.2	280	2 108	122	285	175	2.3	206	788	1.8	<0.2	<0.100	<0.025	0.504	<0.025
HER-B39D	2016/02/29	7.3	268	2 012	114	305	119	2.4	171	659	3.5	0.2	<0.100	<0.025	<0.025	<0.025
HER-B40D	2016/02/29	7.5	130	894	70	90	76	16.4	56	262	19	0.2	<0.100	<0.025	0.102	<0.025
HER-B41D	2016/02/29	7.3	226	1 660	136	150	160	2.9	154	466	59	0.4	<0.100	<0.025	0.059	<0.025
HER-B52	2016/02/29	7.3	146	942	78	110	89	1.6	78	147	17	0.2	<0.100	<0.025	<0.025	<0.025
HER-B56	2016/03/29	7.9	93.4	532	57	59	50	1.7	78	116	0.5	<0.2	<0.100	0.026	0.277	<0.025
HER-B57	2016/03/29	7.5	215	1 622	204	160	63	0.7	183	529	38	<0.2	<0.100	<0.025	0.119	<0.025
HER-B58	2016/03/29	7.6	152	1 028	92	79	116	2.2	109	259	22	0.3	<0.100	0.095	0.195	<0.025
HER-B59	2016/03/30	7.6	227	1 660	116	167	170	1.1	199	539	48	<0.2	<0.100	<0.025	0.487	<0.025
HER-B60	2016/03/30	7.6	241	1 694	111	136	254	10.9	206	561	33	0.4	<0.100	<0.025	0.499	<0.025
HER-B61	2016/03/30	7.9	238	1 770	92	255	83	2.2	200	642	49	0.2	<0.100	<0.025	0.328	<0.025
HER-B62	2016/03/30	7.4	547	3 714	791	20	201	7.9	1 694	91	27	<0.2	0.300	<0.025	<0.025	<0.025
HER-B63	2016/03/29	7.9	119	734	50	95	69	1.4	65	172	3	<0.2	<0.100	<0.025	0.051	<0.025
HER-MA	2016/03/01	7.7	218	1 590	91	209	125	1.3	177	516	26	<0.2	<0.100	<0.025	<0.025	1.36
HER-MC1	2016/02/29	7.3	250	1 876	254	116	154	1.4	281	683	<0.1	0.4	<0.100	0.046	0.821	<0.025
HER-MC2	2016/02/29	7.3	284	2 350	289	139	188	1.6	218	899	74	<0.2	<0.100	<0.025	<0.025	12
HER-MD	2016/03/01	7.4	205	1 472	128	202	56	2.1	178	451	<0.1	<0.2	<0.100	<0.025	0.135	<0.025
HER-ME	2016/03/01	7.3	314	2 328	113	308	212	7.5	243	666	3.8	0.3	<0.100	0.025	0.372	<0.025
HER-UN	2016/03/01	7.4	153	1 006	89	162	15	2.6	47	160	34	<0.2	<0.100	<0.025	<0.025	0.057
HF-1	2016/02/29	7.6	82	510	63	28	78	4	21	128	<0.1	<0.2	<0.100	<0.025	0.044	<0.025
HF-4	2016/02/29	8.0	152	1 022	63	106	122	1.5	65	243	28	0.2	<0.100	<0.025	<0.025	0.043
Baseline Water Quality Limits stipulated in WUL		**7-9**	**260**	**1200**	**150 - 300**	**70 - 100**	**200 - 400**	**50 - 100**	**200 - 600**	**400 - 600**	**10 - 20**	**1.0 - 1.5**	**0.3 - 0.5**	**0.2 - 2.0**	**0.1 – 1.0**	**0.1 - 0.5**

Groundwater Use

The use of groundwater within the study area was assessed during the groundwater hydrocensus and geohydrological field investigations that were conducted within the study area during February and March 2016. A total of 44 external user boreholes were identified during the groundwater hydrocensus, 32 of which are being used as groundwater abstraction points. Groundwater is also currently abstracted from 3 boreholes at HERNIC.

External Groundwater Use

Groundwater is abstracted from 32 external user boreholes within a 1 km radius from the HERNIC operations (Figure 8.4.12.3(u)). The groundwater abstracted from these boreholes is predominantly used for irrigation, livestock watering, gardening and domestic purposes. A summary of the use of the groundwater abstracted from these external user boreholes, as provided by the owners during the groundwater hydrocensus is given in Table 8.4.12.3(n) below.

Table 8.4.12.3(n): Summary of External Groundwater Use

Borehole Number	Owner	Volume used (m^3/day)	Use
EUB-1	F. Lombard	Unknown	The abstracted groundwater is used for agriculture & domestic purposes; 35 people are currently dependent on the groundwater from the borehole.
EUB-4	H. Roos	2.5	The abstracted groundwater is used for agriculture & domestic purposes; 10 people are currently dependent on the groundwater from the borehole. The borehole is also used for gardening purposes.
EUB-5	H.J. Briel	10	The borehole is used for agriculture & domestic purposes as borehole as for cattle (150) and wild game (50) water. 40 people are also dependent on the groundwater from the borehole. The borehole is also used for gardening purposes.
EUB-6	H.J. Briel	60	The borehole is currently used for domestic purposes; an unknown amount of people is dependent on the groundwater abstracted from the borehole.
EUB-9	K.F. Dekker	Unknown	The borehole is mainly used for irrigation of 7ha. It is also used as a water source for a guest lodge, for around 100 people.
EUB-10	K.F. Dekker	Unknown	The borehole is currently used for 3 ha of irrigation, 80 large livestock and 30 wild game.
EUB-11	K.F. Dekker	169	The borehole is used for domestic purposes as borehole as 80 large livestock and 30 wild game, but mainly for domestic purposes.
EUB-12	K.F. Dekker	22.5	The borehole is used for domestic and some industrial purposes.
EUB-15	K.F. Dekker	0.8	The borehole is used to water the garden and also for 90 large livestock.
EUB-16	J.M. Barnard	1.56	The borehole is used for domestic purposes. Currently 9 people are dependent on the water from the borehole.
EUB-17	J.R. Carsten	39.6	The borehole is used by 15 people for domestic purposes.
EUB-18	J.R. Carsten	2.88	The borehole is used by 15 people for domestic purposes.
EUB-21	J.R. Carsten	Unknown	The borehole is used by 75 people for domestic purposes.
EUB-22	G.V. Barnardo	Unknown	The borehole is used by 20 people for domestic purposes.
EUB-23	L.H.S. Terreblanche	3.42	The borehole is used for domestic purposes of an unknown amount of people and 8 large livestock.
EUB-25	L. de Jager	4.86	The borehole is used by 6 people for domestic purposes.
EUB-26	A.J. von Wielligh	Unknown	This borehole is used mostly for domestic purposes. It used by 90 people and for a small garden.

Borehole Number	Owner	Volume used (m^3/day)	Use
EUB-27	P.A. von Wielligh	Unknown	The borehole is used for domestic use and gardening.
EUB-28	P.A. von Wielligh	Unknown	The borehole is used for domestic use and gardening.
EUB-29	M. Schwartz	0.13	The borehole is used for irrigation and for domestic purposes. 32 people are dependent on the borehole.
EUB-30	J.L.Wepener	0	The borehole is currently not used due to a bad smell in the water. The water is normally used for as domestic water for 12 people, 16 large livestock and 65 small livestock.
EUB-31	V. Bezuidenhout	2.86	The borehole is used for domestic use as borehole as cattle. 15 People and 7 large livestock are dependent on the borehole.
EUB-36	A. Swanepoel	3.03	The borehole is used for domestic use as borehole as cattle. 20 People and 40 small livestock are dependent on the borehole.
EUB-37	H. Lategan	1.65	This borehole is currently used purely for gardening purposes around the farmstead.
EUB-38	H. Lategan	432	The borehole is used for agriculture, domestic and irrigation purposes. This borehole is partly abstracted for filling a reservoir from which irrigation can commence.
EUB-39	H. Lategan	324	The borehole is used purely for irrigation. It is also partly used for filling the reservoir from which irrigation takes place
EUB-40	H. Lategan	1.70	The borehole is used only for domestic purposes. 8 people are dependent on the use of the borehole.
EUB-41	D. Lategan	4.28	The borehole is used for irrigation and domestic purposes. 8 people are currently dependent on the borehole.
EUB-42	D. Lategan	432	The borehole is specifically used for irrigation purposes. The water is abstracted into a reservoir from where irrigation takes place.
EUB-43	D. Lategan	1.98	The borehole is used for domestic purposes. 10 people are currently dependent on the water from the borehole.
EUB-44	D. Lategan	1.13	The borehole is used for domestic purposes.
EUB-45	H. Lategan	Unknown	The borehole is used for domestic purposes. 12 people are currently dependent on the water from the borehole.

Based on the information obtained during the groundwater hydrocensus conducted within a 1 *km* radius from HERNIC, it is observed that more than approximately 1,500 m^3/day of groundwater is abstracted for private use. The abstracted groundwater is predominantly used for irrigation, gardening, livestock watering and as a source of domestic water.

The abstracted groundwater is used by more than 500 people for drinking / domestic purposes and also as a source of drinking water for over 270 large livestock (typically cattle), over 100 small livestock (sheep / goats) and over 80 wild game animals. Although a large volume of groundwater is abstracted for irrigation (< 1,000 m^3/day), it is indicated that most of the water used for irrigation adjacent to HERNIC is obtained from the Eastern Hartbeespoort Irrigation Board Canal.

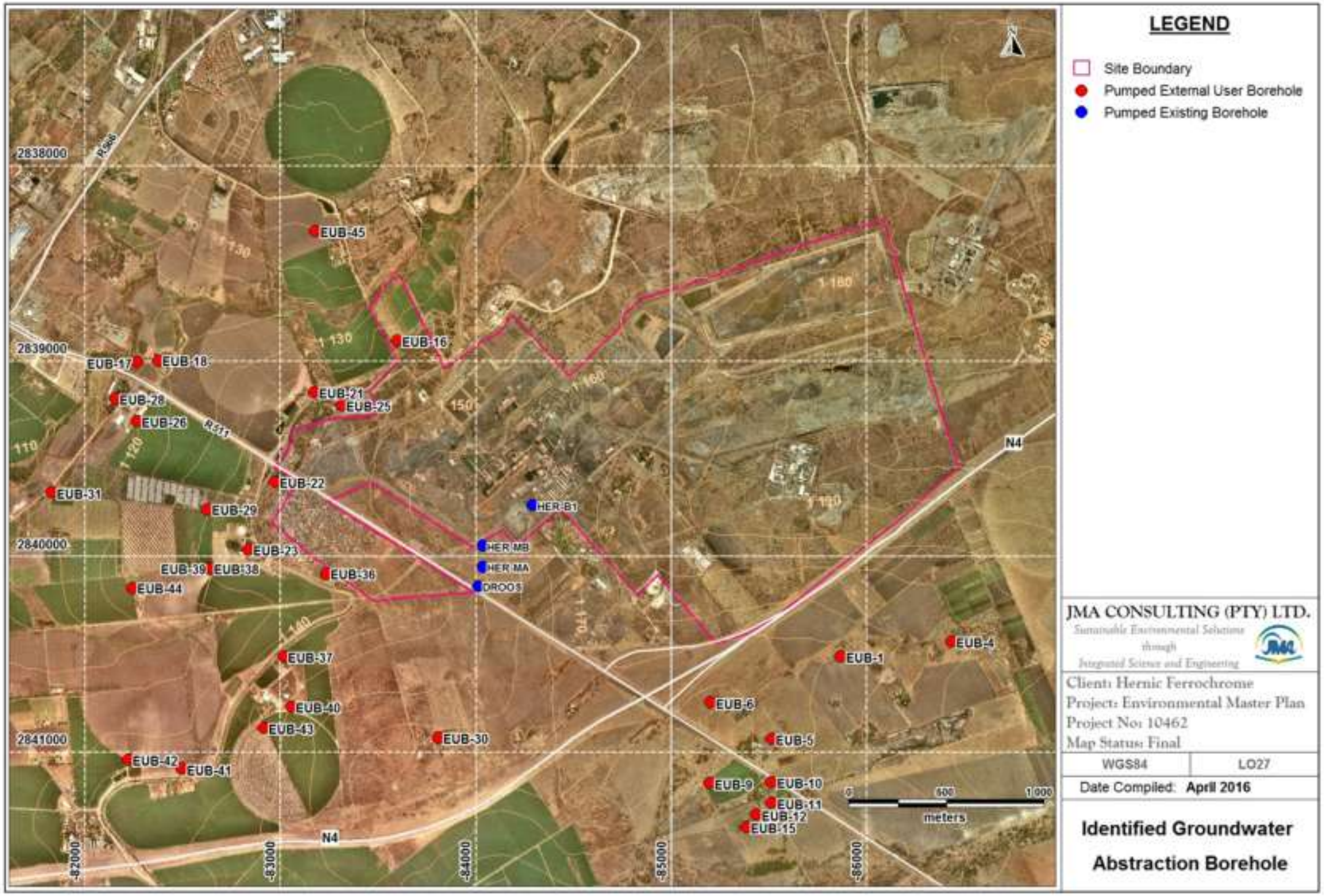


Figure 8.4.12.3(u) Groundwater Abstraction Boreholes at and around HERNIC

HERNIC Groundwater Use

The HERNIC WUL authorises the abstraction of **436,175 m³/annum** of groundwater for aquifer dewatering purposes (to be re-used in the mining operations) and **47,450 m³/annum** of contaminated groundwater from 3 groundwater abstraction boreholes (HER-B1, HER-MA and HER-MB) for remediation purposes and dust suppression. The abstraction of groundwater from the 3 boreholes forms part of HERNIC's current Groundwater Remediation Plan.

A summary of the groundwater permitted to be abstracted at HERNIC is indicated in Table 8.4.12.3(o) below.

Table 8.4.12.3(o): Summary of HERNIC Groundwater Use

Abstraction Point	Volume used (m^3/day)	Use
Underground Workings	1,195	Groundwater dewatering purposes and for re-use in the mining processes / operations.
Borehole HER-B1	60	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression.
Borehole HER-MA	50	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression.
Borehole HER-MB	20	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression.

Potential Future Groundwater Use

It is anticipated that groundwater will continue to be abstracted from the external user boreholes within the study area. Although not the primary source of water for irrigation or domestic use, groundwater will continue to be abstracted as an additional water supply for the adjacent land users. Groundwater will furthermore also continue to be abstracted for aquifer dewatering and as a source of process water for as long as the mining and industrial activities are operational within the study area.

Aquifer Classification

The aquifer classification is done in accordance with the formal DWAF (1995) "*South African Aquifer System Management Classification*" protocol. Special aquifer attributes related to certain structural features (such as along dyke/fault contact zones, or karst development) have been incorporated into the classification through the "Second Variable Classification".

Aquifer System Management

The aquifer classification at HERNIC is done in accordance with the following definitions of the 4 Aquifer System Management Classes:

Sole Aquifer System:

An aquifer which is used to supply 50% or more of domestic water for a given area and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System:

Highly permeable formations, usually with a known, or probable, presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m Electrical Conductivity).

Minor Aquifer System:

These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

Non-Aquifer System:

These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Aquifer System Management Classifications

Aquifer System Management Classification		
Class	**Points**	**Shallow Weathered Zone Aquifers**
Sole Source Aquifer System:	6	-
Major Aquifer System:	4	-
Minor Aquifer System:	2	3
Non-Aquifer System:	0	-
Special Aquifer System:	0 – 6	-

Although the EC of the background groundwater within the study area ranges between 58 *mS/m* and 150 *mS/m* with an average EC of *108 mS/m* these shallow weathered aquifers are unable to sustainably supply large scale abstraction volumes for public supply or irrigation purposes.

Groundwater is however abstracted from the boreholes within the shallow weathered zone aquifers for irrigation purposes and is therefore assigned a rating of **3** according to the Aquifer System Management Classification.

Second Variable Classifications

Second Variable Classification		
Class	**Points**	**Shallow Weathered Zone Aquifers**
High:	3	-
Medium:	2	-
Low:	1	-

There are no special structural aquifer attributes at HERNIC associated with the Second Variable Classification of the shallow weathered zone aquifers. The total points assigned to the shallow weathered zone aquifer system at HERNIC therefore remains **3**.

Aquifer Vulnerability

The groundwater quality management classification is made with regards to the aquifer vulnerability.

Aquifer Vulnerability Classification

Aquifer Vulnerability Classification		
Class	**Points**	**Shallow Weathered Zone Aquifers**
High:	3	-
Medium:	2	2
Low:	1	-

Shallow weathered zone aquifers are vulnerable to surface induced impacts and the shallow weathered zone aquifers at HERNIC are classified as moderately vulnerable and are therefore assigned an aquifer vulnerability rating of **2**.

The indicated level of groundwater protection is derived from the Groundwater Quality Management Index (GQM Index) and is calculated as follows:

GQM Index = Aquifer System Management x Aquifer Vulnerability Classification
= 3 x 2
= 6

The GQM Index is used to determine the level of groundwater protection that is required for the shallow weathered zone aquifer systems present at HERNIC. The level of groundwater protection of the shallow weathered zone aquifer at HERNIC is tabulated below:

Indicated Level of Groundwater Protection

GQM Index	Level of Protection	Shallow Weathered Zone Aquifer
< 1	Limited	-
1 - 3	Low Level	-
3 – 6	Medium Level	6
6 – 10	High Level	-
> 10	Strictly Non-Degradation	-

Aquifer Protection Classification

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a GQMI of 6 for the shallow weathered zone aquifers at HERNIC, indicating that a **medium to high level** of groundwater protection is required.

Conceptual Groundwater Model

The conceptual geohydrological model is a 2-dimensional model (cross sections) which has been developed using the information regarding the regional geohydrological setting, information from the exploration boreholes, from the Mining Work Programme as well as from the quantitative site-specific investigations undertaken during February and March 2016.

A plan view delineating the extent of the three cross-sectional lines is depicted as Figure 8.4.12.3(v). The three cross-sections (conceptual models) are depicted as Figures 8.4.12.3(w), 8.4.12.3(x) and 8.4.12.3(y) for lines A-A', B-B' and C-C' respectively.

Cross Section Lines A-A' and B-B' have been drawn almost perpendicular to the strike of the ore bodies at HERNIC. These cross sectional lines therefore clearly illustrate the dip of the underlying geology (17° to the north) and position of the ore bodies relative to one another.

Cross Section Line C-C' has been drawn almost parallel to the strike of the ore bodies at HERNIC. This cross sectional line clearly illustrates the influence that the normal faults (associated with the regional graben structure to the west of HERNIC) have on the underlying geology and associated ore bodies. These faults also influence the lateral extent and thus the feasibility of the mining operations at HERNIC.

The cross sectional lines, although generally drawn to scale, have been vertically exaggerated for illustrative purposes. The cross-sectional lines delineate the major geological features identified on site and are used in order to contextualise the associated groundwater environment.

Detailed descriptions of the conceptual models, including descriptions regarding the potential impacts associated with the surface infrastructure will be included in the Groundwater Specialist Study Report.

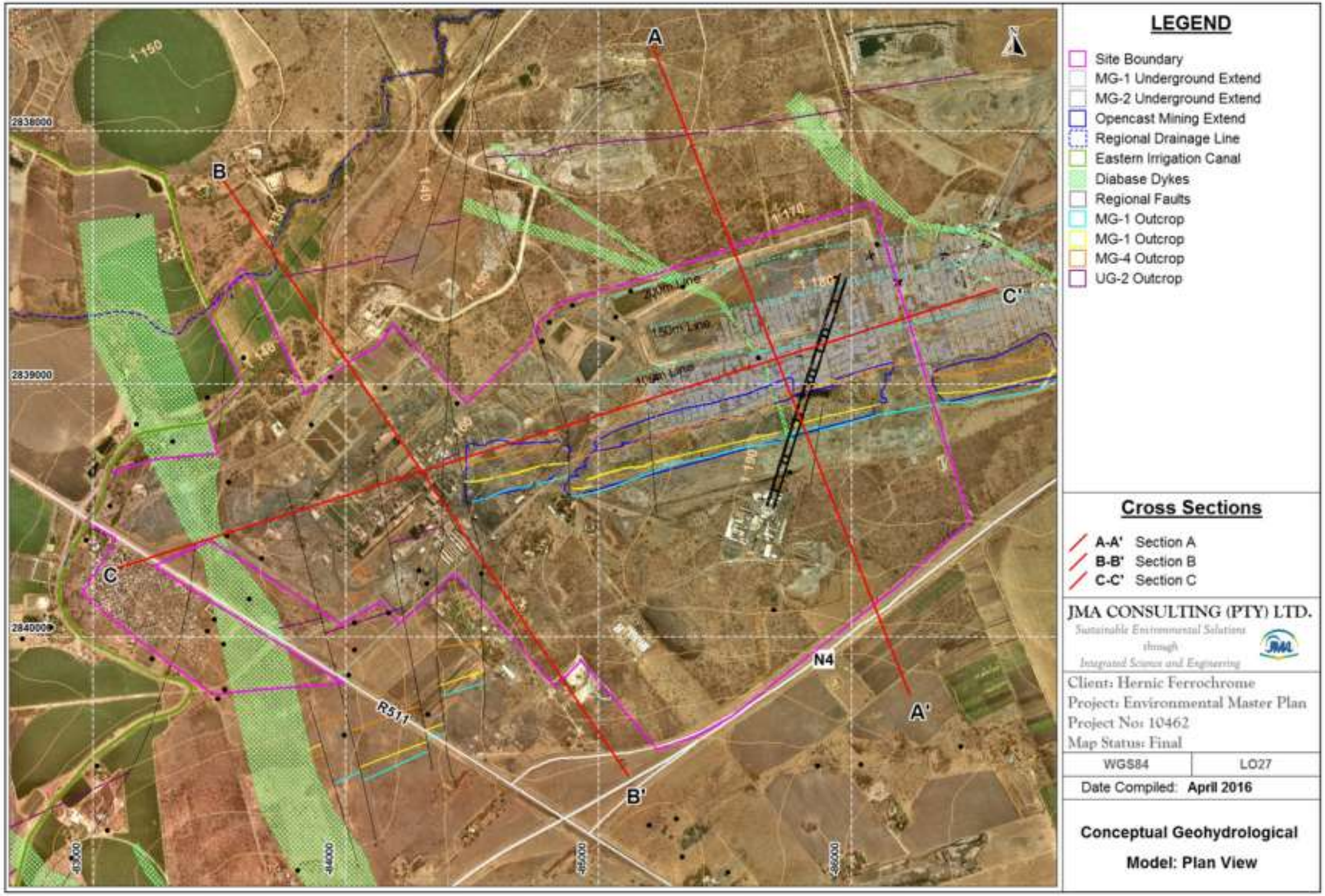


Figure 8.4.12.3(v) Conceptual Geohydrological Model: Plan View

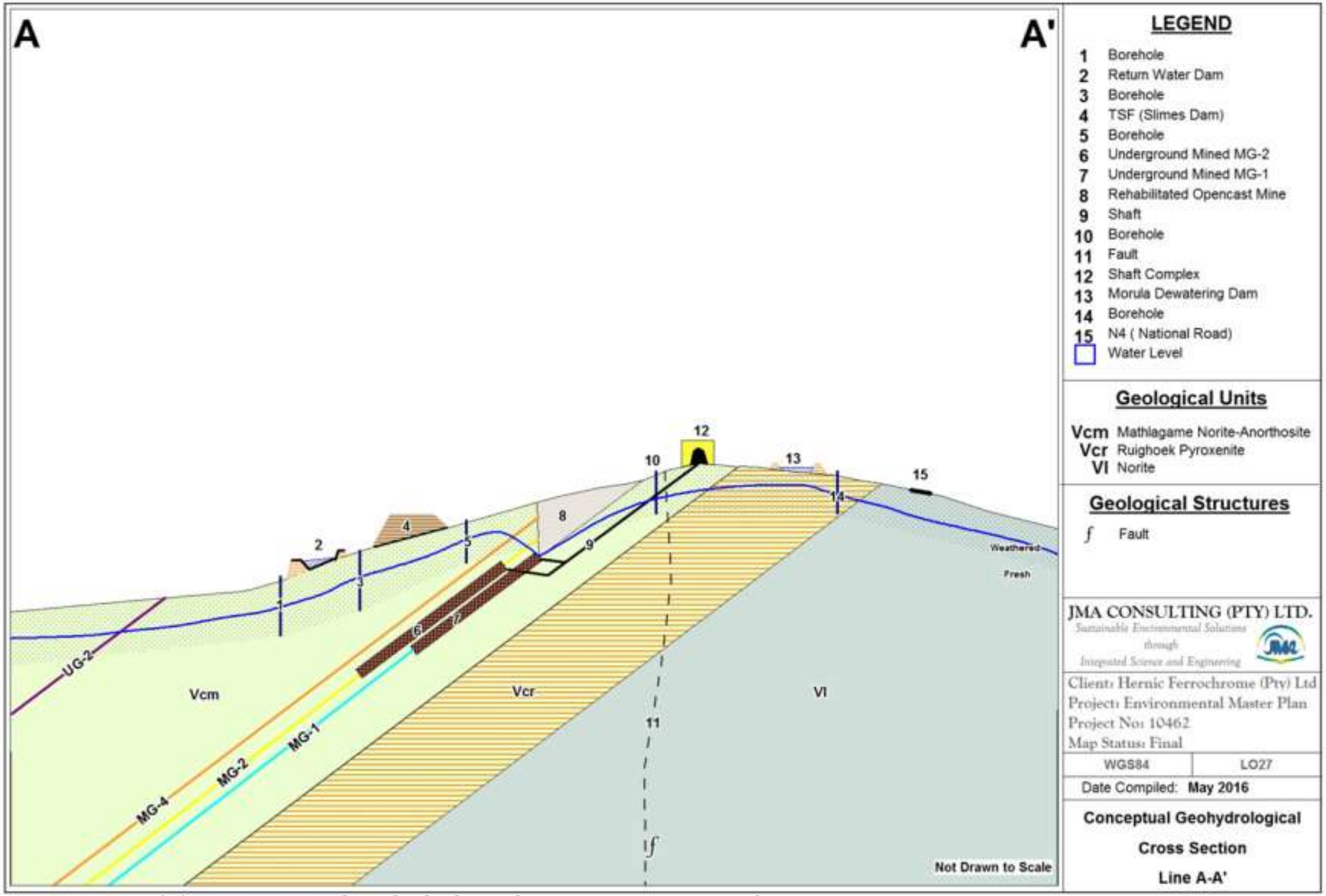


Figure 8.4.12.3(w) Conceptual Geohydrological Cross Section Line A-A'

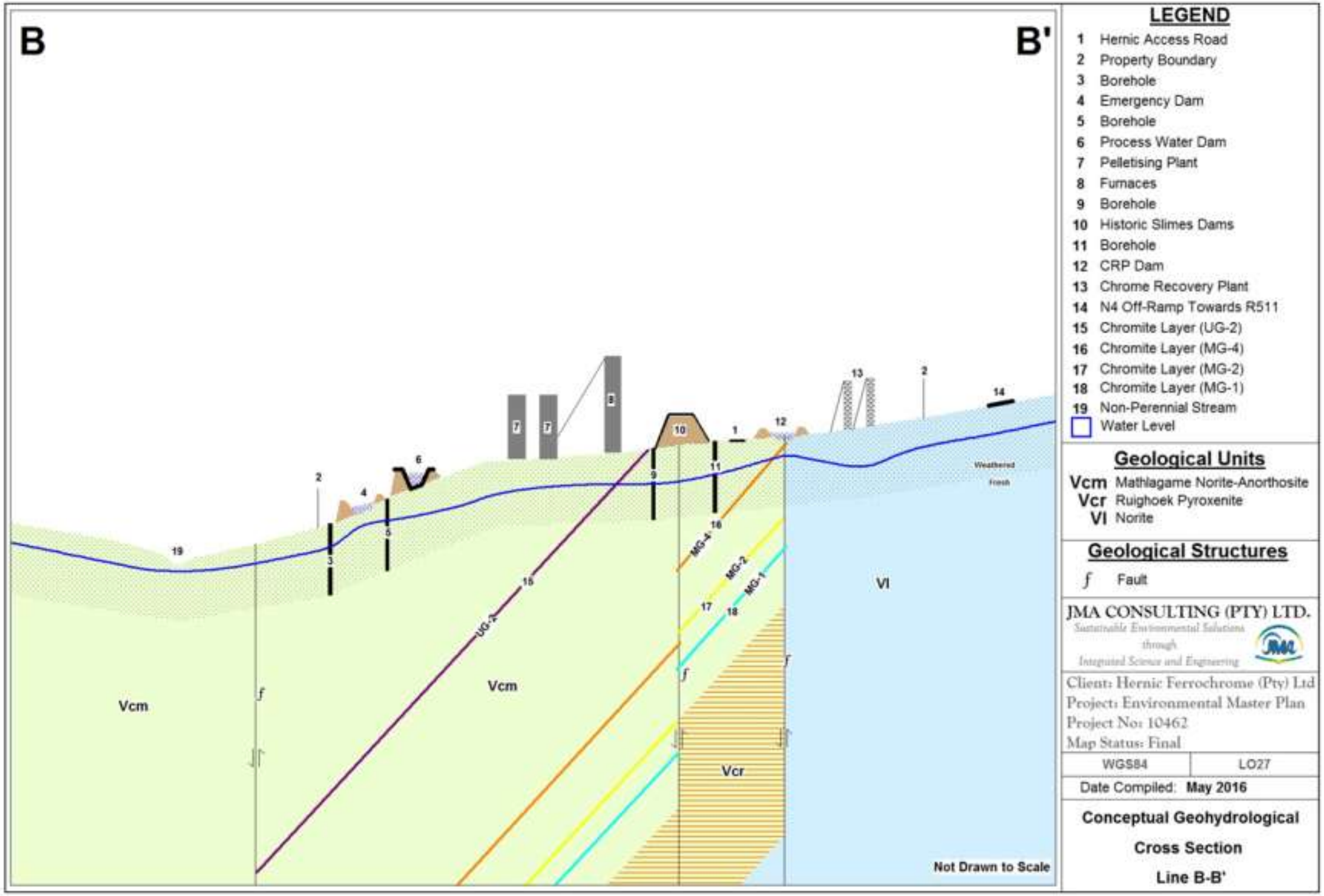


Figure 8.4.12.3(x) Conceptual Geohydrological Cross Section Line B-B'

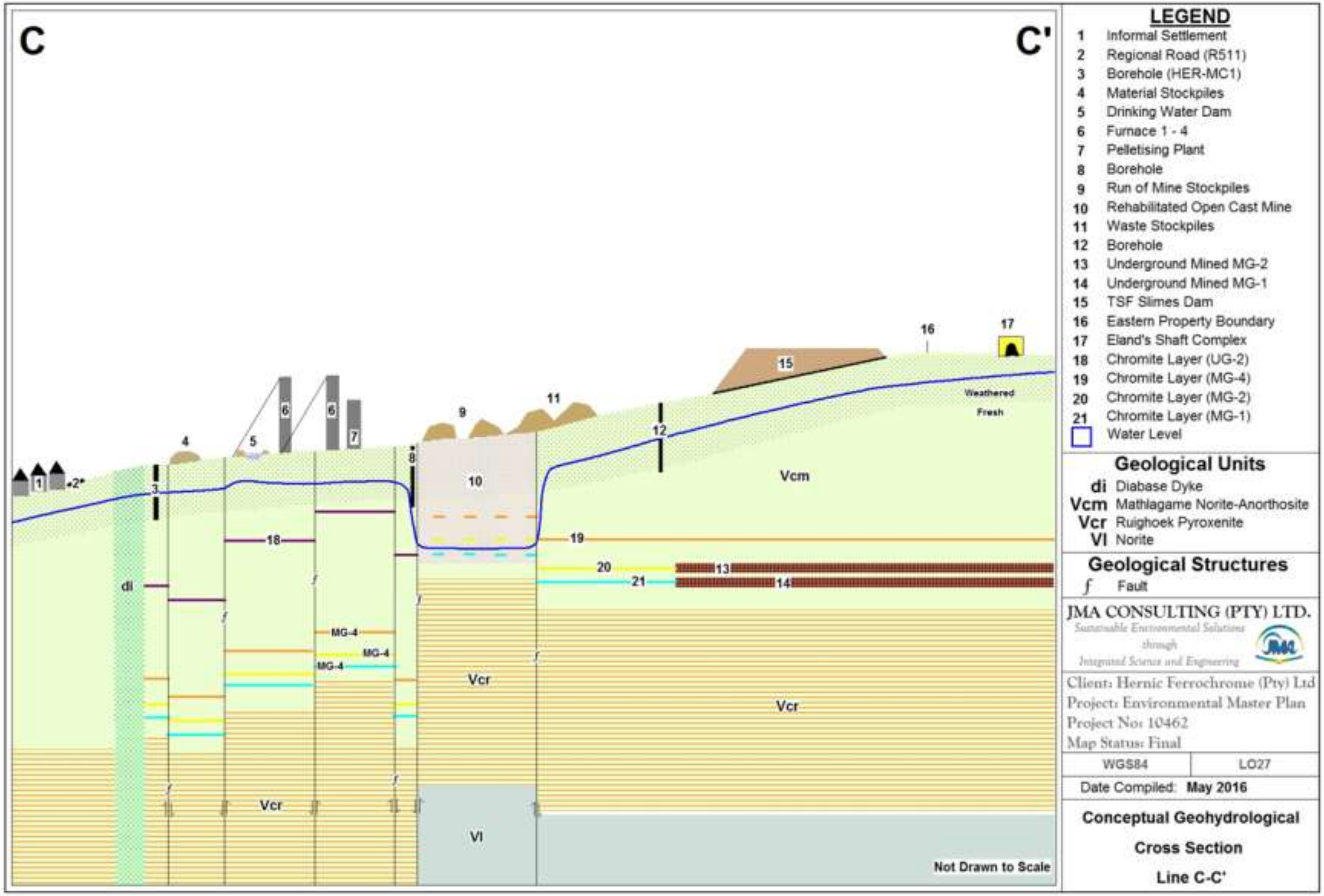


Figure 8.4.12.3(y) Conceptual Geohydrological Cross Section Line C-C'

8.4.13. Surface Water Environment

The relevant Specialist Report is:

HERNIC Ferrochrome (Pty) Ltd - Surface Water Specialist Study Report, April 2016. Inprocon Consultants cc – Consulting Environmental & Civil Engineers.

8.4.13.1. Hydrological Morphology

Hernic Ferrochrome is situated close to the Crocodile River downstream of the Hartbeespoort Dam. Hernic straddles a subtle hill with runoff from the property draining towards a North Stream, a South Stream and westerly towards the right banks of the Crocodile River.

The tributaries North Stream catchment of 112.8 km^2 and the South drainage line catchment of 14.6 km^2 virtually runs parallel and discharges directly in to the Crocodile River.

8.4.13.2. Overall Catchment Boundaries

The HERNIC Ferrochrome site area of 4.33 km^2 straddles a local divide of two unnamed drainage lines herein defined as the North- and South streams running respectively north and south of the HERNIC Site. The North Steam has a catchment area of 119.4 km^2 which is the larger of the two adjacent sub-catchments. The South Stream is rather a less prominent defined drainage line and approximately 14.6 km^2 in area. The more prominent North Stream is approximately 500 m to the north of any infrastructure at HERNIC. However a small narrow strip of HERNIC property consisting of bush and cultivated land stretches north to fence against the North Stream.

The study area lies within the quaternary zone A21J. The regional catchments adjacent to the site are delineated and shown in Figure 8.4.13.2(a).

The Crocodile River is the main receiving waterbody as both North- and South Streams discharges directly in to the Crocodile. Notably is that the western area of the Hernic site drains west towards the North Stream either as sheet flow towards a small drainage line.

The main drainage lines (streams) in the vicinity of the region near the site is more clearly indicated by available vector data of the streams and are indicated in Figure 8.4.13.2(b). The right flank irrigation canal from Hartebeespoort Dam is also indicated and runs close to the western side of the site. It is observed that no significant stream crosses the site.

Both figures mentioned above were delineated on 1:50 000 topographical maps and portrays the overall catchments concerning the site. The overall areas are detailed in the Table 8.4.13.2(a) below. They have been labelled as indicated in Figure 8.4.13.2(a).

Table 8.4.13.2(a): Overall Catchment Area Detail

Catchment	Area (km^2)	Ave Slope (%)	Longest Water course length (km)
South Site (#1)	3,6	3,3	2,0
North Site (#3)	3,0	2,0	2,5
South Stream (#4)	14,6	1,7	8,4
North Stream (#5)	119,4	1,0	21,6

There aren't any farm dams within the applicable catchments that could have an impact on the hydrology of the catchments. However open cast mining and surface disturbances (i.e. paved areas, buildings, roads, yards and stockpiles) have an impact on the runoff factor.

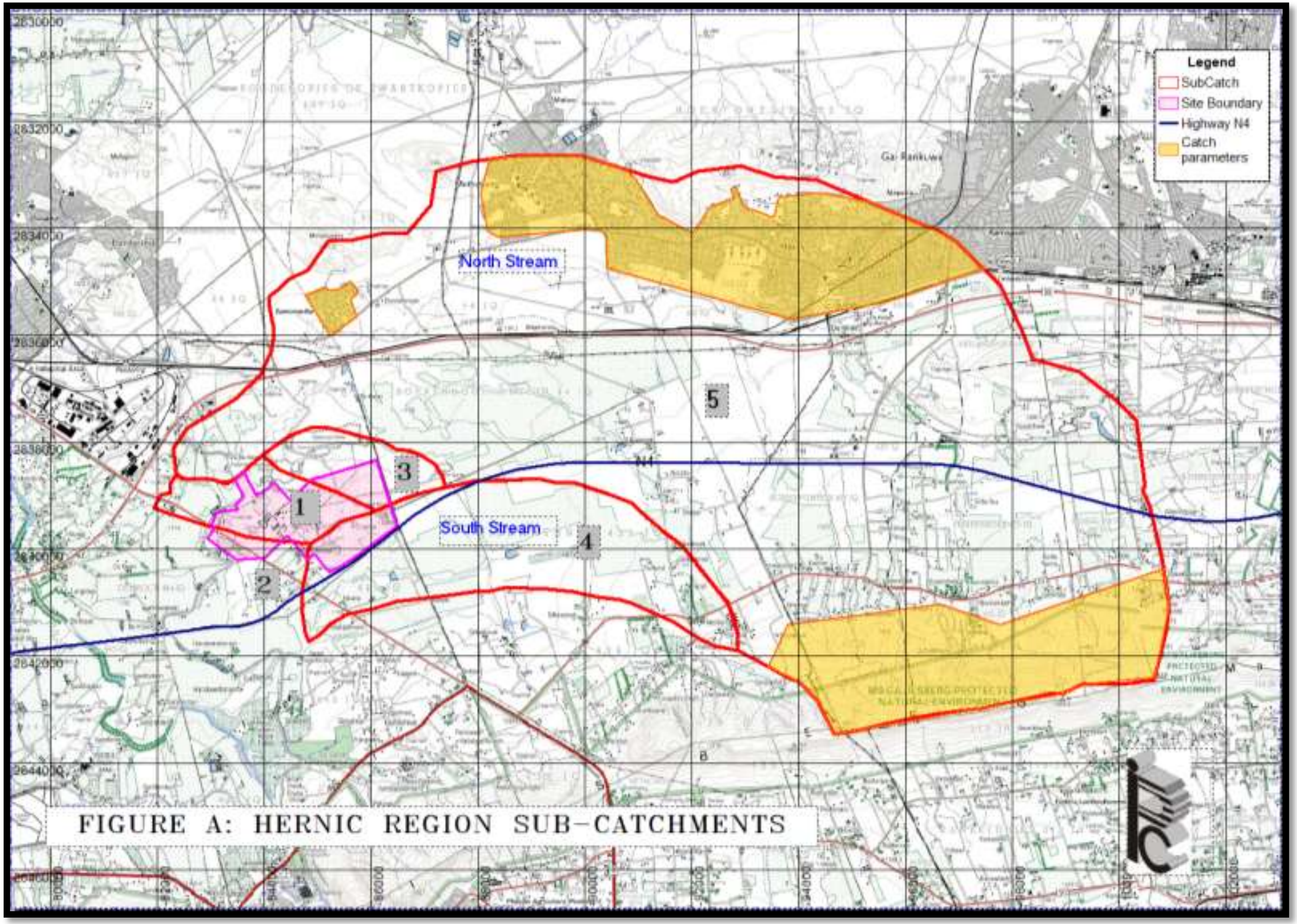


Figure 8.4.13.2(a): Regional Catchments adjacent to the HERNIC site.

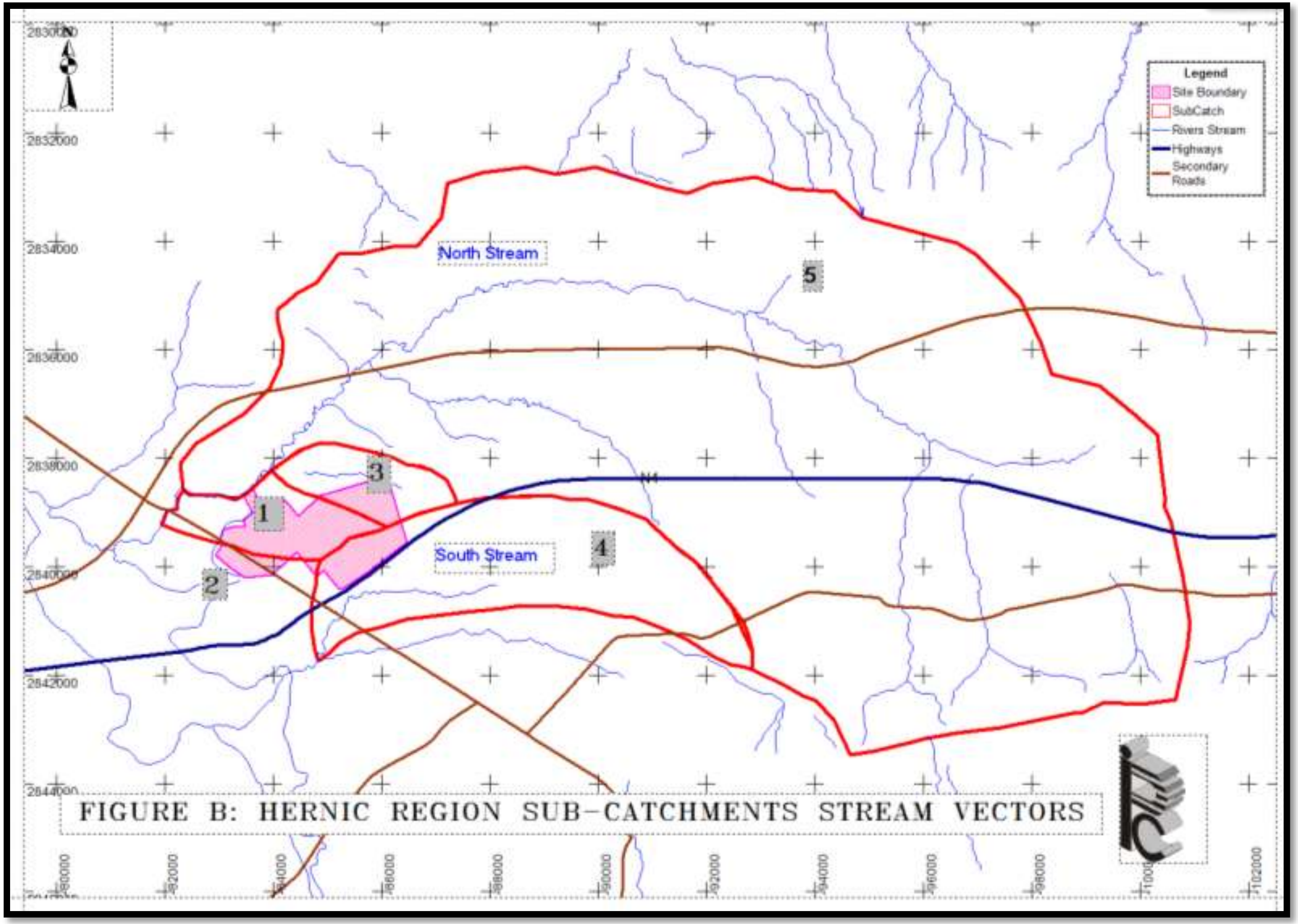


Figure 8.4.13.2(b): HERNIC Region Sub-catchments Stream Vector.

8.4.13.3. Site Sub-catchments

The HERNIC property is divided in four sub-catchments as indicated in Figure 8.4.13.3(a). Hernic 1 the central catchment drains directly towards the North Stream, Hernic 3 is an internal drainage line that includes the northern property and discharges also into the North Stream. The southern sub-catchment, Hernic 2, drains to the South Stream. The south-eastern area of the property, Hernic 4, consists of mainly veld and an informal settlement drains towards another small drainage line of the North Stream.

The beneficiation infrastructure and Furnaces are situated in sub-catchment Hernic 1 and the underground mine facility falls in sub-catchment Hernic 2. The opencast mine runs across Hernic 1 and Hernic 3.

The concentration of activities at HERNIC have changed the baseline drainage characteristics of the site. The open cast mine, process- and storm water impoundments, slimes dam, the beneficiation and smelter infrastructure including the raw materials stockpiles and chrome recovery plants occupies most of the property. The sub-catchment divides represents natural divides. These sub-catchments are listed in Table 8.4.13.3(a).

Table 8.4.13.3(a): Site Sub-Catchment Sizes

Site Sub-Catchment	Area (km^2)
Hernic 1	2,13
Hernic 2	0,98
Hernic 3	0,73
Hernic 4	0,49

8.4.13.4. Water Regulating Authorities

HERNIC site resides in tertiary drainage region A21 which falls in Water Management Area No.3 of the Department of Water and Sanitation (DWS) and named as Crocodile (West) and Marico. This area resorts under the North West Regional Office situated at the Hartbeespoort Dam (Private Bag 352, Hartbeespoort, 0216).

8.4.13.5. Receiving Water Body

HERNIC resides on various portions of the farm De Kroon 444JQ. The property area is approximately 6.5 km downstream of Hartebeespoort Dam and 4 km away from the Crocodile River on the right flank. HERNIC straddles a subtle hill and runoff from the property drains towards a North Stream, a South Stream and westerly towards the Crocodile River.

The North Stream catchment of 112.8 km^2 and the South drainage line catchment of 14.6 km^2 virtually runs parallel and discharges directly in to the Crocodile River. Both these two streams and the Crocodile River are the main receiving water bodies. The North- and South Streams are ephemeral water streams but since township development occurred in the upper reaches of the North Stream with irrigation areas in the South Stream area runoff characteristics have been impacted.

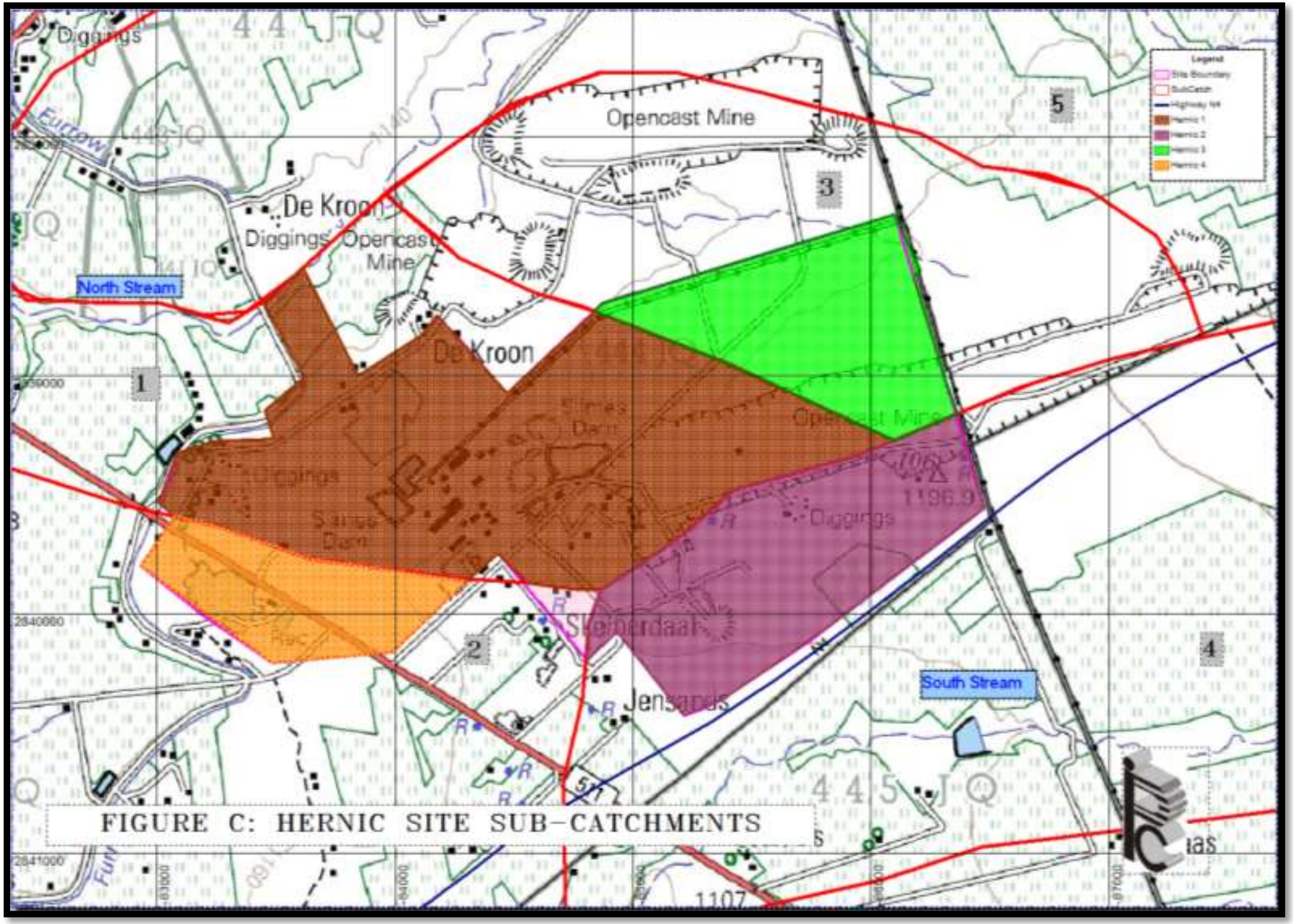


Figure 8.4.13.3(a): Sub-catchments of HERNIC

8.4.13.6. Mean Annual Runoff (MAR)

Mean Annual Runoff (MAR) for the baseline conditions has been based on the relevant quaternary runoff as obtained from the published WR2005. Values are given in the table below.

Table 8.4.13.6(a): Mean Annual Runoff

Catchment	Area km^2	MAR $10^6 m^3/a$	%
Quaternary A21J	1151	22.65	100
South Site (#1)	3,6	0.071	<0.5
North Site (#3)	3,0	0.059	<0.5
South Stream (#4)	14,6	0.287	1.267
North Stream (#5)	119,4	2.350	10.375

It should be noted that the MAR value obtained from WR2005 differ slightly from those in the previous WR90 Report. The MAR has increased from 21.5 to 22.65 $10^6 m^3/a$. The MAR values for the smaller catchments have been scaled in direct proportion to the ratio of catchment areas. These figures are mean stream runoff for virgin conditions. Refer to Figure 8.4.13.6(a) for the expected runoff from the virgin site and region.

8.4.13.7. Average Dry Weather Flows

The average dry weather flows for each of the nearby catchments was again derived from the monthly quaternary flow data set supplied in the WR2005 Report. The dry weather flow is defined as the average flow per month over the lowest three consecutive month period. This period is July to September for the hydro zone (Q) in which the site resides.

Table 8.4.13.7(a): Average Dry Weather Flows

Catchment	Flow $10^3 m^3/month$	Flow l/s
Quaternary A21J	294.45	113
South Stream (#4)	3.73	1.4
North Stream (#5)	30.6	12

As can be seen the average dry weather flow is very low and only about 1.3% of the MAR. This is common for hydro zone Q and means that there is little streamflow contribution from groundwater during winter. It should be further noted that, now endoric areas have been identified implying that the runoff and dry weather flow at the catchment outlet is probably represented by the figures quoted in Table 8.4.13.7(a).

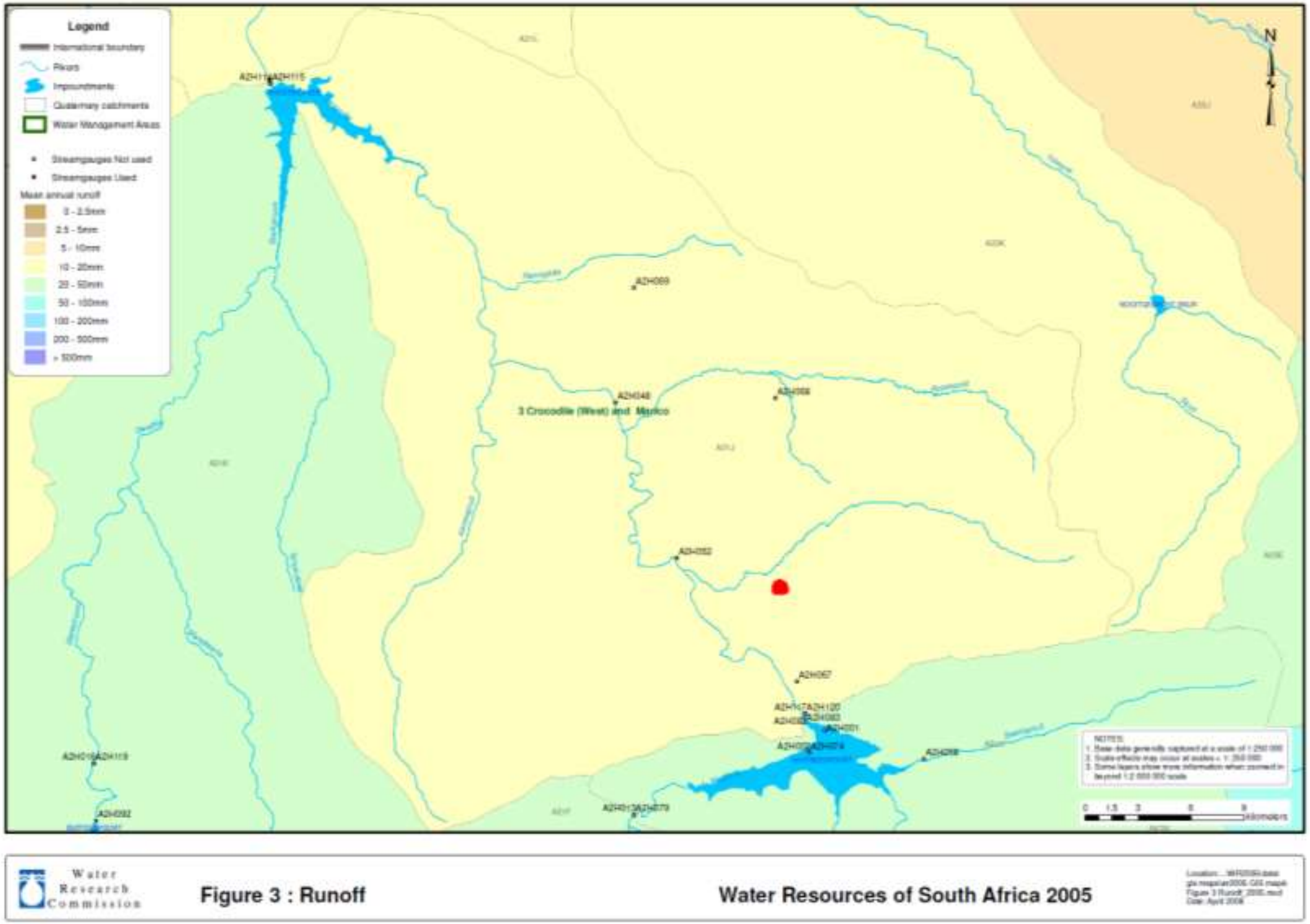


Figure 8.4.13.6(a): HERNIC Runoff

8.4.13.8. Flood Peaks and Volumes

The mining and operational activities of the subject site are located well outside the 100 m zones of the adjacent receiving tributaries to the north and south boundaries. Refer to Figure 8.4.13.2(a) and Figure 8.4.13.2(b).

The North Stream catchment area considered just downstream of the subject site as indicated in Figure 8.4.13.2(a) is categorized as being in the lower band of an intermediate sized catchment. The South Stream is considered as a small catchment. For both sub-catchment sizes, North Stream and South Stream, small-area storms (up to 800 km^2 in area) are applicable for flood calculations.

Five methods have been used to determine the flood peaks for the various return intervals. All methods except for the Unit Hydrograph are based on same basic principles. The output of each method is tabulated below.

Figure 8.4.13.8(a) and Figure 8.4.13.8(b) below indicate the equal area height of the stream lengths relevant for the sub-catchments of the North- and South streams considered in the vicinity of the subject site.

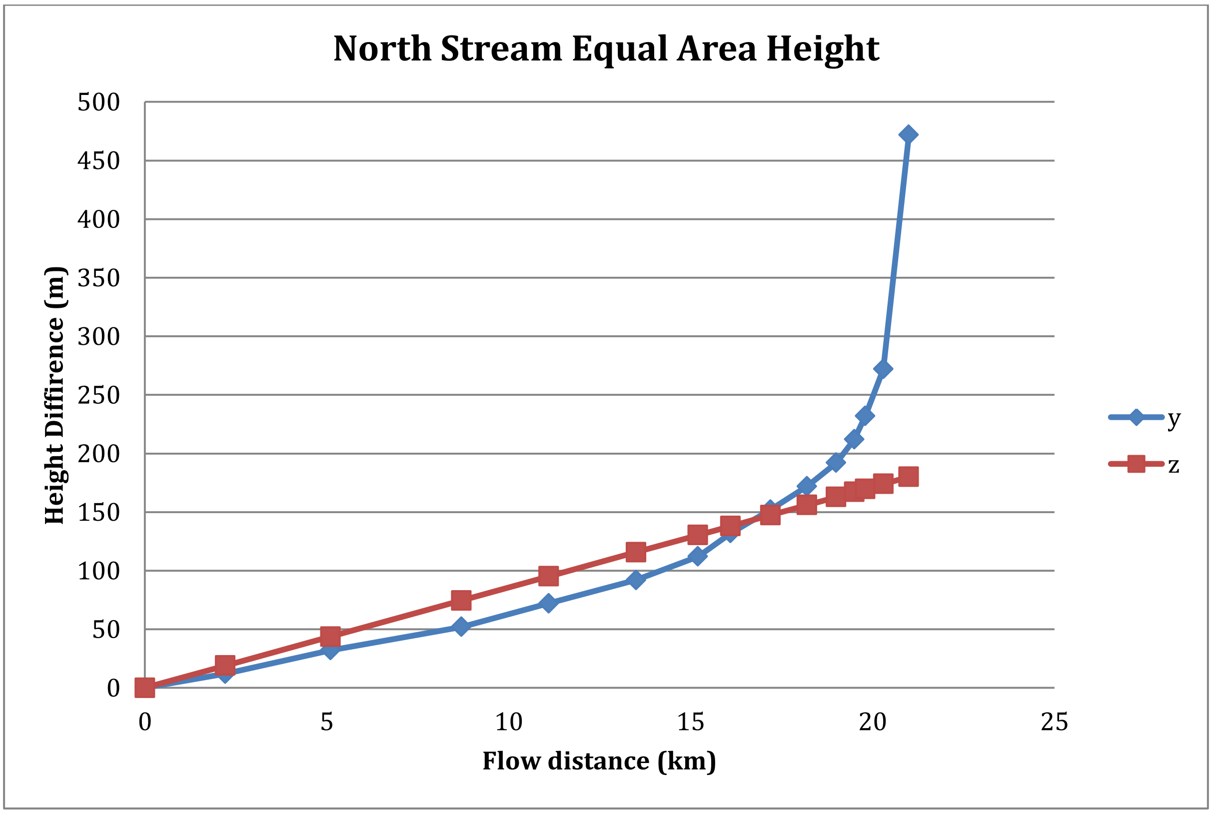


Figure 8.4.13.8(a): North Stream Equal Area height

For the North Stream the equal area height is 180 m and for the South Stream 106 m. The actual stream centerline elevations are indicated by the "y" line and the Equal-Area gradient line by "z". The Equal-Area gradient line denotes the average gradient based on a balance of areas between the "y" and "x" lines. The equal area height and 10-85 slope of each water course are inputs to the various methods used for flood peak calculation. The 10-85 slope for the North Stream and South Stream is respectively 1% and 1.7%.

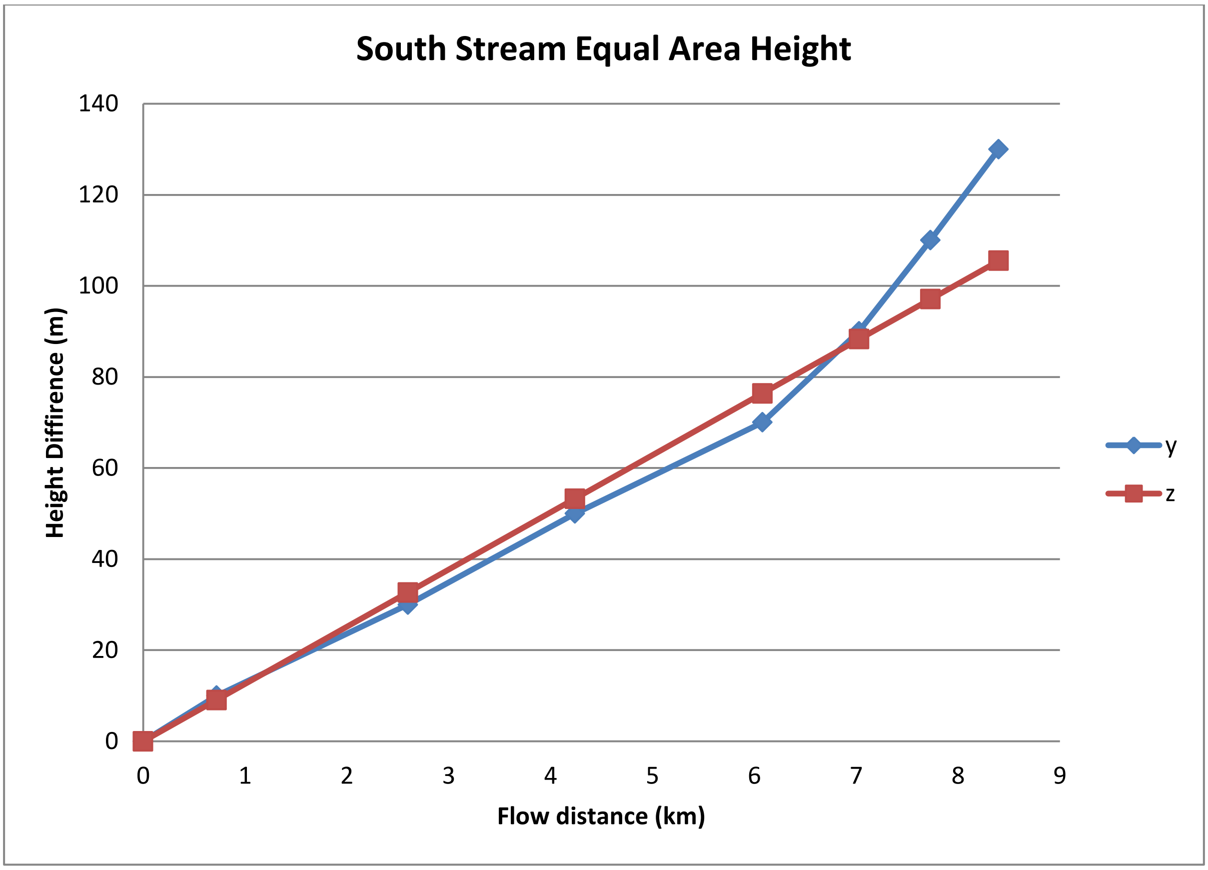


Figure 8.4.13.8(b): South Stream Equal Area height

The methods considered for calculating the flood peaks for the various flood recurrence intervals were Rational-, Alternative Rational-, Unit Hydrograph, Standard Design Flood- and Empirical Method. See results tabulated below.

Table 8.4.13.8(a): North Stream Sub-catchment Flood peaks (*m³/s*) for methods used

Method	Return period (Yrs)			
	1:10	1:20	1:50	1:100
Rational	245.8	302.0	388.0	471.8
Alternative Rational	268.8	334.1	420.8	487.7
Unit Hydrograph	108.2	147.2	213.9	284.4
Standard Design Flood	164.3	238.6	349.4	442.5
Empirical	99.9	135.5	187.8	237.8

Table 8.4.13.8(b): South Stream Sub-catchment Flood peaks (*m³/s*) for methods used

Method	Return period (Yrs)			
	1:10	1:20	1:50	1:100
Rational	56.1	69.4	90.0	110.6
Alternative Rational	64.0	79.5	100.0	115.9
Unit Hydrograph	28.1	38.9	58.1	79.6
Standard Design Flood	39.3	57.1	83.6	105.9
Empirical	28.1	38.1	52.8	66.8

It is expected that the various methods will result in different flood peaks. Three of the five methods applying the same basic methodology also resulted in the same order of peak flow. The Standard Design Flood (SDF) results have been adopted for the study. It was therefore used as preferred method to calculate the flood peaks for the sub-catchments in the vicinity of the site.

The subject site is not sensitive to the outcome of the flood peaks calculated. This is due to the distance of the site located from the two streams. Therefore a conservative approach was followed.

For the determination of flood volumes for the North and South streams a typical hydrograph shape assumed for the flood calculation method used was adopted. Hence a triangular hydrograph with the peak flow occurring at the critical storm duration (Tc) that is also the time of concentration with the recession limb of the hydrograph having a duration equal to 2 times the critical storm duration. The volume results are relayed in Table 8.4.13.8(c).

Table 8.4.13.8(c): Flood Volumes (10^3 m^3)

Catchment	Area	Tc	Return period (Yrs)			
	km^2	hrs	1:10	1:20	1:50	1:100
North Stream	119.4	3.47	3079	4471	6547	8292
South Stream	14.6	1.62	344	500	731	926

The flood peaks and volumes given above are considered baseline values for baseline conditions. These flood peaks need to be adjusted to compensate for any substantial dams or isolated areas that include open voids and open surface mines within the catchments. The flood peaks and volumes calculated are considered representative for the current catchments as the surface disturbances are rather small in relation to the catchment areas.

8.4.13.9. Flood Lines

The unnamed streams in the vicinity of the HERNIC site and herein defined as the North Stream and the South Stream are the only significant drainage lines close to the study area. The activities at HERNIC are located well outside (more than +- 450 *m*) from both streams. The surface flow width of the expected 50 year and 100 year floods for both streams has been examined.

The streams in the vicinity of the HERNIC property have been inspected and any stream flow controls have been examined. Survey data exists for the North Stream but not for the South Stream. The North Stream is a prominent stream and with the survey data available a more comprehensive method was applied. An aerial survey of the North Stream has been used to extract typical river sections at 50 m intervals. The HecRas software was employed for calculating the flood lines. For the South Stream that is a minor ephemeral drainage line no survey data exists and a topographical map was used to determine a typical drainage line cross section and flow gradient opposite the HERNIC site. Basic open channel flow formulae (i.e. Manning & Checy) were used to calculate the normal flow depth opposite the HERNIC site in the stream.

Hydraulic control points that could impact on the natural flow depths or where the natural flow gradient is not considered to be a natural control were verified on site. The methodology followed for determining flood lines is regarded sufficient for the size of streams encountered on site and also the distances of the property sited away from the stream or drainage line.

The flood peaks derived in the previous section were used in calculating the flow depths with resulting flow width. The peak flow reduces upstream within a stream due to the reducing size of the catch area contributing to run-off. In order to determine the peak flows in the mid-section of a catchment area the peak flow was determined by applying the normal procedure of taking the square root of the ratio of the relevant catchment areas.

Hydraulic parameters including stream cross sections could be determined from survey data and field inspection for the North Stream. The pilot canal of the North Stream meanders quite extensively in the downstream reach. However the meanders will be sort circuit during flood events exceeding the 20 year flood. An average Manning “n” value of 0,035 was assumed to reflect the stream condition and roughness. The main canal is very small relative to the flood plain and the roughness of the flanks mainly determine the flow roughness.

For the South Stream no survey data exists and a topographical map was used to determine a typical drainage line cross section and the flow gradient opposite the HERNIC site. The road R511 crosses the South stream and a road portal culvert has been provided. The South Stream pilot canal is poorly defined but with observation an approximate calculation is regarded sufficient for the study. A conservative approach was also followed for the South Stream and the Manning “n” value of 0,035 was also adopted.All channel hydraulic parameters (longitudinal slope, Manning’s roughness coefficient and the contraction/expansion coefficients) and cross-sections, together with the appropriate flood peaks were then applied in the HecRas software or open surface flow formula to determine the flow depths (flood lines) in the streams.

North Stream

Mixed flow conditions will occur and vary close to the transition zone (Froude # = 1). The road R 511 is a cause for slight damming of flood water. The flow velocity in the region of the site is 3 m/s with water depth varying close to 3.5 m but with obstructions causing increased depths at specific river sections of 4.5 m. The 100 year flood line is +-550 m from the closest process water impoundment at HERNIC. Refer to Figure 8.4.13.9(b) for the flood lines.

Figure 8.4.13.9(a) indicates a stream cross section at the vicinity of the HERNIC property boundary. The water surface level for the 100 year flood is at 1130.50 *mamsl* for this river station.

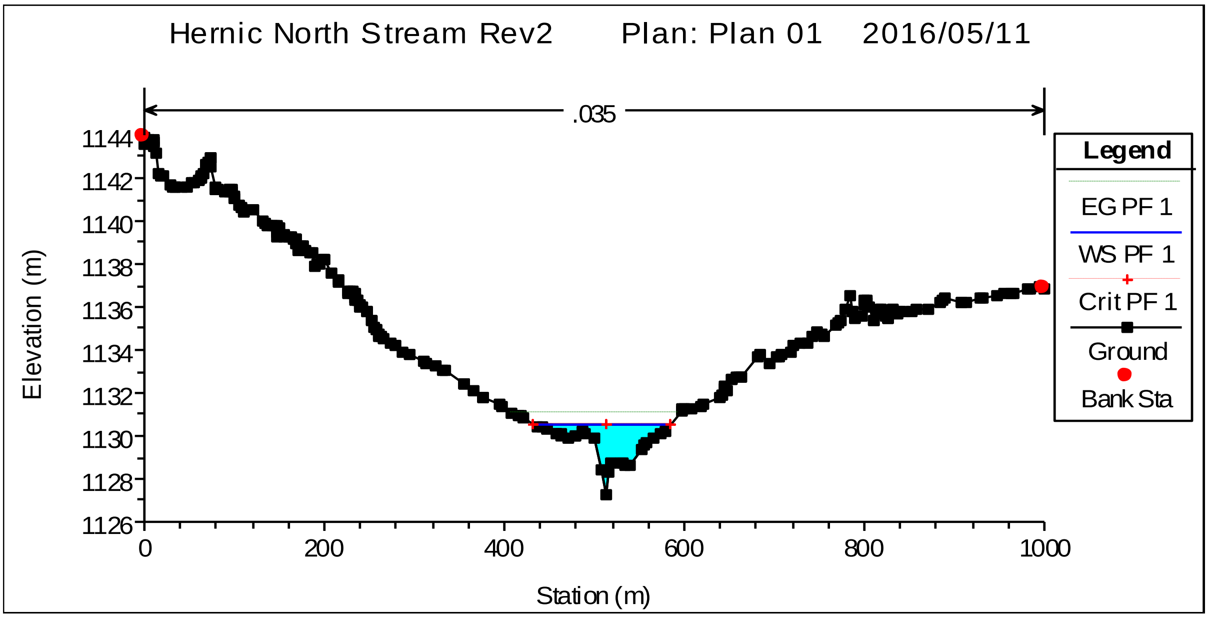


Figure 8.4.13.9(a): North Stream 100 yr Flood Level @ RS 1050 *m*

South Stream

The ‘South Stream’ is a drainage line of which the catchment of has been extensively developed for agricultural activity. It has a flat plain with the result that during extreme events the water plain will be shallow and wide. The cross section of the flow plain varies and a basic flow depth calculation indicated that the flow depth will not exceed 0.8 m with a pilot canal of 0.5 m depth narrow width.

The N4 national road to the west of the stream has been elevated for specific reasons with the 100 year flood plain bordering close to the toe of the road embankment. Refer to Figure 8.4.13.9(b) for the flood lines.

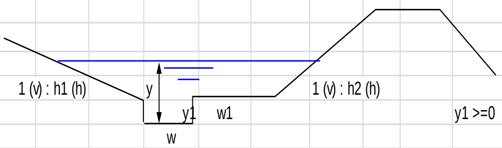
A typical section is defined as a pilot drain of 0.5 m depth and 6 m width with a flat plain >=300 m bounded with banks (side slopes) of approximately 2-2.5% slopes. See Table 8.4.13.9(a) for the water flow depth calculation. A simplified flow cross section has been assumed to assist in calculating the order of flow depth and width. The 100 year flood peak (Q) is 105.9 m^3/s. The average stream gradient (S) is 0.01 m/m. The water flow that is +-330 m wide with flow velocity just above 1 m/s depicting sub-critical flow, therefore mild flow conditions (i.e. Froude # < 1). The variables assumed are:

- Pilot canal depth y1 = 0.5 m
- Pilot canal width w = 6 m
- Flat plain width w1 = 300 m
- Valley side slopes 1:38 and 1:48
- Average stream gradient 1/S = 100
- Manning “n” value = 0.035
- Flood plain flow width B = 330 m (calculated)
- Flow area A = 88.9 m^2 (calculated)
- Flow velocity v = 1.2 m/s (calculated)and
- Froude # = 0.73 (calculated)

Table 8.4.13.9(a): South Stream Flow Depth Calculation

Rev01 Formulas

FLOW DEPTH CALCULATIONS



y	y1	w	w1	side slope	side slope	B	Q	A	v =Q/A	P	R	S	1/S	n	v		delta	Fr	Re	Remarks
(m)	(m)	(m)	(m)	1:h1	1:h2	(m)	m3/s	m2	m/s	(m)	(m)	m/m			m/s				Reynolds	
Manning Formula:																				
0.769	0.50	6.5	300.00	38	48	329.66	105.9	88.9	1.19	330.66	0.27	0.0100	**100**	0.0350	1.190	Average	-0.001	0.73	turbulent	South 100 yr Downstr
1.272	0.50	6.5	0.00	97	97	156.26	105.9	66.1	1.60	157.27	0.42	0.0100	**100**	0.0350	1.603	Average	0.000	0.79	turbulent	South 100 yr Downstr

The flood plain indicated should be considered as indicative and conservative. The flood lines should be regarded as reasonable representations of the stream flows that are expected during the respective flood events. All mining and beneficiating activities are outside the flood plains and 100 m reserve zones of each stream.

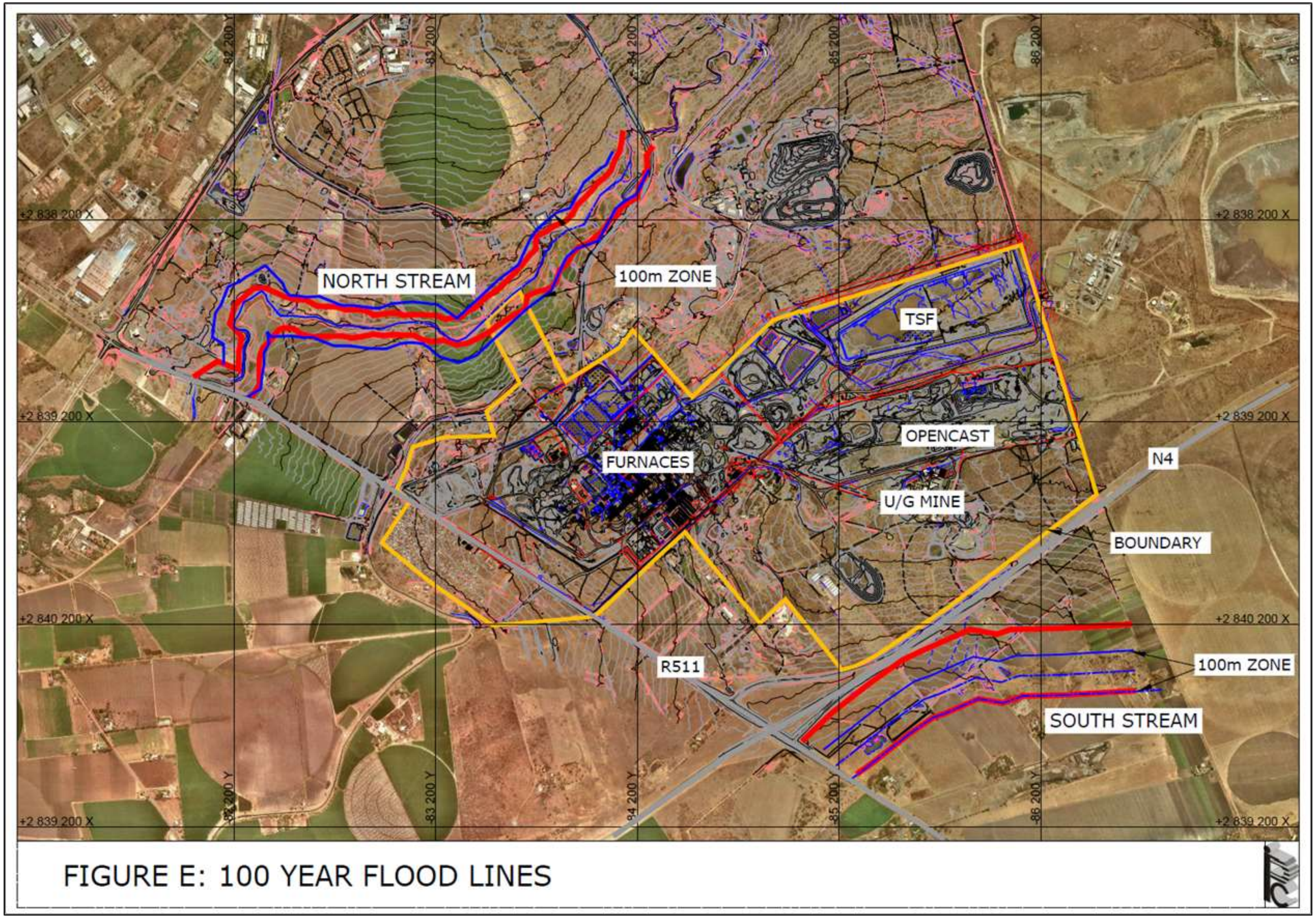


Figure 8.4.13.9(b): HERNIC Flood Lines

8.4.13.10. Watercourse Alterations

The mining and Ferrochrome Smelter activities at Hernic have not required any watercourse disruptions or alterations. However the North and South water courses have been impacted by small dams, ponds, rail crossing and embankment fill by other land owners.

8.4.13.11. Surface Water Use

Surface water in the catchment is used for agricultural, mining and industrial as well as domestic supply purposes.

Cultivated land in the South Stream catchment is mainly commercial irrigation dependent on surface water containment.

Centre Pivot Irrigation agricultural activity within the North Stream total catchment utilizes water from the Hartebeespoort irrigation canal system. These areas are close to the canal system and on the nearby flanks of the Crocodile River.

Water from the North Stream and South Stream is not a sustainable source for large agriculture use. Runoff from the study area feeds to the Roodekopje dam.

Besides agricultural activities other mining like Glencore Eland Platinum Mine is on the adjacent farm Elandsfontein 440 JQ.

The townships of Mothutlung and Makau and a portion of Ramogodi are situated in the area of study. Drinking water is provided by the Brits Municipality.

Hernic utilizes mainly ground water from the underground mine for supplying of water for processing and dust suppression. Water from the Hartebeespoort Irrigation Board is used for domestic purposes after purification. The permitted monthly limit is 72 500 m^3 and the average used from Jan 2015 to Jan 2016 is approximately 42 000 m^3.

8.4.13.12. Climatic Water Balance

The objective of the climatic water balance is to assist in the decision whether leachate management is required or not. This is done by means of a simple calculation which provides a conservative indication whether significant leachate or not will occur at the site of study. This applies to landfill sites and the method is also applicable to any leachate generation MRD.

The Climatic Water Balance (B) in *mm* is calculated using only two components, namely Rainfall (R) in *mm* and Evaporation (E) in *mm* and is defined by B = R – E. The value of B is calculated for the wet season of the wettest year on record.

The value is recalculated for successively drier years to establish whether B is positive for more or less than 20% of the time data is available. If B is positive more than one year in five for the years for which data is available there should be significant leachate generation and the site is classified as B^+.

The Climatic Water Balance has been calculated for the site using data on record for 89 years ending 2014 from Gauge 512 580 De Kroon. The wettest six month period has been determined and falls in the period November to April. Monthly S-pan evaporation figures were obtained from the nearby Hartebeespoort Dam site A2001.

Table 8.4.13.12(a): Climatic Water Balance calculation for Wettest 20 Years (wet season Nov-Apr)

Year	R (mm)	E (mm)	B (mm)
2012/13	717	627	165
2013/14	738	657	160
2009/10	702	724	64
1974/75	960	1036	48
1933/34	815	884	37
1954/55	782	882	5
1966/67	887	1034	-23
1947/48	699	833	-34
1995/96	730	891	-54
1996/97	741	925	-73
1952/53	723	914	-82
1949/50	638	833	-95
2010/11	619	837	-118
1960/61	688	940	-139
1989/90	748	1016	-146
1948/49	598	853	-153
1936/37	666	933	-156
1946/47	574	853	-177
1943/44	661	963	-186
1950/51	543	832	-188

The value of B is positive for 6 years out of the record of 89 years as seen in Table 8.4.13.12(a). In three cases B is marginally positive indicating the likelihood that B will less than 20% be positive. Hence the site, according to these criteria, will not produce significant leachate. However each mine residue must be evaluated for its moisture storage capacity and the impact of storm water runoff.

8.4.13.13. Surface Water Quality

With regards to determining the Surface Water quality, 18 surface water samples were sampled and a description of each of the surface water samples collected is summarized in Table 8.4.13.13(a). The potential pollution source and receptor surface water courses are also indicated. It is necessary to understand the source quality (composition and variability) as it could influence what is observed in the ground water aquifer and surface water streams.

The location of the 18 sample points are mapped and indicated in Figure 8.4.13.13(a). The Hartebeespoort Irrigation Canal operates as a isolated system is not regarded as a receptor water source.

The site of study experienced an abnormal hot summer with rainfall for both the previous two successive years well below the MAPs. The official MAP for the 2014/15 hydrological year measured at the nearby rain gauge De Kroon #512 580 was 375 mm compared with the long-term MAP of 665 mm. Any possible long-term continuous pollution source would not have been diluted and would be detected in the sample run performed. The activities at HERNIC at the time of the sample run were also in full operation.

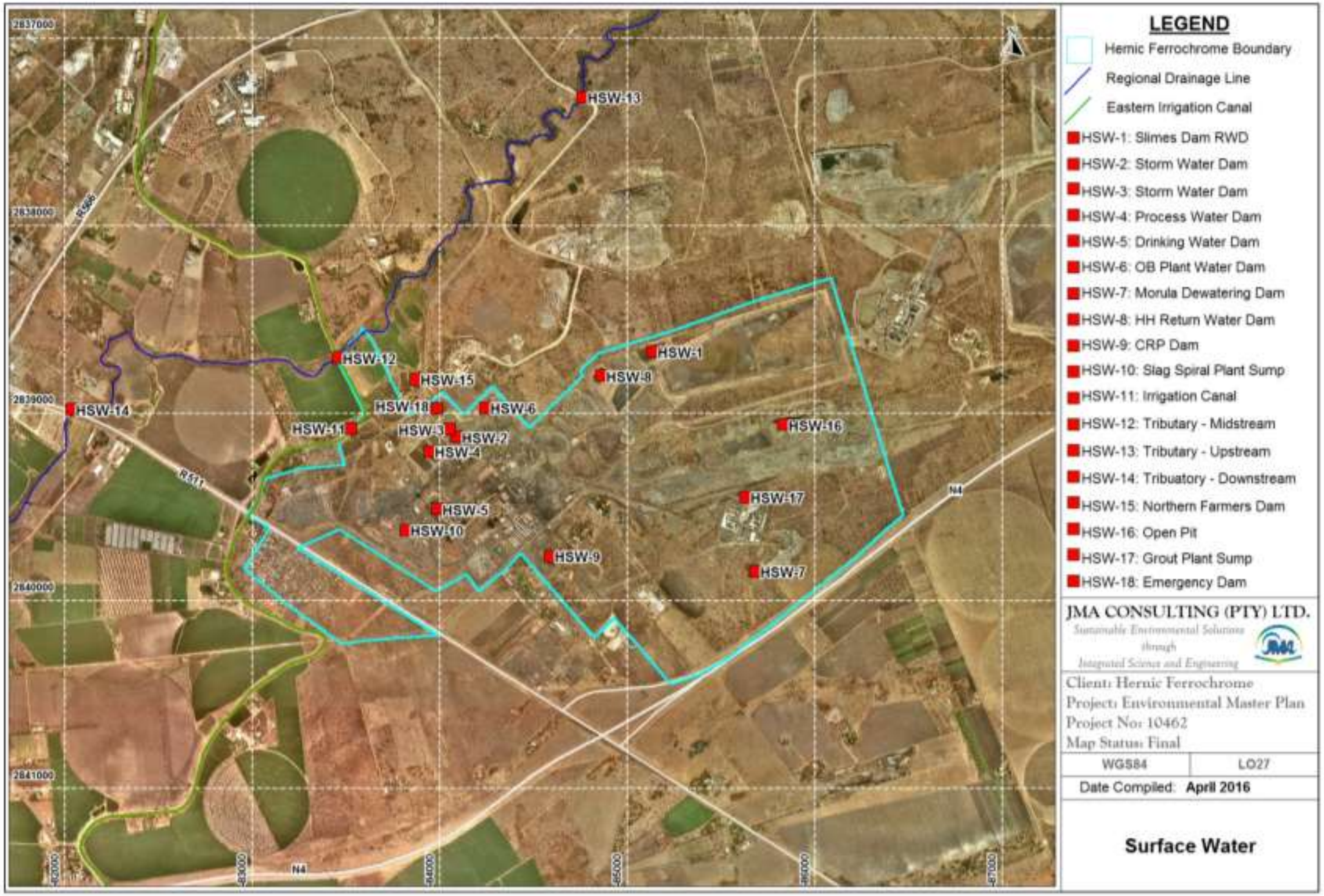


Figure 8.4.13.13(a): Surface Water Sampling Localities

Table 8.4.13.13(a): Sample Description with Potential Pollution Source & Receptor Watercourse

Site No	Description	Potential Pollution Source	Receptor Water Course
HSW-1	Slimes Dam RWD	√	
HSW-2	Storm Water Dam	√	
HSW-3	Storm Water Dam	√	
HSW-4	Process Water Dam	√	
HSW-5	Drinking Water Dam		√
HSW-6	OB Plant Water Dam	√	
HSW-7	Morula Dewatering Dam	√	
HSW-8	HH Return Water Dam	√	
HSW-9	CRP Dam	√	
HSW-10	Slag Spiral Plant Sump	√	
HSW-11	Irrigation Canal		
HSW-12	North Stream Tributary - Midstream		√
HSW-13	North Stream Tributary - Upstream		√
HSW-14	North Stream Tributary - Downstream		√
HSW-15	Northern Farmers Dam		√
HSW-16	Open Pit	√	
HSW-17	Grout Plant Sump	√	
HSW-18	Emergency Dam	√	

Surface Water quality was assessed with regards to the SANS 241:2006 Drinking Water Standard. The results are shown in Table 8.4.13.13(b).

Sample points HSW-12, HSW-13 and HSW-14 denotes to the main receptor water body, the North Stream. HSW 13 is located upstream of HERNIC and portrays the baseline water quality unaffected by any activity performed at HERNIC. HSW-12 and HSW-14 are consecutively opposite and downstream of HERNIC.

The remainder of sample points represents the water quality of all existing impoundments that exists at the time of the sample run on HERNIC property. The surface water sampled from the process water and storm water dams and other potential pollution sources on site generally have variable concentrations that exceed the Class II concentrations of the SANS 241:2006 Drinking Water Standard.

The current potential water pollution sources are all process (HSW-4, HSW-9 and HSW-10), storm water dams (HSW-2) and OB dam (HSW-6) including the Slimes Dam with RWD (HSW-1) and the RWD (HSW-8) of the sealed HH MRD. The Morula Dewatering Dam (HSW-7) reflects clear water except for one constituent, chrome. The open cast void (HSW-16) shows only a high concentration of Hexavalent Chromium as Cr^{6+}.

Table 8.4.13.13(b): Surface Water Quality Compliance Assessment

Table 1.4.3: Current Surface Water Quality	Hernic Surface Water (SANS 241:2006 Drinking Water Standard Compliance)															
(Unless specified otherwise)	HSW-2	HSW-3	HSW-4	HSW-5	HSW-6	HSW-7	HSW-8	HSW-9	HSW-10	HSW-11	HSW-12	HSW-13	HSW-14	HSW-15	HSW-16	HSW-17
pH – Value at 25 °C*	8.4	8.3	8.4	8	8.5	8.3	9.2	7.9	8.1	8.6	8.2	8.2	8.2	8	8.3	8.3
Electrical Conductivity in mS/m at 25 °C*	335	322	422	60.6	320	98.7	2954	344	293	53.5	130	119	130	56	91.4	42.8
Total Dissolved Solids at 180 °C*	2 244	2 358	2 968	356	2 302	640	20 514	2 850	2 088	300	842	768	858	312	560	280
Total Alkalinity as $CaCO_3$*	524	365	624	160	464	265	212	144	245	156	296	220	344	172	316	52
Bicarbonate Alkalinity as $CaCO_3$*	524	365	624	160	464	265	212	144	245	156	296	220	344	172	316	52
Chloride as Cl	226	245	267	47	236	54	7 735	299	210	39	118	119	113	45	29	25
Sulphate as SO_4	690	754	792	73	656	158	3 551	1 302	769	61	183	147	187	42	141	115
Fluoride as F*	5.5	7.3	14	0.3	5.9	0.2	4.9	2.2	5.1	0.2	0.2	0.2	0.2	0.2	0.5	0.3
Nitrate as N	45	57	107	1.9	45	11	20	24	45	0.4	19	27	15	<0.1	6.7	<0.1
Nitrite as N	26	25	29	1.2	27	0.1	5	6	19	0.3	<0.05	<0.05	<0.05	<0.05	0.2	<0.05
Ortho Phosphate as P	<0.1	<0.1	0.1	0.7	<0.1	<0.1	<0.1	<0.1	<0.1	0.9	<0.1	<0.1	<0.1	1.1	<0.1	<0.1
Free & Saline Ammonia as N	9.9	1.1	26	1	11	0.1	0.9	2.6	4	2.4	0.2	0.2	0.1	3.2	0.3	0.1
Sodium as Na	327	350	379	48	327	64	5 099	292	275	44	88	96	64	40	51	34
Potassium as K	226	241	397	13.1	227	9.1	3 574	143	213	9.2	4.7	3.1	4	10.6	15.5	25
Calcium as Ca	50	56	62	45	51	47	52	213	93	40	69	59	74	41	32	32
Magnesium as Mg	140	129	157	18	149	65	60	161	106	15	78	62	88	15	72	3
Aluminium as Al (Dissolved)	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100
Antimony as Sb (Dissolved)*	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Arsenic as As (Dissolved)*	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Barium as Ba (Dissolved)*	0.076	0.116	0.062	0.025	0.093	0.039	0.054	0.077	<0.025	0.031	0.054	0.065	0.059	0.037	0.051	0.033
Bismuth as Bi (Dissolved)*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Boron as B (Dissolved)*	0.313	0.218	0.429	0.037	0.293	0.067	0.736	0.191	0.235	0.036	0.043	0.07	0.075	0.056	0.103	0.292
Cadmium as Cd (Dissolved)	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Chromium as Cr (Dissolved)	<0.025	<0.025	<0.025	<0.025	<0.025	0.075	3.2	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.247	<0.025
Hexavalent Chromium as Cr^{6+}*	<0.010	<0.010	<0.010	<0.010	<0.010	0.075	0.294	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.247	<0.010
Cobalt as Co (Dissolved)	0.025	<0.025	0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Copper as Cu (Dissolved)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Iron as Fe (Dissolved)	0.043	<0.025	0.099	<0.025	<0.025	<0.025	<0.025	<0.025	0.134	<0.025	<0.025	<0.025	<0.025	0.03	<0.025	<0.025
Lead as Pb (Dissolved)	0.057	0.031	0.045	<0.010	<0.010	<0.010	0.049	0.035	0.035	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Lithium as Li (Dissolved)*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.83	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.438
Manganese as Mn (Dissolved)	0.068	<0.025	0.193	<0.025	0.08	<0.025	<0.025	0.068	0.173	<0.025	<0.025	<0.025	<0.025	0.193	<0.025	<0.025
Molybdenum as Mo (Dissolved)*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.133	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Nickel as Ni (Dissolved)	0.098	0.049	0.064	<0.025	0.079	<0.025	0.047	0.071	0.068	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Phosphorus as P (Dissolved)*	0.279	0.173	0.759	0.754	0.264	0.097	0.115	0.102	0.191	0.949	0.059	0.051	0.099	1.11	0.038	<0.025
Selenium as Se (Dissolved)*	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.068	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Silicon as Si (Dissolved)*	14.2	10.6	24	5.3	15.1	16.2	1.7	5.6	7.7	4.9	17.9	17.4	15.4	5.3	15	12.5
Silver as Ag (Dissolved)*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Sulphur as S (Dissolved)*	319	352	347	33	321	72	1 900	574	345	27	82	49	66	16	44	33
Strontium as Sr (Dissolved)*	0.461	0.505	0.356	0.143	0.471	0.195	0.365	0.594	0.256	0.131	0.259	0.268	0.396	0.13	0.163	0.173
Titanium as Ti (Dissolved)*	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Vanadium as V (Dissolved)*	0.051	0.075	0.06	<0.025	0.054	0.027	0.08	0.083	0.052	<0.025	0.041	0.039	0.043	<0.025	0.025	<0.025
Zinc as Zn (Dissolved)	0.027	0.046	0.035	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.033

The background surface water quality upstream of the HERNIC Site reflected by sample point HSW-13 complies with the baseline water quality standard set by the SANS 241:2006 Drinking Water Standard (except for the Nitrate content) as well as the WUL No.27/2/2/A921/18/1 issued to HERNIC.

The background water quality of the North Stream in the vicinity of HERNIC Site and downstream also generally complies with SANS 241:2006 Drinking Water Standard. It indicates elevated concentrations of Nitrates and Aluminium but in the same order as the upstream quality.

From the sample run it can be concluded that the upstream and downstream water quality are equal. Based on the above, a Table was drawn up showing typical ranges for background water quality in the surface streams in the study area – Table 8.4.13.13(c).

Table 8.4.13.13(c): Typical Surface Water Background Quality

Water Quality Variable	Max Quality Baseline (mg/l)
pH – Value at 25°C*	7-9
Electrical Conductivity in mS/m at 25°C *	260
Total Dissolved Solids at 180°C *	1200
Chloride as Cl	200-600
Sulphate as SO_4	400-600
Fluoride as F *	1-1.5
Nitrate as N	10-20
Sodium as Na	200-400
Potassium as K	50-100
Calcium as Ca	150-300
Magnesium as Mg	70-100
Aluminium as Al (Dissolved)	0.3-0.5
Chromium as Cr (Dissolved)	0.1-0.5
Hexavalent Chromium as Cr^{6+} *	0.1-0.5
Iron as Fe (Dissolved)	0.2-2
Manganese as Mn (Dissolved)	0.1-1

8.4.14. Plant Life Environment

The relevant Specialist Report is:

Baseline Ecological Assessment as Part of the EMPR Amendment Process for the Proposed HERNIC Ferrochrome Operations near Brits, North West Province – Section B : Floral Assessment, May 2016. Scientific Aquatic Services CC.

Two field assessments were undertaken during February and March 2016 in order to determine the ecological status of the study area.

A reconnaissance 'walkabout' was initially undertaken to determine the general habitat types found throughout the study area.

Following this, specific study sites were selected that were considered to be representative of the habitats found within the area, with special emphasis being placed on areas that may potentially support floral Species of Conservational Concern (SCC).

Sites were investigated on foot in order to identify the occurrence of the dominant plant species and habitat diversities.

8.4.14.1. Overall Floral Habitat Description

Three main habitat units were identified (see Figure 8.4.14.1(a)), namely:

- Secondary Marikana Thornveld, where historic agricultural activities and edge effects from mining have transformed the natural vegetation to a secondary state of ecological succession;
- Ephemeral drainage lines comprised of weakly developed wetland conditions; and
- Transformed areas comprised of current and historic mining and smelter infrastructure, buildings, pollution control systems, waste rock dumps and other associated infrastructure.

The sensitivity of each of the habitat units was determined in terms of the presence or potential for floral SCC, habitat integrity and levels of disturbance, threat status of the habitat type, the presence of unique landscapes and overall levels of diversity, and is summarised in the table below (Table 8.4.14.1(a)) and illustrated on Figure 8.4.14.1(b).

Several potential risks to the receiving floral environment by the proposed operation, such as further degradation of ecosystems, have been identified which relate to floral habitat integrity, floral diversity and the impact on floral SCC.

These impacts will be assessed in detail in the impact assessment phase of the project and as far as possible mitigatory recommendations will be presented in line with the mitigation hierarchy as advocated by the DMR (2013) in order to ensure informed decision making and improved sustainable development in the area.

The three Habitat Units will be discussed in the tables below.

Table 8.4.14.1(a): Summary of the three main Floral Habitat Units within the Project Area

Habitat Unit	Sensitivity	Conservation Objective	Development Implications
Secondary Marikana Thornveld	**Moderately Low**	Optimise development potential while improving biodiversity integrity of surrounding natural habitat and managing edge effects.	This habitat unit is of moderately low ecological sensitivity. However, if any further development is to take place within this habitat unit, care must be taken to limit footprint sizes and unnecessary additional habitat transformation. Furthermore, it is recommended that a rehabilitation plan be developed which must aim to improve the condition of the Secondary Marikana Thornveld within the study area. Finally, alien floral species management measures must be implemented in order to avoid further encroachment and proliferation of these species.
Ephemeral Drainage Lines	**Intermediate**	Preserve and enhance biodiversity of the habitat unit and surrounds while optimising development potential.	This habitat unit is of intermediate ecological sensitivity. If any further development is to take place near this habitat unit, care must be taken to limit footprint sizes and avoid development within this habitat unit. Finally, it is recommended that the natural flow regime be re-instated (if possible) and that alien floral species management measures must be implemented in order to avoid further encroachment and proliferation of these species.
Transformed	**Low**	Optimise development potential.	This habitat unit is of low ecological importance and sensitivity. Activities within this habitat unit must be optimised and limited to the existing disturbance footprint. However, care must be taken to limit edge effects on the surrounding natural areas. Furthermore, it is recommended that an alien and invasive floral species management plan be developed to manage alien floral species infestation.

Figure 8.4.14.1(a): **Conceptual Illustration of the Habitat Units within the Study Area**

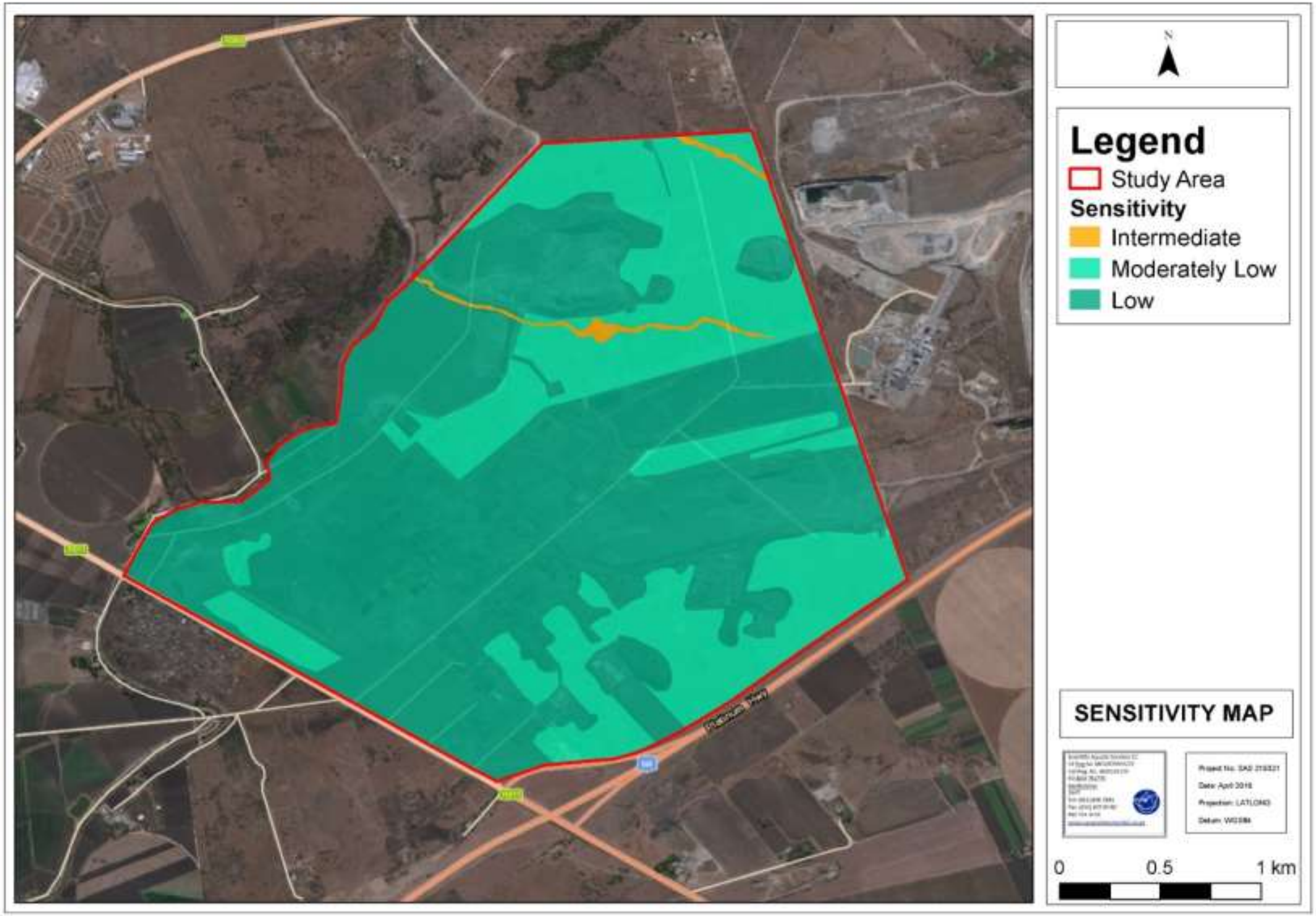
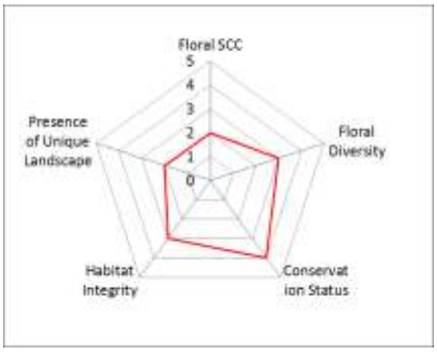


Figure 8.4.14.1(b): Sensitivity Map of the HERNIC Study Area

Table 8.4.14.1(b): Habitat Unit 1- Secondary Marikana Thornveld

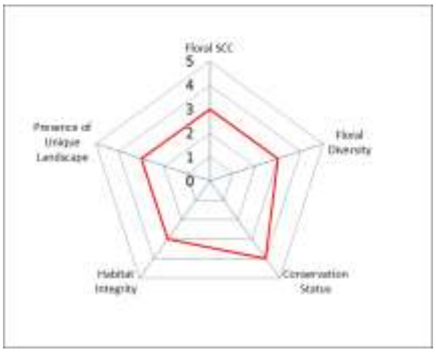
<table>
<tr><td rowspan="2">Habitat Unit:
Secondary Marikana Thornveld, where historic agricultural activities and edge effects from mining and minerals beneficiation have transformed the natural vegetation to a secondary state of ecological succession;</td><td>Floral Habitat Sensitivity</td><td>Moderately Low</td><td rowspan="3">
</td></tr>
<tr><td colspan="2">Notes on Photograph:
Typical view of the Secondary Marikana Thornveld habitat unit. Very few broad-leaved woody species were present, woody layer dominated by Vachellia karroo</td></tr>
<tr><td colspan="3">Floral Habitat Sensitivity Graph:

</td></tr>
</table>

<table>
<tr><td>Floral Species of Conservation Concern (SCC)</td><td colspan="3">No floral SCC were encountered in this habitat unit during the assessment. However, suitable habitat for Boophane disticha (Declining) and Crinum macowanii (Declining) was encountered, although none of these species were recorded during the assessment. Furthermore, several individuals of Sclerocarya birrea (Marula) trees were encountered. These trees are protected under the National Forest Act (NFA) of 1998. The trees were limited to the EastPlats Marula section, and none were encountered within the Hernic Ferrochrome boundaries.</td></tr>
<tr><td>Floral Diversity</td><td>Floral diversity was moderate with impacts from historic agricultural activities evident. The woody layer was dominated by Vachellia karroo and Dichrostachys cinerea, with very few broad-leaved woody species present. This is typical of old agricultural areas where vegetation was cleared for crops. For a list of species recorded during the assessment, please refer to Appendix C.</td><td rowspan="4">General comments:
This habitat unit is associated with a relatively large plain dominated by dark vertic soils. Historic agricultural activities and edge effects from mining activities have led to this habitat unit being severely invaded by the indigenous Vachellia karroo and Dichrostachys cinerea. Furthermore, several alien invasive floral species were present, especially close to the surrounding mining activities.</td><td rowspan="4">Business Case, Conclusion and Mitigation Requirements:
This habitat unit is of moderately low ecological sensitivity. However, if any further development is to take place within this habitat unit, care must be taken to limit footprint sizes and unnecessary additional habitat transformation.
Furthermore, it is recommended that a rehabilitation plan be developed which must aim to improve the condition of the Secondary Marikana Thornveld within the study area. Finally, alien floral species management measures must be implemented in order to avoid further encroachment and proliferation of these species.</td></tr>
<tr><td>Conservation Status of Vegetation Type/Ecosystem</td><td>The vegetation type is listed as Endangered (Mucina & Rutherford 2006). However, the vegetation associated with the study area is only moderately representative of the vegetation type as it has been transformed to a secondary state of ecological condition due to agriculture and mining.</td></tr>
<tr><td>Habitat integrity/Alien and Invasive species</td><td>Habitat was moderately modified due to historic agricultural activities and invasion by microphyllous trees such as Vachellia karroo and Senegalia caffra. Furthermore, various alien floral species were present such as Zinnia peruviana, Campuloclinium macrocephalum and Hibiscus trionum.</td></tr>
<tr><td>Presence of Unique Landscapes</td><td>The landscape associated with the habitat unit is well represented regionally and not considered to be unique.</td></tr>
</table>

Table 8.4.14.1(c): Habitat Unit 2 - Ephemeral Drainage Lines

Habitat Unit: Ephemeral drainage lines comprised of weakly developed wetland conditions	**Floral Habitat Sensitivity**	**Intermediate**	 
	Notes on Photograph: Earth dam constructed within drainage line (top) and drainage line running between waste dumps (bottom).		

Floral Habitat Sensitivity Graph:

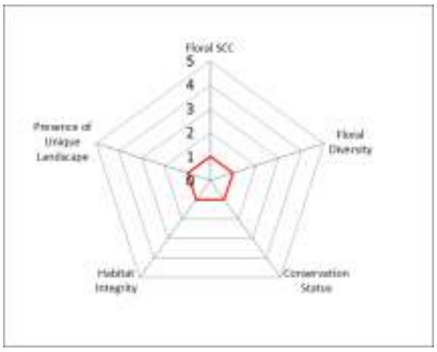


Floral Species of Conservation Concern (SCC)	No floral SCC were encountered in this habitat unit during the assessment. However, suitable habitat for *Stenostelma umbelluliferum* (Near Threatened) and *Crinum macowanii* (Declining) was encountered, although none of these species were recorded during the assessment.		
Floral Diversity	Floral diversity was moderate with impacts from historic agricultural activities evident. However, diversity was slightly higher than the surrounding terrestrial areas. For a list of species recorded during the assessment, please refer to Appendix C.	**General comments:** This habitat unit is associated with lower lying areas where surface runoff concentrates. Historic agricultural activities and edge effects from mining activities have led to this habitat unit being transformed and in several instances, the natural flow direction of the features has been altered by mining infrastructure. Furthermore, several alien invasive floral species were present, especially close to the surrounding mining activities.	**Business Case, Conclusion and Mitigation Requirements:** This habitat unit is of intermediate ecological sensitivity. If any further development is to take place near this habitat unit, care must be taken to limit footprint sizes and avoid development within this habitat unit. Finally, it is recommended that the natural flow regime be re-instated (if possible) and that alien floral species management measures must be implemented in order to avoid further encroachment and proliferation of these species.
Conservation Status of Vegetation Type/Ecosystem	The vegetation type is listed as Endangered (Mucina & Rutherford 2006). However, the vegetation associated with the study area is only moderately representative of the vegetation type as it has been transformed to a secondary state of ecological condition due to agriculture and mining.		
Habitat integrity/Alien and Invasive species	Habitat was moderately modified due to edge effects from historic agricultural activities and mining infrastructure. In certain areas, the natural flow of the drainage line has been altered by discard dumps. Furthermore, various alien floral species were present such as *Zinnia peruviana, Campuloclinium macrocephalum* and *Hibiscus trionum.*		
Presence of Unique Landscapes	The landscape associated with the habitat unit is well represented regionally and not considered to be unique.		

Table 8.4.14.1(d): Habitat Unit 3 – Transformed

Habitat Unit: Transformed areas comprised of current and historic mining and minerals beneficiation infrastructure, buildings, pollution control systems, waste rock dumps and other associated infrastructure.	**Floral Habitat Sensitivity** — **Low** **Notes on Photograph:** Typical views of transformed areas and infrastructure associated with the habitat unit.	 

Floral Habitat Sensitivity Graph:



Floral Species of Conservation Concern (SCC)	No floral SCC were encountered in this habitat unit and it is highly unlikely that any such species will occur as habitat is severely transformed and has been in this transformed state for many years.		
Floral Diversity	Floral diversity was low and dominated by alien and invasive species. . For a list of species recorded during the assessment, please refer to Appendix C.	**General comments:** This habitat unit is associated with current and historic disturbance and natural floral habitat has been completely modified and transformed. Alien floral infestation is rife and species diversity is low.	**Business Case, Conclusion and Mitigation Requirements:** This habitat unit is of low ecological importance and sensitivity. Activities within this habitat unit must be optimised and limited to the existing disturbance footprint. However, care must be taken to limit edge effects on the surrounding natural areas. Furthermore, it is recommended that an alien and invasive floral species management plan be developed to manage alien floral species infestation.
Conservation Status of Vegetation Type/Ecosystem	The vegetation type is listed as Endangered (Mucina & Rutherford 2006), however very little to no representative vegetation remains and the habitat unit is dominated by pioneer species and weeds		
Habitat integrity/Alien and Invasive species	Habitat integrity is severely transformed and is dominated by pioneer and alien species such as *Sesbania punicea, Melia azedarach, Zinnia peruviana, Campuloclinium macrocephalum* and *Hibiscus trionum.*		
Presence of Unique Landscapes	No unique landscapes important to flora were present.		

8.4.14.2. Floral Species of Conservation Concern

An assessment considering the presence of any plant species of concern, as well as suitable habitat to support any such species was undertaken. The complete PRECIS Red Data Listed plants for the grid reference 2527DB was acquired from SANBI.

Threatened species are species that are facing a high risk of extinction. Any species classified in the IUCN categories Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) is a threatened species.

SCC are species that have a high conservation importance in terms of preserving South Africa's high floristic diversity and include not only threatened species, but also those classified in the categories Extinct in the Wild (EW), Regionally Extinct (RE), Near Threatened (NT), Critically Rare, Rare and Declining.

The SCC listed for the area together with their calculated POC are tabulated in Appendix B of the Specialist Report.. Table 8.4.14.2(a) below represents those species that obtained a POC score of 60 or more.

Table 8.4.14.2(a) Floral SCC listed for the QDS that obtained a POC score of 60% or more

Species	POC	Motivation
Boophone disticha (L.F) Herb.	75%	Within distribution range and suitable habitat present, especially within the Secondary Marikana Thornveld habitat. Not recorded during assessment
Crinum macowanii Baker	70%	Within distribution range and suitable habitat present, especially within the Drainage Line and Secondary Marikana Thornveld habitat. Not recorded during assessment
Stenostelma umbelluliferum (Schltr.) s.p. Bester & Nicholas	60%	Within distribution range and suitable habitat present, especially within the Drainage Line habitat. Not recorded during assessment

From the above assessment, it is evident that three of the five species listed for the QDS are likely to occur within the study area, specifically within the Ephemeral Drainage Line and Secondary Marikana Thornveld habitat units, although they were not recorded during the site assessment.

Furthermore, it is likely that these species will be limited to the north of the Hernic Ferrochrome facility, where larger expanses of Secondary Marikana Thornveld is associated with the EastPlats Marula section. If individuals or communities of these species will be disturbed by operational activities, they must be relocated to suitable, similar habitat in close proximity to where they were removed from, but outside the disturbance footprint by a suitably qualified ecologist.

Finally, one tree species protected by the National Forest Act (NFA) of 1998, namely Sclerocarya birrea, was identified in the EastPlats Marula section. No S. birrea were recorded with the Hernic Ferrochrome footprint area. In terms of this act, protected tree species may not be cut, disturbed, damaged or destroyed and their products may not be possessed, collected, removed, transported, exported, donated, purchased or sold - except under licence granted by the Department of Water and Sanitation (DWS) (or a delegated authority).

8.4.14.3. Alien and Invasive Plant Species

During the floral assessment, dominant alien and invasive floral species were identified and are listed in the table below.

Table 8.4.14.3(a): Dominant Alien Vegetation Species Identified during the Field Assessment

Species	English name	Origin	NEMBA Category*
Trees and Shrubs			
Acacia mearnsii	Black wattle	Australia	2
Agave americana	Spreading century plant	Central and North America	N/L
Jacaranda mimosifolia	Jacaranda	Central America	1b
Melia azederach	Seringa	Asia	1b
Agave sisalana	Sisal	Central America	2
Eucalyptus camaldulensis	Red River Gum	Australia	2
Sesbania punicea	Red sesbania	South America	1b
Forbs			
Agemone ochroleuca	Mexican poppy	Central America	1b
Bidens formosa	Cosmos	Central America/	N/L
Bidens pilosa	Common blackjack	South America	N/L
Campuloclinium macrocephalum	Pompom Weed	South America	1b
Centaurea solstitialis	Yellow star thistle	Europe	N/L
Cirsium vulgare	Spear thistle	Europe and Asia	1b
Conyza bonariensis	Flax-leaf fleabane	Americas	N/L
Datura stramonium	Common thorn-apple	North America	1b
Gomphrena celosioides	Prostrate globe amaranth	South America	N/L
Hibiscus trionum	Bladder hibiscus	Uncertain	N/L
Oenothera rosea	Pink evening primrose	Central America	N/L
Parthenium hysterophorus	Parthenium	North America	1b
Persicaria lapathifolia	Spotted knotweed	Europe	N/L
Physalis angulata	Wild gooseberry	America	N/L
Plantago lanceolata	Buckhorn plantain	Europe	N/L
Rumex crispus	Curly dock	Europe	N/L
Schkuhria pinnata	Dwarf marigold	South America	N/L
Tagetes minuta	Tall khaki weed	South America	N/L
Verbena bonariensis	Purple top	South America	1b
Grasses			
Pennisetum clandestinum	Kikuyu	East Africa	N/L

N/L = Not Listed and not categorised

National Environmental Management: Biodiversity Act (Act 10 of 2004): Alien and Invasive Species Regulations, GN R598 of 2014:

Category 1a: Invasive species that require compulsory control.

Category 1b: Invasive species that require control by means of an invasive species management programme.
Category 2: Commercially used plants that may be grown in demarcated areas, provided that there is a permit and that steps are taken to prevent their spread.

Category 3: Ornamentally used plants that may no longer be planted. Existing plants may remain, except within the flood line of watercourses and wetlands, as long as all reasonable steps are taken to prevent their spread (Bromilow, 2001).

From the table above it is clear that a relatively high diversity of alien species occurs within the study area. Of particular concern is the high levels of alien floral species proliferation within the transformed areas. Alien species located in the study area need to be removed on a regular basis as part of maintenance activities according to the National Environmental Management: Biodiversity Act (Act 10 of 2004): Alien and Invasive Species Regulations, GN R598 of 2014. Thus, it is recommended that a comprehensive alien and invasive floral species control plan be developed and implemented to manage and eradicate alien floral species from the facility.

8.4.14.4. Medicinal Plant Species

Medicinal plant species are not necessarily indigenous species, with many of them regarded as alien invasive weeds. The table below presents a list of dominant plant species with traditional medicinal value, plant parts traditionally used and their main applications, which were identified during the field assessment.

Table 8.4.14.4(a)1: Dominant traditional medicinal floral species identified during the field assessment. Medicinal applications and application methods are also presented (van Wyk, Oudtshoorn, Gericke, 2009)

Species	Name	Plant Parts Used	Medicinal Uses
Aslepias fruticosa	Milkweed	Leaves, sometimes roots	Used as snuff to treat headaches and tuberculosis.
Acacia karroo	Sweet thorn	Bark, leaves and gum	Remedy for diarrhoea and dysentery.
Aloe greatheadii var davyana	Aloe	Stems and leaves	Decoction of powdered stems and leaf bases is taken orally twice a day after delivery to cleanse the system.
Boophane disticha	Bushman poison bulb	Bulb scales	Dry outer scales of the bulb are used as an outer dressing after circumcision and are applied to boils or septic wounds to alleviate pain. Weak decoctions are administered by mouth or as and enema for various complaints such as headaches, abdominal pain, weakness and eye conditions.
Centella asiatica	Pennywort	Dried aboveground parts (mainly leaves)	Used to treat leprosy, wounds and cancer. It is widely used for wound treatment, fever, syphilis, and as a diuretic and purgative.
Crinum bulbispermum	Orange river lily	Bulbs and leaves	Remedy for scrofula, micturition and rheumatic fever. Also used for blood cleansing, kidney and bladder diseases, glandular swelling, fever and skin problems.
Datura stramonium	Thornapple	Leaves and green fruit	Mainly to relieve asthma and to reduce pain.
Dichrostachys cinerea	Sickle bush	Root and often stems bark, leaves and pods	Root infusions have been used to treat body pain, backache, toothache, elephantiasis, syphilis, leprosy and as a styptic, diuretic, purgative and aphrodisiac.

Species	Name	Plant Parts Used	Medicinal Uses
Gnidia kraussiana	Yellow heads	Rootstock and roots	Uses range from the topical treatment of burns and snake bites to enemas for stomach complaints and decoctions used to ensure an easy childbirth.
Helichrysum nudifolium	Everlasting	Leaves, twigs and sometimes the roots	Many ailments are treated, including coughs, colds, fever, infections, headache and menstrual pains. It is a popular ingredient in wound dressing.
Rumex lanceolatus	Common dock	Roots, sometimes leaves	Traditional remedy for internal parasites. The whole plant is used for vascular diseases and internal bleeding. Applied externally to abscesses, boils and tumours.
Scabiosa columbaria	Wild scabious	Leaves and fleshy roots	Remedy for colic and heartburn, wound healing and used as a baby powder.
Sclerocarya birrea subsp. caffra	Marula	Bark, roots and leaves	Diarrhoea, dysentery and unspecific stomach problems are treated with the bark. Also used as a general tonic, in combatting fever and in the treatment of malaria.
Tagetes minuta	Tall khaki bush	Leaves, flowers	The repellent properties of essential oil have been known for a long time and were found to be effective in preventing sheep from becoming infected with blow-fly larvae. Many gardeners use warm water extracts of the fresh plant to keep roses and other garden plants free from insects and fungal diseases. The essential oil is used in perfumery and as a flavourant in food, beverages and tobacco.
Typha capensis	Bulrush	Rhizomes	Used for venereal diseases during pregnancy to ensure an easy delivery, and for dysmenorrhoea, diarrhoea, dysentery and to enhance male potency and libido.
Vernonia oligocephala	Vernonia	Leaves and twigs, rarely roots	Infusions are taken as stomach bitters to treat abdominal pain and colic. Other ailments treated include rheumatism, dysentery and diabetes.
Xysmalobium undulatum	Uzara/ Bitterwortel	Roots	Used as a remedy for diarrhoea and colic and to treat afterbirth cramps. In addition to treatment of diarrhoea, numerous traditional uses have been recorded including to treat dysentery, stomach cramps, oedema, indigestion and dysmennorhoea. It is used externally as a remedy for sores and wounds.
Ziziphus mucronata	Buffalo thorn	Roots, bark or leaves used separately or in combination.	Warm bark infusions (sometimes together with roots or leaves added) are used as expectorants (also as emetics) in cough and chest problems, while root infusions are a popular remedy for diarrhoea and dysentery. Decoctions of roots and leaves (or chewed leaves) are applied externally to boils, sores and glandular swellings, to promote healing and as an analgesic.

A moderate diversity of medicinal species is present, and most of the species are common and widespread and thus any new activities are unlikely to pose a significant threat to medicinal species locally and regionally.

However, Sclerocarya birrea, which is protected by the National Forest Act (NFA) of 1998, was identified in the EastPlats Marula section. No S. birrea were recorded with the Hernic Ferrochrome footprint area. In the event that these trees may be disturbed, the relevant permits must be obtained from the Department of Water and Sanitation (DWS) (or a delegated authority).

8.4.15. Animal Life Environment

The relevant Specialist Report is:

Baseline Ecological Assessment as Part of the EMPR Amendment Process for the Proposed HERNIC Ferrochrome Operations near Brits, North West Province – Section C : Faunal Assessment, May 2016. Scientific Aquatic Services CC.

Two field assessments were undertaken during February and March 2016, in order to determine the ecological status of the study area. A reconnaissance 'walkabout' was initially undertaken to determine the general habitat types found throughout the study area.

Following this, specific study sites were selected that were considered to be representative of the habitats found within the area, with special emphasis being placed on areas that may potentially support faunal Species of Conservation Concern (SCC).

Sites were investigated on foot in order to identify the occurrence of fauna within the study area. In order to increase overall observation time within the study area, as well as increasing the likelihood of observing shy and hesitant species, motion sensitive camera traps were strategically placed within the study area. Sherman traps were also used to increase the likelihood of capturing and observing small mammal species, notably small nocturnal mammals.

8.4.15.1. Faunal Habitat Description

Three main faunal habitat units were identified namely:

- Transformed Habitat
- Secondary Marikana Thornveld
- Ephemeral Drainage Lines

The Transformed habitat is located within the mining boundaries, around the current beneficiation plant and mining infrastructure and waste dumps. This habitat has undergone long term disturbance, and is largely cut off from the surrounding open areas due to the mining infrastructure and roads, as well as a fairly impermeable fence line, which will limit the movement of larger faunal species, notably mammals. The Transformed habitat is considered to have a low sensitivity.

The Secondary Marikana Thornveld located in the northern portion of the study area (within the East Plats Marulabult Section) was associated with the highest faunal abundance and diversity, due to more intact habitat and less restricted habitat connectivity. The remaining Marikana Thornveld habitat areas were associated with varying degrees of habitat provision, largely restricted by overall habitat sizes and locations. The Secondary Marikana Thornveld is considered to be of an intermediate sensitivity for faunal species.

The Ephemeral Drainage Lines, notably the more wooded sections, provided suitable areas of refuge for faunal species, as well as safer and sheltered movement corridors. This habitat is also considered to be of an intermediate sensitivity for faunal species.

A summary of the findings of the faunal survey with regard to the different faunal classes are given in tabular format below.

8.4.15.2. Mammals

A summary of the findings of the faunal assessment as pertaining to mammals is given in Table 8.4.15.2(a).

Table 8.4.15.2(a): Summary of the Findings for the Faunal Class - Mammals

<table>
<tr><td rowspan="2">Faunal Class: Mammals</td><td>Faunal Habitat Sensitivity</td><td>Intermediate</td><td rowspan="3" colspan="2">Photograph:

</td></tr>
<tr><td colspan="2">Notes on Photograph: Lepus saxatilis (Scrub Hare) scat and Canis mesomelas (Black-backed Jackal) spoor observed within the Secondary Marikana Thornveld habitat.</td></tr>
<tr><td colspan="3">Faunal Sensitivity Graph:

</td></tr>
<tr><td>Faunal SCC/Endemics/TOPS/</td><td colspan="4">No mammal SCC were encountered during the site assessment, however analysis of the habitat indicates that Mystromys albicaudatus (White-tailed Mouse, Endangered) may occur within the drainage lines.</td></tr>
<tr><td>Faunal Diversity</td><td colspan="2">The study area presented a moderate diversity of mammal habitat, and as such a moderate level of mammal diversity was noted to exist within the study area. Commonly encountered species included Lepus saxatilis (Scrub Hare), Sylvicapra grimmia (Common Duiker) and Hystrix africaeaustralis (African Porcupine). Refer to Appendix C for full species list.</td><td rowspan="4">General comments (dominant faunal species/noteworthy records etc.):
Mammal species predominated within the Secondary Marikana Thornveld and Drainage Line habitats. Movement barriers in terms of fences and infrastructure limit the movement and species diversity of the study area. Further, trapping and hunting in the remaining habitable areas further affect mammal species associated with the study area.

A small game park exists within the study area, however as this area and the species within it are artificially managed, and would not occur there naturally under current conditions, therefore they have been excluded from the study in terms of species occurrence.</td><td rowspan="4">Business Case, Conclusion and Mitigation Requirements:
The mammal habitat associated with the study area is of intermediate ecological sensitivity. Long term mining activities have negatively affected mammal species over the years, resulting in a low abundance and diversity. The largest impact on these species is through the loss of habitat and habitat connectivity.
Continuation of mining activities must take into account the remaining habitat areas, with appropriate plans put in place to manage and mitigate edge effects</td></tr>
<tr><td>Food Availability</td><td colspan="2">Food resource availability was highest in the Secondary Marikana Thornveld habitat unit, whilst resources were notably low within the Transformed habitat unit. The herbaceous layer was largely underutilised due to the low number of grazing species within the study.</td></tr>
<tr><td>Habitat Integrity</td><td colspan="2">The Secondary Marikana Thornveld is the most intact habitat unit in terms of habitat provision to mammal species, however habitat size and limited habitat connectivity notably decrease the overall integrity of the study area.</td></tr>
<tr><td>Habitat Availability</td><td colspan="2">Primary mammal habitat is provided by the Secondary Marikana Thornveld habitat unit, whilst limited mammal habitat is available in the transformed areas.</td></tr>
</table>

8.4.15.3. Avifauna

Table 8.4.15.3(a): Summary of the Findings for the Faunal Class - Avifauna

<table>
<tr><td rowspan="2">Faunal Class:
Avifauna</td><td>Faunal Habitat Sensitivity</td><td>Intermediate</td><td colspan="2" rowspan="3">Photograph:

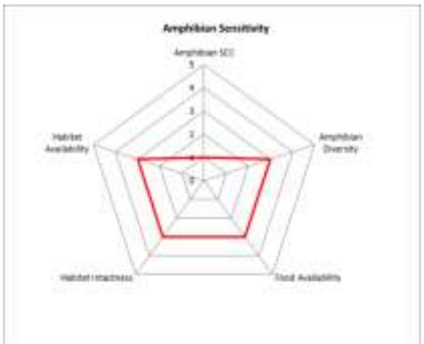
</td></tr>
<tr><td colspan="2">Notes on Photograph: Top: Euplectes albonotatus (White-winged Widow), below: Euplectes orix (Southern Red Bishop)</td></tr>
<tr><td colspan="3">Faunal Sensitivity Graph:

</td></tr>
<tr><td>Faunal SCC/Endemics/TOPS</td><td colspan="4">No avifaunal SCC were observed within the study area during the time of the site assessment. The disturbed nature of the study area and lack of suitable habitat large enough to support SCC within the study area further lowers the probability of any SCC occurrence. However, it must be noted that the study area falls within the Magaliesberg IBA, which is known to support a number of important avifaunal species.</td></tr>
<tr><td>Faunal Diversity</td><td colspan="2">The study area was noted to have an intermediate avifaunal diversity. This is mainly attributed to the ongoing disturbances from mining activities and the disturbed habitat. Only the more common species were observed within the study. It is expected that from time to time larger raptors may be seen foraging within the Secondary Marikana Thornveld, however it is unlikely that these species will nest here due to the lack of suitable nesting sites. Commonly encountered species include: Euplectes albonotatus (White-winged Widow), Euplectes orix (Southern Red Bishop), Quelea quelea (Red-billed Quelea), Charadrius hiaticula (Common Ringed Plover) and Numida meleagris (Helmeted Guineafowl). Refer to Appendix C for full species list.</td><td rowspan="4">General comments (dominant faunal species/noteworthy records etc.):
Common species were observed nesting within areas of the Secondary Marikana Thornveld.
Primarily the study area is likely utilised for foraging purposes, with avifaunal species opting to nest in areas outside of the study area. Food resources within the study area are seasonal, and due to the limited size of the undeveloped areas within the study area, are not likely to support a large diversity and abundance of avifaunal species.</td><td rowspan="4">Business Case, Conclusion and Mitigation Requirements:
The avifaunal habitat sensitivity for the study area is considered to be intermediate, due to the disturbed nature of the study area and ongoing mining activities. Any activities that further impact upon the remaining Marikana Thornveld need to be managed and mitigated. Further impacts upon these areas will result in a further decrease in abundance and diversity of avifauna in the study area.</td></tr>
<tr><td>Food Availability</td><td colspan="2">The food provision capability of the study area is considered to be moderately high, notably in the Drainage Lines and the Secondary Marikana Thornveld. Flowering plant species provide a seasonal abundance of food resources, which is expected to decrease during the winter months.</td></tr>
<tr><td>Habitat Integrity</td><td colspan="2">The Drainage lines and Secondary Marikana Thornveld provided the most intact habitat for avifaunal species. Due to the mobile nature of avifauna, direct habitat connectivity does not affect them as they can fly between more ideal habitats.</td></tr>
<tr><td>Habitat Availability</td><td colspan="2">Habitat availability was highest in the non-disturbed and transformed areas, with the majority of avifaunal species occurring within the northern parts of the study area furthest from the Hernic Ferrochrome facility.</td></tr>
</table>

8.4.15.4. Amphibians

Table 8.4.15.4(a): Summary of the Findings for the Faunal Class - Amphibians

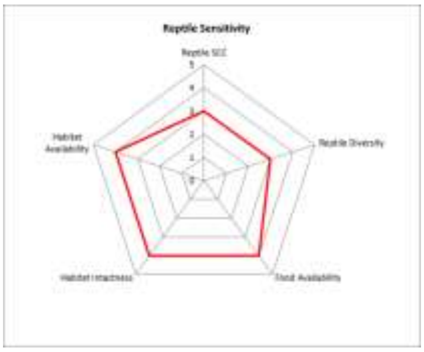
<table>
<tr><td rowspan="2">Faunal Class: Amphibians</td><td>Faunal Habitat Sensitivity</td><td>Intermediate</td><td rowspan="3" colspan="2">Photograph:

</td></tr>
<tr><td colspan="2">Notes on Photograph: Ideal amphibian habitat observed within the study area</td></tr>
<tr><td colspan="3">Faunal Sensitivity Graph:

</td></tr>
<tr><td>Faunal SCC/Endemics/TOPS/</td><td colspan="4">One amphibian SCC, namely Pyxicephalus adspersus (Giant Bullfrog, Vulnerable) is listed for the North West province. However, it is unlikely that this species will occur within the study area due to unsuitable soils (Black turf) and impacts from mining activities.</td></tr>
<tr><td>Faunal Diversity</td><td colspan="2">Although no amphibian species were observed due to dry conditions and an ongoing drought, the study area is expected to be inhabited by a small number of common amphibian species, most likely centered around the drainage lines and ponds formed by obstructions in the drainage lines. Amphibian species expected to occur within the study area include Cacosternum boettgeri (Common caco), Afrana angolensis (Common river frog) and Amietophrynus gutturalis (Guttural toad). Refer to Appendix C for full species list.</td><td rowspan="4">General comments (dominant faunal species/noteworthy records etc.):
Amphibian populations are likely to be localised within the Drainage Lines and moist areas of the Secondary Marikana Thornveld. Expansion of mining activities or accidental effluent discharge will directly impact these remaining habitat areas, resulting in the loss of amphibian species within the study area.</td><td rowspan="4">Business Case, Conclusion and Mitigation Requirements:
The amphibian sensitivity for the study area is considered to be intermediate. The Drainage Lines and surrounding moist areas are ideal amphibian habitat, and as such edge effects need to be effectively managed so as to limit disturbances to these habitats. Most important, spillages and/or seepage of tailings or other effluent must be avoided in order to avoid futher impact on amphibian habitat.</td></tr>
<tr><td>Food Availability</td><td colspan="2">Food availability is highest within the Secondary Marikana Thornveld and the Drainage Lines, notably due to the increased abundance of invertebrate species in these areas which are a primary food source of amphibians.</td></tr>
<tr><td>Habitat Integrity</td><td colspan="2">Habitat integrity is considered to be intermediate. Amphibian habitat extent and suitability is limited within the study area. Impacts from the surrounding mining areas will have an immediate impact on habitat conditions and species diversity.</td></tr>
<tr><td>Habitat Availability</td><td colspan="2">Currently the drainage lines and surrounding moist areas provide primary habitat for amphibian species. These areas provide suitable cover, breeding areas and food resources for amphibian species, albeit not in high numbers.</td></tr>
</table>

8.4.15.5. Reptiles

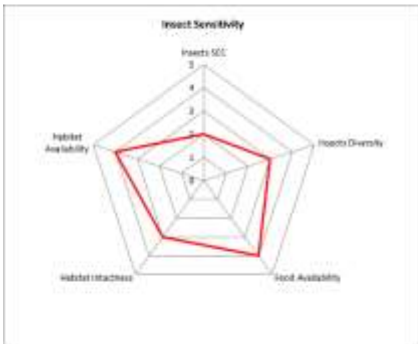
Table 8.4.15.5(a): Summary of the Findings for the Faunal Class - Reptiles

<table>
<tr><td rowspan="2">Faunal Class:
Reptiles</td><td>Faunal Habitat Sensitivity</td><td>Intermediate</td><td colspan="2" rowspan="3">Photograph:

</td></tr>
<tr><td colspan="2">Notes on Photograph: Trachylepis varia (Variable Skink) observed in the study area. Below ideal habitat and refuge created by the rocky outcrops in the north of the study area.</td></tr>
<tr><td colspan="3">Faunal Sensitivity Graph:

</td></tr>
<tr><td>Faunal SCC/Endemics/TOPS/</td><td colspan="4">No SCC were observed during the site assessment, however one reptile SCC has been reported to occur within the study area. According to mine officials Python sebae natalensis (South African Python, Vulnerable) has been observed within the waste rock dumps associated with the EastPlats Marulabult section. Habitat and food resources are available and as such the likelihood of this species occurring in the study area is high. However it is unlikely that it will be affected by the proposed Hernic Ferrochrome expansion activities.</td></tr>
<tr><td>Faunal Diversity</td><td colspan="2">A low reptile diversity was observed during the site assessment, however this is likely due to the secretive nature of many reptile species and the extenuating dry conditions currently being experienced in the region. It is likely that the study area will have an intermediate level of reptile diversity. Species observed included Pachydactylus capensis (Cape Gecko) and Trachylepis varia (Variable Skink), whilst mine personnel mentioned seeing Python sebae natalensis (South African Python) and Naja mossambica (Mozambique Spitting Cobra). Refer to Appendix C for full species list.</td><td rowspan="4">General comments (dominant faunal species/noteworthy records etc.):
Many of the reptiles observed within the study area were seen in the Secondary Marikana Thornveld habitat, within the rocky areas. Reptile abundance and diversity of the study area will be directly related to the availability of food resources, notably small mammals and invertebrates, the decrease or loss of such will result in a decrease in reptile species.</td><td rowspan="4">Business Case, Conclusion and Mitigation Requirements:
The reptile habitat sensitivity for the study area is intermediate. The Secondary Marikana Thornveld and associated rocky outcrops are considered to be ideal reptile habitat, and as such impacts and edge effects within these habitats need to be managed so as to limit habitat and species loss.</td></tr>
<tr><td>Food Availability</td><td colspan="2">Small mammals and amphibian's occurring in the study area will provide a suitable food resources for many of the predatory snakes within the study area, whilst the insect diversity provided food for the smaller lizards and skinks observed.</td></tr>
<tr><td>Habitat Integrity</td><td colspan="2">Overall the habitat integrity of the study area was considered to be moderately high. Reptile species are capable of inhabiting a variety of landscapes, both pristine and disturbed. Further, the fences surrounding much of the study area will not restrict the movement of reptile species, allowing them free movement between habitats.</td></tr>
<tr><td>Habitat Availability</td><td colspan="2">The study area provided a varied range of habitat areas for various reptile species, from open grassed areas for predatory snakes to rocky outcrops favoured by lizards and skinks. Further, buildings and old infrastructure is also utilised by a number of reptile species.</td></tr>
</table>

8.4.15.6. Insects

Table 8.4.15.6(a): Summary of the Findings for the Faunal Class - Insects

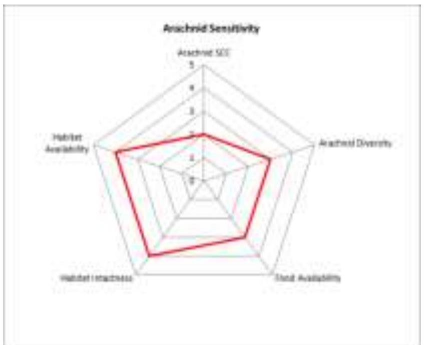
Faunal Class: Insects	**Faunal Habitat Sensitivity**	**Intermediate**	**Photograph:**   
	Notes on Photograph: Top left to bottom: *Byblia ilythia* (Spotted Joker), *Acraea neobule neobule* (Wandering Donkey Acraea), *Orthetrum Julia* (Julia Skimmer), *Crocothemis sanguinolenta* (Little Scarlet), *Astylus atromaculatus* (Spotted Maize Beetle).		
Faunal Sensitivity Graph: 			
Faunal SCC/Endemics/TOPS/	No SCC were observed, nor are any listed SCC expected to occur in the study area due to the study area lacking suitable habitat and being out of the known distribution ranges of a number of the known SCC.		
Faunal Diversity	Overall insect diversity of the study area is considered to be intermediate. Although there were a high number of insects observed, the species diversity was low. This may be attributed to the lower than normal rainfall, as well as later seasonal shifts. Species observed included *Belenois aurota* (Brown-veined White), *Junonia hierta* (Yellow Pansy), *Danaus chrysippus* (African Monarch), *Crocothemis sanguinolenta* (Little Scarlet), *Eyprepocnemis plorans* and *Orthetrum Julia* (Julia Skimmer). Refer to Appendix C for full species list.	**General comments (dominant faunal species/noteworthy records etc.):** The Secondary Marikana Thornveld and Drainage lines are important in terms of continued insect diversity and abundance in the study area. Maintenance of a suitable insect population is paramount for the continued survival of other faunal species, notably small mammals, reptiles and amphibians.	**Business Case, Conclusion and Mitigation Requirements:** The insect habitat sensitivity is considered to be intermediate. The varying floral characteristics of the Secondary Marikana and Drainage Lines provide a range of suitable habitats for a variety of insect species. These species in turn are utilised as a food source by numerous other faunal species. As such, impacts and edge effects within these habitats need to be managed to limit habitat and species loss.
Food Availability	The study area had a moderately high food availability for insects. Flowering trees and plants were utilised by butterflies and moths whilst there was sufficient suitable herbaceous material to support herbivorous insects.		
Habitat Integrity	Overall the study area is considered to have an intermediate level of integrity for insects. Due to their size they are not restricted by boundary fences and therefore such obstructions pose no threat to habitat connectivity.		
Habitat Availability	The Drainage Lines and Secondary Marikana Thornveld provided suitable habitat to a number of insect species, with suitable food resources.		

8.4.15.7. Arachnids

Table 8.4.15.7(a): Summary of the Findings for the Faunal Class - Arachnids

Faunal Class: **Arachnids**	**Faunal Habitat Sensitivity**: **Intermediate**
	Notes on Photograph: *Parabuthus transvaalicus* above and *Hadogenes gunningii* below.

Faunal Sensitivity Graph:



Photograph:

Faunal SCC/Endemics/TOPS/	No arachnid SCC were observed within the study area, nor have any of these species been recorded in the study area previously.
Faunal Diversity	Whilst very few arachnid species were observed, it is expected that the Secondary Marikana Thornveld and the rocky outcrops are likely to be inhabited by a number of common arachnid species, as noted by the scorpions observed in these habitats. Refer to Appendix C for full species list.
Food Availability	The high number of insects within the study area provide a suitable food source for many of the arachnid species, with some larger scorpions and spiders also preying on small reptiles.
Habitat Integrity	Habitat integrity is considered to be moderately high. The Secondary Marikana Habitat and associated rocky outcrops are considered primary habitat for many arachnid species.
Habitat Availability	The study area is considered to have a moderately high level of habitat availability for arachnid species, predominantly within the Secondary Marikana Thornveld and associated rocky outcrops. These habitats provide sufficient resources for the continued survival of arachnid species.

General comments (dominant faunal species/noteworthy records etc.):	**Business Case, Conclusion and Mitigation Requirements:**
The rocky outcrops and surrounding Secondary Marikana Thornveld surrounding was noted to have the highest abundance of arachnid species. The habitat structure of these areas is generally favoured by arachnid species.	Arachnid habitat sensitivity is considered to be intermediate. The rocky areas within the Secondary Marikana Thornveld and Drainage Lines are of importance as these areas are considered to have an increased potential for the occurrence of arachnid species. All steps must be taken so as to ensure that expansion activities do not further negatively impact these areas.

8.4.15.8. Faunal Species of Conservational Concern

During field assessments it is not always feasible to identify or observe all species within the study area, largely due to the secretive nature of may faunal species, possible low population numbers or varying habits of species.

As such, and to specifically assess an area for faunal SCC, a Probability of Occurrence (POC) matrix is used, utilising a number of factors to determine the probability of faunal SCC occurrence within the study area.

Species listed in Appendix B of the Specialist Report whose known distribution ranges and habitat preferences include the study area were taken into consideration. The species listed below are considered to have a probability of occurring within the study area.

Table 8.4.15.8(a): Faunal Species of Conservational Concern

Scientific Name	Common Name	POC %
Mystromys albicaudatus	White-tailed Mouse	65%
Python sebae natalensis	South African Python	80%

*Species observed during site assessment

From the above list of species it is evident that the study area has the potential to provide habitat to a small number of faunal SCC. The Secondary Marikana Thornveld and Drainage Lines within the EastPlats Marulabult section are considered to provide suitable habitat for the above listed species, and as such increased importance needs to be placed on limiting, and where applicable mitigating impacts that occur within these habitats.

8.4.15.9. Sensitivity Mapping

Figure 8.4.15.9(a) below conceptually illustrates the areas considered to be of increased faunal ecological sensitivity. The areas are depicted according to their sensitivity in terms of the presence or potential for faunal SCC, habitat integrity, levels of disturbance and overall levels of diversity. The Table below presents the sensitivity of each area along with an associated conservation objective and implications for development.

Table 8.4.15.9(a): Summary of the Sensitivity of Each Habitat Unit and Implications for Development

Sensitivity	Conservation Objective	Development Implications
Intermediate	Preserve and enhance biodiversity of the habitat unit and surrounds while optimising development potential.	Although mining activities in this area are unlikely to have a significant impact on the receiving environment, faunal species will be further affected as a result of the loss of habitat and foraging areas
Low	Optimise development potential.	Activities within this area must be optimised and limited to the existing disturbance footprint. Care must be taken to limit edge effects on the surrounding natural areas.

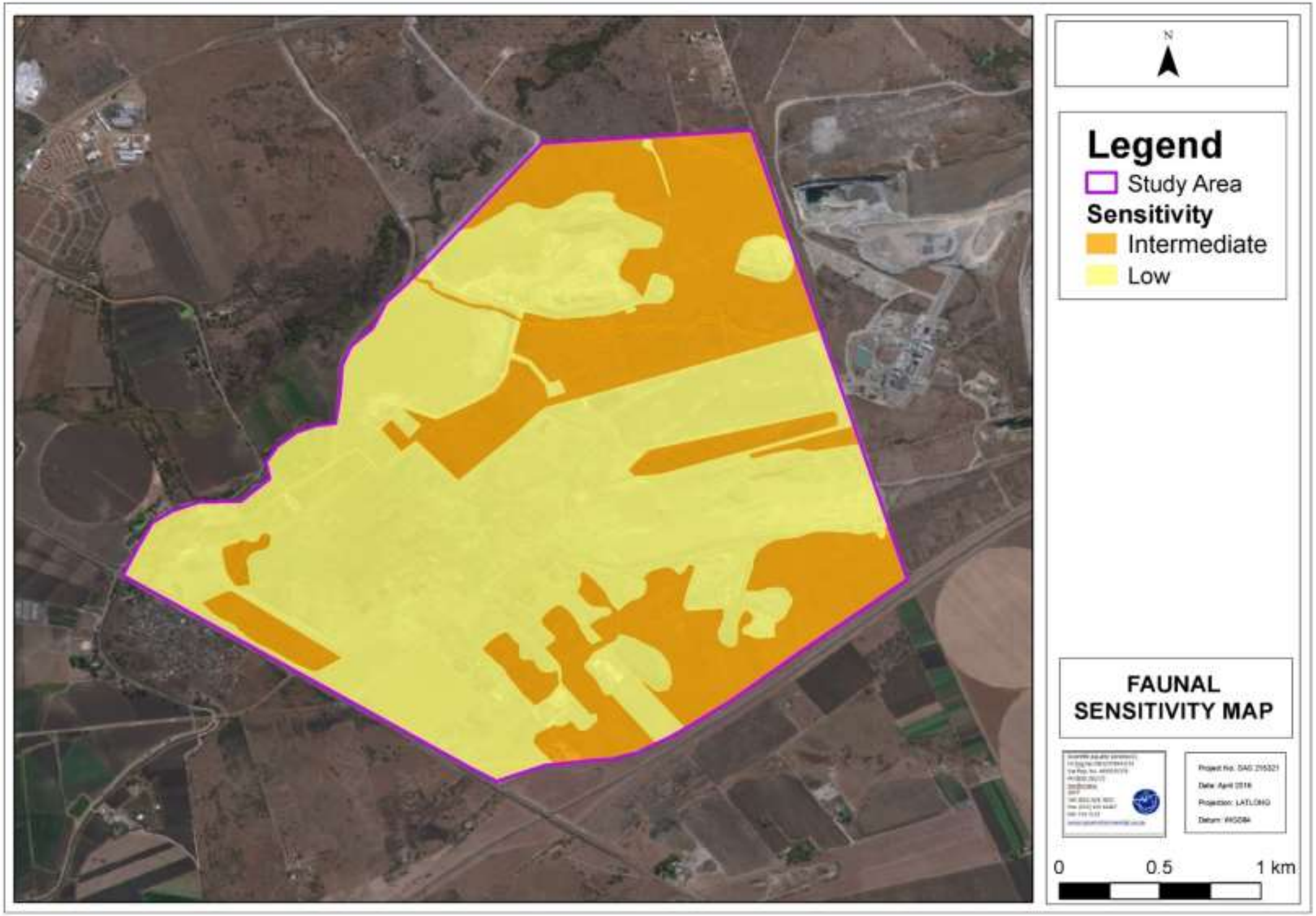


Figure 8.4.15.9 (a): **Faunal Habitat Sensitivity Map of the Study Area**

8.4.16. Wetland Environment

The relevant Specialist Report is:

Baseline Ecological Assessment as Part of the EMPR Amendment Process for the Proposed HERNIC Ferrochrome Operations near Brits, North West Province – Section D : Wetland Environment, May 2016. Scientific Aquatic Services CC.

Two site visits were undertaken during February and March 2016, to assess as many of the points of interest as possible which were identified during the desktop assessment phase.

The presence of any wetland characteristics as defined by the DWAF 2008 was noted at each of these points to determine if features can be considered to contain areas displaying wetland characteristics.

Factors influencing the habitat integrity of each feature group identified during the field survey was noted, and the functioning and the environmental and socio-cultural services provided by the various features was determined.

8.4.16.1. Freshwater Feature Characterization

Two ephemeral drainage lines were encountered within the study area, more specifically, to the north of HERNIC Ferrochrome within the East Plats Marulabult section.

These drainage lines are characterised by seasonally wet zones that form a wet savanna mosaic with the surrounding terrestrial habitat. The floral species composition was largely similar to the surrounding Marikana Thornveld, however where earth dams and other obstructions have caused artificial ponding, wetland species such as *Phragmites australis* and *Imperata cylindrica* were present. However, the dominant soil form in the area is dark vertic clays, which limited soil form as a suitable indicator of wetland conditions.

Thus, the drainage lines were determined not to contain sufficient characteristics that would classify them as natural wetlands as defined by the “Updated Manual for the Identification and Delineation of Wetland and Riparian Resources” published by the DWS in 2008. However, the drainage lines were still assessed according to the wetland assessment methodology as they perform and important ecological service provision role in a largely transformed landscape.

In addition to the above considerations, should it be determined that sufficient water is contained in these features during a storm event to create a floodline, then the features are considered to be watercourses and any disturbance within these features will require Section 21 (c) and (i) water use license authorisation in terms of the National Water Act of 1998.

During the course of the assessment, it was determined that the hydrogeomorphic (HGM) unit that best describes the ephemeral drainage features is a channelled valley bottom system. The ephemeral drainage lines were classified as Inland Systems falling within the Bushveld Basin and Western Bankenveld Aquatic Ecoregions, and within the Central Bushveld Group 2 WetVeg type, which is classified by SANBI (2013) as Critically Endangered.

The characterisation of the freshwater resources is summarised in the table (Table 8.4.16.1(a)) below and the Figure 8.4.16.1(a) below indicates the locality of the freshwater resources identified during the site assessment in relation to the study area.

Table 8.4.16.1(a): SANBI National Wetland Classification for Freshwater Features present within the Study Area.

Level 1: System	Level 2: Regional Setting	Level 3: Landscape unit	Level 4: Hydrogeomorphic (HGM) unit
Inland: An ecosystem that has no existing connection to the ocean but which is inundated or saturated with water, either permanently or periodically.	**Ecoregion:** The study area falls within the Bushveld Basin & Western Bankenveld Ecoregions NFEPA WetVeg Groups Central Bushveld Group 2 (Critically Endangered)	**Valley floor:** The typically gently sloping, lowest surface of a valley	**Channelled valley bottom feature**: A valley bottom feature with a river channel running through it.

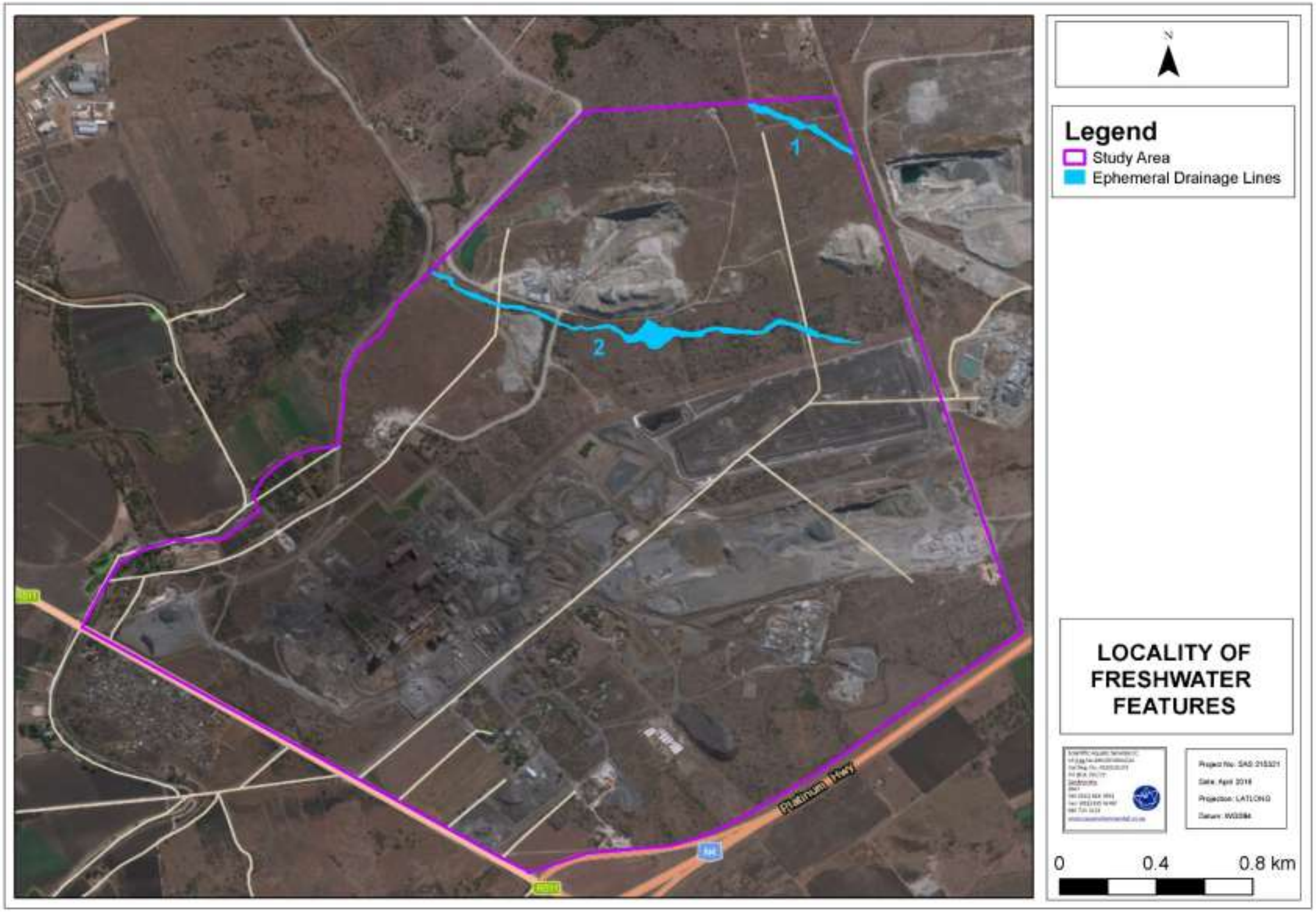


Figure 8.4.16.1(a): Map of the Freshwater Features within the greater HERNIC Study Area

8.4.16.2. PES, Service Provision, EIS and Appropriate Enhancement REC

Following the site visit that was undertaken, assessments were conducted in order to determine the following:

- PES which incorporates aspects such as hydrology, vegetation and geomorphology;
- Service provision which incorporates biodiversity maintenance, flood attenuation, streamflow regulation and assimilation, to name a few;
- EIS is based on consideration of the overall ecology of the receiving environment, although the results obtained from the assessment of PES, and service provision of the resources is also taken into consideration as part of the EIS assessment; and
- An appropriate REC for the enhancement of the resources;

The results of the assessment are presented in the dashboard reports below. Each dashboard report presents the PES categories of the freshwater resources and which are conceptually illustrated in Figure 8.4.16.2(a).

Table 8.4.16.2(a): Summary of results of the Assessment of Ephemeral Drainage Line 1

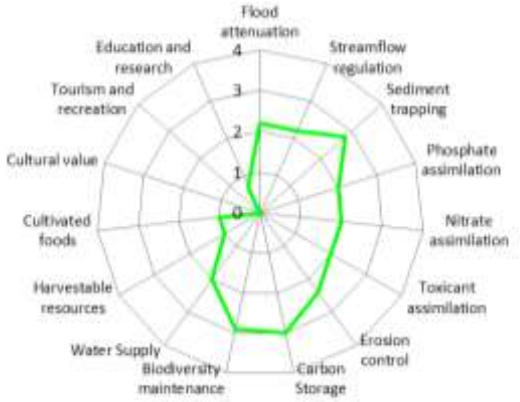
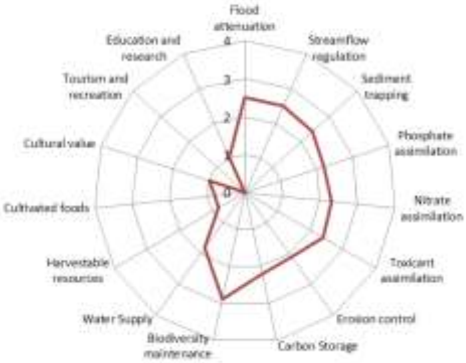
Resource: Ephemeral Drainage Line 1.			
Ecological & socio-cultural service provision graph: 			
Feature HGM Unit Description	Channelled Valley Bottom Feature	**Photograph notes**	Typical view of the feature, indicating only a slight change in vegetation structure, while terrestrial species such as *Vachellia karroo* are still dominant.
PES discussion	**PES Category: D** Modifiers include edge effects from surrounding mining activities, historic agriculture, dumping of waste material in wetland, flow obstructions and alien and terrestrial floral invasion.	**Watercourse characteristics:** **a) Hydraulic regime** The hydraulic regime of the system has been affected by in-catchment effects such as mining related impacts (open pit) and historic cultivation. Increased runoff velocity and volumes due to catchment hardening, together with in-channel disturbances, have resulted in incision and erosion of the main channel in sections. As a result, the hydraulic regime is considered to be moderately modified from its natural condition.	
Ecoservice provision	**Intermediate**; considered important for biodiversity maintenance, sediment trapping, nutrient and toxicant assimilation, and erosion control. The seasonal nature of the system limits it importance for streamflow regulation and the ability to supply water for human use, harvestable resources and for educational/tourism purposes.	**b) Water quality** Limited surface water was present at the time of the assessment, and therefore water quality parameters could not be ascertained. However, it is anticipated that water quality may be partially impaired in terms of nutrient and sediment inputs as a result of mining and agricultural activities in the vicinity.	
EIS discussion	**EIS Category: C.** Wetlands in this category are considered to be ecologically important and sensitive on a provincial and local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. The system is not considered important in terms of unique or protected species, however the WetVeg Group is considered to be endangered (NFEPA 2011) and the system plays an important role as a migratory route for faunal species in an area characterised by high levels of habitat transformation.	**c) Geomorphology and sediment balance** The natural geomorphology of the system has been affected by mining activities, road crossings and historic agriculture. Furthermore, increased runoff volumes and intensity from the catchment, combined with surrounding mining activities and infrastructure, are likely to add significantly to volumes of sediment in the system.	
REC Category	**Category: C** Although the ephemeral drainage lines are not considered to be as ecologically important and sensitive as would a larger wetland system, they nevertheless remain in good condition, and therefore efforts should be made to retain current levels of ecological functioning and prevent degradation of these resources.	**d) Habitat and biota** Encroachment of alien and invasive vegetation has negatively affected the habitat integrity of the system, however, the system should not be viewed in isolation, but with full recognition of the contribution it makes to the overall ecological functioning of the total landscape. In an area characterised by significant transformation, the feature is considered to be an important migratory corridor for wildlife, as well as providing breeding and foraging habitat for various faunal species.	
Business case, Conclusion and Mitigation Requirements: As Ephemeral Drainage Feature 1 is situated a considerable distance away from the Hernic Ferrochrome footprint area, it is unlikely that expansion activities will have a significant impact on this feature. However, should any future activities be planned in the vicinity of the feature, it must be ensured that no activities encroach upon the feature and that edge effects are managed in order to prevent negative impacts on the feature.			

Table 8.4.16.2(b): Summary of Results of the Assessment of Ephemeral Drainage Line 2

Resource: Ephemeral Drainage Line 2.			
Ecological & socio-cultural service provision graph: 			
Feature HGM Unit Description	Channelled Valley Bottom Feature	**Photograph notes**	View of an impoundment within the feature, which has led to the establishment of *Imperata cylindrica* and *Typha capensis.*
PES discussion	**PES Category: D** Modifiers include edge effects from surrounding mining activities, historic agriculture, dumping of waste material in wetland, flow alterations and obstructions and alien and terrestrial floral invasion.	**Watercourse characteristics:** **a) Hydraulic regime** The hydraulic regime of the system has been affected by in-catchment effects such as mining related impacts an historic cultivation. Increased runoff velocity and volumes due to catchment hardening, together with in-channel disturbances, have resulted in incision and erosion of the main channel in sections. As a result, the hydraulic regime is considered to be moderately modified from its natural condition.	
Ecoservice provision	**Intermediate**; considered important for biodiversity maintenance, sediment trapping, nutrient and toxicant assimilation, and erosion control. The seasonal nature of the system limits it importance for streamflow regulation and the ability to supply water for human use, harvestable resources and for educational/tourism purposes.	**b) Water quality** Limited surface water was present at the time of the assessment, and therefore water quality parameters could not be ascertained. However, it is anticipated that water quality may be partially impaired in terms of nutrient and sediment inputs as a result of mining and agricultural activities in the vicinity of the drainage feature.	
EIS discussion	**EIS Category: C.** Wetlands in this category are considered to be ecologically important and sensitive on a provincial and local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. The system is not considered important in terms of unique or protected species, however the WetVeg Group is considered to be endangered (NFEPA 2011) and the system plays an important role as a migratory route for faunal species in an area characterised by high levels of habitat transformation.	**c) Geomorphology and sediment balance** The natural geomorphology of the system has been affected by mining activities, road crossings and historic agriculture. Furthermore, increased runoff volumes and intensity from the catchment, combined with surrounding mining activities and infrastructure, are likely to add significantly to volumes of sediment in the system.	
REC Category	**Category: C** Although the ephemeral drainage lines are not considered to be as ecologically important and sensitive as would a larger wetland system, they nevertheless remain in good condition, and therefore efforts should be made to retain current levels of ecological functioning and prevent degradation of these resources.	**d) Habitat and biota** Encroachment of alien and invasive vegetation has negatively affected the habitat integrity of the system, however, the system should not be viewed in isolation, but with full recognition of the contribution it makes to the overall ecological functioning of the total landscape. In an area characterised by significant transformation, the feature is considered to be an important migratory corridor for wildlife, as well as providing breeding and foraging habitat for various faunal species.	
Business case, Conclusion and Mitigation Requirements: As Ephemeral Drainage Feature 2 is situated closer to the Hernic Ferrochrome footprint area, expansion activities may have an impact on this feature. Specific mention is made of possible seepage from the tailings storage facilities into the feature. Thus, it must be ensured that the tailings management facilities are in working order and that any seepage or spills from the tailings facility are controlled. Finally, should any future activities be planned in the vicinity of the feature, it must be ensured that no activities encroach upon the feature and that edge effects are managed in order to prevent negative impacts.			

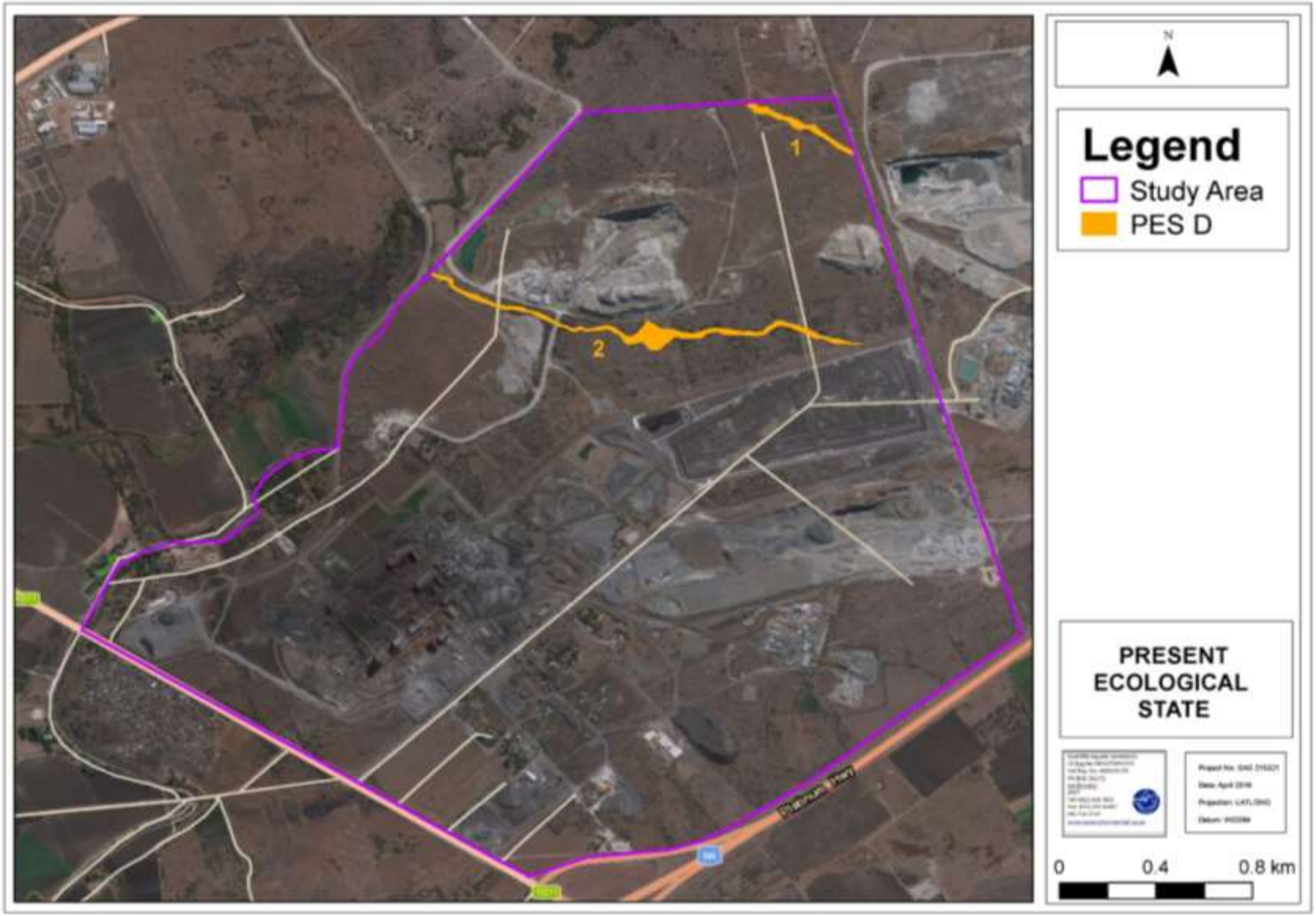


Figure 8.4.16.2(a): **Conceptual Illustration of the PES Categories of the Freshwater Features**

8.4.16.3. Wetland Delineation

Due to the current mining and historic agricultural activities and prevailing dry conditions at the time of the assessment, the delineation as presented in this report is regarded as a best estimate of the drainage line boundaries based on the site conditions present at the time. However, use was made of historical and current digital satellite imagery to further aid in the delineation of the resources.

During the assessment, the following indicators were used to ascertain the boundaries of the ephemeral drainage line features:

- Terrain units were used as the primary indicator since clear and easily discernible landscape units were present, except where waste dumps are present in the wetland areas, which limited the accuracy of this indicator;
- Vegetation was used as a secondary indicator, as the change in vegetation communities between the terrestrial areas and drainage lines was not always clear with terrestrial species still dominant; and
- The soil form indicator was considered; however, the dominant soil form is dark vertic soil with concretions, and thus the soil form indicator was of limited use in discerning the boundary of the drainage features.

8.4.16.4. Legislative Requirements

The drainage lines were determined not to contain sufficient characteristics that would classify them as wetlands as defined by the "Updated Manual for the Identification and Delineation of Wetland and Riparian Resources" published by the DWS in 2008 although some areas where artificial impoundment has occurred show true signs of wetland characteristics.

However, should it be determined that sufficient water is contained in these features during a storm event to create a floodline, then the features are considered to be watercourses and any disturbance within these features will require Section 21 (c) and (i) water use license authorisation in terms of the National Water Act of 1998.

Furthermore, if any activities are to take place within 100 meters of the watercourse or the 1:100 year flood lines, whichever is greatest, exemption terms of Regulation GN 704 of the NWA, 1998 (act no. 36 of 1998) needs to be obtained. Section 21 of the NWA (Act 36 of 1998) as well as General Notice no. 1199 of 2009 as it relates to the NWA will also apply and therefore a Water Use License will be required.

A 32m regulated zone is indicated around all features which will require authorisation in terms of the National Environmental Management Act (NEMA) 107 of 1998 if any activities are to take place within this regulated zone.

8.4.16.5. Sensitivity Mapping

The Table below presents the sensitivity of the freshwater resources in terms of their associated EIS along with implications for the proposed construction activities. The Sensitivity delineation is shown in Figure 8.4.16.5(a)

Table 8.4.16.5(a): Summary of Sensitivity of each Freshwater Feature and Implications for the Project

Wetland Feature	EIS Class	EIS Description	Sensitivity	Project Implications
Ephemeral Drainage Line 1	**C**	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale.	**Moderate**	As Ephemeral Drainage Feature 1 is situated a considerable distance away from the Hernic Ferrochrome footprint area, it is unlikely that expansion activities will have a significant impact on this feature. However, should any future activities be planned in the vicinity of the feature, it must be ensured that no activities encroach upon the feature and that edge effects are managed in order to prevent negative impacts on the feature.
Ephemeral Drainage Line 2	**C**	Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale.	**Moderate**	As Ephemeral Drainage Feature 2 is situated closer to the Hernic Ferrochrome footprint area, expansion activities may have an impact on this feature. Specific mention is made of possible spillage of tailings into the feature from the adjacent tailings dams. Thus, it must be ensured that the tailings management facilities are in working order and that any seepage or spills from the tailings facility are controlled. Finally, should any future activities be planned in the vicinity of the feature, it must be ensured that no activities encroach upon the feature and that edge effects are managed in order to prevent negative impacts.

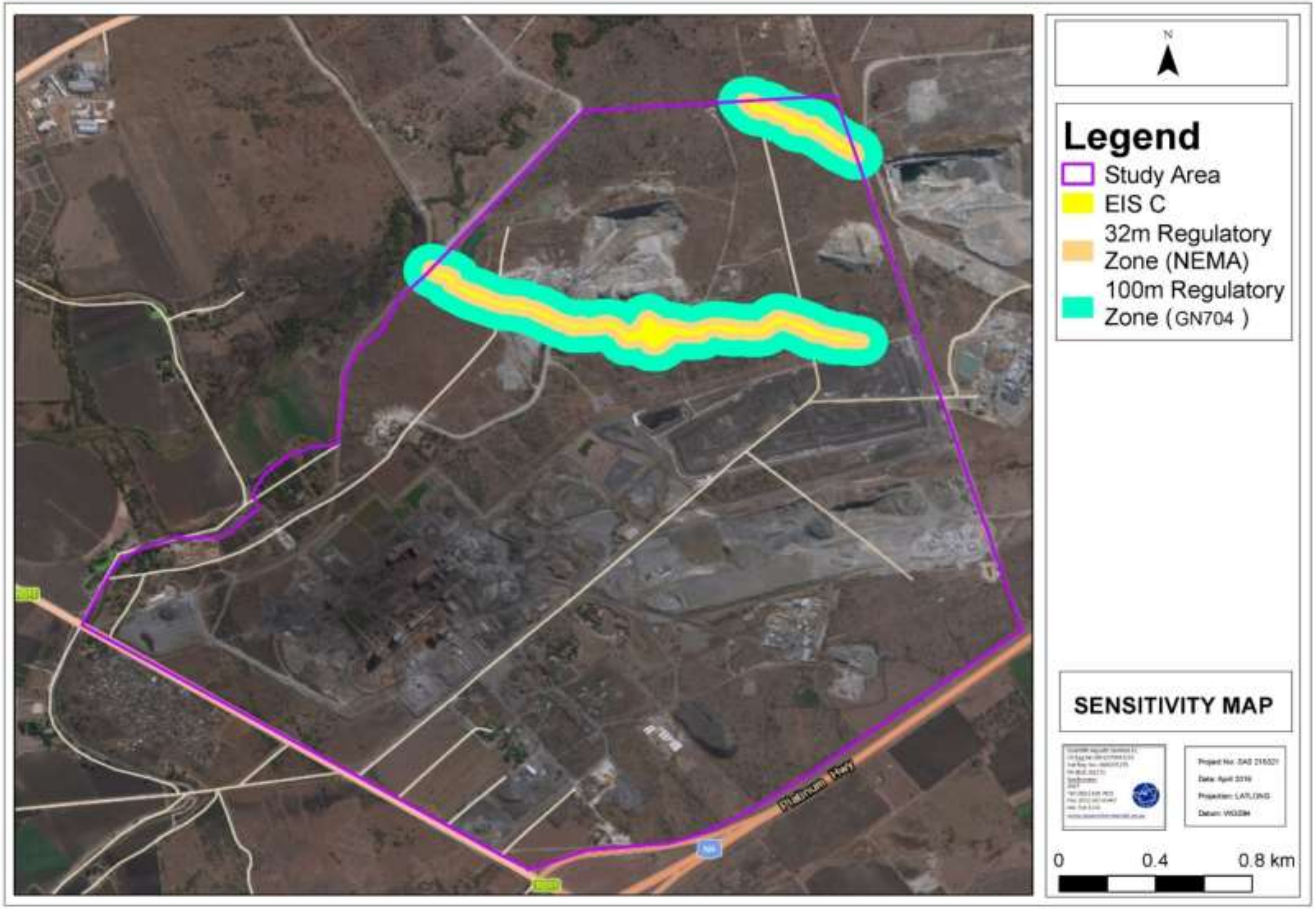


Figure 8.4.16.5(a): Conceptual Presentation of the Freshwater Features within the Study Area, Buffer Zones and Associated Zone of Regulation in terms of Regulation GN704

8.4.17. Aquatic Ecosystems Environment

The relevant Specialist Report is:

Baseline Ecological Assessment as Part of the EMPR Amendment Process for the Proposed HERNIC Ferrochrome Operations near Brits, North West Province – Section E : Aquatic Assessment, May 2016. Scientific Aquatic Services CC.

This summary below presents the results obtained during the ecological survey of aquatic ecosystems during both the winter and the summer seasons (August 2015 and January 2016, respectively).

8.4.17.1. Desktop and Field Assessment

It is based upon a desktop assessment of the aquatic ecosystems and a field assessment which included a survey of habitat conditions for aquatic macro-invertebrates, aquatic macro-invertebrate community integrity, diatom analysis and toxicological analysis on both the Crocodile River as well as the Kareespruit, which occur in the vicinity of the proposed HERNIC Ferrochrome facility.

The protocols of applying the indices were strictly adhered to and all work was carried out or overseen by a South African River Health Program (SA RHP) accredited assessor. Toxicological analysis of samples obtained from the process water facility of the HERNIC operations is included.

In order to assess the levels of aquatic ecological integrity in the vicinity of the HERNIC operations, careful site selection took place. The following criteria were used in identifying suitable sites:

- The site location in relation to the HERNIC mine and smelter and the suitability for making spatial comparisons.
- Accessibility with a vehicle in order to allow for the transport of equipment.
- The sampling sites were selected to represent areas both up- and downstream from possible impact sources that may emanate from the proposed HERNIC Ferrochrome facility and to include suitable control sites, as far as possible. As far as possible, sites were also selected where there were good habitat conditions with a good level of diversity, suitable for supporting a diverse aquatic community.

Six biomonitoring sites were assessed as indicated in a digital satellite image in Figure 8.4.17.1(a), which shows the biomonitoring points in red.

In addition, five toxicological sampling points were included in addition to the biomonitoring assessment localities, four on the HERNIC Ferrochrome process water system and one on a small unnamed tributary of the Kareespruit into which a leather tannery is currently discharging effluent (Figure 8.4.17.1(a)). Refer to Table 8.4.17.1(a) for the coordinates of the sample sites.

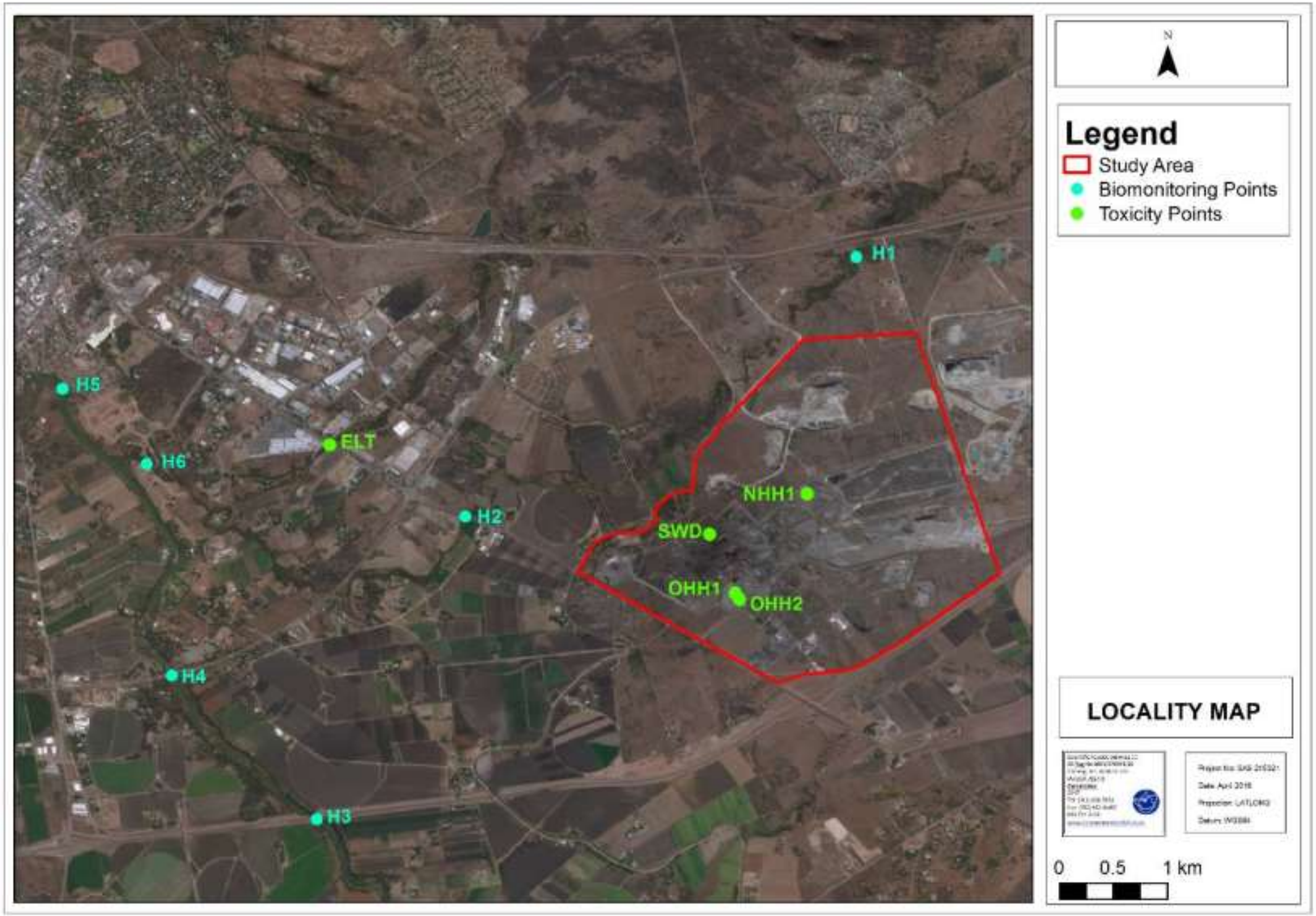


Figure 8.4.17.1(a): Aquatic Ecosystems Assessment Points

Table 8.4.17.1(a): Co-ordinates of each Sample Site

Site	Description	GPS co-ordinates	
		South	East
H1	Located on the Kareespruit upstream of any potential impacts from Hernic Ferrochrome. The site is important as a spatial reference point to compare data obtained from the H2 site.	25°37'57.38"S	27°50'58.77"E
H2	Located on the Kareespruit downstream of the Hernic Ferrochrome mine area. Site serves to indicate the ecological state of the Kareespruit River and any potential impacts from the activities of Hernic Ferrochrome. Any impacts as a result of seepage or overflows from the SWD will be evident at this point.	25°39'21.68"S	27°49'01.02"E
H6	Located on the Kareespruit downstream of the confluence with the leather tannery discharge stream. Any impact as a result of the activities of the leather tannery will be evident at this point.	25°39'06.47"S	27°47'26.27"E
H3	Located on the Crocodile River upstream of any potential impacts from Hernic Ferrochrome. The site is important as a spatial reference point to compare data obtained from the H4 site.	25°40'52.01"S	27°48'16.86"E
H4	Located on the Crocodile River downstream of the Hernic Ferrochrome mine area. Site serves to indicate the ecological state of the Crocodile River at this point and any potential impacts from the activities of Hernic Ferrochrome, with special mention of seepage from the OHH1 and OHH2 slimes dam sites.	25°40'09.27"S	27°47'33.64"E
H5	Located on the Crocodile River downstream of the confluence with the Kareespruit. Any impacts as a result of contributions from the Kareespruit will be evident at this point.	25°38'41.87"S	27°46'58.21"E
NHH1	Located within the Hernic Ferrochrome mine surface rights area. This is a new lined slimes dam is located upgradient and upstream of the operational areas of the Hernic Ferrochrome mine.	25°39'15.11"S	27°50'43.14"E
OHH1	Located within the Hernic Ferrochrome mine surface rights area. This is an old lined slimes dam located downgradient of the operational areas of the Hernic Ferrochrome mine. The site is covered, however there is a concern that there is a potential impact as a result of seepage from this dam at the current time.	25°39'44.55"S	27°50'21.66"E
OHH2	Located within the Hernic Ferrochrome mine surface rights area. This is an old lined slimes dam located downgradient of the operational areas of the Hernic Ferrochrome mine. The site is covered, however there is a concern that there is a potential impact as a result of seepage from this dam at this stage.	25°39'46.61"S	27°50'23.15"E
SWD	Located within the Hernic Ferrochrome mine surface rights area. The dam is located downgradient and downstream of the operational areas. This dam is unlined and receives any overflows from the process water system.	25°39'27.45"S	27°50'14.12"E
ELT	Toxicological sample taken on a small tributary of the Kareespruit, which confluences with the Kareespruit upstream of the H6 site and downstream of the H2 site. A leather tannery upstream of this point discharges effluent into the stream. Any toxicological impact of the discharge on the aquatic communities present will be evident at this point.	25°39'01.06"S	27°48'20.60"E

8.4.17.2. Ecoregion

The mine and hence study area is located within the western portion of the platinum-rich Bushveld Igneous Complex (Botha and Maleka 2011; Potgieter and Malan 2010), falling within the Bushveld Basin Ecoregion as well as the boundary of the Western Bankenveld Ecoregion (refer to Figure 8.4.17.2(a)).

The Bushveld Basin Ecoregion is considered to be more representative of the site specific conditions within the study area and as such, the desktop information for this ecoregion was used as the source of background information. For the same reason reference scores for the Bushveld Basin Ecoregion were also employed for interpretation of macro-invertebrate data with reference to the SASS5 and the fish community data with reference to the FRAI.

The Bushveld Basin ecoregion can be considered to contain relatively low aquatic macro-invertebrate community diversity with fairly low community sensitivity. A fairly diverse fish community can be expected in these systems.

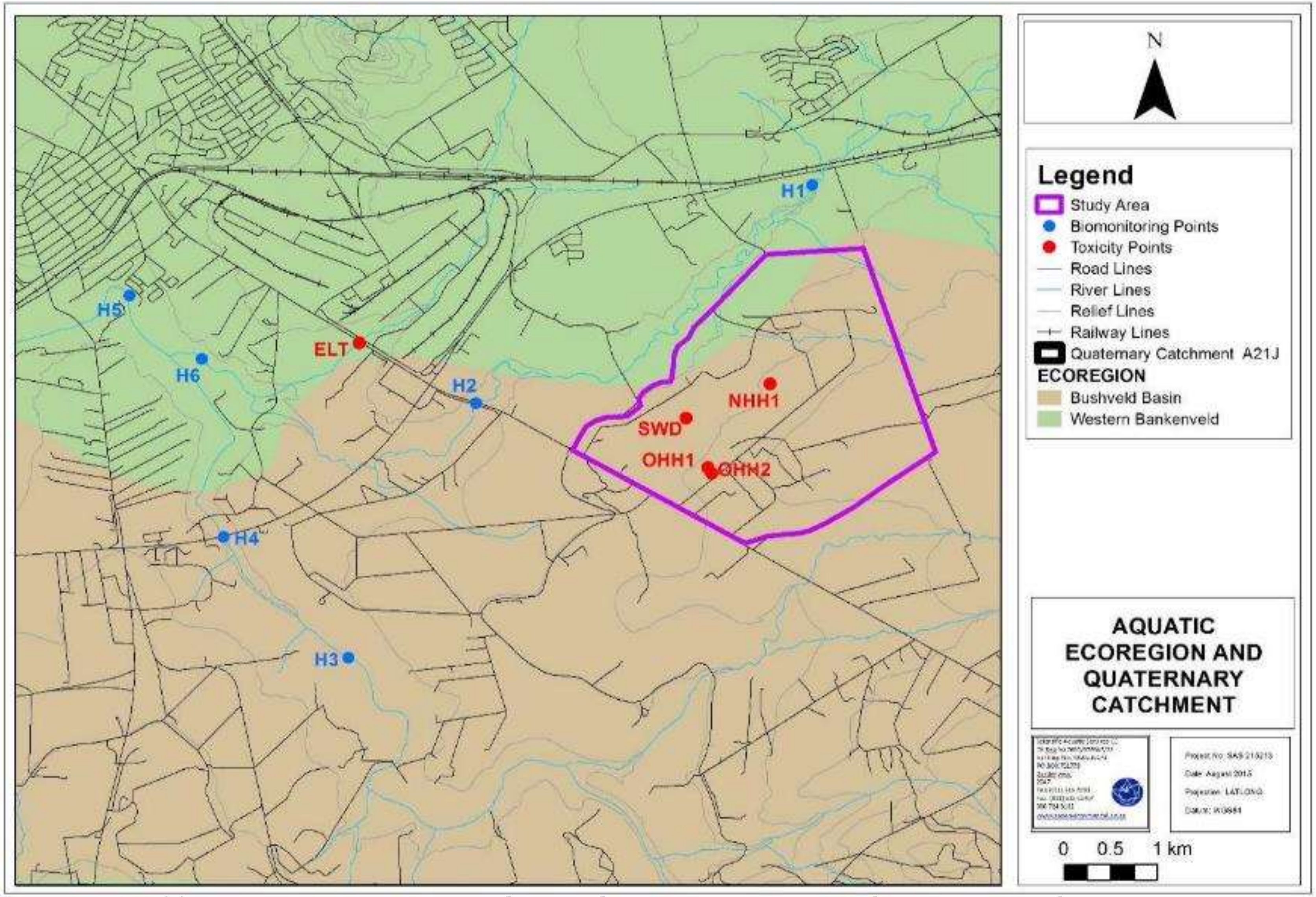


Figure 8.4.17.2(a): Assessment Points presented on Level 1 Aquatic Ecoregions and Quaternary Catchment Map.

Table 8.4.17.2(a): Main attributes of the Bushveld Basin Ecoregion

MAIN ATTRIBUTES	BUSHVELD BASIN
Terrain Morphology: Broad division (dominant types in bold) (Primary)	Plains; Low Relief; Plains; Moderate Relief; Lowlands; Hills and Mountains: Moderate and High Relief; Open Hills; Lowlands; Mountains: Moderate to High Relief; Closed Hills; Mountains: Moderate and High Relief (limited)
Vegetation types (dominant types in bold) (Primary)	Mixed Bushveld; Clay Thorn Bushveld; Waterberg Moist Mountain Bushveld (limited)
Altitude (m a.m.s.l) (modifying)	700-1700 (1700-1900 very limited)
MAP (mm) (Secondary)	400 to 600
Coefficient of Variation (% of annual precipitation)	25 to 35
Rainfall concentration index	55 to >65
Rainfall seasonality	Early to mid-summer
Mean annual temp. (°C)	14 to 22
Mean daily max. temp. (°C): February	22 to 32
Mean daily max. temp. (°C): July	14 to 24
Mean daily min. temp. (°C): February	12 to 20
Mean daily min temp. (°C): July	0 to 6
Median annual simulated runoff (mm) for quaternary catchment	20 to 100

8.4.17.3. Ecostatus

Studies undertaken by the Institute for Water Quality Studies assessed all quaternary catchments as part of the Resource Directed Measures for Protection of Water Resources. In these assessments, the Ecological Importance and Sensitivity (EIS), Present Ecological Management Class (PEMC) and Desired Ecological Management Class (DEMC) were defined and serve as a useful guideline in determining the importance and sensitivity of aquatic ecosystems prior to assessment, or as part of a desktop assessment. The study area falls within the A21J quaternary catchment.

This database was searched for the quaternary catchment of concern (A21J) in order to define the EIS, PEMC and DEMC.

According to the ecological importance classification for the A21J quaternary catchment, the Crocodile River system, the primary river of concern in the vicinity of the proposed HERNIC Ferrochrome expansion project, can be classified as a moderately sensitive system which, in its present state can be considered to be a Class C (Moderately Modified) stream (Class D based on desktop certainty).

The findings are based on a study undertaken by Kleynhans (1999) as part of "A procedure for the determination of the ecological reserve for the purpose of the national water balance model for South African rivers".

The results of the assessment are summarised in the table below. It must however be noted that the results of this study are now largely outdated and with the results more applicable to the larger Crocodile River system, they must be interpreted and extrapolated with caution.

Table 8.4.17.3(a): Summary of the Ecological Status of Quaternary Catchment A21J, (based on Kleynhans 1999)

Catchment	Resource	EIS	PEMC	DEMC
A21J	Crocodile	Moderate	Class B	Class C: Moderately sensitive systems

The points below summarise the impacts on the aquatic resources in this quaternary catchment (Kleynhans 1999):

- The aquatic resources in this quaternary catchment provide a moderate diversity of habitat with pools, rapids, riffles, wetlands and waterfalls being present;
- The aquatic resources in this quaternary catchment have a low importance in terms of natural areas conservation;
- The aquatic resources in this quaternary catchment are regarded as having no importance for rare and endangered aquatic species conservation;
- The aquatic resources in this quaternary catchment are of moderate importance in terms of the maintenance of unique habitats and endemic species with special mention of Aplocheilichthys johnstoni and Chiloglanis pretoriae;
- The aquatic resources in this quaternary catchment are considered moderately important in terms of provision of migration routes in the instream and riparian environments with special mention of avifauna and fish. This is more pertinent to the Crocodile River and its larger tributaries;
- The aquatic resources in this quaternary catchment have a moderate importance in terms of providing refugia for aquatic community members. This is more pertinent to the Crocodile River and its larger tributaries;
- The aquatic resources in this quaternary catchment can be considered to moderately sensitive to changes in water quality and flow. This is more pertinent to the Crocodile River and its larger tributaries; and
- The aquatic resources in this quaternary catchment are of high importance in terms of species richness. This is more pertinent to the Crocodile River and its larger tributaries.

In terms of ecological functions, importance and sensitivity, the following points summarise the conditions in this catchment:

- High impact on the bed structure of the Crocodile River has occurred at this point in time with special mention of impacts from sedimentation, scouring and algal growth proliferation;
- Very high flow modification has occurred due to water abstraction of water from the Crocodile River as well as flow regulation at the Hartebeespoort Dam;
- High impact in the catchment from the introduction of alien fish species, namely Cyprinus carpio, has occurred. An impact from the alien aquatic vegetation species Eichornia crassipes has occurred leading to congestion of the Crocodile River with this weed;
- Very high impact from inundation is evident at the present time due to the construction of weirs and small earth dams on the drainage lies in the quaternary catchment; and
- High riparian impacts from riparian activities are evident and the riparian vegetation of the area is often affected due to the encroachment of Acacia mearnsii. Further impacts from agriculture on riparian zones have taken place along with eutrophication of the systems caused by agricultural return water.

8.4.17.4. DWS Resource Quality Information Services PES/EIS Database

According to the PES/EIS database, as developed by the DWS RQIS department, the following sub-quaternary catchment reaches (SQR) are applicable to the proposed HERNIC Ferrochrome expansion project:

- A21J-01053 Crocodile
- A21J-01011 Crocodile
- A21J-01026 Kareespruit

Refer to Tables 8.4.17.4(a), 8.4.17.4(b) and 8.4.17.4 (c) for information pertaining to these sub-quaternary catchments. The information is spatially depicted in Figure 8.4.17.4(a).

8.4.17.5. National Freshwater Ecosystem Priority Areas

The National Freshwater Ecosystem Priority Areas (NFEPA) (2011), database was consulted to define the aquatic ecology of the river systems in the vicinity of the proposed expansion project that may be of ecological importance. Aspects applicable to the study area and surroundings are indicated in the table below.

Table 8.4.17.5(a): NFEPA Rivers in the Vicinity of the Study Area

Area	WMA	SubWMA	FEPACODE	NFEPA Rivers	RIVCON
Study Area	Crocodile (West) & Marico	Upper Crocodile	Fish Support Area in south eastern portion of study area	Crocodile River Trib. of Crocodile River	Z (Critically modified)

8.4.17.6. Outcome of the Aquatic Ecosystems Assessment

The results for the Kareespruit are discussed first (Tables 8.4.17.6(a), (b) and (c)), followed by the Crocodile River (Tables 8.4.17.6(d), (e) and (f)), the Kareespruit Tributary (8.4.17.6(g), (h) and (i)) and the HERNIC Process Water System (8.4.17.6(j), (k), (l) and (m)).

Table 8.4.17.4(a): Summary of the Ecological Status of the Sub-quaternary Catchment (SQ) reach SQR A21J-01053 (Crocodile River) based on the DWS RQIS PES/EIS database

Synopsis (SQ reach A21J-01053 Crocodile)					
PES[1] category median	**Mean EI[2] class**	**Mean ES[3] class**	**Length**	**Stream Order**	**Default EC[4]**
E	Moderate	High	15.6	3	B
PES details					
Instream habitat continuity MOD		Large	**Riparian/wetland zone MOD**		Serious
RIP/wetland zone continuity MOD		Large	**Potential flow MOD activities**		Serious
Potential instream habitat MOD activities		Serious	**Potential physico-chemical MOD activities**		Large
EI details					
Fish spp/SQ		14.00	**Fish average confidence**		3.86
Fish representivity per secondary class		High	**Fish rarity per secondary class**		Very high
Invertebrate taxa/SQ		40.00	**Invertebrate average confidence**		3.05
Invertebrate representivity per secondary class		High	**Invertebrate rarity per secondary class**		Very high
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		High	**Habitat diversity class**		Low
Habitat size (length) class		Low	**Instream migration link class**		Moderate
Riparian-wetland zone migration link		Moderate	**Riparian-wetland zone habitat integrity class**		Low
Instream habitat integrity class		Low	**Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m**		Moderate
Riparian-wetland natural vegetation rating based on expert rating					High
ES details					
Fish physical-chemical sensitivity description		Very high	**Fish no-flow sensitivity**		Very high
Invertebrates physical-chemical sensitivity description		High	**Invertebrates velocity sensitivity**		Very high
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description					Very high
Stream size sensitivity to modified flow/water level changes description					Low
Riparian-wetland vegetation intolerance to water level changes description					High

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.
NA = Not Available

Table 8.4.17.4(b): Summary of the Ecological Status of the Sub-quaternary Catchment (SQ) reach SQR A21J-01011 (Crocodile River) based on the DWS RQIS PES/EIS database

Synopsis (SQ reach A21J-01011 Crocodile)					
PES[1] category median	**Mean EI[2] class**	**Mean ES[3] class**	**Length**	**Stream order**	**Default EC[4]**
D	Moderate	High	14.51	3	B
PES details					
Instream habitat continuity MOD		Moderate	**Riparian/wetland zone MOD**		Large
RIP/wetland zone continuity MOD		Moderate	**Potential flow MOD activities**		Serious
Potential instream habitat MOD activities		Serious	**Potential physico-chemical MOD activities**		Large
EI details					
Fish spp/SQ		14.00	**Fish average confidence**		3.86
Fish representivity per secondary class		High	**Fish rarity per secondary class**		Very high
Invertebrate taxa/SQ		40.00	**Invertebrate average confidence**		3.00
Invertebrate representivity per secondary class		High	**Invertebrate rarity per secondary class**		Very high
EI importance: riparian-wetland-instream vertebrates (excluding fish) rating		High	**Habitat diversity class**		Very low
Habitat size (length) class		Low	**Instream migration link class**		High
Riparian-wetland zone migration link		High	**Riparian-wetland zone habitat integrity class**		Moderate
Instream habitat integrity class		Low	**Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m**		Moderate
Riparian-wetland natural vegetation rating based on expert rating					High
ES details					
Fish physical-chemical sensitivity description		Very high	**Fish no-flow sensitivity**		Very high
Invertebrates physical-chemical sensitivity description		High	**Invertebrates velocity sensitivity**		Very high
Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description					High
Stream size sensitivity to modified flow/water level changes description					Low
Riparian-wetland vegetation intolerance to water level changes description					High

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.
NA = Not Available

Table 8.4.17.4(c): Summary of the Ecological Status of the Sub-quaternary Catchment (SQ) reach SQR SQR A21J-01026 (Kareespruit) based on the DWS RQIS PES/EIS database

<table>
<tr><th colspan="6">Synopsis (SQ reach A21J-01026 Kareespruit)</th></tr>
<tr><th>PES[1] category median</th><th>Mean EI[2] class</th><th>Mean ES[3] class</th><th>Length</th><th>Stream order</th><th>Default EC[4]</th></tr>
<tr><td>D</td><td>Moderate</td><td>High</td><td>25.87</td><td>1</td><td>B</td></tr>
<tr><th colspan="6">PES details</th></tr>
<tr><th colspan="2">Instream habitat continuity MOD</th><td>Moderate</td><th colspan="2">Riparian/wetland zone MOD</th><td>Large</td></tr>
<tr><th colspan="2">RIP/wetland zone continuity MOD</th><td>Large</td><th colspan="2">Potential flow MOD activities</th><td>Moderate</td></tr>
<tr><th colspan="2">Potential instream habitat MOD activities</th><td>Large</td><th colspan="2">Potential physico-chemical MOD activities</th><td>Large</td></tr>
<tr><th colspan="6">EI details</th></tr>
<tr><th colspan="2">Fish spp/SQ</th><td>11.00</td><th colspan="2">Fish average confidence</th><td>1.00</td></tr>
<tr><th colspan="2">Fish representivity per secondary class</th><td>Moderate</td><th colspan="2">Fish rarity per secondary class</th><td>Very high</td></tr>
<tr><th colspan="2">Invertebrate taxa/SQ</th><td>38.00</td><th colspan="2">Invertebrate average confidence</th><td>2.95</td></tr>
<tr><th colspan="2">Invertebrate representivity per secondary class</th><td>High</td><th colspan="2">Invertebrate rarity per secondary class</th><td>High</td></tr>
<tr><th colspan="2">EI importance: riparian-wetland-instream vertebrates (excluding fish) rating</th><td>Low</td><th colspan="2">Habitat diversity class</th><td>Low</td></tr>
<tr><th colspan="2">Habitat size (length) class</th><td>Low</td><th colspan="2">Instream migration link class</th><td>High</td></tr>
<tr><th colspan="2">Riparian-wetland zone migration link</th><td>Moderate</td><th colspan="2">Riparian-wetland zone habitat integrity class</th><td>Moderate</td></tr>
<tr><th colspan="2">Instream habitat integrity class</th><td>Moderate</td><th colspan="2">Riparian-wetland natural vegetation rating based on percentage natural vegetation in 500m</th><td>High</td></tr>
<tr><th colspan="5">Riparian-wetland natural vegetation rating based on expert rating</th><td>High</td></tr>
<tr><th colspan="6">ES details</th></tr>
<tr><th colspan="2">Fish physical-chemical sensitivity description</th><td>High</td><th colspan="2">Fish no-flow sensitivity</th><td>High</td></tr>
<tr><th colspan="2">Invertebrates physical-chemical sensitivity description</th><td>Moderate</td><th colspan="2">Invertebrates velocity sensitivity</th><td>Very high</td></tr>
<tr><th colspan="5">Riparian-wetland-instream vertebrates (excluding fish) intolerance water level/flow changes description</th><td>Low</td></tr>
<tr><th colspan="5">Stream size sensitivity to modified flow/water level changes description</th><td>High</td></tr>
<tr><th colspan="5">Riparian-wetland vegetation intolerance to water level changes description</th><td>High</td></tr>
</table>

[1] PES = Present Ecological State; confirmed in database that assessments were performed by expert assessors;
[2] EI = Ecological Importance;
[3] ES = Ecological Sensitivity
[4] EC = Ecological Category; default based on median PES and highest of EI or ES means.
NA = Not Available

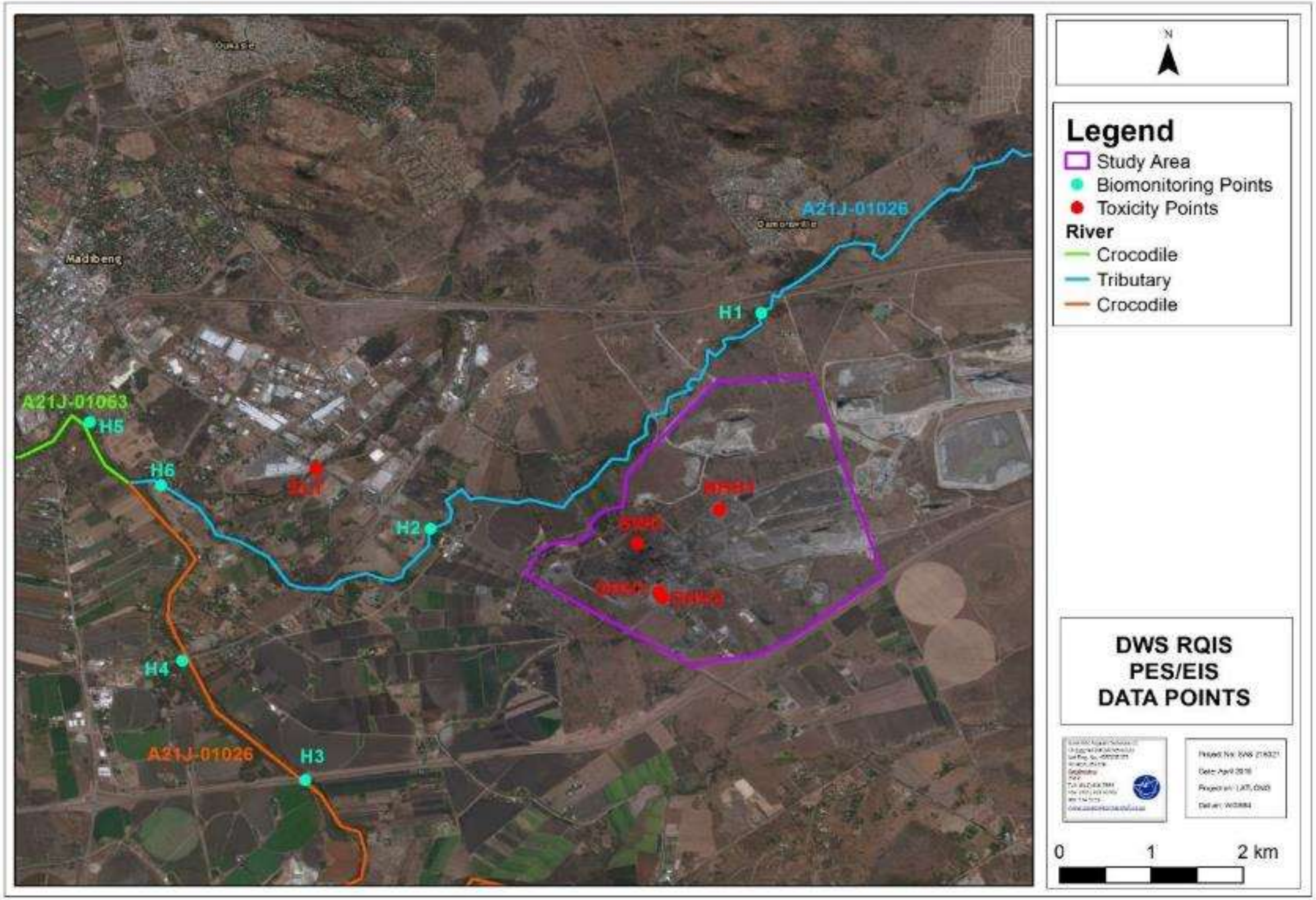


Figure 8.4.17.4(a): DWS RQIS PES/EIS Sub-quaternary Catchment Reaches (SQRs) indicated in the Vicinity of HERNIC

Table 8.4.17.6 (a): Summary of the Findings on the Kareespruit – Site H1

Kareespruit		
Site H1 (Reference site upstream of the activities of the Hernic Ferrochrome Operation)		
August 2015	**January 2016**	
Water Quality pH 7.72 Conductivity (mS/m) 159.0 Temperature (º C) 13.4 DO (mg/L) 9.29 DO (% sat) 88.3	**Water Quality** pH 7.79 Conductivity (mS/m) 97.0 Temperature (º C) 23.5 DO (mg/L) 3.33 DO (% sat) 49.08	
Habitat Assessment Class Inadequate IHAS Score 49	**Habitat Assessment** Class Inadequate IHAS Score 56	
Aquatic Macro-invertebrate community assessment Dickens & Graham, 2001: Category D Dallas, 2007: Category C/D MIRAI: Category C SASS5 Score: 67 ASPT Score: 4.8	**Aquatic Macro-invertebrate community assessment** Dickens & Graham,2001: Category D Dallas, 2007: Category E/F MIRAI: Category C SASS5 Score: 53 ASPT Score: 3.8	
Fish Response Assessment Index (FRAI) FRAI Score: 6.7 FRAI EC: Category F	**Diatom analysis** Category C	
Toxicity testing Class 2 *Daphnia pulex*: 15% mortalities *Poecilia reticulata*: No mortalities	**Toxicity testing** Class 3 *Daphnia pulex*: 55% mortalities *Poecilia reticulata:*13% mortalities	
Current impacts: Terrestrial vegetation encroachment. The stream substrate shows signs of excessive sediment deposition which may be introduced to the system from activities upstream of this point on the Kareespruit.		

Table 8.4.17.6 (b): Summary of the Findings on the Kareespruit – Site H2

Site H2 (Downstream of the activities of the Hernic Ferrochrome Operation)		
August 2015	**January 2015**	
Water Quality pH 7.84 Conductivity (mS/m) 147.0 Temperature (º C) 14.0 DO (mg/L) 9.20 DO (% sat) 89.4	**Water Quality** pH 7.93 Conductivity (mS/m) 150.0 Temperature (º C) 23.3 DO (mg/L) 5.93 DO (% sat) 87.08	
Habitat Assessment Class Inadequate IHAS Score 63	**Habitat Assessment** Class Adequate IHAS Score 68	
Aquatic Macro-invertebrate community assessment Dickens & Graham,2001: Category C Dallas, 2007: Category D MIRAI: Category C SASS5 Score: 79 ASPT Score: 4.4	**Aquatic Macro-invertebrate community assessment** Dickens & Graham,2001: Category D Dallas, 2007: Category B/C MIRAI: Category C SASS5 Score: 61 ASPT Score: 5.1	
Fish Response Assessment Index (FRAI) FRAI Score: 9.6 FRAI EC: Class F	**Diatom analysis** Category C	
Toxicity testing Class 2 *Daphnia pulex*: 25% mortalities *Poecilia reticulata:* 10% mortalities	**Toxicity testing** Class 3 *Daphnia pulex*: 55% mortalities *Poecilia reticulata:* 13% mortalities	
Current impacts: Some impacts on water quality as a result of the activities of the Hernic Ferrochrome is deemed possible with a 54.6% increase in EC observed at this point in relation to the H1 site but other contributors are possible. The stream substrate has also been significantly affected by sedimentation at this point.		

Table 8.4.17.6 (c): Summary of the Findings on the Kareespruit – Site H6

Site H6 (On the Kareespruit, downstream of the confluence with a small tributary which is affected by discharges from a leather tannery further upstream)		
August 2015	**January 2015**	
Water Quality pH 7.85 Conductivity (mS/m) 140.0 Temperature (º C) 16.9 DO (mg/L) 4.47 DO (% sat) 46.3	**Water Quality** pH 7.82 Conductivity (mS/m) 220.0 Temperature (º C) 23.9 DO (mg/L) 3.48 DO (% sat) 51.67	
Habitat Assessment Class Adequate IHAS Score 70	**Habitat Assessment** Class Highly suited IHAS Score 77	
Aquatic Macro-invertebrate community assessment Dickens & Graham, 2001: Category F Dallas, 2007: Category F MIRAI: Category E SASS5 Score: 12 ASPT Score: 2.4	**Aquatic Macro-invertebrate community assessment** Dickens & Graham,2001: Category F Dallas, 2007: Category E/F MIRAI: Category E SASS5 Score: 6 ASPT Score: 2.0	
Fish Response Assessment Index (FRAI) FRAI Score: 6.7 FRAI EC: Category F	**Diatom analysis** Category E	
Current impacts: An impact as a result of impaired water quality, specifically with reference to elevated EC, is evident at this point. Severe sedimentation and inundation evident upstream of the bridge crossing.		

Kareespruit Spatial Comparisons

Water Quality

- Electrical conductivity (EC) at all three points may be considered elevated from what can expected under natural, un-impacted conditions;
- In the January 2016 assessment, between the upstream H1 site and the H2 site, the EC level increased by 54.6%. Between the H2 site and the H6 site, the EC level increased by a further 46.7%. Between the Upstream H1 site and the downstream H6 site, the EC increased by 126.8%. This level of change significantly exceeds the DWS (formerly DWAF, 1996) Target Water Quality Requirements (TWQR) for aquatic ecosystems, which advocates a change of no more than 15%;
- The high salt load in the system can be partially attributed to a combination of geological factors as well as impact from various diffuse and/or point sources upstream from the Hernic Ferrochrome operation, however, impacts as a result of the activities of the Hernic Ferrochome operation as well as a further impact as a result of the activities of the leather tannery downstream of site H2 are deemed likely;
- The recorded pH values are considered as largely natural judged by absolute values;
- The water quality guideline for aquatic ecosystems (DWS formerly DWAF, 1996) states that dissolved oxygen concentrations should range between 80% and 120% of saturation. Saturation (i.e. maximum dissolved oxygen concentrations) shall in turn depend on the temperature of the water sampled (USA EPA website accessed February 2015). The dissolved oxygen readings can thus be expressed as a percentage of the potential maximum. From this calculation it is evident that the oxygen levels at the H2 site is compliant with the recommended guideline during both the August 2015 and the January 2016 assessment periods;
- Based on this it can be concluded that the Hernic Ferrochrome activities did not have a negative effect on DO concentration in the system at the time of assessment;
- The dissolved oxygen level at both the H1 and the H6 sites were found to be well below the required minimum saturation level during the January 2016 assessment.

The results thus indicate catchment-wide impacts upstream of the Hernic Ferrochrome operation. Furthermore, the decrease in dissolved oxygen level at the H6 site in relation to the H2 site during both the August 2015 and the January 2016 assessment suggests a high level of oxygen demand downstream of any impact as a result of the activities of the Hernic Ferrochrome operation.

It is deemed possible that either a chemical or biological point source of impact may be occurring between the H2 and H6 points and may possibly be related to discharges into the leather tannery stream which confluences with the Kareespruit upstream of the H6 point;

- The temperatures observed at each of the points are deemed natural for the time of year and nature of the systems.

Aquatic Community Integrity

- SASS5 results for the Kareespruit River sites assessed, indicate a fair level of variability along this section of the stream;
- From the results indicated in the dashboard tables above, it can be concluded that the activities at Hernic Ferrochrome are unlikely to be causing a negative impact on the macro-invertebrate community within the Kareespruit system at this stage, while impacts further downstream and unrelated to the activities of the Hernic Ferrochrome Operation are resulting in severe changes to the aquatic community integrity of this system in a downstream direction;
- The presence of other point and diffuse sources of pollution within the larger catchment complicates attempts at quantifying the potential contribution of the Hernic Ferrochrome activities to the impact on sensitive species observed;
- However, changes in macro-invertebrate community and structure needs to be continuously monitored to confirm the results and monitor any temporal trends.

Fish Community Integrity

- The application of the FRAI indicates that the fish communities in this area have suffered a severe loss in integrity when compared to the reference score for a pristine Bushveld Basin Ecoregion water resource;
- It is likely that the introduction of weirs and impoundments along this system, in addition to impacts as a result of the mining and residential activities in the area have begun to affect migration routes and fish distributions and abundances in the smaller streams in the catchment;
- It must be mentioned that the stream at the H1 point consisted only of deeper pools, with shallower areas towards the banks. Many fish in this kind of habitat tend to remain deeper at lower temperatures thus increasing the difficulty with which to successfully collect specimens during sampling efforts;
- Conditions at the H6 site were very poor with very deep pools instream and unstable sediment and mud substrates dominating the deeper areas of the stream. There was also significant flow modification as a result of dense instream vegetation, which significantly hindered sampling efficiency in some areas at this point.

Diatom Analysis

- Based on the OMNIDIA results, the ecological water quality at site H2 is of an Ecological Category C (Moderate quality);
- The presence of dominant taxa such as Nitzschia frustulum, Rhoicosphenia abbreviata, Navicula symmetrica and Eolimna subminuscula, which are found in eutrophic, electrolyte-rich waters are indicative of fluctuations in osmotic pressure as a result of changes in salinity and of critical levels of pollution;
- Sites H1 and H6 were sampled within slow flowing waters which may be subject to strong fluctuations in its condition, specifically salinity, organic and nutrient levels. Any attempt to use existing diatom indices suitable for freshwater ecosystems (Specific Pollution sensitivity Index (SPI), Coste in CEMAGREF, 1982, Biological Index for Diatoms (BDI), Lenoir and Coste, 1996, Prygiel and Coste, 2000) to determine the biological integrity of such systems will likely result in misleading conclusions. Analyses of diatoms were therefore based on measures of relative abundance and species composition (i.e. assemblage patterns) to infer baseline water quality conditions at each site;

- At site H1 is the presence of dominant taxon Nitzschia agnewi, which suggests eutrophic conditions;
- In addition, dominant taxa include Nitzschia linearis and Nitzschia dissipata, often associated with oxygen rich waters of moderate to high electrolyte content, and can be found in alkaline hard waters (calcium based salinity). The presence of dominant taxon Navicula veneta, a highly pollution tolerant species often found in industrially impacted waters with elevated nutrients and electrolyte, suggests that there is some level of anthropogenic disturbance at this site;
- Recorded at site H6 is the presence of prevalent taxon Nitzschia palea, which implies that the site is heavily anthropogenically impacted by nutrients, electrolytes and organics;
- For reasons outlined above, the Ecological Category for site H1 is a category C (Moderate quality) and for site H6, a category E (Bad quality).

Table 8.4.17.6(d): Summary of the Findings on the Crocodile River – Site H3

Crocodile River		
Site H3 (Reference site upstream of the activities of the Hernic Ferrochrome Operation)		
August 2015	**January 2016**	
Water Quality pH 8.59 Conductivity (mS/m) 60.0 Temperature (º C) 19.1 DO (mg/L) 11.28 DO (% sat) 122.9	**Water Quality** pH 8.09 Conductivity (mS/m) 74.0 Temperature (º C) 27.2 DO (mg/L) 4.36 DO (% sat) 68.47	
Habitat Assessment Class Inadequate IHAS Score 56	**Habitat Assessment** Class Inadequate IHAS Score 52	
Aquatic Macro-invertebrate community assessment Dickens & Graham, 2001: Category D Dallas, 2007: Category C MIRAI: Category C SASS5 Score: 55 ASPT Score: 5.0	**Aquatic Macro-invertebrate community assessment** Dickens & Graham,2001: Category E Dallas, 2007: Category E/F MIRAI: Category C SASS5 Score: 43 ASPT Score: 3.6	
Fish Response Assessment Index (FRAI) FRAI Score: 11.8 FRAI EC: Category F	**Diatom analysis** Category D	
Toxicity testing Class 2 *Daphnia pulex*: 25% mortalities *Poecilia reticulata:* No mortalities	**Toxicity testing** Class 2 *Daphnia pulex*: 40% mortalities *Poecilia reticulata:*13% mortalities	
Current impacts: Impoundments resulting in flow variations		

Table 8.4.17.6(e): Summary of the Findings on the Crocodile River – Site H4

Site H4 (Downstream of the activities of the Hernic Ferrochrome Operation)		
August 2015	**January 2016**	
Water Quality pH 7.96 Conductivity (mS/m) 67.0 Temperature (º C) 15.5 DO (mg/L) 9.33 DO (% sat) 86.9	**Water Quality** pH 7.98 Conductivity (mS/m) 75.0 Temperature (º C) 27.9 DO (mg/L) 5.75 DO (% sat) 91.3	
Habitat Assessment Class Highly suited IHAS Score 77	**Habitat Assessment** Class Highly suited IHAS Score 75	
Aquatic Macro-invertebrate community assessment Dickens & Graham,2001: Category E Dallas, 2007: Category B MIRAI: Category C SASS5 Score: 48 ASPT Score: 5.3	**Aquatic Macro-invertebrate community assessment** Dickens & Graham,2001: Category E Dallas, 2007: Category E/F MIRAI: Category D SASS5 Score: 27 ASPT Score: 3.0	
Fish Response Assessment Index (FRAI) FRAI Score: 9.6 FRAI EC: Category F	**Diatom analysis** Category C	
Toxicity testing Class 1 *Daphnia pulex*: No mortalities *Poecilia reticulata:* No mortalities	**Toxicity testing** Class 4 *Daphnia pulex*: 100% mortalities *Poecilia reticulata:*13% mortalities	
Current impacts: The results of the toxicological assessment indicate a high toxicological risk to the aquatic communities at this point (Class 4). These results are supported by the decrease in SASS5 (-43.8%) and ASPT (-43.4%) scores in the January 2016 assessment. However, the impact observed at this site is not related to the biota-specific water quality variables measured (similar at upstream and downstream sites) and also not reflected in diatom analysis results (higher classification in relation to that observed at site H5). At present the nature of the impact is not clear but this trend needs to be closely monitored in future to elucidate any potential impact from mining activities.		

Table 8.4.17.6(f): Summary of the Findings on the Crocodile River – Site H5

Site H5 (Downstream of the confluence with the Kareespruit)		
August 2015	**January 2016**	
Water Quality pH 7.85 Conductivity (mS/m) 68.0 Temperature (º C) 17.0 DO (mg/L) 8.15 DO (% sat) 84.5	**Water Quality** pH 8.02 Conductivity (mS/m) 81.0 Temperature (º C) 27.8 DO (mg/L) 5.96 DO (% sat) 94.49	
Habitat Assessment Class Highly suited IHAS Score 90	**Habitat Assessment** Class Inadequate IHAS Score 52	
Aquatic Macro-invertebrate community assessment Dickens & Graham, 2001: Category D Dallas, 2007: Category D MIRAI: Category C SASS5 Score: 51 ASPT Score: 4.6	**Aquatic Macro-invertebrate community assessment** Dickens & Graham, 2001: Category E Dallas, 2007: Category E/F MIRAI: Category D SASS5 Score: 33 ASPT Score: 3.7	
Fish Response Assessment Index (FRAI) FRAI Score: 9.6 FRAI EC: Category F	**Diatom analysis** Category D	
Current impacts: Weirs and impoundments leading to loss of flow and flow variability.Water quality impacts with specific reference to salt load.		

Crocodile River Spatial Comparisons

Water Quality

- Electrical conductivity (EC) recorded at each of the three sites is considered high during both the August 2015 and the January 2016 assessments;
- Negligible variations in the pH values along this section of the Crocodile River were observed between each site during each assessment;
- Based on the dissolved oxygen concentrations observed during each assessment, it is considered likely that natural flow variations largely affects the dissolved oxygen concentrations along this section of the Crocodile River, however, some upstream catchment-wide impacts resulting in an increased level of chemical or biological oxygen demand in some areas is deemed possible.
- The temperatures observed at each of the points are deemed natural for the time of year and nature of the systems. The observed variations can be attributed to diurnal variation between sampling times and the variation in the volume of water in the various water bodies sampled.

Aquatic Community Integrity

- SASS5 results for the Crocodile River sites assessed, indicate largely to severely impaired conditions;
- The SASS5 index indicates that conditions at site H3 are already significantly impaired prior to any impact from the activities of the Hernic Ferrochrome operations;
- The SASS5 results appear to have deteriorated at each of the sites since the August 2015 assessment;
- It is considered likely that these changes are related to seasonal variations and the nation-wide drought conditions in the months prior to the January 2016 assessment;
- Based on the sensitivity of the aquatic community present at the H4 site, it is considered possible that the activities of the Hernic Ferrochrome Operation is placing some additional strain on the aquatic macro-invertebrate community of the system as a result of seepage from the Hernic Ferrochrome slimes dams;
- Some improvement in the aquatic community integrity is observed at the H5 site in relation to that observed at site H4; as depicted by the SASS5 and the ASPT scores, however, community composition at each point may be considered largely similar and the observed variation is likely related to flow conditions and habitat structure for aquatic macro-invertebrates at each point;

- The application of the MIRAI to each site on the Crocodile River further supports the results obtained from both the application of the Dickens & Graham (2001) and the Dallas (2007) classification systems in the current assessment;
- In light of the results obtained, should the proposed expansion proceed, it is considered essential that any changes in macro-invertebrate community and structure needs to be continuously monitored to confirm emerging impacts and any spatial and temporal trends.

Fish Community Integrity

- The application of the FRAI indicates that the fish communities in this area have suffered a severe loss in integrity when compared to the reference score for a pristine Bushveld Basin Ecoregion water resource;
- It is likely that the introduction of weirs and impoundments along this system, in addition to impacts as a result of the mining and residential activities in the area have begun to affect migration routes and fish distributions and abundances in the smaller streams in the catchment;
- In addition, water a number of impacts as a result of anthropogenic impacts and activities along the Crocodile River were noted, which are likely to limit the occurrence of some of the more sensitive species which have a lower tolerance of poor water quality.

Diatom Analysis

- Based on the OMNIDIA results, the ecological water quality at sites H4 is of an Ecological Category C (Moderate quality) and at site H5, a category D (Poor quality);
- Sites H4 and H5 are largely dominated by taxon Nitzschia agnewi which occurs in eutrophic waters;
- Also recorded at sites H4 and H5 is dominant taxon Staurosira elliptica (significantly more at H5) which is found in the benthos of electrolyte-rich waters;
- At Site H4, taxa Cocconeis pediculus, Cocconeis placentula and Nitzschia palea are indicative of nutrient enriched waters. C. pediculus can be found in alkaline waters;
- At Site H5, dominant taxon Diadesmis confervacea is typical of eutrophic, electrolyte-rich, extremely polluted waters.
- Site H3 was sampled within slow flowing waters which may be subject to strong fluctuations in its condition, specifically salinity, organic and nutrient levels. Any attempt to use existing diatom indices suitable for freshwater ecosystems (Specific Pollution sensitivity Index (SPI), Coste in CEMAGREF, 1982, Biological Index for Diatoms (BDI), Lenoir and Coste, 1996, Prygiel and Coste, 2000) to determine the biological integrity of such systems will likely result in misleading conclusions;
- Existing diatom indices used to determine anthropogenic stress in freshwater systems relate to the abundances of stress-tolerant species, which may be equally tolerant to natural stressors (elevated salinity/organics/nutrients) as to anthropogenic ones. Analyses of diatoms were therefore based on measures of relative abundance and species composition (i.e. assemblage patterns) to infer baseline water quality conditions at each site;
- At site H3 is the presence of dominant taxon Nitzschia agnewi which suggests that the site is eutrophic;
- The dominant taxa Staurosira elliptica, Nitzschia perspicua and Nitzschia amphibia which are indicative of elevated electrolytes were observed at this point. N. perspicua is commonly affiliated with industrially impacted waters and N. amphibia is often linked to fertiliser runoff;
- Based on the above observations, the Ecological Category for site H3 may be defined as a category D (Poor quality).

Table 8.4.17.6(g): Summary of the Findings on the Tributary of the Kareespruit – Site ELT

<table>
<tr><th colspan="2">The Kareespruit Tributary</th></tr>
<tr><th colspan="2">Site ELT</th></tr>
<tr><th>August 2015</th><th>January 2016</th></tr>
<tr><td>Water Quality
pH 7.81
Conductivity (mS/m) 116.6
Temperature (º C) 18.6
DO (mg/L) 5.23
DO (% sat) 56.5</td><td>Water Quality
pH 8.31
Conductivity (mS/m) 326.0
Temperature (º C) 27.4
DO (mg/L) 1.06
DO (% sat) 15.11</td></tr>
<tr><td>Toxicity testing
Class 2
Daphnia pulex: 20% mortalities
Poecilia reticulata: 10% mortalities</td><td>Toxicity testing
Class 5
Daphnia pulex: 100% mortalities
Poecilia reticulata: 100% mortalities</td></tr>
<tr><td colspan="2">Comments
The toxicological analysis of the sample obtained from the tributary of the Kareespruit revealed that at the ELT site, the toxicological threat posed to the aquatic communities present in the receiving environment has deteriorated significantly from a Class 2 (slight acute hazard) to a Class 5 (severe acute hazard);
The results therefore indicate that a significant impact as a result of the leather tannery discharging into the tributary of the Kareespruit may currently be expressed on the aquatic resources further downstream;
These results furthermore serve to indicate that the Kareespruit and in turn, the Crocodile River, is affected by various point and diffuse sources further downstream and, while a slight impact is likely being expressed on the Kareespruit as a result of the activities of the Hernic Ferrochrome Operation, a number of cumulative impacts are currently affecting the downstream integrity of the Crocodile River. The presence of other point and diffuse sources within the larger catchment thus complicates any attempt at quantifying any potential contribution from the Hernic Ferrochrome activities.</td></tr>
</table>

Physico-Chemical Water Quality

Table 8.4.17.6(h): Biota Specific Water Quality Data for the Tributary of the Kareespruit Site ELT

Site	Assessment	pH (pH units)	Conductivity (mS/m)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	Temp (ºC)
ELT	August 2015	7.81	116.6	5.23	56.5	18.6
	January 2016	8.31	326.0	1.06	15.11	27.4

The following key points on the water quality of the tributary were observed:

- Electrical conductivity (EC) recorded at the site may be considered elevated from what is expected under natural/unimpacted conditions;
- Since August 2015, the general water quality at this point has deteriorated significantly;
- The conductivity has increased significantly by 2.8X, the pH value has increased by 6.4% and the dissolved oxygen levels have declined significantly by 79.7%;
- The increased EC at this point is likely compounded by the effects of the nation-wide drought conditions experienced in the months preceding the January 2016 assessment;
- The water quality guideline for aquatic ecosystems (DWS formerly DWAF, 1996) states that dissolved oxygen concentrations should range between 80% and 120% of saturation. Saturation (i.e. maximum dissolved oxygen concentrations) shall in turn depend on the temperature of the water sampled (USA EPA website accessed February 2015);
- The oxygen saturation levels observed in this system are therefore well below the required target range. The low levels of dissolved oxygen observed at this point are likely to limit the integrity and sensitivity of the aquatic communities likely to occur at this point;
- In addition, the low level of dissolved oxygen observed at this point indicates some impact as a result of increased chemical or biological oxygen demand possibly related to discharge activities from the leather tannery upstream of this point;
- The temperature observed is deemed natural for the time of day and season when sampling took place.

Toxicological Assessment

Table 8.4.17.6(i): Summary of the Toxicity Testing Results obtained from the Water Sample collected on the Tributary of the Kareespruit – Site ELT

Site	Assessment	Daphnia pulex (48 hour % mortality)	Poecilia reticulata (96 hour % mortality)	Toxicological Classification
ELT	August 2015	20	10	Class 2: Slight acute hazard
	January 2016	100	100	Class 5: Severe acute hazard

The toxicological analysis of the sample obtained from the tributary of the Kareespruit revealed that at the ELT site, the toxicological threat posed to the aquatic communities present in the receiving environment has deteriorated significantly from a Class 2 (slight acute hazard) to a Class 5 (severe acute hazard):

- The results therefore indicate that a significant impact as a result of the leather tannery discharging into the tributary of the Kareespruit may currently be expressed on the aquatic resources further downstream;
- These results furthermore serve to indicate that the Kareespruit and in turn, the Crocodile River, is affected by various point and diffuse sources further downstream and, while a slight impact is likely being expressed on the Kareespruit as a result of the activities of the Hernic Ferrochrome Operation, a number of cumulative impacts are currently affecting the downstream integrity of the Crocodile River. The presence of other point and diffuse sources within the larger catchment thus complicates any attempt at quantifying any potential contribution from the Hernic Ferrochrome activities.

Table 8.4.17.6(j): Summary of the Findings on the Process Water System – Site OHH1

The Process Water System		
Site OHH1		
August 2015	**January 2016**	
Water Quality pH 9.13 Conductivity (mS/m) 4350.0 Temperature (º C) 14.3 DO (mg/L) 8.67 DO (% sat) 84.3	**Water Quality** pH 7.84 Conductivity (mS/m) 431.0 Temperature (º C) 23.7 DO (mg/L) 6.33 DO (% sat) 88.1	
Toxicity testing Class 5 *Daphnia pulex*: 100% mortalities *Poecilia reticulata:* 100% mortalities	**Toxicity testing** Class 4 *Daphnia pulex:*100% mortalities *Poecilia reticulata:* 25% mortalities	
Comments The toxicological response observed at the OHH1 site has improved from a Class 5 (Severe Acute Hazard) classification, to a Class 4 (High Acute hazard) state since the August 2015 assessment; This may be attributed to the improved survival rate observed in *the Poecilia reticulata* toxicity test, indicating that macro-invertebrates were affected to a greater degree compared to fish at the time of assessment.		

Table 8.4.17.6(k): Summary of the Findings on the Process Water System – Site OHH2

Site OHH2		
August 2015	**January 2016**	
Water Quality pH 8.51 Conductivity (mS/m) 2800.0 Temperature (º C) 7.68 DO (mg/L) 5.26 DO (% sat) 74.6	**Water Quality** pH 7.90 Conductivity (mS/m) 1548.0 Temperature (º C) 24.6 DO (mg/L) 5.26 DO (% sat) 76.8	
Toxicity testing Class 5 *Daphnia pulex*: 100% mortalities *Poecilia reticulata*: 100% mortalities	**Toxicity testing** Class 5 *Daphnia pulex*: 100% mortalities *Poecilia reticulata*: 100% mortalities	
Comments The toxicological response observed at the OHH2 site has remained in a Class 5 condition, posing a severe toxicological hazard to the aquatic communities present in the receiving environment since the assessment in August 2015.		

Table 8.4.17.6(l): Summary of the Findings on the Process Water System – Site NHH1

Site NHH1		
August 2015	**January 2016**	
Water Quality pH 8.20 Conductivity (mS/m) 6110.0 Temperature (º C) 17.0 DO (mg/L) 7.92 DO (% sat) 82.1	**Water Quality** pH 8.75 Conductivity (mS/m) 1304.0 Temperature (º C) 25.8 DO (mg/L) 6.46 DO (% sat) 95.2	
Toxicity testing Class 5 *Daphnia pulex*: 100% mortalities *Poecilia reticulata*: 100% mortalities	**Toxicity testing** Class 5 *Daphnia pulex*: 100% mortalities *Poecilia reticulata*: 100% mortalities	
Comments The toxicological response observed at the NHH1 site has remained in a Class 5 condition, posing a severe toxicological hazard to the aquatic communities present in the receiving environment since the assessment in August 2015;		

Table 8.4.17.6(m): Summary of the Findings on the Process Water System – Site SWD

<table>
<tr><th colspan="3">Site SWD</th></tr>
<tr><th>August 2015</th><th>January 2016</th><th></th></tr>
<tr><td>Water Quality
pH 8.25
Conductivity (mS/m) 242.0
Temperature (º C) 15.8
DO (mg/L) 7.37
DO (% sat) 74.8</td><td>Water Quality
pH 8.52
Conductivity (mS/m) 222.0
Temperature (º C) 26.3
DO (mg/L) 6.22
DO (% sat) 90.5</td><td rowspan="2"></td></tr>
<tr><td>Toxicity testing
Class 5
Daphnia pulex: 100% mortalities
Poecilia reticulata: 100% mortalities</td><td>Toxicity testing
Class 4
Daphnia pulex: 100% mortalities
Poecilia reticulata: 63% mortalities</td></tr>
<tr><td colspan="3">Comments
The toxicological response observed at the SWD site has improved from a Class 5 (Severe Acute Hazard) classification, to a Class 4 (High Acute hazard) state since the August 2015 assessment;
This may be attributed to the improved survival rate observed in the Poecilia reticulata toxicity test, indicating that macro-invertebrates were affected to a greater degree compared to fish at the time of assessment.</td></tr>
</table>

8.4.17.7. Conclusion

The results of the aquatic ecosystem study indicate that prior to any impacts as a result of the activities of the HERNIC Ferrochrome operations or of the proposed expansion, impaired water quality is a key driver of change along the Crocodile River as well as its associated tributaries, with special mention of the Kareespruit in the vicinity of the study area.

The high salt load in these systems can be attributed to a combination of geological factors as well as impact from other diffuse and/or point sources upstream from the HERNIC Ferrochrome operation, compounded by drought conditions preceding this baseline assessment. Electrical conductivity (EC) along both systems may be considered elevated from what can expected under natural, un-impacted conditions.

In addition, the stream substrates show signs of excessive sediment deposition which may be introduced to the system from various construction activities in the area, agricultural activities as well as other site clearing activities resulting in a loss of vegetation cover and resulting in increased erosion and sedimentation of these resources.

In addition to the high level of toxicity observed in the existing HERNIC Ferrochrome process water system and the associated risks this poses, the results of the baseline assessment indicate that before any impacts as a result of the activities of the HERNIC Ferrochrome Operation, a toxicological response is observed on both the Kareespruit as well as on the Crocodile River.

Once again these results indicate a significant amount of stress placed on these systems as a result of catchment-wide impacts. Flow variability was found to play a role in shaping the aquatic communities present. This is compounded by the presence of weirs and dams along the system. The proposed expansion is likely to place additional stress on the aquatic resources in the vicinity of the study area.

8.4.18. Air Quality Environment

The relevant Specialist Report is:

Atmospheric Impact Report / Air Quality Impact Assessment for HERNIC Ferrochrome, July 2016. G D Fourie and J G Potgieter – EnviroNgaka CC.

HERNIC operates two Sinter & Pelletizing plants, and four closed submerged arc furnaces to produce ferrochrome. The two Sinter & Pelletizing plants are used to sinter pellets produced from raw materials supplied. Chrome ore concentrate/fines are first ground to very small sizes and agglomerated to form pellets. The pellets are then sintered to minimise dust loss. Carbon (coke, coal / anthracite or char) is used as reductant. Quartzite, dolomite and limestone are used as flux. The pellets, carbon and flux are charged by preheating it with carbon monoxide (CO) gas.

After cooling these pellets produced from the Sinter & Pelletizing plants, are fed into the furnaces (i.e. a total of four closed submerged arc type furnaces) from where the liquid metal is tapped. HERNIC currently operates Listed Activities in terms of Section 21 of NEM:AQA: Sinter plants (Subcategory 4.5) as well as Ferro-alloy production (Subcategory 4.9), as specified by the current Atmospheric Emissions License (AEL).

Emission Monitoring & Calculation Monitoring is done at HERNIC in order to inform the operations with respect to emission inventory compilation, atmospheric impact assessments and to assess compliance against the limits contained in the AEL and or relevant local by-laws. Emission monitoring/testing is defined as sampling/testing of the primary point sources under normal operating conditions in order to assess the emissions. There are 13 point sources listed in the AEL which are being tested/measured on a quarterly basis to inform the emission inventory. There are also uncontrolled / emergency emission points which emit under ad-hoc abnormal uncontrolled conditions, for which the emissions are estimated to inform the emission inventory.

8.4.18.1. Gaseous and Particulate Matter Emissions

A detailed air quality investigation for the facility based on the current emissions inventory was conducted during July 2016. The purpose / objective of the investigation was to identify and quantify the expected effect of the site's impact, emanating from atmospheric emissions on the surrounding ambient air quality. The impact assessment was done against the emissions of all relevant pollutants at expected concentrations against normal conditions assessed against full production capacity (achievable emissions). This scenario includes no modifications or improvements made to the current process, and does not imply AEL emission limits.

Representative site specific meteorological data was simulated for a period from January 2013 to December 2015, and utilised for the scenario for the impact assessment and data interpretation. The location for the simulated meteorological monitoring data is located approximately 1.5 *km* south of the site. Point and secondary / fugitive sources emitting PM_{10}, $PM_{2.5}$, SO_2, NO_2, CO and Cr(VI) were assessed under the scenario mentioned above.

Results from the impact assessment were conclusive, and highlighted the risk and potential negative impact of PM_{10}, $PM_{2.5}$ and NO_2 emissions on the receiving environment. Although exceedances for PM_{10} and $PM_{2.5}$ of the national ambient air quality standards was reported for the short time averages (24-hr), the annual standards were not exceeded in the region (Figures 8.4.18.1(a)–(d)). Exceedances for NO_2 of the national ambient air quality standards was reported for the short time averages (1-hr), as well as the annual standards in the region, as highlighted by Figures 8.4.18.1(e) and (f).

It is foreseen to be "likely" that the site's contribution to the SO_2 and CO ambient air quality falls within the relevant standards.

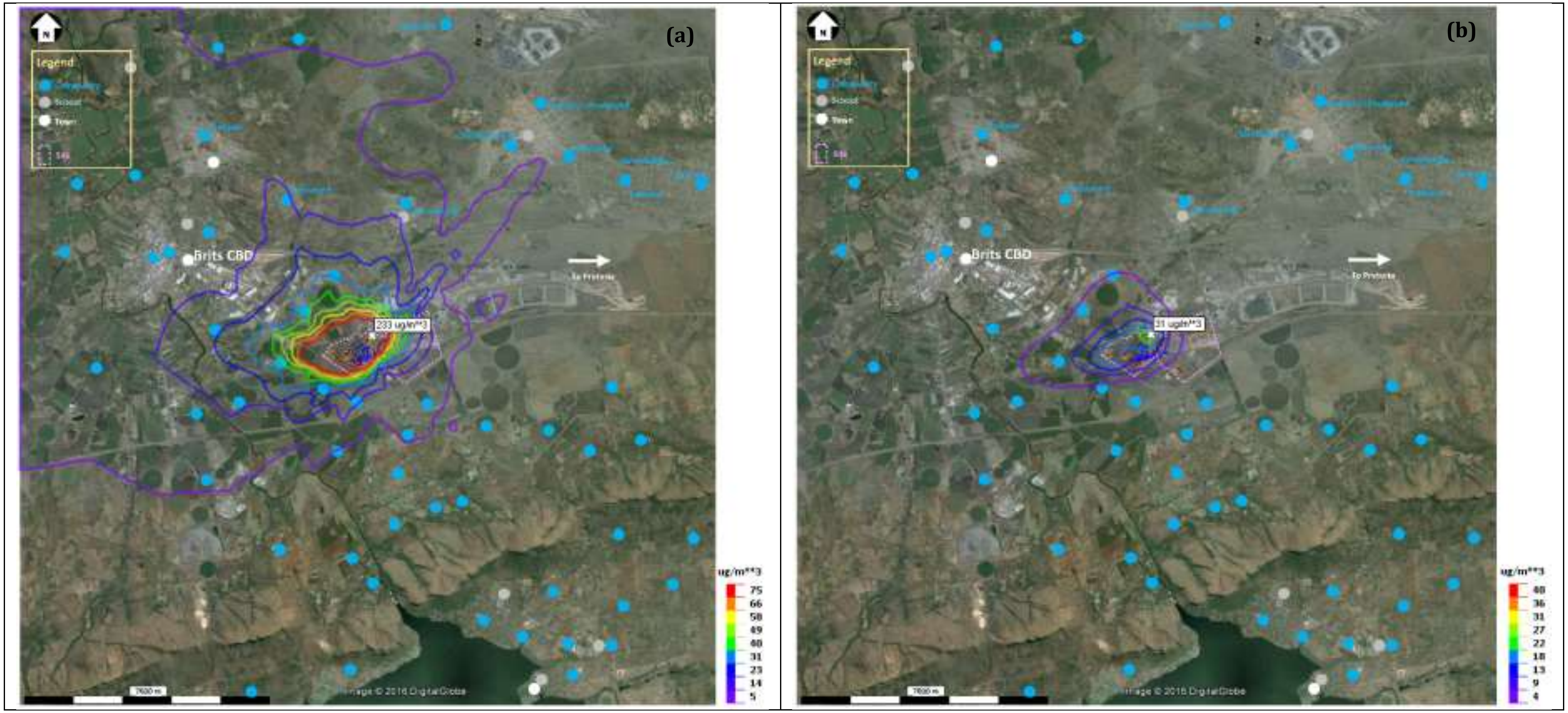


Figure 8.4.18.1(a): All Sources – Particulate Matter (PM_{10}) – 24hour, 99th percentile; (b): All Sources – Particulate Matter (PM_{10}) – Annual Average

Figures 8.4.18.1(a) and (b) provides an indication of the expected impact of PM_{10} emissions for all emission sources for a 24-hr and annual time average respectively. The impact region is localised around the facility, and exceedances of the ambient air quality standard (75µg/m^3) is expected for the 24-hr average. The exceedance impact region is approximately 300 *m* toward a westerly and north-westerly direction. No exceedances of the annual ambient air quality standard of 40µg/m^3 are eminent.

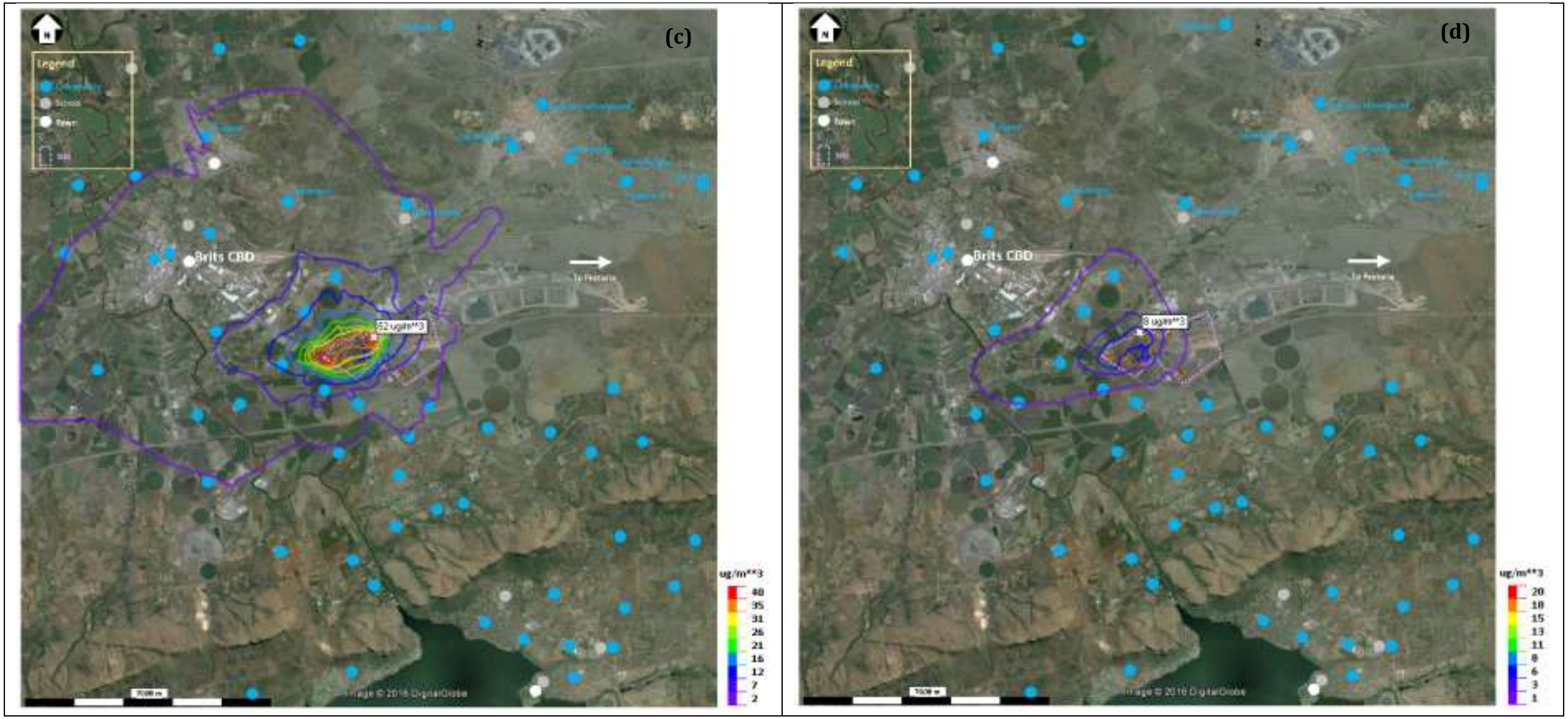


Figure 8.4.18(c): All Sources – Particulate Matter ($PM_{2.5}$) – 24hour, 99th percentile; (d): All Sources – Particulate Matter ($PM_{2.5}$) – Annual Average

Figures 8.4.18.1(c) and (d) provides an indication of the expected impact of $PM_{2.5}$ emissions for all emission sources for a 24-hr and annual time average respectively. The impact region is localised around the facility, and exceedances of the ambient air quality standard (40µg/m^3) is expected for the 24-hr average. The exceedance impact region is approximately 50m towards both a westerly and easterly direction. No exceedances of the annual ambient air quality standard of 20µg/m^3 are eminent.

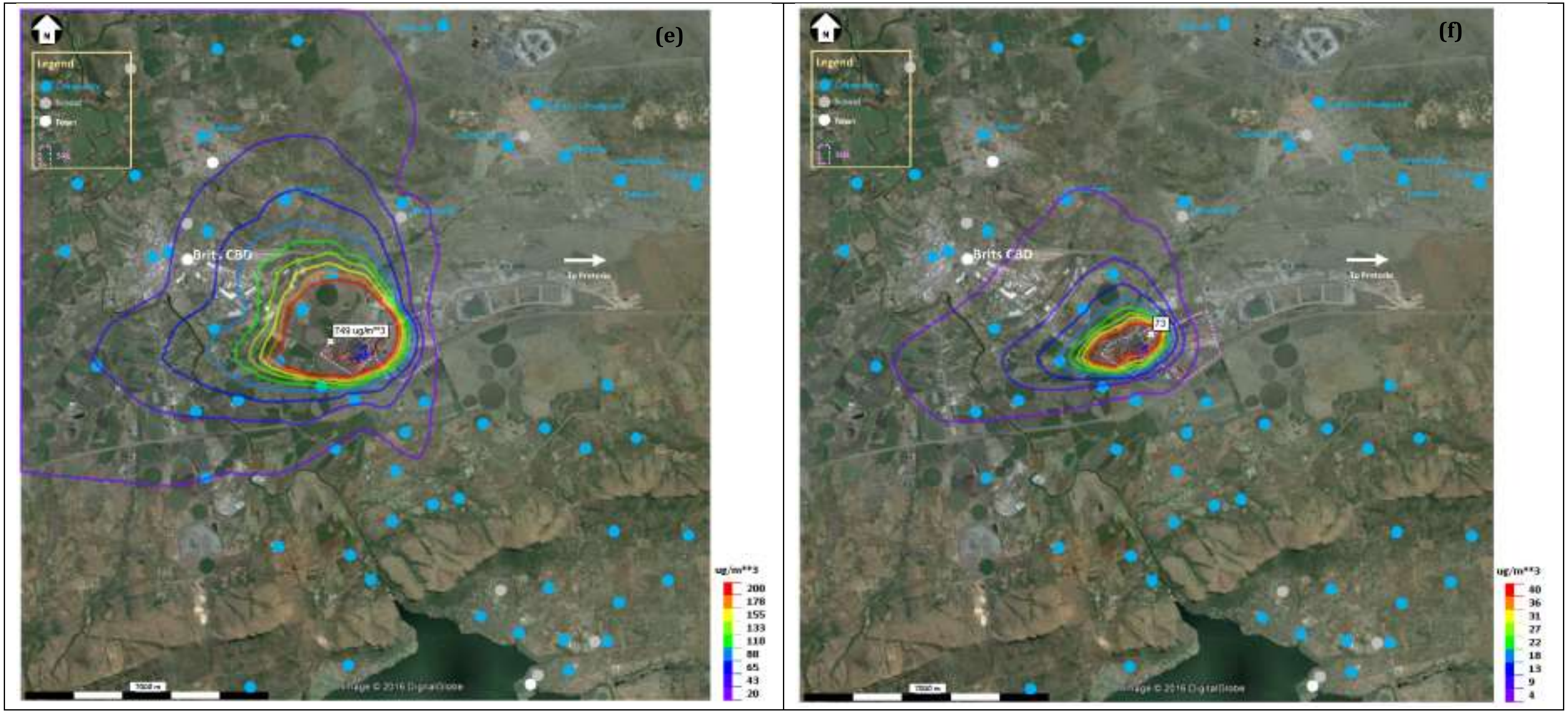


Figure 8.4.18.1(e): All Sources – Nitrogen Dioxide (NO_2) – 1hour, 99th percentile; (f): All Sources – Nitrogen Dioxide (NO_2) – Annual Average

Figures 8.4.18.1(e) and (f) provides an indication of the expected impact of NO_2 emissions for all emission sources for a 1-hr and annual time average respectively. The impact region is localised around the facility, and exceedances of the ambient air quality standard is expected for both the 1-hr (200µg/m^3) and annual average (40µg/m^3). The exceedance impact region is toward a westerly and north-westerly direction (indicated by the red isopleth).

The impact study highlighted the fact that primarily fugitive and secondary emission sources gave rise to the PM_{10}, $PM_{2.5}$ and NO_2 exceedances, and the impact region is localized around the facility.

Possible mitigation/reduction strategies to reduce these secondary / fugitive sources are recommended as a first step to minimise and reduce impacts from the facility:

- Apply more efficient dust suppression techniques;
- Reduce vehicle movement and associated diesel consumption;
- Reduce fugitive emissions.

It is foreseen to be "likely" that the site's contribution to the Cr(VI) ambient air quality is simulated to be such that the risk over populated areas is believed to be around 1 per 100 000, or lower risk. This risk is highlighted by Figure 8.4.18.1(g). The impact region is negligible. The impact risk factors are indicted by the figures' legend. A risk factor of 1 in a populous of 100 000 and 1 in 500 000 are indicated by the red line and purple line respectively. All residential settlements are foreseen to fall outside the risk of 1 in a populous of 100 000.

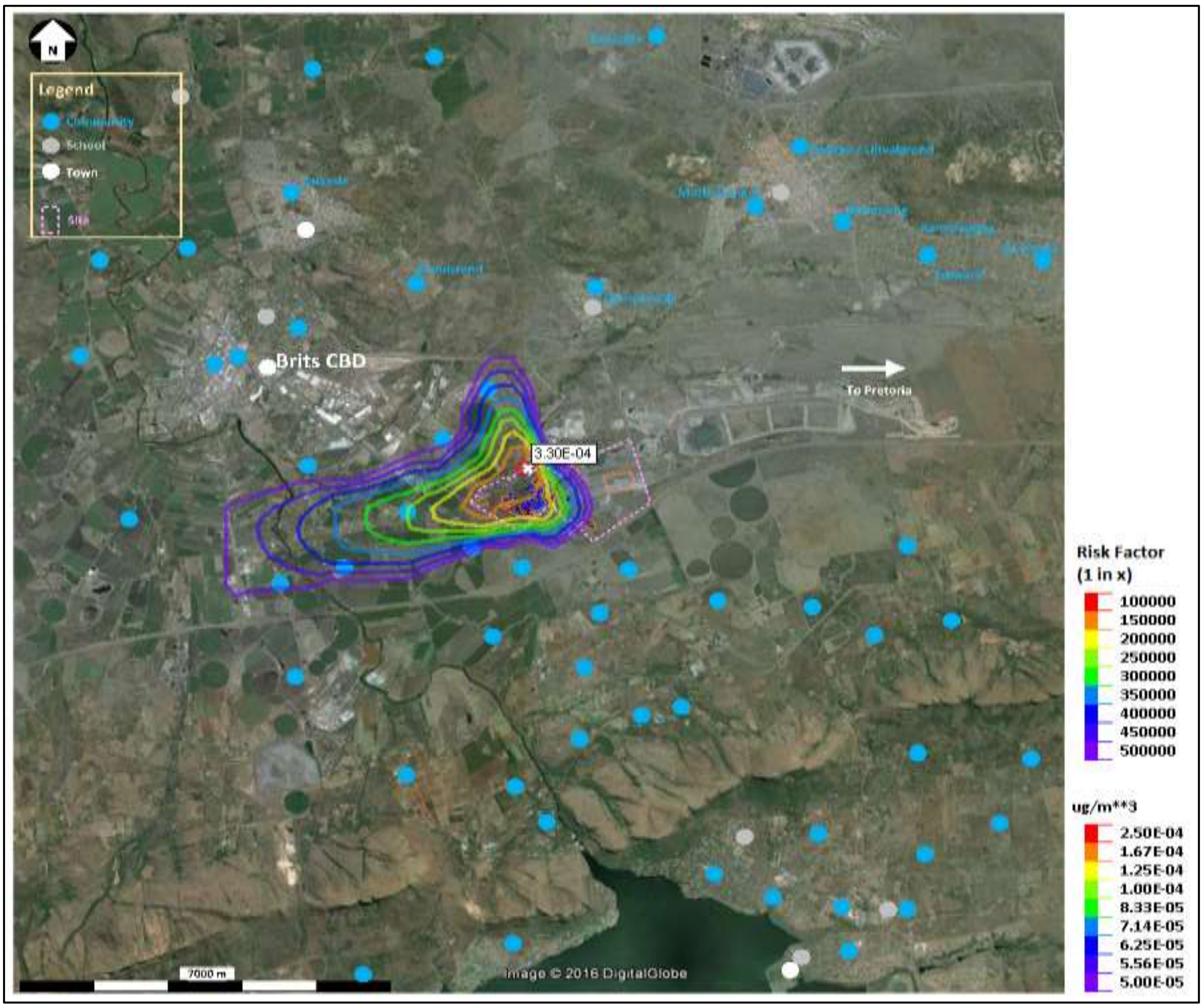


Figure 8.4.18.1(g): All Sources – Chromium (Cr(VI)) – Annual Average

There are no continuous ambient air quality monitoring stations (AQMS) in close vicinity to HERNIC. The closest station in Damonsville owned and operated by the North West Provincial Government has undergone a revamp and reliable data is anticipated for the future.

8.4.18.2. Dust Fallout

In accordance with AEL requirements, Dust Fallout (DFO)measurements should be conducted by the facility. The dust fallout monitoring network (27 sites) is indicated in Figure 8.4.18.2(a). Meteorological data is also obtained from a meteorological station located in close proximity to the HERNIC, which is used to interpret the DFO results for the site as "site-specific".

Figure 8.4.18.2(a): HERNIC ambient air Dust Fallout Monitoring and Locations

The potential contribution from HERNIC to DFO levels is assessed on an ongoing basis and the effect of the secondary / fugitive sources are identified and managed by Site Management. Compliance of these DFO levels with the National Dust Control Regulations (NDCR) varies during the year and compliance of off-site locations is fairly good.

It is also noted that other sources in the area are also contributing to DFO levels sampled by HERNIC. It is however also noted that the possibility of fugitive dust from secondary sources such as roads and storage facilities, is foreseen to increase significantly during spring and some winter months.

Tables 8.4.18.2(a) and 8.4.18.2(b) below provides an assessment of the Off-site dust fallout (DFO) bucket locations against the National Dust Control Regulation for the period June 2015 till May 2016.

Table 8.4.18.2(a): Year 2015-16 (12-Month) DFO Results: Off-Site (Residential Locations)

Period from:	Jun-15	Reference Number	24	21	22	25	11
to:	May-16	Sensitive Area:	EHM / 24 / W	EHM / 21 / W	EHM / 22 / W	EHM / 25 / W	EHM / 11 / W
		Area Classification	Residential	Residential	Residential	Residential	Residential
National Dust Control Regulation (NDCR), Table 1: Acceptable dustfall rate:			600	600	600	600	600
Annual Average (against SANS1929 Target: 300mg/m^2/day, No NDCR limit):			302	432	559	677	318
Minimum during past 12 months:			220	232	216	194	126
Maximum during past 12 months:			361	666	884	1399	712
NDCR, Regulation: D > Acceptable dustfall rate: Max of 2 times /year:			Comply	Comply	> 2 / year	> 2 / year	Comply
NDCR, Regulation: D > Acceptable dustfall rate: No Sequential Months:			Comply	Comply	Seq Months	Seq Months	Comply
SANS1929 Guideline: D > 2400; Immediate Action Req.:			Comply	Comply	Comply	Comply	Comply
			Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate
Month	Sampling Period	Date / Unit	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}
1	1/06/15 to 3/07/15	Jun-15	NT	496	884	NT	231
2	3/07/15 to 30/07/15	Jul-15	NT	401	513	NT	139
3	30/07/15 to 31/08/15	Aug-15	NT	535	690	NT	361
4	31/08/15 to 1/10/15	Sep-15	NT	666	599	NT	373
5	1/10/15 to 2/11/15	Oct-15	NT	424	742	NT	176
6	2/11/15 to 3/12/15	Nov-15	361	587	811	903	656
7	3/12/15 to 4/01/16	Dec-15	338	339	533	1399	215
8	4/01/16 to 1/02/16	Jan-16	220	382	NT	403	319
9	1/02/16 to 3/03/16	Feb-16	326	425	395	1326	126
10	3/03/16 to 4/04/16	Mar-16	356	367	428	299	189
11	4/04/16 to 3/05/16	Apr-16	249	232	338	212	NT
12	3/05/16 to 2/06/16	May-16	266	334	216	194	712
w/w%	Mass percentage of element in dust sampled - excluding contribution from copper sulphate						
NT	Not Tested						
RA	Results Awaited						
#N/A / ---	Not sampled / analysed yet						

Table 8.4.18.2(b): Year 2015-16 (12-Month) DFO Results: Off-Site (Non-Residential Locations)

Period from:	Jun-15	Reference Number	7	26	27	6	10	23	5	14	20	17	15
to:	May-16	Sensitive Area:	EHM / 07 / NW	EHM / 26 / SW	EHM / 27 / W	EHM / 06 / W	EHM / 10 / NE	EHM / 23 / SE	EHM / 05 / W	EHM / 14 / NE	EHM / 20 / E	EHM / 17 / E	EHM / 15 / NE
		Area Classification	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential	Non-residential
tional Dust Control Regulation (NDCR), Table 1: Acceptable dustfall rate:			1200	1200	1200	1200	1200	1200	1200	1200	1200	1200	1200
nual Average (against SANS1929 Target: 300mg/m^2/day, No NDCR limit):			533	Not assessable	Not assessable	529	496	240	585	510	150	259	200
Minimum during past 12 months:			251	675	817	322	121	132	478	50	42	47	19
Maximum during past 12 months:			786	996	1620	824	1346	412	744	1905	366	576	457
NDCR, Regulation: D > Acceptable dustfall rate: Max of 2 times /year:			Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply
NDCR, Regulation: D > Acceptable dustfall rate: No Sequential Months:			Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply
SANS1929 Guideline: D > 2400; Immediate Action Req.:			Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply	Comply
			Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate	Dustfall Rate
Month	Sampling Period	Date / Unit	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-1}	mg.m^{-2}.day^{-2}	mg.m^{-2}.day^{-3}
1	1/06/15 to 3/07/15	Jun-15	545	NT	NT	511	461	NT	653	401	42	454	437
2	3/07/15 to 30/07/15	Jul-15	251	NT	NT	322	859	NT	499	50	69	215	176
3	30/07/15 to 31/08/15	Aug-15	643	NT	NT	NT	494	NT	744	301	161	330	311
4	31/08/15 to 1/10/15	Sep-15	737	NT	NT	332	1346	NT	666	314	148	399	215
5	1/10/15 to 2/11/15	Oct-15	432	NT	NT	422	121	NT	500	105	145	83	19
6	2/11/15 to 3/12/15	Nov-15	786	NT	NT	704	NT	412	598	290	265	576	457
7	3/12/15 to 4/01/16	Dec-15	526	NT	NT	551	354	204	507	809	NT	136	58
8	4/01/16 to 1/02/16	Jan-16	488	NT	NT	716	553	378	605	1905	366	107	158
9	1/02/16 to 3/03/16	Feb-16	488	996	1547	537	254	132	656	514	90	85	45
10	3/03/16 to 4/04/16	Mar-16	339	675	1155	402	216	142	478	189	129	412	188
11	4/04/16 to 3/05/16	Apr-16	579	902	817	824	450	187	524	1002	105	47	186
12	3/05/16 to 2/06/16	May-16	580	947	1620	499	343	228	590	235	134	262	155
w/w%	Mass percentage of element in dust sampled - excluding contribution from copper sulphate												
NT	Not Tested												
RA	Results Awaited												
#N/A / ---	Not sampled / analysed yet												

Figures 8.4.18.2(b) and 8.4.18.2(c) provide the DFO rates observed at the Offsite locations respectively, for the period June 2015 till May 2016.

Figures 8.4.18.2(d) and 8.4.18.2(e) provide the rolling annual averages for DFO rates observed at the Offsite locations respectively, for the period June 2015 till May 2016.

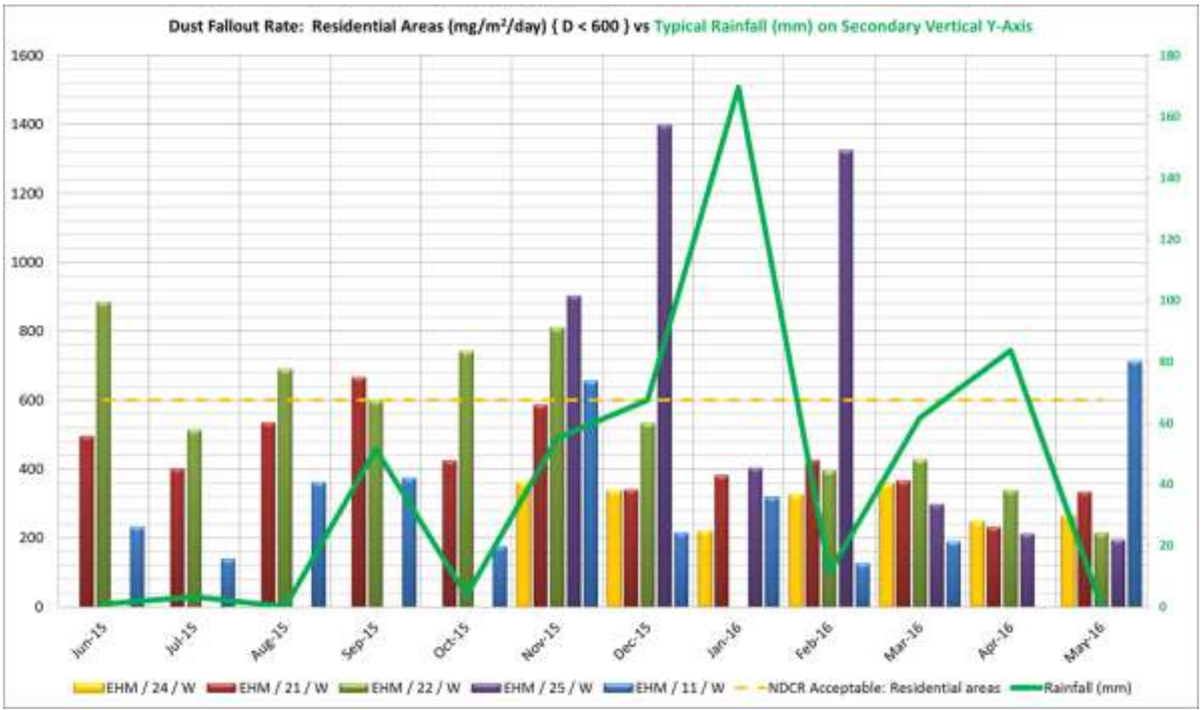


Figure 8.4.18.2(b): 2015-2016 Dust Fallout Rate – Residential Areas

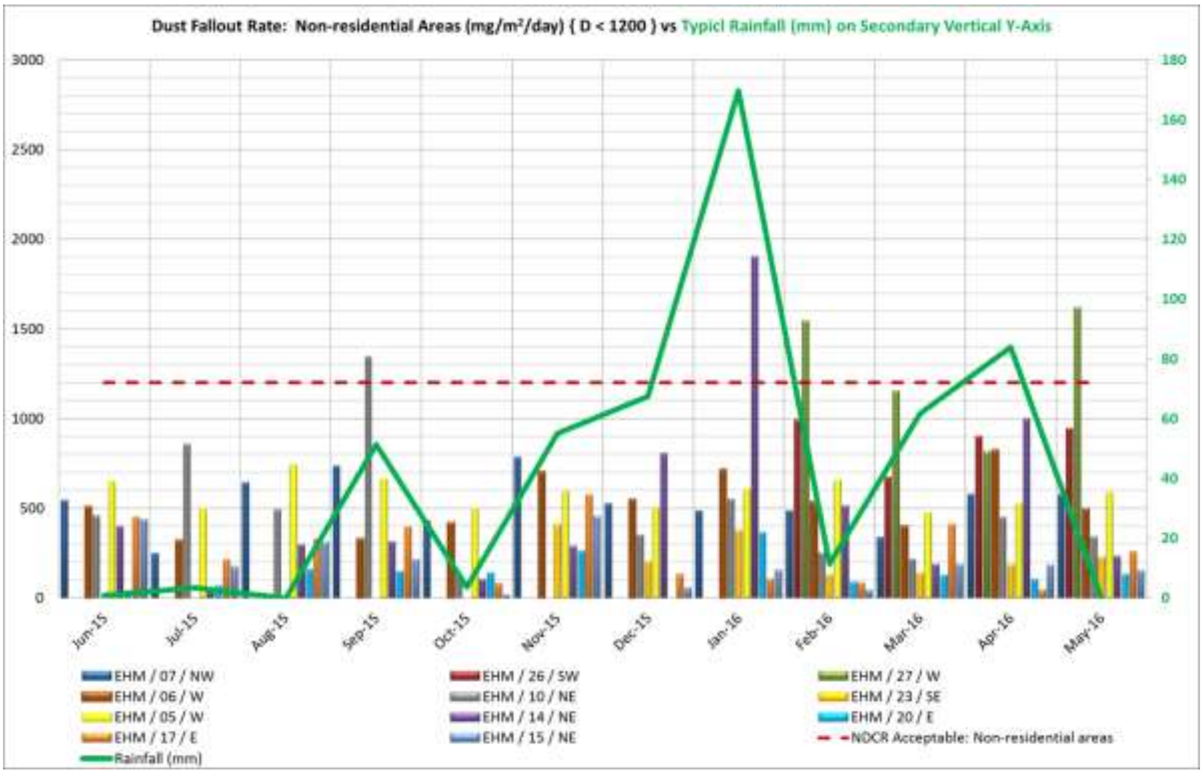


Figure 8.4.18.2(c): 2015-2016 Dust Fallout Rate – Non-Residential Areas

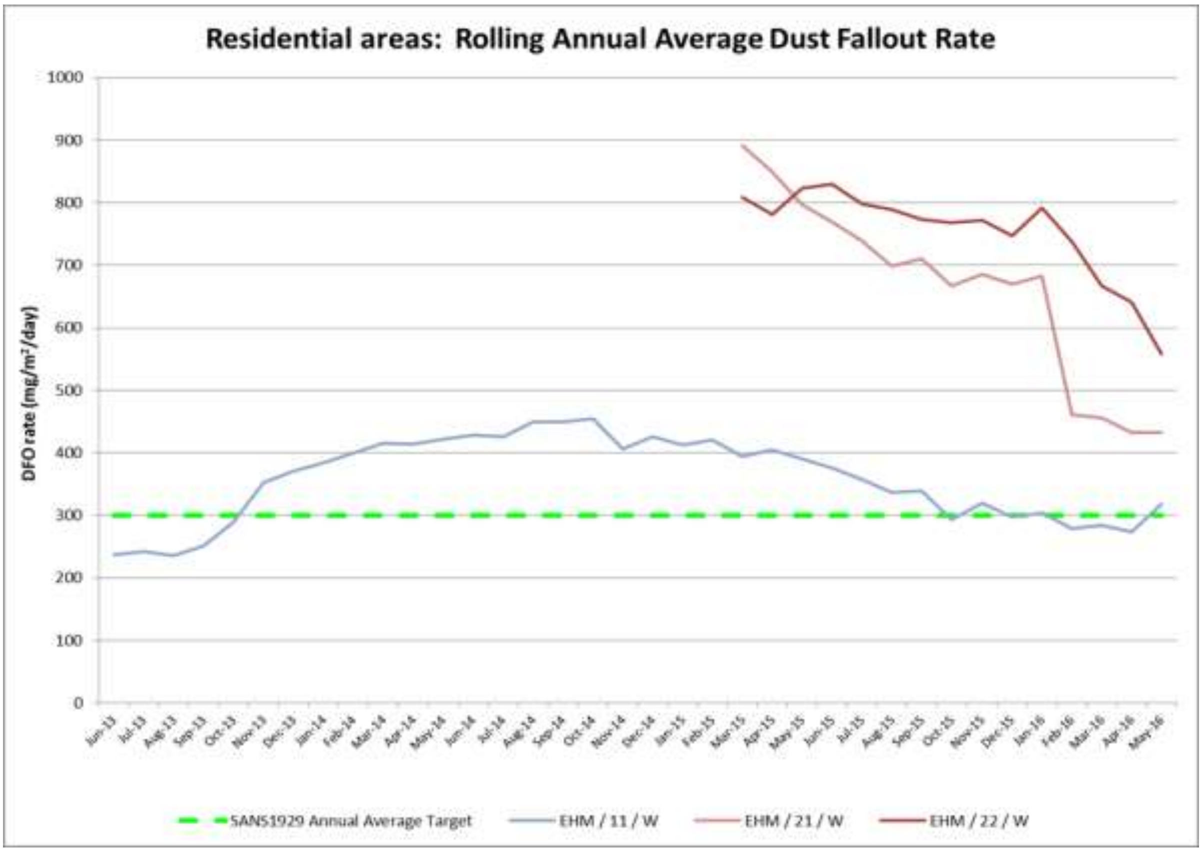


Figure 8.4.18.2(d): 2015-2016 Dust Fallout Rate – Rolling Annual Average Dust Fallout Rate - Residential Areas

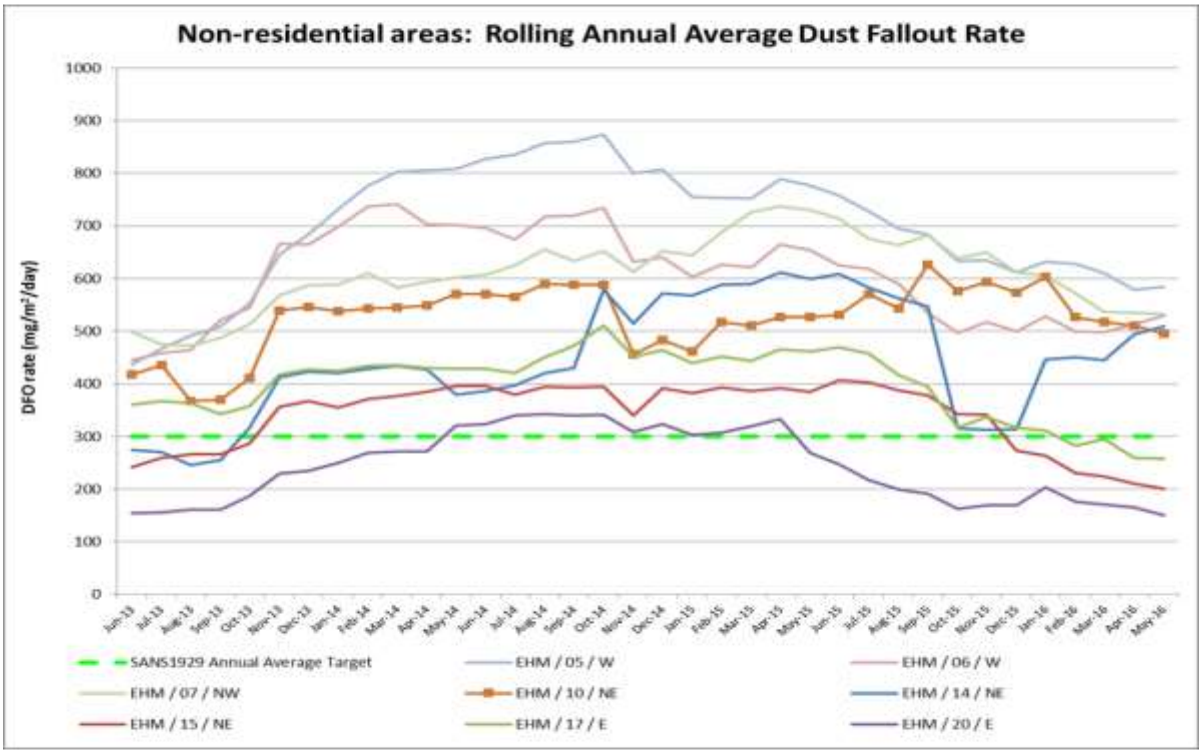


Figure 8.4.18.2(e): 2015-2016 Dust Fallout Rate – Rolling Annual Average Dust Fallout Rate - Non-Residential Areas

8.4.19. Noise Environment

The relevant Specialist Report is:

De Jager, M. (2016). Baseline Noise Report - HERNIC Smelter and Mining Complex, Brits. Enviro-Acoustic Research cc, Pretoria.

HERNIC Ferrochrome (Pty) Ltd (HERNIC) is located just south-east of Brits in the North-west Province, South Africa. HERNIC was established in 1995 with the purpose to produce ferrochrome to the market. HERNIC operates two chrome mines which can produce up to 1.5mt per annum, however one shaft is currently on care and maintenance due to the economic downturn. It also operates four ferrochrome furnaces with a capacity of 420kt per annum with these furnaces in full operation. All ferrochrome are exported mainly to Asian and European markets in association with Mitsubishi Corporation and ELG Haniel GmbH.

8.4.19.1. Study area

The HERNIC site is located within the Madibeng Local Municipality (Bojanala District) in North-West Province. This is of relevance as the Model Bylaws for noise control is proposed on municipal level with Noise Control Regulations promulgated on provincial level. The North-West Province has not promulgated provincial noise control regulations.

8.4.19.2. Relevant Factors for the Noise Assessment

Topography

ENPAT (1998) describes the topography as slightly undulating plains. There are no local topographical features that will limit the propagation of noises.

Ground Conditions and Vegetation

Area falls within the Savannah biome with the vegetation type being mainly *"Clay Thorn Bushveld".* The natural veldt has been significantly disturbed due to industrial activities. The ground surface is generally covered with grasses, a sedges and shrubs albeit sparsely in areas. It is the opinion of the author that the ground surface is generally hard and reflective and only 25% soft ground conditions will be used for modelling purposes. It should be noted that this factor is only relevant for sound waves being reflected from the ground surface, with certain frequencies slightly absorbed by the vegetation.

Land Use

HERNIC operates in a complex soundscape, with the land use surrounding the operation being a mixture of industrial, residential, mining and agriculture.

Roads and Rail Roads

The R511 route pass the site on the west with the N4 passing the site on the south. There is a small private railway line bordering HERNIC north. This railway line is exclusive for the transport of the HERNIC ferrochrome product.

Residential Areas

There is a large informal community just west of the R511 route, directly west of the smelting complex. In addition to this community there are a number of private residences and farming homesteads within approximately 2,000m from the HERNIC operations.

Other Noise Sources

The area is well developed, with other noise sources being the traffic on the R511 and N4 route, as well as smaller industrial activities close to the HERNIC activities. Road traffic is a significant noise source.

Existing Ambient Noise Levels

Ambient sound levels are very high in the vicinity of HERNIC, corresponding to an urban area with one or more main roads, workshops and business. SANS 10103:2008 defines rating levels of 50 and 60 dBA during the night and daytime periods. This is higher than the noise limits proposed by the International Finance Corporation for residential use.

Available Information

No other noise studies were available at the time this report was compiled.

8.4.19.3. Noise-Sensitive Developments

An assessment of the area was done using available topographical maps to identify potential Noise-Sensitive Developments (NSD) in the area (up to 2 km from boundary of facility). The data was imported into GoogleEarth® to allow a more visual view of the areas where Noise-Sensitive Developments were identified. Closest NSD's are indicated as green dots with residential communities being shown as a light-green area.

The assessment indicated there are a number of such developments that occurs in the area. Note that one dot may represent a number of surrounding receptors. Noise-sensitive developments identified are highlighted in Figure 8.4.19.3(a).

Figure 8.4.19.3(a): Aerial Image indicating identified Noise-Sensitive Developments

8.4.19.4. Onsite Measurements – Ambient Sounds

Ambient sound measurements were collected in the area to assist in defining the soundscape around the HERNIC operations. This included long-term measurements augmented by a number of short measurements.

Measurements were collected as defined by the SANS 10103 guideline with the sound measuring equipment calibrated directly before and after the measurements were collected.

The locations used to measure ambient (background) sound levels are presented in Figure 8.4.19.4(a) and 8.4.19.4(b).

A number of single measurements were collected to gauge the noise levels from the plant at the boundary of the operation. Due to the variability of the sound levels as traffic passed, some measurements were collected over a shorter time period. The ambient sound measurements indicated that the ambient sound environment is noisy, especially closer to the mining activities, the R 511 and the N4 roads. Sounds close to the routes is dominated by traffic noises, with various activities at the HERNIC operation impacting on the soundscape around that operation.

Figure 8.4.19.4(a): **Aerial Image where Ambient Sound Levels were Measured – Greater Study Area**

Figure 8.4.19.4(b): Aerial Image indicating Locations where Ambient Sound Levels were Measured – HERNIC Access Road

8.4.19.5. Measurement Point HASM01 (NSD17 – Mr. Johan Carstens)

Ambient sound levels were measured at this location from 18th – 23rd February 2016. Equipment used to gather data is presented in Table 8.4.19.5(a)**Table 8.4.19.5(a)**. This measurement location was also chosen as it was a safe area for the equipment to be left overnight. It had a direct line of sight to the R511 route and there were little other significant sources of noise in its vicinity. The instrument was erected close to the property fence for app. ±120 hours. Ambient sound levels measured are illustrated in Figure 8.4.19.5(a).

Table 8.4.19.5(a): Equipment used to gather data at the NSD17 (HASM01)

Equipment	Model	Serial no	Calibration
SLM	SVAN 977	34160	May 2015
Microphone	ACO Pacific 7052E	54645	May 2015
Calibrator	Quest QC-20	QOC 020005	June 2015
Weather Station	WH3081PC	-	-

* Microphone fitted with the appropriate windshield (WS-03).

Sounds heard during deployment and collection of equipment is qualified in Table 8.4.19.5(b).

Table 8.4.19.5(b): Noises/sounds heard during site visits at HASM01

Color scale to illustrate the magnitude of the sound level (subjective): **Barely Audible** **Audible** **Dominating**	**Faunal and natural sounds:**
	None detectable (likely dominated by road traffic noises and the sounds of the water sprayers).
	Residential and other anthropogenic sounds:
	There were dogs on the property with a large coop with chickens, geese and turkeys. Sounds from these sources were inaudible.
	Industries, Commercial and Road/Rail traffic sounds:
	Traffic on the R511 was the clear dominant sound, especially during the passing of vehicles. There was water sprayers operating in the agricultural fields located close to the measurement location, clearly audible and would have been dominating during periods when there were no vehicles on the R511. It was confirmed that the water sprayers were stopped at night between 8 and 10 PM.

Measured 10-minute impulse time-weighted day/night-time data: This sound descriptor is mainly used in South Africa to define sound and noise levels. L_{AIeq} values ranged from 44 to 81 dBA during the daytime period (for each 10 minute measurement or "bin") with an arithmetic average of 54 dBA. The night-time L_{AIeq} values (reference period 22:00 – 06:00) ranged from 46 to 67 dBA with an arithmetic average of 53 dBA. Equivalent (average) daytime values were 66, 60, 55, 53, 56, 56 dBA with an arithmetic average of 58 dBA. Equivalent (average) night-time values were 53, 56, 54, 54, 54 dBA with an arithmetic average of 54.1 dBA.

Measured 10-minute fast time-weighted day/night-time data: This sound descriptor is used in various international countries to set sound and noise limits. L_{AFeq} values ranged from 43 to 73 dBA during the daytime period (for each 10 minute measurement or "bin") with an arithmetic average of 56 dBA. The night-time L_{AFeq} values (reference period 22:00 – 06:00) ranged from 45 to 58 dBA with an arithmetic average of 50.8 dBA. Equivalent (average) daytime values were 59, 55, 53, 52, 54, 54 dBA with an arithmetic average of 55 dBA. Equivalent (average) night-time values were 51, 53, 52, 52, 50 dBA with an arithmetic average of 51.6 dBA.

Measured 10-minute L_{A90} day/night-time data: L_{A90} is a statistical indicator that describes the noise level that is exceeded 90% of the time in a number of international countries. Daytime values ranged from 39 to 56 dBA90 with an average of 48 dBA90. The night-time L_{A90} values ranged from 40 to 53 dBA (night-time reference period 22:00 – 06:00) with the night-time average 45 dBA. Measured L_{A90} data indicated that there are consistent background ambient sounds in the study area during all hours at this receptor.

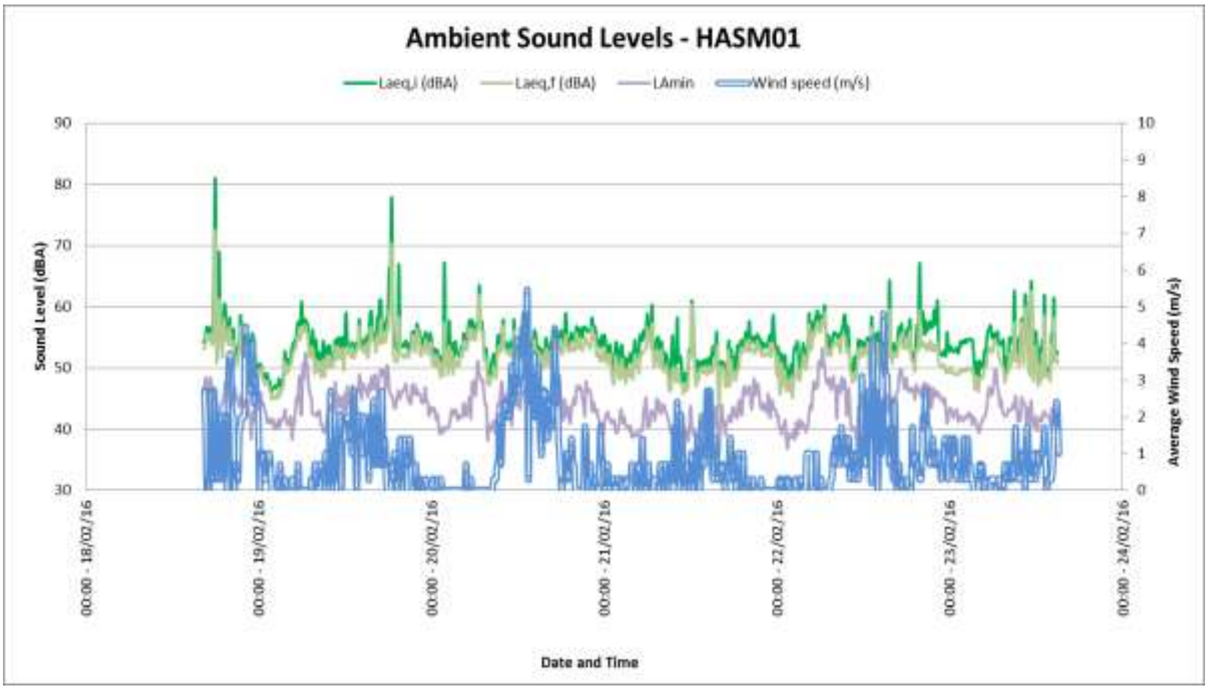


Figure 8.4.19.5(a): Ambient Sound Levels at HASM01 (18th – 23rd February 2016)

Third octave spectral analysis: Third octaves at this monitoring point were measured and are displayed in Figures 8.4.19.5(b), 8.4.19.5(c), 8.4.19.5(d) and 8.4.19.5(e).

Lower frequency (20 – 250 Hz) – Noise sources of significance contributing to this frequency band would include nature (especially wind) and sounds of anthropogenic origin (especially vehicles). Lower frequencies can travel further through the atmosphere than higher frequencies. Most of the measurements reflected higher acoustic energy in these frequency bands than a more "natural" area. The dominant day and night-time sound source were engine revolutions. While there may have been other sounds they were generally masked by sounds road traffic. The third night (and part of the third day) indicated a significant peak at 200 Hz, although the source is unknown. The peak at around 63 Hz (3rd octave sound levels between 50 and 60 dB) relates to vehicles accelerating from stationary to travelling speed (from the stop sign).

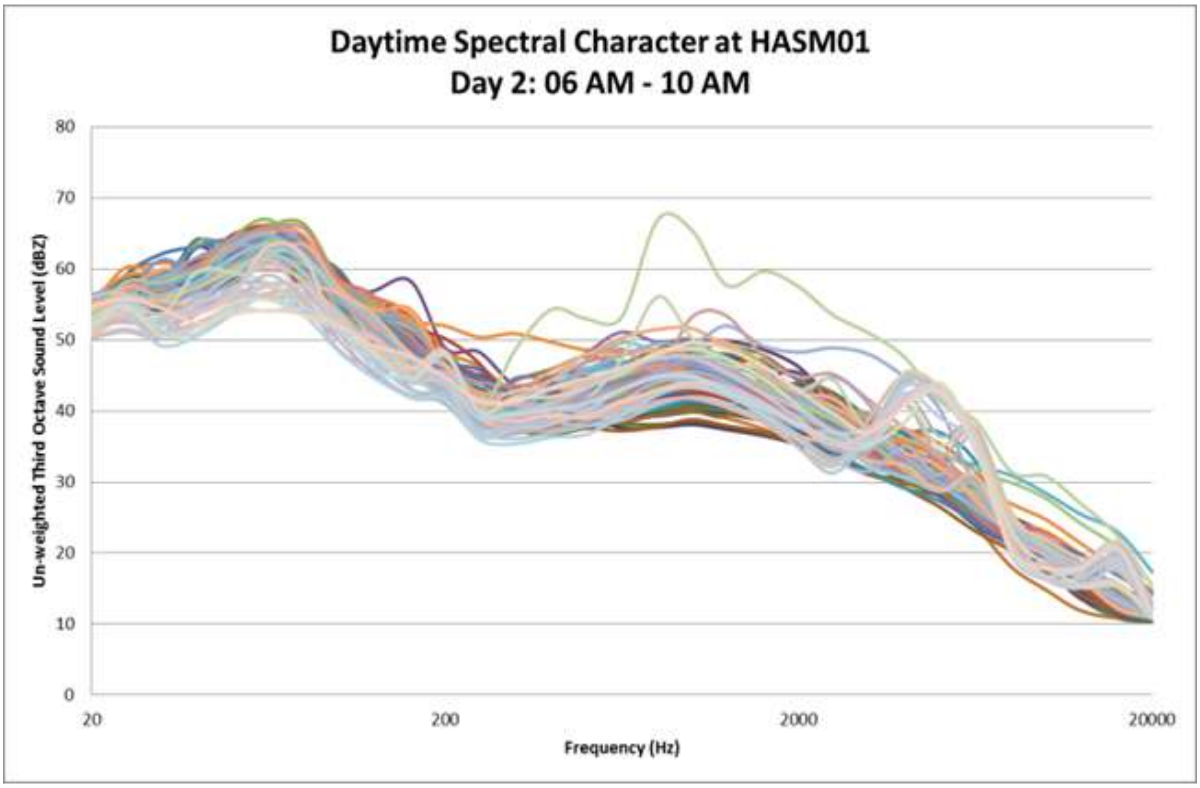


Figure 8.4.19.5(b): Spectral character at HASM01: 19 February 2016

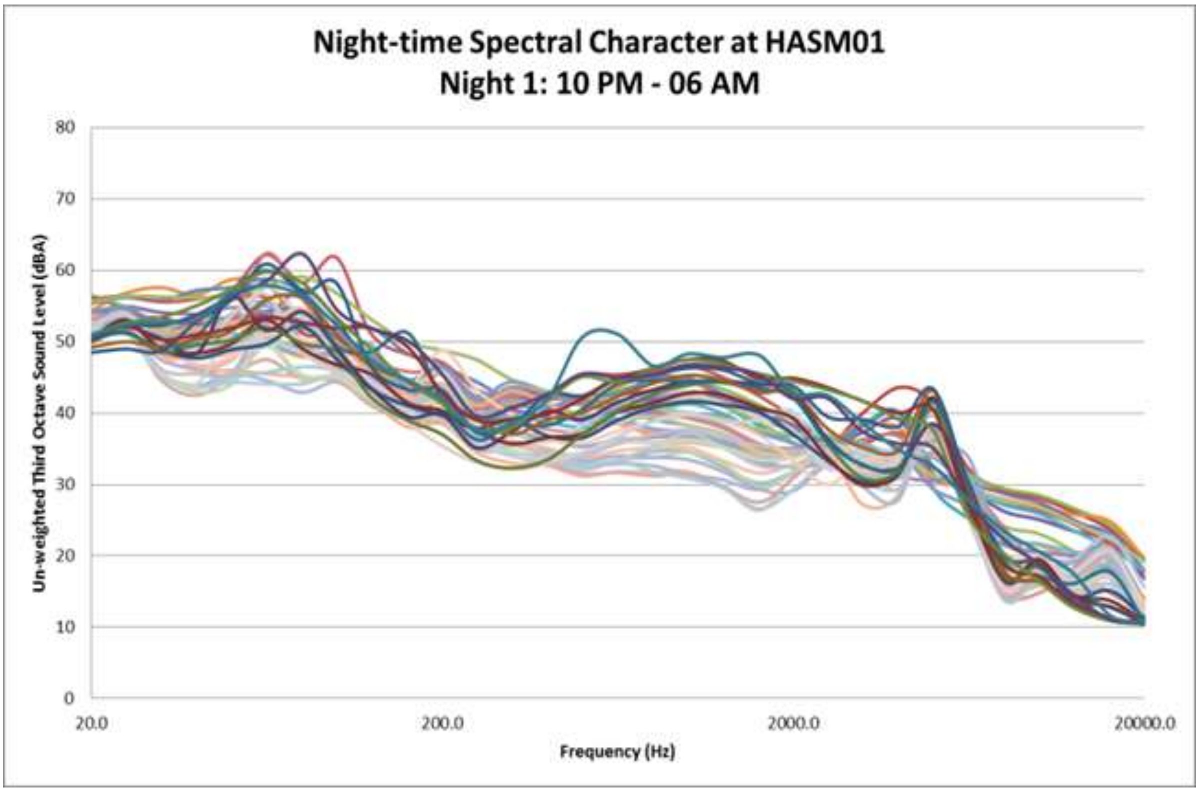


Figure 8.4.19.5(c): Spectral character at HASM01: 18 to 19 February 2016

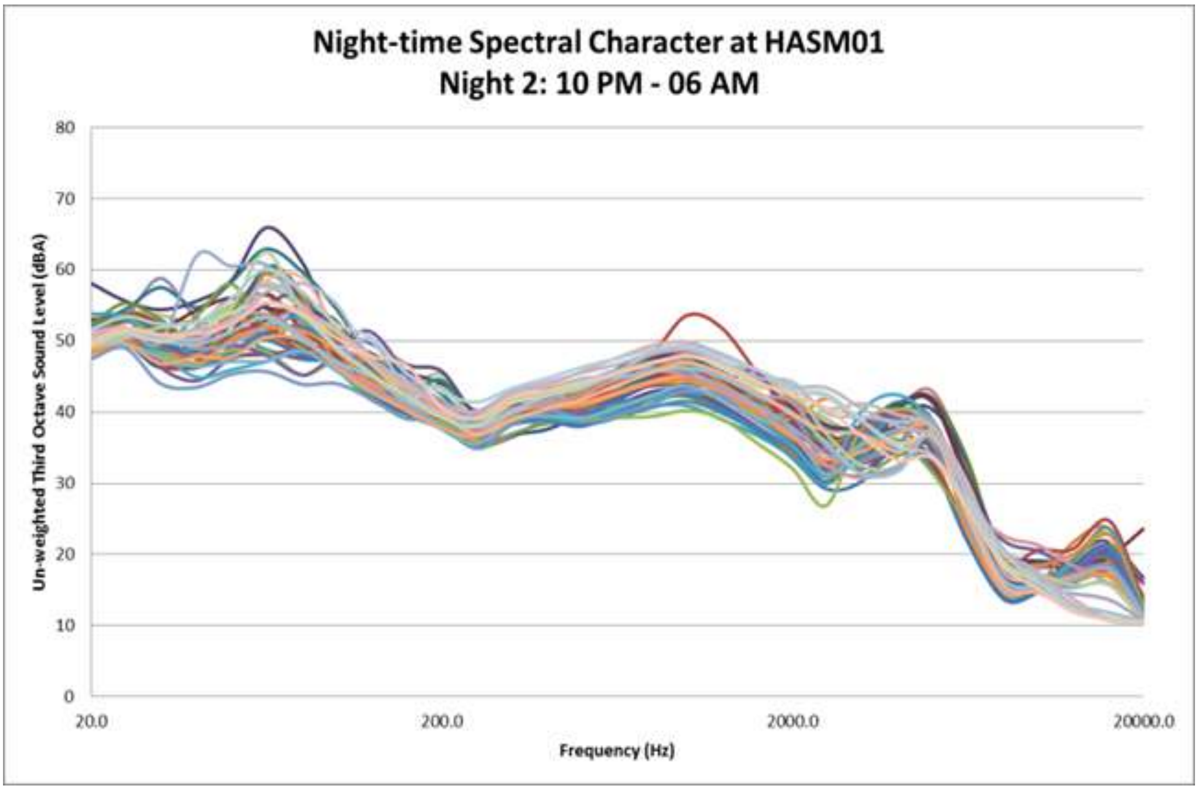


Figure 8.4.19.5(d): Spectral character at HASM01: 19 to 20 February 2016

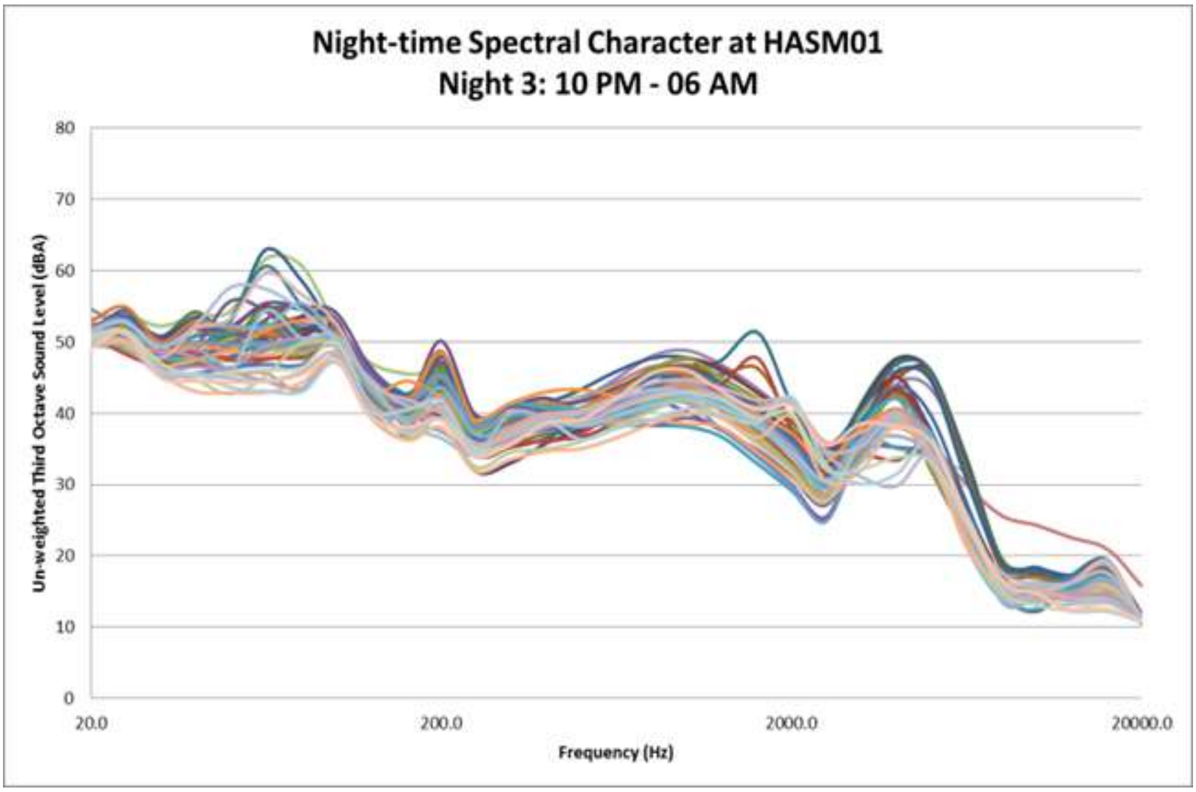


Figure 8.4.19.5(e): Spectral character at HASM01: 20 to 21 February 2016

<u>Third octave surrounding the 1000 Hz</u> – This range contains energy mostly associated with human speech (350 Hz – 2500 Hz; mostly below 1,000 Hz) and dwelling related noises (radios and TV's playing, people working, voices etc.). There is consistent acoustic energy in the 1,000Hz frequency band, likely relating to road noises (road-tyre interaction).

<u>Higher frequency (2,000 Hz upwards)</u> – Smaller faunal species such as birds, crickets and cicada use this range to communicate and hunt etc. Some peaks (peaks at 4,000 and 5,000 Hz) were observed in this frequency range (mainly evenings and at night) that could be contributed to faunal species such as bird song or cicada communications.

Spectral data analysis indicates that the R511 is the dominant noise source in the area.

L_{Amax} night-time occurrences: There were numerous sound events where the noise level exceeded 65dBA at night (at least 95 instances out of 240 night-time 10-minute measurements). Maximum noise events may affect sleeping patterns in humans.[1]

SANS 10103:2008 Rating Levels: Considering the data collected, the SANS 10103:2008 sound district could be typical of a *"Central Business District"* (65/55 dBA day/night rating). The measured $L_{Aeq,f}$ levels during the day and night does not conform to the recommendation of 55 and 45 dBA respectively of the World Health Organization, World Bank and International Finance Corporation guidelines for residential areas.

[1] World Health Organization, 2009, *'Night Noise Guidelines for Europe.*

8.4.19.6. Measurement Point HASM02 (NSD16 – Mr. Gunther Jacobs)

Ambient sound levels were measured at this location from 26th February – 3rd March 2016. This measurement location is located in an open area just north of the house with a clear line of sight to the N4 road. The sound character was dominated by sounds from the N4 road. While it may have been present, natural sounds were not observed (likely masked by road noises). Equipment used to gather data is presented in Table 8.4.19.6(a). Measured data is presented in Figure 8.4.19.6(a) (A-weighted, impulse).

Table 8.4.19.6(a): Equipment used to gather data at HASM02

Equipment	Model	Serial no	Calibration
SLM	Svan 955	27637	November 2014
Microphone	ACO 7052E	52437	November 2014
Calibrator	Quest QC-20	QOC 020005	June 2015
Weather Station	WH3081PC	-	-

* Microphone fitted with the appropriate windshield (WS-03).

Sounds heard during deployment and collection of equipment is presented below.

Table 8.4.19.6(b): Noises/sounds heard during site visits at HASM02

Color scale to illustrate the magnitude of the sound level (subjective): Barely Audible, Audible, Dominating	**Faunal and Natural sounds:**
	None audible (faunal and natural sounds likely softer than road traffic noises and therefore dominated by road traffic noises and the sounds of the water sprayers).
	Residential and other Anthropogenic sounds:
	There were dogs on the property although they were quiet during the 10 times the author was on the site.
	Industries, Commercial and Road/Rail traffic sounds:
	Traffic on the N4 was the dominant sound, especially during the passing of vehicles.

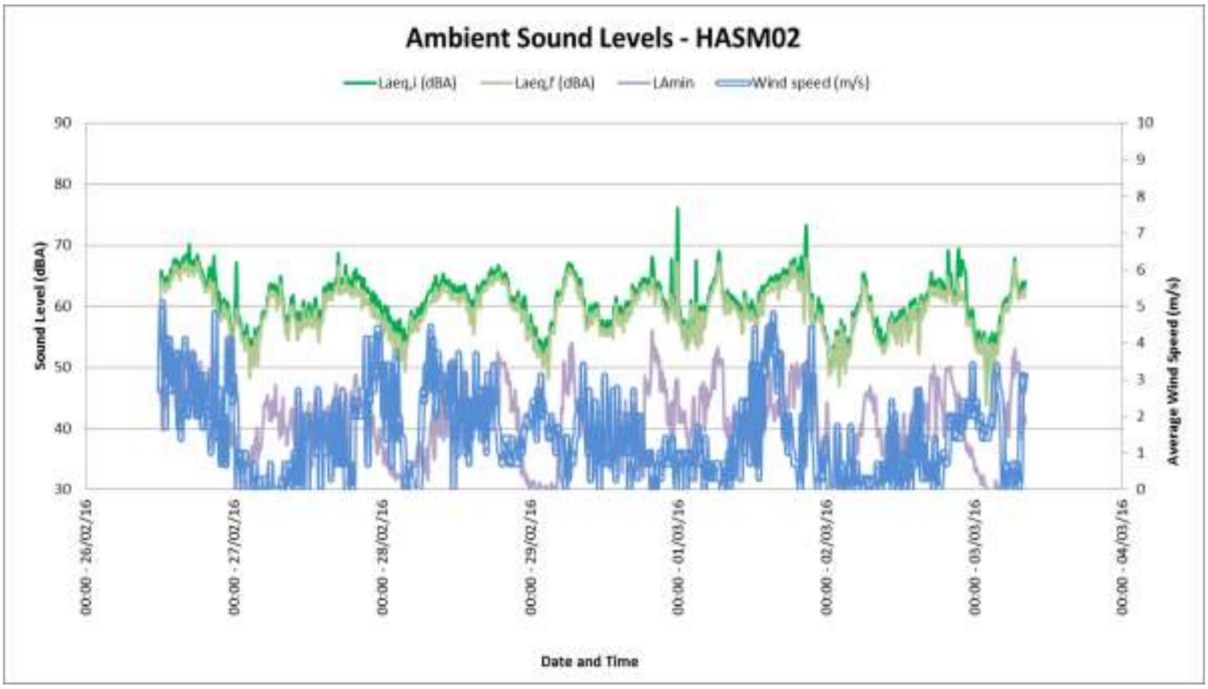


Figure 8.4.19.6(a): Ambient Sound Levels at HASM02 (25th – 26th March)

Measured 10-minute impulse time-weighted day/night-time data: This sound descriptor is mainly used in South Africa to define sound and noise levels. $\mathbf{L_{AIeq}}$ values ranged from 54 to 73 dBA during the daytime period (for each 10 minute measurement or "bin") with an arithmetic average of 62 dBA. The night-time L_{AIeq} values (reference period 22:00 – 06:00) ranged from 48 to 76 dBA with an arithmetic average of 58 dBA. Equivalent (average) daytime values were 66, 62, 63, 62, 64, 59 and 61 dBA with an arithmetic average of 63 dBA. Equivalent (average) night-time values were 59, 58, 60, 63, 58 and 59 dBA with an arithmetic average of 60 dBA.

Measured 10-minute fast time-weighted day/night-time data: This sound descriptor is used in various international countries to set sound and noise limits. L_{AFeq} values ranged from 52 to 68 dBA during the daytime period (for each 10 minute measurement or "bin") with an arithmetic average of 61 dBA. The night-time L_{AFeq} values (reference period 22:00 – 06:00) ranged from 47 to 67 dBA with an arithmetic average of 56 dBA. Equivalent (average) daytime values were 65, 61, 62, 61, 63, 58 and 60 dBA with an arithmetic average of 61 dBA. Equivalent (average) night-time values were 57, 57, 58, 59, 56 and 57 dBA with an arithmetic average of 57 dBA.

Measured 10-minute $\mathbf{L_{A90}}$ day/night-time data: $\mathbf{L_{A90}}$ is a statistical indicator that describes the noise level that is exceeded 90% of the time (used in a number of international countries). Daytime values ranged from 38 to 62 dBA90 with an average of 51 dBA90. The night-time L_{A90} values ranged from 28 to 57 dBA (night-time reference period 22:00 – 06:00) with the night-time average 41 dBA. Measured L_{A90} data indicated that there are consistent background ambient sounds in the study area during all hours at this receptor, although the site appears quieter at night then measurement location HASM01.

$\mathbf{L_{AIeq}}$ - $\mathbf{L_{AFeq}}$ average difference, day/night-time: The average difference between the L_{AIeq} and L_{AFeq} variables was less than two for both the day and night-time. There are little impulsive sounds in this area.

Third octave spectral analysis:

Third octaves were measured and are displayed in Figure 8.4.19.6(b), 8.4.19.6(c), 8.4.19.6(d) and 8.4.19.6(e),

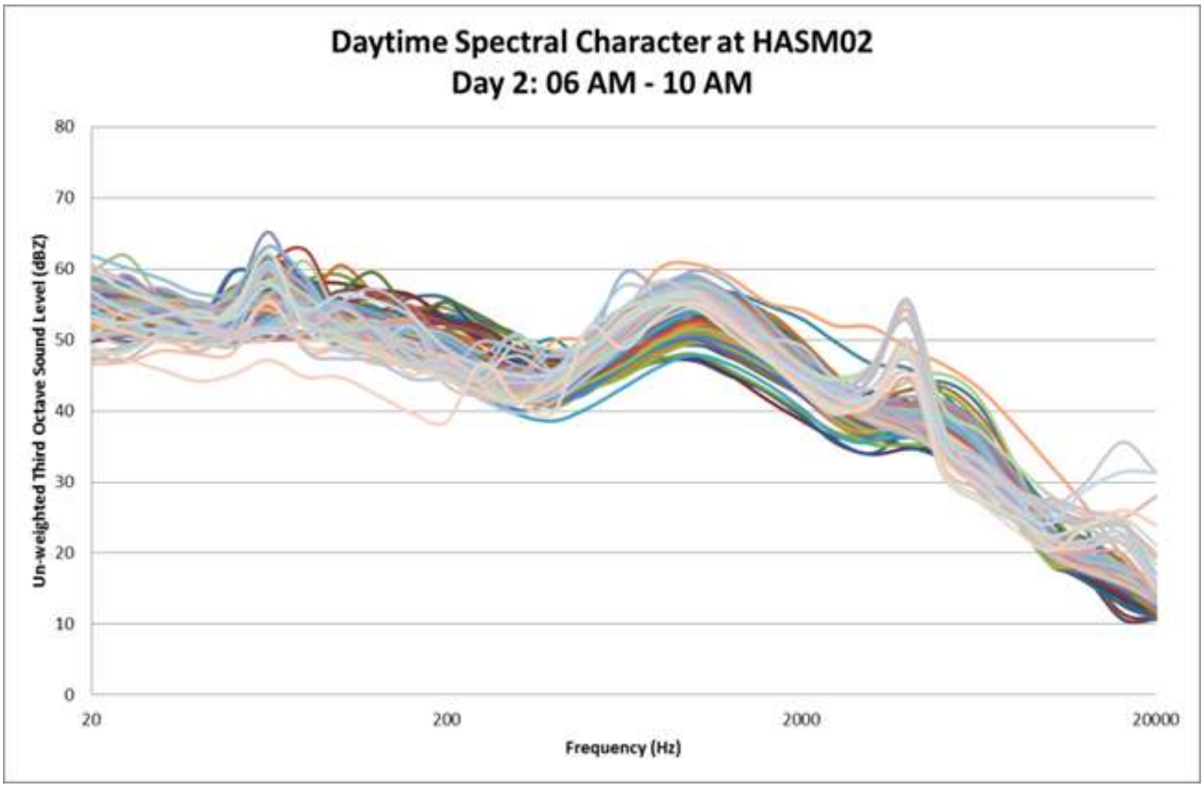


Figure 8.4.19.6(b): **Spectral caharcterHASMO2 (27 th February 2016)**

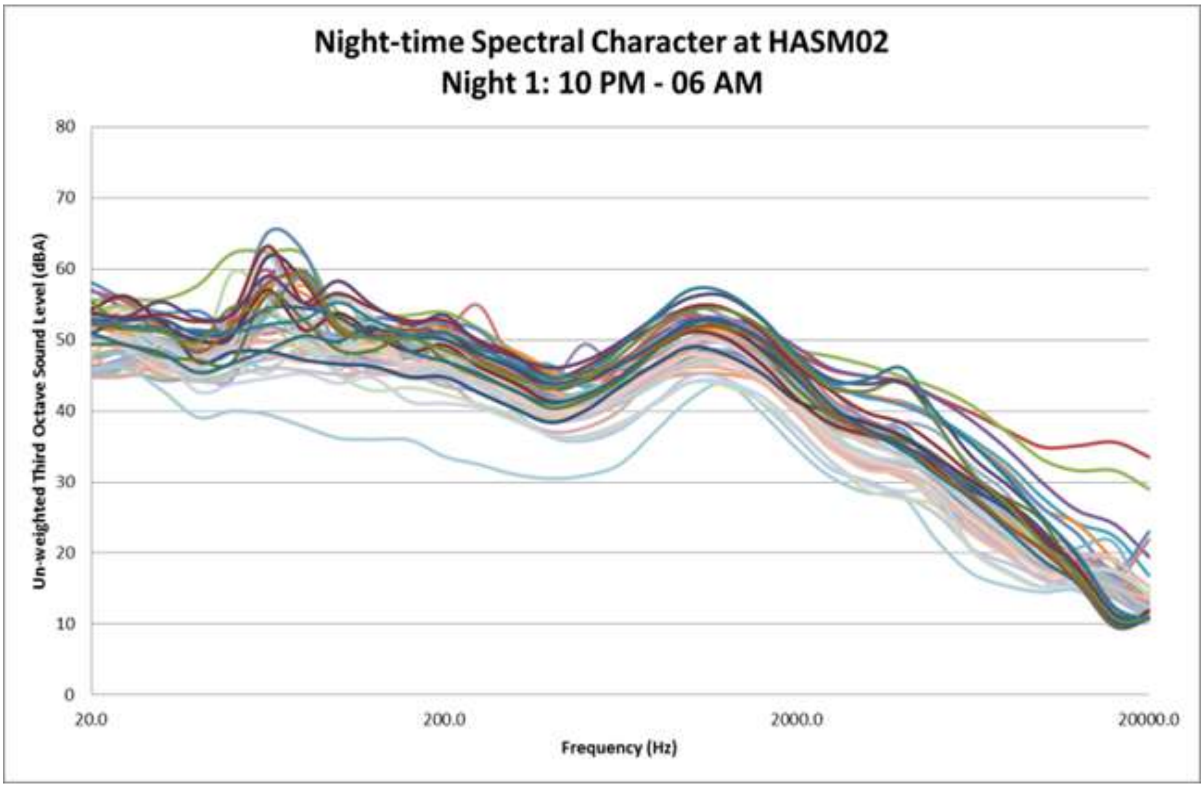


Figure 8.4.19.6(c): **Spectral caharcterHASMO2 (26 th to 27 th February 2016)**

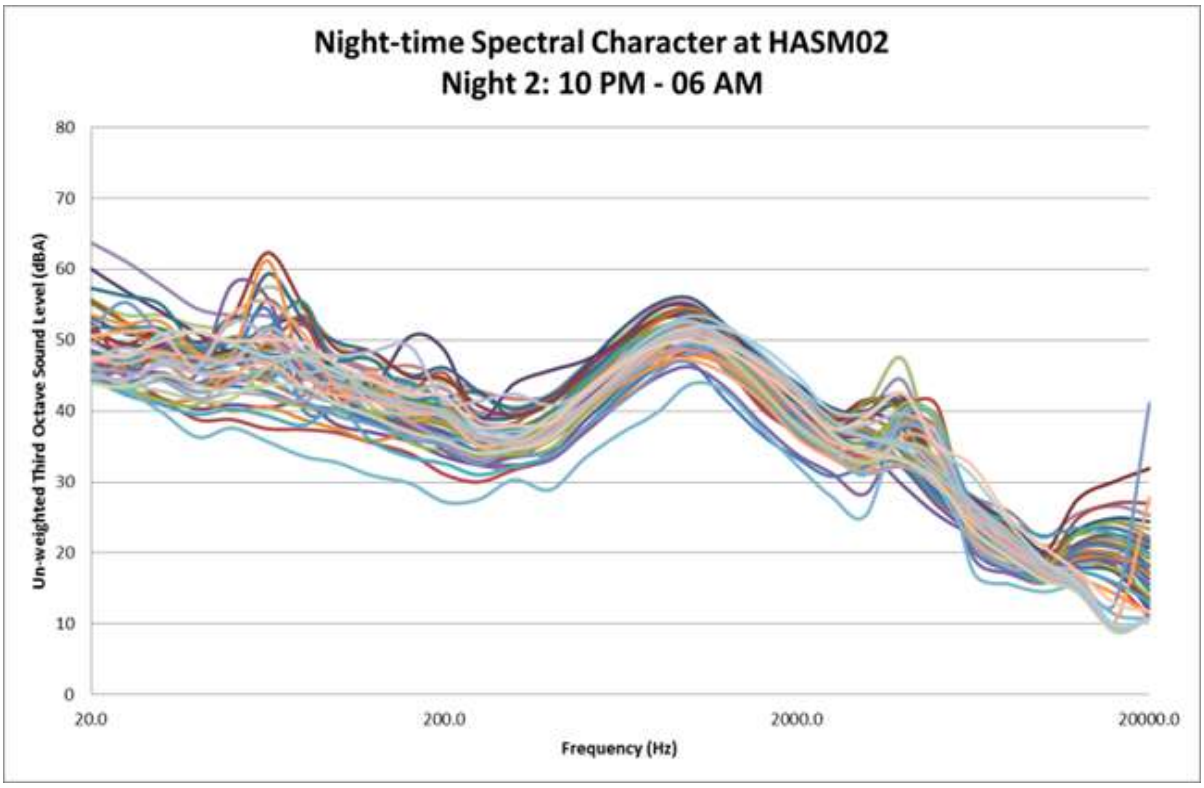


Figure 8.4.19.6(d): **Spectral caharcterHASMO2 (27 th to 28 th February 2016)**

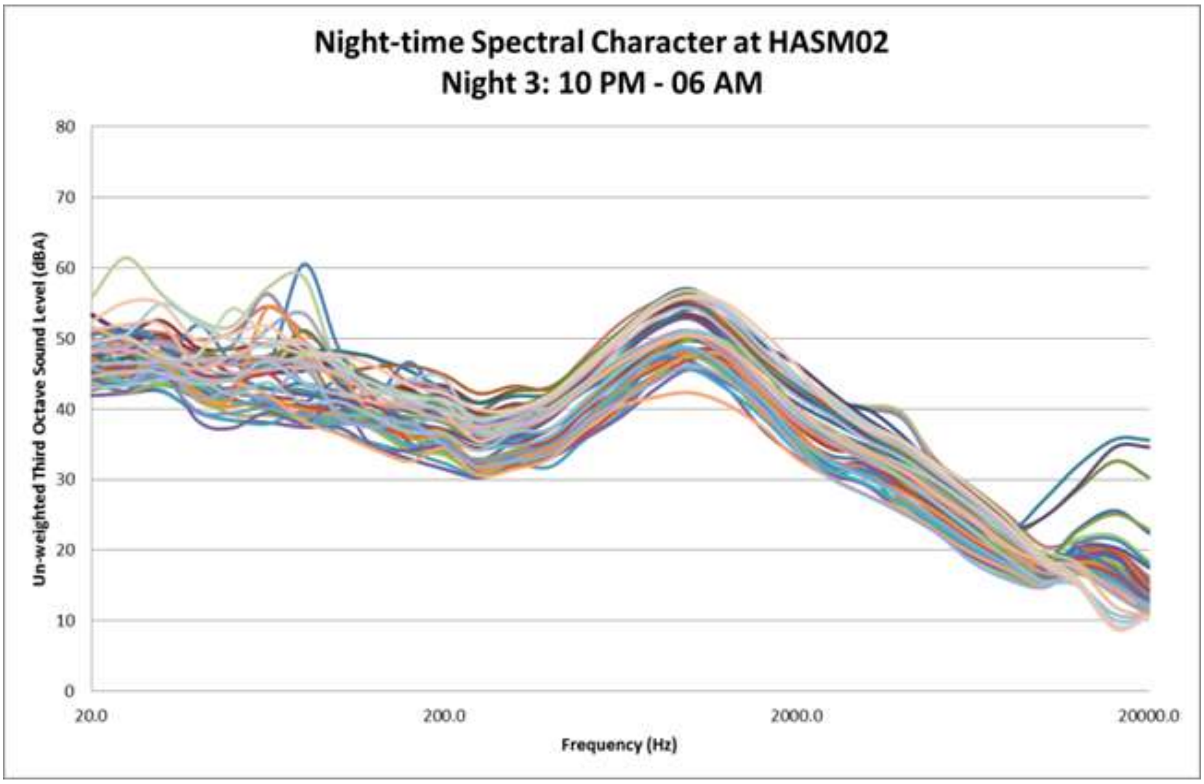


Figure 8.4.19.6(e): **Spectral caharcterHASMO2 (28 th to 29 th February 2016)**

<u>Lower frequency (20 – 250 Hz)</u> – Noise sources of significance in this frequency band would include nature (wind especially) and sounds of anthropogenic origin, especially vehicles. Lower frequencies can travel further through the atmosphere than higher frequencies. Most of the measurements reflect significant acoustic energy in these frequency bands, likely relating to traffic on the N4 (reflecting engine revolutions between 1200 and 4000 rpm).

<u>Third octave surrounding the 1000 Hz</u> – This range contains energy mostly associated with human speech (350 Hz – 2500 Hz; mostly below 1,000 Hz) and dwelling noises. A fair amount of acoustic energy was measured at this range with a distinctive peak between 500 – 2,500 Hz for most measurements (both night and day). Because this peak can be identified with almost all the measurements, including the typical quiet night-time period, it is likely that this relates to the traffic on the N4 road (road-tyre interaction due to higher road speeds).

<u>Higher frequency (2,000 Hz upwards)</u> – Smaller faunal species such as birds, crickets and cicada use this range to communicate and hunt etc. There are evidence of some communication, especially in the 4,000 and 12,500 – 20,000 Hz bands. These were low compared to a quiet rural area.

Spectral data analysis concludes a noisy area with road noises that dominates the soundscape.

L_{Amax} night-time occurrences: Numerous instantaneous noise events occurred in the area during night-time measurement hours (almost all measurements indicated an event at night where noise levels exceeded 65 dBA). These could likely be attributed to noises on the N4 road. Maximum noise events may affect sleeping patterns in humans.[2]

SANS 10103 Rating Level: Measured data indicate sound levels typical of an industrial area with rating levels of 70/60 dBA (day/night). The measured L_{AFeq} levels during the day and night does not conform to the recommendation of 55 and 45 dBA respectively of the World Health Organization, World Bank and International Finance Corporation guidelines for residential areas.

[2] World Health Organization, 2009, '*Night Noise Guidelines for Europe.*

8.4.19.7. Single Measurements –Boundary of HERNIC Smelter

A number of single measurements were collected to gauge the noise levels from the plant at the boundary of the operation. Due to the variability of the sound levels as traffic passed, some measurements were collected over a shorter time period. A summary of the outcomes of the Singular noise Measurements is given in Table 8.4.19.7(a)

Table 8.4.19.7(a): Summary of Singular Noise Measurements

Measurement Lcation	Number of Measurements	Duration of each Measurement	Average Noise Level (range)	Comments
HNM0501	10	60 s	60 dBA (58 – 62 dBA)	Crusher. Various fans and other sounds. LDV idling last few measurements though did not appear to influence measurements.
HNM0502	10	60 s	52 dBA (52 – 53 dBA)	Frogs. Crickets dominating. Fans and crushers and reverse alarms from HERNIC. Fan in area. Birds at times. Sounds from HERNIC clear and constant background.
HNM0503	10	60 s	52 dBA (50 – 53 dBA)	Sounds from HERNIC clear, almost dominant noise. Frogs and other insects very audible.
HNM0504	10	60 s	62 dBA (61 – 64 dBA)	Crusher dominating. Material falling on stockpiles. Sounds of vehicles moving around. Reverse alarms. Fans from smelter area audible.
HNM0505	1	20 s	63 dBA	Product crusher dominating sound. Numerous measurements collected but traffic on the R511 made measurements difficult. Only one measurement not influenced by traffic noise.
HNM1101	10	60 s	58 dBA (56 – 60 dBA)	100m from elevated tip. Wind blowing at 3 m/s towards tip from mic. Truck clearly audible at times upwind from mic.
HNM1102	20	30 s	76 dBA (80 – 72 dBA)	Between tip and conveyor exit. Secondary crusher is close by and audible. Light westerly wind.
HNM1103(a)	23 (around 47 total, crusher not operational for measurements)	30 s	73 dBA (71 – 75 dBA)	Close to secondary crusher. First few measurements only tip crusher operational. Measurement 8 onwards sec crushers start to operate but not crushing stone. Conveyor alarm during measurement 23 (for 10 s in 23).
HNM1103(b)	21 (around 47 total, crusher operational for last few measurements)	30 s	84 dBA (80 – 86 dBA)	Sec crusher fully operational measurement from 25 onward although quiet for short periods at times. Alarm again at end of measurement 41. Fully operational from measurement 44.
HNM1104	11	20 s	66 dBA (63 – 71 dBA)	Other side of berm. No line of sight to crusher and equipment but can see flare from furnace. Truck passing measurement 9.
HNM1105	15	20 s	71 dBA (70 – 72 dBA)	Line of sight to product crusher. Not operational. Vibrating screen operational.
HNM1106	16	20 s	62 dBA (50 – 77 dBA)	Crusher at material tip dominating. Material falling on stockpiles. Sounds of vehicles moving around. Reverse alarms. Fans from smelter area audible.
HNM1108	25	20 s	74 dBA (72 – 76 dBA)	Product crusher. Product tip shielding the effect of the crusher at this point.
HNM1109	74	20 s	78 dBA (77 – 80 dBA)	Final product crusher dominates although Front End Loader moving material around are audible.
HNM1110	36	20 s	61 dBA (51 – 72 dBA)	Product crusher operational. 13 and 14 crusher and clean. 25 - 31 clean.

Contours of constant noise levels will be developed for the HERNIC operation during the EIA phase. The data will be used to calibrate the model to improve its accuracy.

8.4.19.8. Baseline Findings

The ambient sound measurements indicated that the ambient sound environment is noisy, especially closer to the mining activities, the R511 and the N4 roads. Sounds close to the routes is dominated by traffic noises, with various activities at the HERNIC operation impacting on the soundscape around that operation.

Sound measurements further confirmed that there are a number of activities at the operation that is impacting on the sound environment in the area. Noises unrelated to the HERNIC operation are associated with traffic on the R511 and N4 roads.

8.4.20. Visual Environment

The relevant Specialist Report is:

Visual Aspects Specialist Study Report, HERNIC Ferrochrome (Pty) Ltd, April 2016. Studio IWM Architects (Pty) Ltd.

8.4.20.1. Project Background

HERNIC FERROCHROME (here after referred to as HERNIC) wishes to add/expand/upgrade activities to their current mining and smelting operations which require Environmental Authorization in terms of the provisions of the Mineral and Petroleum Resources Development Act (MPRDA), the National Environmental Management Act (NEMA), the National Environmental Management: Waste Act (NEMWA), as well as the National Water Act (NWA).

It is to be expected that any mining activity will have some form of visual impact and therefore JMA Consulting (Pty) Ltd, whom was appointed as the Environmental Assessment Practitioner (EAP) on the project, contracted Studio IMW Architects (Pty) Ltd to conduct a Visual Impact Assessment (VIA) in support of the required amendment to the EMPR for Hernic Ferrochrome.

The VIA represents a Social Component within the holistic realm of EIA components and must as such be integrated with the Biophysical and Economic components of the studies done.

The specific deliverables of the Baseline component of the VIA includes:

- The performance of a Contextual Analyses.
- The performance of a View Shed Analyses.
- The performance of a current status Photographic Assessment.
- A description of the Visual Base Line (current) Conditions.

HERNIC is located in a semi-rural setting. Due to the nature and extent of the mining activities, a degree of visual impact will occur, affecting observers in the vicinity of the site. It is the aim of this Visual Impact Assessment (VIA) to determine the extent and significance of the visual impact, and if negative and possible, methods to mitigate these effects.

Using the information generated during the compilation of a contextual analysis, view shed analyses and a photographic assessment, a comprehensive base line description was compiled in order to establish the current visual conditions in the area where the proposed development will occur. This is required to serve as "base line" against which to assess any changes that the development will have on visual aspects as well as against which to evaluate any future complaints received from the public once the project gets underway.

8.4.20.2. Project Aspects Relevant To Visuals

HERNIC has been in operation since May 1996. The Operations, which expanded over the years, comprise both mining of Chromite Ore (initially opencast and then later from underground), ore beneficiation to yield feedstock chromite concentrate and lumpy ore, followed by pelletizing and sintering of the fine ore and finally Ferrochrome Smelting in four closed Furnaces, with an annual production capacity of 420 000 tonnes of ferrochrome. Several chrome recovery operations from chromite containing slag are also active on the site.

HERNIC is currently in the process of planning the upgrading and refining of various management measures as relating to waste and water management. In this regard projects are being designed to cater for inter alia:

- The final rehabilitation and closure of two Historic Slimes Dams on site.
- The final rehabilitation and closure of an existing Hazardous Waste Disposal Facility on site.
- The upgrading of Storm Water Management Measures on site.
- The upgrading of Process Water Management Measures on site.
- The development of a new Salvage Yard on site.
- The Expansion of the OB Plant Tailings Storage Facility

8.4.20.3. Project Infrastructure and Layout

The current and proposed project infrastructure that will have an impact on the Visual Assessment can be set into three categories:

- Infrastructure, elements or activities that generate dust or hosts activities that generate dust, visible from close, medium or long range views.
- Infrastructure that creates Stack Emissions visible from close, medium or long range views.
- Infrastructure that has a physical size or height as to create a Visual Intrusion in the landscape. Thus these elements are highly visible from close, medium and long range views.

Category 1 can further be sub-divided as follows:

- Infrastructure hosting activities that generate dust, such as Crushing and Screening Operations. Activities that generate dust from moving vehicles.
- Elements that generate windblown dust such as dumps and stockpiles.

8.4.20.4. Site Sensitivity

From a visual perspective, the site sensitivity will be discussed with reference to the following aspects:

- Landscape Visual Quality.
- Visual Character.

In Conclusion: The Site Sensitivity is Low, due to the fact that neither the current Operation of HERNIC, nor the proposed new upgrades will have an extreme Visual Impact, as the Landscape Visual Quality and the Landscape Visual Character is already typically mining in character with occurred human intervention. This however does not conclude that no visual mitigation should be done and suggestions will be made to improve the Visual Aspects of HERNIC.

8.4.20.5. Fatal Flaw Assessment

A detailed photographic survey was done of the study site and adjacent areas from numerous surrounding vantage points. After the study survey an assessment was done and the conclusion was reached that there are no fatal flaws regarding the visual impacts.

8.4.20.6. Contextual Analysis

A contextual analysis was performed in order to establish the visual character “base line” for the site.

Location

The HERNIC site falls within the Madibeng Local Municipality which is located within the Bojanala District Municipality of the North-West Province of the Republic of South Africa The central coordinates of the site are 25°39'40.80"S and 27°50'26.51"E (WGS84).

Figure 8.4.20.6(a): The HERNIC Site indicated near the Town of Brits located within the Bojanala Region, North-West.

Economy

Although the North-West province has many tourism attractions the mainstay of the economy of the province is mining, which generates more than half of the province's gross domestic product and provides jobs for a quarter of its workforce.

Vegetation And Topography

HERNIC and its surrounds are located within the Savannah Biome. The vegetation of the Bojanala-Rustenburg region can be described as covered in natural bushveld vegetation and the topography as mountainous.

Near Vicinity Land Use

Currently the land use located in the near vicinity of the site is predominantly:

- Agricultural,
- Rural and Informal settlements,
- Farms/Small Holdings,
- Residential, Commercial and Industrial (Town of Brits),
- Interspersed Mining activities.

HERNIC is compatible with the near vicinity land use of the area and will be assessed as such. As can clearly be seen, HERNIC is only one of many mining activities in the area.

8.4.20.7. Visibility Analysis

Where views are not obstructed by nearby objects, the existing HERNIC mining/industrial complex draws the observer's attention. Part of the Operation's infrastructure is furnaces, which is the highest vertical objects in the Plant Management Area. These elements are the most visible elements of HERNIC. If not for the setting of the site, within an active mining area, in a mountainous area with rich natural vegetation, this element would probably have been a short/medium-range visual concern. But in this instance, considering the setting of the site, the visual intrusion becomes moderate and acceptable.

The visual impact of the site, on the settlements in near vicinity of the site is moderate, but little or no measures can be taken to improve this. The fact that HERNIC is viewed against the backdrop of hills contributes to camouflage it, and the vegetation blocking many close, medium and long range views, helps to make it becomes visually acceptable.

During the topographical assessment of the sites, surface contours were generated over 5 meter intervals. The 5m surface elevation contour data was then used to create maps representing the surface topography of the study area. The 5m surface elevation contour data was further used to create a view-shed analysis of the surface topography of the area in which the sites are located.

View Shed Analysis

A view shed analysis was performed prior to the site specific photographic analysis in order to determine the visibility of the site from priority access points/routes such as public roads and community settlements.

The analysis was performed with SURFER, creating a 3-dimensional topographical contour map (Figure 8.4.20.7(a)), using the 1:50 000 published DTM information obtained from the Surveyor General and ARCVIEW creating the 2-dimesional View-Shed map (Figure 8.4.20.7(b)).

The view-shed analysis represented in Figure 8.4.20.7(b) indicates the visibility of the site from all areas shown as green, and non-visibility from all areas shown in purple. It is however important to note here that the view-shed analysis is based entirely on the surface elevation data obtained from the 5m contours and does not take vegetation or surface infrastructure into consideration.

The resulting maps provided a sound basis from which to assess potential vantage points to the sites and on which to base planning for the photographic assessment.

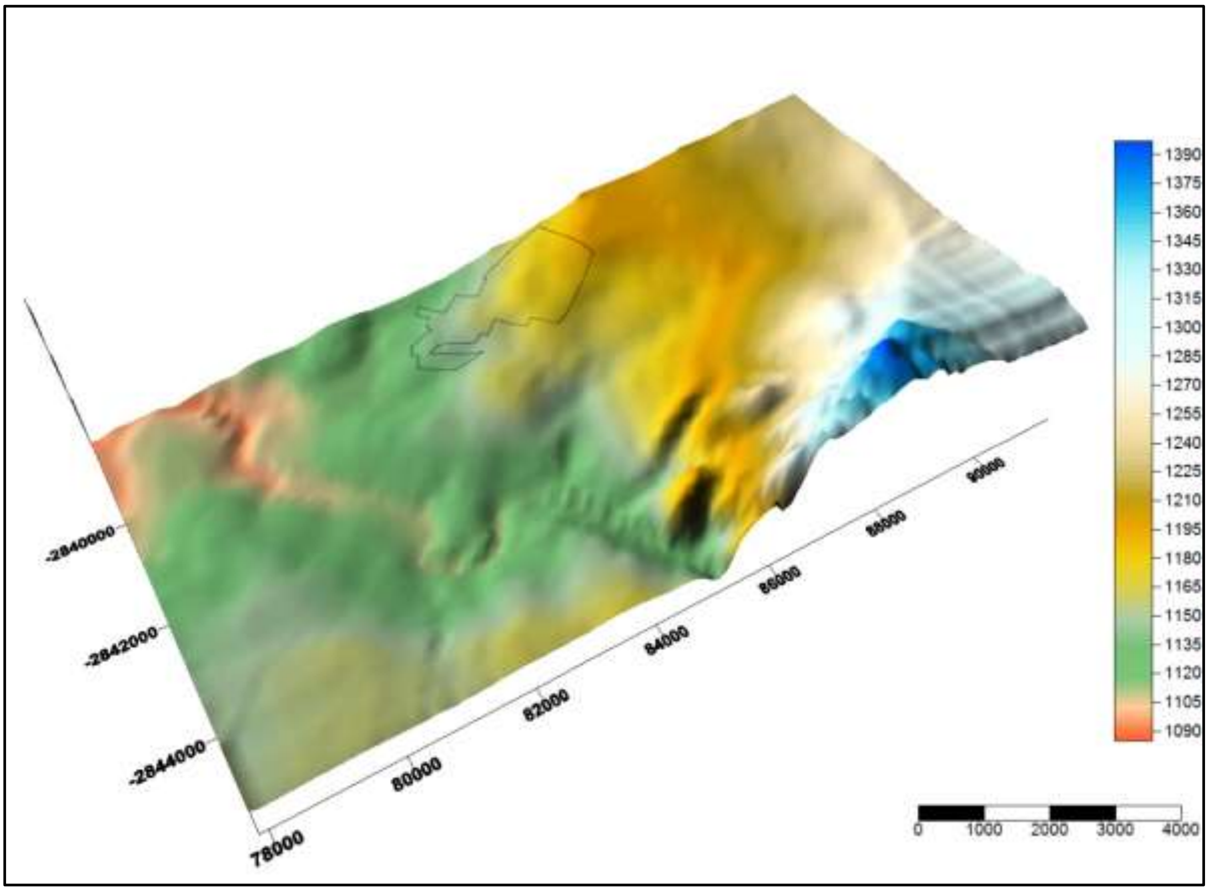


Figure 8.4.20.7(a): Three Dimensional Regional Relief Map of the HERNIC Area

Visibility Range of Proposed Sites

Due to the vegetation (a grassy ground layer and a distinct upper layer of woody plants ranging from 3 m to 7 m high) and the topography (mountainous) associated with the area in which HERNIC is located a restricted visibility range is created. The hills cause a restricted visibility range when on lower ground, resulting in short range views of physical objects, but when standing on higher ground though, long range views to the site are the result.

<u>**In conclusion:** after visiting the sites, and selecting the View Points for the photographical survey along public roads and from rural- and informal settlements surrounding the sites, it was observed that although there are some long range views to HERNIC, the true visibility of the sites are more restricted than indicated on the View Shed Analysis, because of the vegetation and infrastructure.</u>

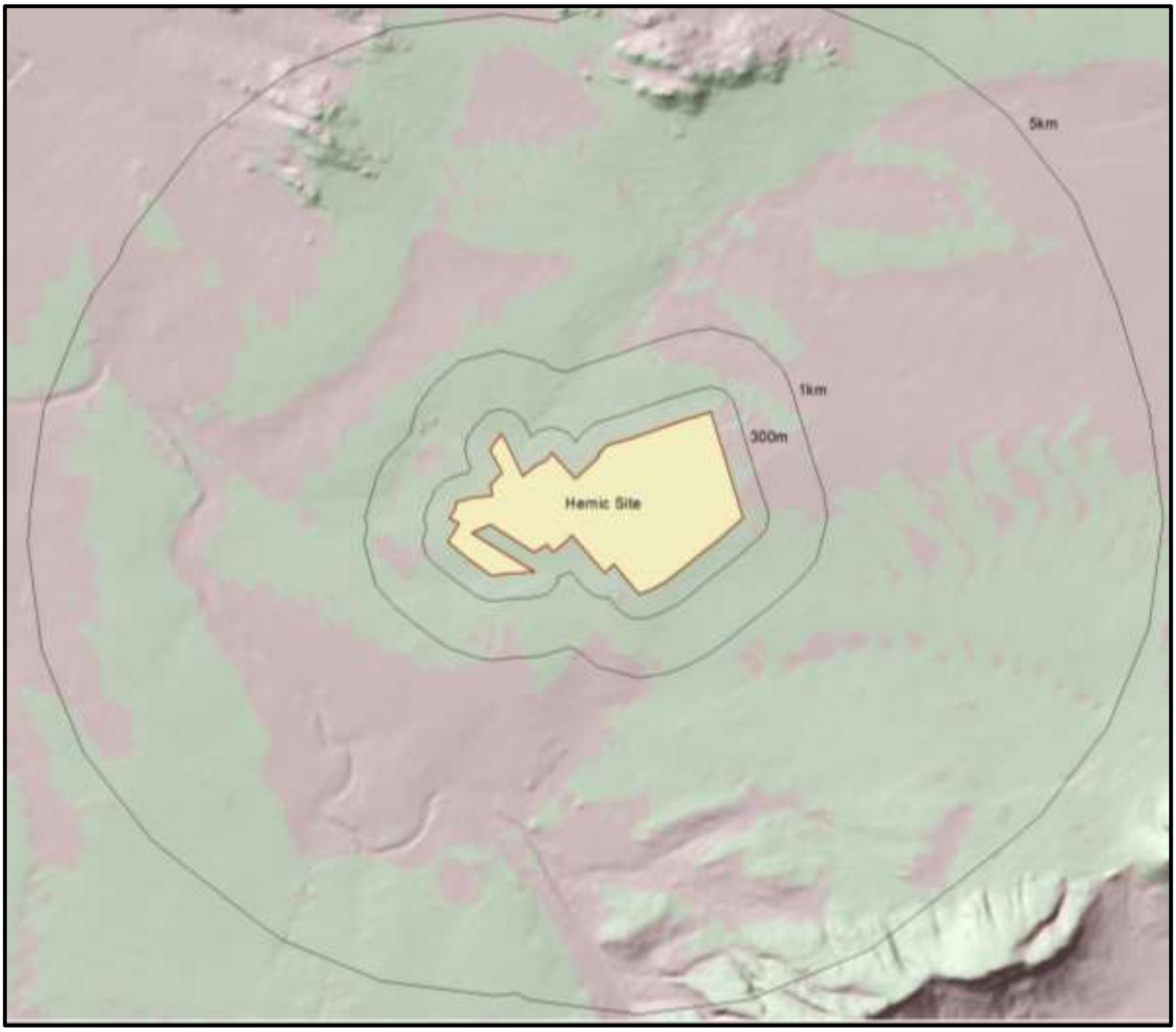


Figure 8.4.20.7(b): View Shed Map (HERNIC visible from within the green areas)

Photographic Assessment

A detailed photographic survey was done of the study site and adjacent areas from numerous surrounding vantage points shown in Figure 8.4.20.7(c). The photographic compilations are produced in 2D by taking a series of photographs of a 3D environment. These are used to complete a view of the study area. This is done to give a clearer indication of the visual nature of the areas that will visually be affected by the activities, which will in turn aid in the design and installation of visual mitigation measures.

The photographic assessment proves support of the mentioned visibility range of the HERNIC sites. The assessment distinguishes between long-, medium- and short range views as well as highly-, slightly-, and not-visible views. Also indicated on the map in Figure 8.4.20.7(c) are several buffers. Within and on the 300 meter buffer around the sites, the vantage points will be Short Range Views. Within and on the 1 km buffer around the sites, the vantage points will be Medium Range Views. Further than that, all vantage points will be Long Range Views.

To avoid clustering of data and information, the photographic assessment is presented at the hand of 14 photographic compilations. An example of such a compilation is shown in Figure 8.4.20.7(d).

Figure 8.4.20.7(c): **Map of HERNIC and Vantage Points from which Photographs were taken**

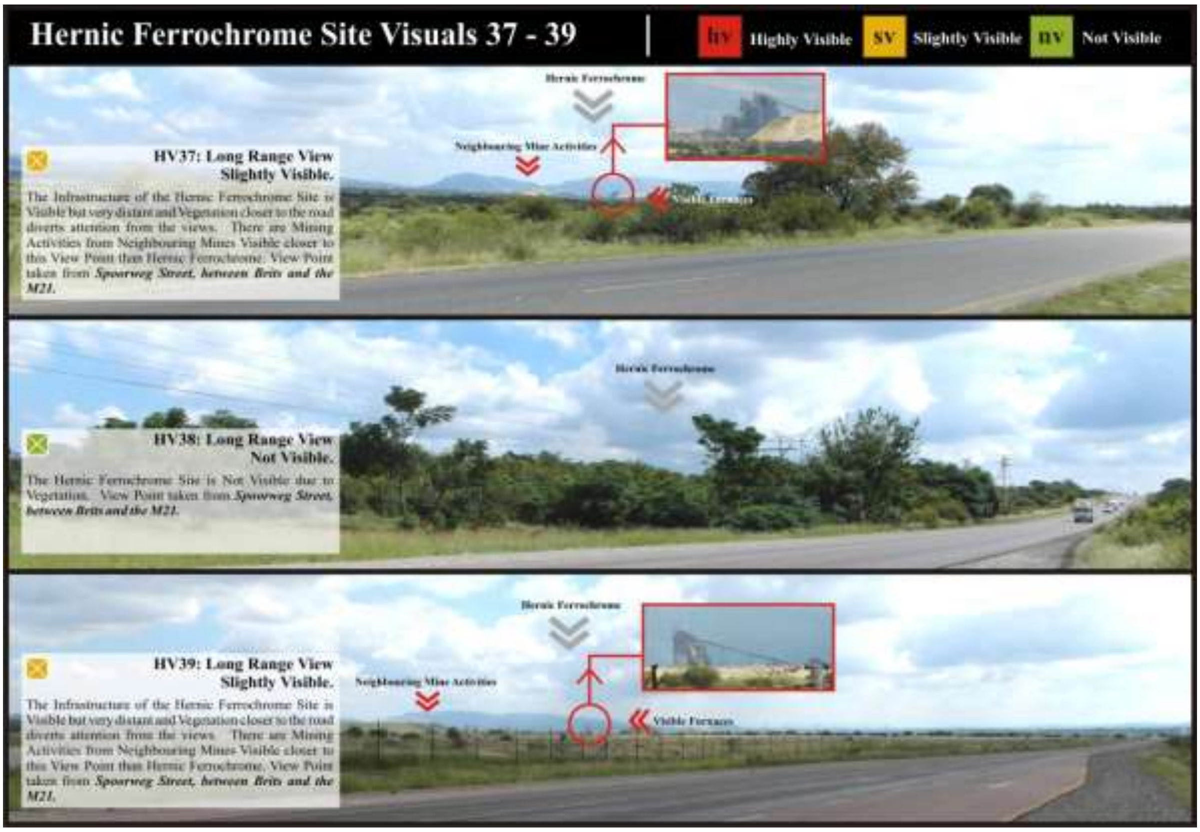


Figure 8.4.20.7(d): **Hernic Ferrochrome Site Visuals 37 - 39. An Example of a Photographic Compilation Analysing HERNIC.**

8.4.20.8. Visual Base Line Conditions – Current Visual Character

Regional Visual Character – Long Range Views

Regionally the visual character is three-fold:

The first: is that of the mining belt between Brits and Rustenburg. This area along the N4 Highway is largely occupied by mining facilities. Here the perceived degree of human intrusion is very high, and the vegetation not uniquely bushveld anymore.

Therefore if the HERNIC infrastructure is viewed, against the visual character of the mining belt as backdrop, the visual impact will be relatively insignificant, as the nature of these elements will not contrast greatly with their surrounding visual context.

The second: is that of the bushveld vegetation and mountainous topography of the area. The perceived degree of human intrusion in the area of the site is moderate with a grassy ground layer and a distinct upper layer of woody plants. Although the HERNIC Site is situated on relatively flat pieces of land, this type of vegetation and topography can be found in most of the surrounding areas. The vegetation adjacent to the site is acceptable for natural camouflage of lower structures.

Together with the vegetation the topography also lends itself to natural camouflage. The hills create an effective background against which the infrastructure can be viewed. The hills have relatively dark colours and many shade variations, which cause a significant degree of visual "camouflage" of these structures. The visual impact of the HERNIC Operations in the larger area will be moderate.

The third: is that of human settlement.

The (a) Town of Brits, (b) rural- and informal settlements, (c) farms and small holdings make out the bulk of human settlement in the near vicinity of the site. Because HERNIC is situated right in the middle of these human settlements, the Operations are visible from these settlements and the roads situated close by in all directions.

a) Town of Brits

HERNIC is visible from the edges of the Town of Brits which is the nearest large formal human settlement, from long range views. Within the town itself the infrastructure in close views next to the roads, block out views to HERNIC completely.

b) Rural- and Informal Settlements

The rural settlement population density in the area is high, but views are generally restricted due to vegetation in the foreground, the backdrop of the hills and infrastructure in close range next to the roads. The Operation is mostly seen by long range views, rendering the visual intrusion moderate. Also when a view is situated at a medium or long range from the Operations, other mining activities can be seen in the immediate area, rendering the visual intrusion insignificant.

c) Farms and Small Holdings

The visual impact of the site, on the Farms and Small Holdings in near vicinity of the site is moderate, but little or no measures can be taken to improve this. The fact that vegetation next to the road provides natural camouflage makes the intrusion visually acceptable.

The HERNIC site's visual impact on the town of Brits and the regional areas is moderate, as it is not a unique feature in the area's landscape - many other mining activities can be identified.

The visual impact of the site, on the settlements in near vicinity of the site is moderate, but little or no measures can be taken to improve this. The fact that HERNIC is viewed against the backdrop of hills contributes to camouflage it, and the vegetation blocking many close, medium and long range views, helps to make it becomes visually acceptable.

In terms of visual character, the existing facility does not intrude radically with the surrounding regional visual character.

Local Visual Character – Short/Medium Range Views

In this report, short-range views are defined as those views that are closer than 300 meters to a feature, whether the view is not visible, slightly visible or highly visible.

Physical Objects Obscuring Views

When buildings, vegetation or landforms obscure a view, the range of the view is shortened, thus, eliminating the long-range view concerning objects further away. This view can no longer be influenced by the visual intrusion of an object you are no longer able to see.

In instances where physical objects do not dominate short-range views or obscure objects that are further off in the distance, the eye is automatically drawn to any prominent vertical feature, even if these are some distance away.

In this proposed context, this phenomenon is illustrated by the presence of the existing HERNIC Operations in the landscape. Short range views across to the site and its surroundings are generally not restricted. Although many parts along the roads are planted with trees, consist of natural vegetation or contain structures closer to the road which can be observed, restricting views to the site, the HERNIC site are still visible from several sections along the roads. Furthermore the vegetation found along the road is constantly changing, and as such the visibility of the site and surroundings subtly changes as time passes. The fact that the site is visible from short-range views does not however suggest a complete negative visual impact, as there are other factors also to consider.

The Setting of the Site

Where views are not obstructed by nearby objects, the existing mining/industrial complex draws the observer's attention. Part of the Operation's infrastructure re furnaces, which is the highest vertical objects in the Plant Management Area. These elements are the most visible elements of HERNIC. If not for the setting of the site, within an active mining area, in a mountainous area with rich natural vegetation, this element would probably have been a short/medium-range visual concern. But in this instance, considering the setting of the site, the visual intrusion becomes moderate and acceptable.

The Backdrop against which an Element is viewed

Another factor that may influence short-range views is the backdrop against which an element is viewed. When viewed from close up, landscape elements are usually seen against the sky and are therefore more visible. When the same elements are viewed against a backdrop of similar colour, they tend to be "hidden" more. This phenomenon is generally reserved for medium/long-range views, as in this instance, accept in specific cases where an operation is situated close to objects higher than the components of the site.

Landscape Character

In this document, Landscape Character is a discussion of the nature and occurrence of the physical environment:

Morphology and Topography

Even though the site and surrounding areas for the most part still possess their natural landscape form, they occur in an area where the local topography and morphology have been altered in some way due to mining and other activities. The area therefore by no means represents a greenfields morphological and/or topographical environment.

Surface Vegetative Cover

However, at the HERNIC site significant portions of both, the sites themselves, as well as parts of the immediate surroundings, farms and rural settlement areas, have been disturbed and altered by anthropogenic activities, resulting in only isolated patches of the original vegetation to be present. In the larger area though, the vegetation is still semi-pristine.

Current On-Site and Adjacent Land Use

From a land use perspective, the overall landscape character is dominated by mining, agricultural and residential activities.

HERNIC is compatible with the near vicinity land use of the area.

Existing Visual Character

The existing visual character of the site and greater region is far from undisturbed and is in fact characterised extensively by manmade elements and mining activities. The existing HERNIC site is not uniquely visible and therefore do not visually dominate the area, and do not visually contrast with the area's character context.

Landscape Visual Quality Assessment

In this document, Landscape Quality is a measurement of the union of ecological integrity and aesthetic appeal. Ecological integrity refers to the condition or overall health of the landscape measured in terms of the quality of the physical environment – morphology, topography and vegetation.

Using these criteria to analyse the landscape quality of the HERNIC sites and their immediate surroundings, the following conclusions were subjectively (but in a professional opinion) made. Where the natural/expected condition of the site and immediate surroundings is unaltered, a rating of 1 is given, and where the expected existing condition is not present or has been changed, a rating of 0 is given.

Table 8.4.20.8(a): Local Landscape Quality

Ecological Integrity	
Morphology	0
Topography	0
Vegetation	0
Aesthetic Appeal	
Topographical ruggedness	0
Presence of water	0
Natural versus human landscape	0
Land use compatibility	1

As can be seen from the Table above, the ecological integrity of the sites and immediate surroundings has been largely altered.

It can be argued that the landscape quality is relatively low, but acceptable, considering that industry and mining in this area is a major economic booster for the region and the country. The area character is already damaged and typically mining. Substantial human intervention has already occurred locally and the visual intrusion of HERNIC is relatively low.

Visual Character (Sense of Place) Assessment

According to Lynch (Lynch, 1992) sense of place is "the extent to which a person can recognise or recall a place as being distinct from other places, as having a vivid or unique, or at least particular character of its own".

Using this definition, the HERNIC Site's Sense of Place was analysed and, the following subjective conclusions are made:

- The region discussed in the mining belt between Brits and Rustenburg has a very specific character, which is a mining/industrial and residential/rural combination. The area itself and the site of HERNIC both have a relatively moderate visual quality, but fits into the character of place. The natural landscape though, the mountainous topography and natural bushveld does give the region a unique feeling when viewed from other vantage points.
-
- The current HERNIC Operations character is similar to those of other mining facilities in the larger area and it can therefore not be considered to have a unique genius loci or sense of place.
-
- The presence of HERNIC does detract from the aesthetic appeal of the area, but as other mining activities also occur in the larger area, the visual impact is to some extent lessened. The nature of the visual impact will however be undesirable and visual mitigation should be considered where applicable.

8.5. DESCRIPTION OF THE CURRENT LAND USES

A detailed description of the current land uses at HERNIC, as well as in the surrounding area is given in section 8.4.4 of this report and which will not be duplicated here. As far as the proposed new activities are concerned, it is only the following ones which will be developed or expanded on/onto new footprints:

- Development and Expansion of the Site Storm Water and Process Water Management Facilities:
  - Development and Expansion of the Process Water and Storm Water Canal System including Silt Traps
  - Development of the Morula PCD
  - Development of Storm Water PCD No.2
  - Development of Storm Water PCD No.3
  - Development of Storm Water PCD No.4
- Development of a New Salvage Yard
- Expansion of the HERNIC TSF

For the purposes of this discussion, it is important to note that all the proposed activities for which new footprints are required will be developed within the existing HERNIC operations perimeter. By virtue of the fact that HERNIC holds mining rights on all the relevant properties, it implies an **overall land use status of mining**.

With reference to the detailed Land Use mapping conducted for this assessment though, the proposed sites for the new footprints are located on sub-categories for land use which can be broadly classified as either transformed or untransformed - described in section 8.4.4 – see Figure 8.4.4(a).

It is quite obvious from the information shown in Table 8.5(a) that the majority of the new developments will be done on transformed land. As far as the untransformed land is concerned, it invariably represents isolated patches of Marikana Thornveld, which is neither endangered nor critically endangered.

With reference to this, it is only the Development of Storm Water PCD No.2 and the Expansion of the HERNIC TSF that would, from a vegetation clearance perspective, actually trigger an EIA Listed Activity in terms of GNR 983, Listing Notice 1 of the EIA Regulations.

However, it should further be noted that as far as the Storm Water Management Measures are concerned, their localities are all dictated by topographical considerations resulting in no alternatives for locality.

The proposed expansion of the TSF can also only be done in a southerly direction and therefore no alternative footprint is available.

Table 8.5(a): Subcategory Land Use for new Footprints (Overall Land Use is Mining)

Activity with new Footprint	Size of Development Footprint (m^2)	Land Use Sub-Category	
		Transformed	Untransformed
Dirty Water Canal SWD1	1 580	X	
Dirty Water Canal SWD2	1 750	X	
Dirty Water Canal SWD3	3 900	X	
Dirty Water Canal SWD4	870	X	
Dirty Water Canal SWD5	2 200	X	
Dirty Water Canal SWD6	700	X	
Dirty Water Canal SWD7	2 600	X	
Dirty Water Canal SWD8	900	X	
Dirty Water Canal SWD9	1 800	X	
Dirty Water Canal SWD10	1 400		X
Dirty Water Canal SWD11	80		X
Dirty Water Canal SWD12	500	X	
Dirty Water Canal SWD13	1 400	X	
Dirty Water Canal SWD14	400	X	
Clean Water Canal SWC1	1 800	X	
Clean Water Canal SWC2	1 600	X	
Clean Water Canal SWC3	2 100	X	
Clean Water Canal SWC4	650	X	
Earth Berm EB1	2 200	X	
Earth Berm EB2	2 800	X	
Earth Berm EB3	1 300	X	
Earth Berm EB4	650	X	
Isolation Berm IB1	550	X	
Isolation Berm IB2	700	X	
Isolation Berm IB3	960		X
Isolation Berm IB4	900	X	
Isolation Berm IB5	2 100	X	
Silt Trap Junction SWD6/SWD7	1 500	X	
Morula PCD	6 000		X
Storm Water PCD No.2	22 000	X	X
Storm Water PCD No.3	6 000	X	
Storm Water PCD No.4	500	X	
New Salvage Yard	6 600	X	
Expansion of the HERNIC TSF	96 000		X

8.6. ENVIRONMENTAL FEATURES & INFRASTRUCTURE AT NEW SITES/ACTIVITIES

The assessment made in this section was done based on the map which shows the proposed new infrastructure superimposed on the relevant environmental features as mapped by the different specialists and which is reported on in section 8.4 of this report.

The proposed development infrastructure and environmental features map is attached as Figure 8.7(a), the details of which is discussed in section 8.7.

Table 8.6(a) below, lists the proposed infrastructure with new footprints and also classifies the footprints as being located on either disturbed or undisturbed ground from a surface disturbance perspective (topography, soil, land capability, land use, ecology and surface water).

Table 8.6(a): Environmental Features at New Sites

Activity with new Footprint		Relevant Environmental Feature
Disturbed	**Undisturbed**	
Dirty Water Canal SWD1		None
Dirty Water Canal SWD2		None
Dirty Water Canal SWD3		Geological Dyke and Geological Fault
Dirty Water Canal SWD4		Geological Fault
Dirty Water Canal SWD5		Geological Fault
Dirty Water Canal SWD6		Geological Fault
Dirty Water Canal SWD7		Geological Fault
Dirty Water Canal SWD8		None
Dirty Water Canal SWD9		Geological Fault
	Dirty Water Canal SWD10	Marikana Thornveld
	Dirty Water Canal SWD11	Marikana Thornveld
Dirty Water Canal SWD12		None
Dirty Water Canal SWD13		Geological Fault
Dirty Water Canal SWD14		Geological Fault
Clean Water Canal SWC1		Geological Fault
Clean Water Canal SWC2		None
Clean Water Canal SWC3		None
Clean Water Canal SWC4		None
Earth Berm EB1		Geological Fault
Earth Berm EB2		Geological Fault
Earth Berm EB3		Marikana Thornveld
Earth Berm EB4		None
Isolation Berm IB1		None
Isolation Berm IB2		None
	Isolation Berm IB3	Marikana Thornveld
Isolation Berm IB4		None
Isolation Berm IB5		None
Silt Trap Junction SWD6/SWD7		Geological Fault
	Morula PCD	Marikana Thornveld
	Storm Water PCD No.2	Marikana Thornveld and Geological Dyke
Storm Water PCD No.3		None
Storm Water PCD No.4		None
New Salvage Yard		None
	Expansion of the HERNIC TSF	Marikana Thornveld and Underground Mining

8.7. ENVIRONMENTAL AND CURRENT LAND USE MAP

All the information generated by the specialists during their detailed base line studies for HERNIC, was collated to result in polygons that could be plotted onto a map which would show the geographical distribution of all the relevant environmental features for the HERNIC site. The existing infrastructure, the current land use, as well as the proposed new activities/developments, were then also superimposed and plotted onto this map. The resulting Environmental Features and Infrastructure Map is depicted in Figure 8.7(a). A large Scale version of this map is attached as APPENDIX 8(A) to this report.

The following Environmental Components are represented on this map:

- Archaeological and Heritage Environment
- Palaeontological Environment
- Land Use
- Soils and Land Capability
- Geology
- Groundwater Environment
- Surface Water Environment
- Plant Life Environment
- Animal Life Environment
- Wetland Environment
- Aquatic Ecosystems Environment

The following existing Infrastructure is also shown:

- Existing HERNIC Smelting Activities
- Morula Opencast and Underground Mining Activities

The following proposed Decommissioning, Development and Expansion Activities are shown:

- Decommissioning of two Historic Slimes Dams
- Decommissioning of Phase 1 of the H:H Slimes Dam
- Development and Expansion of the Storm Water Canal System including Silt Traps
- Development of the Morula PCD
- Expansion of Storm Water PCD No.1
- Development of Storm Water PCD No.2
- Development of Storm Water PCD No.3
- Development of Storm Water PCD No.4 (within perimeter of new Salvage Yard)
- Expansion of the OB Plant Process Water Dam
- Expansion of the Plant Process Water Dam
- Expansion of the CRP Process Water Dam
- Decommissioning of the Morula Dewatering Dam
- Development of a New Salvage Yard
- Expansion of the HERNIC Tailings Storage Facility (TSF)
- Re-Use of Slag Sand at the Fine Slag Processing Plant
- Re-Use of Coarse Slag at the Chrome Recovery Plant
- Re-Use of Mine Waste Rock at the Mine Waste Rock Stockpile

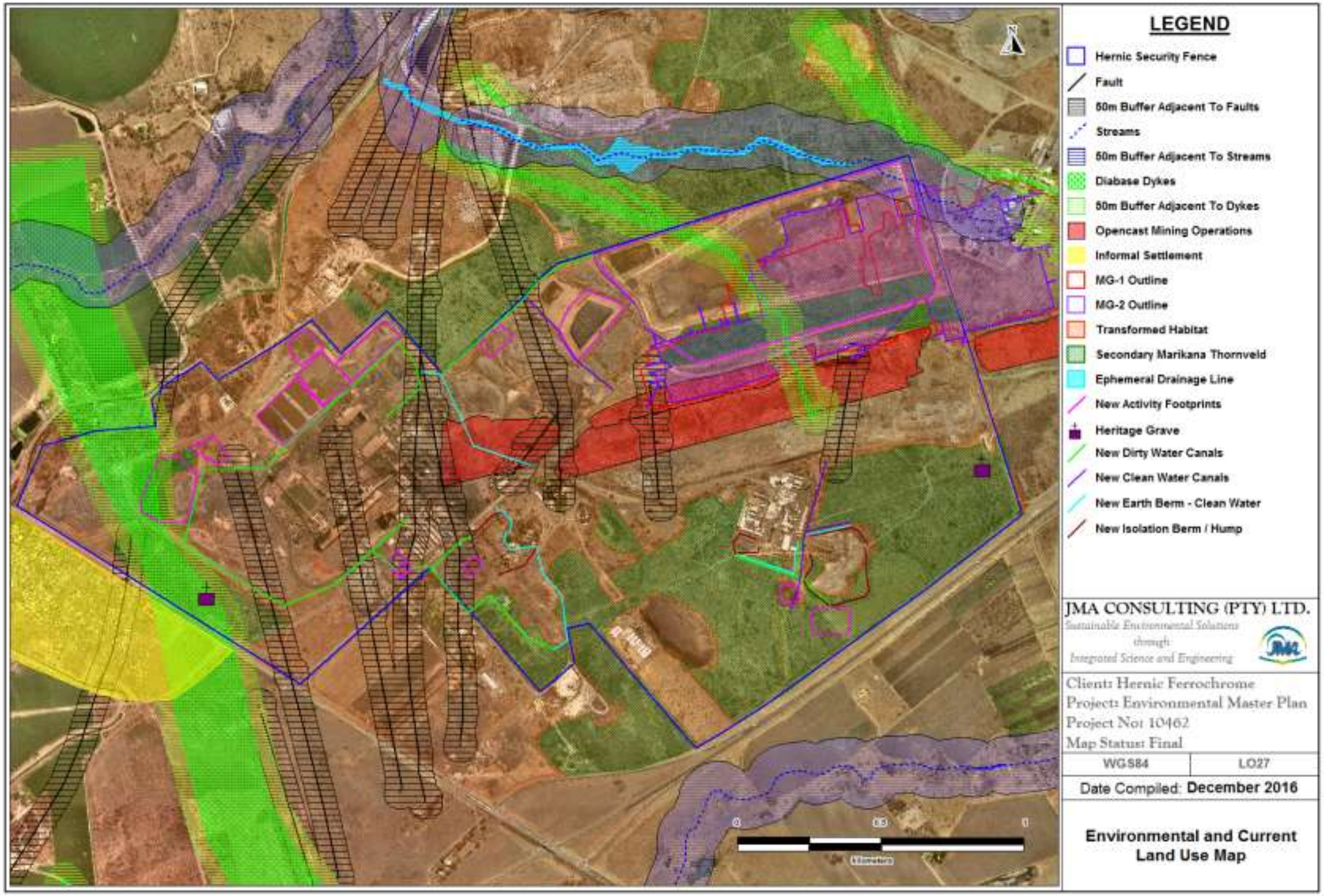


Figure 8.7(a): Environmental Features, Current Land Use and Infrastructure Map

8.8. POTENTIAL IMPACTS ASSOCIATED WITH NEW ACTIVITIES

This section is not about the main impact assessment for the project, but relates specifically to the impact assessment conducted during the selection of the preferred sites for the new developments and expansions.

The initial proposed site plan did take environmental features and conditions into consideration in as far as critical environmental features could be avoided. The site layout reflected in Figure 8.7(a) therefore already represents a considered layout in which certain environmental realities have been considered.

The potential impacts listed in Table 8.8(a) therefore relate specifically to impacts, that if not acceptable after mitigation, would require an alteration in the site layout as proposed in Figure 8.7(a). A favourable outcome of the impact assessment would therefore confirm the proposed site layout as acceptable from an environmental perspective.

Please note that only activities requiring new site footprints are listed in the Potential Impact Table.

It should also be noted that the impact assessment was conducted from the premise that all the design features aimed at environmental protection would be implemented during development and expansion. These include the minimization of developmental footprints as well as the appropriate lining of all canals and dams which would convey/contained “dirty water”. This includes all dirty water canals, silt traps and PCD’s.

Furthermore the expansion of the OB Plant TSF footprint and its subsequent operation, would be done in strict compliance with recommendations from a stability perspective with reference to the presence of the underground mine workings.

With reference to the outcome of the impact assessment as reflected in Table 8.8(a), the following conclusions are now relevant:

- Aspects that could influence site selection varied between **Low** and **Medium** for consequence, but due to the unlikely nature of the **Medium** impacts to manifest, the overall impact significance ratings are all recorded as **Low**.
- This overall significance rating of **Low** confirms that the sites shown on the proposed project layout drawings are all acceptable from an environmental perspective.

Table 8.8(a): Potential Impacts Identified and Assessed (Design Mitigation taken into Consideration)

Activity with new Footprint	Relevant Environmental Feature that could influence Site Selection	Potential Impact	Magnitude	Scale	Duration	Consequence	Probability	Significance
Dirty Water Canals	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	**Low**
	Geological Faults & Dykes	In the event that the canals should leak and cause groundwater pollution, the faults and dykes could act as preferential groundwater flow zones for groundwater pollution migration.	Moderate	Local	Medium Term	**Medium**	Unlikely	**Low**
Earth Berms	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	**Low**
Isolation berms	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	**Low**

Activity with new Footprint	Relevant Environmental Feature that could influence Site Selection	Potential Impact	Magnitude	Scale	Duration	Consequence	Probability	Significance
Silt Trap Junction SWD6/SWD7	Geological Fault	In the event that the silt trap should leak and cause groundwater pollution, the faults and dykes could act as preferential groundwater flow zones for groundwater pollution migration.	Moderate	Local	Medium Term	**Medium**	Unlikely	**Low**
Morula PCD	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	**Low**
Storm Water PCD No.2	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	**Low**
	Geological Dyke	In the event that the PCD should leak and cause groundwater pollution, the faults and dykes could act as preferential groundwater flow zones for groundwater pollution migration.	Moderate	Local	Medium Term	**Medium**	Unlikely	**Low**

Activity with new Footprint	Relevant Environmental Feature that could influence Site Selection	Potential Impact	Magnitude	Scale	Duration	Consequence	Probability	Significance
Storm Water PCD No.3	None	-	-	-	-	-	-	-
Storm Water PCD No.4	None	-	-	-	-	-	-	-
New Salvage Yard	None	-	-	-	-	-	-	-
Expansion of the HERNIC TSF	Marikana Thornveld	Clearance of vegetation could impact on plant life habitat and diversity.	Minor	Local	Medium Term	**Low**	Possible	Low
	Underground Mining	Should insufficient safety factors be used for deposition, over deposition could cause subsidence.	Major	Local	Medium Term	**Medium**	Unlikely	Low

8.9. ENVIRONMENTAL IMPACT SIGNIFICANCE ASSESSMENT METHODOLOGY

The impact significance assessment methodology utilized by JMA Consulting in this Scoping Report, is the same as the methodology to be used during the EIA phase for the proper EIA. The methodology is used widely by EAP's in South Africa and represents best practice. The basic elements used in the Evaluation of Impact Significance are described in the Table 8.9(a) and the characteristics used to describe the consequence of an impact are outlined in Table 8.9(b).

Table 8.9(a): Key elements in the evaluation of Impact Significance

Element	Description	Questions applied to the test of Significance
Consequence	An impact or effect can be described as the change in an environmental parameter, which results from a particular project activity or intervention. Here the term consequence refers to: • The sensitivity of the receiving environment, including its capacity to accommodate the kinds of changes the project may bring about • The type of change and the key characteristics of the change (these are magnitude, extent and duration) • The importance of the change (the level of public concern/ value attached to environment by the stakeholders and the change effected by the project) The following should be considered in the determination of impact consequence: • Standards and Guidelines (e.g. pollution and emissions thresholds) • Scientific evidence and professional judgement • Points of reference from comparable cases • Levels of stakeholder concern	Will there be a change in the biophysical environment? Is the change of consequence (of any importance)?
Probability	Likelihood/ Chances of an impact occurring	Is the change likely to occur?
Effectiveness of the Management Measures	Significance of the impact needs to be determined both without management measures and with management measures. The significance of the unmanaged impact needs to be determined so there is an appreciation of what could occur in the absence of management measures and of the effectiveness of the proposed management measures.	Will the management measures reduce impact to an acceptable level?
Uncertainty/ Confidence	Uncertainty in impact prediction and the effectiveness of the proposed management measures. Sources of uncertainty in impact prediction include: • Scientific uncertainty – limited understanding of an ecosystem or affected stakeholder and the processes that govern change • Data uncertainty – restrictions introduced by incomplete, contradictory or incomparable information, or by insufficient measurement techniques • Policy uncertainty – unclear or disputed objectives, standards or guidelines	What is the degree of confidence in the significance ascribed to the impact?

Table 8.9(b): Characteristics to be used in Impact Description

Characteristics used to describe Consequence	Sub-Components	Terms used to describe the Characteristics
Type		Biophysical, social or economic
Nature		Direct or Indirect or Cumulative
Status		Positive (a Benefit), Negative (a Cost) or Neutral
Phase of Project		During the Pre-Construction (if applicable), Construction, Operational, Decommissioning/ Post Closure
Timing		Immediate, Delayed
Magnitude	**Sensitivity of the Receiving environment/ receptors**	High, Medium or Low Sensitivity Low capacity to accommodate the change (impact)/ tolerant of the proposed change
	Severity/ Intensity (degree of change measured against thresholds and/ or professional judgment)	Gravity/ seriousness of the impact Intensity / Influence/ Power/ Strength
	Level of Stakeholder concern	High, Medium or Low levels of concern All or some stakeholders are concerned about the change
Spatial Extent The area affected by the impact.		Area/ Volume covered , Distribution, Population Site/ Local, Regional, National or International
Duration (and Reversibility) Length of time over which an impact occurs and potential for recovery of the endpoint from the impact		Short term. Long term Intermittent, Continuous Reversible, Irreversibility Temporary, Permanent
Confidence		High, Medium, Low

The Impact Significance Rating system is presented in Table 8.9(c) and involves four parts:

- Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration;
- Part B: Use the matrix to determine a rating for impact consequence based on the definition identified in Part A;
- Part C: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence;
- Part D: Define the Confidence level.

Table 8.9(c): Method for rating the Significance of Impacts

PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE (Use these definitions to define the consequence in Part B) + *denotes a positive impact*		
Impact Characteristics	**Definition**	**Criteria**
MAGNITUDE	Major	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate	Moderate/ measurable deterioration of harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
SPATIAL SCALE	Site or Local	Site specific or confined to the immediate project area
	Regional	May be defined in various ways e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond
DURATION	Short term	Quickly reversible. Less than two years
	Medium term	Reversible over time. Life of the project
	Long term	Permanent. Beyond closure

PART B: DETERMINING CONSEQUENCE RATING (Rate consequence based on definition of magnitude, spatial extent and duration)					
			SPATIAL SCALE		
			Site or Local	**Regional**	**National/ International**
MAGNITUDE					
Minor	**DURATION**	**Long term**	**Medium**	**Medium**	**High**
		Medium term	**Low**	**Low**	**Medium**
		Short term	**Low**	**Low**	**Medium**
Moderate	**DURATION**	**Long term**	**Medium**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Low**	**Medium**	**Medium**
Major	**DURATION**	**Long term**	**High**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Medium**	**Medium**	**High**

PART C: DETERMINING SIGNIFICANCE RATING (Rate significance based on consequence and probability)				
		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	**Medium**	**Medium**	**High**
	Possible	**Low**	**Medium**	**High**
	Unlikely	**Low**	**Low**	**Medium**

PART D: CONFIDENCE LEVEL		
High	Medium	Low

8.10. POSITIVE AND NEGATIVE IMPACTS

All the decommissioning, developments and expansions which form the subject matter of this project, are aimed at improving the efficiency of environmental management at HERNIC.

It can therefore be stated categorically that implementation of the proposed action plan will have a significant and definite positive impact on the environment at HERNIC.

8.11. POSSIBLE MITIGATION MEASURES

The mitigation measures contemplated for the potential impacts associated with the proposed activities are included in the designs of the facilities and are essentially two fold in nature:

- The footprint sizes of all the facilities (canals, silt traps and dams) are minimized through detailed design according to site specific surface water run-off characteristics and precipitation event return intervals.
- All facilities conveying or containing “dirty water” are designed with appropriate liner systems to prevent seepage of contaminated water into the sub-surface.
- Furthermore the capacities of these facilities are designed to prevent spillages during storm rainfall events as specified by the regulator.

8.12. OUTCOME OF SITE SELECTION MATRIX

In as much as the ideal situation would be to fully avoid sensitive environmental features, the nature of the new developments and expansions at HERNIC are such that their respective localities are dictated by topographical, logistical and operational aspects. In this regard the following is relevant:

- The selected localities of the proposed storm water isolation berms, the clean water diversion berms, the clean water canals, the dirty water canals, the silt traps as well as the storm water pollution control dams, are all dictated by topographical considerations as well as site surface water drainage realities.
- The expansion of the HERNIC TSF requires an immediately adjacent footprint of sufficient size to make the expansion practicable. In this regard the final geometry of the TSF, as well as the current location of operational infrastructure plays a pivotal role. The only site within the current HERNIC operational area that fits these requirements is the area located due south of the existing TSF.

Based on the above, it follows that a traditional Site Selection Matrix was not employed to select the preferred sites. Sites were selected optimally from an engineering perspective and then subjected to an environmental impact assessment to confirm their suitability/acceptability from an environmental perspective.

8.13. NO ALTERNATIVE SITE MOTIVATION

A comprehensive Alternatives Consideration Exercise was conducted on all the proposed activities associated with this application. Specifically as far as Site Alternatives are concerned the following is relevant:

- All activities which represent decommissioning will, due to the fact that they already exist at a specific locality, not have any site alternatives.
- Expansion activities will occur at the existing facilities to be expanded.
- The sites selected for the storm water management related activities, are dictated by topographical and storm water run-off realities at HERNIC.
- Activities associated with re-use of materials are located at the sites where the materials to be re-used is currently located.

The environmental acceptability of all the sites located at relevant environmental features, were confirmed during an environmental impact assessment.

8.14. MOTIVATED PREFERRED ALTERNATIVE SITE

The proposed sites for the following proposed activities at HERNIC are shown on the map depicted as Figure 8.14(a):

- Decommissioning of two Historic Slimes Dams
- Decommissioning of Phase 1 of the H:H Slimes Dam
- Development and Expansion of the Process Water and Storm Water Canal System including Silt Traps
- Development of the Morula PCD
- Expansion of Storm Water PCD No.1
- Development of Storm Water PCD No.2
- Development of Storm Water PCD No.3
- Development of Storm Water PCD No.4
- Expansion of the OB Plant Process Water Dam
- Expansion of the Plant Process Water Dam
- Expansion of the CRP Process Water Dam
- Decommissioning of the Morula Dewatering Dam
- Development of a New Salvage Yard
- Expansion of the Tap Hole Fume Extraction System
- Expansion of the Finished Product Plant Dust Abatement System
- Expansion of the HERNIC Tailings Storage Facility (TSF)
- Re-Use of Slag Sand at the Fine Slag Processing Plant
- Re-Use of Coarse Slag at the Chrome Recovery Plant
- Re-Use of Mine Waste Rock at the Mine Waste Rock Stockpile

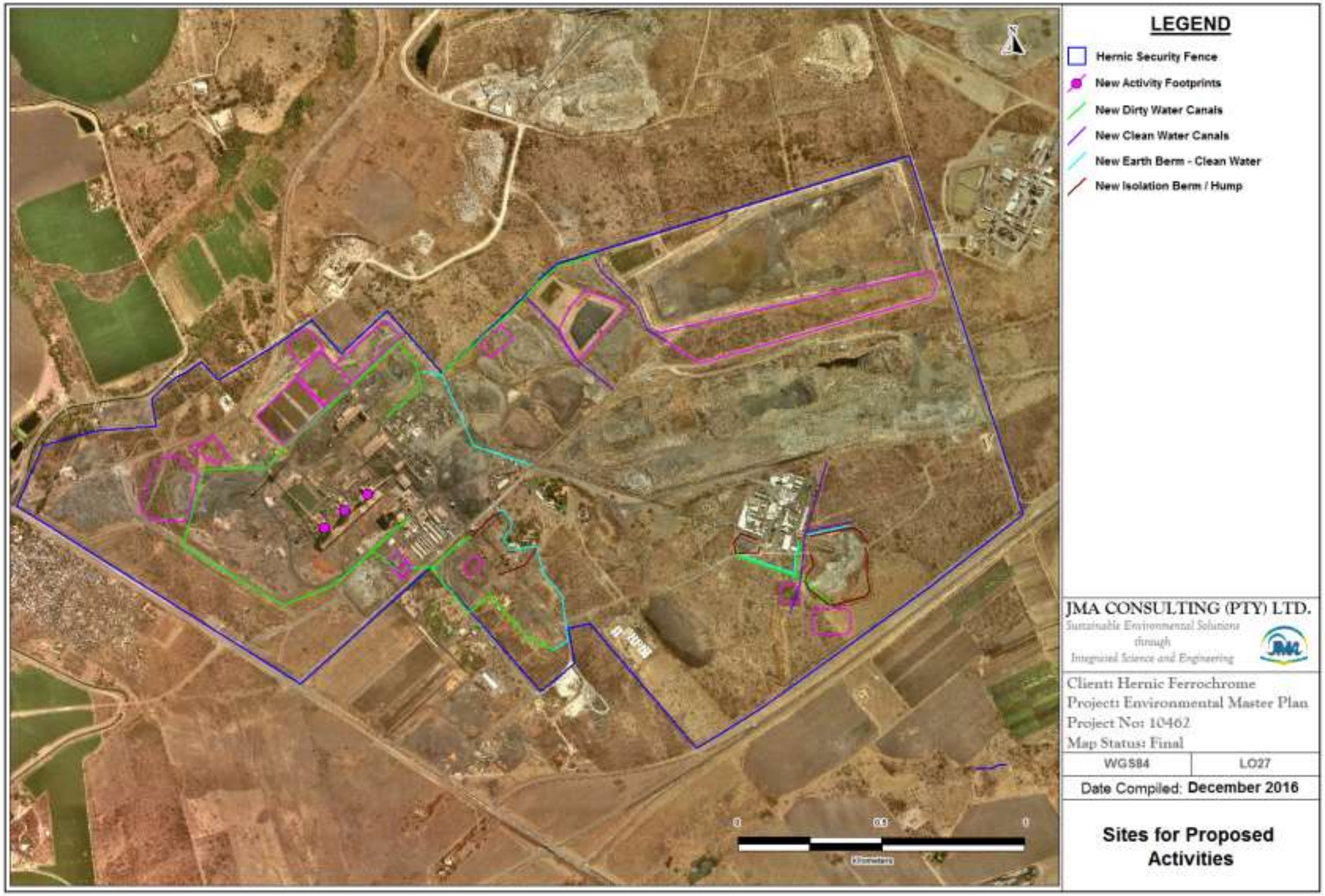


Figure 8.14(a): Preferred Alternative Sites for the Proposed Activities at HERNIC

9. PLAN OF STUDY

9.1. DESCRIPTION OF ALTERNATIVES TO BE CONSIDERED (Including No-Go)

A detailed identification of and motivation for alternatives associated with the proposed new activities (including the no-go options), has been conducted and reported on in section 8.1.1 of this report. The outcome of this assessment is presented in Tabular format below and the alternatives still under consideration and for which the **Preferred Alternative** still has to be selected and motivated during the EIA Phase of this application process, are highlighted orange in the Table.

The alternatives identified for further assessment, are currently being investigated by specialists and the outcomes of their assessments will be provided as specialist feasibility study reports during the EIA Phase.

Table 8.1.1(a): Alternatives Identification and Motivation

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Decommissioning of two Historic Slimes Dams	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of the two Historic Slimes Dams is a legal requirement.	No design or layout is required to decommission the two Historic Slimes Dams. A procedure will be documented by a qualified civil engineer.	The decommissioning of the two Historic Slimes Dams will be done through standard civil construction technologies as determined by site and material conditions.	Alternative 1. Mechanical removal of the Slimes from the two Historic Slimes Dams followed by transport of the material on trucks via road for depositing on the H:H Slimes Dam. Alternative 2. Hydro-mining of the slimes from the two Historic Slimes Dams, followed by slurrying and pumping of the slurried slimes for depositing on the H:H Slimes Dam. Alternative 3. Mechanical mining of the slimes from the two Historic Slimes Dams, followed by on-site pelletizing and recycling through the Furnaces to extract residual chrome.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	**Preferred Alternative to be determined after further research and to be finalized during the EIA Phase.**	The no-go option is not feasible.
Decommissioning of Phase 1 of the H:H Slimes Dam	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of Phase 1 of the H:H Slimes Dam is a legal requirement.	A formal civil engineering design, giving full compliance with DWS and DEA standard procedure requirements as relating to the closure of Waste Disposal Facilities, is currently being performed to rehabilitate and close the H:H facility.	The decommissioning of the H:H Slimes Dam will be done through standard civil construction technologies as determined by site and material conditions.	Alternative 1: Deposition of the slimes from the two Historic Slimes Dams onto the H:H Slimes Dam, followed by final shaping, capping and closure of the H:H Slimes Dam. Alternative 2: No additional deposition but only final shaping, capping and closure of the H:H Slimes Dam.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	**The outcome of the operational aspects alternative assessment for the two Historic Slimes Dams will determine which one of the two alternatives will be implemented.**	The no-go option is not feasible.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Development and Expansion of the Site Storm Water and Process Water Management Measures	Existing Activity on the Farm De Kroon 444 JQ	The site locations for the process water and storm water management systems are dictated by the location of the current mining and smelting activities, as well as by surface topographical and footprint availability considerations.	The upgrading of the Storm and Process Water Management Systems is required in order to comply with GNR 704 as well as with DWS Best Practice Guidelines on Water Management at Mines.	The design and layout of these facilities need to comply with rigorous DWS Best Practice Guidelines and need to conform the GNR 704. Designs are done in strict compliance with these requirements.	The upgrading of the Storm and Process Water Management Systems will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The actual upgrading and operation of the Storm Water and Process Water management systems will be done in strict compliance with DWS approved designs as well as DWS Best Practice Guidelines for process water and storm water management at mines.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternatives Existing locations will be used as far as possible. Alternatives are excluded due to the fact that placement of drains, silt traps and dams are dictated by topographical and footprint availability considerations.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Decommissionin g of the Morula Dewatering Dam	Existing Activity on the Farm De Kroon 444 JQ	Existing Activity	The decommissioning of the Morula Dewatering Dam is a legal requirement.	A civil engineering design and closure protocol is currently being performed to decommissioning the Morula Dewatering Dam according to DWS Best Practice.	The decommissioning of the Morula Dewatering Dam will be done through standard civil construction technologies as determined by site and material conditions.	The decommissioning will be done in strict compliance with DWS Best Practice and according to a documented closure work protocol.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternatives	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
Development of New Salvage Yard	Activity Required on the Farm De Kroon 444 JQ	Two Site Alternatives were considered. Site Alternative 1: Upgrading and Expansion of the Existing Salvage Yard. Site Alternative 2: Development of a New Salvage Yard in proximity to the redundant Old Civil Workshop Area.	The Hernic Mining and Smelting Operations generate a large volume of salvageable materials and a Salvage Yard is therefore a basic requirement.	The design and layout of the new Salvage Yard is dictated by logistical considerations, none of which have any environmental implication.	The development of the new Salvage Yard will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The construction of the new Salvage Yard will be done in strict compliance with the DEA approved designs and the operation will be done in compliance with DEA Norms and Standards.	The option of not implementing the activity will compromise the entire Hernic mining and smelting operation.
Motivation for Preferred Alternative	No Property Alternative	Site Alternative 1 was discarded as the site is too small. **Site Alternative 2** is the preferred alternative site as it is big enough, it is located along favourable access route, it does not interfere with existing plant activities and is located optimally from a salvage logistical perspective.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Expansion of the Tap Hole Fume Extraction System	Existing Activity on the Farm De Kroon 444 JQ	The fume extraction system is required at the existing furnace tap holes.	Air quality control, and in this instance particulate emission abatement at the furnaces, is a legal requirement.	The design and layout of these measures are dictated by the existing site specific conditions. No new stacks are required as cleaned gas will be vented through existing stacks.	Alternative 1: Cyclones Alternative 2: Electrostatic Precipitators Alternative 3: Fabric/Bag Filters	Alternative 1: Vent the cleaned gas through current active stacks. Alternative 2: Vent the cleaned gas through existing but currently in-active stacks.	The option of not implementing the activity will result in a legal non-compliance.

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
					Alternative 4: Wet Scrubbers Alternative 5: Combinations of the above		
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative	No Activity Type Alternative.	No Design/Layout Alternative.	Furnaces 1 and 2 – **Existing** Wet Scrubbers. Furnaces 3 and 4 – **Existing** Bag Filters.	**Preferred Alternative to be determined after further research and to be finalized during the EIA Phase.**	The no-go option is not feasible.
Expansion of the Finished Product Plant Dust Abatement System	Existing Activity on the Farm De Kroon 444 JQ	The dust abatement system is required at the existing crushing and screening plant.	Air quality control, and in this instance dust abatement at the finished product plant, is a legal requirement.	The existing bag plant just needs to be enlarged to increase its capacity and efficiency.	None. Existing bag plant.	The plant will be operated as per the instructions in the design report.	The option of not implementing the activity will result in a legal non-compliance.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Expansion of the HERNIC Tailings Storage Facility	Existing Activity on the Farm De Kroon 444 JQ	The expansion of the OB Plant TSF can only be done in a southerly direction. The footprint expansion size is limited due to the proximity of the underground and opencast mining.	The expansion of the OB Plant TSF is a basic requirement to cater for the disposal of the Smelting Plant Fine Waste. The waste is deposited as a slurry.	The design and layout for the TSF Expansion is governed by the design and layout of the current facility, the available footprint for expansion as well as the current disposal method and infrastructure.	The expansion of the OB Plant TSF will be done through standard civil construction technologies as determined by the approved designs as well as site conditions.	The expansion of the OB Plant TSF will be done in strict compliance with the DWS approved designs and the operation will be done in accordance with Standard Best Practices and the Operational Plan for the TSF Slimes Dam.	The option of not implementing the activity will compromise the entire Hernic mining and smelting operation.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option is not feasible.
Re-use of Fine Slag from the Fine Slag Processing Plant	Existing Activity on the Farm De Kroon 444	The fine slag is one of the two final products from the Fine Chrome Recovery Plant It	The fine slag is one of the two final products from the Fine Chrome	The manufacturing of the Fine Slag represents a current activity. No design or	The manufacturing of the Fine Slag represents a current activity. No	The Fine Slag is manufactured in an existing activity. Selling of the fine slag entails the placement of orders, payment and then loading onto trucks	The option of not implementing the activity will result in the requirement

Activity	Alternative Property	Alternative Site	Alternative Type of Activity	Alternative Design/Layout	Alternative Technology	Alternative Operational Aspects	No-Go Alternative
	JQ	therefore represents an existing activity.	Recovery Process.	layout is applicable.	technology is required.	with a front end loader and transport from the site by road.	for Disposal of the Fine Slag.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.
Re-use of Coarse Slag (Slag Chips) from the Chrome Recovery Plant.	Existing Activity on the Farm De Kroon 444 JQ	The Slag Chips is one of the two final products from the Chrome Recovery Plant It therefore represents an existing activity.	The Slag Chips is one of the two final products from the Chrome Recovery Process.	The manufacturing of the Slag Chips is a current activity. No design/layout applicable.	The manufacturing of the Slag Chips represents a current activity. No technology is required for the selling of the Slag Chips.	The Slag Chips are manufactured in an existing activity. Selling of the Slag Chips entails the placement of orders, payment and then loading onto trucks with a front end loader and transport from the site by road.	The option of not implementing the activity will result in the requirement for Disposal of the Slag Chips.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.
Re-use of Mine Waste Rock from the Mine Waste Rock Dump.	Existing Activity on the Farm De Kroon 444 JQ	The manufacturing of the aggregate represents a crushing and screening operation of mine waste rock currently contained on the Morula Mine Waste Rock Dump. There is ample space for the aggregate plant, transport routes are favourable and the required storm water management measures will be in place.	The manufacturing of aggregate from the Mine Waste Rock represents a crushing and screening process.	The infrastructure required to support the crushing and screening of the Mine Waste Rock comprises a small and standardized crushing and screening plant whilst the actual site layout is governed by the existing infrastructure and access roads.	The crushing and screening of the Mine Waste Rock comprises a small and standardized crushing and screening operation. Neither this, nor the selling of the Aggregate requires any technology.	The Aggregate is manufactured through a standard crushing and screening operation. Selling of the aggregate entails the placement of orders, payment and then loading onto trucks with a front end loader and transport from the site by road.	The option of not implementing the activity will result in the requirement for Disposal of the Mine Waste Rock.
Motivation for Preferred Alternative	No Property Alternative	No Site Alternative.	No Activity Type Alternative.	No Design/Layout Alternative.	No Technology Alternative.	No Operational Aspects Alternative.	The no-go option does not support the overall waste management objectives.

9.2. ASPECTS FOR ENVIRONMENTAL IMPACT ASSESSMENT

The EAP for this project, JMA Consulting, has compiled comprehensive guidance documentation for the various specialists involved in the EIA. The guidance has been compiled in Tabular format and supports the Impact Assessment Methodology discussed in section 9.4.

The aspects listed in Table 9.2(a) below are provisional. In preparation for the EIA phase, workshops were held with all the relevant specialists and they will now define the aspects and impacts for each of the activities listed in Table 9.2(a), after which they will conduct their individual impact assessments.

By completing this Table it will enable the Specialist to complete different sections and tables of the Impact and Risk Assessment Chapter of his Specialist Report (template and guideline will be provided).

Column 1: **Activity Area** as discussed in Chapter 4.2 and 4.3 in the Scoping Report

Column 2: Specific **Activities** that could potentially have an environmental impact. Current Activities discussed in chapter 4.2 of the Scoping Report, New Proposed Activities discussed in chapter 4.3 of the Scoping Report.

Column 3: All the **Environmental Components** identified by the EAP and verified by the Specialist that will be impacted on during a specific project phase (Construction Phase, Operational Phase and Decommissioning Phase).

Column 4: **Aspects** associated with the Activity. Aspects were identified by the EAP and verified by the Specialist. Aspects are defined as the mechanisms by which the project activities impact on receptors (e.g. people, economy, infrastructure, institutions and natural environment).

Table 9.2(b) provides guidance on impact identification and description and was compiled subject to an assessment of all potential impacts that could possibly occur at HERNIC Ferrochrome.

Table 9.2(a): HERNIC Ferrochrome Activity and Aspect Table to be used for Environmental Impact Assessment

Activity Area	Activity	Environmental Component Affected	Aspect
CURRENT ACTIVITY AND INFRASTRUCTURE AND PROCESS (SECTION 4.2 IN SCOPING REPORT)			
General	Access Roads	Infrastructure, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Traffic, Visuals	Road Surface
		Soils, Groundwater, Surface Water, Plant Life, Air Quality, Noise, Traffic, Visuals	Road Verge
	Railway Lines	Soils, Land Capability, Surface Water, Plant Life, Animal Life, Wetlands, Aquatic Ecosystems, Air Quality, Noise, Visuals	Railroad and Rail Vehicles
	Security Fence and Access	Surface Water, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Fences and Booms
	Water Supply	Infrastructure, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Canal and Pump Station
	Power Supply	Infrastructure, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Eskom Yard and Substations
		Infrastructure, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Overhead Power Lines
	Gas Supply	Air Quality	Propane Gas Tanks
			Oxygen Gas Tank
			Argon Gas Tank
	Fuel Supply	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Diesel Fuel Tanks
	Internal Roads	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Road Surface
		Soils, Groundwater, Surface Water, Air Quality, Noise, Visuals	Road Verge
	Office Complexes	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Building Material
Morula Mining Operation	Morula Mining Shaft Complex	Soils, Groundwater, Surface Water, Air Quality, Noise, Visuals	Decline Shafts
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Water Storage Dams
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Offices and Workshops
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Ore/Waste Rock Transfer House
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Change House Complex
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Conveyors
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Grout Plant
		Soils, Groundwater, Surface Water, Plant Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Peoples Walkway
		Topography, Soils, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic	Emergency ROM Stockpile

Activity Area	Activity	Environmental Component Affected	Aspect
		Ecosystems, Air Quality, Noise, Visuals	
		Topography, Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Topsoil Stockpile
		Soils, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Redundant Explosives Magazine
	Morula Mining Opencast Operation	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Water Abstraction and Pipelines
		Topography, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Steep Slopes/Uneven Surfaces
		Geology, Groundwater, Surface Water, Air Quality, Noise, Visuals	Existence of the Void
	Morula Mining Underground Operation	Geology, Geochemistry, Groundwater	Underground Mining
	Morula Mining Accommodation	Soils, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Building Material
Morula Mining Waste Management	Mine Waste Rock Dump	Topography, Soils, Groundwater, Surface Water, Plant Life, Animal Life, Air Quality, Visuals	Storage of Waste Rock on un-lined footprint
	Mine Sewage Plant	Soils, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Sludge Drying Beds
Morula Mining Water Use and Management	Storm Water Berms and Canals	Soils, Groundwater, Surface Water, Wetlands, Aquatic Ecosystems, Air Quality, Noise, Visuals	Reduction of Run-off to Natural Resource
	Morula Dewatering Dam	Facility to be decommissioned – Evaluate impact and provide management measures for Operational Phase. Impact evaluation and management measures for Decommissioning Phase addressed later as a new activity.	
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Plant Life, Animal Life	Storage of Process Water
Alloys Smelting Plant Facilities	General Plant Infrastructure	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Building Material
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clinic
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Laboratory
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Canteen
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Change House/Laundry
	Raw Materials Stockpile Area 1	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Raw Materials
	Raw Materials Stockpile Area 2	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Raw Materials

Activity Area	Activity	Environmental Component Affected	Aspect
	Ore Beneficiation Plant – Crushing and Screening	Infrastructure, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Traffic, Visuals	Transport of Ore
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Crushing and Screening
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Mixed Materials
	Ore Beneficiation Plant – Lumpy Section (HMS Plant)	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	HMS Waste Material
	Mixed Material Stockpiling and Screening	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Mixed Materials
	Returns Materials Stockpiles	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Returns Materials
	Pelletizing and Sintering Plants 1 & 2	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Structure/Complex
		Air Quality, Visuals	Gaseous Emissions
			Particulate Matter Emissions
	Furnaces 1, 2, 3 and 4	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Structure/Complex
		Air Quality, Visuals	Gaseous Emissions
			Particulate Matter Emissions
	Ferrochrome Break Floor Area	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Mechanical Activity
	Finished Product Plant	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Final Product
	Slag Stockpiling Areas	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Slag
	Primary Chrome Recovery Plant	Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Current Arising Slag Loading
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Crushing and Screening Plant
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Stockpiling of Product
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Stockpiling of Waste

Activity Area	Activity	Environmental Component Affected	Aspect
	Fine Slag Processing Plant (Secondary CRP)	Activity discussed under New Activities	
	Product Rail Dispatch Area	Infrastructure, Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Product Stockpiles
	Platinum Group Minerals (PGM) Plant	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Pumping of PGM Feed Material
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Spiral Plant
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Ball Milling
		Soils, Groundwater, Surface Water, Aquatic Ecosystems	Thickening and Flotation Process
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Pump Tailings to TSF
	Internal Transport and Contractors Yard and Wash Bay	Air Quality, Visuals	Gaseous Emissions
		Air Quality, Visuals	Particulate Matter Emissions
	Redundant Historic Bag Plant	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Building Material
	Redundant Old Civil Workshop	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Building Material
	Rehabilitated Quarry Area	Topography, Surface Water, Aquatic Ecosystems, Air Quality, Visuals	Uneven Surfaces
Alloys Smelting Plant Waste Management Facilities	Historic Slimes Dams (1 & 2)	Facilities to be decommissioned. Currently not Operational. Decommissioning of Activity discussed later under New Activities	
	H:H Slimes Dam and Return Water Dam (RWD)	Phase 1 of H:H Slimes Dam to be decommissioned. Currently not Operational. Activity discussed later under new activities.	
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	RWD Dam
	HERNIC Tailings Storage Facility (TSF) and Return Water Dam (RWD)	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Disposal to TSF
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	RWD Dam

Activity Area	Activity	Environmental Component Affected	Aspect
	Salvage Yard	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Yard Footprint
	Sewage Plant	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Sludge Drying Beds
	OB Plant Fines in Open Pit (Slurry)	Topography, Soils, Geology, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Disposal of OB plant Fines in Open Pit
	OB Plant Coarse Waste in Open Pit (Trucks)	Topography, Soils, Geology, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Disposal of OB Plant Coarse Waste in Open Pit
Alloys Smelting Plant Process Water Management Facilities	Plant Drinking Water Dam	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Dam Footprint
	Plant Drinking Water Treatment Plant	Soils, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Sand Filters
		Soils, Groundwater, Surface Water, Aquatic Ecosystems	Chlorination Pump
	Plant Process Water Dam and Silt Traps	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water/ Silt
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Dam Liner
	OB Plant Return Water Dam	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Chrome Recovery Plant Process Water Dam	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
Alloys Smelting Plant Storm Water Management Facilities	Storm Water Management Berms and Canals	Soils, Groundwater, Surface Water, Wetlands, Aquatic Ecosystems, Air Quality, Noise, Visuals	Reduction of Run-off to Natural Resource
	Plant Storm Water Pollution Control Dam (PCD)	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Emergency Dam	Expansion of the Storm Water Process Water Dam. Currently not Operational.	
Alloys Smelting Plant Groundwater Management Facilities	Abstraction Boreholes	Groundwater	Cone of Depression
	Groundwater Treatment Plant	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Settling Pond A & B
		Soils, Groundwater, Surface Water, Aquatic Ecosystems	Dosing Pump
Alloys Smelting Plant Air Quality Control Systems		Air Quality, Visuals	Gaseous Emissions
		Air Quality, Visuals	Particulate Matter Emissions

Activity Area	Activity	Environmental Component Affected	Aspect
PROPOSED NEW ACTIVITIES/ EXPANSIONS/ UPGRADES (SECTION 4.3 IN SCOPING REPORT)			
Proposed New Activities/ Develop-ments/ Expansions	Decommissioning of two Historic Slimes Dams	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Excavate Historic Slimes
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Transport Historic Slimes to H:H Slimes Dam
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Dispose Historic Slimes on H:H Slimes Dam
	Decommissioning of Phase 1 of the H:H Slimes Dam	Soils, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Capping of H:H Slimes Dam
	Development and Expansion of the Process Water and Storm Water Canal System including Silt Traps	Soils, Groundwater, Surface Water, Wetlands, Aquatic Ecosystems, Air Quality, Noise, Visuals	Reduction of Run-off to Natural Resource
	Development of the Morula PCD	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Expansion of Storm Water PCD No. 1	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Development of Storm Water PCD No. 2	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Development of Storm Water PCD No. 3	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Development of Storm Water PCD No. 4	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation

Activity Area	Activity	Environmental Component Affected	Aspect
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Expansion of the OB Plant Process Water Dam	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Expansion of the Plant Process Water Dam	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Expansion of the CRP Process Water Dam	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Storage of Process Water
	Decommissioning of the Morula Dewatering Dam	Soils, Groundwater, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems	Dewatering of Dam
		Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems	Removal of contaminated sediment on basin
		Topography, Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Flatten & Shape Dam Walls
		Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Re-vegetate
	Development of a New Salvage Yard	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Yard Footprint
	Expansion of the Tap Hole Fume Extraction System	Air Quality, Visuals	Gaseous Emissions
		Air Quality	Particulate Matter Emissions
		Soils, Groundwater, Surface Water, Aquatic Ecosystems	Scrubber Effluent
	Expansion of the Finished Product Plant Dust Abatement System	Air Quality, Visuals	Gaseous Emissions
		Air Quality	Particulate Matter Emissions
		Soils, Groundwater, Surface Water, Aquatic Ecosystems	Scrubber Effluent
	Expansion of the OB Plant Tailings Storage Facility (TSF)	Soils, Surface Water, Plant Life, Animal Life, Aquatic Ecosystems, Air Quality, Noise, Visuals	Clearance of Vegetation
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Stabilisation of Facility Walls

Activity Area	Activity	Environmental Component Affected	Aspect
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Disposal to TSF
	Re-Use (Screening, Stockpiling, Internal Use and /or Selling) of Slag Sand at the Fine Slag Processing Plant	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Feed Material from CRP
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Screening and Separation Plant
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Spiral Plant
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Fine Chrome Bin (product)
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Slag Sand
		Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Water Recovery Sumps
	Re-Use (Screening, Stockpiling, Internal Use and /or Selling) of Coarse Slag at the CRP	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Screening Plant
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Stockpiling of Coarse Slag
	Re-Use of Mine Waste Rock at the Mine Waste Rock Stockpile	Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Crushing and Screening Plant
		Topography, Soils, Groundwater, Surface Water, Aquatic Ecosystems, Air Quality, Noise, Visuals	Stockpiling of Waste Rock Product

Table 9.2(b): HERNIC Ferrochrome Potential Impact Categories and Impact Descriptions for Environmental Impact Assessment

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
Socio Cultural	Geographic Processes (land use patterns)	Changes in land use patterns due to conversion of agricultural land to mining and industrial land use.
	Demographic Processes (population composition e.g. age, gender, race)	Changes in population numbers and profile due to potential influx of migrant workers for construction, operation and decommissioning.
	Institutional & Legal Processes (municipal services, public infrastructure, housing)	Changes in the demand for municipal services, transport and housing due to the increased in population.
	Cultural Processes (social, cultural and traditional practices)	Changes in the cultural dynamics of the area due to influx of people with different cultural and social backgrounds.
Heritage Resources	Historical and Cultural (places, buildings, structures, burial grounds, graves)	Damage to, or destruction of, graveyards and graves due to construction, mining and decommissioning activities.
Socio Economic	Economic Efficiency (labour, employment, output and growth)	Positive changes in economic output and regional exports due to the beneficiation of chrome ore to ferrochrome at HERNIC.
	Economic Equity (poverty, income)	Positive changes in employment, tax income, increased social spending and increased incomes due to employment offered by HERNIC.
	Economic Stability (diversity, resource use)	Positive changes in economic stability through diversification due to the beneficiation of the chrome ore at HERNIC.
Land Use	Beneficial Land Use (derelict, vacant, residential, industrial, mining, agricultural, recreational, wilderness, conservation)	Changes in land use due to the transformation of the agricultural land use to mining and smelting.
Infrastructure	Services (roads, pipelines, powerlines, rail lines, telecommunications)	Damage to roads due to increased heavy transport of ore and product to and from HERNIC.
Topography	Morphology	Creation of dangerous/unstable excavations due to mining, as well as dangerous/unstable mounds/piles/dumps due to stockpiling of soil, raw materials and product and due to disposal of waste onto land.
	Stability	Creation of areas prone to surface subsidence due to backfilling of the open cast mining pits.
Soils	Soil Horizon	Loss of soil horizon due to site clearance for construction of roads, buildings and plant infrastructure and utilities.
	Soil Fertility	Loss of soil fertility due to incorrect stockpiling of soils required for rehabilitation purposes.
	Soil Contamination	Contamination of soil due to spillages of raw material, ore and product during transport or due to spillages/seepages/leakages of contaminated water from pipes, canals, sumps and dams.
Land Capability	Land Capability (wetland, arable (dryland), arable (irrigation), grazing, wilderness, rehabilitated)	Changes in the land capability due to the construction and operation of mining and beneficiation infrastructure and processes.

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
Geology	Lithology	Changes in lithology due to mining from and backfilling into the open pits.
	Mineral Resources	Sterilization of mineral resources due to the construction of infrastructure on potential future mining areas.
Geochemistry	Acid Mine Generation (AMD)	Due to the geochemical inertness of the chrome ore, AMD is not expected to form – confirmed with testing.
Ground Water	Quantity (presence, flow, availability) of Ground Water	Depletion in the quantity of ground water available in the area due to the formation of cones of ground water level depression around the open mining pits, as well as around boreholes from which ground water is abstracted.
	Quality of Ground Water	Contamination of the ground water resource due to spillages of contaminated water from tanks, sumps, pipes and dams and/or the infiltration of soluble contaminants into the subsurface through the basins of stockpiles, dumps, sumps and dams.
Surface Water	Quantity (presence, flow, availability) of Surface Water	Depletion in the quantity of surface water due to the capture of direct rainfall in the open pits, in quarries and dams, as well as the capture of contaminated storm water run-off in Pollution Control Dams.
	Quality of Surface Water	Contamination of the surface water resource due to contaminated run-off from "dirty areas" directly into the surface water resources and/or spillages of contaminated water from tanks, sumps, pipes and dams.
Plant Life	Habitat	Impact on, or destruction of habitat due to site clearance for construction of roads, buildings and plant infrastructure and utilities.
	Bio-Diversity	Impact on, or destruction of Bio-Diversity due to a loss in habitat or as a result of contamination of soils or water.
	Red Data List Species (sensitive, threatened, endangered)	Potential threat to identified species at HERNIC if construction and operational activities are not prevented in close proximity to the identified specimens.
Animal Life	Habitat	Impact on, or destruction of habitat due to vegetation habitat disturbance as well the construction and presences of fences.
	Bio-Diversity	Impact on, or destruction of Bio-Diversity due to habitat disturbance or as a result of water pollution, air pollution, noise and traffic.
	Red Data List Species (sensitive, threatened, endangered)	Potential threat to potential present threatened species at HERNIC if construction and operational activities are not prevented in close proximity to identified specimens.
Wetlands	Habitat	Impact on, or destruction of habitat due to site clearance for construction of roads, buildings and plant infrastructure and utilities.

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue
	Functions and Services Provision (FSP)	Deterioration in FSP due to impact on wetland services provision attributes.
	Present Ecological State (PES)	Deterioration in PES due to impacts on habitat as well as wetland functions and services attributes.
Aquatic Ecosystems	Habitat (IHAS)	Impact on, or Destruction of Habitat due to impacts on habitat attributes such as water flow and water quality.
	Bio-Diversity (SASS5, FAII, Toxicity)	Impact on, or Destruction of Bio-Diversity due to impacts on habitat.
Air Quality	Gaseous Emissions	Deterioration in Ambient Air Quality due to gaseous emissions at the pelletizing/sinter plant and the smelter, or the Improvement in Ambient Air Quality as a result of the re-cycling/utilization of gas at these facilities.
	Particulate Matter	Deterioration in Ambient Air Quality due to particulate matter emissions at the pelletizing/sinter plant and the smelter, or the Improvement in Ambient Air Quality as a result of the cleaning of gas at these facilities.
	Dust Fallout	Deterioration in Ambient Air Quality due to dust generated by road transport, conveyor transport, crushing, handling, stockpiling and wind entrainment of raw materials, wastes and product as well as during construction and decommissioning activities.
Noise	Ambient Sound Level	Increase in the Ambient Sound Levels due to construction, mining, smelting, transport and decommissioning activities at HERNIC.
	Noise	Generation of Noise from specific HERNIC noise generating activities.
Traffic	Traffic Demand	Increase in Traffic Volumes due to road transport of personnel, raw materials, infrastructure and plant components, ore and final product.
Visuals	Visual Aspects (visibility, visual exposure, visual intrusion and landscape morphology)	Impacts on visibility, visual exposure, visual intrusion and landscape morphology due to the presence of infrastructure, as well the occurrence of particulate matter and dust emissions during the construction, operation and decommissioning of infrastructure and processes at HERNIC.

9.3. ASPECTS TO BE ASSESSED BY SPECIALISTS

A team of Environmental Specialists will consider and assess all aspects and impacts related to the following Environmental Components:

- Socio-Cultural/ Socio-Economic Aspects
- Archaeological and Heritage Aspects
- Palaeontological Aspects
- Land Use Aspects
- Aspects related to Infrastructure (Roads)
- Blasting and Vibration Aspects
- Traffic Aspects
- Topographical Aspects
- Soils and Land Capability Aspects
- Geology and Geochemistry Aspects
- Groundwater Aspects
- Surface Water Aspects
- Plant Life Aspects
- Animal Life Aspects
- Wetland Aspects
- Aquatic Ecosystems Aspects
- Air Quality Aspects
- Noise Aspects
- Visual Aspects

The outcomes of their assessments will be combined by the EAP and compiled into the EIA Report.

9.4. IMPACT ASSESSMENT METHODOLOGY

An Environmental Impact Assessment will be performed for each of HERNIC's project life-cycle phases (i.e. pre-construction/design phase, construction phase, operational phase, decommissioning and post-closure phase), for all project related activities (both existing and new), to determine what the impact will be on the environment. For existing activities, the life cycle phases of pre-construction/design and construction phase, will obviously fall away.

The Impact Assessment methodology comprises of three parts and will be conducted in Tabular format:

- Aspect Identification
- Impact Definition
- Impact Evaluation

These three parts are systematically addressed in the sections below. Firstly, the Activities deemed to have a potential environmental impact will be identified and categorised in order to identify the Aspect related to each Activity per life cycle phase. Afterwards, the Environmental Impact associated with the Aspect will be defined and finally, evaluated with reference to the Impact Assessment Methodology.

9.4.1. Relevant Project Activities

Activities as defined by the National Environmental Management Act 107 of 1998, means policies, programmes, processes, plans and projects. Activities associated with the HERNIC Operations were identified and are listed in Table 9.2(a).

9.4.2. Identification of Aspects per Life Cycle Phase

An Environmental Aspect as defined by the EAP is the mechanisms by which the project activities impact on receptors (e.g. people, economy, infrastructure, institutions and natural environment).

Aspects associated with the above mentioned activities will be identified per activity for all life-cycle phases and will be listed in Tabular Format.

9.4.3. Impact Description/Definition per Life Cycle Phase

Direct/Indirect and Cumulative Impacts associated with the above mentioned Aspects will be identified per life-cycle phase and these will be added to the Table.

Direct impacts require quantitative assessment as opposed to Indirect and Cumulative Impacts that are described qualitatively. In addition, an indication of any fatal flaws (i.e. very significant adverse impact which cannot be avoided or mitigated) will also be considered and provided in the Tables if applicable.

9.4.4. Evaluation of Environmental Impacts

9.4.4.1. Impact Rating Methodology

The basic elements used in the Evaluation of Impact Significance are described in the table below (Table 9.4.4.1(a)) and the characteristics used to describe the consequence of an impact are outlined in Table 9.4.4.1(b).

Table 9.4.4.1(a): Key elements in the evaluation of Impact Significance

Element	Description	Questions applied to the test of Significance
Consequence	An impact or effect can be described as the change in an environmental parameter, which results from a particular project activity or intervention. Here the term consequence refers to: • The sensitivity of the receiving environment, including its capacity to accommodate the kinds of changes the project may bring about • The type of change and the key characteristics of the change (these are magnitude, extent and duration) • The importance of the change (the level of public concern/ value attached to environment by the stakeholders and the change effected by the project) The following should be considered in the determination of impact consequence: • Standards and Guidelines (e.g. pollution and emissions thresholds) • Scientific evidence and professional judgement • Points of reference from comparable cases • Levels of stakeholder concern	Will there be a change in the biophysical environment? Is the change of consequence (of any importance)?
Probability	Likelihood/ Chances of an impact occurring	Is the change likely to occur?
Effectiveness of the Management Measures	Significance of the impact needs to be determined both without management measures and with management measures. The significance of the unmanaged impact needs to be determined so there is an appreciation of what could occur in the absence of management measures and of the effectiveness of the proposed management measures.	Will the management measures reduce impact to an acceptable level?
Uncertainty/ Confidence	Uncertainty in impact prediction and the effectiveness of the proposed management measures. Sources of uncertainty in impact prediction include: • Scientific uncertainty – limited understanding of an ecosystem or affected stakeholder and the processes that govern change • Data uncertainty – restrictions introduced by incomplete, contradictory or incomparable information, or by insufficient measurement techniques • Policy uncertainty – unclear or disputed objectives, standards or guidelines	What is the degree of confidence in the significance ascribed to the impact?

Table 9.4.4.1(b): Characteristics to be used in Impact Description

Characteristics used to describe Consequence	Sub-Components	Terms used to describe the Characteristics
Type		Biophysical, social or economic
Nature		Direct or Indirect or Cumulative
Status		Positive (a Benefit), Negative (a Cost) or Neutral
Phase of Project		During the Pre-Construction (if applicable), Construction, Operational, Decommissioning/ Post Closure
Timing		Immediate, Delayed
Magnitude	**Sensitivity of the Receiving environment/ receptors**	High, Medium or Low Sensitivity Low capacity to accommodate the change (impact)/ tolerant of the proposed change
	Severity/ Intensity (degree of change measured against thresholds and/ or professional judgment)	Gravity/ seriousness of the impact Intensity / Influence/ Power/ Strength
	Level of Stakeholder concern	High, Medium or Low levels of concern All or some stakeholders are concerned about the change
Spatial Extent The area affected by the impact.		Area/ Volume covered , Distribution, Population Site/ Local, Regional, National or International
Duration (and Reversibility) Length of time over which an impact occurs and potential for recovery of the endpoint from the impact		Short term. Long term Intermittent, Continuous Reversible, Irreversibility Temporary, Permanent
Confidence		High, Medium, Low

The Impact Significance Rating system is presented in Table 9.4.4.1(c) and involves four parts:

- Part A: Define impact consequence using the three primary impact characteristics of magnitude, spatial scale/ population and duration;
- Part B: Use the matrix to determine a rating for impact consequence based on the definition identified in Part A;
- Part C: Use the matrix to determine the impact significance rating, which is a function of the impact consequence rating (from Part B) and the probability of occurrence;
- Part D: Define the Confidence level.

Table 9.4.4.1(c): Method for rating the Significance of Impacts

PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE (Use these definitions to define the consequence in Part B) + *denotes a positive impact*		
Impact Characteristics	**Definition**	**Criteria**
MAGNITUDE	Major	Substantial deterioration or harm to receptors; receiving environment has an inherent value to stakeholders; receptors of impact are of conservation importance; or identified threshold often exceeded
	Moderate	Moderate/ measurable deterioration of harm to receptors; receiving environment moderately sensitive; or identified threshold occasionally exceeded
	Minor	Minor deterioration (nuisance or minor deterioration) or harm to receptors; change to receiving environment not measurable; or identified threshold never exceeded
	Minor +	Minor improvement; change not measurable; or threshold never exceeded
	Moderate +	Moderate improvement; within or better than the threshold; or no observed reaction
	Major +	Substantial improvement; within or better than the threshold; or favourable publicity
SPATIAL SCALE	Site or Local	Site specific or confined to the immediate project area
	Regional	May be defined in various ways e.g. cadastral, catchment, topographic
	National/ International	Nationally or beyond
DURATION	Short term	Quickly reversible. Less than two years
	Medium term	Reversible over time. Life of the project
	Long term	Permanent. Beyond closure

PART B: DETERMINING CONSEQUENCE RATING (Rate consequence based on definition of magnitude, spatial extent and duration)					
			SPATIAL SCALE		
			Site or Local	**Regional**	**National/ International**
MAGNITUDE					
Minor	**DURATION**	**Long term**	**Medium**	**Medium**	**High**
		Medium term	**Low**	**Low**	**Medium**
		Short term	**Low**	**Low**	**Medium**
Moderate	**DURATION**	**Long term**	**Medium**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Low**	**Medium**	**Medium**
Major	**DURATION**	**Long term**	**High**	**High**	**High**
		Medium term	**Medium**	**Medium**	**High**
		Short term	**Medium**	**Medium**	**High**

PART C: DETERMINING SIGNIFICANCE RATING (Rate significance based on consequence and probability)				
		CONSEQUENCE		
		Low	**Medium**	**High**
PROBABILITY (of exposure to impacts)	**Definite**	**Medium**	**Medium**	**High**
	Possible	**Low**	**Medium**	**High**
	Unlikely	**Low**	**Low**	**Medium**

PART D: CONFIDENCE LEVEL		
High	Medium	Low

9.5. METHOD FOR ASSESSING DURATION SIGNIFICANCE

The proposed method for assessing the duration of an impact is listed in Table 9.5(a) below.

Table 9.5(a): Method for Assessing Duration as Part of the Impact Significance Rating

PART A: DEFINING CONSEQUENCES OF MAGNITUDE, DURATION AND SPATIAL SCALE (Use these definitions to define the consequence in Part B) + *denotes a positive impact*		
Impact Characteristics	**Definition**	**Criteria**
DURATION	Short term	Quickly reversible. Less than two years
	Medium term	Reversible over time. Life of the project
	Long term	Permanent. Beyond closure

9.6. CONSULTATION TIME LINE WITH COMPETENT AUTHORITIES

HERNIC operates as a mine in terms of the MPRDA and hence the application(s) to be lodged for environmental authorization as part of this project are done in terms of the Single Environmental System, with DMR as the Competent Authority and therefore the primary authority to be consulted.

However, in order to facilitate the Integrated Water Use License Application process, the DWS will also be consulted.

The Consultation and Interaction Time Lines for the DMR and DWS are detailed in the two Tables below:

Table 9.6(a): Consultation Time Line with DMR

Hernic Ferrochrome (Pty) Ltd Environmental Master Plan Discussion Meeting with DMR - Klerksdorp	**01 November 2016**
Hernic Ferrochrome (Pty) Ltd Environmental Master Plan Discussion Meeting with DWS - Hartbeespoort	**28 November 2016**
Submission of the Environmental Authorisation (EA) application in terms of the NEMA and NEMWA to the DMR (CA)	**26 January 2017**
Draft Scoping Report submitted to DMR (CA)	**26 January 2017**
Scoping Phase Public Meeting for I&AP's	**27 January 2017**
Draft Scoping Report available to I&AP's	**27 January 2017**
CA and I&AP Review Process (30 days) concludes	**28 February 2017**
Submit Final Scoping Report (which has been subjected to Public Participation) to DMR (CA) 44 days after Application was received by CA	**13 March 2017**
CA to Review/Accept Scoping Report (43 days)	**02 May 2017**
Draft EIA and EMP Report submitted to DMR (CA)	**13 June 2017**
Impact Phase Public Meeting for I&AP's	**14 June 2017**
Draft EIA and EMP Report available to I&AP's	**15 June 2017**
CA and I&AP Review Process (30 days) concludes	**18 July 2017**
Submit Final EIA and EMP Report (which has been subjected to Public Participation) to DMR (CA) 106 days after Acceptance of Scoping Report by CA	**18 August 2017**
DMR and DWS Meetings	**14 November 2017**
Approval by CA 107 days after receipt of the Final EIA and EMP Reports	**04 December 2017**

Table 9.6(b): Consultation Time Line with DWS

Submission of the Environmental Authorisation (EA) application in terms of the NEMA and NEMWA to the DMR (Start of Process)	**26 January 2017**
Submission of Notice of Intent to submit an integrated Water Use Licence and Amendment application to the DWS (This Letter)	**26 January 2017**
Notice of Intent (This Letter) to be acknowledged by the DWS (*within 10 days of submission*)	**06 February 2017**
Site Inspection and Permission to Proceed (*30 days after Notice of Intent Acknowledgement by DWS*)	**08 March 2017**
Pre-Application Consultation Meeting with the DWS regarding the integrated Water Use Licence and Amendment application	**(Same day as Site Inspection)**
Submission of the integrated Water Use Licence and Amendment application to the DWS	**Mid to End June 2017**
WUL Recommendations made by the DWS	**Mid October 2017**
Meeting(s) between the DMR and DWS (*within 20 days of DWS Recommendations*)	**Start to Mid November 2017**
WUL Decision made by the DWS (*300 days after EA Application submitted to DMR*)	**Start to Mid December 2017**

9.7 EIA STAGE PUBLIC PARTICIPATION PROGRAMME PARTICULARS

9.7.1 Notification of Interested and Affected Parties

An extensive list/register of I&AP's and authorities will have been compiled by this phase and the same database will be used for communication with I&AP's during the EIA phase.

However should any person be identified, or should any person request to be registered as an I&AP to the project, at any stage of the project, he/she will be given the opportunity to do so and be notified of the project accordingly.

Notification of I&APs and authorities on the progress of the project will be done according to the regulations as set out in GNR 982 which includes notification letters, press advertisements, and site notices. These notices and advertisements will inform the I&AP's on details of the Public Meeting during the EIA phase.

9.7.2 Details of Engagement Process

Meetings with authorities during the EIA phase will be organized on request. The I&AP's will be invited to attend a Public Meeting during which the results of the environmental impact assessment and proposed management and mitigation measures will be communicated to them. Should some of the I&AP's wish to be consulted in a Focus Group format, such meetings will be scheduled and conducted.

All I&APs will receive the opportunity to comment on any of the information generated during the EIA/EMP Process, in the review periods of the reports, which will be submitted to the relevant authorities.

The IWWMP which will be submitted to the DWS is not usually presented for formal public review due to the complex and technical nature of the report, but should any I&AP wish to view this report, it will be made available to them. Irrespective of this fact the results of the IWWMP will be discussed with the I&AP's during the EIA Phase Public Meeting and possible Focus Group Meetings.

All comments that are raised by I&AP's will be incorporated into an I&AP Comments Register. JMA will then address each and every issue or comment raised. Once this is completed the I&AP's will be notified of how their issue or comment have been addressed and the finalized report will be submitted to the relevant authorities.

9.7.3 Information to be provided to Interested and Affected Parties

Throughout the Public Participation Process, I&AP's will have access to draft reports at public venues. They will also be able to access all draft reports on the JMA Consulting website (www.jmaconsult.co.za).

A detailed Public Participation Report, containing information of all the actions that were undertaken with regard to the Public Participation Process (for both phases, Scoping and EIA), will be compiled for this project and be submitted along with the final reports to the relevant competent authority.

9.8 TASKS TO BE UNDERTAKEN DURING ENVIRONMENTAL IMPACT ASSESSMENT

The following tasks will be conducted during the EIA Phase:

9.8.1 EIA Stage 3: Environmental Impact Assessment

- Commence to Implement Plan of Study
- Continue Public Participation Process
- Conduct Specialist Studies including Alternative Assessments, Feasibility Studies and Engineering Designs
- Prepare EIA Report (EIAR comprising EIA, EMPr as per Regulations and Guidelines)
- EIA/EMP Public Meeting
- Make EIAR available for Review
- Capture and Consider Comments from I&AP's and Relevant Authorities
- Finalize and Submit EIAR to I&AP's and Authorities

9.8.2 EIA Stage 4: Consideration and Decision

- Authority Review & Decision
- Notification of Decision on the EIAR
- Granting of Environmental Authorization
- Inform I&AP's of Decision/Approval and of Opportunity to Appeal

9.8.3 EIA Stage 5: Appeal

- Appellant to give notice of intention to Appeal to Authority and Applicant
- Consultation between Applicant and Appellant to Resolve Issues
- Submission of appeal to Authority and Applicant
- Submission of Responding Statement from Respondent/Applicant to Authority and Appellant
- Submission of Answering Statement by Appellant to Authority and Applicant
- Acknowledgment of all by Authority within 10 days
- Processing of Appeal
- Decision on Appeal
- Notification of Decision on Appeal to Appellant and Respondents by Authority

9.9 MANAGEMENT MEASURES TO AVOID, MANAGE OR MITIGATE IMPACTS

The details of the management measures to be implemented at HERNIC Ferrochrome will of course be developed during the EIA Phase of the project. However, JMA Consulting has developed a Mitigation/Management Measure Table which indicates the options available for the mitigation/management of specific environmental impacts and risks.

The Table was compiled specifically for Ferrochrome Smelting Operations and considered all typical activities associated with this type of operation and identifies and describes the impacts and possible mitigation/management measures per environmental component. The last column in the Table indicates if a potential Residual Risk would be present after decommissioning and closure.

Table 9.9(a): Mitigation and Management Measures and Potential Residual Risk

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Socio Cultural	Geographic Processes (land use patterns)	Changes in land use patterns due to conversion of agricultural land to mining and industrial land use.	Optimize the post closure land use to support the post closure land use objectives.	X	
	Demographic Processes (population composition e.g. age, gender, race)	Changes in population numbers and profile due to potential influx of migrant workers for construction, operation and decommissioning.	Implement an employment policy of local first as far as possible.	X	
	Institutional & Legal Processes (municipal services, public infrastructure, housing)	Changes in the demand for municipal services, transport and housing due to the increase in population.	Consult with local authorities to ensure the availability and maintenance of services as a result of increased demand. Contribute to local development through the mine social and labour plan.	X	
	Cultural Processes (social, cultural and traditional practices)	Changes in the cultural dynamics of the area due to influx of people with different cultural and social backgrounds.	Implement an employment policy of local first as far as possible. Contribute to local upliftment and cultural development through the mine social and labour plan.	X	
Heritage Resources	Historical and Cultural (places, buildings, structures, burial grounds, graves)	Damage to, or destruction of, graveyards and graves due to construction, mining and decommissioning activities.	Avoid the encroachment upon and destruction of Heritage Resources.		X
Socio Economic	Economic Efficiency (labour, employment, output and growth)	Positive changes in economic output and regional exports due to the beneficiation of chrome ore to ferrochrome at HERNIC.	Maximize local recruitment.		X
	Economic Equity (poverty, income)	Positive changes in employment, tax income, increased social spending and increased incomes due to employment offered by HERNIC.	Maximize local procurement. Minimize Risks of external costs.		X
	Economic Stability (diversity, resource use)	Positive changes in economic stability through diversification due to the beneficiation of the chrome ore at HERNIC.	Maximize impact of tax and social funds.		X
Land Use	Beneficial Land Use (derelict, vacant, residential, industrial, mining, agricultural, recreational, wilderness, conservation)	Changes in land use due to the transformation of the agricultural land use to mining and smelting.	Minimize the development footprints. Optimize the post closure land use to achieve the post closure land use objectives.	X	
Infrastructure	Services (roads, pipelines, powerlines, rail lines, telecommunications)	Damage to roads due to increased heavy transport of ore and product to and from HERNIC.	Maintain all access roads used by the Operations. Ensure that vehicles are not over loaded.		X

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Topography	Morphology	Creation of dangerous/unstable excavations due to mining, as well as dangerous/unstable mounds/piles/dumps due to stockpiling of soil, raw materials and product and due to disposal of waste onto land.	Ensure that relevant facilities (stcokplies, dumps, excavations) are operated in strict accordance with the design principles and ensure final decommissioning and closure in compliance with closure designs.		X
	Stability	Creation of areas prone to surface subsidence due to backfilling of the open cast mining pits.	Ensure adequate compaction during backfilling.	X	
Soils	Soil Horizon	Loss of soil horizon due to site clearance for construction of roads, buildings and plant infrastructure and utilities.	Minimize development footprints.	X	
	Soil Fertility	Loss of soil fertility due to incorrect stockpiling of soils required for rehabilitation purposes.	Handle and stockpile soil in compliance with guidelines provided.		X
	Soil Contamination	Contamination of soil due to spillages of raw material, ore and product during transport or due to spillages/seepages/leakages of contaminated water from pipes, canals, sumps and dams.	Minimize spillages and leakages. Remediate spillages as soon as possible.	X	
Land Capability	Land Capability (wetland, arable (dryland), arable (irrigation), grazing, wilderness, rehabilitated)	Changes in the land capability due to the construction and operation of mining and beneficiation infrastructure and processes.	Minimize the development footprints. Optimize the post closure land capability to achieve the post closure land use objectives.	X	
Geochemistry	Acid Mine Generation (AMD)	Due to the geochemical inertness of the chrome ore, AMD is not expected to form – confirmed with testing.	No measures required.		X
Ground Water	Quantity (presence, flow, availability) of Ground Water	Depletion in the quantity of ground water available in the area due to the formation of cones of ground water level depression around the open mining pits, as well as around boreholes from which ground water is abstracted.	Allow for re-flooding of the rehabilitated open pit post closure. Manage abstraction from production boreholes to optimize the sustainability of the groundwater resource.		X
	Quality of Ground Water	Contamination of the ground water resource due to spillages of contaminated water from tanks, sumps, pipes and dams and/or the infiltration of soluble contaminants into the subsurface through the basins of stockpiles, dumps, sumps and dams.	Operate PCD's, Process Water Dams and Slimes Dams to prevent spillages. Maintain liner integrity to prevent seepage for these facilities.	X	

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Surface Water	Quantity (presence, flow, availability) of Surface Water	Depletion in the quantity of surface water due to the capture of direct rainfall in the open pits, in quarries and dams, as well as the capture of contaminated storm water run-off in Pollution Control Dams.	Minimize dirty water areas at the site.		X
	Quality of Surface Water	Contamination of the surface water resource due to contaminated run-off from "dirty areas" directly into the surface water resources and/or spillages of contaminated water from tanks, sumps, pipes and dams.	Operate PCD's, Process Water Dams and Slimes Dams to prevent spillages. Optimize the Storm Water Management Plan to capture run-off from dirty water areas.		X
Plant Life	Habitat	Impact on, or destruction of habitat due to site clearance for construction of roads, buildings and plant infrastructure and utilities.	Minimize the development footprints. Optimize the post closure land capability to achieve the post closure land use objectives.		X
	Bio-Diversity	Impact on, or destruction of Bio-Diversity due to a loss in habitat or as a result of contamination of soils or water.	Minimize the development footprints. Minimize spillages of contaminants. Optimize the post closure land capability to achieve the post closure land use objectives.		X
	Red Data List Species (sensitive, threatened, endangered)	Potential threat to identified species at HERNIC if construction and operational activities are not prevented in close proximity to the identified specimens.	No Red Data Species observed.		X
Animal Life	Habitat	Impact on, or destruction of habitat due to vegetation habitat disturbance as well the construction and presences of fences.	Minimize the development footprints. Optimize the post closure land capability to achieve the post closure land use objectives.		X
	Bio-Diversity	Impact on, or destruction of Bio-Diversity due to habitat disturbance or as a result of water pollution, air pollution, noise and traffic.	Minimize the development footprints. Minimize spillages of contaminants. Optimize the post closure land capability to achieve the post closure land use objectives.		X
	Red Data List Species (sensitive, threatened, endangered)	Potential threat to potential present threatened species at HERNIC if construction and operational activities are not prevented in close proximity to identified specimens.	No Red Data Species observed.		X
Wetlands	Habitat	Impact on, or destruction of habitat due to site clearance for construction of roads, buildings and plant infrastructure and utilities.	Avoid development within wetlands.		X

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
	Functions and Services Provision (FSP)	Deterioration in FSP due to impact on wetland services provision attributes.	Avoid development within wetlands.		X
	Present Ecological State (PES)	Deterioration in PES due to impacts on habitat as well as wetland functions and services attributes.	Avoid development within wetlands.		X
Aquatic Ecosystems	Habitat (IHAS)	Impact on, or Destruction of Habitat due to impacts on habitat attributes such as water flow and water quality.	Prevent surface water impacts into wetlands and streams through effective storm water management.		X
	Bio-Diversity (SASS5, FAII, Toxicity)	Impact on, or Destruction of Bio-Diversity due to impacts on habitat.	Prevent surface water impacts into wetlands and streams through effective storm water management.		X
Air Quality	Gaseous Emissions	Deterioration in Ambient Air Quality due to gaseous emissions at the pelletizing/sinter plant and the smelter, or the Improvement in Ambient Air Quality as a result of the re-cycling/utilization of gas at these facilities.	Minimize gaseous emissions through the implementation and operation of effective air quality abatement equipment.		X
	Particulate Matter	Deterioration in Ambient Air Quality due to particulate matter emissions at the pelletizing/sinter plant and the smelter, or the Improvement in Ambient Air Quality as a result of the cleaning of gas at these facilities.	Minimize particulate matter emissions through the implementation and operation of effective air quality abatement equipment.		X
	Dust Fallout	Deterioration in Ambient Air Quality due to dust generated by road transport, conveyor transport, crushing, handling, stockpiling and wind entrainment of raw materials, wastes and product as well as during construction and decommissioning activities.	Minimize dust fallout through the implementation and operation of effective dust suppression programmes.		X
Noise	Ambient Sound Level	Increase in the Ambient Sound Levels due to construction, mining, smelting, transport and decommissioning activities at HERNIC.	Conduct Noise Audits and implement noise reduction measures where possible.		X
	Noise	Generation of Noise from specific HERNIC noise generating activities.	Conduct Noise Audits and implement noise reduction measures where possible.		X
Traffic	Traffic Demand	Increase in Traffic Volumes due to road transport of personnel, raw materials, infrastructure and plant components, ore and final product.	Optimize Rail Transport of Raw Materials and Product. Ensure that road capacities are not exceeded and implement effective traffic safety measures.		X

Environmental Component	Impact Category	Description of Nature of Potential Impact/Issue	Possible Mitigation/Management Measure	Potential for Residual Risk	
				Yes	No
Visuals	Visual Aspects (visibility, visual exposure, visual intrusion and landscape morphology)	Impacts on visibility, visual exposure, visual intrusion and landscape morphology due to the presence of infrastructure, as well the occurrence of particulate matter and dust emissions during the construction, operation and decommissioning of infrastructure and processes at HERNIC.	Optimize Air Quality Management measures. Conduct effective housekeeping for public visible areas.		X

10. INFORMATION REQUIRED BY THE COMPETENT AUTHORITY

10.1 IMPACT ON SOCIO-ECONOMIC CONDITIONS OF DIRECTLY AFFECTED PERSONS

Required for the EIA Report.

A Socio-economic Specialist has been appointed and will compile a Specialist Study Report in this regard.

10.2 IMPACT ON THE NATIONAL ESTATE (SECTION 3(2) OF THE NHRA)

Required for the EIA Report.

A Heritage Specialist has been appointed and will compile a Specialist Study Report in this regard.

11. REQUIREMENTS IN TERMS OF SECTION 24(4)(A) AND (B) OF THE ACT

Section 24 (4) (b) (i) of the National Environmental Management Act, Act 107 of 1998, as amended, states:

(4) *Procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment -*

(b) *must include, with respect to every application for an environmental authorization and where applicable –*

(i) *investigation of the potential consequences or impacts of the alternatives to the activity on the environment and assessment of the significance of those potential consequences or impacts, including the option of not implementing the activity;*

Refer to the Table provided below which provides the sections in this report which relays the information as requested in terms of Section 24(4)(A) and (B) of the Act.

24 (4) Procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment-	
(a) must ensure, with respect to every application for an environmental authorisation-	**Section**
(i) coordination and cooperation between organs of state in the consideration of assessments where an activity falls under the jurisdiction of more than one organ of state;	
(ii) that the findings and recommendations flowing from an investigation, the general objectives of integrated environmental management laid down in this Act and the principles of environmental management set out in section 2 are taken into account in any decision made by an organ of state in relation to any proposed policy, programme, process, plan or project;	
(iii) that a description of the environment likely to be significantly affected by the proposed activity is contained in such application;	
(iv) investigation of the potential consequences for or impacts on the environment of the activity and assessment of the significance of those potential consequences or impacts; and	
(v) public information and participation procedures which provide all interested and affected parties, including all organs of state in all spheres of government that may have jurisdiction over any aspect of the activity, with a reasonable opportunity to participate in those information and participation procedures; and	
(b) must include, with respect to every application for an environmental authorisation and where applicable-	**Section**
(i) investigation of the potential consequences or impacts of the alternatives to the activity on the environment and assessment of the significance of those potential consequences or impacts, including the option of not implementing the activity;	
(ii) investigation of mitigation measures to keep adverse consequences or impacts to a minimum;	
(iii) investigation, assessment and evaluation of the impact of any proposed listed or specified activity on any national estate referred to in section 3(2) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999), excluding the national estate contemplated in section 3(2)(i)(vi) and (vii) of that Act;	
(iv) reporting on gaps in knowledge, the adequacy of predictive methods and underlying assumptions, and uncertainties encountered in compiling the required information;	
(v) investigation and formulation of arrangements for the monitoring and management of consequences for or impacts on the environment, and the assessment of the effectiveness of such arrangements after their implementation;	
(vi) consideration of environmental attributes identified in the compilation of information and maps contemplated in subsection (3); and	
(vii) provision for the adherence to requirements that are pre scribed in a specific environmental management Act relevant to the listed or specified activity in question	

12. UNDERTAKING - CORRECTNESS OF INFORMATION

I, **Jasper Lodewyk Muller**, herewith undertake that the information provided in the foregoing report is correct, and that the comments and inputs from Stakeholders and Interested and Affected Parties has been correctly recorded in the report.

Will be completed after the Public Review Period

Signature of the EAP: ____________________________

Jasper L Muller (Pr. Sci. Nat.)

Date: ____________________________

13. UNDERTAKING - PLAN OF STUDY LEVEL OF AGREEMENT

I, **Jasper Lodewyk Muller**, herewith undertake that the information provided in the foregoing report is correct, and that the level of agreement with Interested and Affected Parties and Stakeholders, has been correctly recorded and reported herein.

Will be completed after the Public Review Period

Signature of the EAP: ____________________
Jasper L Muller (Pr. Sci. Nat.)

Date: ____________________

-END-