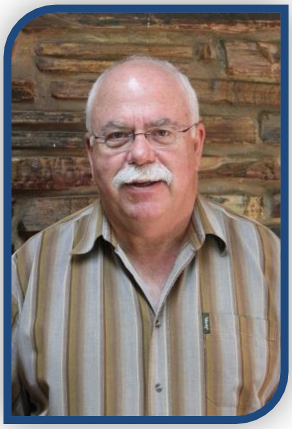
APPENDIX 1(A)

CV of the Environmental Assessment Practitioner (EAP)

JASPER MüLLER (Pr. Sci. Nat.)



Geohydrologist/EAP

Position: Managing Director | Consulting Scientist

Founded JMA: 1988

Qualifications:

M. Sc. (Cum Laude) Geohydrology, University of the Free State, 1984
B. Sc. (Hons) Geohydrology, University of the Free State, 1980
B. Sc.: Geology and Geohydrology, University of the Free State, 1979

Career:

- **1988:** Founded JMA Consulting (Pty) Ltd.
- **1987:** Divisional Head, Geohydrology, Environmental Science Services
- **1983**: Researcher with Institute for Ground Water Studies, UOFS.
- **1981**: Hydrologist with Dept. of Water Affairs.

Key Experience:

Since 1988 Jasper Müller was involved on a consulting level on more than 200 JMA projects related to Water Supply, Aquifer Management, Groundwater Quality investigations, Groundwater Monitoring, Groundwater Impact and Risk Modelling, Groundwater Pollution Remediation, EIA and EMPR applications, Integrated Water Use License applications, Waste License applications and Litigation consultative work.

Professional Associations:

Contact Details:

Phone: +27 13 665 1788
Mobile: +27 82 495 0169
E-mail: jasper@jmaconsult.co.za

Selected Recent Relevant Projects:

- **Glencore Atcom East:** Groundwater Modelling in support of IWULA (2015)
- **Canyon Resources:** Groundwater Specialist Report in support of EIA, EMP and IWULA (2015)
- **Xstrata Alloys Boshoek Operation:** EMPr Amendment Project (2015)
- **Evraz Vametco:** EIA/EMPr Amendment (2015)
- **Samancor Chrome Ferrometals:** Environmental Authorizations (Water Use & Waste License) (2014)
- **Sasol Mining Borrow Pits:** EIA, EMP and IWULA (2013)
- **Sasol Mining Shondoni Mine:** EIA, EMP and IWULA (2011)
- **Xstrata Alloys Wonderkop Operations:** EIA/EMPr Amendment, Water Use License and Waste License (2011)
- **Xstrata Alloys Rustenburg Works:** EIA/ EMP Water Use License and Waste License (2010)

APPENDIX 4(A)

HERNIC Process and Materials Characterization Report

PROCESS AND MATERIALS CHARACTERISATION REPORT

Hernic Ferrochrome (Pty) Ltd

DECEMBER 2016

JMA Consulting

Purpose of Report

JMA Consulting (Pty) Ltd was appointed by Hernic Ferrochrome (Pty) Ltd to develop an Environmental Master Plan for their Chromite Mining and Ferrochrome Beneficiation operations situated 7 km to the south-east of Brits. This Process and Materials Characterisation Report has been compiled in support of the Environmental Master Plan including the associated requirements for environmental authorisations as required for Hernic Ferrochrome (Pty) Ltd.

The purpose of this Process and Materials Characterisation Report is to provide a detailed description of the processes undertaken on site, the raw materials used, flow of materials, water reticulation and containment, waste streams generated and associated details in support of the characterisation thereof. This Process and Materials Characterisation Report will be used to characterise the water and materials used on site to identify the areas of higher risks from those of little to no risks to support the specialists in developing their risk assessments and proposed management plans. The information documented in this report will also be used during the planning and designing of future water and waste management facilities and infrastructure.

Report Reference Numbers

JMA Project: JMA/10462
JMA Report: Prj6000
Date: December 2016

Report Status

Final
Version – 01
Volume 1 of 2

Compiled for

HERNIC FERROCHROME (PTY) LTD
PO Box 4534
Brits
0250
(t): 012 381 1100
(f): 012 381 1111

Compiled by

JMA CONSULTING (PTY) LTD
15 Vickers Street
Delmas
2210
(t): 013 665 1788
(f): 013 665 2364

Mr Riaan Grobbelaar (Pr.Sci.Nat.)
riaan@jmaconsult.co.za

Mr Shane Turner (Pr.Sci.Nat)
shane@jmaconsult.co.za

Mrs René Rademeyer (Pr.Sci.Nat)
rene@jmaconsult.co.za

Mr Michael Lombard (Cand.Sci.Nat)
michael@jmaconsult.co.za

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

LIST OF APPENDICES

LIST OF ACRONYMS

ABA	:	Acid Base Accounting
AEL	:	Atmospheric Emission Licence
AP	:	Acid Potential
AUC	:	Average Upper Crust
BIC	:	Bushveld Igneous Complex
CRP	:	Chrome Recovery Plant
C.V.	:	Curriculum Vitae
DMS	:	Dense Medium Separation
EC	:	Electrical Conductivity
EIA	:	Environmental Impact Assessment
EMP	:	Environmental Management Programme
EMPR	:	Environmental Management Programme Report
ETP	:	Effluent Treatment Plant
GIS	:	Geographic Information System
HMS	:	Heavy Medium Separation
ICP-MS	:	Inductively Coupled Plasma Mass Spectrometry
IEM	:	Integrated Environmental Management
JORC	:	Joint Ore Reserves Committee
LC	:	Leachable Concentration
LCT	:	Leachable Concentration Threshold
MG	:	Middle Group
MVA	:	Megavolt Ampere
NAG	:	Net Acid Generation
NEMA	:	National Environmental Management Act (Act No. 107 of 1998)
NEMAQA	:	National Environmental Management Air Quality (Act No. 39 of 2004)
NEMWA	:	National Environmental Management: Waste Act (Act No. 59 of 2008)
NNP	:	Net Neutralizing Potential
NP	:	Neutralisation Potential
NWA	:	National Water Act (Act No. 36 of 1998)
OB	:	Ore Beneficiation
PCD	:	Pollution Control Dam
PGM	:	Platinum Group Mineral
PWT	:	Plant Water Treatment
RLS	:	Rustenburg Layered Suite
ROM	:	Run of Mine
RWD	:	Return Water Dam
RWLP	:	Reagent Water Leachate Procedure
SACNASP	:	South African Council for Natural Scientific Professions
SSD	:	Safety and Sustainable Development
TC	:	Total Concentration
TCT	:	Total Concentration Threshold
TDS	:	Total Dissolved Solids
TSF	:	Tailings Storage Facility
UFS	:	University of the Free State
UG	:	Upper Group
UP	:	University of Pretoria
US	:	University of Stellenbosch
WGS	:	World Geodetic System
WMA	:	Water Management Area
WML	:	Waste Management Licence
WUL	:	Water Use Licence
WWTW	:	Waste Water Treatment Works
XRD	:	X-Ray Diffraction
XRF	:	X-Ray Fluorescence

EXECUTIVE SUMMARY

This Process and Materials Characterisation Report is one of a series of Specialist Reports compiled in support of the terms of reference for the compilation of an Environmental Master Plan for the chromite mining and ferrochrome beneficiation operations at Hernic Ferrochrome (Pty) Ltd (referred to as HERNIC).

HERNIC is an existing operation and has been in operation since May 1996. The HERNIC Operation has expanded over the years and currently includes the mining of chromite ore (initially via opencast and then later via underground mining methods), ore beneficiation to yield feedstock chromite concentrate and lumpy ore, followed by pelletising and sintering of the fine ore and finally ferrochrome smelting in four closed furnaces, with a production capacity of 420 000 tonnes of ferrochrome per annum. Several chrome recovery operations from chromite containing slag are also active on the site.

A summary of the major processes undertaken at HERNIC is listed below:

- **mining of chromite ore** via previous opencast and current underground mining methods,
- **ore beneficiation** to yield feedstock chromite concentrate and lumpy ore,
- **pelletising and sintering** of the fine chromite ore,
- **ferrochrome smelting** in four closed furnaces,
- **ferrochrome recovery** via the chrome recovery plant(s).

Each of these major processes, including the activities and infrastructure associated therewith are addressed in detail in Section 9 of the report.

The surface operations at HERNIC are located on and restricted to the **Farm De Kroon 444 JQ** and cover a surface area of approximately 386 *ha*. The HERNIC Mining Right Boundary includes the neighbouring **Farm Elandsfontein 440 JQ** as well, but at present no surface activities occur on this property. Historically both opencast as well as underground mining occurred on / below the Farm Elandsfontein 440 JQ. Whereas the opencast mining has been completed and is currently in a state of partial rehabilitation, underground mining of the MG-1 and MG-2 seams will continue below both properties.

The purpose of this Process and Materials Characterisation Report is to provide a detailed description of the processes undertaken on site, the raw materials used, flow of material, water containment, waste streams generated and the associated details in support of the characterisation thereof. This Process and Materials Characterisation Report will be used to characterise and classify the water and waste material on site to identify the areas of higher risks from those of little to no risks to support the specialists in developing their risk assessments and proposed management plans. The information documented in this report will also be used during the planning and designing of future water and waste management facilities and infrastructure.

This report has been compiled in order to give fulfilment with several Regulatory Processes, both in terms of study material content and format. This report should be read in conjunction with the Surface Water, Aquatic Ecosystems, Geology and Geochemistry as well as the Groundwater Specialist Reports and with specific reference to the impact assessments within these reports. This Process and Materials Characterisation Report does not consider the air quality sources or emissions for the current or future expansion/new activities, which are however addressed in detail in the Air Quality Specialist Study Report.

The primary aim / terms of reference of this Process and Materials Characterisation Report is therefore to:

- provide a detailed description of the processes undertaken,
- prove the details of the raw materials used,
- indicate the flow of material throughout the various plants and processes,
- provide the details of the water and water containment facilities,
- provide the details of the waste streams generated, and
- provide the details of the waste disposal facilities, in support of the characterisation thereof.

Based on the project description and site inventory a sampling plan was compiled in order to take material samples that are stockpiled and disposed of on-site at HERNIC which may have a potential impact on the environment. A total of **30** material samples were collected for analytical testing as detailed in the report. The material samples included both raw materials, by-products as well as waste materials. A summary of the materials sampled are indicated in Table I below.

Table I: Material Sample Numbers and Descriptions

Sample Number	Latitude	Longitude	Description	Material Type
HRM-1	25⁰ 39' 40.0"S	27⁰ 50' 29.9"E	Dolomite	Raw Material Stockpile
HRM-2	25⁰ 39' 39.9"S	27⁰ 50' 29.2"E	Quartzite	Raw Material Stockpile
HRM-3	25⁰ 39' 38.7"S	27⁰ 50' 32.4"E	ACP Char	Raw Material Stockpile
HRM-4	25⁰ 39' 37.8"S	27⁰ 50' 32.1"E	Coke Nuts	Raw Material Stockpile
HRM-5	25⁰ 39' 40.3"S	27⁰ 50' 32.5"E	Anthracite	Raw Material Stockpile
HRM-6	25⁰ 39' 34.6"S	27⁰ 50' 29.9"E	Limestone	Raw Material Stockpile
HRM-8	25⁰ 39' 31.6"S	27⁰ 50' 31.6"E	MG - 1 Ore	Raw Material Stockpile
HRM-9	25⁰ 39' 30.1"S	27⁰ 50' 33.5"E	MG - 2 Ore	Raw Material Stockpile
HRM-10	25⁰ 39' 33.5"S	27⁰ 50' 30.1"E	Chemstof Concentrate	Raw Material Stockpile
HRM-11	25⁰ 39' 34.2"S	27⁰ 50' 29.3"E	UG - 2 Concentrate	Raw Material Stockpile
HRM-12	25⁰ 39' 27.3"S	27⁰ 50' 37.9"E	Unprocessed slag	Unprocessed Slag Material
HRM-13	25⁰ 39' 14.5"S	27⁰ 50' 53.1"E	Slimes (TSF)	Waste Material Dam/Dump
HRM-14	25⁰ 39' 29.9"S	27⁰ 50' 30.2"E	DMS Lumpy (10x30) Chrome Ore	Raw Material Stockpile
HRM-15	25⁰ 39' 29.8"S	27⁰ 50' 30.3"E	DMS Waste	Waste Material Stockpile
HRM-16	25⁰ 39' 24.1"S	27⁰ 50' 24.1"E	HFC Concentrate	Raw Material Stockpile
HRM-17	25⁰ 39' 41.5"S	27⁰ 50' 02.3"E	Slag Fines	Waste Material Dump/Stockpile
HRM-18	25⁰ 39' 49.1"S	27⁰ 50' 54.3"E	Final Slag Dump	Waste Material Dump/Stockpile
HRM-19	25⁰ 39' 24.2"S	27⁰ 51' 13.6"E	MG 4 - Ore	Raw Material Stockpile
HRM-21	25⁰ 39' 36.6"S	27⁰ 49' 55.1"E	Return material	Raw and Waste Material Residue
HRM-22	25⁰ 39' 31.9"S	27⁰ 50' 11.3"E	Pellets	Raw Material Stockpile
HRM-23	25⁰ 39' 33.6"S	27⁰ 50' 11.2"E	Process water dam sediment	Raw and Waste Material Residue
HRM-24	25⁰ 39' 22.6"S	27⁰ 50' 23.6"E	OB dam sediment	Raw and Waste Material Residue
HRM-25	25⁰ 39' 31.2"S	27⁰ 50' 47.6"E	Rehabilitated Pit 1	Mixed Waste Backfill Material
HRM-26	25⁰ 39' 28.9"S	27⁰ 50' 51.3"E	Rehabilitated Pit 2	Mixed Waste Backfill Material
HRM-27	25⁰ 39' 26.8"S	27⁰ 50' 59.7"E	Rehabilitated Pit 3	Mixed Waste Backfill Material
HRM-28	25⁰ 39' 25.0"S	27⁰ 51' 01.7"E	Rehabilitated Pit 4	Mixed Waste Backfill Material
HRM-29	25⁰ 39' 45.1"S	27⁰ 51' 17.3"E	Mining Waste Rock Stockpile	Waste Material Stockpile
HRM-30	25⁰ 39' 36.2"S	27⁰ 51' 10.4"E	Grout plant	Waste Rock Stockpile
HRM-31	25° 39' 35.3"S	27⁰ 49' 44.4"E	Western Backfill	Mixed Waste Backfill Material
HRM-32	25⁰ 39' 28.6"S	27⁰ 50' 26.3"E	Mixed Waste	Waste Material Dump

The mineralogical compositions of the material samples were determined by means of X-Ray Diffraction (XRD) analyses, whilst the elemental analyses of the material samples were determined by means of X-Ray Fluorescence (XRF) analyses. The XRD and XRF results are addressed in Section 11.2 of the report.

The potential that the reductants (carbonaceous raw material samples) could have on generating acidic drainage conditions were assessed by means of Acid-Base Accounting (ABA) as well as Net Acid Generation (NAG) tests. The ABA and NAG test results are addressed in Section 11.3 of the report.

The potential that the material samples could have to generate a leachate with elevated elemental concentrations were assessed by means of the Reagent Water Leach extract and analysis. A sample:water ratio of 1:20 was used for the Reagent Water Leach tests. The Reagent Water Leach test results are addressed in Section 11.4 of the report. The quality of the leachate was further assessed with reference to the Leachable Concentration Threshold (LCT) limits as specified in GNR635, as part of the waste classification process.

The waste material samples were further sent for Total Digestion (Aqua Regia) analyses to assess the total elemental concentrations of the materials. The Aqua Regia test results for the waste material samples collected were scrutinised and compared to the Total Concentration Threshold (TCT) limits as indicated in the GNR635 as part of the waste classification process. The Aqua Regia test results are addressed in Section 11.5 of the report.

The geochemical analysis of the material samples further culminated in the classification of the 16 waste material samples collected on site. A summary of the waste material samples collected, as well as the classification thereof is indicated in Table II below.

Table II: Classification of the Waste Materials Sampled

Sample Number	Description	Waste Type	Liner Required
HRM-12	Unprocessed slag	Type 3	Class C
HRM-13	Slimes (TSF)	Type 3	Class C
HRM-15	DMS Waste	Type 3	Class C
HRM-17	Slag Fines	Type 3	Class C
HRM-18	Final Slag Dump	Type 3	Class C
HRM-21	Return material	Type 3	Class C
HRM-23	Process water dam sediment	Type 3	Class C
HRM-24	OB dam sediment	Type 3	Class C
HRM-25	Rehabilitated Pit 1	Type 3	Class C
HRM-26	Rehabilitated Pit 2	Type 3	Class C
HRM-27	Rehabilitated Pit 3	Type 3	Class C
HRM-28	Rehabilitated Pit 4	Type 1	Class A
HRM-29	Mining Waste Rock Stockpile	Type 3	Class C
HRM-30	Grout plant	Type 3	Class C
HRM-31	Western Backfill	Type 3	Class C
HRM-32	Mixed Waste	Type 3	Class C

A total of 13 surface water samples were also collected on site and analysed. A description of each of the water samples collected is given in Table III overleaf.

Table III: Surface Water Sample Numbers and Descriptions

Sample Number	Latitude Longitude	Description	Water Type	Purpose
HSW-1	25° 39' 10.3" S 27° 50' 56.6" E	TSF Slimes Dam RWD	Process Water	Storage Facility For Process Decant Water
HSW-3	25° 39' 28.5" S 27° 50' 15.1" E	Storm Water Dam	Dirty Storm Water	Storage Facility for Storm Water Runoff
HSW-4	25° 39' 12.9" S 27° 50' 12.9" E	Process Water Dam	Process Water	Storage And Treatment Of Process Water
HSW-5	25° 39' 36.2" S 27° 50' 09.7" E	Drinking Water Dam	Hartbeespoort Irrigation Water	The Water Is Treated At The Water Treatment Plant And Distributed For Domestic Use
HSW-6	25° 39' 20.8" S 27° 50' 19.3" E	OB Plant Water Dam	Process Water	Reticulation Facility For Process And Storm Water From The OB Plant
HSW-7	25° 39' 48.1" S 27° 51' 13.4" E	Morula Dewatering Dam	Abstracted Groundwater	Additional Storage For The Dewatering Of Underground Workings
HSW-8	25° 39' 15.2" S 27° 50' 42.4" E	HH Return Water Dam	Process Water	Storage Facility For Process Decant Water
HSW-9	25° 39' 47.0" S 27° 50' 33.0" E	CRP Dam	Process Water	Reticulation Facility For Process And Storm Water From The CRP Facility
HSW-10	25° 39' 42.3" S 27° 50' 04.9" E	Slag Spiral Plant Sump	Process Water	Reticulation Facility For Process And Storm Water
HSW-11	25° 39' 24.6" S 27° 49' 54.7" E	Irrigation Canal	Hartbeespoort Irrigation Water	Isolated Irrigation Water Source From The Hartbeespoort Dam
HSW-16	25° 39' 23.5" S 27° 51' 17.3" E	Open Pit	Mine Water	Rain And Groundwater Will Be Pumped Away From The Pit
HSW-17	25° 39' 36.1" S 27° 51' 10.2" E	Grout Plant Sump	Process Water	Reticulation Facility For Process And Storm Water
HSW-18	25° 39' 21.8" S 27° 50' 09.7" E	Emergency Dam	Dirty Storm Water	Capture And Store All Dirty Surface Storm Water Run-Off From The Alloys Plant Area

The surface water samples collected were analysed by means of a full quantified ICP-MS analyses. The unfiltered total elemental concentrations were assessed with regards to the acceptable drinking water quality limits set in SANS 241:2011, for reference / characterisation purposes.

Based on the analysis of the surface water samples collected, it is evident that the TSF Return Water Dam (HSW-1), Storm Water Dam (HSW-2), Process Water Dam (HSW-3), OB Plant Water Dam (HSW-6), HH Return Water Dam (HSW-8), Chrome Recovery Plant Dam (HSW-9) and at the Slag Spiral Plant Sump (HSW-10) all have elevated concentrations and could potentially have an adverse impact on the environment if the water is not effectively contained within each of the respective facilities.

The quality of the water sampled from the respective facilities on site, was further assessed with regards to the threshold limits specified in GNR635 of the Waste Classification and Management Regulations, to provide an indication of the classification type of the water. This classification of the water quality is important from a design perspective, as it determines the type of liner system required at the respective facilities.

A summary of the water quality classification is indicated in Table IV overleaf.

Table IV: Surface Water Sample Descriptions and Classifications

Sample Number	Description	Water Type	Liner Required
HSW-1	TSF Slimes Dam Return Water Dam	Type 3	Class C
HSW-3	Storm Water Dam	Type 3	Class C
HSW-4	Process Water Dam	Type 3	Class C
HSW-5	Drinking Water Dam	Type 4	Class D
HSW-6	OB Plant Water Dam	Type 3	Class C
HSW-7	Morula Dewatering Dam	Type 4	Class D
HSW-8	HH Return Water Dam	Type 3	Class C
HSW-9	CRP Dam	Type 3	Class C
HSW-10	Slag Spiral Plant Sump	Type 3	Class C
HSW-16	Open Pit	Type 4	Class D
HSW-17	Grout Plant Sump	Type 4	Class D
HSW-18	Emergency Dam	Type 3	Class C

It is evident from the process description, site infrastructure layout, the geochemical analyses and characterisation of the material samples (raw materials and waste materials) and water samples taken that certain areas pose a larger risk than others and certain actions are therefore required to ensure that the operations at HERNIC do not have an impact on the adjacent water resources as well as an impact on human health.

This report provides a holistic description of the processes undertaken as well as the characterisation of the materials and water associated therewith, from which to develop the proposed management and mitigation measures. This Process and Material Characterisation investigation is therefore one of the first steps undertaken in support of developing the Environmental Master Plan at HERNIC and will ensure that the operations are undertaken in line with the respective legislation and associated strategies.

The actions proposed to reduce the identified risks will be addressed as part of the updated Storm Water Management Plan (SWMP), Integrated Water and Waste Management Plan (IWWMP), Environmental Impact Assessment (EIA) as well as in the Surface Water, Aquatic Ecosystems and Groundwater Specialist Studies undertaken in support of developing the Environmental Master Plan at HERNIC.

This Process and Material Characterisation report will be made available to each of the specialists, from to assess the potential impacts and from which to develop the associated management measures for the HERNIC operations. The proposed management measures and upgrades to the existing infrastructure will ensure that HERNIC reduces the potential risk that its operations and activities have on adversely affecting the adjacent environmental medial and human health.

Respectively Submitted,

Original signed by:

Riaan Grobbelaar (Pr.Sci.Nat.)

Original signed by:

Shane Turner (Pr.Sci.Nat.)

Prj6000

1. INTRODUCTION

This Process and Materials Characterisation Report is one of a series of Specialist Reports compiled in support of the terms of reference for the compilation of an Environmental Master Plan for the Chromite Mining and Ferrochrome Beneficiation operations at Hernic Ferrochrome (Pty) Ltd (hereafter referred to as HERNIC).

This report has been compiled in order to give fulfilment with several Regulatory Processes, both in terms of study/report material content and format. This report should be read in conjunction with the Surface Water, Geology and Geochemistry as well as the Groundwater Specialist Reports and with specific reference to the impact assessments within these reports. This Process and Materials Characterisation Report does not consider the air quality sources or emissions for the current or future expansion/new activities, which are however addressed in detail in the Air Quality Specialist Study Report.

The purpose of this Process and Materials Characterisation Report is to provide a detailed description of the processes undertaken on site, the raw materials used, flow of material(s), water reticulation and containment, waste streams generated and the associated details in support of the characterisation thereof. This Process and Materials Characterisation Report will be used to characterise the water and waste materials used on site to identify the areas of higher risks from those of little to no risks to support the specialists in developing their risk assessments and proposed management plans. The information documented in this report will also be used during the planning and designing of future water and waste management facilities and infrastructure.

This Process and Materials Characterisation Report has specifically been compiled for the Chromite Mining and Ferrochrome Beneficiation operations at HERNIC, situated 7 km to the south-east of Brits. The relevant company details and contact details of the Safety and Sustainable Development (SSD) Manager at HERNIC is indicated in Table 1(a) and Table 1(b) respectively.

Table 1(a): Company Details

Name of Company	**Hernic Ferrochrome (Pty) Ltd**
Trading Name	Hernic Ferrochrome (Pty) Ltd
Registration Number	1994/008293/07
Date Established	1994
Country Established	South Africa
VAT Registration Number	4870146521
Physical Address	R/E of Portion 103, De Kroon 444 JQ

Table 1(b): Contact Details of the SSD Manager

Contact Person	Elzanne Moodie
Telephone Number	+ 27 12 381 1118
Cellphone Number	+ 27 82 444 9106
Facsimile Number	+ 27 12 381 1111
Email Address	elzanne.moodie@hernic.co.za
Postal Address	P O Box 4534, BRITS, 0250

2. DETAILS OF THE SPECIALIST AND PROJECT TEAM

This Process and Materials Characterisation Report has been compiled using quantitative information that has been recorded and generated on site and has been compiled by fully qualified Professional Natural Scientists registered with the South African Council for Natural Scientific Professions (SACNASP).

The details of the scientists who were involved with the investigation and in the compilation of this Process and Materials Characterisation Report are summarised in Table 2(a). Synoptic C.V.'s of all personnel who contributed to the compilation of this Process and Materials Characterisation Report are attached as APPENDIX I to this report.

Table 2(a): Details of Scientists involved with the Study

Specialist	Qualification	SACNASP Registration
Riaan Grobbelaar	M.Sc. Geohydrology B. Sc. Honours. Geohydrology (UFS) B.Sc. Geology (UFS)	Pr.Sci.Nat. (400066/01)
Shane Turner	M. Sc. Geohydrology (UFS) B.Sc. Honours. Geology (US) B.Sc. Geology: Earth Science (US)	Pr.Sci.Nat. (400176/13)
René Rademeyer	M.Sc. Ecology BSC. Honours. Ecology (UP) B.Sc Ecology (UP)	Pr.Sci.Nat. (400291/12)
Michael Lombard	B. Sc. Honours. Geology (UFS) B. Sc. Honours. Geohydrology (UFS) B.Sc. Geology (UFS)	Cand.Sci.Nat. (115835)

The Specialist and Project Consultant Details pertaining to the compilation of this Process and Materials Characterisation Report are given in the Table 2(b) and Table 2(c) respectively.

Table 2(b): Project Specialist Details

Specialists	Riaan Grobbelaar & Shane Turner		
Contact Person	Riaan Grobbelaar		
Postal Address	P O Box 883; Delmas		
Postal Code	2210	**Cell**	082 452 1231
Telephone	013 6651788	**Fax**	013 665 2364
E-Mail	riaan@jmaconsult.co.za		
Professional Affiliation(s)	South African Council for Natural Scientific Professions		

Table 2(c): Project Consultant Details

Project Consultant	JMA Consulting (Pty) Ltd		
Contact Person	Riaan Grobbelaar		
Postal Address	P O Box 883; Delmas		
Postal Code	2210	**Cell**	082 452 1231
Telephone	013 6651788	**Fax**	013 665 2364
E-Mail	riaan@jmaconsult.co.za		

3. DECLARATION OF INDEPENDENCE

We **Riaan Grobbelaar and Shane Turner** as the appointed specialist(s) hereby declare/affirm the correctness of the information provided as part of the application, and that we:

- act as the independent specialist(s) in this application;
- will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- declare that there are no circumstances that may compromise our objectivity in performing such work;
- have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- will comply with the Act, Regulations and all other applicable legislation;
- have no, and will not engage in, conflicting interests in the undertaking of the activity;
- undertake to disclose to the applicant and the competent authority all material information in our possession that reasonably has or may have the potential of influencing any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by ourselves for submission to the competent authority;
- ensure that all the particulars furnished by us in this report are true and correct; and
- are aware that it is an offence in terms of Regulation 48 to provide incorrect or misleading information and that a person convicted of such an offence is liable to the penalties as contemplated in section 49B(2) of the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA).

Original signed by: R. Grobbelaar & S. Turner

Signature of the specialist

JMA Consulting (Pty) Ltd

Name of company

Original signed by: R. Grobbelaar & S. Turner

Date

4. TERMS OF REFERENCE

This Process and Materials Characterisation Report will form one of a series of Specialist Reports compiled in support of attaining the terms of reference for the compilation of an Environmental Master Plan for the Chromite Mining and Ferrochrome Beneficiation operations at Hernic Ferrochrome (Pty) Ltd.

The primary aim / terms of reference of this Process and Materials Characterisation Report is to:

- provide a detailed description of the processes undertaken,
- prove the details of the raw materials used,
- indicate the flow of material(s) throughout the various plants and processes,
- provide the details of the water and water containment facilities,
- provide the details of the waste streams generated, and
- provide the details of the waste disposal facilities,

in support of the characterisation thereof.

This Process and Materials Characterisation Report will be used to characterise the water and waste materials used on site to identify the areas of higher risks from those of little to no risks to support the specialists in developing their risk assessments and proposed management plans. The information documented in this report will also be used during the planning and designing of future water and waste management facilities and infrastructure.

The exact requirements for the descriptions may differ from one facility/activity to another within the larger HERNIC boundary, dependant on the statutory processes which have to be supported during formal applications for the different activities. A secondary, but equally important objective for this study is to provide the necessary information and monitoring requirements, for the comprehensive Environmental Monitoring System that is proposed for HERNIC.

5. LEGAL FRAMEWORK

The Process and Materials Characterisation Report aims to support the legal assessment and to provide the required technical information regarding all potential sources of contamination on site. The identification and characterisation of the potential sources of contamination is of significant importance to support of the specialist studies, specifically the impact assessments and from which to propose the required management measures to mitigate these potential impacts.

Reference is made below to certain specific legislation in view of the overarching nature thereof, followed by references to specific legal obligations in order undertake and from which to develop this the Process and Materials Characterisation Study.

The Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)

The Constitution of the Republic of South Africa, 1996 (Act 108 of 1996) is the supreme law of the country and incorporates a Bill of Rights which in particular concerns environmental protection.

Section 24 of the Bill of Rights states that "*everyone has the right to an environment that is not harmful to their health and well-being, and that legislative and other measures should be used to ensure that the environment is conserved and protected for future generations*".

In giving effect to the abovementioned right, environmental impacts must be identified, managed and mitigation measures implemented. This Process and Materials / Source Characterisation Study is therefore fundamental to the aforementioned action steps and to give effect to the constitutional right referred to above.

Whilst there is generally no statutory provision to be identified which directly concerns legal requirements associated with Process and Materials / Source Characterisation Studies, the suite of environmental legislation referred to herein below, collectively provide a general guideline as to how and when Process and Materials / Source Characterisation Studies are to be undertaken.

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

The National Environmental Management Act (Act No. 107 of 1998) (NEMA) imposes certain duties and obligations to persons, including juristic persons and entities such as the operations at HERNIC for the undertaking of certain activities or assessments. The term "*assessment*" is defined in the NEMA to mean, *"…when used in Chapter 5, means the process of collecting, organising, analysing, interpreting and communicating information that is relevant to decision-making*". The process of material characterisation includes all of the abovementioned elements.

Section 2 of the NEMA refers to the national environmental management *principles*, which inter alia:

- *apply alongside all other appropriate and relevant considerations, including the State's responsibility to respect, protect, promote and fulfil the social and economic rights in Chapter 2 of the Constitution and in particular the basic needs of categories of persons disadvantaged by unfair discrimination;*
- *serve as the general framework within which environmental management and implementation plans must be formulated;*
- *serve as guidelines by reference to which any organ of state must exercise any function when taking any decision in terms of this Act or any statutory provision concerning the protection of the environment;*

- *guide the interpretation, administration and implementation of this Act (NEMA), and any other law concerned with the protection or management of the environment*.

Section 2(4)(a) refers to the principles underpinning the concept of *sustainable development*. Relevant to the concept of source / material characterisation is the principle that negative impacts on the environment and on people's health are to be anticipated and *prevented*, and where they cannot be altogether prevented are to be *minimised* and *remediated*. Source characterisation is thus central to the ability of a person to anticipate and manage negative environmental impacts and constitutes essential information for organs of State, bound by the implementation of the NEMA principles, in decision making concerning the protection of the environment and human health.

A further NEMA principle holds that the costs of remediating pollution, environmental degradation and consequent adverse health effects and for preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment. Source characterisation similarly constitutes the point of departure in quantifying the costs of remedying pollution, environmental degradation and consequent health effects and informs decisions associated with the prevention, control or minimisation of further pollution, environmental damage or adverse health effects.

Chapter 5 of NEMA pertains to Integrated Environmental Management (IEM), with the general objectives of IEM recorded in Section 23. Section 23 states *inter alia* that a general objective of IEM is to "*identify, predict and evaluate the actual and potential impact on the environment, socio-economic conditions and cultural heritage as well as the risks and consequences and alternatives and options for mitigation of activities, with a view to minimising negative impacts, maximising benefits, and promoting compliance with the principles of environmental management set out in Section 2*". A further objective is to ensure the consideration of environmental attributes in management and decision making which may have a significant effect on the environment.

Whilst the abovementioned statutory provisions provide a broad outline of statutory intent, a positive and more direct obligation, which by necessary implication involves the undertaking of source characterisation, is found in Section 24 of the NEMA. Section 24 states that "*the potential consequences for or impacts on the environment of listed activities or specified activities must be considered, investigated, assessed and reported on to the competent authority*". Source characterisation forms the basis of meeting the objectives of IEM and of complying with the statutory directive contained in Section 24 of the NEMA.

Section 24(a) of the NEMA, as amended by the National Environmental Management Amendment Act (Act No. 62 of 2008), states that the procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment must ensure, with respect to every application for an environmental authorisation, that a description of the environment likely to be significantly affected by the proposed activity is contained in such application.

Furthermore, Section 24(4)(b) states that procedures for the investigation, assessment and communication of the potential consequences or impacts of activities on the environment must include, with respect to every application for an environmental authorisation, the 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.

Although the NEMA provides a general guideline as to when source characterisation would by necessary implication be required in order to meet the minimum requirements for environmental impact assessment's (EIA's) described in Section 24(4)(b), the manner in which source characterisation is to be undertaken is not regulated in any particular detail in the NEMA. This report thereby accordingly assesses whether the EIA Regulations promulgated in terms of the NEMA provide further guidance on source characterisation.

The EIA Regulations were promulgated under the NEMA during April 2006. The EIA Regulations generally include the regulations prescribing the authorisation processes to be followed and those regulations or notices containing the lists of activities that require authorisation in terms of Section 24. Two authorisation processes have been prescribed, namely a Basic Assessment Process or a full Scoping and EIA Process. Undertaking of certain types of listed activities would require that the applicant embark on a Basic Assessment Process whereas other listed activities require a full Scoping and EIA Process.

The general criteria to be taken into account by competent authorities when considering a Basic Assessment or a full Scoping and EIA Process requires that, amongst others, any pollution, environmental impacts or environmental degradation likely to be caused if the application is approved and the impact on the environment of the activity which is the subject of the application, whether alone or together with existing operations or activities, *must be considered*. The abovementioned criteria can clearly not be met if source characterisation is not undertaken.

Similarly, the ability of the applicant to implement mitigation measures and to comply with any conditions subject to which the application may be granted is also a criterion to be met by the applicant requiring environmental authorisation. This cannot be achieved without source characterisation. Furthermore, the compilation of the Basic Assessment Report within the Basic Assessment Process, as well as the Scoping Report and EIA Report within the Scoping and EIA Process regulated by the regulations include requirements such as the identification of environmental impacts, quantification of risk and the recommendation of mitigation measures, all of which require source characterisation to be undertaken.

Whilst no discernible specific legal obligation or guidance pertaining directly to source characterisation could be identified, it follows that various provisions in the NEMA, establishing principles for environmental management as well as legal obligations pertaining to environmental authorisations, by necessary implication translate into the requirement that source characterisation be undertaken.

Although no particular permit, licence or authorisation is required as stated above, source characterisation nevertheless becomes relevant insofar as Section 28 of the NEMA includes a provision known as the statutory "*duty of care*". The duty of care principle is a general duty that finds application in addition to and over and above any legislation specific legal obligation requiring that an environmental authorisation in terms of the NEMA, a Water Use Licence (WUL) in terms of the National Water Act (Act No. 36 of 1998), an Atmospheric Emission Licence (AEL) in terms of the National Environmental Management: Air Quality Act (Act No. 39 of 2004) etc., as applied for.

Section 28 of the NEMA also provides for a general statutory duty to take *"…reasonable measures to prevent … pollution or degradation …"* as indicated below:

"*(1) Every person who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorised by law or cannot reasonably be avoided or stopped to minimise and rectify such pollution or degradation of the environment.*"

Without limiting the generality of the duty in subsection (1), the persons on whom subsection (1) imposes an obligation to take reasonable measures, include an owner of land or premises, a person in control of land or premises or a person who has a right to use the land or premises in which –

- any activity or process is or was performed or undertaken; or
- any other situation exists, which causes, has caused or is likely to cause significant pollution or degradation of the environment."

The operations at HERNIC are thus currently subject to this statutory duty *inter alia* by virtue of the right to use the land on which its operations are situated and conducted.

In addition, an important prerequisite for the statutory duty to apply, is that the operations at HERNIC have caused or may cause significant pollution or degradation of the environment. Once these requirements are identified, HERNIC must take all reasonable measures to prevent such pollution or degradation from *occurring*, *continuing* or *recurring*.

It follows from the provisions of Section 28 of the NEMA that HERNIC has a statutory duty of care to remediate environmental damage caused by its activities on the site. In order to comply with its duty, it must take reasonable measures to prevent pollution or degradation of the environment from occurring, continuing or recurring and where damage is authorised by law, to rectify such pollution or environmental degradation. The reasonable measures may include those referred to in Section 28(3) of NEMA and may include the undertaking of measures to:

- investigate, assess and evaluate the impact on the environment;
- inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed in order to avoid causing significant pollution or degradation of the environment;
- cease, modify or control any act, activity or process causing the pollution or degradation;
- contain or prevent the movement of pollutants or the causer of degradation;
- eliminate any source of the pollution or degradation; or
- remediate the effects of the pollution or degradation."

The duty of care applies to mining activities as well as industrial activities insofar as these operations impact on the environment. As such, it is important that an EMP be compiled, updated and revised, having regard to the statutory duty of care and its legal implications. More importantly however, it should be emphasized that historical environmental degradation will also be regulated by the duty of care in Section 28 of NEMA.

Determination of what "*reasonable measures*" are under particular circumstances, entail the exercise of administrative discretion by the relevant authorities. The identification of the relevant sources of the pollution and the characterisation thereof are essential in order to assist relevant authorities with the exercise of discretion and to identify the boundaries of the duty of care in relation to industry specific operations.

The National Environmental Management: Waste Act (Act No. 59 of 2008)

The National Environmental Management: Waste Act (Act No. 59 of 2008) (NEMWA) acknowledges the internationally recognised hierarchy of waste management, stating that sustainable development requires that waste generation is avoided, or if it cannot be *avoided*, that it is *reduced*, *re-used*, *recycled* or *recovered*, and as a last resort *treated* and/or safely *disposed* of.

The Act recognises that (i) waste management practices in many areas of the country are not conducive to a healthy environment, which can have an adverse impact both locally and globally,

(ii) under certain circumstances waste is a resource and offers economic opportunities, and (iii) ensuring that the environment is protected from the impact of waste requires the minimisation of natural resource use and of pollution, through vigorous control, cleaner technologies, cleaner production and consumption practices.

The NEMWA therefore accordingly provides for, among others, institutional arrangements and planning matters, national norms and standards, specific waste management measures, licensing and control of waste management activities. Specific waste management measures include the identification of priority wastes and measures to be prescribed for dealing with such wastes. These measures also cover the storage, collection and transportation of waste.

In addition to industry specific waste management plans and measures for remediation of contaminated land, the principle of "*extended producer responsibility*" (*cradle to grave principle*) is also formalised. Central to the Act is the requirement of a Waste Management Licence (WML) to undertake certain specified Waste Management Activities.

The National Water Act (Act No. 36 of 1998)

The purpose of the National Water Act (Act No. 36 of 1998) (NWA) is to ensure that the country's water resources are *protected*, *used*, *developed*, *conserved*, *managed* and *controlled*, in a way, which takes into account, *inter alia* the reduction and prevention or degradation, of water resources.

Pollution Prevention is specifically addressed in Section 19 of the NWA, which addresses the prevention of water resources and remediation of the effects thereof. Section 19 of the NWA states that: *"An owner of land, a person in control of land or a person who occupies or uses land on which;*

- *any activity or process is or was performed or undertaken; or*
- *any other situation exists, which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measures to prevent any pollution from occurring, continuing or recurring*."

Should a person fail to take the reasonable measures required under subsection 1 of Section 19, a Catchment Management Agency may direct such person (who fails to take the measures required under subsection 1) to commence taking specific measures before a given date, diligently continue with those measures and to complete them before a given date.

Whereas Section 28 of NEMA referred to above, relates to the environment in broad sense, Section 19 of the NWA refers to water resources as statutorily defined. However, although Section 19 of the NWA only refers to water resources, the standard to be applied in the protection and remediation of water resources also relates to reasonable measures.

It follows that an EMP should serve to assist HERNIC in giving content and proper motivation to the concept of reasonable measures, which is practicable as well as technically and legally defensible, in relation to water resources.

National Environmental Management: Air Quality Act (Act No. 39 of 2004)

Although not addressed in this report the National Environmental Management: Air Quality Act (Act No. 39 of 2004) (NEMAQA) defines air pollution to mean *"…any change in the composition of the air caused by smoke, soot, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, aerosols and odorous substances.*" Atmospheric emission or emission is defined to mean *"…any emission or entrainment process emanating from a point, non-point or mobile source that results in air pollution.*"

Other definitions include the following:

- "*mobile source" means a single identifiable source of atmospheric emission which does not emanate from a fixed location;*
- *"non-point source" means a source of atmospheric emissions which cannot be identified as having emanated from a single identifiable source or fixed location, and includes veld, forest and open fires, mining activities, agricultural activities and stockpiles;*
- *"point source" means a single identifiable source and fixed location of atmospheric emission, and includes smoke stacks and residential chimneys*.

Section 39 of the NEMAQA concerns the factors to be taken into account by licensing authorities when an application for an Atmospheric Emission Licence (AEL) is considered and processed. These factors include amongst others that consideration be given to:

- any applicable minimum standards set for ambient air and point source emissions that have been determined in terms of the NEMAQA;
- the pollution being or likely to be caused by the carrying out of the listed activity applied for and the effect or likely effect of that pollution on the environment, including health, social conditions, economic conditions, cultural heritage and ambient air quality.
- the best practicable environmental options available that could be taken -
  - to prevent, control, abate or mitigate that pollution; and
  - to protect the environment, including health, social conditions, economic conditions, cultural heritage and ambient air quality, from harm as a result of that pollution.

Source characterisation should therefore be undertaken in order to meet the abovementioned criteria, although no direct legal obligation pertaining to the duty to undertake source characterisation or the manner in which source characterisation must be undertaken, could be identified in the NEMAQA. A similar conclusion is reached in relation to the provisions of the previous Atmospheric Pollution Prevention Act (Act No. 45 of 1965).

The legal framework for source characterisation is therefore to be found in the statutory duty of care recorded in the NEMA as well as the duty to prevent pollution of water resources in the NWA. Implied references to source characterisation are also to be found in specific statutory provisions concerned with applications for permits, licences and environmental authorisations referred to in the environmental legislation mentioned above.

6. APPROACH AND METHODOLOGY

The following approach and methodology was adopted during the assessment and compilation of the Process and Materials Characterisation Report for HERNIC:

- Gather existing information in the form of reports, maps, data sets and discussions with plant personnel.
- Review selective existing reports.
- Extract and collate relevant information.
- Compile GIS base maps with relevant information.
- Compile a project description based on information obtained from the client, with specific focus on aspects with possible impacts.
- Select sampling points and design a field sampling programme.
- Take selected material samples on site.
- Analyse the mineralogical composition of the material samples collected by means of the X-Ray Diffraction (XRD) analyses method.
- Analyse the elemental composition of the material samples collected by means of the X-Ray Fluorescence (XRF) analyses method.
- Analyse the potential that the material has to generate a leachate as well as the quality of the leachate by means of the Reagent Water Leachate Procedure (RWLP) and the Total Digestion (Aqua Regia) methods.
- Determine the potential for the materials to generate an acidic leachate or conditions by means of the Acid Base Accounting (ABA) and Net Acid Generation (NAG) analyses methods.
- Take selected water samples on site.
- Analyse the water and leachate samples by means of the Inductively Coupled Plasma - Mass Spectrometry (ICP-MS) analyses method (Ag, Al, As, Au, B, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Os, P, Pb, Pd, Pr, Pt, Rb, Ru, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn and Zr.) as well as for: pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Ammonia, Total Alkalinity as $CaCO_3$, Bicarbonate Alkalinity as $CaCO_3$, Nitrate as N, Nitrite as N, Calcium, Chromium, Hexavalent Chrome as Cr^{6+}, Chloride, Magnesium, Sulphate, Ortho Phosphate, Sodium, Potassium, Silicon, Aluminium, Fluoride, Iron, Manganese and Total Cyanide.
- Compile a process and materials characterisation description with specific emphasis on the potential impacts resulting from historic, current and future surface activities.
- Using the project description as a reference, perform and consider all potential impacts focussing on possible areas of impacts.
- Identify aspects and impacts for further investigation.

7. SITE LOCALITY

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 (Table 7(a) and Figure 7(a)). A map/ plan depicting the boundary of the proposed activity (Chromite Mining and Ferrochrome Beneficiation operations at HERNIC) and the associated infrastructure is depicted on Figure 7(b).

Table 7(a): Summary of the Regional Setting and Location of the Activity

Central Coordinate of the Site	25°39'40.8"S ; 27°50'26.5"E
Nearest Town / City	Brits
Local Municipality	Madibeng
District Municipality	Bojanala
Province	North-West
Country	Republic of South Africa

HERNIC is located approximately 7km to the south-east of the town of Brits and 11km to the north-west of the town of Hartbeespoort. The HERNIC site is flanked along the western perimeter by the R511 regional road and along the southern perimeter by the N4 national road (Figure 7(b)). Access to the HERNIC operations is obtained via the private entrance / access road from the R511 regional road. A railway siding also provides access to the HERNIC operations, although this is specifically used to load and offload final product and raw materials.

The land use adjacent to HERNIC is dominated by agricultural and mining related activities. The commercial agricultural activities take place adjacent to HERNIC's north-western, western and southern boundary. The mining operations, which include both opencast and underground operations take place adjacent to HERNIC's north-eastern and eastern boundary. The mining operations within the study area target the Rustenburg Layered Suite (RLS) of the Bushveld Igneous Complex (BIC) for its chromium, platinum and platinum group element (PGE) reserves. The BIC contains the world's largest reserves of platinum-group metals; namely platinum, palladium, osmium, iridium, rhodium and ruthenium along with vast quantities of iron, tin, chromium, titanium and vanadium.

The larger study area (1 km radius from site boundary) is relatively flat with the surface elevation ranging between 1125 *mamsl* in the north-west up to 1200 *mamsl* on the east. The surface generally slopes in a north-westerly direction in the northern extent of the study area and in a south-westerly direction in the southern extent (Figure 7(c)). The HERNIC site is in fact situated on the topographically higher area which separates two sub-catchment areas, located within the A21J Quaternary Catchment within the Limpopo River Primary Catchment and within the Crocodile (West) and Marico Water Management Area (WMA) as indicated on Figure 7(d) and Figure 7(e).

The surface water within the northern extent of the site drains in a northerly direction towards an unnamed non-perennial tributary of the Crocodile River. The surface water within the southern extent of the site drains in a southerly to south-westerly direction towards another unnamed non-perennial tributary of the Crocodile River. The surface water to the west and south-west of the HERNIC site drains in a westerly direction towards a tributary of the northern unnamed non-perennial tributary of the Crocodile River. The Crocodile River flows in a north-westerly direction, from the Hartbeespoort Dam towards the Roodekopjes Dam, some 3.5 km – 4.0 km to west of HERNIC (Figure 7(c)).

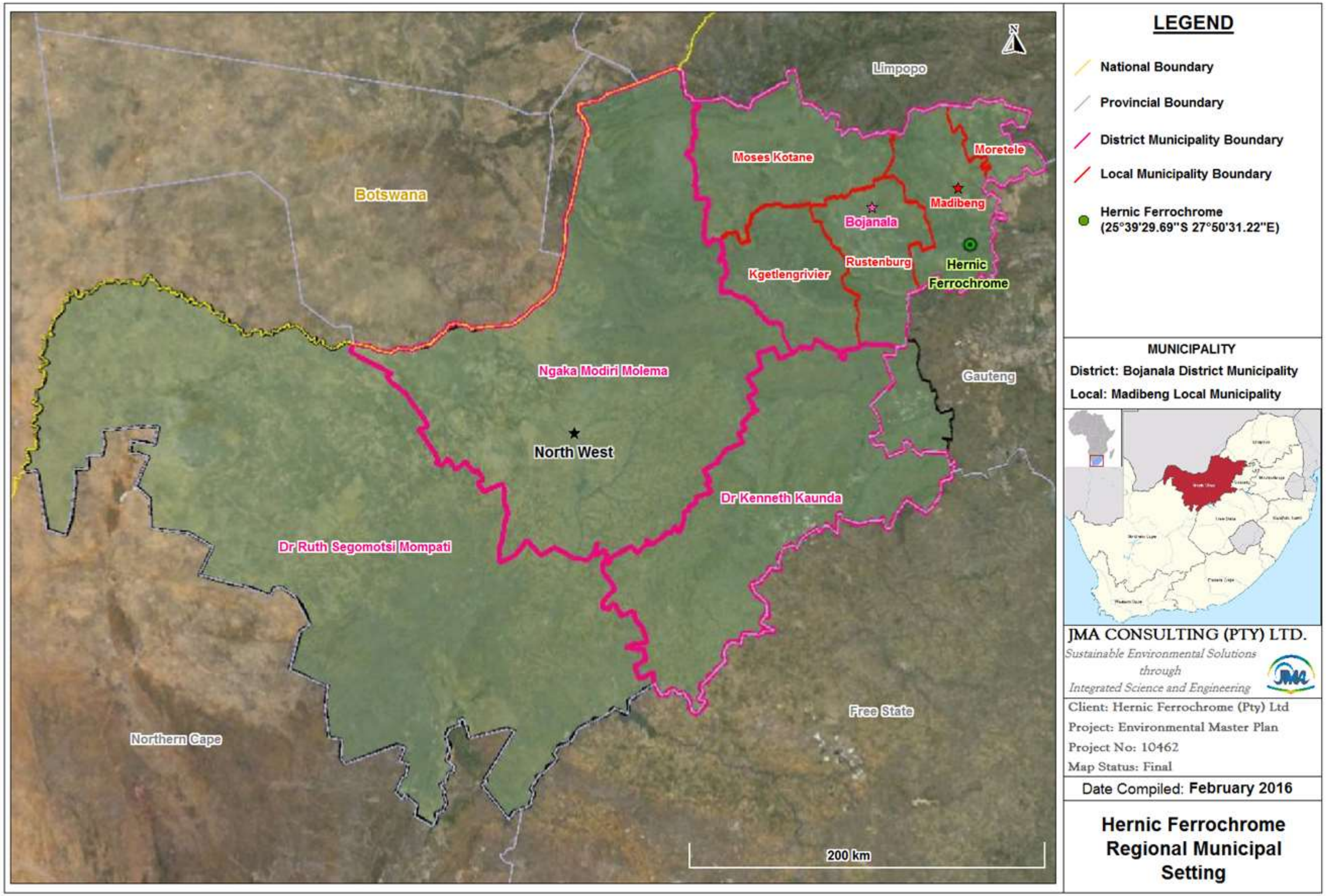


Figure 7(a): Regional Municipal Setting

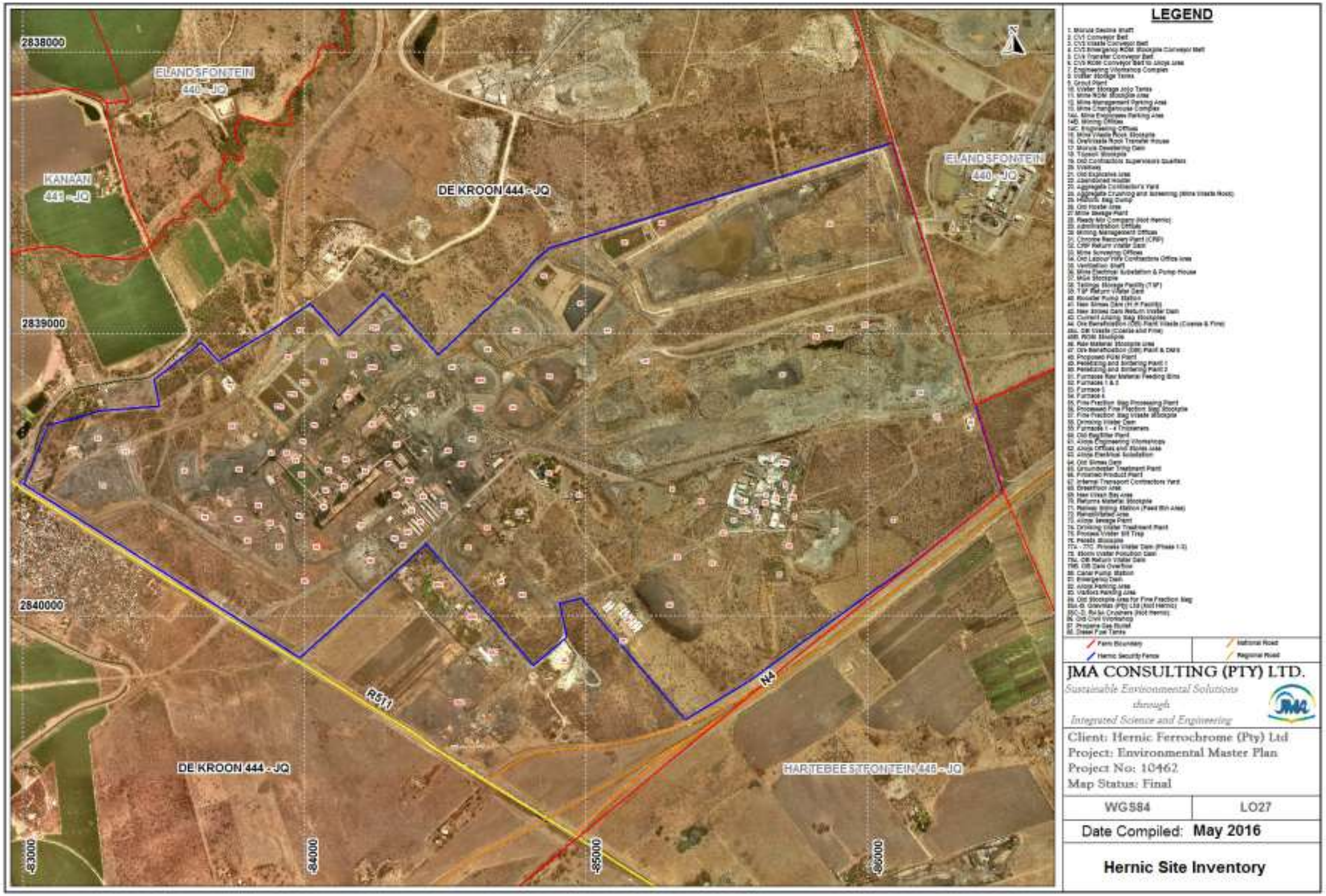


Figure 7(b): Site Layout and Surface Infrastructure Map of the HERNIC Site

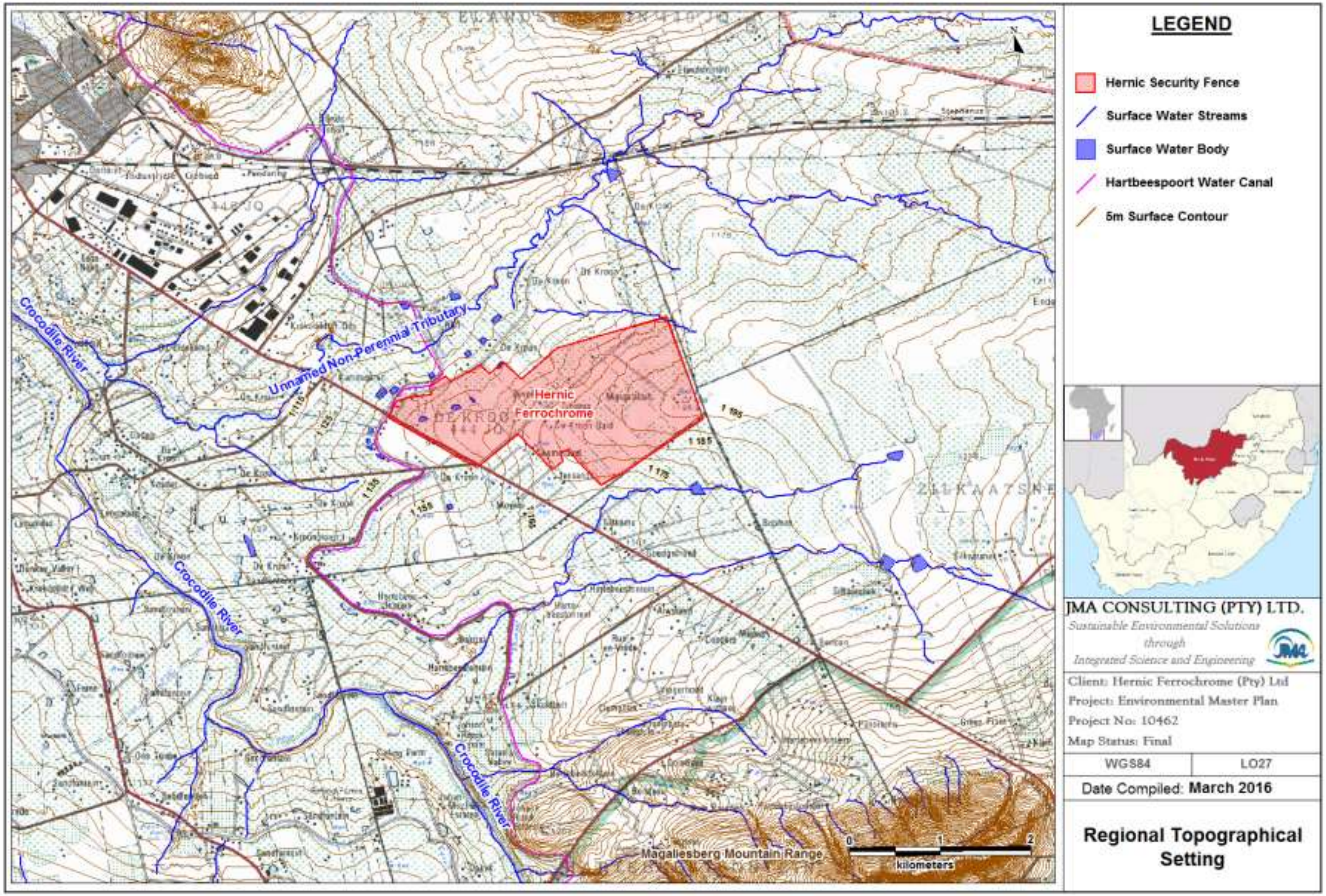


Figure 7(c): Regional Surface Topography (Topographical Map 2527 DB)

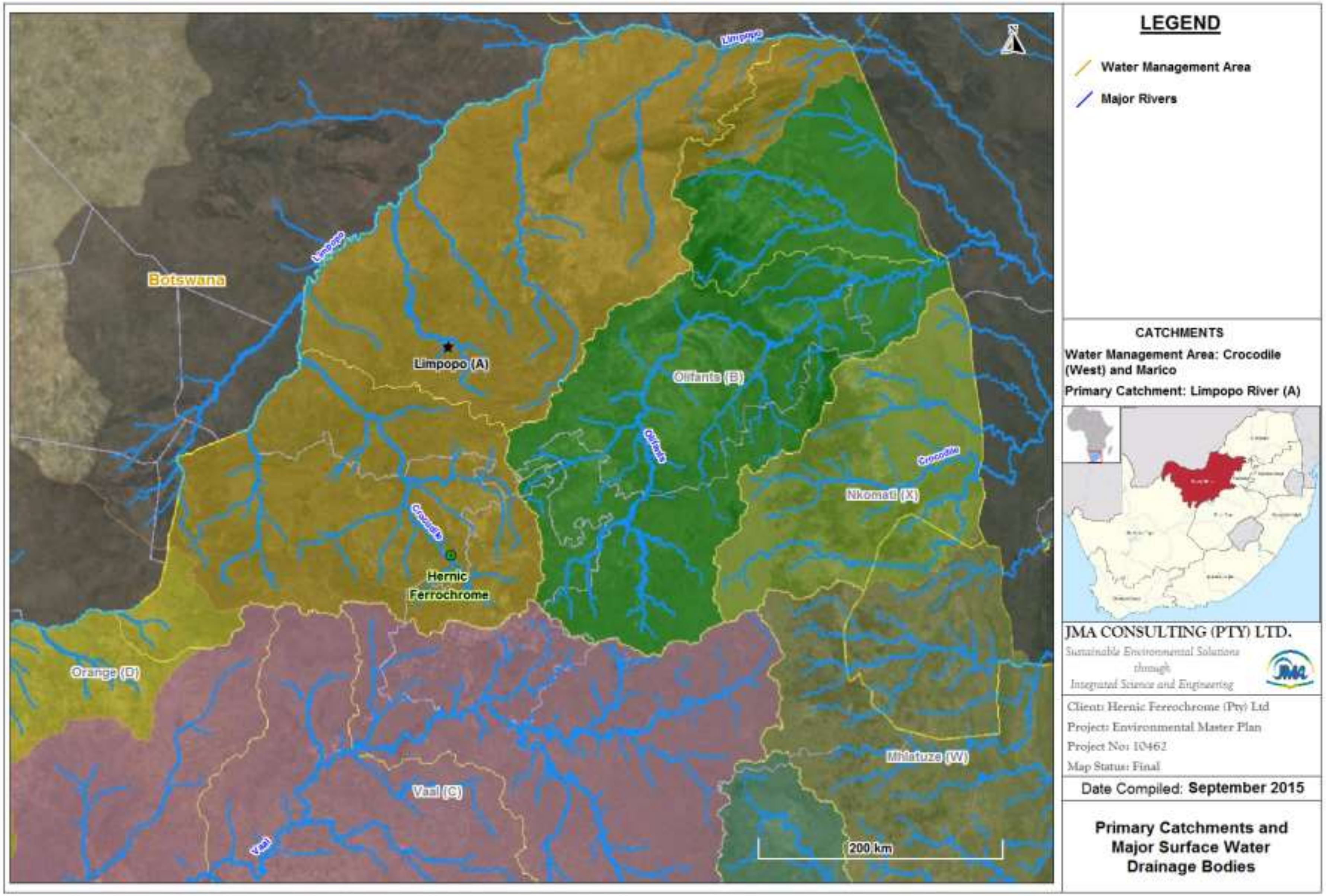


Figure 7(d): Primary Catchments and Major Surface Water Drainage Bodies

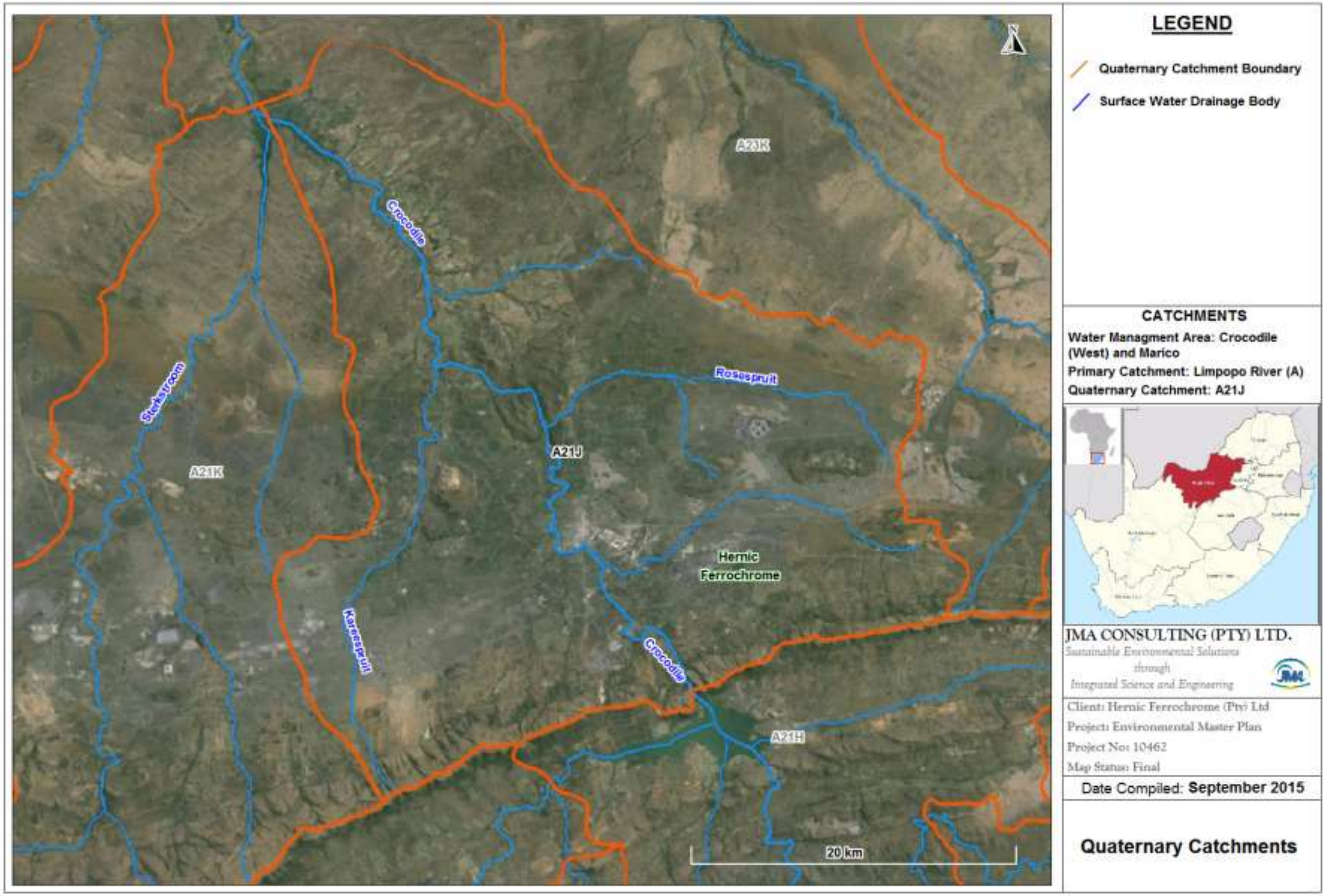


Figure 7(e): Quaternary Catchments and Major Surface Water Drainage Bodies

8. SITE HISTORY AND DESCRIPTION

8.1 SITE BACKGROUND

HERNIC is an existing operation and has been in operation since May 1996. The HERNIC Operation has expanded over the years and currently includes the mining of chromite ore (initially via opencast and then later via underground mining methods), ore beneficiation to yield feedstock chromite concentrate and lumpy ore, followed by pelletising 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.

As the site has expanded and been upgraded since 1996, HERNIC has applied for and obtained several required Environmental Authorisations, as and when required. HERNIC currently operates under an approved Environmental Management Programme Report (EMPR), which was amended as recently as 2012 and also holds a Water Use Licence (WUL), a Waste Management Licence (WML), an Atmospheric Emissions Licence (AEL), as well as relevant EIA Authorisations.

All relevant existing Environmental Authorisations for the project are listed in Table 8.1(a) below. The list below (Table 8.1(a)) provides an indication of timeline of the authorisations and approvals associated with the operations at HERNIC as well.

Table 8.1(a): HERNIC Existing Environmental Authorisations Timeline

Existing Authorisations		
No.	**Year**	**Description**
1	1995	Environmental Management Programme Report for the Maroelabult Mining Operation and Ferrochrome Plant (PWV 6/2/2/549) – October 1995
2	1998	Environmental Management Report for extension of the existing Hernic Ferrochrome Operations – July 1998
3	2001	Amendment to the Environmental Management Report: Disposal of Fine and Coarse Waste (RDNW (KL) 6/2/2/518) – 08 March 2001
4	2004	Authorisation for the Fourth Ferrochrome Closed Furnace (EIA 225/2003NW) for Hernic Ferrochrome (Pty) Ltd – 23 February 2004
5	2004	Amendment to the Approved Environmental Management Programme in terms of Section 39(1) of the Minerals Act (Act 50 of 1991) for Hernic Ferrochrome (Pty) Ltd Fourth Furnace on Portion 103 of the Farm De Kroon 444 JQ in the Magisterial District of Brits (RDNW (KL) 6/2/2/2515) – 01 April 2004
6	2006	Rectification of the Unlawful Commencement of a Listed Activity (REC 386): Scheduled Processes listed in the second schedule to the Atmospheric Pollution Prevention Act, 1965 (Act No. 45 of 1965) as contemplated in Section 24G of the National Environmental Management Act, 1998 as amended (Act No. 107 of 1998). The Development entails existing Ferrochrome Smelter (Furnace 1, 2 and 3), Pelletising and Sintering plant, Hazardous chemical storage area and sewage work– 10 November 2006
7	2006	Authorisation for the Construction of a Railway Siding between the Hernic Ferrochrome Plant and Pendora Station on Spoornet's Rosslyn Line on Portion 51 Uitkoms 443 JQ, RE of Portion 80 of the Farm Elandsfontein 440 JQ, Portions 51, 52, 231 and RE 1 of the De Kroon 444 JQ, Madibeng Local Municipality, North West Province (EIA 268 /2005NW) – 23 June 2006
8	2009	Environmental Authorisation for the Enclosing of Hernic Ferrochrome's Existing Open Furnaces (NWP/EIA/262/2008) in terms of section 24(2) of the National Environmental Management Act, 1998 as amended (Act No. 107 of 1998) in respect of GNR 386 of 21 April 2006 – 13 August 2009
9	2011	Environmental Authorisation for the Construction of Hernic Tailing Storage Facility (NWP/EIA/46/2010 in terms of Section 24(2) of the National Environmental Management Act (Act No. 107 of 1998) in respect of GNR 386 of 21 April 2006 – 11 August 2011
10	2012	Mining Right in terms of Section 22(1) of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002): Portions 51, 52, 122, 121, 123, 132 (Being Portion 267), 115, 160, 159, 161, 157, 50, 49, 120, 119, 47, Half Share of the Remaining Portion of Portion 48, Portions 199 (Portion 297 of Portion 48), 168, 167, 166, 165 (Portions of Portion 47) all of the Farm De Kroon 444 JQ;

Existing Authorisations		
No.	**Year**	**Description**
		situated in the Magisterial District of Brits (NW30/5/1/2/2/308MR J2006/06/09/001) – 25 June 2012.
11	2012	Approval of Environmental Management Programme in terms of Section 39(6) of the Mineral and Petroleum Resources Development Act, 2002 (Act 28 of 2002): for HERNIC Ferrochrome (Pty) Ltd in respect of portions 52, 51, 122, 121, 123, 132, 115, 160, 159, 161, 157, 50, 49, 120, 119, 47, half share of remainder of Portion 48, Portions 119, 168, 167, 166, 165 (Portion of Portion 47) of the Farm De Kroon 444 JQ, situated in the Magisterial District of Brits, North West Region (NW 30/5/1/2/3/2/1/308 EM) - 26 June 2012
12	2012	Converted Mining Right in terms of Item 7 of Schedule II of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) (NW30/5/1/2/2/396MR J2008/03/28/001) – 31 July 2012
13	2012	Amendment of an Environmental Authorisation for the Hernic Electricity Generation on remainder of Portion 103 of the Farm De Kroon 444 JQ, Activities Number 1(a)(i), 1(e) and 1(l) in Government Notice Number R 387, Madibeng Local Municipality, North West Province (NWP/EIA/02/2008) – 18 October 2012
14	2013	Amendment/Variation of a Mining Right (NW30/5/1/2/2/308MR) granted in terms of section 102 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) – 24 May 2013
15	2013	Amendment/Variation of a Mining Right (NW30/5/1/2/2/396MR) granted in terms of section 102 of the Mineral and Petroleum Resources Development Act 2002 (Act No. 28 of 2002) – 24 May 2013
16	2015	Approval of an Amendment to the Approved Environmental Management Programme in terms of Section 102 of the Mineral and Petroleum Resources Development Act, 2002 (Act No. 28 of 2002) to include Tailing Storage Facility in respect of Portions 49, 50, 78, 104, 105, 135, 132, 151 and 199 of the Farm De Kroon 444 JQ, situated in the Magisterial District of Brits (NW 30/5/1/2/3/2/1/308 EM) – 03 November 2015
17	2015	Water Use Licence (03/A21J/ABGJ/4196) in terms of the National Water Act, 1998 (Act No. 36 of 1998) – 18 December 2015
18	2015	Atmospheric Emission Licence issued to Hernic Ferrochrome, in terms of Section 40 (1) (a) read with Sections 41 and 42 of the National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004), in respect of Listed Activities Sub-category 4.5 and 4.9 – 02 September 2015.
19	2016	Approval of the Amended Environmental Impact Assessment (EIA) and Environmental Management Programme (EMPr) Reports in terms of Section 102 of the Mineral and Petroleum Resources Development Act, (Act 28 of 2002) which are now regarded as an Environmental Authorisations issued in terms of Regulation 25(1) of the National Environmental Management Act, 1998 (Act 107 of 1998): Environmental Impact Assessment Regulations 2014, Regarding the Inclusion of additional Minerals which are Platinum, Ruthenium, Rhodium, Palladium, Osmium, Iridium, Gold Ore, Silver Ore, Nickel Ore, Copper Ore, Cobalt, Vanadium, Iron Ore, Rare Group Elements and Non-Metallic Elements being Sulphur, Selenium and Tellurium (in respect of middle group chromitite seams) and sand manufactured from waste rocks (excluding Portion 37 of the Farm Elandsfontein 440JQ (only chrome contained in the MG Chromitite seams in respect of Portion 37 of the farm Elandsfontein 440JQ) in respect of various portions of various farms as described on the issued mining rights, all situated in the Magisterial District of Brits, North West Region (NW 30/5/1/2/3/2/1/(308) EM & NW 30/5/1/2/3/2/1/ (396) EM) – 25 October 2016

8.2 GENERAL PROCESS ACTIVITIES

Mining at HERNIC's Morula (Maroelabult) section commenced in 1996. Initially only opencast mining was conducted with the underground operations only commencing in 2002/2003. The opencast mining operations were completed in 2014 and the underground mining was temporarily stopped as well. Future mining (from 2016 onwards) will take place by underground mining methods only.

The chromite ore which is mined at HERNIC is used together with ore obtained from external sources to produce ferrochrome at the beneficiation plant. There are several operations and activities within the beneficiation plant at HERNIC as detailed below.

The HERNIC operations comprise of the following production related activities:

- mining of the Middle Group Chromite Seams (MG-0, MG-1, MG-2, MG-3 and MG-4) (historic opencast and current underground);
- the sourcing of other ore minerals from neighbouring mines (MG-0, MG-1, MG-2, LG-6 and UG-2 ore);
- the procurement of other raw materials (such as dolomite, limestone, quartzite, anthracite, coke);
- the beneficiation and concentration of ore (crushing, screening, spiralling and dense medium separation (DMS)) in an Ore Beneficiation Plant;
- the pelletising and sintering of the concentrate ore at two Pelletising Plants;
- the blending of lumpy ore, pellets and other raw materials in two Proportioning Plants;
- the smelting of these feed materials in four Closed Submerged Arc Furnaces;
- the separation of Ferrochrome and Slag during tapping at the Furnaces;
- the breaking of the Ferrochrome after smelting;
- the recovery of Ferrochrome from Slag at the Chrome Recovery Plant;
- the recovery of Ferrochrome at the Fine Slag Processing Plant;
- the recovery of Platinum Group Minerals (PGM's) from re-mined and current tailings;
- the final preparation of the Ferrochrome product for dispatch to the markets at the Finished Product Area.

In addition to these production-related activities, ancillary operations relating to environmental management also occur:

- Atmospheric Emissions Control
- Process Water Management
- Storm Water Management
- Groundwater Management
- Waste Management

A detailed description of the site layout, site infrastructure and process description of provided in Section 9 that follows.

9. SITE LAYOUT, INFRASTRUCTURE AND PROCESS DESCRIPTION

9.1 SITE LAYOUT

The surface operations at HERNIC are located on and restricted to the **Farm De Kroon 444 JQ** and cover a surface area of approximately 386 *ha*. The HERNIC Mining Right Boundary includes the neighbouring **Farm Elandsfontein 440 JQ** as well, but at present no surface activities occur on this property. Historically both opencast as well as underground mining occurred on / below the Farm Elandsfontein 440 JQ. Whereas the opencast mining has been completed and is currently in a state of partial rehabilitation, underground mining of the MG-1 and MG-2 seams will continue below both properties.

The layouts of the delineated properties as well as the opencast and underground mining extents are depicted on Figure 9.1(a). The major surface infrastructure associated with the mining and beneficiation operations is depicted on Figure 9.1(b). A high resolution aerial photograph was commissioned during 2015 and was used to support a full site description and activity inventory for the HERNIC operations. This is specifically valuable for the large scale master layout plans. The large scale master layout plan of the surface infrastructure is attached as APPENDIX II and should be used for detailed reference purposes, when reading through this report.

The HERNIC site has been subdivided into 5 operational areas for the purpose of this investigation, based on the geographical position and nature of the surface operations. The 5 operational management areas are namely the:

- Morula Mining Shaft Complex Management Area,
- Morula Opencast Mining Operation Management Area,
- Alloys Smelting Plant Management Area,
- Tailings Storage Facility Management Area,
- Office Complex and Chrome Recovery Plant Management Area.

The 5 operational management areas are delineated on Figure 9.1(c).

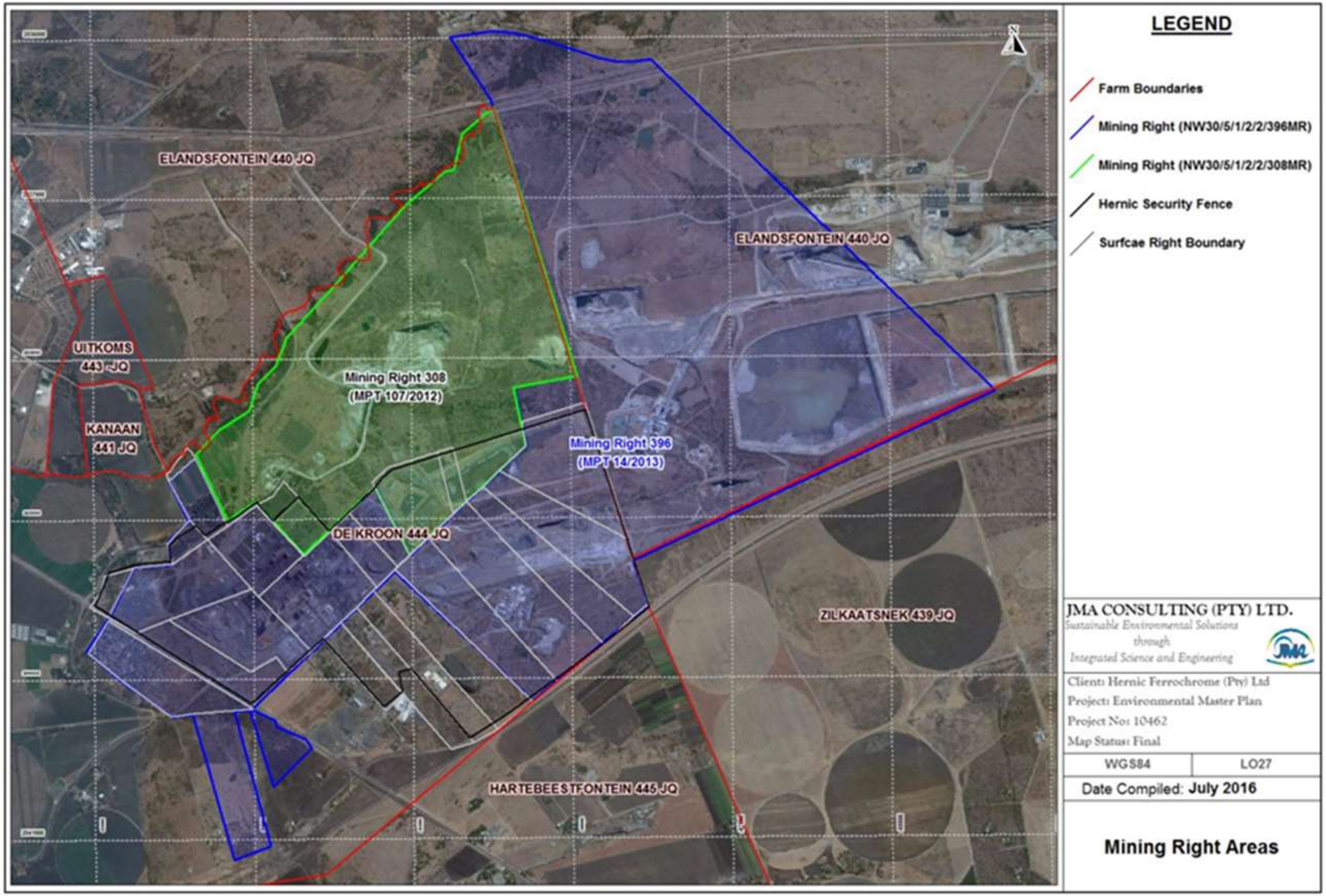


Figure 9.1(a): Mining Right Area and Property Layout Plan

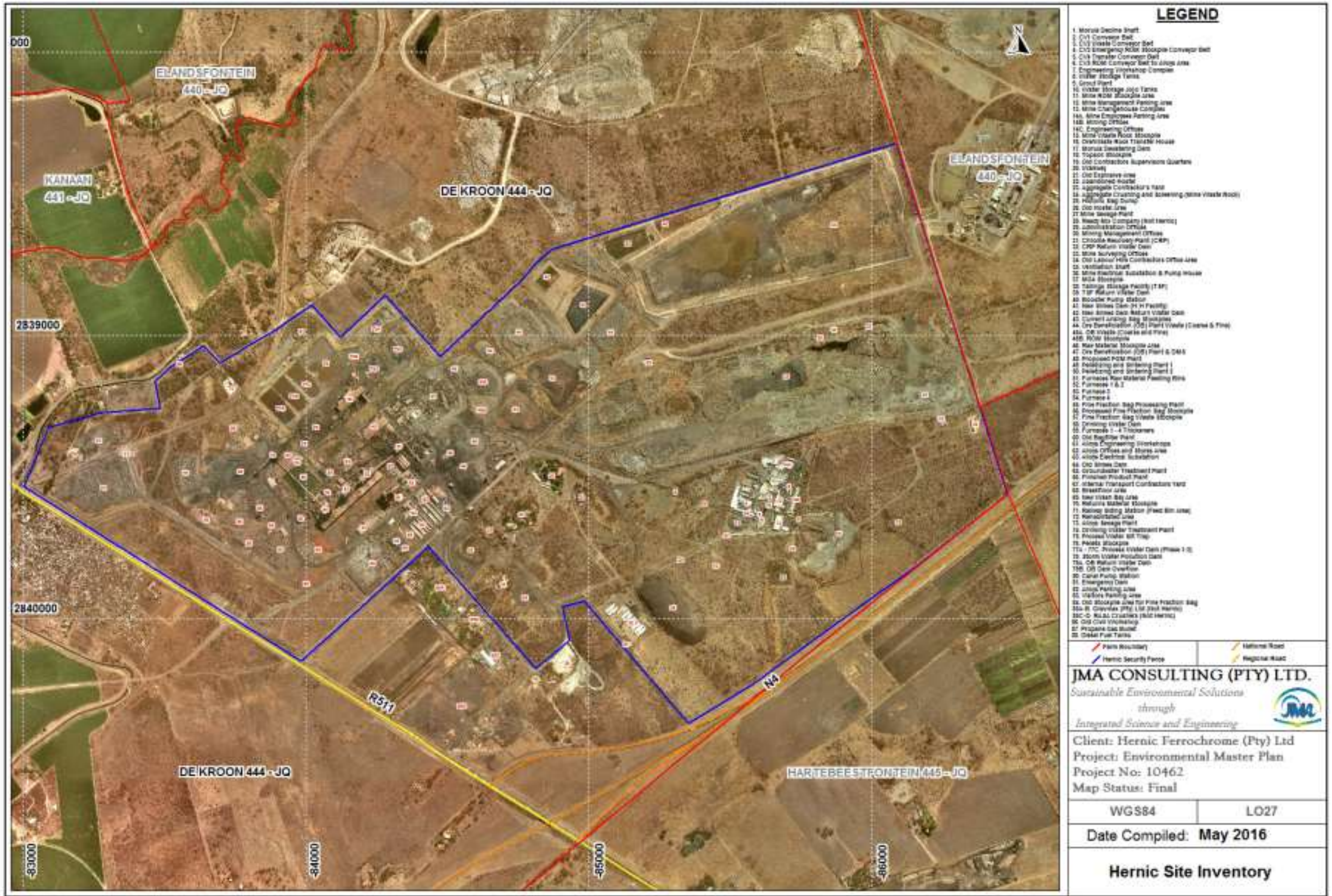


Figure 9.1(b): Site Infrastructure and Activities (Site Inventory)

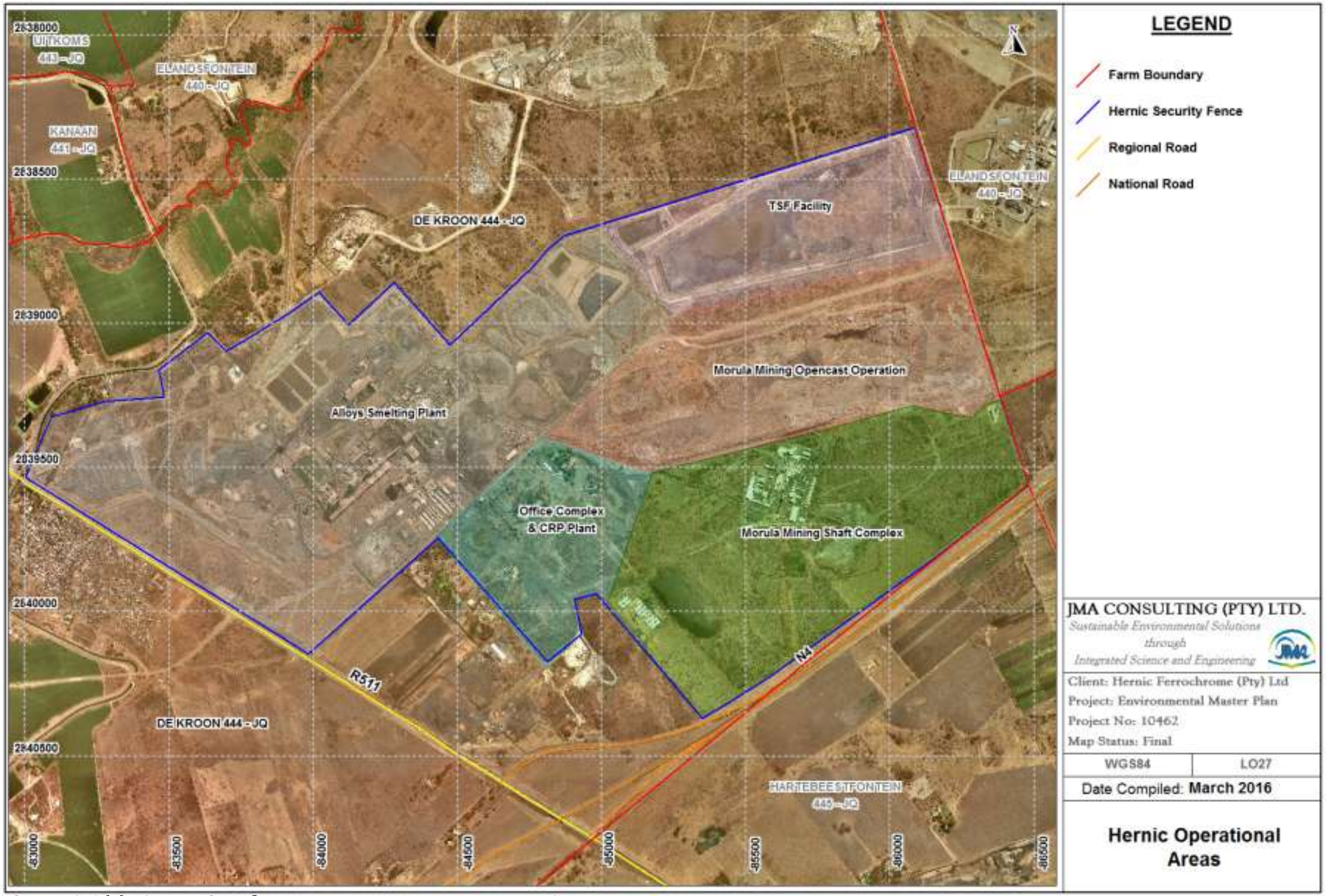


Figure 9.1(c): Operational Management Areas at HERNIC

9.2 SITE INFRASTRUCTURE

A description of the activities and site inventory within each of the 5 operational areas is addressed below.

Morula Mining Shaft Complex Management Area

The Mining Shaft Complex provides access to the underground mining operations through two incline shafts and provides the required ancillary services to the underground mining operations. The following facilities/infrastructure/activities occur within the Morula Mining Shaft Complex operational area:

- Decline Materials Shaft
- Decline People Shaft
- Access Roads
- Water Storage Tanks
- Mining Offices
- Engineering Offices
- Engineering Workshops
- Parking Areas
- Ore/Waste Rock Transfer House
- Change House Complex
- CV1 Conveyor
- CV2 Conveyor
- CV3 Conveyer
- CV4 Conveyor
- CV5 Conveyor
- Grout Plant
- Peoples Walkway (from parking and hostel area to shaft)
- Emergency Run of Mine (ROM) Chromite Stockpile
- Mine Waste Rock Stockpile Area
- Topsoil Stockpile
- Morula Dewatering Dam
- Redundant Explosives Magazine
- Abandoned Hostel
- Old Contractors Supervisors Quarters
- Historic Slag Dump
- Old Hostel Area
- Mine Sewage Plant

Morula Opencast Mining Operation Management Area

The opencast mining operations commenced in 1996 and were completed in 2014. Five chromite seams, the MG-0 - MG-4 were mined from surface up to a depth of some 40 m below surface. The pits are currently being backfilled and will be rehabilitated as part of the Environmental Master Plan. The following facilities/infrastructure/activities occur within the Morula Opencast Mining operational area:

- Backfilled Open Cast Pit
- Ore Beneficiation (OB) Plant Coarse Tailings

- OB Plant Fine Tailings
- OB Plant Mixed Tailings
- MG-4 Stockpile
- Final Void
- Re-Mining of Historical OB Fine Tailings
- Water Abstraction
- Water Pipe Lines

Alloys Smelting Plant Management Area

The Alloys Smelting Plant comprises of a full ferrochrome smelting operation. The chromite sourced from the HERNIC Mining operations, as well as from other mining operations, is beneficiated into lumpy and fine ore concentrate, then blended with imported raw materials before being smelted into ferrochrome in 4 closed submerged arc furnaces.

The plant is further supported with ancillary processes including a finished product plant, a chrome recovery plant, a fine slag recovery plant, waste management facilities, surface water and groundwater management facilities and finally air quality control equipment. After the conversion of the open furnaces to closed furnaces, the Bag House Plant and its associated slimes disposal facilities became redundant and were closed down. The following features are deemed to represent general plant infrastructure within the Alloys Smelting Plant operational area:

- Access Roads
- Visitors Parking
- Security Offices
- Administration Offices
- Clinic
- Laboratory
- Canteen
- Stores
- Workshops
- Change House & Laundry
- Employee Parking
- Capital Yards
- Salvage Yard
- Oil Stores
- Fuel Storage Areas
- Conveyors
- Water and Gas Pipelines
- Clarifiers
- Caustic Soda Storage
- Nitric Acid Storage
- Day Bins
- Weighbridges
- Washbay
- Clean and Dirty Water Containment Facilities
- Rail Loadout Conveyor
- Railway Siding

- Raw Material Stockpiles (Dolomite, Limestone, Quartzite, Char, Coke, Anthracite, Chromite Ore, Chromite Concentrate, Bentonite)
- Pellet Stockpiles
- Pelletising and Sintering Plant
- Smelting Plant
- Spiral Plant
- Final Product Stockpiles
- Mixed Waste Stockpiles
- Product Stockpiles
- Slag Stockpiles
- Slimes Dams

Tailings Storage Facility Management Area

The fine tailings generated at the OB Plant is slurried and pumped to a fully designed Tailings Storage Facility (TSF) for disposal. The supernatant water is decanted from the TSF through an intermediate and final penstock system to the silt trap where suspended solids are allowed to settle out before flowing in the TSF Return Water Dam. The water contained in the TSF Return Water Dam is subsequently reticulated back to the OB Plant for re-use. The surface infrastructure at the TSF operational area comprises of the following:

- Tailings Storage Facility
- TSF Return Water Dam and Sediment Trap
- Pump Station
- Pipelines
- TSF Administration Officers (Containers)

Office Complex and Chrome Recovery Plant Management Area

Current slag arising's are temporarily stockpiled on two current arising Slag Dumps from which the slag aggregate is loaded and deposited at the CRP Loading Area. From here it is transported via conveyor into the CRP. The intention is to also treat the slag currently contained on the Historic Slag Dump at the CRP.

The chrome recovery process comprises a crushing, screening and separation process. Both coarse and fine material is separated (Dense Medium Separation and Magnetic Separation).

The general surface infrastructure at the Office Complex and CRP operational area comprises of the following:

- Mining Administration Offices
- Crushing, Screening and Separation Plant
- Water Storage
- Clarifier
- Pollution Control Dam (PCD) (containing Process and Storm Water)
- Product Stockpiles
- Slag Stockpiles

9.3 PROCESS DESCRIPTION

The HERNIC operation is an existing operation which comprises of both mining and beneficiation operations. A summary of the major processes undertaken at HERNIC is listed below:

- **mining of chromite ore** via previous opencast and current underground mining methods,
- **ore beneficiation** to yield feedstock chromite concentrate and lumpy ore,
- **pelletising and sintering** of the fine chromite ore,
- **ferrochrome smelting** in four closed furnaces,
- **ferrochrome recovery** via the chrome recovery plant(s).

Each of these major processes, including the activities and infrastructure associated therewith are addressed in detail in the subsections that follow. A simplified process flow diagram is depicted as Figure 9.3(a), which indicates these processes.

9.3.1 Mining

The mining operations at HERNIC are directly dependent on the nature of the underlying geology and associated chromite ore layers. The geology underlying and to the north of HERNIC comprises of norites, anorthosites and gabbro-norites of the Main and Critical Zones of the Rustenburg Layered Suite. The MG-1, MG-2 and MG-4 chromite ore layers outcrop at HERNIC (Figure 9.3.1(a)) and are specifically mined for their chromium content. These ores generally have an east-west strike and dip at an angle of 17° to the north at HERNIC.

HERNIC historically mined the chromite ore layers by opencast mining methods 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 details of both the historic opencast and current underground mining operations at HERNIC are addressed in the sub-sections that follow. Additional detailed information regarding the mining operations at HERNIC is addressed in the Mining Works Programme, which is attached as APPENDIX III to this report.

9.3.1.1 Opencast Mining Operations

The opencast mining operations commenced in 1996 and ceased during 2007. Four chromite seams, namely the MG-0, MG-1, MG-2 and MG-4 seams were mined from surface down to a depth of some 40 *m* below surface as part of the opencast mining operations with a final mining production rate of 80 000 *tonnes per month*.

The lateral extents of the historic opencast workings at HERNIC are shown on Figure 9.3.1.1(a). The surface infrastructure and material stockpiles or voids associated with the opencast mining operations at depicted on Figure 9.3.1.1(b) for reference purposes.

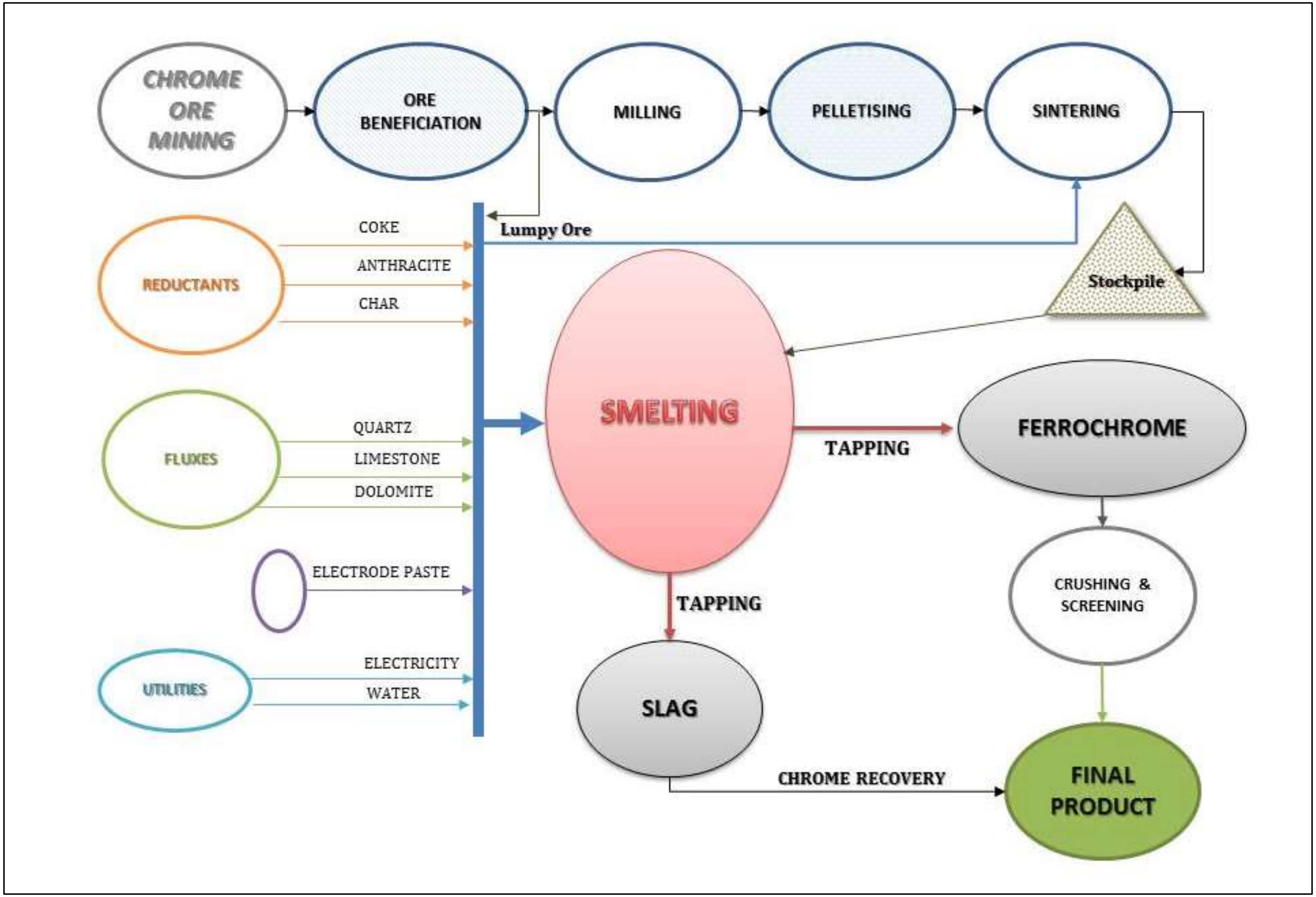


Figure 9.3(a): Schematic Process Flow Diagram for HERNIC

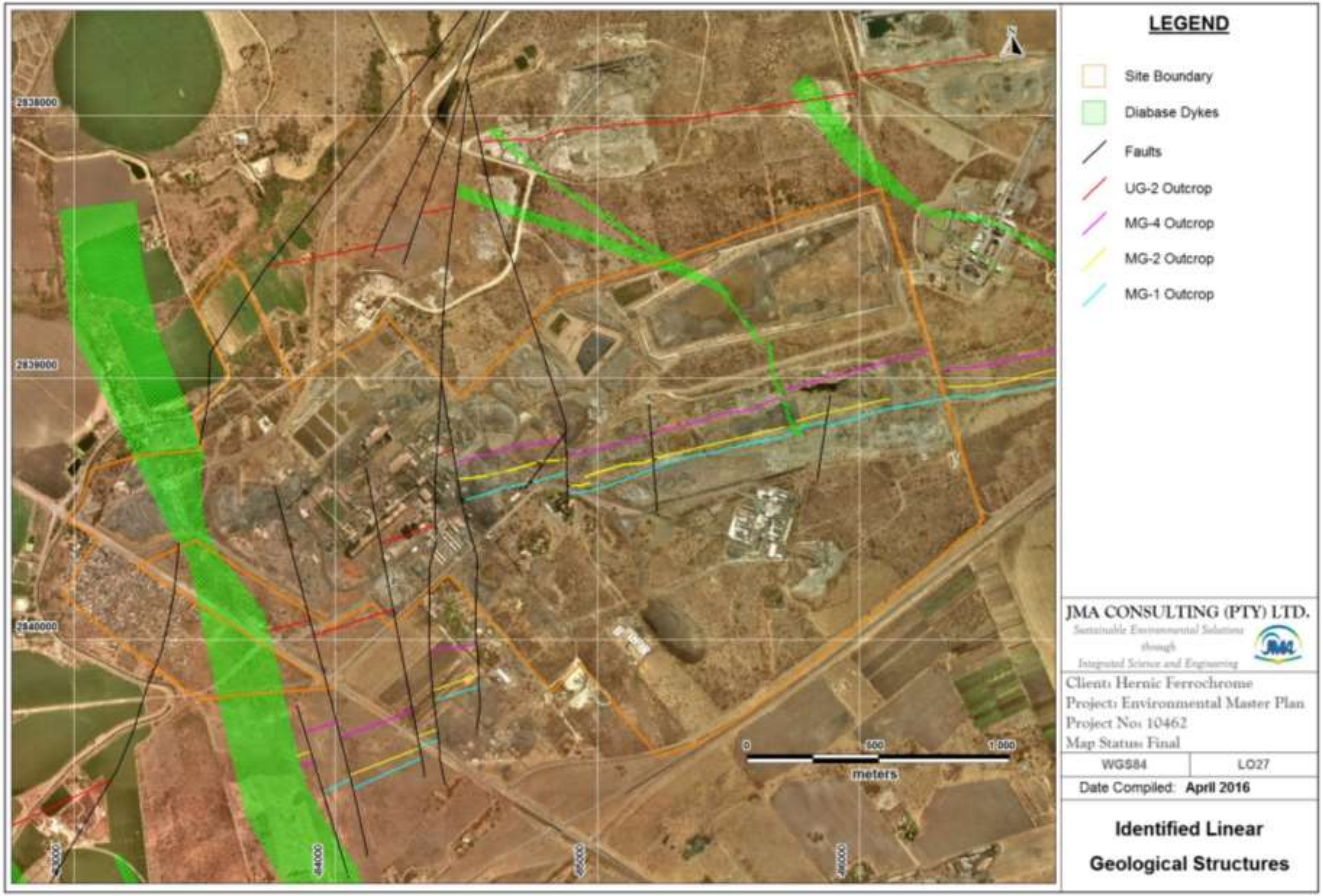


Figure 9.3.1(a): Identified Major Geological Features at HERNIC

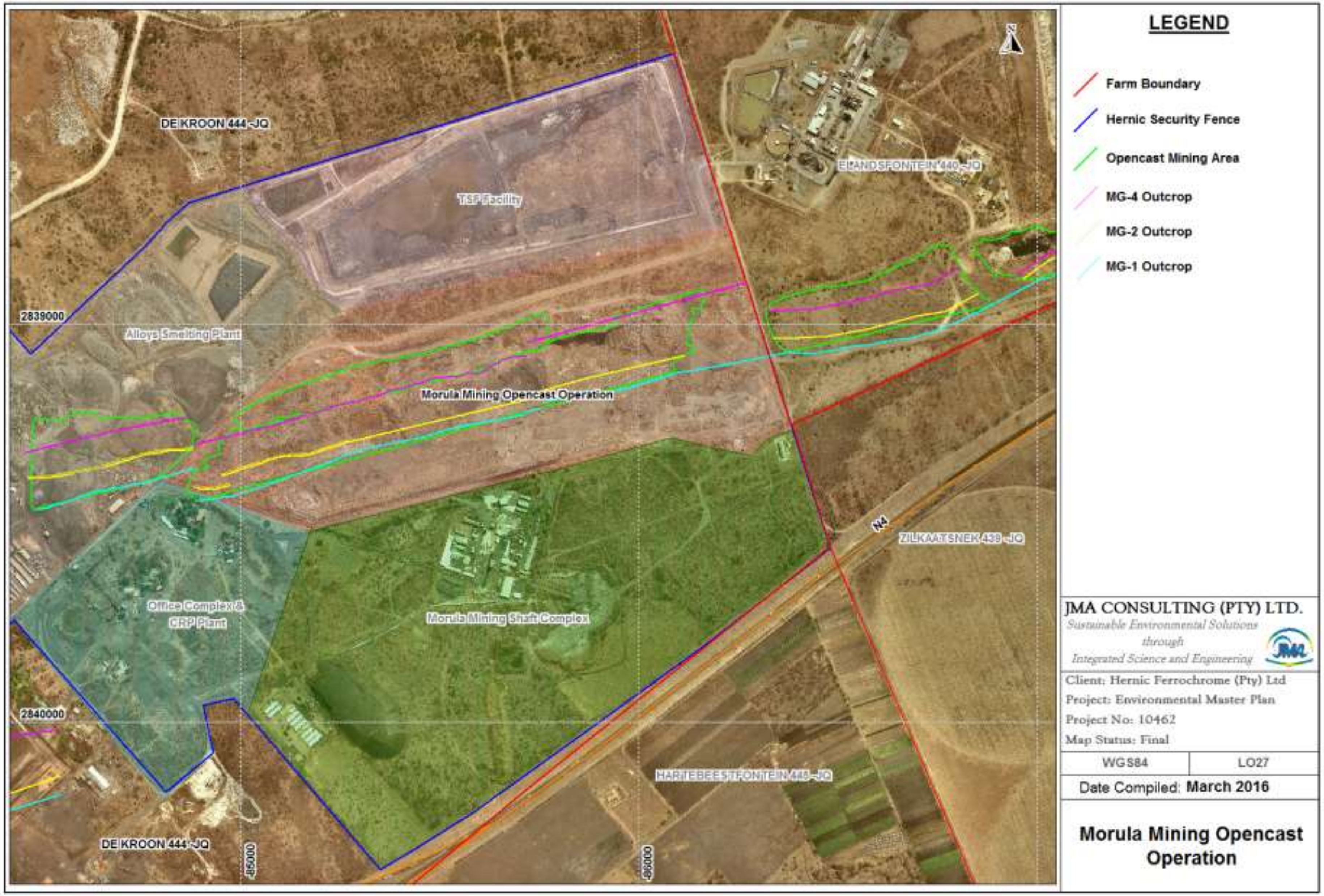


Figure 9.3.1.1(a): Extent of the Historic Opencast Mining Operations

Figure 9.3.1.1(b): Surface Infrastructure and Facilities adjacent to the Opencast Mining Operations

The opencast mining operations undertaken at HERNIC followed a sequence of topsoil stripping and stockpiling, soft overburden stripping and stockpiling, drilling, blasting, hard overburden stripping and stockpiling, extraction of the chromite ore and hauling it on internal haul roads to the Ore Beneficiation (OB) Plant.

During mining, concurrent backfilling of the open-pit sections on De Kroon 444 JQ, was done with both coarse overburden waste rock which was rolled over during mining as well as with inert fine tailings material from the OB Plant which was slurried into the opencast pits. The pits are currently backfilled with OB Plant Coarse Tailings as well as OB Plant Mixed Tailings.

The fine slurry material comprises *inter alia* of minerals referred to as Platinum Group Minerals (PGM's). HERNIC has applied for, and has been granted an amendment to their mining right which now permits them to re-mine the fine slurry and to extract a series of economic minerals from the slurry.

The fine material will therefore be excavated from the open-pit for beneficiation in an approved PGM Plant, after which the open pit will be finally backfilled with inert coarse mine waste rock, then shaped to be free draining and finally re-soiled and re-vegetated. A temporary MG-4 ore stockpile has been developed on the partially rehabilitated pit on the Farm De Kroon 444 JQ.

The opencast section on De Kroon 444 JQ still has a final void that is filled with water. Water is abstracted from this void and pumped to the OB Plant where it is used as process water.

The open-pit section of the Farm Elandsfontein 440 JQ, is currently under management of Glencore's Eland Platinum operations and have contractually been transferred to them for final rehabilitation and closure. They are currently pumping their raw water into this void, prior to pumping it out again from a number of boreholes located in the spoils adjacent to the void.

9.3.1.2 Underground Mining Operations

Shallow underground mining operations commenced at HERNIC in 2002/2003. Access to the underground workings is obtained through two decline shafts entering the sub-surface at an angle of some 12°.

The initial underground mining targeted the MG-1 and MG-2 chromite seams on both the Farm De Kroon 444 JQ and the Farm Elandsfontein 440 JQ, down to depths of 70 *m* below surface. The mining depth has subsequently been increased with current mining at depths below surface of some 200 *m*. It is planned that the two ore seams could be further mined via the underground operations down to depths of between 450 *m* to 500 *m* below surface.

The extents of the current and future underground mining layout plans on the MG-1 and MG-2 chromite seams are delineated on Figure 9.3.1.2(a).

The underground mining operations take place using standard board and pillar mining methods (drilling, blasting and excavation). Active stope and roof support is imported from surface. The cement for the support is mixed at the grout plant located on the surface at the Shaft Complex, due north of the Morula Decline Shaft. The proposed production rate for the underground mining until the end of life of mine is 70 000 *tonnes per month*.

The bulk of waste rock is separated underground from the ore and the ore is transported to the surface along the materials decline shaft. At the surface the ore is directed through the Ore/Waste Transfer House onto a series of conveyers, the final one (CV5) of which transports the ore over a distance of 1 000 *m* to the OB Plant.

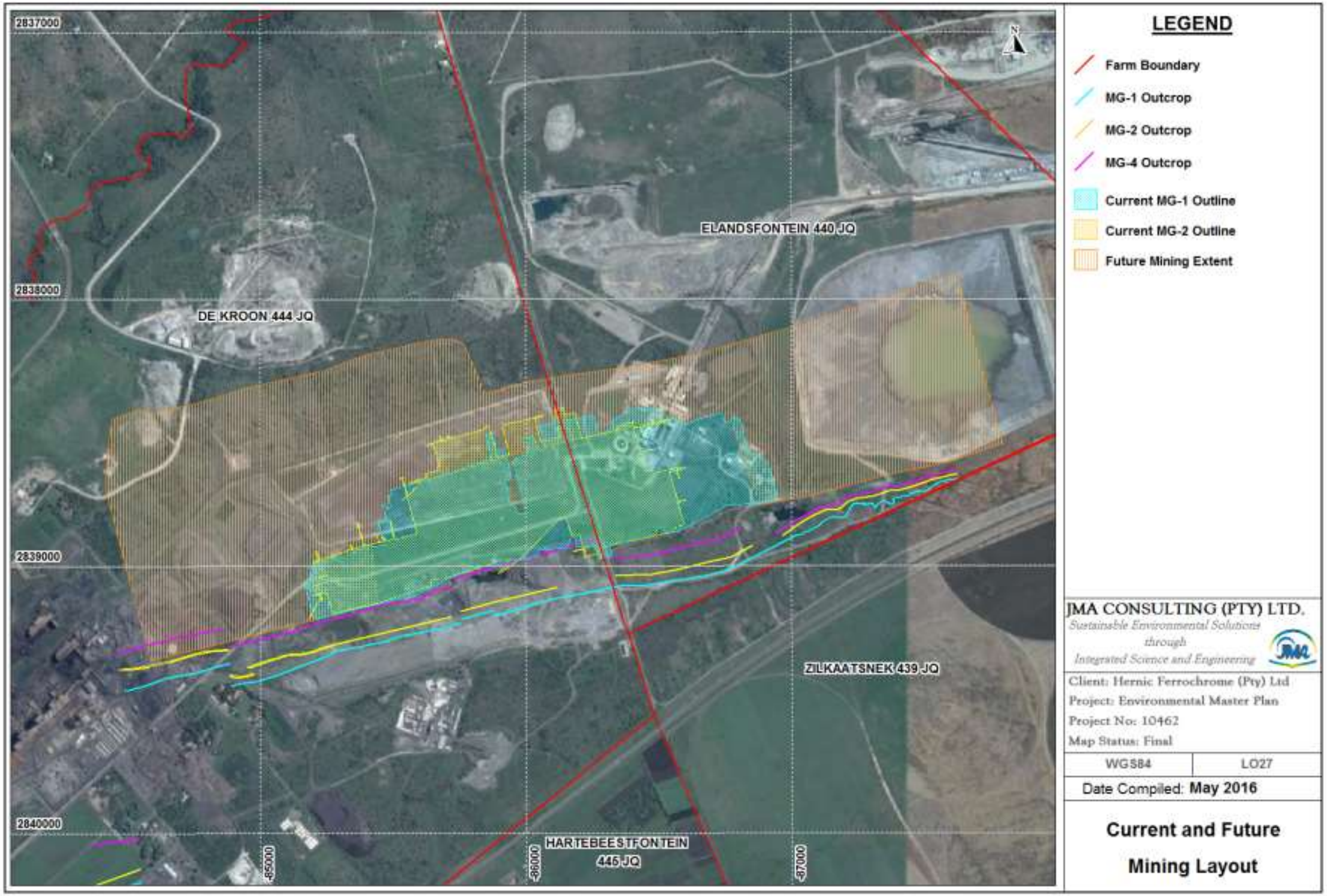


Figure 9.3.1.2(a): Current and Future Underground Mining Layout on the MG-1 and MG-2 Chromite Seams

One of the surface conveyors (CV3) can deposit ore on a surface Run of Mine (ROM) Stockpile at the Shaft Complex in the event that the main conveyor is unserviceable. The underground mining operations are currently under care and maintenance and chromite ore is being fed to the OB plant, amongst others, from this ROM stockpile.

9.3.1.3 Geological Formation

The opencast and underground mining operations at HERNIC are situated within the western limb of the Bushveld Igneous Complex. The in-situ chromite is generally exploited from the Middle Group (MG-1, MG-2 and MG-4) chromitite layers from within the Rustenburg Layered Suite. The MG-1 and MG-2 chromitite layers are the main chromitite layers which are currently being mined within the study area.

The lithologies of the Bushveld Igneous Complex have a west to east strike and have a dip of around 17° to the north within the study area. Dykes, potholes and faults occur within the study area and are expected to influence the continuity and occurrence of the chromitite layers. The extents of the linear geological features at HERNIC, as obtained from the Mining Work Program 396Mr & 308Mr (Approved May 2013) are delineated on Figure 9.3.1(a).

9.3.1.4 Mineral Deposit

The HERNIC mineral deposit consists of the Middle Group (MG) Chromite Seams, specifically the MG-0 to MG-4 seams of the Bushveld Igneous Complex (BIC) in the Brits-Rustenburg area. The ore seams dip northwards at an angle of 100-200 extending over a strike distance of 3 000 *m* from west to east. They are displaced southwards by a north-south trending fault in the western region of the mining area. The seams extend to a minable depth of some 500 *m*.

The average estimated grade of the ore body is 38% Cr_2O_3 with a Cr:Fe ratio of 1.47:1.

The two Mining Rights (NW30/1/2/3/398MR - De Kroon 444 JQ and Elandsfontein 440 JQ – 894.9144 *ha*) and (NW30/1/2/3/308 MR – De Kroon 444 JQ – 329.9599 *ha*) authorize the mining of the following minerals in as far as they are associated with the Middle Group Chromite Seams:

- *Chromite, Platinum Group Metals (namely, Platinum, Ruthenium, Rhodium, Palladium, Osmium and Iridium), Gold Ore, Silver Ore, Nickel Ore, Copper Ore, Cobalt, Rare Group Elements, Vanadium and Iron Ore as well as non-metallic elements such as Sulphur, Selenium and Tellurium, as well as Sand manufactured from Waste Rocks*.

9.3.1.5 Mineable Seam/ Ore Bodies

The overall ore body to be mined is located 10 kilometres south of Brits in the North West Province on the farms De Kroon 444 JQ and Elandsfontein 440 JQ. The reef sub-outcrops under a layer of black turf approximately 1 *m* thick and extends to a mineable depth of 500 *m*.

Due to the fact that the ore body outcrops, all the Middle Group Seams (MG-0, MG-1, MG-2, MG-3 and MG-4) are mineable through opencast methods up to depths of 40 *m* below surface. Below mining depths of 40 *m*, two seams (MG-1 and MG-2) are viable through underground mining methods up to depths of some 500 *m* below surface.

The total estimated MG ore body reserves down to 500 *m* below surface for the 1224.8743 *ha* mining right area, was estimated at between 70 000 000 *tonnes* to 85 000 000 *tonnes*. The remaining ore body as at the end of 2015, is estimated to be some **58 000 000 *tonnes***.

The PGM resource definition was conducted for the tailings stored in the Historical Open Pit, in the HERNIC Tailings Storage Facility (TSF) as well as from the current arisings from HERNIC's mining operations. The estimated reserves contained in the Open Pit and on the TSF alone exceeds 2 245 000 *tonnes*, supplemented of course with new arisings from the underground mining over the life of mine.

The Mineral Resources and Mineral Reserves are obtained from the Mining Work Program 396Mr & 308Mr (Approved May 2013) and are reported using the Joint Ore Reserves Committee Code (JORC) as a guideline. The Mineral Resources at HERNIC are categorised and listed in Table 9.3.1.5(a).

Table 9.3.1.5(a): HERNIC Mineral Resource Categories

Mineral Resource Category	Inferred	Indicated	Measured
Mineral Resource Tonnage (Tonnes)	30	44	28
Ore Reserve Tonnage (Tonnes)	0	54	31

9.3.1.6 Planned Life of Mine/Facility

The initial life of mine for the proposed opencast and shallow underground mining of the reserves as described in the previous section was 20 *years*. Commencing in 1996, the 20 *year* life of mine projects to 2015. This part of the mining was actually completed in 2014.

The planned future production rates for the mine is 960 000 *tonnes per year* which equates to a remaining (after 2015) potential life of mine of some 60 *years*. This will enable the plant to produce some 420 000 *tonnes per year* of ferrochrome for as long as the ore body lasts, i.e. 60 *years*.

The PGM Plant theoretically has the same Life of Mine as the Smelting and Mining operations.

9.3.1.7 Product Specifications

The chrome, lumpy ore and ore concentrate will be converted to ferrochrome (also known as charge chrome) for the production of stainless and speciality steels. Ferrochrome increases mechanical properties and corrosion resistance. HERNIC produces and supplies ferrochrome to the global stainless steel industry.

Typical specifications for the chrome ore mined at HERNIC is listed in Table 9.3.1.7(a) below.

Table 9.3.1.7(a): Typical Specifications for Chrome Ore and Concentrate

	FeO%	Cr_2O_3%	SiO_2%	Al_2O_3%	TiO_2%	MgO%	CaO%	Cr/Fe%
MG-1 ROM	24.0	38.5	6.70	14.5	0.60	10.7	0.60	1.41
MG-2 ROM	23.5	36.0	9.50	14.9	0.70	10.1	0.87	1.35
MG-3 ROM	23.5	35.0	10.7	16.6	0.80	9.00	1.30	1.31
MG-4 ROM	22.0	32.5	13.5	17.4	0.70	10.1	1.40	1.30
Concentrate	27.0	41.5	4.00	16.0	0.70	9.10	0.40	1.33

In 2012/2013 HERNIC successfully applied for an amendment to their mining rights in order to also mine and process other minerals incidental to the ore body mined. These additional minerals will be extracted from the current ore arisings from the underground mining as well as through re-mining of the fine tailings currently present in both, a section of the backfilled open pit, as well as on the HERNIC TSF.

In addition to the ferrochrome produced from the chrome ore, HERNIC will now also recover/produce:

- Platinum Group Minerals (PGM), (platinum, ruthenium, rhodium, palladium, osmium, iridium)
- Gold Ore
- Silver Ore
- Nickel Ore
- Copper Ore
- Cobalt
- Rare Group Minerals
- Vanadium
- Iron Ore
- Non-Metallic Elements (sulphur, selenium, tellurium)
- Sand manufactured from waste rocks.

The PGM Plant is capable of treating 44 000 *tonnes per month* following the chrome removal step. A saleable PGM concentrate in excess of 100 *gram per tonne* 4E PGM is envisaged and based on a recovery of 55%, a total of 2 582 *ounces per month* is estimated from the PGM operations.

The typical product makeup from the PGM Plant will include:

- Platinum 65%
- Palladium 23%
- Rhodium 12%
- Gold 0.4%

9.3.1.8 Mining Waste

Mining Waste was until 2014, not defined as a Waste in terms of the National Environmental Management Waste Act (NEMWA). However, mining waste does now require authorisation in terms of the NEMWA.

The Morula Mine Waste Rock Dump is located within the Morula Mining Shaft Complex adjacent to the Topsoil Stockpile and the Morula Dewatering Dam. The bulk of the waste is separated underground from the ore and transported from underground to the surface along the materials decline shafts on a conveyor, and is then directed through the surface located Ore/Waste Transfer House onto a conveyor that transfers the waste rock onto the Mine Waste Rock Dump.

The Mine Waste Rock has been classified as a Type 4 (Inert) Waste. A Summary of the Mine Waste Rock Dump information is given in Table 9.3.1.8(a). An aerial photograph of the Mine Waste Rock Dump is shown on Figure 9.3.1.8(a).

The designated area for the Mine Waste Rock Dump is some 5.9 *ha* in extent. The mine waste rock currently occupies a footprint of approximately 3.40 *ha* and the volume is estimated at some 680 000 m^3. During active mining the waste rock is deposited at a rate of some 6 700 *tonnes per month*.

Table 9.3.1.8(a): Summary Details of the Mine Waste Rock Dump

Mine Waste Rock Dump		
Central Coordinates	25° 39'45.3" S 27° 51' 18.0" E	
Footprint Area	34 000 m^2	
Storage Capacity	680 000 m^3	
Vertical Wall Height	12 m	
Liner	No Liner	
Property Details	Ptn 104 (a ptn of ptn 1) De Kroon 444 JQ	

In the event that an aggregate plant for the manufacturing of mine waste rock aggregate is to be commissioned, it will now be located at the Mine Waste Rock Dump. The corner coordinates of the Morula Mine Waste Rock Dump are indicated in Table 9.3.1.8(b) below.

Table 9.3.1.8(b): Corner Coordinates of the Morula Mine Waste Rock Dump

Corner Point	Latitude (dms)	Longitude (dms)
1	25° 39' 40.9" S	27°51'15.1"E
2	25° 39' 40.3" S	27°51'19.4"E
3	25° 39' 41.7" S	27°51'21.6"E
4	25° 39' 48.9" S	27°51'22.3"E
5	25° 39' 50.0" S	27°51'19.0"E
6	25° 39' 50.6" S	27°51'16.0"E
7	25° 39' 47.9" S	27°51'13.7"E
8	25° 39' 45.4" S	27°51'14.5"E

The layout and extent of the Mine Waste Rock Stockpile (Dump) is portrayed in Figure 9.3.1.8(a).

Figure 9.3.1.8(a): Layout and extent of the Mine Waste Rock Stockpile (Dump)

9.3.1.9 Mine Sewage Plant

The Mine Sewage Plants operates through the application of a Sequencing Batch Reactor (SBR) technology. The treatment process comprises raw effluent screening, flow balancing and distribution, aeration in a single SBR reactor, settling, decanting of the treated supernatant, dis-infection of the discharged supernatant, retention of the waste sludge in the aeration tank before discharge and dewatering of the activated sludge on sludge drying beds.

The SBR Sewage Treatment Plant is designed to treat an average of 140 m^3 of domestic sewage *per day*.

The treatment plant is designed to produce an effluent in accordance with the requirements of the General Limits of the General Authorizations in terms of Section 39 of the National Water Act, 1998.

The Sludge Drying Beds are manufactured by PRENTEC, which consist of four beds (4 *m* x 4 *m* x 0.5 *m*). The internal bed specification is 90 *mm* thick 19 *mm* stone (bottom layer), 3 *mm* thick Kaymac matting (middle layer) and finally a 100 *mm* thick 1.3 *mm* sand layer (top layer). Dried sludge is removed from site and sent to Holfontein (Class H:H Landfill Facility) via Enviroserv on a bi-quarterly basis.

The centre coordinates for the Alloys Plant Sewage Plant is relayed in Table 9.3.1.9(a).

Table 9.3.1.9(a): Centre Coordinates of the Alloys Sewage Plant

Description	Latitude	Longitude
Alloys Sewage Plant	25° 39' 27.7"S	27° 50' 02.2"E

9.3.2 Ore Beneficiation

The chromite ore sourced from the HERNIC Mining operations, as well as from other platinum mining operations, is beneficiated into lumpy and fine ore concentrate at the Ore Beneficiation Plant before being blended with other raw materials during the production of ferrochrome. The details of the ore beneficiation operations are addressed below.

9.3.2.1 Ore Beneficiation (OB) Plant

Chromite ore mined at HERNIC's mining operations is transported to the Beneficiation Plant via a conveyor (CV5 from MORULA), as well as by road (from BOKONE) and stockpiled on an ore stockpile at the OB Plant.

The ore is loaded by a front-end loader and then deposited into the feeding bunkers of either the Dense Medium Separation (DMS) Plant or the A-Crusher Plant, where it is crushed into workable sizes for further beneficiation.

At the DMS plant, ore is crushed and screened into either lumpy material (-80+30 *mm*), intermediate product (coarse product -30+10 *mm*; fines product -10+1 *mm*) or fines material (-1.25 *mm*). After crushing and screening the two fractions (lumpy and fines) are fed into two respective beneficiation sections, namely the Heavy Medium Separation (HMS) Plant and Spiral Plant A respectively. The intermediate product goes directly to the furnaces for smelting. Coarse and fines waste (referred to as mixed waste) originating from the DMS Plant is stockpiled for future use, i.e. backfill of the opencast pit which will eventually be re-worked in the new proposed PGM Plant. The ore and mixed waste from the DMS Plant are deemed inert.

The two material fractions (lumpy and fines) which are generated after crushing and screening at the A- Crushers Plant, are also similarly fed into the two beneficiation sections (HMS and Spiral Plants A and B).

The layout of the surface infrastructure associated with this ore beneficiation process is depicted on Figure 9.3.2.1(a). The process flow diagram of the ore beneficiation process is depicted in Figure 9.3.2.1(b) and should be referred to for reference.

9.3.2.1.1 Ore Beneficiation Plant – Lumpy Section (HMS Plant)

The lumpy fraction of the crushed ore (from the DMS Plant and the A-Crusher Plant) is fed via the Lumpy bin (-75+32 *mm*) to the HMS Plant where it is separated by means of a heavy medium separation process into HMS product and HMS waste. The HMS product goes to the furnaces for smelting and the HMS waste is used as aggregate for either road building or sold to customers.

9.3.2.1.2 Ore Beneficiation Plant – Fines Section (Spiral Plants A and B)

The fine fraction of the crushed ore originating from the DMS Plant and A-Crusher Plant is fed via conveyer to the two spiral plants (Plant A and Plant B) where the fine ore fraction, i.e. concentrate is beneficiated from the feed and separated from non-chromite bearing tailings material. The beneficiated fine ore is fed as concentrate into the two pelletising plants for pelletising and sintering. The fines waste is slurried and pumped to the HERNIC Tailings Storage Facility (TSF) and the coarse waste is used as aggregate for either road building or sold to customers. The fines and coarse waste is deemed inert.

The infrastructure associated with the two concentrator plants is shown on Figure 9.3.2.1(a).

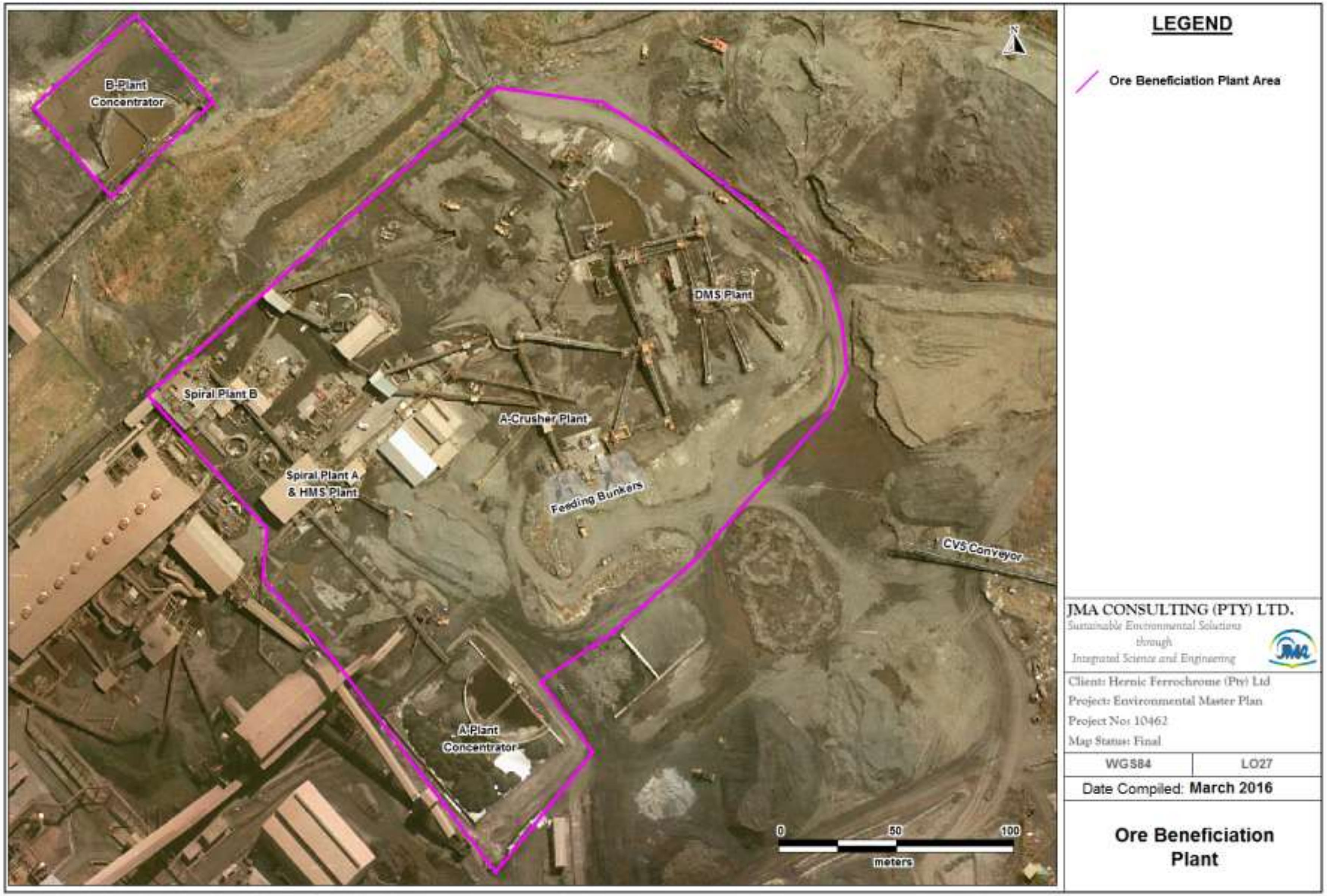


Figure 9.3.2.1(a): Infrastructure associated with the Ore Beneficiation (OB) Plant

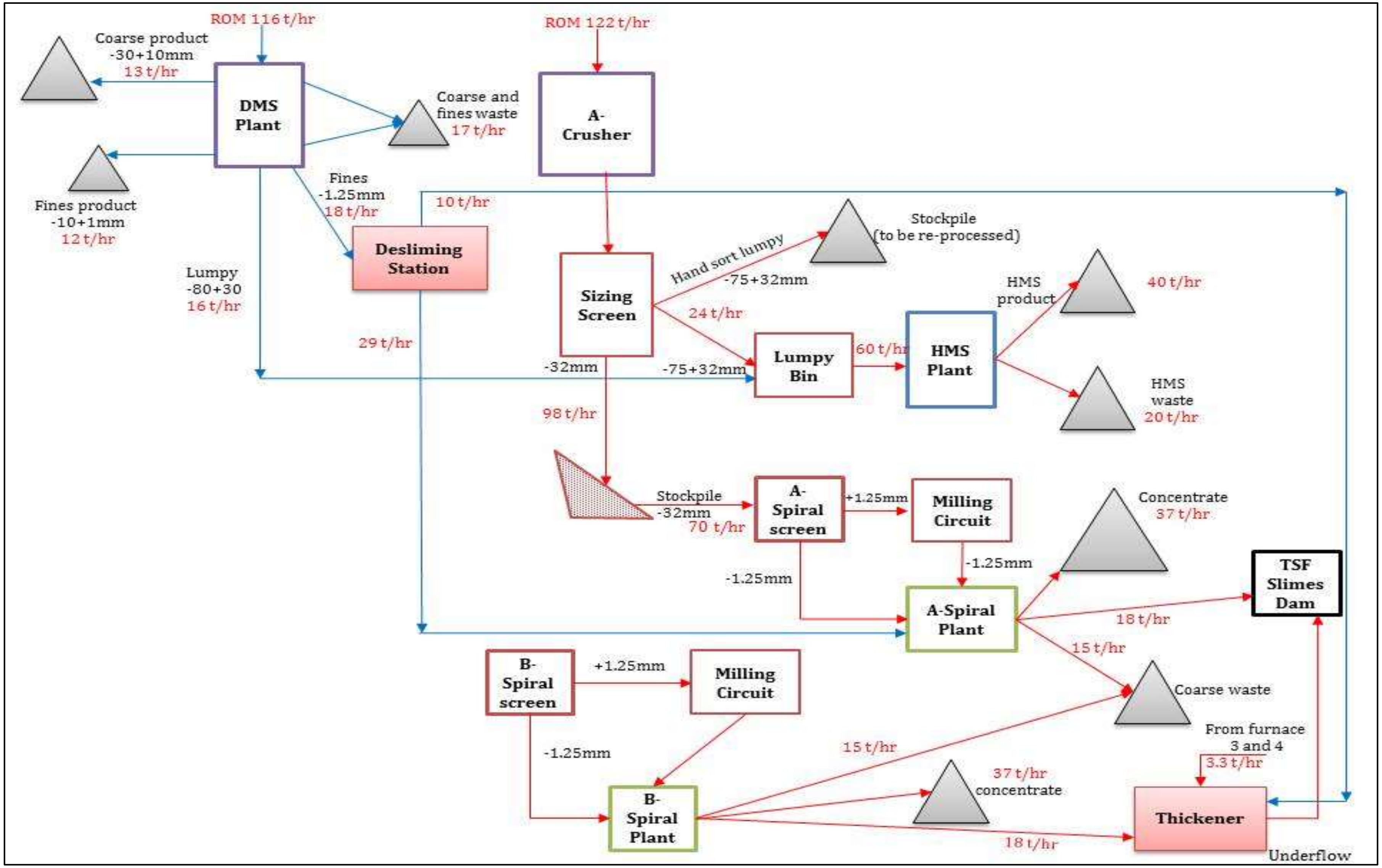


Figure 9.3.2.1(b): Ore Beneficiation (OB) Plant Schematic Process Flow Diagram

9.3.2.2 Raw Material Stockpile and Loading Areas

9.3.2.2.1 Raw Materials Stockpile Area 1

In order to facilitate the smelting process, additional materials need to be blended with the beneficiated lumpy ore and concentrated fine ore prior to it all being fed into the furnaces. These raw materials are stockpiled on site. Approximately 110 000 *tonnes* of raw materials are stored at any one time on site and between 3 000 - 5 000 *tonnes* of raw materials are transported to the OB Plant per day.

The Raw Materials Stockpile Area 1 services Furnaces 1, 2 and 3. The locality of this facility is shown on Figure 9.3.2.2.1(a) and is used for the stockpiling the following raw materials:

- Fluxes
  - Dolomite
  - Limestone
  - Quartzite
- Reductants
  - ACP Char
  - Anthracite Duff
  - Anthracite Peas
  - Coke Nuts
  - Coke Peas
- Ores
  - Chemstof Chromite Concentrate
  - MG- Ores
  - UG-2 Ore Concentrate

The Raw Materials Stockpile Area 1 covers a footprint size of approximately 5.14 *ha***.** The raw materials are deemed chemically inert and therefore the footprints are not lined.

9.3.2.2.2 Raw Materials Stockpile Area 2

The Raw Materials Stockpile Area 2 services Furnace 4. The locality of this facility is shown on Figure 9.3.2.2.2(a) and is used for the stockpiling the following raw materials:

- Fluxes
  - Limestone
  - Quartzite
- Reductants
  - ACP Char
  - Anthracite Duff
  - Anthracite Peas
  - Coke Nuts
  - Coke Peas
- Ores
  - Chemstof Chromite Concentrate
  - HFC Lumpy
  - DMS Lumpy
  - LG-6 Concentrate

The Raw Materials Stockpile Area 2 covers a footprint size of approximately 5.48 *ha*. The raw materials are deemed chemically inert and therefore the footprints are not lined.

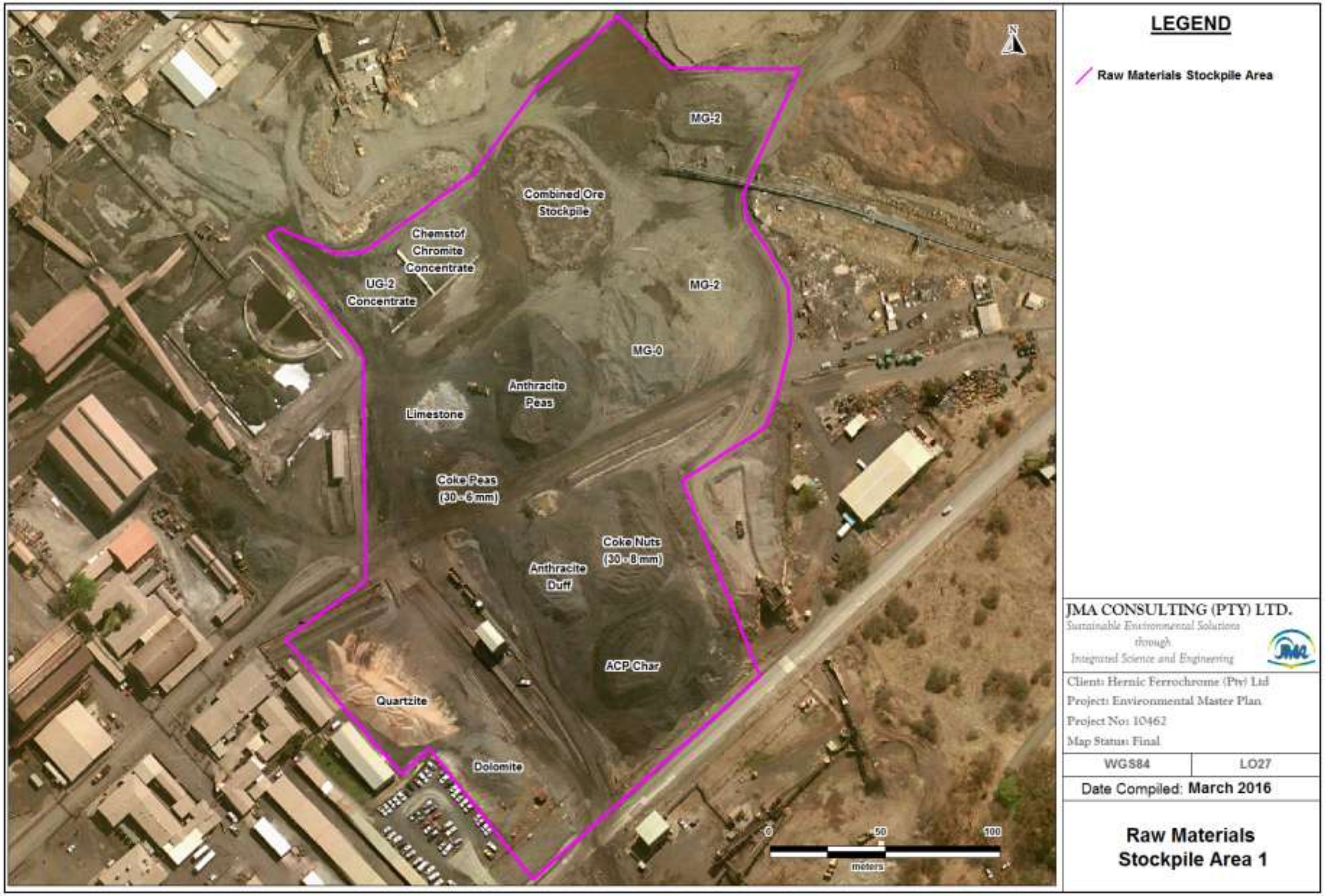


Figure 9.3.2.2.1(a): Raw Materials Stockpile Area 1

Figure 9.3.2.2.2(a): Raw Materials Stockpile Area 2

9.3.3 Pelletising and Sintering

The pelletising and sintering process at HERNIC comprises of an Outokompu steel belt sintering process. Refer to Figure 9.3.3(a) for a flow diagram depicting a summary of the pelletising and sintering process.

The pelletising and sintering process is summarised as follows: the chrome ore concentrate arriving from the OB Plant Fines sections are ground in a ball mill, dewatered in capillary effect ceramic filters, mixed with bentonite (approximately 400 *tonnes per month*) in day bins, pelletised in a drum and finally sintered in a furnace (temperature of the heating zone controlled by burning CO-gas) to form spherical equally sized hard and porous chromite pellets (1700 *tonnes per day*) that will be used as a raw material in the Smelter Plant (Furnaces) together with the lumpy ore and other additives.

From time to time the ceramic filters are regenerated by acid wash (nitric acid) to return the fill permeability. Nitric Acid is stored in a sealed tank and pumped once in every three months.

The Pelletising and Sintering Plant Infrastructure (Plant 1 & 2), as well as the Pellets Stockpile area, is shown on Figure 9.3.3(b). The major surface infrastructure at the Pelletising and Sintering Plant includes the following:

- Ball Mill
- Ceramic Filters
- Nitric Acid Storage
- Bentonite Storage
- Day Bins
- Pelletising
- Sintering
- Pellets Stockpiles

Currently, 350 000 *tonnes* of material is being processed by the Pelletising and Sintering Plants *per annum* (29 167 *tonnes per month*). HERNIC would like to increase the volume of material processed to be at least 100 000 *tonnes per month*, but ideally 148 720 *tonnes per month*, to be in line with their issued Air Emission Licence (AEL).

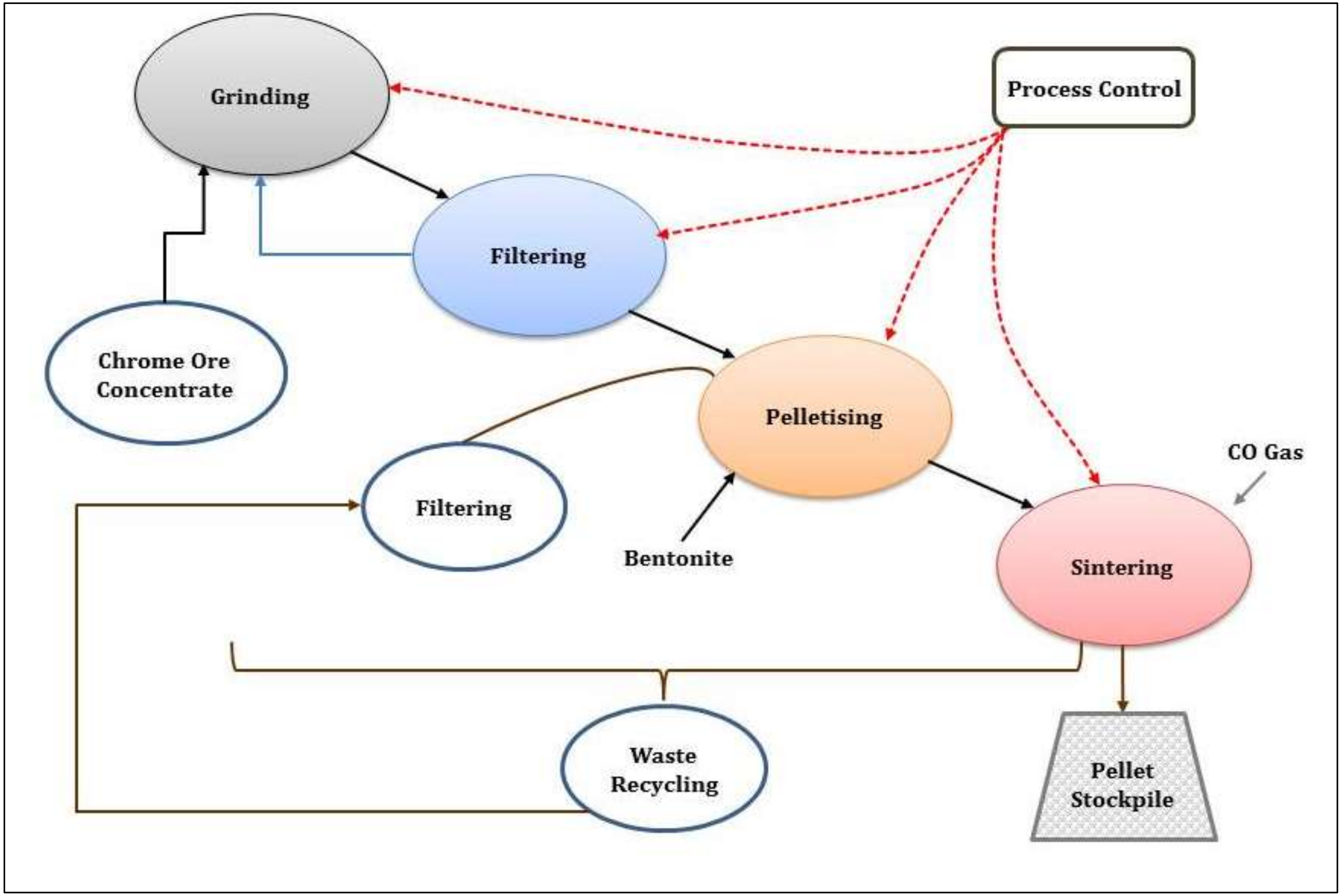


Figure 9.3.3(a): Schematic Process Flow Diagram of the Pelletising and Sintering Process

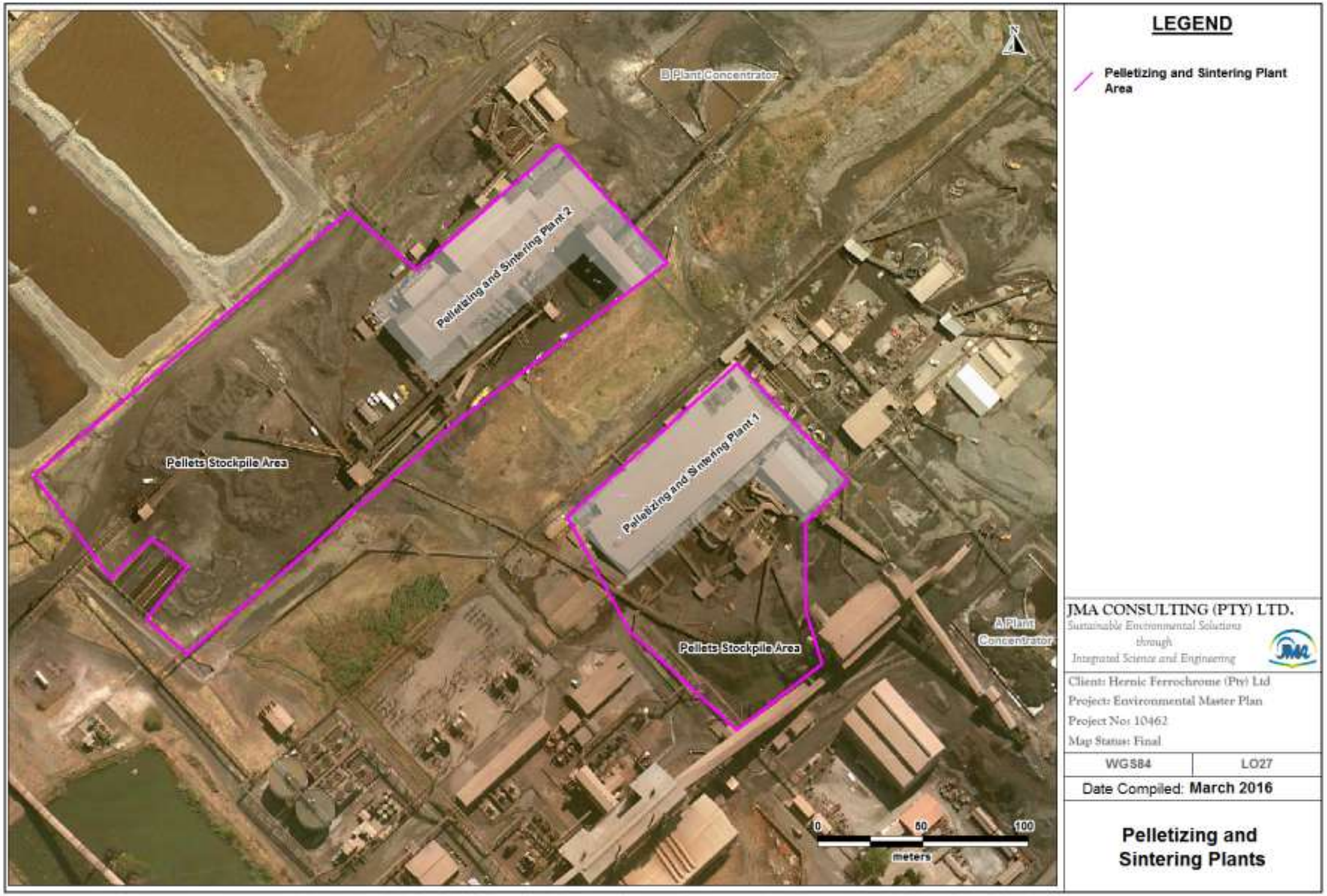


Figure 9.3.3(b): Infrastructure associated with the Pelletising Plant

9.3.4 Ferrochrome Smelting

9.3.4.1 Furnaces 1, 2, 3 and 4

HERNIC operates four Closed Submerged Arc Furnaces. Furnace 1, 2 and 3 are located in line, but Furnace 4, which was only commissioned later, is located separately. The Furnace infrastructure, including the two Proportioning Plants, as well as the tap floor areas (which is located under roof cover immediately next to the furnaces), is shown on Figure 9.3.4.1(a).

Furnace 1, 2 and 3 are being loaded by their own Proportioning Plant, with Furnace 4 also having its own Proportioning Plant. The lumpy ore, sintered pellets and other raw materials (reductants and fluxes) are blended to specification in these plants before being loaded into the respective furnaces for smelting.

During tapping from the furnaces (each furnace is tapped at least three times a day), the ferrochrome product is separated from the slag, the latter which contains all the impurities resulting from smelting through a skimmer device. The slag is cooled down and broken into lumps and chunks before being transported by road to the Primary Chrome Recovery Plant (CRP) where the residual ferrochrome in the slag is recovered.

Currently the furnaces are operating to accommodate 420 000 *tonnes per annum* (35 000 *tonnes per month*), but HERNIC would like to increase the volume of material going through the furnaces to 63 000 *tonnes per month*. This will then be in line with the issued AEL for HERNIC.

In addition, currently 40 000 *tonnes* of slag is produced *per month*, but HERNIC would like to increase this amount of slag to at least 60 000 *tonnes per month*, but ideally to 94 500 *tonnes per month* to optimise the slag to metal ratio of 1.5 *t/t*.

In the past, the slag was conveyed to Slag Dumps (three of which still exist at HERNIC). The intention is now to also recover the residual ferrochrome from this slag material by also putting the slag material contained on these historic facilities through the Primary CRP.

The fine slag fraction is transported by road to the Fine Slag Processing Plant (Secondary CRP).

After cooling down in sand chilling pans, the ferrochrome product from the furnaces is transported by front-end loaders from the tapping floors to the Ferrochrome Break Floor Area. Here the smelted ferrochrome is broken down mechanically into smaller chunks and stored on temporary stockpiles, before being loaded and transported to the Finished Product Plant.

9.3.4.2 Finished Product Plant

The product arriving from the Ferrochrome Break Floor Area is crushed and screened to finish the product into different size fractions as required by the markets.

Product arriving from the Break Floor Area is put through the Primary Crushing and Screening section, from where the undersize material (0x6 *mm*) which needs to be reprocessed is stockpiled. In addition, the fines material (0x6 *mm*) which is a saleable product as well as the sized product is also stockpiled. Oversize material (60-120 *mm*) will be crushed and screened through the Secondary Crushing and Screening section, where after it goes through the Primary Crushing and Screening section to produce saleable product (10x100 *mm*).

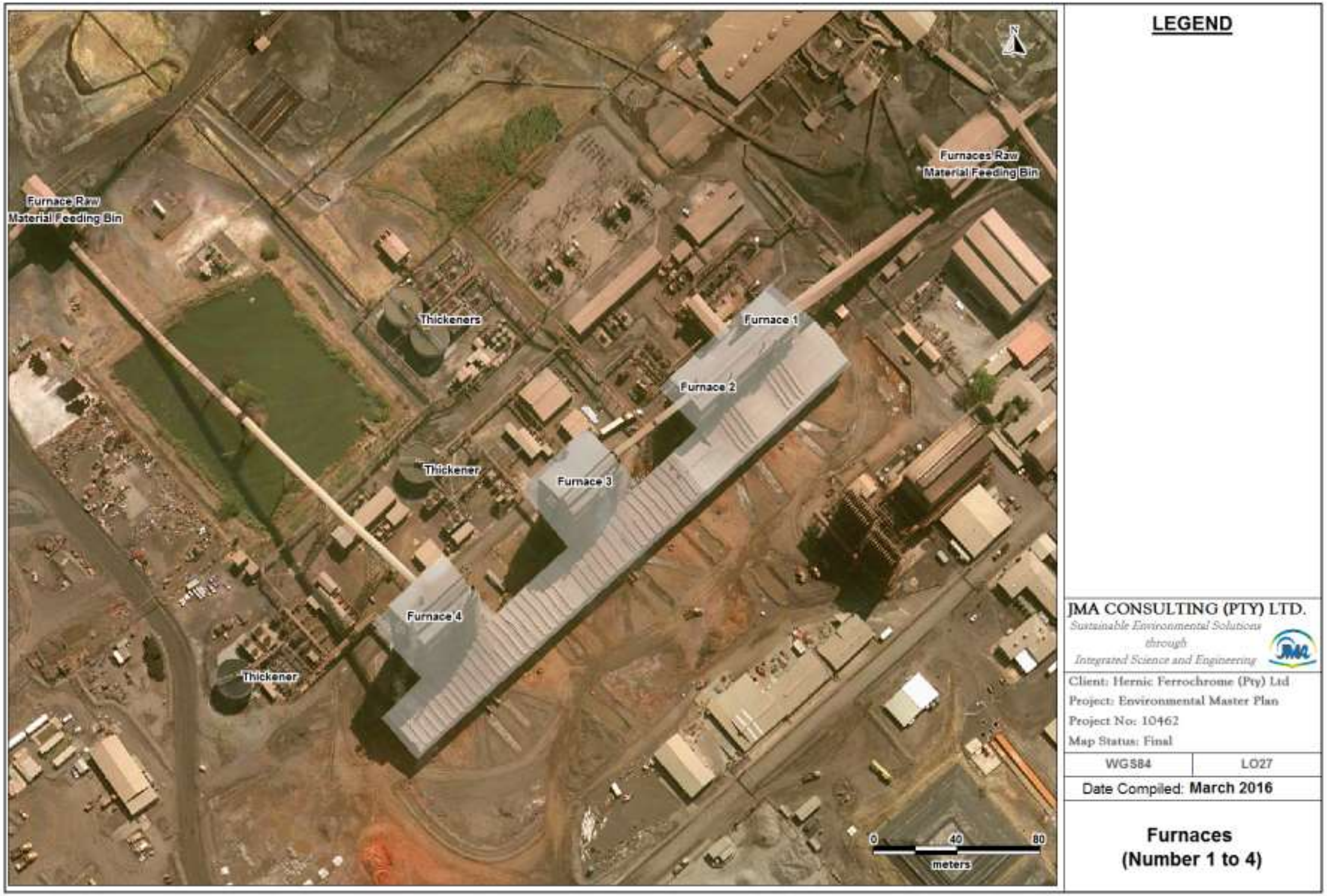


Figure 9.3.4.1(a): The Furnace infrastructure, including the two Proportioning Plants

Finished/Saleable product stockpile bins are located on concrete lined areas. Finished/Saleable products are loaded onto trucks for dispatch to customers or onto trucks for dispatch to the railway siding.

The amount of product dispatched per road and rail is more or less an even split (50:50), with some 420 *trucks* dispatched *per month*. The Finished Product Plant has the capacity to finish 420 000 *tonnes* of product arriving from the Break Floor Area *per annum*.

The infrastructure associated with the Finished Product Plant is shown on Figure 9.3.4.2(a) and comprise of:

- Offices
- Conveyors
- Primary and Secondary Crushing and Screening Plans
- Product Stockpiles
- Weighbridge

Refer to Figure 9.3.4.2(b) for a schematic process flow diagram illustrating the processes at the Finished Product Plant.

Figure 9.3.4.2(a): The Finished Product Plant

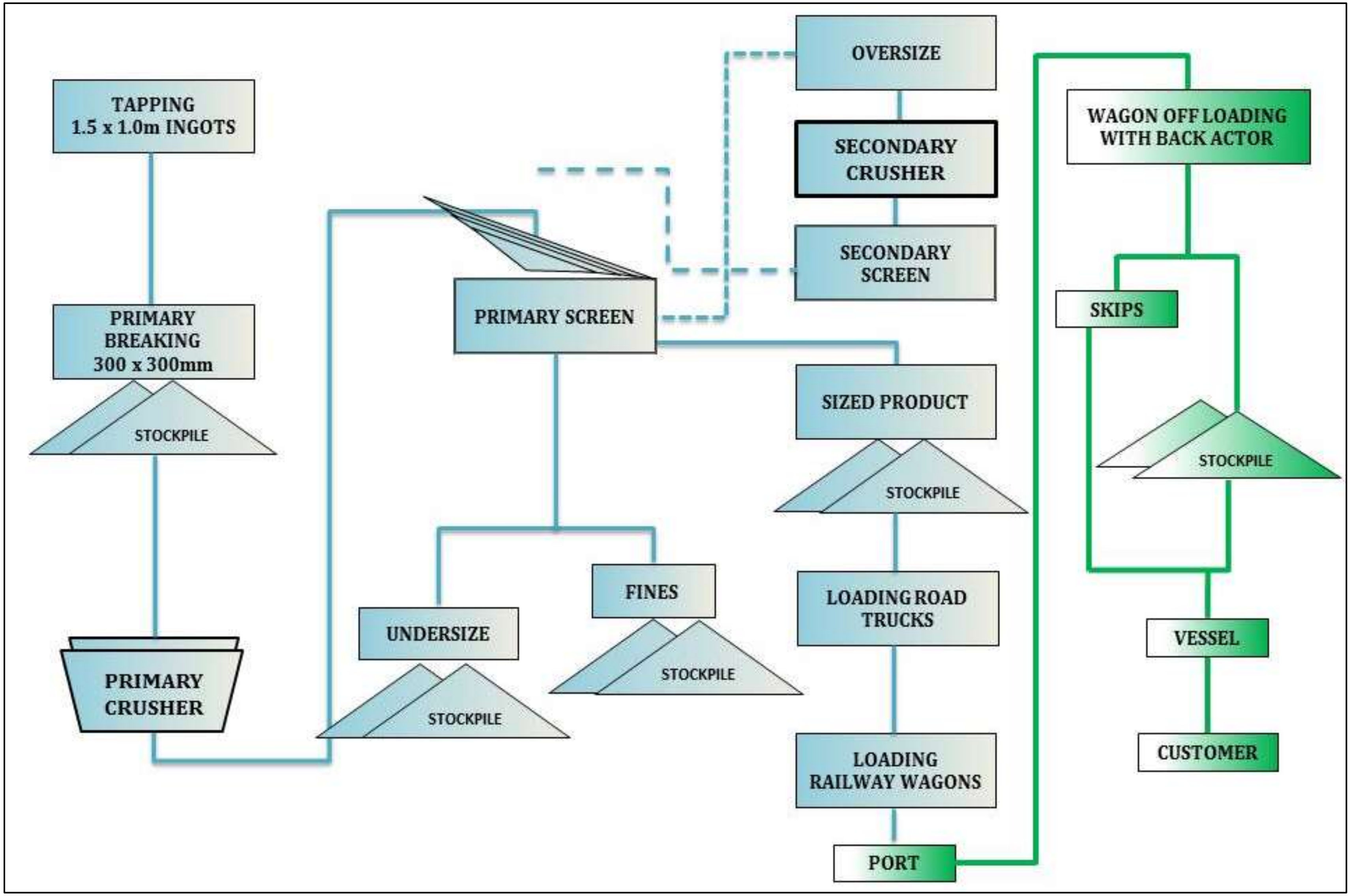


Figure 9.3.4.2(b): Schematic Process Flow Diagram of the Finished Product Plant

9.3.5 Ferrochrome Recovery

9.3.5.1 Primary Chrome Recovery Plant (CRP)

Slag collected from the Furnace Tap Floors is loaded onto trucks and transported to and deposited on two temporary slag storage sites, namely the current Arising Slag Dumps. From here it is loaded and deposited at the Primary CRP Loading Area after which it is transported via conveyor into the Primary CRP. The intention is also to treat the slag currently contained on the Historic Slag Dump through the Primary CRP.

The chrome recovery process comprises a crushing (Jaw crusher), screening (Gyro 1 and 2) and separation process (Jigging). Both coarse and fine material is separated, coarse material through dense medium separation (wet system) and fine material through magnetic separation (dry system).

The location of and infrastructure related to the Primary CRP is shown on Figure 9.3.5.1(a). Refer to Figure 9.3.5.1(b) for a schematic process diagram of the chrome recovery process.

The infrastructure comprises of:

- Crushing, Screening and Separation Plant
- Water Storage
- Clarifier
- Pollution Control Dam (PCD) (containing Process and Storm Water)
- Product Stockpiles
- Slag Stockpiles

After separation the recovered product and remaining slag is stockpiled separately. The fine slag is transported by road to the Fine Slag Processing Plant (Secondary CRP) and the coarse slag, i.e. slag chips is sold to customers. The recovered chrome is transported to the Final Product Area for dispatch.

Currently the plant is operating at 85 000 *tonnes per month*, but HERNIC would like to increase the capacity to 186 000 *tonnes per month* according to the design capacity of the plant.

Figure 9.3.5.1(a): Location of and Infrastructure related to the Primary Chrome Recovery Plant (CRP)

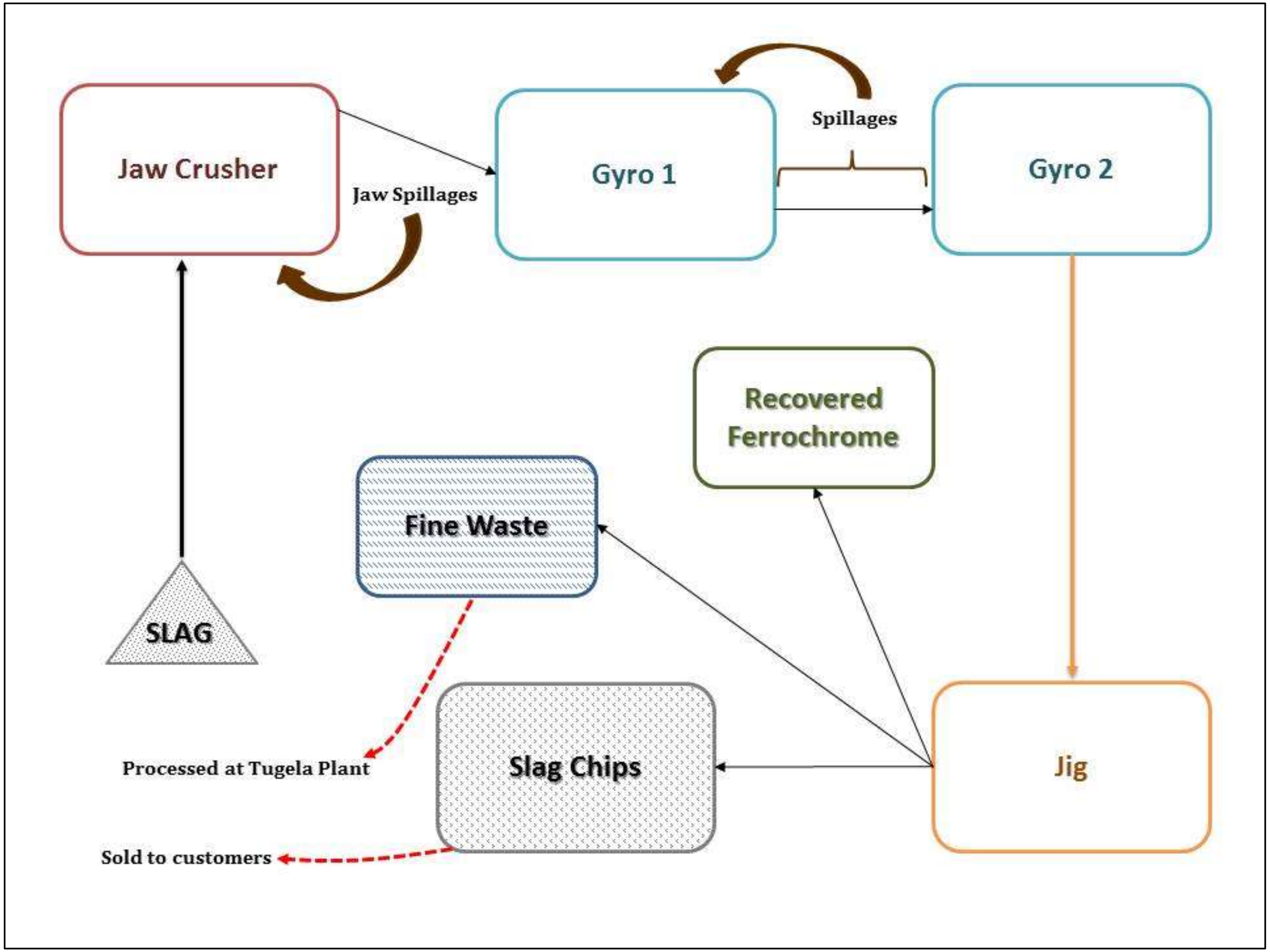


Figure 9.3.5.1(b): Schematic Process Diagram of the Primary Chrome Recovery Plant (CRP)

9.3.5.2 Fine Slag Processing Plant (Secondary CRP)

The fine slag originating from the Primary CRP is picked up from the fine slag stockpiles and transported via road to the Fine Slag Processing Plant for further recovery, resulting in a fine Ferrochrome Product and Fine Slag Sand, the latter which is also sold as a recovered product.

After separation, the fine ferrochrome fraction is loaded from a recovery bin whilst the fine sand is stockpiled on a series of fine sand stockpiles at the Fine Slag Processing Plant, ready for re-use.

The location of, and the infrastructure related to the Fine Slag Processing Plant is shown on Figure 9.3.5.2(a). Refer to Figure 9.3.5.2(b) for a schematic process diagram of the Fine Slag Processing Plant.

The infrastructure comprises of:

- Fine Slag Stockpiles
- Screening and Separation Plant
- Spiral Plant
- Fine Chrome Bin (product)
- Spiral Plant Tailings (fine sand product)
- Water Recovery Sumps

Figure 9.3.5.2(a): Location of and Infrastructure related to the Fine Slag Processing Plant

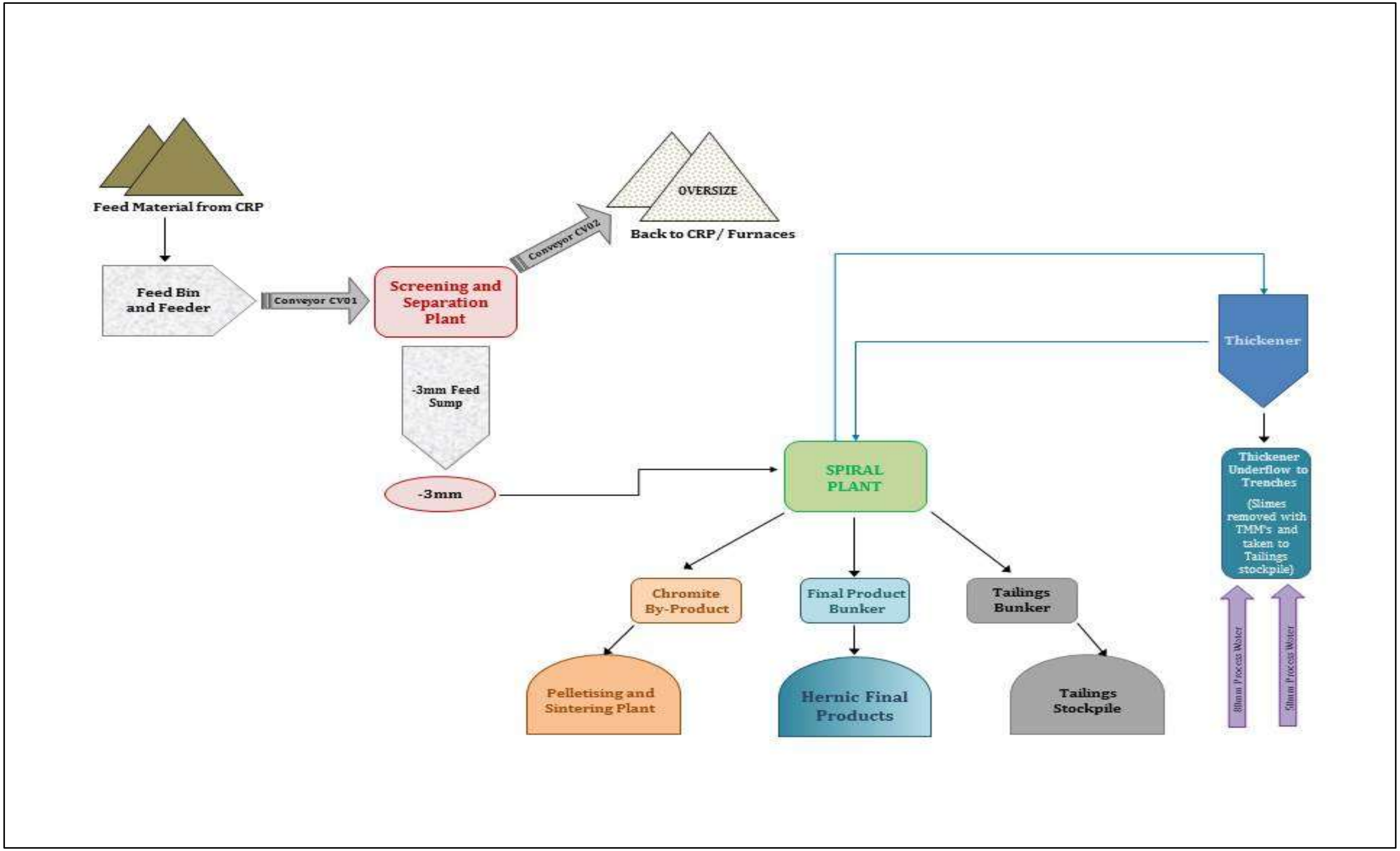


Figure 9.3.5.2(b): Schematic Process Diagram of the Fine Slag Processing Plant

9.3.6 Platinum Group Minerals (PGM) Recovery

HERNIC has successfully applied for an amendment to their Mining Right which authorised them to mine and beneficiate the Platinum Group Minerals (PGM) present in existing fine mine tailings in both the Morula open pit as well as in the HERNIC TSF and also present in the MG ore to be mined in future (current arisings).

The DMR issued an approved EMP in 2013 and the plant is currently being constructed. The locality for the PGM Plant, superimposed with a diagrammatic layout of the infrastructure currently constructed, is shown in Figure 9.3.6(a), whilst a process flow diagram for the proposed PGM Flotation Plant is shown in Figure 9.3.6(b).

The PGM recovery plant has an overall capacity of 55 000 *tonnes per month* of tailings. HERNIC will re-mine the historic tailings and pump it to the PGM Plant. HERNIC will also pump the current arisings tailings via their OB Plant thickener underflow to the PGM Plant. At the re-mining site, several stages of screens will be installed in order to remove tramp material prior to overland pumping to the plant.

The process starts by splitting the feed and classifying it into slimes and fines. Hereafter the slimes and fines go to a separate PGM flotation recovery process with a 44 000 *tonnes per month* capacity. Additionally the fines portion will, prior to the PGM recovery plant, be subjected to spiral chrome recovery.

The recovery process will extract some 18% of the mass feed to be sold as chromite, some 2% of the feed to be sold as PGM, whilst the remaining 80% of the feed will represent tailings for deposition on the HERNIC TSF at a deposition rate of some 43 000 *tonnes per month*.

The process steps include:

- Collection in a surge buffer tank
- De-sliming of the feed
- Spiral recovery of chromite from the de-slimed feed
- Primary and secondary ball milling of spiral tailings
- Thickening of slimes
- Ceramic bead milling of thickened slimes
- Separate PGM flotation of slimes and milled spiral tailings
- Thickening of the final PGM concentrate
- Pumping of tailings to the HERNIC TSF
- Final depositing of the tailings onto the HERNIC TSF

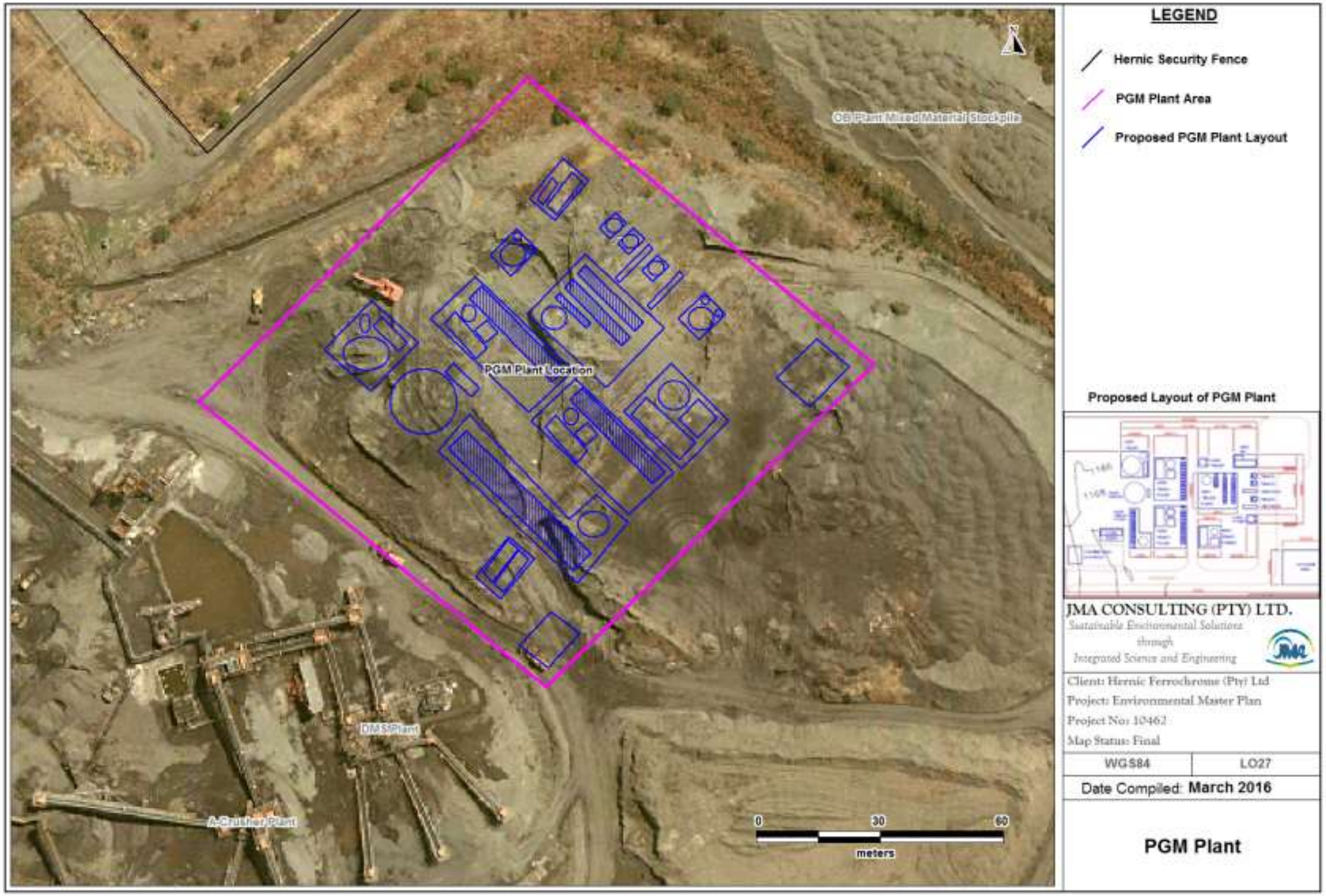


Figure 9.3.6(a): Location of the Platinum Group Minerals (PGM) Plant

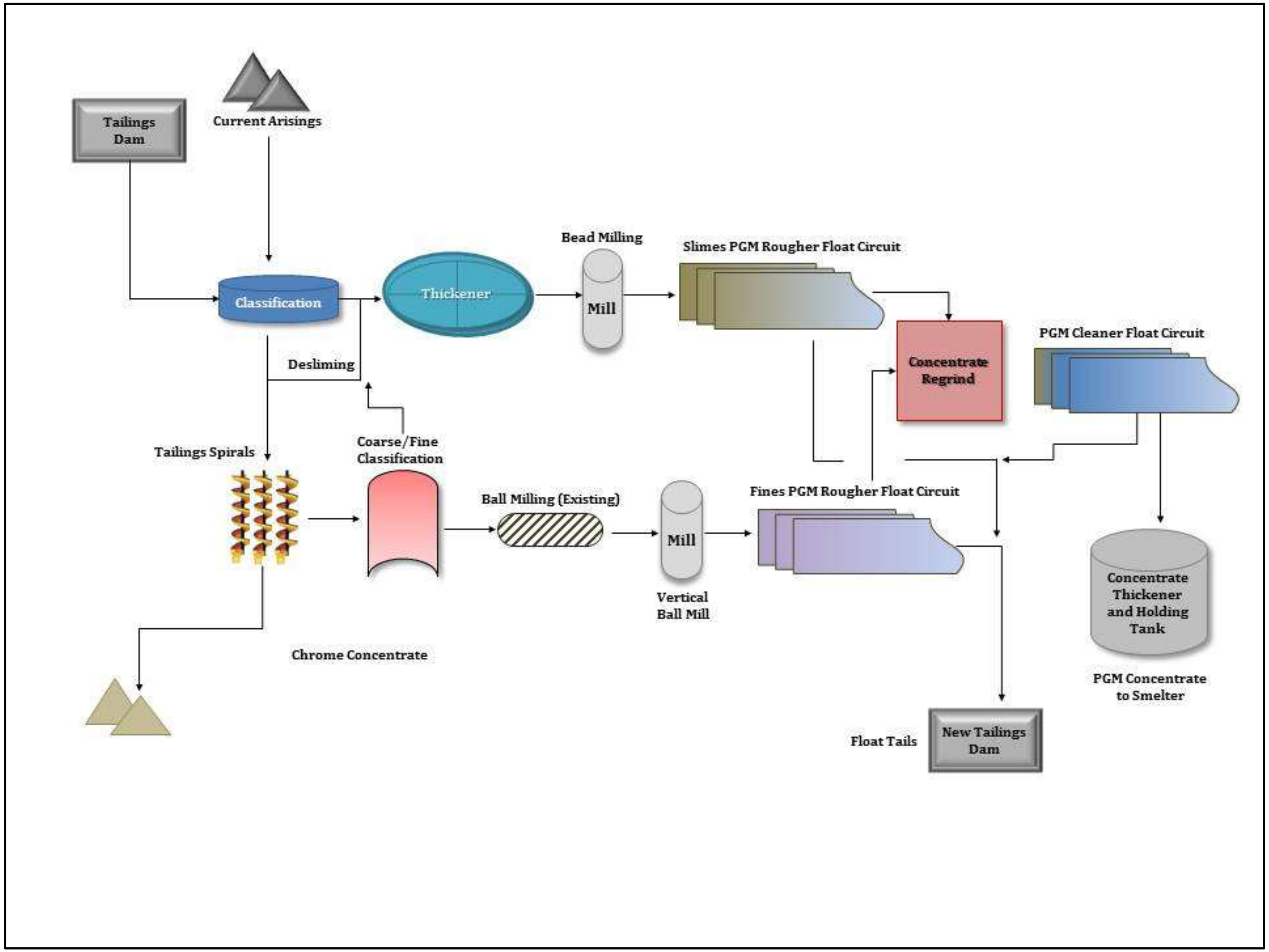


Figure 9.3.6(b): Schematic Process Diagram of the Platinum Group Minerals (PGM) Flotation Plant

9.3.7 Alloys Smelting Plant Waste Management Infrastructure

All aspects related to waste management will be regulated through the Waste Licence for the site. The discussion to follow will therefore deal with all aspects related to waste associated with the HERNIC Alloys Plant.

A number of waste management activities have been on-going since the plant started up initially. Due to process changes over the years some of these have become redundant whilst other have reached the end of their life and had to be replaced with new facilities. However, for the sake of completeness, both old and current facilities will be discussed.

9.3.7.1 Historic Slag Stockpile

Historically, slag collected from the Furnace Tap floors was loaded onto trucks and transported to and deposited on a slag stockpile, now designated the Historic Slag Stockpile. The location and extent of the Historic Slag Stockpile is shown on Figure 9.3.7.1(a). The slag stockpile covers a footprint of approximately 3.84 *ha* and contains an estimated 490 000 m^3 of material. The facility is unlined.

Details pertaining to the Historic Slag Stockpile are indicated in Table 9.3.7.1(a) below.

Table 9.3.7.1(a): Details of the Historic Slag Stockpile

Historic Slag Stockpile		
Central Coordinates	25° 39' 53.0" S 27° 50' 58.6" E	
Footprint Area	3.84 *ha*	
Storage Capacity	490 000 m^3	
Vertical Wall Height	31 *m*	
Liner	No Liner	
Property Details	R/E of Ptn 103 (ptn of ptn 1) De Kroon 444 JQ	

The intention is to re-process the slag material for ferrochrome recovery through the Primary CRP, with the subsequent rehabilitation and closure of the residual footprint.

Figure 9.3.7.1(a): Location and Extent of the Historic Slag Stockpile

9.3.7.2 Current Arising Slag Stockpiles (1 & 2)

Current arisings slag collected from the Furnace Tap Floors is loaded onto trucks and transported to and deposited on two slag storage stockpiles prior to being fed through the Primary CRP. The two facilities are not lined.

The location and extent of the two current arising slag stockpiles is shown on Figure 9.3.7.2(a). The footprint occupied by the two stockpiles is approximately 4.57 *ha* and it is estimated that the two facilities combined contain some 265 000 m^3 of slag.

A summary of the details pertaining to these two facilities are relayed in Table 9.3.7.2(a) and Table 9.3.7.2(b) below.

Table 9.3.7.2(a): Details of the Current Arising Slag Stockpile 1

Current Arising Slag Stockpile 1		
Central Coordinates	25° 39' 26.9" S 27° 50' 43.8" E	
Footprint Area	2.11 *ha*	
Current Capacity	148 588 m^3	
Vertical Wall Height	24 *m*	
Liner	No Liner	
Property Details	Ptn 296 & Ptn 169	

Table 9.3.7.2(b): Details of the Current Arising Slag Stockpile 2

Current Arising Slag Stockpile 2		
Central Coordinates	25° 39' 30.5" S 27° 50' 39.5" E	
Footprint Area	2.46 ha	
Current Capacity	113 553 m^3	
Vertical Wall Height	16 m	
Liner	No Liner	
Property Details	Ptn 170 (a ptn of ptn 47) De Kroon 444 JQ	

Similar to the slag on the Historic Slag Stockpile, the future intention is to re-process the slag material for ferrochrome recovery through the Primary CRP, with the eventual rehabilitation and closure of the residual footprint.

At the same time of re-processing the existing slag stockpiles, the intention is to feed the new slag arisings directly from the Tap Floors into the Primary CRP for ferrochrome recovery.

Figure 9.3.7.2(a): Location and Extent of the two Current Arisings Slag Dumps

9.3.7.3 Historic Slimes Dams (1 & 2)

The location and extent of the two Historic Slimes Dams are shown on Figure 9.3.7.3(a). Details pertaining to these two facilities are relayed in Table 9.3.7.3(a) and Table 9.3.7.3(b) below.

Table 9.3.7.3(a): Details for Historic Slimes Dam 1

Historic Slimes Dam 1		
Central Coordinates	25° 39' 45.4" S 27° 50' 23.5" E	
Footprint Area	2 920.25 m^2	
Final Maximum Height	8 m	
Liner	Combined Clay and HDPE Liner with Drainage Layer	

Table 9.3.7.3(b): Details for Historic Slimes Dam 2

Historic Slimes Dam 2		
Central Coordinates	25° 39' 46.4" S 27° 50' 24.5" E	
Footprint Area	922.84 m^2	
Final Maximum Height	7 m	
Liner	Combined Clay and HDPE Liner with Drainage Layer	

These two facilities were used since the commissioning of the first two furnaces at HERNIC for the disposal of the Bag House Dust that was collected as part of the furnace off-gas emissions control systems. Both facilities were provided with compacted clay and HDPE liner systems and also had drainage layers below the HDPE and above the compacted clay.

Upon reaching their end of life, these two facilities were taken out of operation and replaced with a new H:H Slimes Disposal Facility. At this time the two Historic Slimes Dams were covered with HDPE capping liner systems as a temporary measure to prevent water ingress and dust generation pending their final rehabilitation and closure.

The intention is to remove the slimes contained in these facilities for final disposal at the now redundant H:H Slimes Disposal Facility. The closure and rehabilitation of these facilities will require the necessary NEMA and NEMWA approvals and due process will be followed for that.

Figure 9.3.7.3(a): Location and Extent of the two Historic Slimes Dams

9.3.7.4 H:H Slimes Dam

The location and extent of the H:H Slimes Dam (Phase 1) and its associated Return Water Dam (RWD) is shown on Figure 9.3.7.4(a). This facility was primarily used for the disposal of the Bag House Dust that was collected as part of the furnace off-gas emissions control systems for the old open furnaces.

This facility replaced the two Historic Slimes Dams and was constructed in accordance with waste disposal regulatory requirements to exacting specifications for the protective footprint liners for both the Waste Site itself as well as the associated RWD.

The facility became redundant when the open furnaces were converted to closed furnaces after which the H:H Waste Site as well as the RWD, were temporarily covered with HDPE Capping Liners to prevent water ingress and dust generation pending their final rehabilitation and closure.

The intention is to dispose of the Old Historic Slimes Dams material on Phase 1 of this appropriately lined facility, after which Phase 1 will be fully rehabilitated and closed in full compliance with regulatory requirements.

The footprint occupied by the H:H Slimes Dam is approximately 1.35 *ha* and that of the downstream associated RWD approximately 0.3765 *ha*.

The liner system for the H:H Slimes Dam consists of 2 *mm* FML / geomembrane, 600 *mm* compacted clay liner (in 4 x 150 *mm* layers), geotextile layer, 150 *mm* leakage detection and collection layer, 300 *mm* compacted clay liner (in 2 x 150 *mm* layers) and a 150 *mm* base preparation layer.

Table 9.3.7.4(a): H:H Slimes Dam Design Specifications

H:H Slimes Dam		
Central Coordinates	25° 39' 18.5" S 27° 50' 46.9" E	
Footprint Area	1.35 *ha*	
Final Maximum Height	15 *m*	
Limiting Rate of Rise	0.7 *m/y*	
In Situ Density	2.1 t/m^3	
Storage Capacity	52 000 m^3	
Liner Type	H:H Liner	

Figure 9.3.7.4(a): Location and Extent of the H:H Slimes Dam and Return Water Dam

9.3.7.5 HERNIC Tailings Storage Facility (TSF)

The fine tailings generated at the OB Plant, the PGM Plant, as well as fine clarifier underflow from the air scrubbing and bag house systems at the furnaces and the pelleting plants, are slurried and pumped to a fully designed TSF for disposal. The option to dispose of fine slag from the Primary CRP onto the TSF also exists and is currently being investigated.

The supernatant water is decanted from the slurry dam through an intermediate and final penstock system. The water then reports to the silt trap where suspended solids are allowed to settle out. The water subsequently is reticulated to a dedicated RWD. The water is re-cycled back to the OB Plant for re-use via a dedicated pump station.

The location and extent of the TSF and associated RWD is shown on Figure 9.3.7.5(a). The TSF footprint comprises of the following components; a starter wall embankment of 6.7 *m* high to elevation 1173.70 *mamsl*, catchment paddocks, 5 *m* wide toe drains, 5 *m* wide blanket drains, pool wall, an enclosed solution collector system, final and intermediate penstocks, catwalks, an access road, silt trap (HDPE and concrete lined) with a concrete division wall, a Return Water Dam (HDPE lined) with an approximate capacity of 24 000 m^3, pump station, storm water diversion trench and bund wall and a TSF division wall.

The footprint occupied by the TSF and the RWD is approximately 31.14 *ha* and 0.9486 *ha* respectively. The TSF is an upstream impoundment and has to accommodate an average deposition rate of 26 000 *tonnes* of fine tailings *per month* with and estimated final storage capacity of 7 800 000 *tonnes.* The TSF is constructed on a gradient which implies that there is a catchment area upstream of the TSF. Any storm water generated upstream of the TSF is diverted around the facility by means of a storm water diversion trench and is discharged at the north western and north eastern corners of the dam. The location of the slurry pool on top is controlled by the deposition of the slurry from the edge of the walls. As the slurry is deposited, the pool tends towards the centre of the dam. Alternate deposition points must be utilised in order to keep the pool in the centre of the dam.

Table 9.3.7.5(a): Details of the Tailings Storage Facility (TSF)

Tailings Storage Facility		
Central Coordinates	25° 39' 10.5" S 27° 51' 11.7" E	
Footprint Area	31.14 *ha*	
Lifespan	10 - 25 *years*	
Ave Deposition Rate	43 000 *tpm*	
Ave Slurry Relative Density	1.2 t/m^3	
Solids Specific Gravity	3.6 t/m^3	
In Situ Dry Density	2.043 t/m^3	
Tailings Upper Cut-off	0.5 *mm*	
Final Maximum Height	39 *m*	
Limiting Rate of Rise	3 *m/y*	
Design Storm	1:50 *yr* : 121 *mm*	
Minimum Decant Period	72 *hours*	
Liner	No Liner	

Figure 9.3.7.5(a): Location and Extent of the OB Plant TSF and its associated RWD

All of HERNIC's tailings (underflow from the various process clarifiers – Furnaces, CRP and OB Plant) from the Alloys site are currently disposed onto the TSF.

The expansion to the TSF is required to accommodate disposal of fine tailings from the new PGM Plant. The proposed expansion of the TSF footprint towards the south is shown in Figure 9.3.7.5(b). The TSF is designed to hold a total of 7.8 *mega tonnes* of tailings at a deposition rate of 26 000 *tonnes per month* for 25.5 *years*. All of HERNIC's tailings (underflow from the various process clarifiers) from the Alloys site are disposed onto the TSF.

The TSF has two compartments. Compartment 1 will contain 1 *mega tonnes* of tailings when the PGM Plant starts operation in February 2017 and there is also 1.4 *mega tonnes* of tailings in the Morula Open Cast Pit. The 2.4 *mega tonnes* of historic tails will be hydraulically mined and processed through the PGM Plant along with current arising tails.

The PGM Plant will process 55 000 *tonnes per month* of tails that will be made up of around (depending on current arising production) 22 000 *tonnes per month* of current arising tails from the OB Plant and 33 000 *tonnes per month* of historic tails. HERNIC will therefore process the 1 *mega tonnes* of tails in Compartment 1 of the TSF within 3 *years* where after HERNIC will process the 1.4 *mega tonnes* of tails in the open pit for another 3.5 *years* along with the monthly 22 000 *tonnes per month* current arising tails.

The PGM Plant will produce 12 000 *tonnes per month* of Chromite, a few *kilograms* of PGM and around 42 000 *tonnes per month* of tails for the first 6.5 *years* and thereafter around 5 000 *tonnes per month* of Chromite and 17 000 *tonnes per month* of tails.

HERNIC will be depositing 42 000 *tonnes per month* of tails into Compartment 2 for the first 3 *years* (while HERNIC removes 33 000 *tonnes per month* from Compartment 1) – therefore the net deposition rate is around 9 000 *tonnes per month*. HERNIC will then deposit 42 000 *tonnes per month* of tails into Compartment 1 for the next 3.5 *years*; and thereafter 17 000 *tonnes per month* of tails into either compartments for the remainder of its lifetime (270 *months* or 22 *years*).

The challenge will be to cope with the rate of rise for the first 3 *years* (into Compartment 2), and the next 3.5 *years* (into Compartment 1) from a TSF stability perspective. The solution is to build a support wall with either waste rock or slag and to compact it so that it interlocks and carries the tails. There will also be a layer of bidim placed between the tails and the rocky wall to prevent any seepage of tails through the rock. Alternatively, OB Plant coarse waste will also be suitable material for the wall. The wall will take up approximately 800 000 *tonnes* of the total capacity of the TSF which has already been included in the calculations above (28.5 *year* lifetime = 3+3.5+22 *years*).

The TSF was commissioned in 2012 and is currently operated and managed in terms of the following authorisations:

- An EMPR titled "The Mineral and Petroleum Resources Development Act 28 of 2002 section 102 Environmental Management Plan Amendment" ("the TSF EMPR")." A section 102 Environmental Management Plan Amendment to include the TSF on various portions of the farm De Kroon 444 JQ was prepared by ENVASS Environmental Assurance (Pty) Ltd and submitted to the DMR during 2012. The TSF EMPR was approved on the 3rd of November 2015;
- An Environmental Authorisation ("EA") granted in terms of section 24 of the NEMA read with the Environmental Impact Assessment Regulations 2006 ("the EIA Regulations 2006") authorising the TSF.

Figure 9.3.7.5(b): Proposed Footprint Expansion of the HERNIC Tailings Storage Facility (TSF)

Feasibility and Design

Consulting Civil and Environmental Engineers, INPROCON, have been appointed to conduct a Detailed Feasibility Study and to compile a Preliminary Engineering Design Report for the expansion of the TSF. This report will be completed as part of the Plan of Study for the EIA Phase of the project.

9.3.7.6 Mixed Material Stockpiling and Screening

The Mixed Material Stockpile and Screening Area as well as the mobile screening plant, is shown in Figure 9.3.7.6(a). These facilities are continuously being reworked and therefore their footprints are not static. The footprints are unlined.

Mixed material originates from essentially two sources. The Coarse and fines waste product from the OB Plant (deemed inert), together with spillages of raw materials throughout the plant and process (pellets, concentrate and other raw materials) are all stockpiled in the Mixed Material Stockpile Area. A mobile screening plant, which is moved from stockpile to stockpile, screens and separates the different materials and factions for re-use and further beneficiation.

The pellets, ore concentrate and other raw materials are fed back into the furnaces, the fines material is stockpiled for future extraction of PGM Group minerals at the new PGM Plant.

The collective footprint designated for Mixed Material Stockpiles is approximately 15.43 *ha* and it is estimated that the six current stockpiles combined contain some 525 000 m^3 of material

The remaining coarse material is disposed of in the open pit as final backfill.

9.3.7.7 Returns Materials Stockpiles

The Plant Process Water Dam is prone to silting up with fine ore concentrate originating from the Concentrator Plant areas. Although a silt trap system has been installed upstream from the Process Water Dam, silt still does enter this facility. Silt build-up in the silt trap as well as in the three compartments of the Process Water Dam is removed from time to time and stockpiled on two Returns Materials Stockpiles. Material is either returned to the concentrator plants for re-blending into the ore feed to the pelletising plants, or sold to customers.

The location and extent of the two returns materials stockpiles is shown on Figure 9.3.7.7(a). Details pertaining to these two stockpiles are relayed in Tables 9.3.7.7(a) and 9.3.7.7(b). The footprints of these stockpiles are not lined.

The collective footprint occupied by the two Returns Material Stockpiles is approximately 4.23 *ha* and it is estimated that the two facilities combined contain some 28 000 m^3 of material

It should be noted however, that these stockpiles are continuously being re-worked and therefore only the centre coordinates of the designated areas on site for these stockpiles are given in the Tables 9.3.7.7(a) and 9.3.7.7(b).

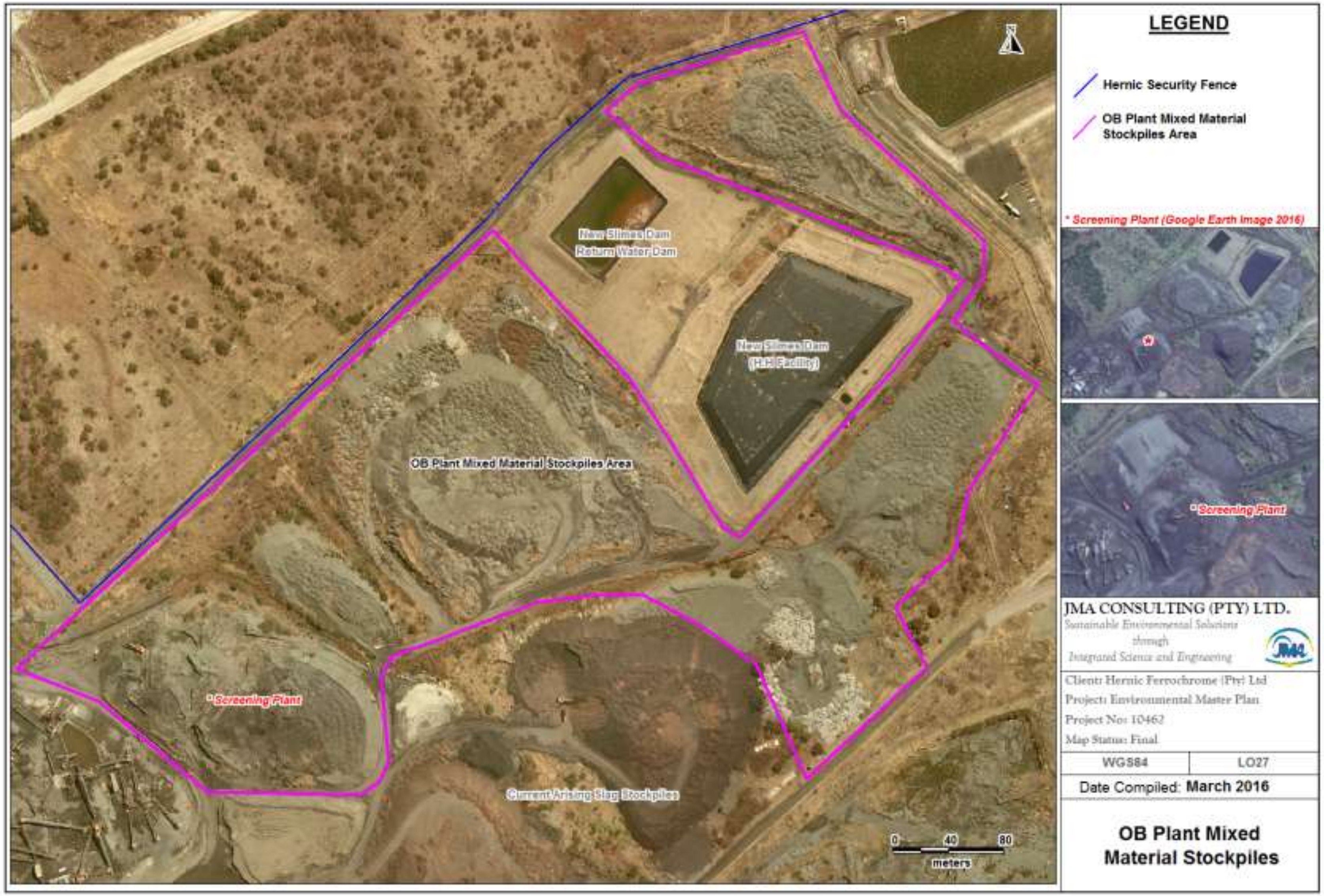


Figure 9.3.7.6(a): Location and Extent of Mixed Material Stockpiling and Screening Operation

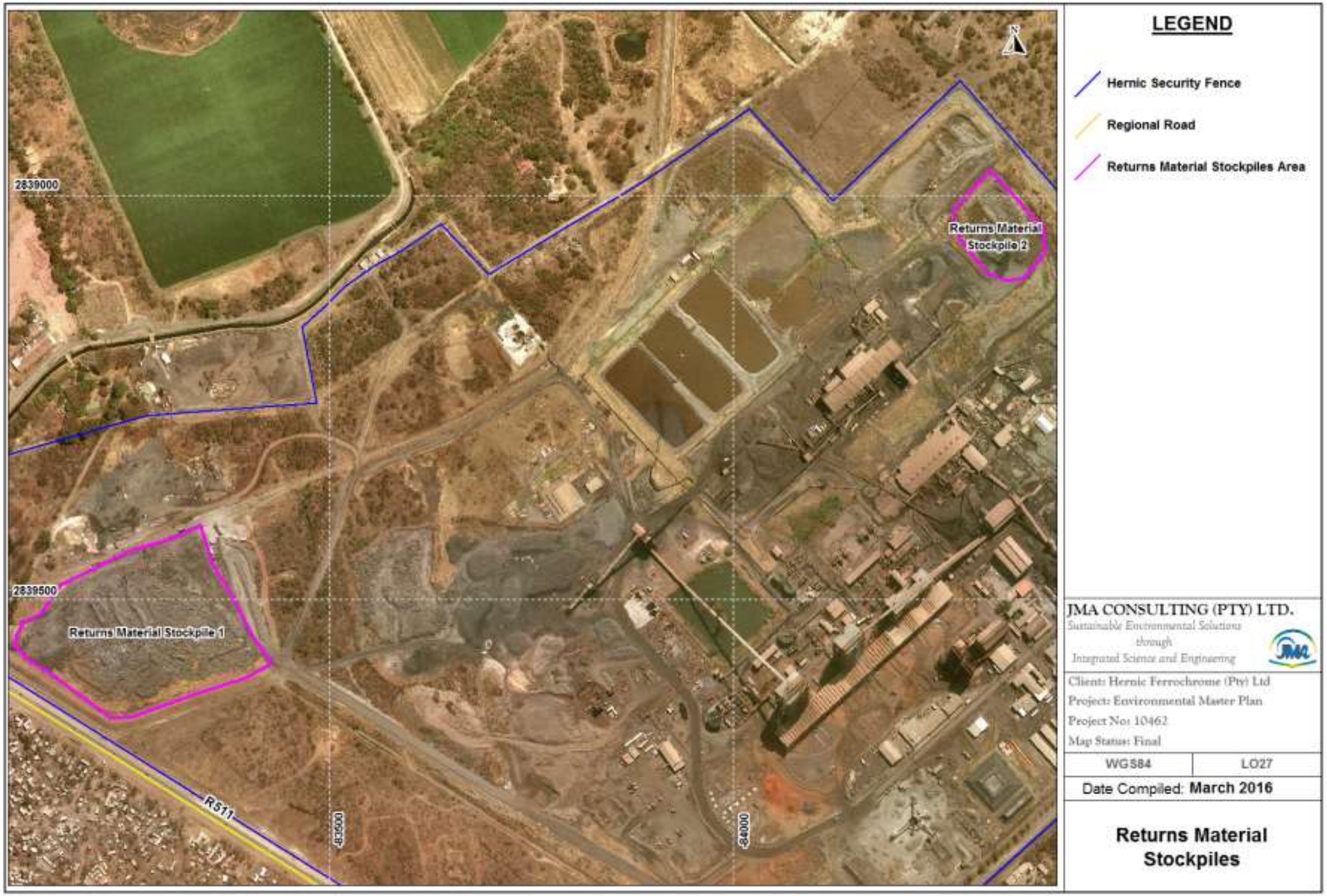


Figure 9.3.7.7(a): Location and Extent of the two Returns Materials Stockpiles

Table 9.3.7.7(a): Details of the Returns Material Stockpile 1

Returns Material Stockpile 1		
Central Coordinates	25° 39' 39.4" S 27° 49' 45.8" E	
Footprint Area	3.41 *ha*	
Current Capacity	16 602 m^3	
Vertical Wall Height	3 *m*	
Liner	No Liner	

Table 9.3.7.7(b): Details of the Returns Material Stockpile 2

Returns Material Stockpile 2		
Central Coordinates	25° 39' 23.7" S 27° 50' 23.4" E	
Footprint Area	0.82 *ha*	
Current Capacity	10 808 m^3	
Vertical Wall Height	4 *m*	
Liner	No Liner	

9.3.7.8 Salvage Yard

HERNIC operates a small Salvage Yard for domestic waste and waste produced in the operational activities of the ferrochrome smelter facility. An appointed waste contractor manages and removes waste at and from the Salvage yard. The locality and extent of the current Salvage Yard is shown on Figure 9.3.7.8(a).

The operating of a Salvage Yard requires compliance with the Waste Management Legislation as prescribed by the National Environmental Management Waste Act, 2008 (Act 59 of 2008) - NEMWA. More specifically the HERNIC Salvage Yard must be operated in terms of the National Norms & Standards for the Storage of Waste under the NEMWA.

In order to give compliance with said Norms and Standards, HERNIC appointed INPROCON to conduct an assessment to determine the requirements to upgrade the existing Salvage Yard at HERNIC to be fully compliant with the legal requirements.

The assessment concluded that the existing Salvage Yard had various constraints as far as upgrading was concerned, especially in terms of the available footprint size required to accommodate all the required infrastructure and its related storm water control measures, and HERNIC therefore requested INPROCON the expand their assessment to assess the requirements for the development of a new Salvage Yard facility.

The proposed site locality and extent is shown on Figure 9.3.7.8(b). The proposed New Salvage Yard layout is shown on Figure 9.3.7.8(c).

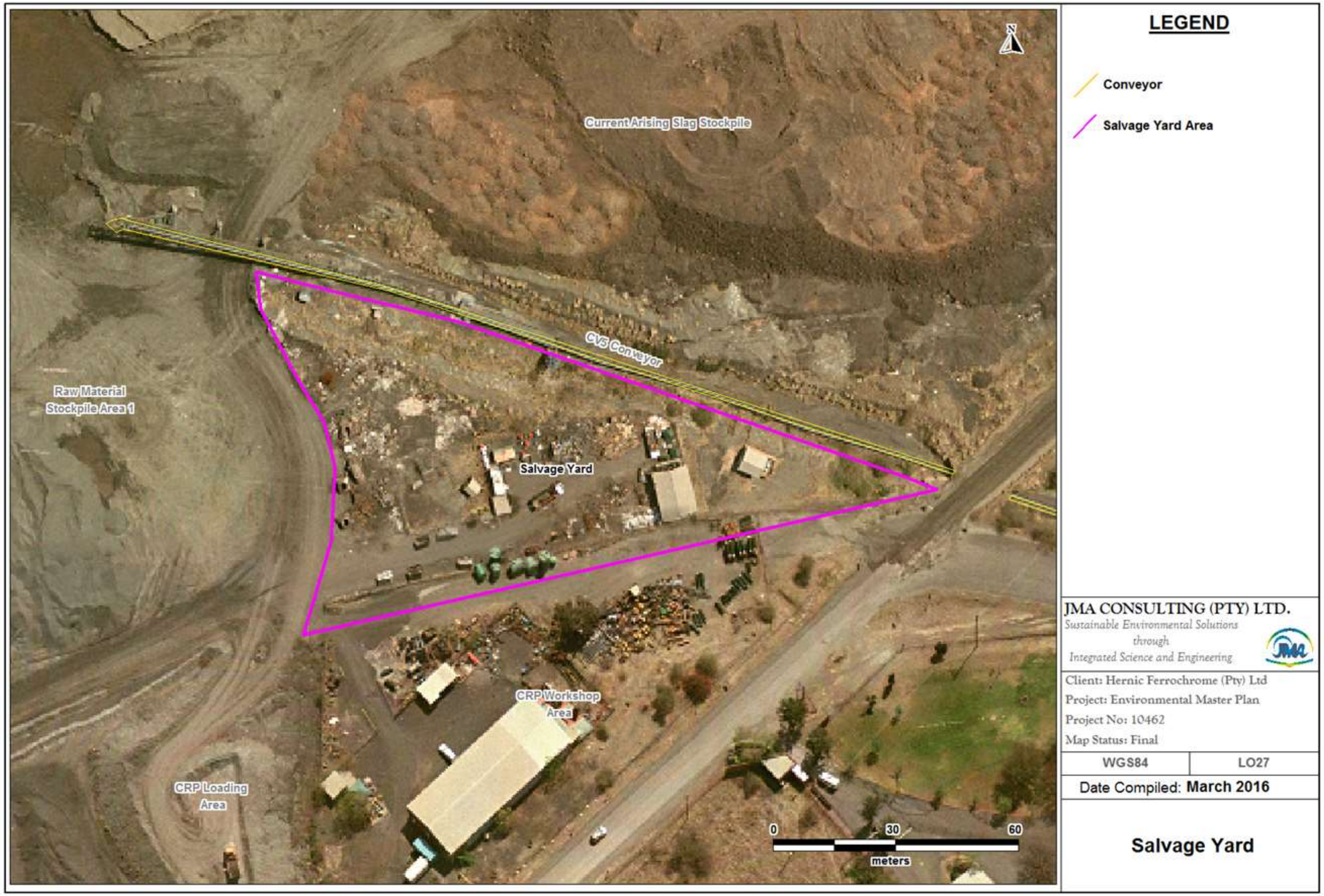


Figure 9.3.7.8(a): The Locality and Extent of the Existing Salvage Yard

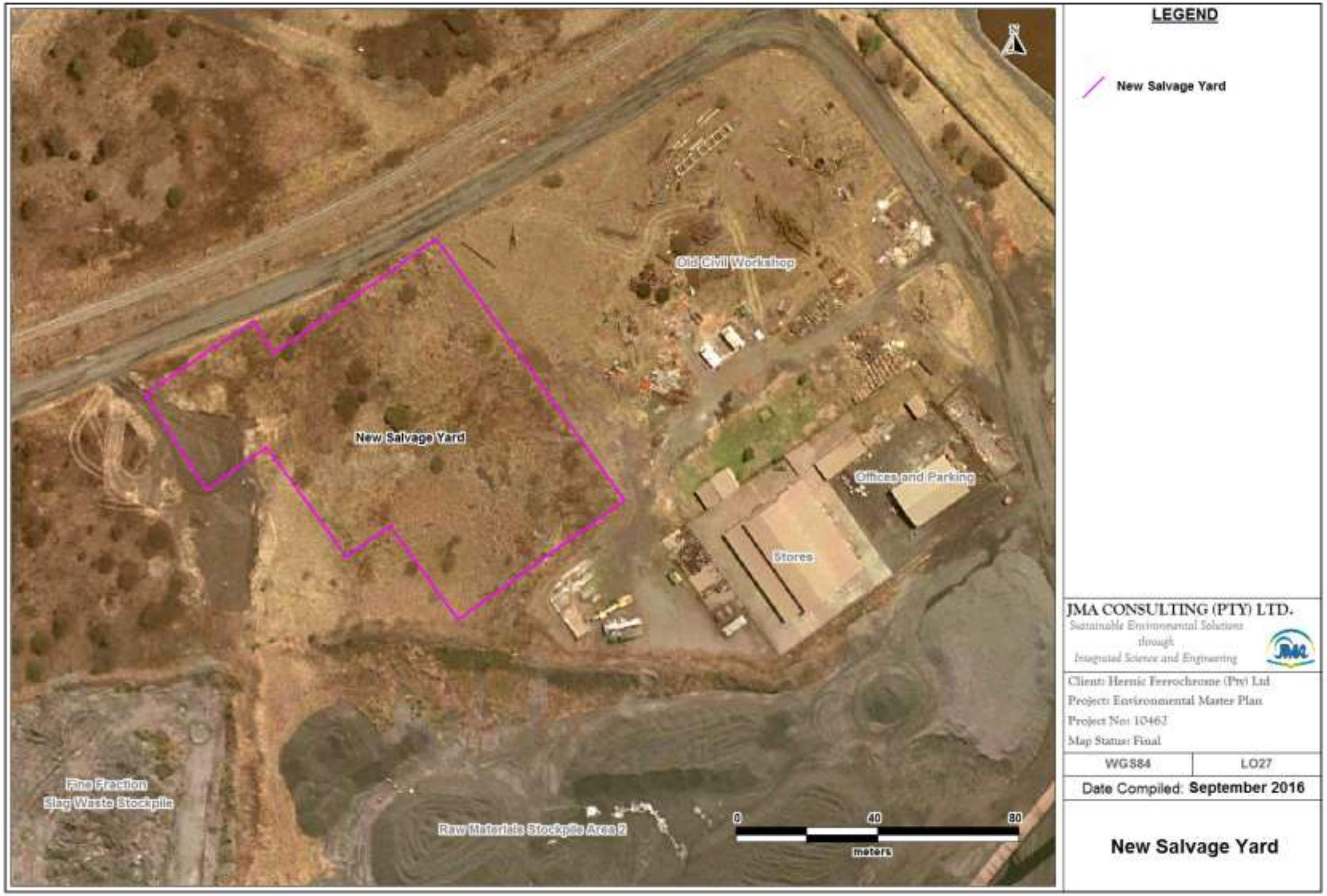


Figure 9.3.7.8(b): Proposed Locality and Extent of the New Salvage Yard

Figure 9.3.7.8(c): Conceptual Design Layout of the New Proposed Salvage Yard

The following surface infrastructure is associated with the current Salvage Yard:

- Engineered Platform for the Salvage Yard Footprint
- Wash Bay Slab
- Tip and Sort Slabs
- Oil Drum Storage
- Dirty Runoff Drainage System & Interception
- Office
- Mess
- Hazardous Bunded Slab

In order to accommodate the above, a site of at least 0.65 *ha* would be required. An assessment of site alternatives was conducted and the proposed preferred site for the new Salvage Yard is an area located next to the now redundant Old Civil Workshop area. This site is located out of sight, close to access roads, out of the way of existing activities and is located optimally from a surface water run-off management perspective.

Consulting Civil and Environmental Engineers, INPROCON, have been appointed to conduct a Detailed Feasibility Study and to compile a Preliminary Engineering Design Report for the construction of the New Salvage Yard. This report will be completed as part of the Plan of Study for the EIA Phase of the project

9.3.7.9 Sewage Plant

The locality and extent of the HERNIC Alloys Plant Sewage Plant is indicted on Figure 9.3.7.9(a). Centre coordinates for the facility is relayed in Table 9.3.7.9(a).

Table 9.3.7.9(a): Centre Coordinates of the Alloys Sewage Plant

Description	Latitude	Longitude
Alloys Sewage Plant	25°39'27.68"S	27°50'2.18"E

The Sewage Plant operates through the application of a Sequencing Batch Reactor (SBR) technology. The treatment process comprises raw effluent screening, flow balancing and distribution, aeration in a single SBR reactor, settling, decanting of the treated supernatant, dis-infection of the discharged supernatant, retention of the waste sludge in the aeration tank before discharge and dewatering of the activated sludge on sludge drying beds.

The SBR Sewage Treatment Plant is designed to treat an average of 140 m^3 of domestic sewage *per day*. The treatment plant is designed to produce and effluent in accordance with the requirements of the General Limits of the General Authorisations in terms of Section 39 of the National Water Act, 1998.

The Sludge Drying Beds are manufactured by PRENTEC and which consist of four beds (4 *m* x 4 *m* x 0.5 *m*). The internal bed specification is 90 *mm* thick 19 *mm* stone (bottom layer), 3 *mm* thick Kaymac matting (middle layer) and finally a 100 *mm* thick 1.3 *mm* sand layer (top layer). Dried sludge is removed from site and sent to Holfontein (Class H:H Landfill Facility) via Enviroserv on a bi-quarterly basis.

Figure 9.3.7.9(a): Location and Infrastructure related to the HERNIC Alloys Plant Sewage Plant

9.3.7.10 OB Plant Fines in Open Pit (Slurry)

During mining, concurrent backfilling of the open-pit sections on De Kroon 444 JQ, was done with both coarse overburden waste rock which was rolled over during mining as well as with inert fine tailings material from the OB Plant which was slurried into the open pit.

The locality and extent of the portions of the open pit backfilled with this fine material is shown on Figure 9.3.7.10(a).

The fine slurry material comprises *inter alia* of minerals referred to as Platinum Group Minerals. HERNIC has applied for, and has been granted an amendment to their mining right which now permits them to re-mine the fine slurry and to extract a series of economic minerals from the slurry.

The fine material will therefore be excavated from the open-pit for beneficiation in a new PGM Plant, after which the open pit will be finally backfilled with inert coarse mine waste rock, as well as with coarse mixed waste from the OB Plant.

9.3.7.11 OB Plant Mixed Waste in Open Pit (Trucks)

Areas available for final backfilling in the Morula open pit are currently also backfilled with coarse waste from the OB Plant.

The locality and extent of the portions of the open pit backfilled with this coarse material is also shown on Figure 9.3.7.10(a). The coarse material essentially represents mining waste and is deemed inert.

9.3.7.12 Fine Fraction Slag

The fine slag originating from the CRP is picked up from the fine slag stockpiles and transported via road to the Fine Slag Processing Plant for further recovery, resulting in a fine Ferrochrome Product and Fine Slag Sand, the latter which is also sold as a recovered product.

After separation, the fine ferrochrome fraction is loaded from a recovery bin whilst the fine sand is stockpiled on a series of fine sand stockpiles at the Fine Slag Processing Plant.

The corner coordinates of the Fine Fraction Slag are indicated in Table 9.3.7.12(a) below.

Table 9.3.7.12(a): Corner Coordinates of the Fine Fraction Slag

Corner Point	Latitude (dms)	Longitude (dms)
1	25° 39' 41.2" S	27° 50' 03.3" E
2	25° 39' 43.7" S	27° 50' 06.6" E
3	25° 39' 44.2" S	27° 50' 06.1" E
4	25° 39' 44.5" S	27° 50' 06.3" E
5	25° 39' 47.4" S	27° 50' 04.7" E
6	25° 39' 42.9" S	27° 49' 56.3" E
7	25° 39' 41.3" S	27° 49' 57.2" E
8	25° 39' 41.5" S	27° 50' 02.6" E

The layout and extent of the Fine Fraction Slag Stockpile are portrayed in Figure 9.3.7.12(a). There are currently no designs available for the Fine Fraction Slag Stockpile/Dump.

Figure 9.3.7.10(a): Location and Extent of Deposition of OB Plant Fines in the Morula Open Pit

Figure 9.3.7.12(a): Layout and Extent of the Fine Fraction Slag Stockpile

9.3.8 Alloys Smelting Plant Water Use and Management

All aspects related to water use will be regulated through the integrated Water Use Licence (WUL) for the site. The discussion to follow will therefore deal with all the water uses and aspects related to the management of water on site.

9.3.8.1 Hartbeespoort Canal Pump Station

The site is supplied with raw water for process and potable purposes from the Hartbeespoort Irrigation Canal via a canal from the Hartbeespoort Dam. A copy of the original contract with and confirmation of the water allocation from the Hartbeespoort Government Water Scheme, dated 05 January 1995 is attached as APPENDIX IV and states that HERNIC may "*abstract a maximum of **876 000 m³** of unpurified water from the canal for industrial and household purposes for use on Portion 47 of the farm De Kroon 444 JQ in the district of Brits*".

This water use has however since been authorised in the Water Use Licence issued 18 December 2015 (03/A21J/ABGJ/4196), attached as APPENDIX V which states that *"Hernic may take a maximum of **870 000 m³** of water per annum from the Hartbeespoort Irrigation Canal for domestic, mining and industrial purposes at the mine".*

The canal runs along the northern perimeter of the site and a raw water pump station is located along the canal. The centre coordinates of this pump station is relayed in the Table below. The locality of the pump station is shown in Figure 9.3.8.1(a).

Table 9.3.8.1(a): Centre Coordinates of the Hartbeespoort Dam Canal Pump Station

Description	Latitude	Longitude
Hartbeespoort Dam Canal Pump Station	25° 39' 24.7" S	27° 49' 55.4" E

9.3.8.2 Plant Drinking Water Dam

The water pumped from the Hartbeespoort Dam Canal is stored in the Plant Drinking Water Dam on site.

The location and the extent of the Plant Drinking Water Dam is shown on Figure 9.3.8.2(a). The dam covers a footprint area of approximately 9 120.95 m^2 and has an estimated storage capacity of 30 000 m^3.

Table 9.3.8.2(a): Details of the Plant Drinking Water Dam

Plant Drinking Water Dam		
Central Coordinates	25° 39' 38.4" S 27° 50' 11.4" E	
Footprint Area	10 042 m^2	
Crest Length	392 m	
Max Wall Height	-	
Freeboard	-	
Dam Storage Capacity	30 000 m^3	
Wall Type	Earth Fill	
Liner Type	No Liner	

Figure 9.3.8.1(a): The location of and infrastructure associated with the Hartbeespoort Dam Canal Pump Station

Figure 9.3.8.2(a): The location and the extent of the Plant Drinking Water Dam

9.3.8.3 Plant Drinking Water Treatment Plant

The water sourced from the Hartbeespoort Dam canal is treated at an on-site water treatment plant (Mintek Water Treatment Plant) to produce potable water. The potable water is distributed from the treatment plant to the various points for domestic use.

The location of and the infrastructure associated with the Plant Drinking Water Treatment Plant is shown on Figure 9.3.8.3(a) and the centre coordinates of the facility is given in Table 9.3.8.3(a) below.

The treatment process comprises a series of sand filters followed by chlorination. More specifically, the raw water passes through the filter bed in a down flow direction and gradually distributes the turbidity throughout the filtering mass. The first layer of filter media holds large suspended particles, while the finer and progressively more compact underlying strata hold smaller particles. The chemical dosing systems are made up of one flocculent, one polyelectrolyte as well as a chlorine dosing pump. Water is dosed with flocculent and hypochlorite. The plant has a capacity to treat 75 m^3 per hour.

Table 9.3.8.3(a): Centre Coordinates of the Plant Drinking Water Treatment Plant

Description	Latitude	Longitude
Plant Drinking Water Treatment Plant	25° 39' 36.4" S	27° 50' 10.6" E

9.3.8.4 Plant Process Water Dam

The Plant Process Water Dam comprises of a series of upstream silt traps and three storage cells, i.e. Phase 1, Phase 2 and Phase 3. The three phases actually also serve as silt settlement dams. The location and extent of the Plant Process Water Dam and Silt Traps is shown on Figure 9.3.8.4(a). A summary of the details pertaining to this dam is relayed in the Table below. The dam covers a footprint area of 3.06 *ha* and has a total storage capacity of 76 000 m^3, and has a composite liner.

The silt comprises primarily fine ore concentrate and originates from the general areas of the concentrator, pelletising and furnace proportioning plants. The spillages at these plants are washed with water into the process water dam circuit. The silt therefore actually represents fine ore and is recycled back into the process once it is removed from the silt traps and the process water dam.

Table 9.3.8.4(a): Details of the Plant Process Water Dam

Plant Process Water Dam		
Central Coordinates	25° 39' 28.5" S 27° 50' 10.2" E	
Footprint Area	31 146 m^2	
Crest Length	713 *m*	
Max Wall Height	-	
Freeboard	0.95 *m*	
Dam Storage Capacity	76 000 m^3	
Wall Type	Earth Fill	
Liner Type	Composite Liner	

Figure 9.3.8.3(a): The location of and infrastructure associated with the Plant Drinking Water Treatment Plant

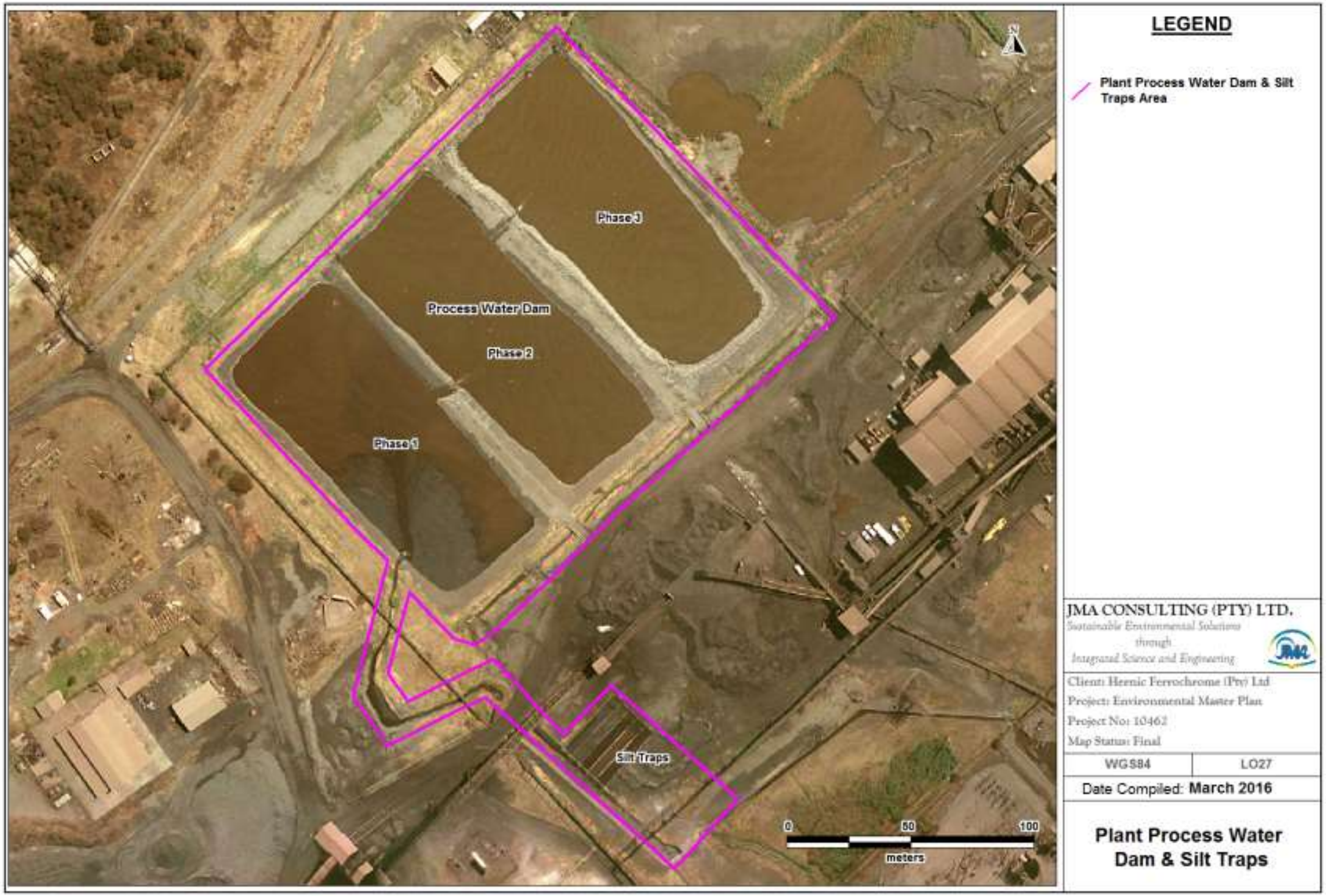


Figure 9.3.8.4(a): The location of and infrastructure associated with the Plant Process Water Dam and Silt Traps

9.3.8.5 Storm Water Management Berms and Canals

A series of storm water management berms and canals are present within the HERNIC Alloys Plant area. These features are intended to separate clean and dirty storm water and to ensure that all dirty storm water is conveyed towards the Plant Storm Water Pollution Control Dam (PCD).

The current storm water management canal system, as well as the general surface flow directions for storm water run-off for the HERNIC plant areas is shown on Figure 9.3.8.5(a). This system is in need of upgrade. The upgraded HERNIC Storm Water Management Plan/System is currently being designed and will form part of the proposed new activities to be authorised as part of the current process.

INPROCON Environmental and Civil Engineers conducted a preliminary assessment to determine the requirements and overall design objectives for activities that would be required to fully upgrade (development and expansion) the HERNIC Process Water and Storm Water Management System.

The HERNIC Plant operations can in general terms be classified as a dirty site area that poses a risk to surface water, soil and ground water pollution. The affected plant facility area and mining area have been inspected to assess the surface water management infrastructure and general management at the site. With the Regulations pertaining to the Management of Water at Mines (Regulation GN704) as primary requirement, the short comings have been identified and conceptual betterment measures have been developed.

The study includes the evaluation of the runoff management situation at the site and ultimately has to comply with regulations promulgated under the Water Act. Furthermore it should be noted that certain parts of the HERNIC Process Water Management System is integrated with the HERNIC Storm Water Management System, and vice versa. The two systems will therefore be assessed together.

The objective of this assignment was to identify all risk areas pertaining to current Storm Runoff and Process Water Management Measures and to develop a concept management plan addressing the present short comings. The following principles were applied:

- Keep clean water clean;
- Collect & contain dirty water;
- Sustainability over mine life cycle; and
- Consideration of regulations and stakeholders.

This was done by following a catchment-based approach as input to the HERNIC SWMP (Storm Water Management Plan) culminating in identification of current and potential future water management issues on a sub-catchment basis. This is followed by devising proactive measures and solutions complying with relevant regulations and procedures.

The assessment and improvements to the SWMP include the following considerations:

- Assessment of the layout of existing mining sites and surface water management infrastructure;
- Site assessments and verifications;
- Delineation of clean and dirty water management areas (including process water);
- Determination of all relevant catchment and sub-catchment boundaries;
- Perform a surface runoff water balance for all impoundments;

- Hydrological assessment of flood peaks and capacity requirements;
- Hydraulic assessment / confirmation of sizing requirements;
- Perform a gap analyses on non-compliances; and
- Develop pre-feasibility Storm Water Management Layout Plan.

The pre-feasibility Storm Water Management Layout Plan will include all primary Storm Water Management Measures.

Sub-Catchment Delineation

The main sub-catchment areas at HERNIC are delineated on Figure 9.3.8.5(b). These sub-catchments are indicated by the red polylines. The site boundary is a magenta polyline with the site area hatched in solid shades indicating the site areas within each main sub-catchment. The HERNIC site is also sub-divided into 4 areas, each of which falls within the main sub-catchments and which are labelled as Hernic 1, Hernic 2, Hernic 3 and Hernic 4.

Hernic 1 is the smelter site that includes the Offices, Raw Materials Yards, Waste Stockpiles, CRP Plant, Old Slimes Dams, Process Water Dams and Storm Water Dams as well as a portion of the Opencast Mine. Hernic 2 is the remaining portion of the Opencast Mine and the property that houses the Underground Mining Facility.

Hernic 3 is the most eastern site area with the TSF and H:H Slimes Dam. Hernic 4 is regarded a clean area that is the western property. Hernic 1 to 3 accommodates all operational infrastructure with areas that are classified as moderate dirty and dirty.

The main drainage directions are indicated with the arrows on Figure 9.3.8.5(b).

Existing Storm/Process Water Drainage System

The HERNIC site has a few Storm and Process Water Drains as indicated on Figure 9.3.8.5(a). Drains HH and AE are the only drains that can be regarded as proper concrete drains. The internal drains (indicated light green) are a combination of storm water drains and process water drains from the Furnaces and Pelletising areas that link up to discharge into the process water dams.

All existing drains have been designed to deal with normal rain events with a typical design recurrence period of 2 years. Hence the drains are relative small and shallow. Most of the drains observed are blocked or obstructed with sediments or process/waste material. The process water and storm water are not clearly separated and regarded as an integrated system.

This is acceptable as long as the storage capacities of impoundments and conveyance drains are designed to be compliant in terms of capacity and sufficient barrier systems. The development of the Storm Water Management Master Plan will also accept this as a site specific property and measure.

Clean runoff diversion at the TSF (drain KK) and at the mine surface infrastructure (drain LL) are with earth canals of suitable size and layout. Some additions at the mine surface are necessary to contain all dirty runoff from temporary stockpile and crasher area.

An aspect that requires provisional measures is sediment control as sources of sediment are situated close to the Storm Water PCD's and OB Plant Process Water Dam. The main Storm Water PCD as well as the OB Pant Process Water Dam are silted up and currently act as silt traps as well.

Figure 9.3.8.5(a): Current Storm Water Canals at HERNIC (Alloys Plant and Morula Mining)

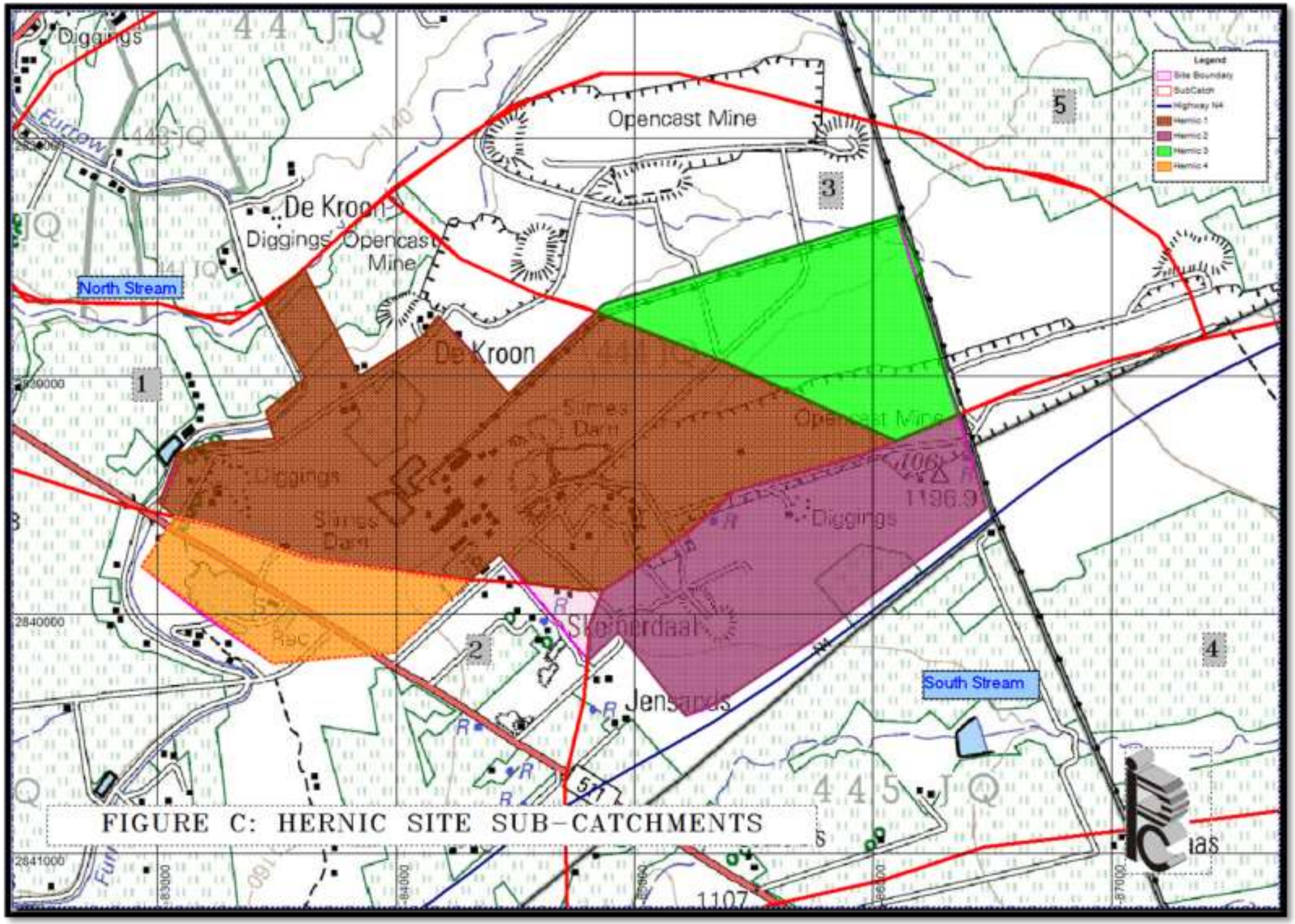


Figure 9.3.8.5(b): HERNIC Sub-Catchment Delineation

The dirty storm water system currently also covers the central furnace area whilst the south-western area where the Tugela plant is situated falls beyond the catchment area of the storm water dams.

The CRP plant site located to the south of the main entrance road has no formal storm water management system. The Plant process water recovering drains are vulnerable to storm runoff and regular spilling from the site is evident.

HERNIC Existing Clean & Dirty Areas

When homing in to the site in distinguishing clean, moderately dirty and dirty areas the following areas that also relates to the main drainage sub-catchments have been delineated. Refer to Figure 9.3.8.5(c). These are tabulated below.

Table 9.3.8.5(a): HERNIC Demarcated Clean and Dirty Water Areas

Area	Description	Size (Ha)	Classification
A1	CRP Plant and Slag Stockpile	12.3	Dirty
A2	Final Product & Old Slimes Dams	6.0	Dirty
A3	Tugela Plant & Site Area	12.7	Dirty
A4	Furnaces, Pelletising, OB Plant & Raw Materials	15.72	Dirty
A5	Mixed Materials Stockpiles, Slag Stockpiles, etc.	19.7	Moderate Dirty
A6	HH Slimes Dam Site	13.88	Moderate Dirty
A7	U/G Mine Surface Infrastructure Site	18.7	Moderate Dirty
A8 & A9	Uphill of CRP	17.66	Clean
A10	Open Cast Mine	52.9	Dirty
A11	TSF Area	53.9	Moderate Dirty
A12	Storm Water PCD's & Process Water Dams Area	9.45	Dirty
Total		**232.91**	

The dirty classified areas have impacted water qualities and with an extremely high sediment (& silts) loads. The moderate dirty areas include old dump sites with a lesser degree of sediment. Besides all other clean areas, A8 & A9 are clean up-gradient areas that require additional measures to divert it past the affected down-gradient CRP Plant area.

Non-Compliance Issues of Existing Site Storm Water Drainage

The following issues were observed regarding the Storm Water Management System and are regarded as non-compliance with regards to the requirements of Regulation GN 704 that resorts under the Water Act.

CRP Plant Area (A1)

The CRP plant area that accommodates all crushing, screening, spirals, slimes dam and tailing slag stockpile yard has no storm water management measures in place. Runoff discharges in a north and west direction off the site uncontrolled.

Figure 9.3.8.5(c): HERNIC Clean and Dirty Water Areas

Final Product & Old Slimes Dams (A2)

This area has been isolated with berms on the south and west boundary. A new truck wash bay is also in this catchment. Runoff drains mainly north towards the smelter cool down area and towards the west discharging from the property. Ponding at the cool down area occurs that could impact on the ground water. Runoff interception and directing to a containment impoundment is lacking.

Tugela Plant & Site Area (A3)

The Tugela Plant site that stockpiles various sand piles and the raw materials for the pelletising plant is not isolated with interception and runoff management infrastructure. Runoff discharges in a west to northerly direction off the property and can't be directed to the existing SW Dams due to the natural fall of the topography towards the northwest. Sediment loads and affected runoff is expected from this area.

Furnaces, Pelletising, OB Plant & Raw Materials (A4)

This area forms the central area that houses the furnaces, pelletising plants, OB Plant, DMS Plant and raw materials stockpiles. The existing salvage yard without any interception and containment measures is situated towards the southeast corner. Most of the site is unpaved. Runoff is directed with formal and informal drains towards the Process Water Dams, OB Plant Process Water Dam and the Storm Water PCD's. The silting up of dams are evident and a threat to capacity requirements. Spilling is unavoidable due to available storage capacity that is impeded by sediment loads in the runoff that settles in the impoundments.

The main storm water earth drain that runs from southwest to northeast next to dams (Figure 9.3.8.5(a): (DD to BB to EE) is obstructed with sediments.

Mixed Materials and Current arisings Slag Stockpiles (A5)

This area contains mixed materials and the current arisings slag stockpiles as well as the PGM Plant. Runoff and seepage leach water from the stockpiles and discharges north without any management measures. The site is regarded as moderate dirty due to sediment laden runoff and leach water that contains contaminants.

H:H Slimes Dam Site (A6)

The H:H Slimes Dam has been temporary closed with a HDPE geomembrane. This area is also classified as moderate dirty due to Mixed Materials Stockpiles to the south and north of the site. This site is a closed system when in operation with the Slimes Dam and RWD liner compliant with regulations. Clearing of the rather small stockpiles would declare the surrounding areas as clean.

U/G Mine Surface Infrastructure Site (A7)

The U/G mine facility with workshops, stores, offices and mine related gear is also classified as moderate dirty. Some ROM stockpiles to be transferred to the smelter raw materials yard area also located in this sub-catchment. A mine dewatering dam is also located in the site. Runoff from the yards and stockpiles will be silt loaded with a possibility of the presence of bio-carbons. However, no downstream catchment/ return water dam serves as precaution to intercept affected runoff from this area.

Up-gradient of CRP (A8 & A9)

Up-gradient of the CRP Plant site where the main admin offices also resides is regarded clean area and currently clean runoff is not adequately directed past the CRP Plant area. Diversion of clean runoff is required.

Open Cast Mine (A10)

Open cast mining has seised. Some slimes previously dumped in the open cast is going to be re-processed at the PGM Plant. An open void is situated to the northeast axis of the mine. Any runoff from this site is sediment and silt loaded. Rehabilitation will not commence soon. Runoff should be managed and contained within the open cast area.

TSF Area (A11)

The TSF site mainly exists of the Slimes Dam with Return Water Dam. Runoff from the surrounding area of this site is moderately affected by few smaller Mixed Materials Stockpiles. This site with marginal effort may be regarded as clean. This is true if the TSF is properly managed and zero spillages from the decant system manholes can be guaranteed.

Storm Water Pollution Control Dams & Process Water Dams Area (A12)

The water qualities for the Process Water Dams and Storm Water PCD's are virtually the same and it is suggested that this must be managed as one impoundment management area. Only the Process Water Dams consisting of three in series cells are recently HDPE lined. The first receiving cell is already filled with sediments from the process water circuit.

The Storm Water PCD's are also silted up and requires constant clearing. The same applies for the OB Plant Process Water Dam that is overloaded with sediments. Spilling occurred at the time of the inspection.

All dams in this area are excessively exposed to sediments and silts. The existing sediment/silt traps in the process water circuit close to the process water dams are not adequate to manage the high loads of sediment.

The management of sediments requires a comprehensive solution to be compliant. All canals leading to these impoundments should be concrete lined.

Proposed Storm Water Drainage Master Plan

Demarcated Drainage Management Areas

The sub-drainage areas delineated in Figure 9.3.8.5(c) also forms the master drainage areas taken up in the master drainage plan. Figure 9.3.8.5(d) indicates the drainage master plan with primary storm water canals and storm water impoundments. The primary storm water drainage system allows for the classification in terms of clean or dirty runoff and primary storm water measures are proposed to manage these areas accordingly.

These drainage areas will be isolated by a combination of natural surface gradients, man-made berms, main storm water surface drains and existing or new impoundments. The filling of depressions caused by unintentional excavation during scooping up of materials (e.g. at the raw materials yard, OB plant, slag cooling bays, etc.) will also be necessary.

Primary Drainage System Elements

A1: The CRP Plant will require an interception drain (SWD7) and an upslope diversion berm. The site is limited in area and a containment Storm Water PCD (SW-PCD2) to contain runoff from this site is located in the A3 area. The water would be reticulated from SWD7, via SWD14, SWD5b, SWD3b and SWD3a into Storm Water PCD2. A sediment trap should be located immediately down gradient from the CRP area to prevent down-gradient drains to block and spill. The proposed site for this silt trap is in area A2 on the rehabilitated footprint of the two Old Slimes Dams, linking SWD7 and SWD14.

A2: This site drainage requires that runoff emanating from this area be intercepted and directed down to Storm Water PCD2, via drains SWD14, SWD5b, SWD3b and SWD3a. This includes run-off from the rehabilitated Slimes Dams, the Final Product Area, as well as the new Wash Bay.

A3: Runoff from this site is isolated with a natural divide along the east of the Tugela Plant and a new drain SWD3a and SWD3b. Runoff is intercepted by providing a new Storm Water PCD2. SWD4 is the north drain that cuts off runoff discharging to the north of this site and directs to Storm Water PCD2.

A4: The existing drains SWD1 and SWD2 require upgrading and the incorporation of a series of accessible silt traps before discharging into the relevant Process Water and Storm Water Dams. Runoff from this site will discharge into the Process Water Dams, Storm Water PCD1A and 1B and the OB Plant Storm Water Dam. Sediment management of the up-gradient and adjacent yard areas must be pursued. This includes that stockpile yards be levelled and concrete paved and regular area clean-ups must be instituted.

A5: This area will accommodate the new PGM Plant. The site is also covered with Mixed Materials Stockpiles as well as the two Current arisings Slag Stockpiles. The north boundary is also a natural low point where a new Storm Water PCD3 will intercept runoff from this area. This drainage area must be isolated with a west earth berm preventing more surface runoff from the raw material yard to drain towards the Storm Water PCD3 area. Runoff from this area can only be directed to the existing Storm Water PCD's with deep and wide drains at the downstream side. This is avoided due to cost an available space required by providing Storm Water PCD3.

A6: The H:H Slimes Dam has been temporary closed. The decision to finally close or to keep the facility mothballed will determine the future actions. Clearing of the rather small Mixed Materials Stockpiles is necessary to declare the surrounding areas as clean. Space for an extension of the slimes dam is available. The RWD will remain in place either for future operation or monitoring of the leachate from the underdrainage system. When permanently closed and rehabilitated and no leachate emanating from the drains the RWD can also be rehabilitated.

A7: Runoff from the Crusher Yard, the ROM Stockpile and the Mine Waste Rock stockpile should be intercepted. The existing mine dewatering dam should be decommissioned and replaced by a new Morula Storm Water PCD, that can also accommodate the de-watering component from the underground operations. The water abstracted from the mine must be treated for Cr^{6+} prior to being discharged into the new Morula Storm Water PCD. Isolation and diversion berms should be constructed to limit the size of the site and maximize clean runoff. The Morula Storm Water PCD should provide capacity over and above the storm water run-off requirements for an additional storage of 15 extra days of reserve capacity for the underground extraction at a discharge flow at 600 m^3/day – 9 000 m^3.

A8 & A9: Earth drains must direct clean runoff towards the north and south of the CRP area. The existing main road can serve to direct clean runoff paste the A1 and A4 dirty areas. A road side drain will serve the purpose.

A10: The open cast mine requires temporary drains and grading to direct surface runoff towards the open void. Water from the void must be extracted for use in the Smelter Facility. Rehabilitation of the surface should be done once the slimes placed at the open cast has been re-mined and processed at the PGM Plant.

A11: The TSF in terms of runoff management is a closed system and if operated accordingly and the surrounding area cleared from stockpiles, no particular additional Storm Water measures are required.

A12: The Process Water Dams, Storm Water PCD's 1A & 1B and the OB Plant Process Water Dam should be upgraded and lined with a Class C liner system. The existing Emergency Dam should be converted to Storm Water PCD1B that links up with Storm Water PCD1A. The Process Water Dams and the OB Plant Process Water Dam should be able to discharge in case of excessive storms to the Storm Water PCD's via emergency spillways. As part of sediment management the first cell of the Process Water Dams and intake of the Storm Water PCD1A should be lined with concreted multi-cells to trap sediments and allow access for dredging equipment and TLBs to clear sediments without damaging the liners. A large sediment trap must be provided at the OB Plant Process Water Dam inlet.

A13: New Proposed salvage Yard: A new salvage yard will make it possible to intercept dirty runoff and wash water for re-use without the risk of spilling. The existing yard has not enough space to install proper drainage and intercept impoundment. This area also includes the Civils Yard that is regarded clean area.

Peak Flows

Utilising the Rational Method for small catchments and obtaining catchment parameters from the inspection and survey the following peak flows have been calculated for the sizing of the primary storm water canals anticipated for the master SW Plan.

Table 9.3.8.5(b): HERNIC Storm Water Peak Flows

Project: HERNIC SW System					
HydroCube HQ3.005			Ser: 3504610481		
Total Area; 146.89 ha			Strom Shape: Triangular		
MAP: 649 mm			Recurrence Interval: 50 years		
Sub-Catchment	Area (ha)	Peak-Outlet (m^3/sec)	% Imp (Present)	% Imp (Future)	Storm Duration (min)
A1	9.56	2.84	10	10	20
A2	7.90	2.62	35	10	25
A3	11.57	4.77	2	10	25
A4	42.20	15.72	35	10	25
A5	30.39	11.79	15	10	25
A6	21.17	7.89	6	10	25
A7	18.70	7.25	10	10	25
A8	5.40	2.05	2	10	25
A9	10.54	3.97	2	10	25

Drain Sizing

The sizes of the drains envisaged are indicated in Figure 9.3.8.5(d). Trapezoidal forms are used for the primary drains with the exception of a rectangular drain to join with an existing drain or where space doesn't permit a trapezoidal drain.

Runoff Interception Water Balances & Storm Water Containment Capacity Requirements

Preliminary runoff water balances have been compiled based on monthly runoff for each of the dirty sub-catchments. The sizing of the storm water impoundments was based on sustainable extraction rates for re-cycling to the process water circuit. On top of the average maximum operational capacity required, an additional 1 in 50 *year*, 24 hour, flood volume was added.

Five Storm Water impoundments or temporary intercept measures are required enabling interception of all affected runoff from the identified dirty areas. These impoundments with the catchment areas that they service are listed below.

Table 9.3.8.5(c): HERNIC Impoundment Catchment Areas

Impoundment Ref.	Sub-Catchment	Sub-Catchment Area (ha)
Storm Water PCD1A & 1B	A4	42.2
Storm Water PCD2	A1, A2 & A3	31.0
Storm Water PCD3	A5	18.2
Morula PCD	A7	5.7
Open Cast Void	A10	51.8

The following feasible extraction rates for the Storm Water PCD's have been adopted. These rates correlate with the current water balance for HERNIC.

Table 9.3.8.5(d): HERNIC Impoundment Extraction Rates

Impoundment Ref.	Extraction Rates m^3/month	Extraction Duration (months)
Storm Water PCD1A & 1B	6000	8
Storm Water PCD2	3000	9
Storm Water PCD3	2700	9
Morula PCD	18500	12
Open Cast Void	5500	9

The flood volumes (1 in 50 *year* occurrence 24 hour duration) to be allowed for interception by the impoundments are as follows:

Table 9.3.8.5(e): HERNIC Impoundment 1:50 year Flood Volumes

Impoundment Ref.	Volume (m^3)
Storm Water PCD1A & 1B	45 833
Storm Water PCD2	36 450
Storm Water PCD3	18 009
Morula PCD	7 733
Open Cast Void	-

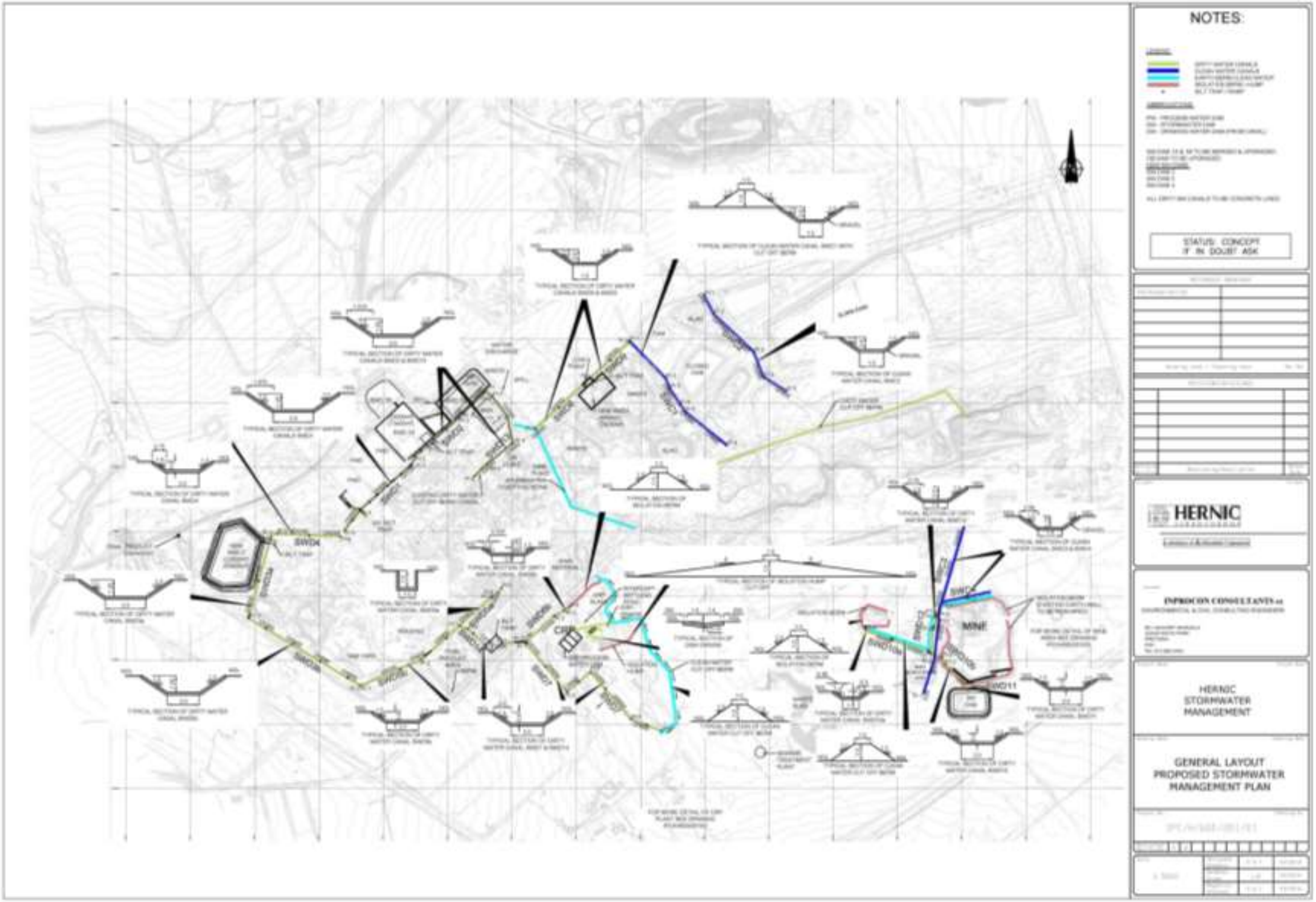


Figure 9.3.8.5(d): Conceptual Layout of Infrastructure required for a Storm/Process Water Management Plan Upgrade

The impoundment sizing derived from balancing monthly runoff, evaporation rates, extraction rates and flood volumes (freeboard of 0.8 *m* included) are as follows:

Table 9.3.8.5(f): HERNIC Impoundment Required Storage Capacities

Impoundment Ref.	Capacity Volume (m^3)	Average Area (m^2)
Storm Water PCD1A & 1B	73 400	23 000
Storm Water PCD2	65 600	22 000
Storm Water PCD3	23 020	6 000
Morula PCD	25 000	6 000
Open Cast Void	64 000	4 000

Barrier Class

The storm water quality analyses indicate all Storm Water PCD's need to be lined with a Class C liner system.

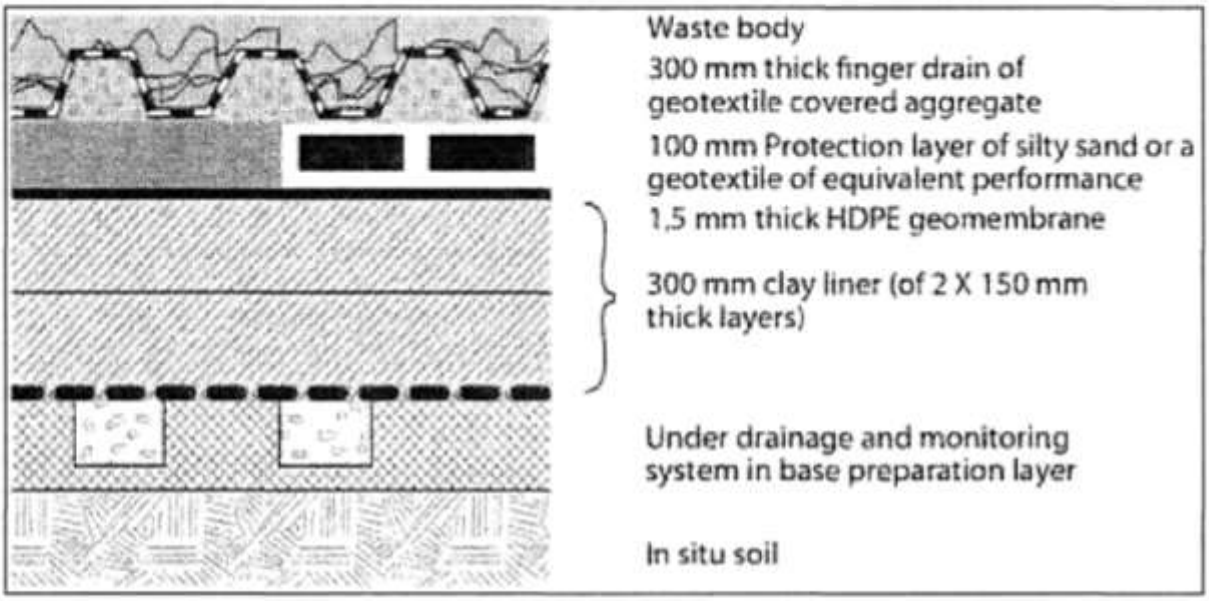


Figure 9.3.8.5(e): Schematic Profile of a Class C Liner System

Feasibility and Design

Consulting Civil and Environmental Engineers, INPROCON, have been appointed to conduct a Detailed Feasibility Study and to compile a Preliminary Engineering Design Report for the upgrading of the Site Process and Storm Water Management Plan. This report will be completed as part of the Plan of Study for the EIA Phase of the project.

9.3.8.6 Plant Storm Water Pollution Control Dam (PCD)

The purpose of the Plant Storm Water Pollution Control Dam is to capture and store all dirty surface storm water run-off from the Alloys Plant area.

The location and extent of the Plant Pollution Control Dam is shown on Figure 9.3.8.6(a). A summary of the details pertaining to the Plant Pollution Control Dam is relayed in the Table below.

The dam covers a footprint area of 1.71 *ha* and has a total storage capacity of 38 000 m^3. The PCD does not have a liner system.

Table 9.3.8.6(a): Details of the Plant Storm Water Pollution Control Dam

Plant Storm Water Pollution Control Dam		
Central Coordinates	25°39'24.95"S 27°50'14.25"E	
Footprint Area	23 605 m^2	
Crest Length	667 *m*	
Max Wall Height	-	
Freeboard	-	
Dam Storage Capacity	38 000 m^3	
Wall Type	Earth Fill	
Liner Type	No Liner	

9.3.8.7 OB Plant Return Water Dam (RWD)

The purpose of the OB Plant Return Water Dam (RWD) is to capture and store all dirty surface storm water run-off from the OB Plant area, from where it is recycled back into the slurry process for OB Plant Fines disposal. The location and extent of the OB Plant RWD is shown on Figure 9.3.8.7(a).

The dam covers a footprint area of 1.72 *ha* and has a total storage capacity of 25 000 m^3. The OB Plant RWD does not have a liner system.

Table 9.3.8.7(a): Details of the OB Plant Return Water Dam

OB Plant Return Water Dam		
Central Coordinates	25°39'20.93"S 27°50'20.50"E	
Footprint Area	16 608 m^2	
Crest Length	536 *m*	
Max Wall Height	-	
Freeboard	-	
Dam Storage Capacity	25 000 m^3	
Wall Type	Earth Fill	
Liner Type	No Liner	

Due to the fact that the solids suspended in the storm water run-off from the OB Plant, essentially represent fine inert mine waste rock, the OB Plant RWD is not lined.

Figure 9.3.8.6(a): The location and extent of the HERNIC Alloys Plant Storm Water Pollution Control Dam

Figure 9.3.8.7(a): The location of and infrastructure associated with the OB Plant Return Water Dam (RWD)

9.3.8.8 Emergency Dam

The purpose of the Emergency Dam is to capture and store all dirty surface storm water run-off from the HERNIC Alloys Plant area in the event that extreme/upset run-off conditions cause the upstream storage facilities to overflow.

The location and extent of the Emergency Dam is shown on Figure 9.3.8.8(a). A summary of the details pertaining to the Emergency Dam are relayed in the Table below.

The dam covers a footprint area of 9 760.12 m^2. This dam is a man-made feature and no formal designs are in place, hence no accurate volume estimate is available. The dam does not have a liner system.

Table 9.3.8.8 (a): Details of the Emergency Dam

Emergency Dam		
Central Coordinates	25°39'21.39"S 27°50'11.76"E	
Footprint Area	14 808 m^2	
Crest Length	619 m	
Max Wall Height	-	
Freeboard	-	
Wall Type	Earth Fill	
Liner Type	No Liner	

9.3.8.9 Chrome Recovery Pollution Control Dam (PCD)

The purpose of the CRP Pollution Control Dam (PCD) is to serve as a reticulation facility for process water at the CRP as well as to capture and store all dirty surface storm water run-off from the facility.

The location and extent of the CRP PCD is shown on Figure 9.3.8.9(a). A summary of the details pertaining to the CRP PCD is relayed in the Table 9.3.8.9(a).

The dam covers a footprint area of 3462.70 m^2 and has a total storage capacity of 9 000 m^3.

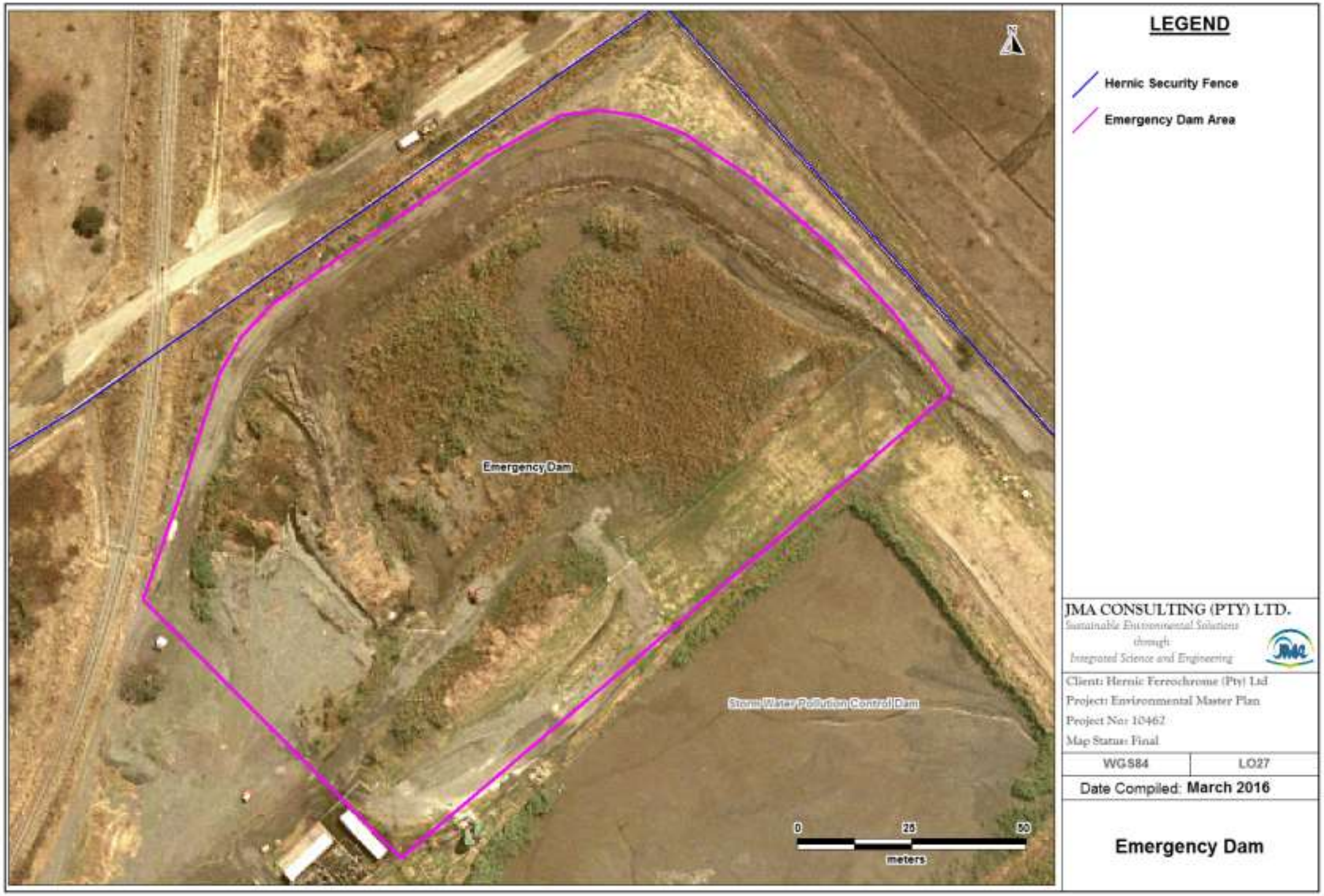


Figure 9.3.8.8(a): The location and extent of the Emergency Dam

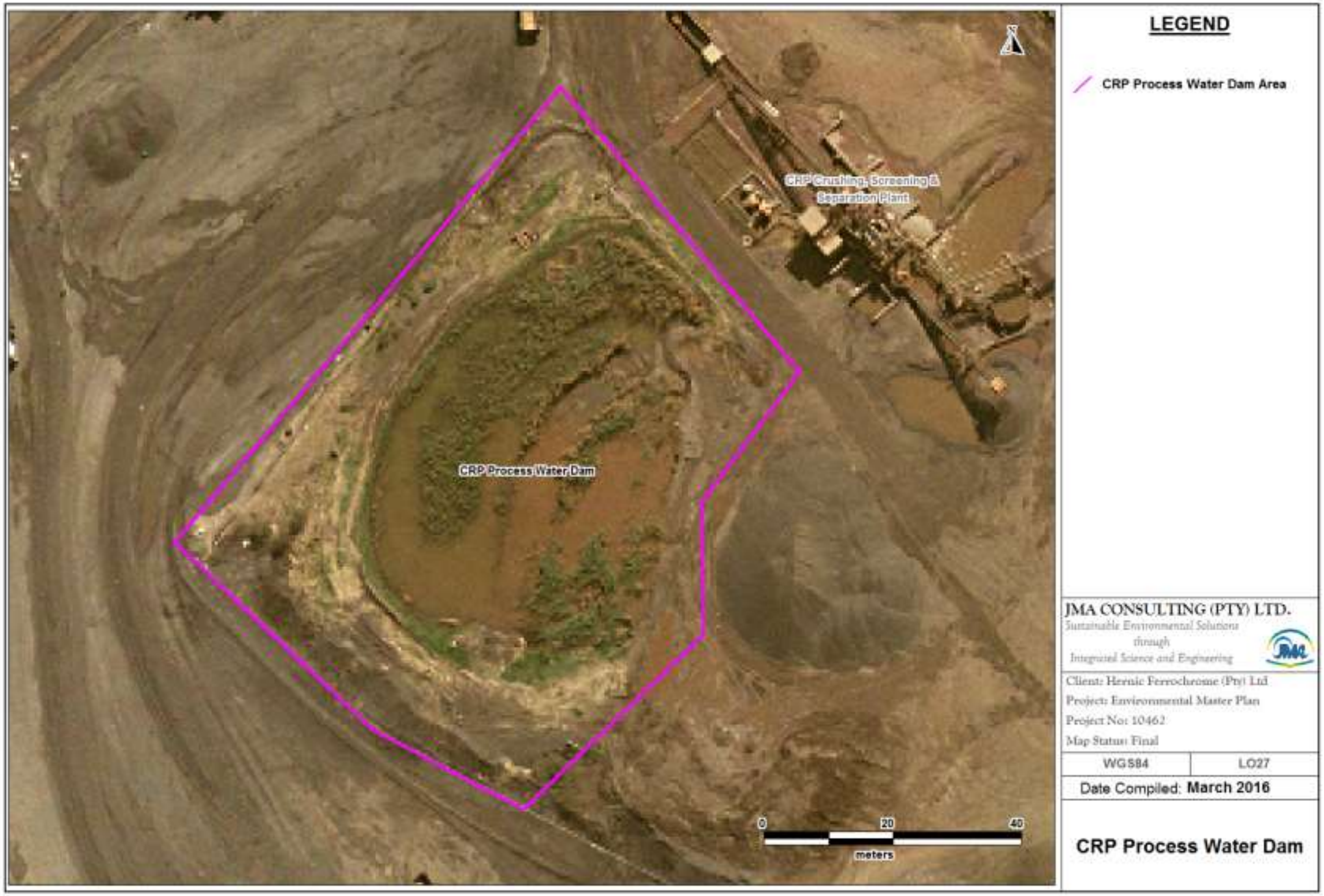


Figure 9.3.8.9(a): The location and extent of the Chrome Recovery Plant Process Water Dam (PCD)

Table 9.3.8.9(a): CRP Pollution Control Dam Design Specifications

CRP Pollution Control Dam	
Central Coordinates	25°39'46.09"S 27°50'32.85"E
Footprint Area	7 082 m^2
Crest Length	333 m
Max Wall Height	-
Freeboard	-
Dam Storage Capacity	9 000 m^3
Wall Type	Earth Fill
Liner Type	No Liner

9.3.8.10 OB Plant Tailings Storage Facility Return Water Dam (RWD)

The purpose of the OB Plant TSF RWD is to serve as a collection and storage facility for process decant water from the Tailings Storage Facility and from where the water is then returned to the OB Plant for re-use to slurry the fine tailings.

The location and extent of the OB Plant TSF RWD is shown on Figure 9.3.8.10(a). A summary of the details pertaining to the OB Plant Tailings Storage Facility Return Water Dam is relayed in the Table 9.3.8.10(a).

The dam covers a footprint area of 9486.50 m^2 and has a total storage capacity of 24 000 m^3.

Table 9.3.8.10(a): Details of the TSF Return Water Dam

TSF associated Return Water Dam	
Central Coordinates	25°39'11.16"S 27°50'52.39"E
Footprint Area	13 458 m^2
Crest Length	519 m
Max Wall Height	3.8 m
Freeboard	0.8 m
Dam Storage Capacity	24 000 m^3
Wall Type	Composite
Liner Type	HDPE Liner

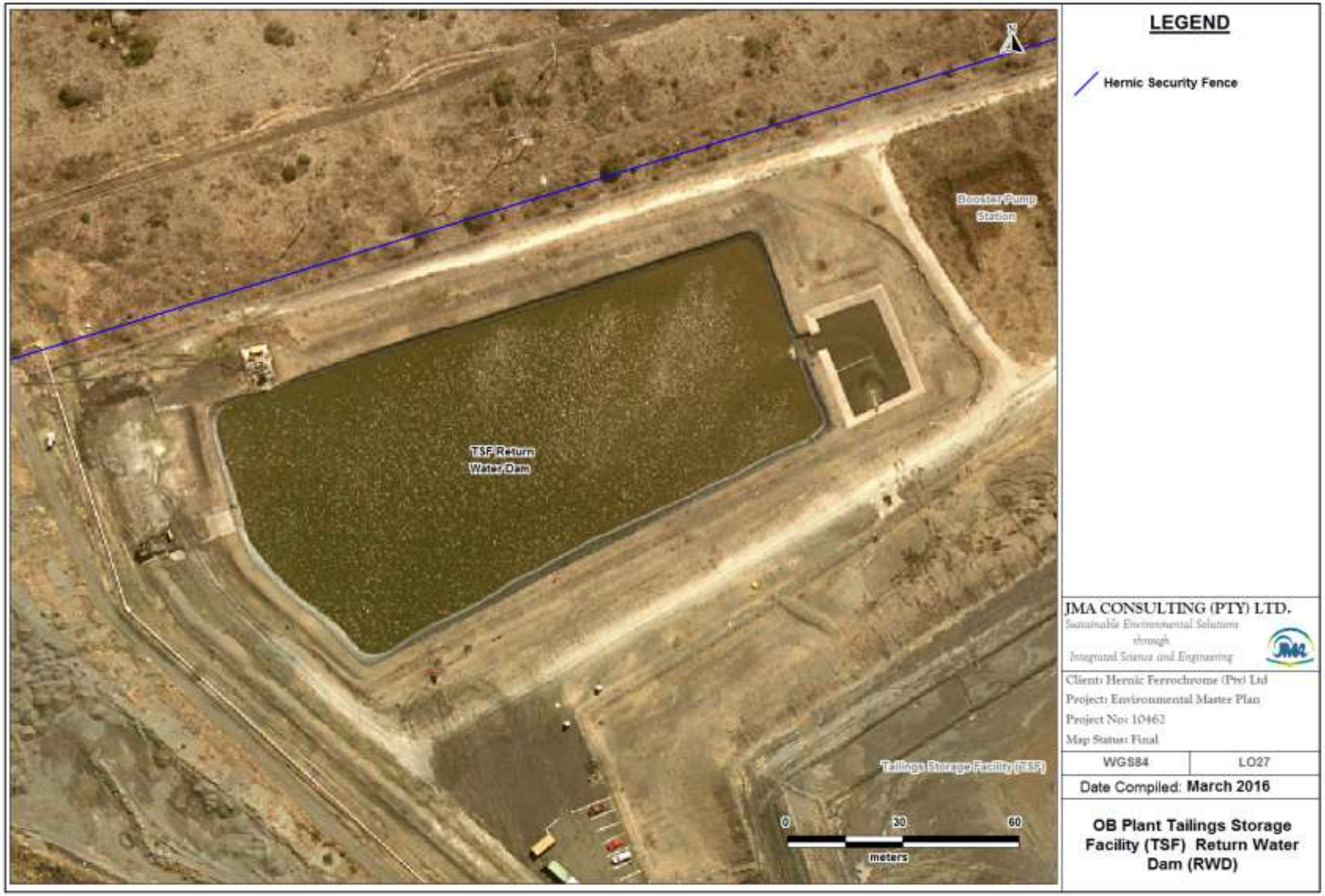


Figure 9.3.8.10(a): The location and extent of the OB Plant Tailings Storage Facility Return Water Dam

9.3.8.11 H:H Slimes Dam Return Water Dam (RWD)

The purpose of the old H:H Slimes Dam and Return Water Dam (RWD) was two-fold. Firstly it was used to serve as a collection and storage facility for process decant water from the facility and from where the water was then returned to the Smelting Plant for re-use to slurry the slimes and secondly it was used as a containment facility for any seepage that might have been collected by the facility underdrain system.

The location and extent of the old H:H Slimes Dam RWD is shown on Figure 9.3.8.11(a). A Summary of the details pertaining to the New H:H Slimes Dam Return Water Dam is relayed in the Table 9.3.8.11(a).

The dam covers a footprint area of 3765.15 m^2 and has a total storage capacity of 6130 m^3.

Table 9.3.8.11(a): H:H Slimes Dam RWD Design Specifications

H:H Slimes Dam Return Water Dam		
Central Coordinates	25°39'15.13"S 27°50'42.27"E	
Footprint Area	6 362 m^2	
Crest Length	327 *m*	
Top of Wall Level	1163.25 *mamsl*	
Full Supply Level	1162.85 *mamsl*	
Freeboard	0.4 *m*	
Dam Storage Capacity	6130 m^3	
Wall Type	Composite	
Liner Type	H:H Liner	

Figure 9.3.8.11(a): The location and extent of the new H:H Slimes Dam Pollution Control and Return Water Dam

9.3.9 Groundwater Management Infrastructure

HERNIC has commissioned a groundwater remediation scheme to address groundwater contamination located in a groundwater pollution plume underlying sections of the site.

The scheme comprises three groundwater abstraction boreholes, the water from which is then pumped to a groundwater treatment plant. Water is used for dust suppression after being treated.

9.3.9.1 Abstraction Boreholes

The locations of the groundwater remediation abstraction boreholes (HER BH-1, HER MA and HER MB) are shown on Figure 9.3.9.1(a).

9.3.9.2 Groundwater Treatment Plant

The location of and infrastructure associated with the Groundwater Treatment Plant, is shown on Figure 9.3.9.2(a) and the centre coordinates of the plant is relayed in the Table 9.3.9.2(a).

Table 9.3.9.2(a): Centre Coordinates of the Groundwater Treatment Plant

Description	Latitude	Longitude
Groundwater Treatment Plant	25°39'43.86"S	27°50'24.18"E

The remediation process comprises of the following steps:

1) Pumping of 130 m^3/day of groundwater from boreholes (HER BH-1, HER MA and HER MB) into a Settling Pond (Settling Pond A) filled with chromite ore and scrap metal. Cr^{6+} reacts with the chromite ore and scrap metal to precipitate Cr^{3+}.
2) Following the reaction with chrome ore in Settling Pond A, the water is pumped through a dosing pump system of which 0.1 m^3 Fe_2S for every 100 m^3 of water will be dosed.
3) The treated water is then pumped into Settling Pond B which is filled with scrap iron metal to further reduce Cr^{6+} to Cr^{3+}.
4) It is estimated that HERNIC pumps a volume of 130 m^3 a day from Settling Pond B.

Settling Pond A has a maximum available capacity of 160 m^3. Groundwater flows from the abstraction boreholes into Settling Pond A at a rate of 100 - 130 m^3/day. Water is allowed to react with the chrome and scrap metal over a period of 10 hours. Chrome ore and scrap metal placed at the bottom of Settling Pond A should be replaced every three months.

The dosing pump system is mounted between Settling Pond A and B. Water is abstracted from Settling Pond A through a centrifugal pump into a pipe at a rate of 5 000 *l/h* (5 m^3/h). The dosing pump is connected to this pipe at the connection where doing with ferrous sulphate takes place, at a rate of 4.5 *l/h*. The dosing pump abstracts the ferrous sulphate from two 10 m^3 storage tanks located in a bund wall next to Settling Pond A. The water is pumped to Settling Pond B while dosing takes place.

Settling Pond B has a maximum available capacity of 160 m^3. After water from Settling Pond A has been treated, water is pumped to Settling Pond B at a flow rate of between 100 – 130 m^3 per day.

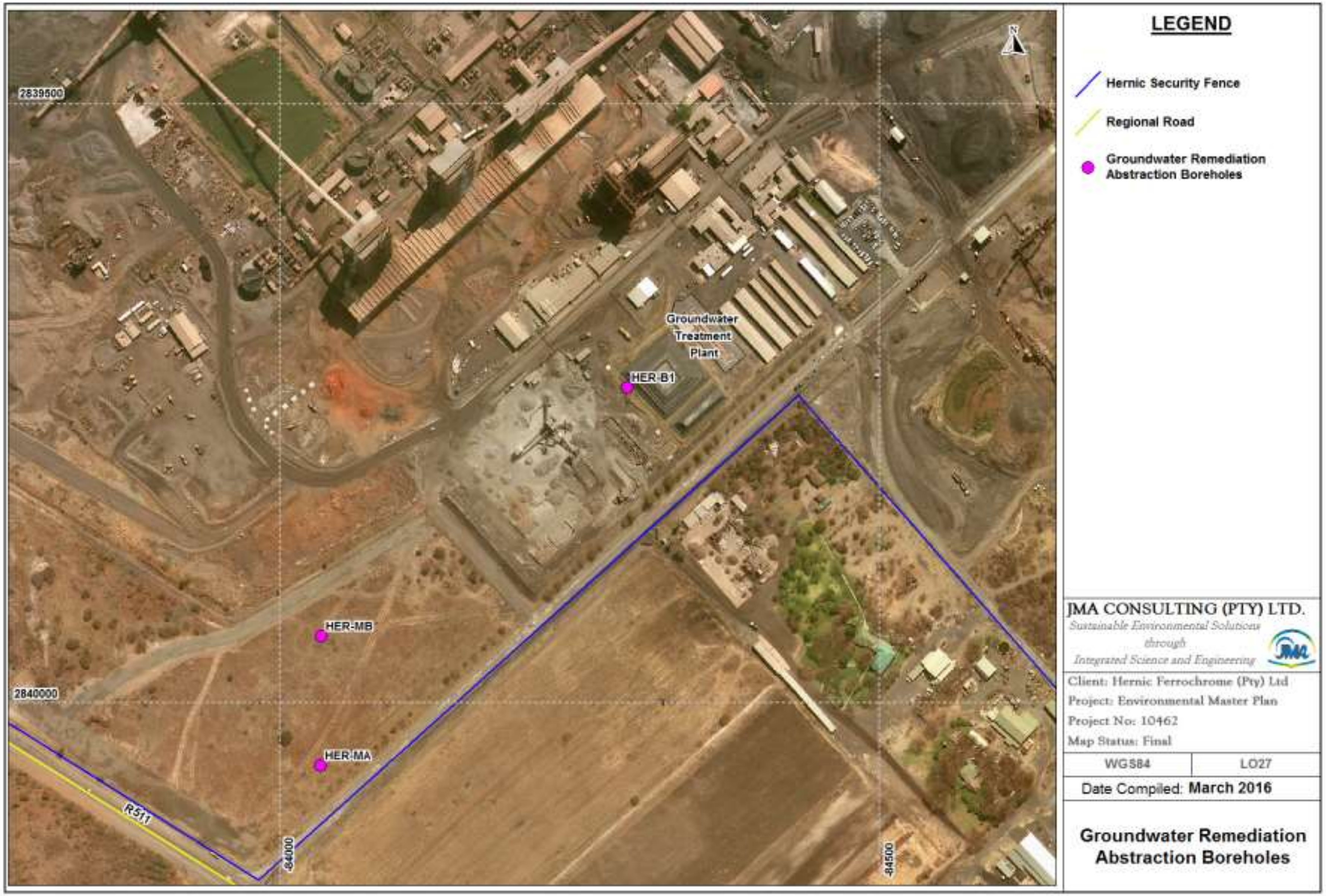


Figure 9.3.9.1(a): Location of the Groundwater Remediation Abstraction Boreholes

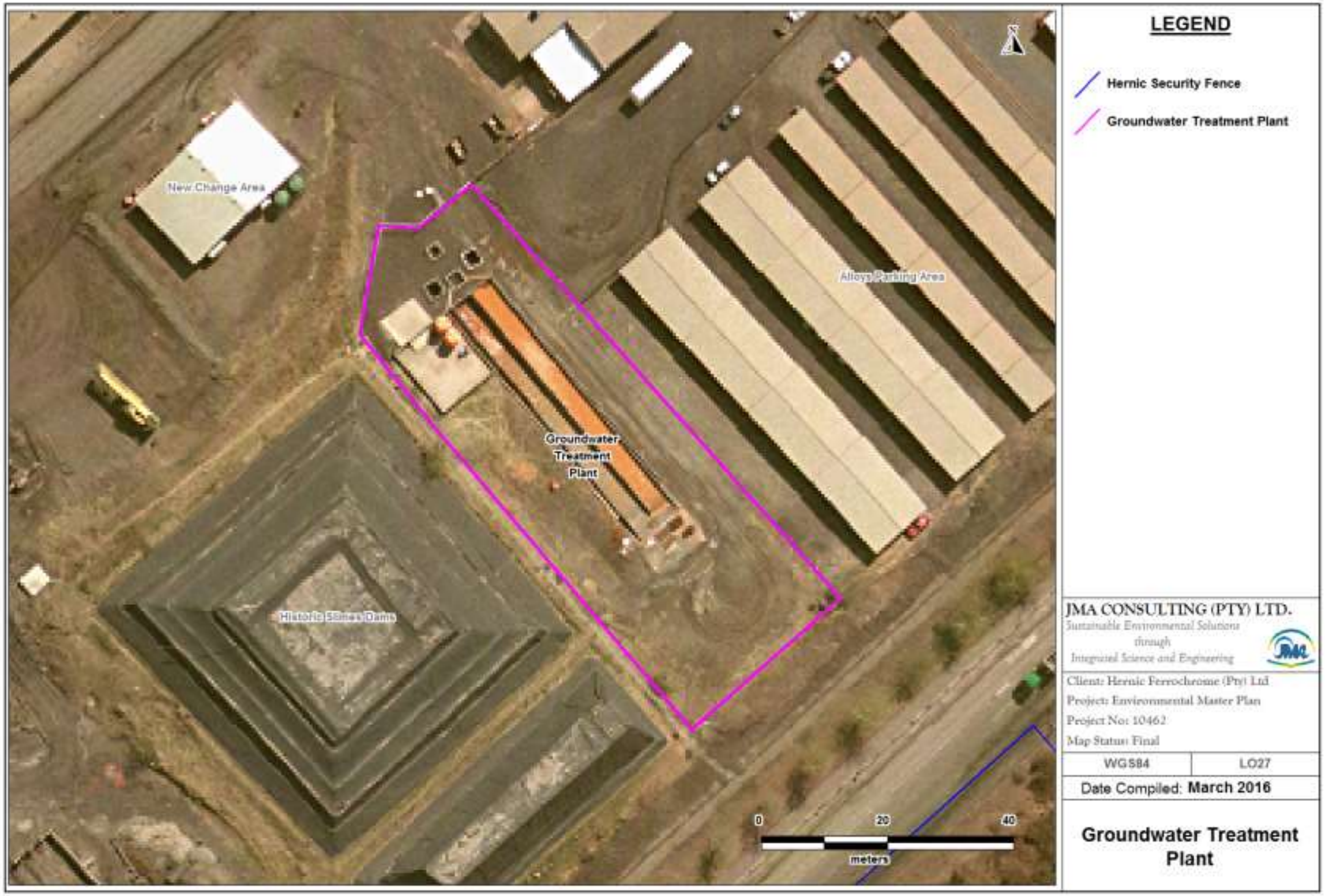


Figure 9.3.9.2(a): Location of and Infrastructure related to the Groundwater Treatment Plant

9.3.10 Air Emissions Control Systems

The HERNIC Alloys Plant operates a number of Air Quality Control Systems to manage Atmospheric Emissions in accordance with the requirements of the NEMAQA and the conditions of the Atmospheric Emissions Licence for the HERNIC site.

The locations of all the emission points active at HERNIC is shown on Figure 9.3.10(a).

9.3.10.1 Pelletising Plant 1

Point Source: Pelletising and Sintering Plant 1 - Clean Gas Stack

9.3.10.2 Pelletising Plant 2

Point Source: Pelletising and Sintering Plant 2 - Clean Gas Stack
Point Source: Pelletising and Sintering Plant 2 - Conveyor Dust Extraction Unit

9.3.10.3 Furnace 1

Point Source: Furnace 1 Clean Gas Stack
Point Source: Furnace 1 Fugitive Smokehood

9.3.10.4 Furnace 2

Point Source: Furnace 2 Clean Gas Stack
Point Source: Furnace 2 Fugitive Smokehood

9.3.10.5 Furnace 3

Point Source: Furnace 3 Clean Gas Stack
Point Source: Furnace 3 Building Fugitive Stack
Point Source: Furnace 3 Preheater Stack

9.3.10.6 Furnace 4

Point Source: Furnace 4 Clean Gas Stack
Point Source: Furnace 4 Building Fugitive Stack
Point Source: Furnace 4 Preheater Stack

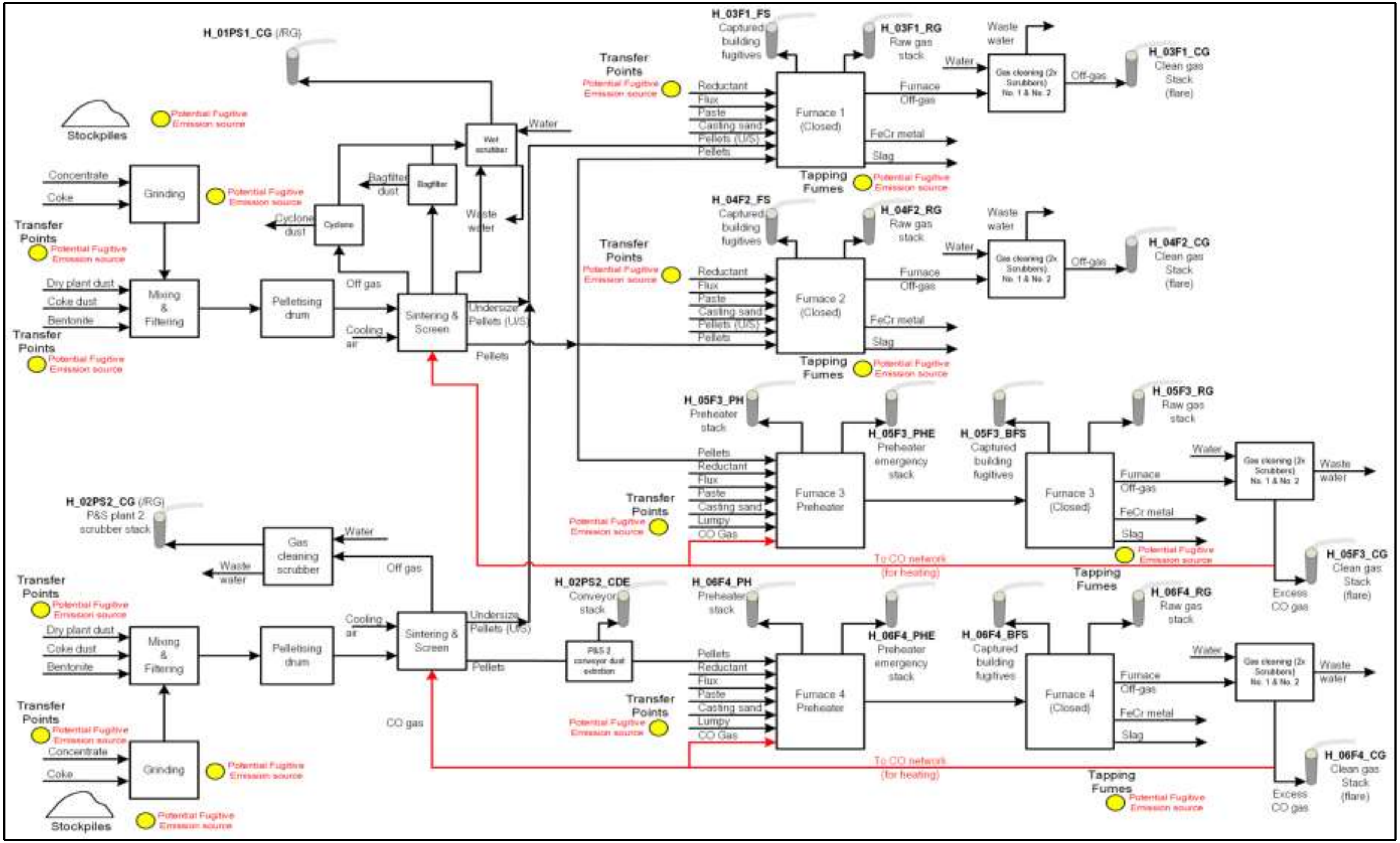


Figure 9.3.10(a): Location of all Atmospheric Emission Points at HERNIC

9.4 Water Containment Facilities

Surface water samples from each of the surface water containment facilities at HERNIC were taken and analysed as part of the Process and Materials Characterisation study. These surface water containment facilities include:

- Tailings Storage Facility Return Water Dam
- Plant Storm Water Dam
- Plant Process Water Dam
- Plant Drinking Water Dam
- Ore Beneficiation Plant Pollution Control Dam
- Morula Dewatering Dam
- H:H Return Water Dam
- Chrome Recovery Plant Pollution Control Dam
- Fine Fraction Slag Spiral Plant Sump
- Grout Plant Sump
- Emergency Dam

A summary of the dam design details as well as the quality of the water samples collected are indicated in Tables 9.4(a) to 9.4(l). The surface water sampling field form is attached as APPENDIX XII to this report. The surface water samples collected were not filtered in the field or the laboratory and were analysed by means of a full quantified ICP-MS analyses by Waterlab (Pty) Ltd. The time dependent chemistry report is attached as APPENDIX XIII.

The technical information indicated in the in the tables was obtained from the available designs and drawings for each of the water management facilities. These designs and drawings are attached as APPENDIX XIV to this report. The inlets and outlets of the water facilities were obtained from the 2015 Annual Water Balance Report which is attached as APPENDIX XV. The technical information pertaining to the water containment facilities including the water balances will be addressed in more detail in the Integrated Water and Waste Management Plan.

Table 9.4(a): Summary of the Features and Chemistry of the Tailings Storage Facility Return Water Dam

Facility Name:	**Tailings Storage Facility Return Water Dam**

Corner Coordinates:

Corner Point	Latitude (dms)	Longitude (dms)
1	25° 39' 09.0" S	27° 50' 54.6" E
2	25° 39' 09.8" S	27° 50' 55.0" E
3	25° 39' 10.7" S	27° 50' 56.2" E
4	25° 39' 13.2" S	27° 50' 50.9" E
5	25° 39' 12.1" S	27° 50' 49.6" E
6	25° 39' 10.8" S	27° 50' 49.2" E
7	25° 39' 10.6" S	27° 50' 49.6" E
8	25° 39' 10.3" S	27° 50' 49.5" E
9	25° 39' 10.2" S	27° 50' 50.0" E
10	25° 39' 10.4" S	27° 50' 50.3" E

Surface Dimensions:	135 m x 55 m (Google Earth)
Storage Capacity:	24,000 m^3
Type of Water:	Slimes Return Water
Liner Specifications:	HDPE liner
Drawing Reference:	T1022-101
Inlet:	Rainfall (8030 m^3/a), TSF Return Water (2 050 205 m^3/a)
Outlet:	Evaporation (12 775 m^3/a), OB Plant Process Water (2 045 460 m^3/a)

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.4	325	2 244	50	140	327	228	524	226	690	14.2	48	26	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
5.8	0.043	0.068	9.9	0.027	<0.025	<0.010	<0.025	<0.010	0.076	<0.025	0.313	0.004	0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.098	0.279	0.057	<0.1	<0.020	<0.010	319	0.461	<0.025	0.081	

Table 9.4(b): Summary of the Features and Chemistry of the Plant Storm Water Dam

Facility Name:	**Plant Storm Water Dam**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 21.7" S	27° 50' 14.0" E
	2	25° 39' 23.5" S	27° 50' 15.7" E
	3	25° 39' 23.0" S	27° 50' 16.4" E
	4	25° 39' 22.7" S	27° 50' 18.0" E
	5	25° 39' 23.9" S	27° 50' 19.4" E
	6	25° 39' 27.9" S	27° 50' 14.4" E
	7	25° 39' 24.3" S	27° 50' 10.4" E
Surface Dimensions:	73m x 118 m and 36 m x 118 m		
Storage Capacity:	38,000 m^3		
Type of Water:	Dirty Storm Water		
Liner Specifications:	No liner		
Drawing Reference:	00-21-037		
Inlet:	Runoff (137 605 m^3/a), Rainfall (12 775 m^3/a)		
Outlet:	Evaporation (20 075 m^3/a), seepage (58 0.5 m^3/a), Process Water Dam (27 270 m^3/a)		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.3	333	2 356	56	139	350	241	368	245	784	10.6	57	25	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
7.3	<0.025	<0.025	1.1	0.046	<0.025	<0.010	<0.025	<0.010	0.116	<0.025	0.318	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.049	0.173	0.031	<0.1	<0.020	<0.010	352	0.508	<0.025	0.078	

Table 9.4(c): Summary of the Features and Chemistry of the Plant Process Water Dam

Facility Name:	**Process Water Dam**			
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**	
	1	25° 39' 24.5" S	27° 50' 10.6" E	
	2	25° 39' 28.0" S	27° 50' 14.6" E	
	3	25° 39' 32.5" S	27° 50' 09.1" E	
	4	25° 39' 29.1" S	27° 50' 05.4" E	
Surface Dimensions:	134 m x 190 m			
Storage Capacity:	76,000 m^3			
Type of Water:	Process Water			
Liner Specifications:	Composite Liner			
Drawing Reference:	00-21-036			
Inlet:	Canal (268 480 m^3/a), Rainfall (18 615 m^3/a), Runoff (58 035 m^3/a), OB Plant (606 360 m^3/a), Furnaces (565 312 m^3/a), WWTW (68 813.45 m^3/a), Pelletising Plant (182 500 m^3/a), Storm Water Dam (72 270m^3/a)			
Outlet:	Evaporation (29 770 m^3/a) , Furnaces (1 407 925.45 m^3/a), Pelletising Plant (402 960 m^3/a)			

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.4	422	2 966	62	157	379	397	624	267	792	24	107	29	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
14	0.099	0.193	26	0.038	<0.025	<0.010	<0.025	<0.010	0.062	<0.025	0.429	<0.003	0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.084	0.759	0.045	0.1	<0.020	<0.010	347	0.386	<0.025	0.08	

Table 9.4(d): Summary of the Features and Chemistry of the Plant Drinking Water Dam

Facility Name:	**Drinking Water Dam**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 36 6" S	27° 50' 11.4" E
	2	25° 39' 38.7" S	27° 50' 13.9" E
	3	25° 39' 40.6" S	27° 50' 11.6" E
	4	25° 39' 40.6" S	27° 50' 11.3" E
	5	25° 39' 38.1" S	27° 50' 08.6" E
	6	25° 39' 37.1" S	27° 50' 10.0" E
Surface Dimensions:	118 m x 84 m x 85 m		
Storage Capacity:	30,000 m^3		
Type of Water:	Hartbeespoort Irrigation Water		
Liner Specifications:	No liner		
Drawing Reference:	00-21-35		
Inlet:	Canal Water (601 520 m^3/a), Rainfall (6 935 m^3/a)		
Outlet:	Evaporation (10 950 m^3/a), Seepage (31 390 m^3/a), PWT (541 660 m^3/a), Furnaces 24 455 m^3/a)		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	**EC**	**TDS**	**Ca**	**Mg**	**Na**	**K**	**T.Alk**	**Cl**	**SO_4**	**Si**	**NO_3**	**NO_2**	**Al**
8	60.6	356	45	18	48	13.1	160	47	73	5.3	1.9	1.2	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
0.3	<0.025	<0.025	1	<0.025	<0.025	<0.010	<0.025	<0.010	0.035	<0.025	0.037	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	<0.025	0.784	<0.010	0.7	<0.020	<0.010	32	0.143	<0.025	<0.025	

Table 9.4(e): Summary of the Features and Chemistry of the Ore Beneficiation Plant Pollution Control Dam

Facility Name:	**Ore Beneficiation Plant Pollution Control Dam**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 18.0" S	27° 50' 21.3" E
	2	25° 39' 18.0" S	27° 50' 21.9" E
	3	25° 39' 20.1" S	27° 50' 24.0" E
	4	25° 39' 23.9" S	27° 50' 19.4" E
	5	25° 39' 21.8" S	27° 50' 17.0" E
Surface Dimensions:	70 m x 155 m (Google Earth)		
Storage Capacity:	16,000 m^3		
Type of Water:	Process Water / Storm Water		
Liner Specifications:	No liner		
Drawing Reference:	00-21-038		
Inlet:	Runoff (59 495 m^3/a), Rainfall (12 045 m^3/a), Mine Pit 1, OB Plant (238 345 m^3/a)		
Outlet:	Evaporation (18 980 m^3/a), Seepage (54 750 m^3/a), OB Plant (110 230 m^3/a), CRP Plant (18 980 m^3/a)		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.5	320	2 202	51	149	327	227	464	236	686	15.1	48	27	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
5.9	<0.025	0.06	11	<0.025	<0.025	<0.010	<0.025	<0.010	0.093	<0.025	0.293	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.079	0.264	<0.010	<0.1	<0.020	<0.010	321	0.471	<0.025	0.084	<0.010

Table 9.4(f): Summary of the Features and Chemistry of the Morula Dewatering Dam

Facility Name:	**Morula Dewatering Dam**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 47.2" S	27° 51' 11.2" E
	2	25° 39' 47.3" S	27° 51' 12.8" E
	3	25° 39' 48.0" S	27° 51' 13.5" E
	4	25° 39' 49.6" S	27° 51' 13.6" E
	5	25° 39' 50.1" S	27° 51' 13.4" E
	6	25° 39' 50.2" S	27° 51' 10.7" E
	7	25° 39' 49.7" S	27° 51' 10.1" E
	8	25° 39' 47.8" S	27° 51' 10.2" E
Surface Dimensions:	60 m x 63 m		
Storage Capacity:	12,000 m^3		
Type of Water:	Abstracted Groundwater From Underground Mining		
Liner Specifications:	No liner		
Drawing Reference:	00-21-039		
Inlet:	Runoff (53 169.55 m^3/a), Rainfall (2 920 m^3/a), Underground Shaft Potable (61 775.25 m^3/a), Underground Shaft Dewatering (436 175 m^3/a), WWTW (26 645 m^3/a)		
Outlet:	Evaporation (3 650 m^3/a), Seepage (700.25 m^3/a), Chrome Recovery Plant (85 045 m^3/a), OB plant (491 290 m^3/a)		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	**EC**	**TDS**	**Ca**	**Mg**	**Na**	**K**	**T.Alk**	**Cl**	**SO_4**	**Si**	**NO_3**	**NO_2**	**Al**
8.3	98.7	640	47	68	64	9.1	268	54	158	16.2	11	0.1	<0.100
F	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
0.2	<0.025	<0.025	0.1	<0.025	0.075	0.075	<0.025	<0.010	0.039	<0.025	0.067	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	<0.025	0.097	<0.010	<0.1	<0.020	<0.010	72	0.198	<0.025	0.027	

Table 9.4(g): Summary of the Features and Chemistry of the H:H Return Water Dam

Facility Name:	**HH Return Water Dam**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 13.1" S	27° 50' 42.6" E
	2	25° 39' 14.7" S	27° 50' 44.2" E
	3	25° 39' 16.8" S	27° 50' 42.1" E
	4	25° 39' 15.6" S	27° 50' 40.1" E
Surface Dimensions:	50 m x 75 m (Google Earth)		
Storage Capacity:	6,130 m^3		
Type of Water:	Process Water		
Liner Specifications:	H:H liner		
Drawing Reference:**	T 765/1		
Inlet:	Return water from the Slimes Dam (volumes unknown)		
Outlet:	Returned to Plant as Process Water (volumes unknown)		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	**EC**	**TDS**	**Ca**	**Mg**	**Na**	**K**	**T.Alk**	**Cl**	**SO_4**	**Si**	**NO_3**	**NO_2**	**Al**
9.2	2 954	20 814	52	80	5 099	3 574	212	7 735	3 851	1.7	20	5	<0.100
F	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
4.9	<0.025	<0.025	0.9	<0.025	3.2	0.294	<0.025	<0.010	0.054	<0.025	0.736	0.004	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	0.83	0.133	0.047	0.115	0.049	<0.1	<0.020	0.068	1 900	0.368	<0.025	0.08	

Table 9.4(h): Summary of the Features and Chemistry of the Chrome Recovery Plant Pollution Control Dam

Facility Name:	**Chrome Recovery Plant Pollution Control Dam**			
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**	
	1	25° 39' 44.2" S	27° 50' 32.5" E	
	2	25° 39' 44.2" S	27° 50' 32.9" E	
	3	25° 39' 45.8" S	27° 50' 34.8" E	
	4	25° 39' 48.0" S	27° 50' 32.9" E	
	5	25° 39' 46.4" S	27° 50' 30.7" E	
Surface Dimensions:	65 m x 58 m			
Storage Capacity:	9,000m³			
Type of Water:	Process Water			
Liner Specifications:	No Liner			
Drawing Reference:	00-21-040			
Inlet:	Runoff (60 955 m³/a), Rainfall (1 460 m³/a), Chrome Recovery Plant (30 295 m³/a)			
Outlet:	Evaporation (2 555 m³/a), Seepage (7 300 m³/a), Product (30 295 m³/a), Chrome Recovery Plant (52 560 m³/a)			

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
7.9	344	2 680	213	161	292	143	144	299	1 303	5.6	34	6	<0.100
F	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
2.2	<0.025	0.066	2.6	<0.025	<0.025	<0.010	<0.025	<0.010	0.077	<0.025	0.191	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.071	0.102	0.035	<0.1	<0.020	<0.010	574	0.594	<0.025	0.083	

Table 9.4(i): Summary of the Features and Chemistry of the Fine Fraction Slag Spiral Plant Sump

Facility Name:	**Fine Fraction Slag Spiral Plant Sump**			
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**	
	1	25° 39' 41.6" S	27° 50'05.6" E	
	2	25° 39' 42.0" S	27° 50' 05.9" E	
	3	25° 39' 42.3" S	27° 50' 05.4" E	
	4	25° 39' 42.4" S	27° 50' 05.5" E	
	5	25° 39' 42.5" S	27° 50' 05.2" E	
	6	25° 39' 42.1" S	27° 50' 04.8" E	
Surface Dimensions:	20 m x 10 m (Google Earth)			
Storage Capacity:	Unknown			
Type of Water:	Process Water			
Liner Specifications:	No Liner (Cement Bounded Area)			
Drawing Reference:	None Available			
Inlet:	Unspecified			
Outlet:	Unspecified			

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.1	293	2 088	93	106	275	213	248	210	769	7.7	48	19	<0.100
F *	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
5.1	0.134	0.173	4	<0.025	<0.025	<0.010	<0.025	<0.010	<0.025	<0.025	0.238	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	0.068	0.191	0.035	<0.1	<0.020	<0.010	345	0.286	<0.025	0.082	

Table 9.4(k): Summary of the Features and Chemistry of the Grout Plant Sump

Facility Name:	**Grout Plant Sump**		
Corner Coordinates:	**Corner Point**	**Latitude (dms)**	**Longitude (dms)**
	1	25° 39' 35.3" S	27°51'11.0" E
	2	25° 39' 35.6" S	27°51'11.1" E
	3	25° 39' 35.8" S	27°51'10.5" E
	4	25° 39' 35.4" S	27°51'10.4" E
Surface Dimensions:	10 m x 15 m (Google Earth)		
Storage Capacity:	Unknown		
Type of Water:	Process Water		
Liner Specifications:	No Lining (Cement Bounded)		
Drawing Reference:	None Available		
Inlet:	Unspecified		
Outlet:	Unspecified		

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.3	43.8	280	32	3	34	25	52	25	115	12.5	<0.1	<0.05	<0.100
F	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
0.3	<0.025	<0.025	0.1	0.033	<0.025	<0.010	<0.025	<0.010	0.033	<0.025	0.292	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	0.438	<0.025	<0.025	<0.025	<0.010	<0.1	<0.020	<0.010	33	0.173	<0.025	<0.025	

Table 9.4(l): Summary of the Features and Chemistry of the Emergency Dam

Facility Name:	**Emergency Dam**

Corner Coordinates:

Corner Point	Latitude (dms)	Longitude (dms)
1	25° 39' 19.3" S	27° 50' 11.7" E
2	25° 39' 19.7" S	27° 50' 13.2" E
3	25° 39' 23.0" S	27° 50' 16.5" E
4	25° 39' 23.5" S	27° 50' 15.7" E
5	25° 39' 21.7" S	27° 50' 14.0" E
6	25° 39' 24.4" S	27° 50' 10.4" E
7	25° 39' 23.3" S	27° 50' 09.4" E
8	25° 39' 22.8" S	27° 50' 10.1" E
9	25° 39' 22.3" S	27° 50' 09.7" E
10	25° 39' 20.6" S	27° 50' 09.5" E

Surface Dimensions:	13 m x 80 m (Google Earth)
Storage Capacity:	Unknown
Type of Water:	Dirty Storm Water
Liner Specifications:	None
Drawing Reference:	None Available
Inlet:	Unspecified
Outlet:	Unspecified

Water Quality:

Assessed with regards to the limits set in the SANS 241:2011.

pH	EC	TDS	Ca	Mg	Na	K	T.Alk	Cl	SO_4	Si	NO_3	NO_2	Al
8.1	114	708	54	44	97	41	228	75	244	3.1	3.8	0.5	<0.100
F	**Fe**	**Mn**	**NH_4**	**Zn**	**Cr**	**Cr^{6+}**	**Ag**	**As**	**Ba**	**Bi**	**B**	**Cd**	**Co**
1.6	<0.025	<0.025	0.4	<0.025	<0.025	<0.010	<0.025	<0.010	0.06	<0.025	0.118	<0.003	<0.025
Cu	**Li**	**Mo**	**Ni**	**P**	**Pb**	**PO_4**	**Sb**	**Se**	**S**	**Sr**	**Ti**	**V**	
<0.010	<0.025	<0.025	<0.025	0.052	<0.010	<0.1	<0.020	<0.010	105	0.259	<0.025	<0.025	

10. IDENTIFICATION OF IMPACT MECHANISMS

With specific reference to the soils, surface water and groundwater environmental media, the following conceptual sketches illustrate the potential impact mechanisms and migration of contaminants with reference to the Source-Pathway-Receptor management hierarchy.

SOURCE → PATHWAY → RECEPTOR

Without a continuous link between the source, pathway and receptor there cannot be an impact on the receptor that primarily originates from the source, whether it be a stockpile area, disposal area or containment facility. This implies that from a source perspective, the aim is to implement source control measures / controls that prohibit contaminants from passing into the pathway (soils and the unsaturated groundwater zone) in order to break the link between the source and the pathway(s). This will ensure that the source is managed and controlled in an environmentally sustainable manner.

Figure 10(a) conceptually illustrates the impact mechanism for a material (raw material or waste) stockpile / disposal facility and Figure 10(b) conceptually illustrates the impact mechanism for a water containment facility.

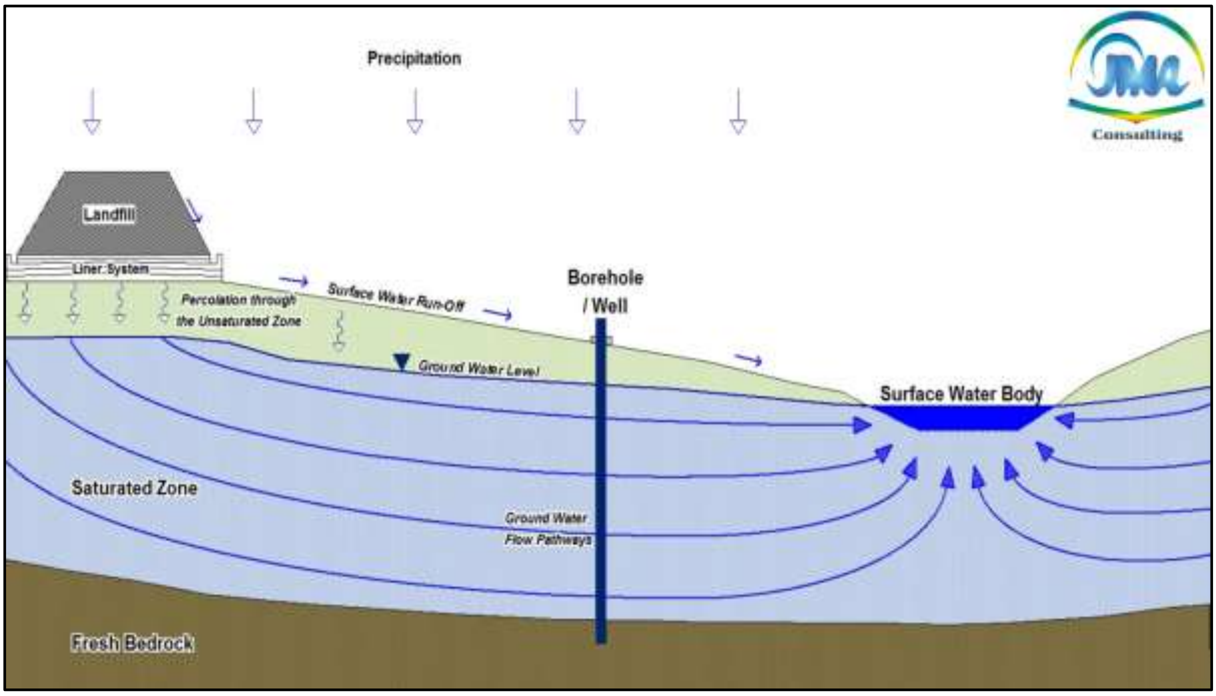


Figure 10(a): Schematic 2D Conceptual Sketch for a Material Stockpile / Disposal Facility

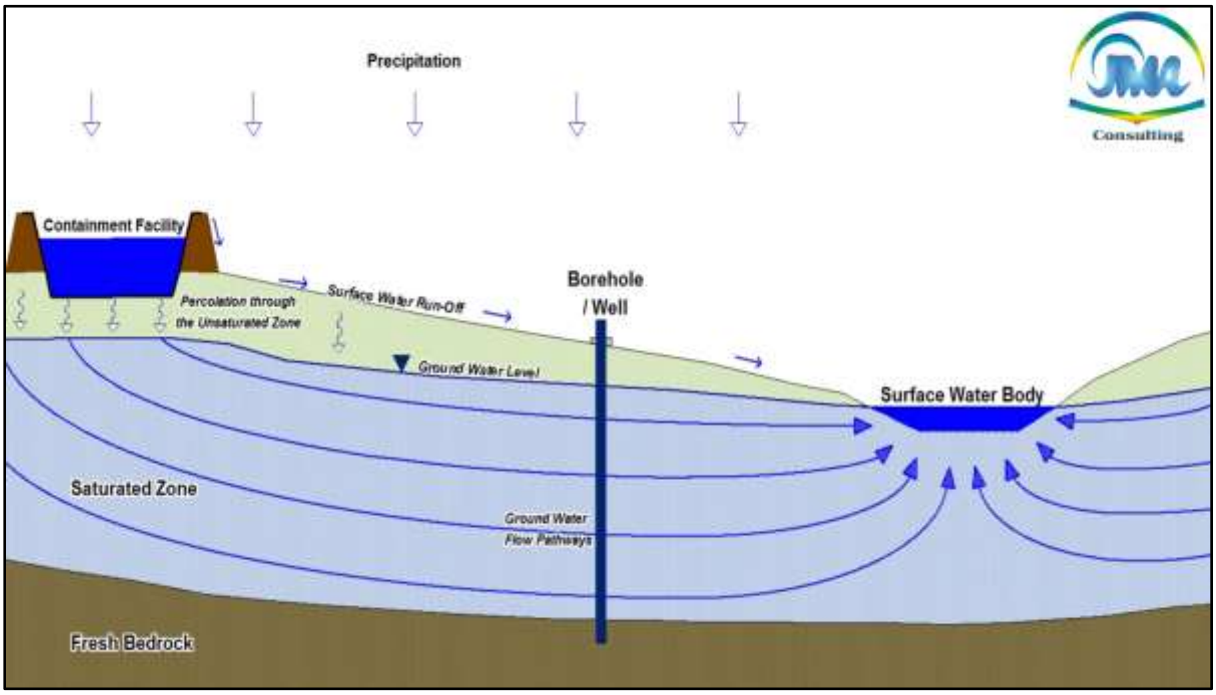


Figure 10(b): Schematic 2D Conceptual Sketch for a Water Containment Facility

Any contaminants present at the surface, whether contained within the surface water bodies or within the raw materials, waste or final product stockpile or disposal areas (*Potential Sources*) have the potential of infiltrating directly into (or the potential of generating a leachate that may infiltrate into) the soils and underlying unsaturated zone (*Pathways*) and further saturated groundwater zone and potentially contaminate the groundwater resource (*Receptor*). If insufficient surface water infrastructure is implemented on site, these contaminants may potentially flow across the surface and into surface water drainage bodies (*Receptor*) as well.
The unsaturated zone is that part of the earth's crust, including the soils and clays that occur above the groundwater table. Water and any potential contaminants in the unsaturated zone occur within the interstices or voids between the individual grains or host rock material along with air and other gases. Water in the unsaturated zone is exposed to atmospheric conditions and will percolate downwards through the voids in the unsaturated zone and into the underlying saturated groundwater zone under the influence of gravity.

The saturated groundwater zone is the part of the earth's crust that is situated beneath the groundwater table or piezometric surface. The voids in the saturated zone are entirely filled with water at pressures equal to or greater than that of atmospheric pressure. Once any infiltrating water or contaminants enter the saturated zone, the solutes will move laterally primarily as a result of the bulk movement or transport of groundwater due to advection. Advection is the predominant process by which solutes are transported in the saturated groundwater zone, especially in highly permeable material during which the solutes are carried along with the flowing groundwater.

Contaminants within the groundwater may also migrate laterally as a result of adsorption, diffusion and dispersion, although to a much smaller degree than advection. Contaminants within the saturated groundwater zone will therefore primarily be transported away from the infiltration source, due to the mass movement of groundwater until it is abstracted or intercepted by a surface water body.

The potential movement of leachate or contaminants, generated at the surface, or within the surface water bodies, through the unsaturated and saturated groundwater zones towards the groundwater receptors is schematically depicted in Figures 10(a) and 10(b). The movement of surface water, subsurface water and associated contaminant flow paths are indicated by the arrows on the two schematic sketches.

Precipitation that falls within the plant areas, onto the raw material stockpile areas, unprocessed and processed slag dumps, slimes dam or water that is stored within the various dams at HERNIC can potentially mobilize soluble constituents within these areas. The solutes will then manifest as a leachate at the toe of the dams/dump/stockpiles and if not captured by the underlying liner systems (if in place), will infiltrate through the base of the dams/dumps and into the underlying unsaturated and saturated groundwater zones within the weathered zone aquifer at HERNIC.

The actual magnitude of this impact will be a function of the mobilised load of contaminants, the dams/dumps/stockpiles' infiltrating water balance, the designs and permeability of the base of the dams/dumps/stockpiles (designs) as well as the physical, hydraulic and dynamic aquifer characteristics of the shallow weathered zone aquifers and their hydraulic interaction with surface streams.

Further impact mechanisms relate to surface spillages, process water sump overflows and pipe ruptures during operation. These impacts are localised incidents and clean-up management plans should address these as emergency actions depending on the content of the material and extent of the impact.

Each of the impacts addressed above could therefore essentially affect one or a combination of the soils, surface water, wetlands, plant life, animal life and the groundwater environments if not managed correctly.

11. MATERIALS CHARACTERISATION AND CLASSIFICATION

11.1 MATERIAL SAMPLING

Based on the project description and site inventory a sampling plan was compiled in order to take material samples that are stockpiled and disposed of on-site at HERNIC which may have a potential impact on the environment. A total of **30** material samples were collected for analytical testing. The material sampling field form is attached as APPENDIX VI to this Report.

The localities and descriptions of each of the material samples collected are given in Table 11.1(a). The material sampling localities are depicted on Figure 11.1(a). Photographs of the material samples collected are indicated in Table 11.1(b).

Table 11.1(a): Material Sample Numbers and Descriptions

Sample Number	Latitude	Longitude	Description	Material Type
HRM-1	25^0 39' 40.0"S	27^0 50' 29.9"E	Dolomite	Raw Material Stockpile
HRM-2	25^0 39' 39.9"S	27^0 50' 29.2"E	Quartzite	Raw Material Stockpile
HRM-3	25^0 39' 38.7"S	27^0 50' 32.4"E	ACP Char	Raw Material Stockpile
HRM-4	25^0 39' 37.8"S	27^0 50' 32.1"E	Coke Nuts	Raw Material Stockpile
HRM-5	25^0 39' 40.3"S	27^0 50' 32.5"E	Anthracite	Raw Material Stockpile
HRM-6	25^0 39' 34.6"S	27^0 50' 29.9"E	Limestone	Raw Material Stockpile
HRM-8	25^0 39' 31.6"S	27^0 50' 31.6"E	MG - 1 Ore	Raw Material Stockpile
HRM-9	25^0 39' 30.1"S	27^0 50' 33.5"E	MG - 2 Ore	Raw Material Stockpile
HRM-10	25^0 39' 33.5"S	27^0 50' 30.1"E	Chemstof Concentrate	Raw Material Stockpile
HRM-11	25^0 39' 34.2"S	27^0 50' 29.3"E	UG - 2 Concentrate	Raw Material Stockpile
HRM-12	25^0 39' 27.3"S	27^0 50' 37.9"E	Unprocessed slag	Unprocessed Slag Material
HRM-13	25^0 39' 14.5"S	27^0 50' 53.1"E	Slimes (TSF)	Waste Material Dam/Dump
HRM-14	25^0 39' 29.9"S	27^0 50' 30.2"E	DMS Lumpy (10x30) Chrome Ore	Raw Material Stockpile
HRM-15	25^0 39' 29.8"S	27^0 50' 30.3"E	DMS Waste	Waste Material Stockpile
HRM-16	25^0 39' 24.1"S	27^0 50' 24.1"E	HFC Concentrate	Raw Material Stockpile
HRM-17	25^0 39' 41.5"S	27^0 50' 02.3"E	Slag Fines	Waste Material Dump/Stockpile
HRM-18	25^0 39' 49.1"S	27^0 50' 54.3"E	Final Slag Dump	Waste Material Dump/Stockpile
HRM-19	25^0 39' 24.2"S	27^0 51' 13.6"E	MG 4 - Ore	Raw Material Stockpile
HRM-21	25^0 39' 36.6"S	27^0 49' 55.1"E	Return material	Raw and Waste Material Residue
HRM-22	25^0 39' 31.9"S	27^0 50' 11.3"E	Pellets	Raw Material Stockpile
HRM-23	25^0 39' 33.6"S	27^0 50' 11.2"E	Process water dam sediment	Raw and Waste Material Residue
HRM-24	25^0 39' 22.6"S	27^0 50' 23.6"E	OB dam sediment	Raw and Waste Material Residue
HRM-25	25^0 39' 31.2"S	27^0 50' 47.6"E	Rehabilitated Pit 1	Mixed Waste Backfill Material
HRM-26	25^0 39' 28.9"S	27^0 50' 51.3"E	Rehabilitated Pit 2	Mixed Waste Backfill Material
HRM-27	25^0 39' 26.8"S	27^0 50' 59.7"E	Rehabilitated Pit 3	Mixed Waste Backfill Material
HRM-28	25^0 39' 25.0"S	27^0 51' 01.7"E	Rehabilitated Pit 4	Mixed Waste Backfill Material
HRM-29	25^0 39' 45.1"S	27^0 51' 17.3"E	Mining Waste Rock Stockpile	Waste Material Stockpile
HRM-30	25^0 39' 36.2"S	27^0 51' 10.4"E	Grout plant	Waste Rock Stockpile
HRM-31	25° 39' 35.3''S	27^0 49' 44.4''E	Western Backfill	Mixed Waste Backfill Material
HRM-32	25^0 39' 28.6"S	27^0 50' 26.3"E	Mixed Waste	Waste Material Dump

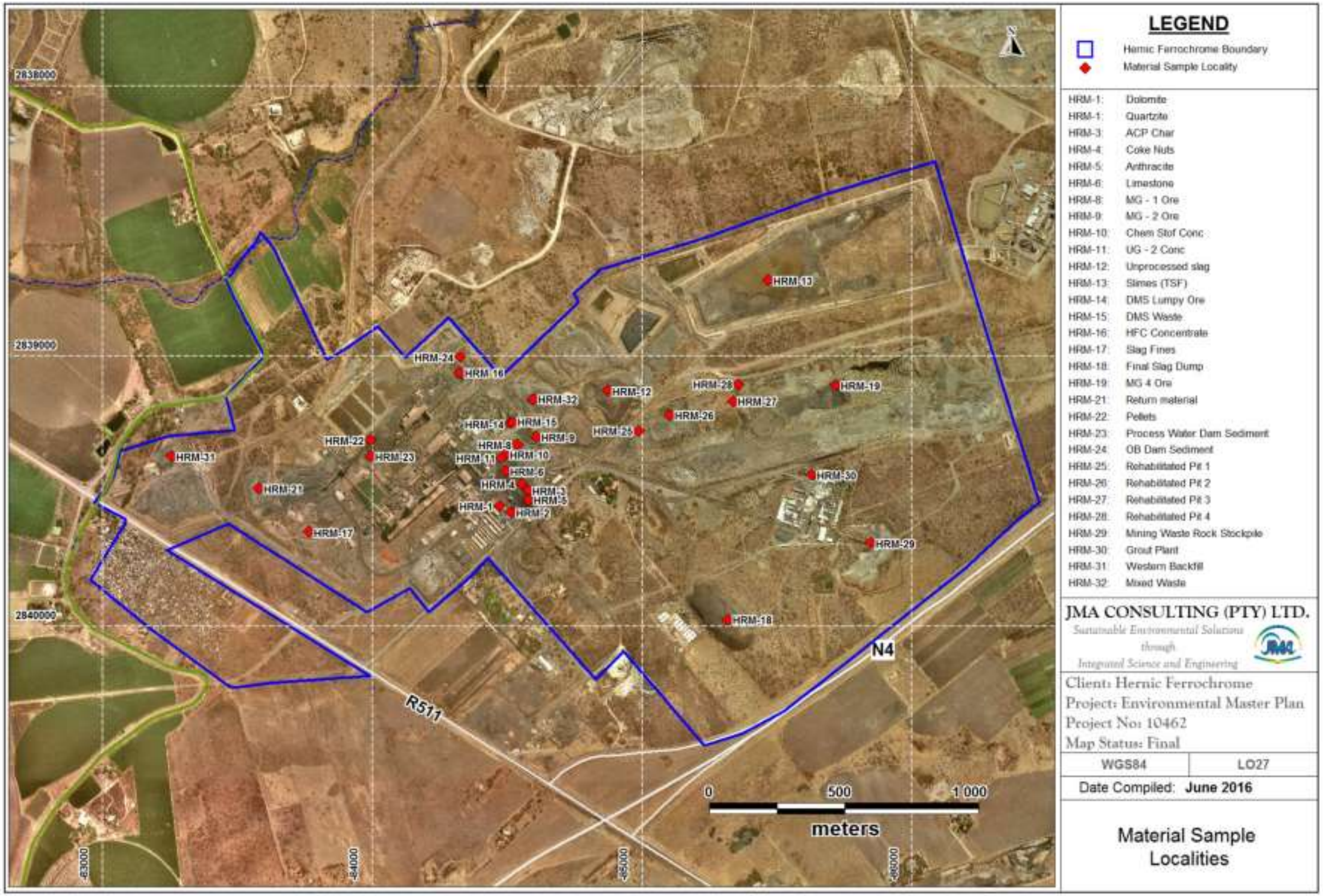


Figure 11.1(a): Material Sampling Localities (30 Locations)

Table 11.1(b): Photographs of the Material Samples Collected

Sample Number	**HRM-1**	**HRM-2**	**HRM-3**
Photo			
Description	**Dolomite** (Raw Material Stockpile)	**Quartzite** (Raw Material Stockpile)	**ACP Char** (Raw Material Stockpile)
Sample Number	**HRM-4**	**HRM-5**	**HRM-6**
Photo			
Description	**Coke Nuts** (Raw Material Stockpile)	**Anthracite** (Raw Material Stockpile)	**Limestone** (Raw Material Stockpile)
Sample Number	**HRM-8**	**HRM-9**	**HRM-10**
Photo			
Description	**MG - 1 Ore** (Raw Material Stockpile)	**MG - 2 Ore** (Raw Material Stockpile)	**Chemstof Concentrate** (Raw Material Stockpile)
Sample Number	**HRM-11**	**HRM-12**	**HRM-13**
Photo			
Description	**UG - 2 Concentrate** (Raw Material Stockpile)	**Unprocessed slag** (Unprocessed Slag Material)	**Slimes (TSF)** (Waste Material Dam/Dump)
Sample Number	**HRM-14**	**HRM-15**	**HRM-16**
Photo			
Description	**DMS Lumpy** (Raw Material Stockpile)	**DMS Waste** (Waste Material Stockpile)	**HFC Concentrate** (Raw Material Stockpile)

Sample Number	HRM-17	HRM-18	HRM-19
Photo			
Description	**Slag Fines** (Waste Material Dump/ Stockpile)	**Final Slag Dump** (Waste Material Dump/ Stockpile)	**MG-4 Ore** (Raw Material Stockpile)
Sample Number	**HRM-21**	**HRM-22**	**HRM-23**
Photo			
Description	**Return Material** (Raw and Waste Material Residue)	**Pellets** (Raw Material Stockpile)	**Process Water Dam Sediment** (Raw and Waste Material Residue)
Sample Number	**HRM-24**	**HRM-25**	**HRM-26**
Photo			
Description	**OB Dam Sediment** (Raw and Waste Material Residue)	**Rehabilitated Pit-1** (Mixed Waste Backfill Material)	**Rehabilitated Pit-2** (Mixed Waste Backfill Material)
Sample Number	**HRM-27**	**HRM-28**	**HRM-29**
Photo			
Description	**Rehabilitated Pit-3** (Mixed Waste Backfill Material)	**Rehabilitated Pit-4** (Mixed Waste Backfill Material)	**Mining Waste Rock Stockpile** (Waste Material Stockpile)
Sample Number	**HRM-30**	**HRM-31**	**HRM-32**
Photo			
Description	**Grout Plant** (Waste Rock Stockpile)	**Western Backfill** (Mixed Waste Backfill Material)	**Mixed Waste** (Waste Material Dump)

11.2 MINERALOGY AND TOTAL ELEMENT ANALYSIS (XRD AND XRF ANALYSIS)

The mineralogical composition of the material samples were determined by means of X-Ray Diffraction (XRD) analyses, performed by *XRD Analytical and Consulting*. The elemental analyses of the material samples were determined by means of X-Ray Fluorescence (XRF) analyses, performed by *Sci-ba Laboratories and Scientific Consultants*. The XRD and XRF are attached as APPENDIX VII and APPENDIX VIII.

The mineral phases identified in the material samples collected are listed in Table 11.2(a) whilst the XRD and XRF results are listed in Table 11.2(b), Table 11.2(c) and Table 11.2(d).

Table 11.2(a): Mineral Phases

Mineral	*	Formula	Mineral type/group	Sub-group
Actinonlite	Green	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	Inosilicate	Amphibole
Biotite	Red	$K(Mg,Fe)_3(AlSi_3O_{10})(F,OH)_2$	Phyllosilicate	Mica
Calcite	Blue	$CaCO_3$	Anhydrous Carbonate	Calcite Group
Chlorite	Grey	$(Mg,Fe)_5Al(AlSi_3O_{10})(OH)_8$	Phyllosilicate	Mica
Chromite	Grey	$(Mg,Fe)Cr_2O_4$	Multiple Oxide	Chromium subgroup
Cristobalite	Green	SiO_2	Tectosilicate	-
Diopside	Green	$CaMgSi_2O_6$	Inosilicate	Ca clino-pyroxene
Dolomite	Blue	$CaMg(CO_3)_2$	Anhydrous Carbonate	Dolomite Group
Enstatite	Green	$Mg_2Si_2O_6$	Inosilicate	Orthopyroxenes
Eskolaite	Grey	Cr_2O_3	Simple Oxide	Corundum-Hematite group
Graphite	Yellow	C	Native	-
Hematite	Grey	Fe_2O_3	Oxides	Hematite Group
Kaolinite	Red	$Al_2Si_2O_5(OH)_4$	Phyllosilicate 1:1 layer	Kaolinite subgroup
Magnetite	Grey	Fe_3O_4	Multiple Oxide	Spinel group (Iron Subgroup)
Mica	Red	$K_{0.7}\ Al_2\ ((OH)_2\ Al\ Si_3\ O_{10})$	Phyllosilicate	Mica
Muscovite	Red	$KAl_2(AlSi_3O_{10})(F,OH)_2$	Phyllosilicate	Mica
Plagioclase	Green	$(Na,Ca)(Si,Al)_4O_8$	Tectosilicate	Plagioclase series
Quartz	Green	SiO_2	Tectosilicate	Tectosilicate
Smectite	Red	$(Na,Ca)_{0,3}(Al,Mg)_2Si_4O_{10}(OH)_2{\cdot}n(H_2O)$	Phyllosilicate 2:1 clay	Smectite group
Spinel	Grey	$MgAl_2O_4$ (Replacement: Mg by Fe, Zn or Mn; and Al by Cr)	Multiple Oxides	Spinel Group (Aluminum subgroup)
Talc	Red	$Mg_3(Si_2O_5)_2(OH)_2$	Phyllosilicate 2:1 layer	Pyrophyllite-talc group

* **Mineral Type**: Grey = Oxides, Yellow = Native Elements, Red = Phyllosilicates, Green = Other silicates

Table 11.2(b): X-Ray Diffraction Results (wt%) (Sheet 1)

Sample	HRM-1	HRM-2	HRM-3	HRM-4	HRM-5	HRM-6	HRM-8	HRM-9	HRM-10	HRM-11
Description /Rock Type*	Dolomite	Quartzite	ACP Char	Coke Nuts	Anthracite	Limestone	MG-1 Ore	MG-2 Ore	Chemstof Concentrate	UG-2 Concentrate
Actinolite	-	-	-	-	-	-	-	-	-	-
Amorphous	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-
Biotite		-	-	-	-	-	-	-	-	-
Calcite	-	-	-	-	0.42	85.88	0.63	0.9	-	-
Chlorite	-	-	-	-	-	-	5.88	4.6	-	-
Chromite	-	-	-	-	-	-	46.91	38.99	90.77	88.84
Cristobalite	-	-	-	-	-	-	-	-	-	-
Dolomite	86.5	-	-	-	-	5.98	-	0.32	-	-
Diopside	-	-	-	-	-	-	-	-	-	-
Enstatite	-	-	-	-	-	-	9.76	21.31	1.73	3.18
Eskolaite	-	-	-	-	-	-	-	-	-	-
Graphite	-	1.05	85.78	88.96	63.41	-	-	-	-	-
Hematite	-	-	-	-	-	-	-	-	-	-
Kaolinite	-	0.37	3.46	-	5.36	-	0.78	-	-	-
Magnetite	-	0.36	-	-	-	-	-	-	-	-
Mica	0.33	0.55	-	-	13	4	1.53	0.82	-	-
Muscovite	-	-	-	-	-	-	-	-	-	-
Plagioclase	-	10.03	-	-	-	-	18.88	23.66	7.5	7.98
Quartz	13.16	87.64	10.76	11.04	17.8	4.13	1.02	0.46	-	-
Smectite	-	-	-	-	-	-	4.64	1.16	-	-
Spinel	-	-	-	-	-	-	4.44	-	-	-
Talc	-	-	-	-	-	-	5.55	7.79	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.

Table 11.2(b): X-Ray Diffraction Results (wt%) (Sheet 2)

Sample	HRM-12	HRM-13	HRM-14	HRM-15	HRM-16	HRM-17	HRM-18	HRM-19	HRM-21	HRM-22
Description /Rock Type*	Unprocessed Slag	Slimes (TSF)	DMS Lumpy Chrome Ore	DMS Waste	HFC Concentrate	Slag Fines	Final Slag Dump	MG-4 Ore	Return Material	Pellets
Actinolite	-	-	-	-	-	-	-	-	-	-
Amorphous	52.18	-	-	-	-	32.61	47.46	-	-	-
Amphibole	-	-	-	-	-	-	-	-	-	-
Biotite	-	-	-	-	-	-	-	-	-	-
Calcite	-	1.37	0.6	0.61	-	-	-	0.77	0.61	-
Chlorite	-	5.77	2.24	0.4	-	-	-	0.63	0.31	-
Chromite	-	19.46	41.47	4.04	78.86	-	-	40.17	64.24	80.17
Cristobalite	-	-	-	-	-	-	-	-	-	0.77
Dolomite	-	-	-	-	-	-	-	0.36	-	-
Diopside	-	-	-	-	-	2.68	6.89	-	-	-
Enstatite	13.79	14.43	3.97	62.03	-	12.25	12.17	12.91	12.34	-
Eskolaite	-	-	-	-	-	-	-	-	-	18.51
Graphite	-	-	-	-	-	-	-	-	-	-
Hematite	-	-	-	-	-	-	-	-	-	-
Kaolinite	-	-	0.74	-	-	-	-	-	-	-
Magnetite	-	-	-	-	-	-	-	-	-	-
Mica	-	1.22	0.76	0.77	-	-	-	0.6	-	-
Muscovite	-	-	-	-	-	-	-	-	-	-
Plagioclase	-	45.41	45.67	25.62	5.81	-	-	40.46	18.35	-
Quartz	-	2.98	0.38	1.58	-	39.3	1.26	1.31	1.11	0.55
Smectite	-	3.15	0.69	0.98	-	-	-	0.01	-	-
Spinel	34.03	-	-	0.47	-	13.16	32.23	-	-	-
Talc	-	6.21	3.48	3.53	-	-	-	2.78	3.04	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.**

Table 11.2(b): X-Ray Diffraction Results (wt%) (Sheet 3)

Sample	HRM-23	HRM-24	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32
Description /Rock Type*	Process Water Dam Sediments	OB Dam Sediment	Rehabilitated Pit 1	Rehabilitated Pit 2	Rehabilitated Pit 3	Rehabilitated Pit 4	Mining Waste Rock Stockpile	Grout Plant	Western Backfill	Mixed Waste
Actinolite	-	-	-	-	-	-	-	-	2.16	1.65
Amorphous	-	-	-	-	-	-	-	-	-	-
Amphibole	-	-	-	-	-	-	5.9	-	-	-
Biotite	-	-	-	-	-	-	2.03	-	-	-
Calcite	-	0.3	1.48	1.32	1.27	2.04	-	-	-	-
Chlorite	0.61	0.93	12.46	7.83	6.87	9.07	-	9.61	3.64	1.48
Chromite	57.01	65.43	32.97	49.05	42.33	37.97	8.86	30.12	23.07	22.23
Cristobalite	-	-	-	-	-	-	-	-	-	-
Dolomite	-	-	-	-	-	-	-	0.14	-	-
Diopside	-	-	-	-	-	-	-	-	4.02	3.19
Enstatite	12.95	11.37	11.69	13.32	18.87	16.68	-	14.56	5.48	36.68
Eskolaite	-	-	-	-	-	-	-	-	-	-
Graphite	-	-	-	-	-	-	-	-	-	-
Hematite	-	-	-	-	-	-	-	-	-	-
Kaolinite	1.24	-	0.19	1.53	2.52	2.85	0.11	0.08	2.46	0.85
Magnetite	-	-	-	-	-	-	-	-	-	-
Mica	1.4	1.11	3.26	1.06	1.64	1.89	-	2.5	-	-
Muscovite	-	-	-	-	-	-	-	-	0.96	0.71
Plagioclase	17.1	13.86	9.3	10.25	11.81	11.31	33.48	8.83	30.67	19.31
Quartz	3.58	2.25	2.84	2.67	2.29	3.07	-	21.91	3.42	1.63
Smectite	-	17.15	5.74	5.04	5.77	-	5.8	-	7.88	3.21
Spinel	-	-	-	-	-	-	-	-	-	-
Talc	6.12	4.74	8.64	7.23	7.35	8.95	1.97	6.45	16.24	9.05

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.

Table 11.2(c): X-Ray Fluorescence Major Oxide Results (weight %) (Sheet 1)

Sample ID	HRM-1	HRM-2	HRM-3	HRM-4	HRM-5	HRM-6	HRM-8	HRM-9	HRM-10	HRM-11	Average Upper Crust (Rudnick and Gao, 2003)
Description /Rock Type*	Dolomite	Quartzite	ACP Char	Coke Nuts	Anthracite	Limestone	MG-1 Ore	MG-2 Ore	Chemstof Concentrate	UG-2 Concentrate	
SiO_2	15.43	91.15	12.85	10.36	9.76	2.83	17.7	16.36	3.55	4.17	66.6
TiO_2	0.01	0.22	0.29	0.31	0.14	0.02	0.21	0.3	0.71	0.81	0.647
Al_2O_3	0.51	4.66	7.35	3.18	3.04	0.82	15.06	14.38	13.4	13.27	15.4
Fe_2O_3	0.86	1.89	0.22	1.62	0.89	0.45	19.69	24.41	35.6	27.82	11.2
MnO	0.46	<0.01	0.01	0.01	0	0.73	0.22	0.21	0.24	0.23	0.1
MgO	16.86	0.08	0.31	0.1	0.15	2.5	13.56	12.77	7.07	9.85	2.48
CaO	26.9	0.12	0.47	0.2	0.31	49.79	2.38	1.82	0.37	0.48	3.59
Na_2O	0.02	0.58	0.02	0.01	0.08	<0.01	<0.01	0.14	<0.01	<0.01	3.27
K2O	0.08	0.66	0.14	0.17	0.23	0.39	0.14	<0.01	0.03	0.02	2.8
P_2O_5	0.05	0.08	0.02	0.04	0.02	<0.01	0.01	0.01	<0.01	<0.01	0.15
Cr_2O_3	0.05	0.04	0.02	0.07	0.1	0.01	30.2	29.83	40.54	41.14	0.013
SO_3	0.02	0.04	0.01	0.01	0.04	0.01	0.03	0.03	<0.01	0.01	-
LOI	39.11	0.6	73.45	82.55	84.3	41.41	0.16	-0.14	-1.5	1.78	-
Total	**100.39**	**100.24**	**99.34**	**100.84**	**99.39**	**99.1**	**99.45**	**100.19**	**<0.01**	**99.07**	**-**
H_2O^-	0.03	0.13	4.2	2.22	0.32	0.15	0.1	0.09	0.05	0.02	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.**

Table 11.2(c): X-Ray Fluorescence Major Oxide Results (weight %) (Sheet 2)

Sample ID	HRM-12	HRM-13	HRM-14	HRM-15	HRM-16	HRM-17	HRM-18	HRM-19	HRM-21	HRM-22	Average Upper Crust (Rudnick and Gao, 2003)
Description /Rock Type*	Unprocessed Slag	Slimes (TSF)	DMS Lumpy Chrome Ore	DMS Waste	HFC Concentrate	Slag Fines	Final Slag Dump	MG-4 Ore	Return Material	Pellets	
SiO_2	28.66	30.36	9.04	45.45	16.92	50.14	22.53	21.28	10.21	6.38	66.6
TiO_2	0.74	<0.01	0.43	0.21	0.04	0.49	0.75	<0.01	0.34	0.51	0.647
Al_2O_3	26.6	12.54	14.39	9.08	12.09	16.17	27.35	17.6	14.88	12.9	15.4
Fe_2O_3	5.46	16.53	31.47	13.9	28.54	7.02	7.6	19.53	25.32	33.56	11.2
MnO	0.29	0.21	0.21	0.21	0.2	0.2	0.32	0.17	0.25	0.23	0.1
MgO	19.35	14.03	9.13	19.66	11.77	9.18	21.42	11.6	10.88	9.94	2.48
CaO	4.94	4.03	1.6	4.83	2.51	3.2	6.5	3.39	1.03	0.3	3.59
Na_2O	3.6	0.85	<0.01	0.52	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3.27
K2O	0.64	0.21	0.06	0.16	0.02	0.55	0.29	0.04	0.05	<0.01	2.8
P_2O_5	0.02	0.02	0.01	0.04	0.01	0.02	0.03	0.01	0.01	<0.01	0.15
Cr_2O_3	11.09	17.36	34.57	4.56	27.46	11.33	13.13	26.91	35.25	37.64	0.013
SO_3	0.2	0.06	0.01	0.06	0.03	0.09	0.15	0.04	0.01	0.01	-
LOI	-1.55	-6.97	-0.91	0.85	-1.18	-0.27	-1.75	-0.07	1.12	-0.49	-
Total	**100.22**	**100.13**	**100.1**	**99.56**	**97.89**	**99.18**	**98.28**	**100.21**	**99.04**	**100.47**	**-**
H_2O^-	0.17	10.94	0.46	0.03	0.02	1.07	0.01	0.07	0.12	0.01	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.**

Table 11.2(c): X-Ray Fluorescence Major Oxide Results (weight %) (Sheet 3)

Sample ID	HRM-23	HRM-24	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	Average Upper Crust (Rudnick and Gao, 2003)
Description /Rock Type*	Process Water Dam Sediments	OB Dam Sediment	Rehabilitated Pit 1	Rehabilitated Pit 2	Rehabilitated Pit 3	Rehabilitated Pit 4	Mining Waste Rock Stockpile	Grout Plant	Western Backfill	Mixed Waste	
SiO_2	12.74	14.21	31.49	4.35	24.11	29.9	54.99	36.69	29.83	31.7	66.6
TiO_2	0.45	0.42	0.38	0.73	<0.01	<0.01	0.18	0.47	0.47	0.42	0.647
Al_2O_3	15.4	15.02	9.74	15.37	14.03	12.34	6.26	13.8	19.67	10.39	15.4
Fe_2O_3	23.6	22.64	18.52	27.64	20.74	16.27	10.84	15.14	13.6	17.69	11.2
MnO	0.24	0.23	0.34	0.21	0.19	0.21	0.2	0.26	0.41	0.72	0.1
MgO	11.32	10.52	13.14	10.64	13.44	13.81	20.7	11.73	8	16.68	2.48
CaO	1.66	1.78	2.61	0.13	3.72	3.97	4.19	3	4.93	2.32	3.59
Na_2O	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.43	0.13	<0.18	2.47	3.27
K2O	0.2	0.16	0.4	<0.01	0.09	0.21	0.16	0.29	1.07	0.4	2.8
P_2O_5	0.01	0.01	0.29	<0.01	0.01	0.02	0.04	0.05	<0.19	<0.19	0.15
Cr_2O_3	31.99	30.6	17.21	39.18	22.14	17.1	1.25	14.63	15.14	17.06	0.013
SO_3	0.02	0.02	0.32	<0.01	0.05	0.05	0.04	0.08	<0.4	<0.4	-
LOI	1.88	3.52	5.95	2.07	1.99	5.2	1.16	1.76	-14.17	0.01	-
Total	**99.03**	**98.72**	**100.74**	**99.86**	**100.09**	**99.04**	**100.42**	**98.08**	**<0.4**	**<0.4**	**-**
H_2O^-	0.05	0.01	0.37	0.05	-0.01	0.18	-0.01	0.05	19.96	0.35	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.**

Table 11.2(d): X-Ray Fluorescence Trace Element Results (Sheet 1)

Sample ID	HRM-1	HRM-2	HRM-3	HRM-4	HRM-5	HRM-6	HRM-8	HRM-9	HRM-10	HRM-11	Average Upper Crust (Rudnick and Gao, 2003)
Description/ Rock Type*	Dolomite	Quartzite	ACP Char	Coke Nuts	Anthracite	Limestone	MG-1 Ore	MG-2 Ore	Chemstof Concentrate	UG-2 Concentrate	
As	4.57	4.92	10.1	7.97	8.37	3.86	15.4	7.14	60.6	55.7	4.8
Ba	37	97	85.2	42.8	65.9	40.9	76.3	80.2	39.3	31.5	628
Bi	1.73	1.48	1.35	1.54	1.49	1.49	3.14	<0.68	<0.68	<0.68	0.16
Cd	<3.04	<3.04	<3.04	<3.04	<3.04	8.91	<3.04	<3.04	<3.04	16	1.6
Ce	4.07	37.9	57.9	69.5	12.6	<3.08	<3.08	<3.08	<3.08	<3.08	0.09
Cl	206	146	126	253	401	169	111	130	86.6	101	63
Co	6.35	<0.56	49.3	<0.56	<0.56	29.9	225	<0.56	235	182	370
Cs	1.12	1.06	1.21	1.15	1.14	1.1	1.19	1.3	1.36	1.25	17.3
Cu	<4.19	<4.19	14.5	<4.19	<4.19	<4.19	<4.19	4.96	<4.19	<4.19	4.9
Ga	<3.21	5.31	11.1	22.4	7.4	<3.21	<3.21	<3.21	<3.21	<3.21	28
Ge	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	17.5
Hf	6.37	6.18	6.47	6.35	6.37	6.38	5.58	5.98	5.27	5.4	1.4
Hg	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.3
La	107	94.4	98.5	76.7	85	77.7	<0.62	9.88	<0.62	9.28	0.05
Lu	1.47	1.6	1.79	1.91	1.61	1.29	6.24	5.65	8.37	8.28	0.022
Mo	2.19	1.23	2.11	0.7	2.31	2.3	1.19	2.01	1.56	1.75	31
Nb	<2.15	<2.15	<2.15	7.3	<2.15	2.47	5.32	2.83	8.27	7.43	0.31
Ni	<5.14	9.41	36.8	38.2	18.6	9.37	563	483	784	897	12
Pb	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	17
Rb	6.85	25.7	9.9	12.6	13	10.4	11.6	7.89	12.6	9.44	82
Sb	<1.48	<1.48	<1.48	<1.48	<1.48	1.82	<1.48	<1.48	<1.48	6.3	0.4
Sc	108	13.7	16.2	15.2	16.3	141	30.7	24.7	12.4	14.1	14
Se	<0.36	<0.36	<0.36	1.63	<0.36	<0.36	8.42	5.33	22.8	19.6	0.09
Sm	5.36	9.73	12	14.2	11.8	3.47	<1.62	<1.62	20	15.6	4.7
Sn	2.69	3.03	3.56	6.24	4.99	1.66	7.28	8.96	8.92	8.72	2.1
Sr	9.79	17.3	68.4	46	57.7	28.4	43.7	32.2	8.84	3.69	320
Ta	1.03	1.02	0.52	0.6	0.93	0.82	2.29	2.47	2.56	3	0.9
Te	4.21	<0.16	<0.16	0.24	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	-
Th	<0.88	3.59	5.96	1.92	1.17	<0.88	<0.88	<0.88	<0.88	<0.88	10.5
Tl	2.59	2.49	2.16	2.25	2.24	2.5	5.43	5.32	3.96	2.73	0.9
U	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	2.7
V	74.3	83.1	91.5	177	93.9	65.4	991	802	1 767	1 388	97
W	1	0.75	0.73	0.78	0.84	0.98	6.21	5.36	7.95	6.73	1.9
Y	4.18	14.4	33.2	21.3	9.98	3.67	3.8	4.1	<0.97	1.46	21
Yb	3.54	1.84	<1.05	1.65	2.28	3.29	28.5	24.8	38.6	32.7	2
Zn	<5.49	<5.49	74	<5.49	<5.49	<5.49	525	255	720	576	67
Zr	<1.47	238	72.9	194	37	<1.47	26.4	3.29	10.2	4.08	193

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.

Table 11.2(d): X-Ray Fluorescence Trace Element Results (Sheet 2)

Sample ID	HRM-12	HRM-13	HRM-14	HRM-15	HRM-16	HRM-17	HRM-18	HRM-19	HRM-21	HRM-22	Average Upper Crust (Rudnick and Gao, 2003)
Description /Rock Type*	**Unprocessed Slag**	**Slimes (TSF)**	**DMS Lumpy Chrome Ore**	**DMS Waste**	**HFC Concentrate**	**Slag Fines**	**Final Slag Dump**	**MG-4 Ore**	**Return Material**	**Pellets**	
As	5.24	<0.43	41.3	<0.43	46.7	3.66	4.52	<0.43	46.1	57	**4.8**
Ba	149	108	47.3	72.7	26	136	139	63.5	72.2	65.6	**628**
Bi	4.12	4.71	<0.68	1.31	<0.68	3.32	4.33	3.62	<0.68	<0.68	**0.16**
Cd	<3.04	7.92	<3.04	<3.04	<3.04	<3.04	21.4	<3.04	39.6	<3.04	**1.6**
Ce	27.6	<3.08	<3.08	<3.08	<3.08	<3.08	14.4	13.3	<3.08	<3.08	**0.09**
Cl	105	172	111	147	109	123	105	129	113	89.1	**63**
Co	<0.56	101	301	<0.56	69.4	<0.56	<0.56	41	313	205	**370**
Cs	1.18	1.26	1.29	1.08	1.37	1.16	1.15	1.19	1.32	1.43	**17.3**
Cu	<4.19	28.5	<4.19	<4.19	<4.19	<4.19	<4.19	<4.19	<4.19	<4.19	**4.9**
Ga	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	**28**
Ge	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	**17.5**
Hf	6.3	5.93	5.22	6.28	5.63	6.26	6.29	5.66	5.78	5.82	**1.4**
Hg	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	**5.3**
La	41.4	1.32	39.3	34.2	<0.62	48.2	62.8	<0.62	<0.62	<0.62	**0.05**
Lu	2.42	5.78	7.76	3.48	7.49	2.7	2.59	6.3	9.07	9.67	**0.022**
Mo	1.23	2.11	1.75	2.11	1.78	1.39	1.27	1.86	1.67	1.81	**31**
Nb	<2.15	4.13	5.93	<2.15	4.5	<2.15	<2.15	3.43	8.08	7.45	**0.31**
Ni	40.8	501	670	269	819	94.6	62.3	480	693	743	**12**
Pb	<2.03	45.4	<2.03	8.75	<2.03	<2.03	<2.03	<2.03	<2.03	<2.03	**17**
Rb	17.9	21.9	12.2	8.12	8.73	16.9	9.14	9.91	15.4	11.3	**82**
Sb	1.68	3.41	<1.48	1.81	<1.48	2.22	2.04	<1.48	3.82	<1.48	**0.4**
Sc	29.9	32.3	22.9	27.4	16.9	23.1	34.6	37.2	16.3	13.9	**14**
Se	<0.36	0.48	17.2	<0.36	19.6	<0.36	<0.36	3.98	21.3	23.6	**0.09**
Sm	<1.62	<1.62	5.81	7.12	21.3	<1.62	<1.62	<1.62	8.17	18.5	**4.7**
Sn	3.92	7.41	8.21	8.64	9.37	4.93	4.19	8.12	7.55	8.98	**2.1**
Sr	68.3	60.6	33.9	67.1	4.36	43	60.7	66.1	18.1	11.1	**320**
Ta	1.01	2.56	4.27	1.32	3.9	0.95	0.77	2.42	3.47	2.85	**0.9**
Te	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	**-**
Th	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	**10.5**
Tl	2.78	5.86	4.83	2.96	3.53	3.21	3.37	4.71	5.09	4.5	**0.9**
U	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	**2.7**
V	360	659	1 320	171	1 219	309	404	863	1 385	1 461	**97**
W	1.41	4.47	7.15	1.91	6.65	1.6	1.5	5.05	7.64	7.46	**1.9**
Y	14.2	7.13	<0.97	5.05	1.4	11.3	14	4.34	2.1	<0.97	**21**
Yb	5.54	28.3	33.7	7.66	32.7	6.99	5.98	25.1	37.7	34.2	**2**
Zn	<5.49	2 638	547	<5.49	505	49.1	15.7	302	1 579	731	**67**
Zr	102	19.2	3.66	6.02	2.14	106	80.8	14.1	18.3	15.4	**193**

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.**

Table 11.2(d): X-Ray Fluorescence Trace Element Results (Sheet 3)

Sample ID	HRM-23	HRM-24	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	Average Upper Crust (Rudnick and Gao, 2003)
Description /Rock Type*	Process Water Dam Sediments	OB Dam Sediment	Rehabilitated Pit 1	Rehabilitated Pit 2	Rehabilitated Pit 3	Rehabilitated Pit 4	Mining Waste Rock Stockpile	Grout Plant	Western Backfill	Mixed Waste	
As	17.3	20.1	<0.43	9.28	<0.43	<0.43	<0.43	<0.43	0.78	<0.43	4.8
Ba	48.3	102	82.2	116	87.8	93.7	79.1	102	80.6	83.5	628
Bi	<0.68	<0.68	1.95	<0.68	4.17	2.68	1.04	4.04	3.74	3.93	0.16
Cd	<3.04	<3.04	<3.04	<3.04	<3.04	<3.04	3.27	<3.04	<3.04	<3.04	1.6
Ce	<3.08	<3.08	<3.08	<3.08	<3.08	<3.08	36.2	<3.08	18.1	<3.08	0.09
Cl	146	209	157	120	143	137	178	124	135	140	63
Co	206	207	32	236	92.3	65	<0.56	7.78	<0.56	23.4	370
Cs	1.48	1.33	1.23	1.29	1.25	1.26	1.11	1.14	1.17	1.19	17.3
Cu	6	11.6	24.6	8.93	20.5	21.8	<4.19	<4.19	<4.19	<4.19	4.9
Ga	<3.21	<3.21	<3.21	<3.21	<3.21	<3.21	9.4	<3.21	<3.21	<3.21	28
Ge	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	17.5
Hf	5.35	5.45	5.81	5.68	5.73	6.04	6.28	6.23	6.25	5.62	1.4
Hg	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	5.3
La	<0.62	<0.62	<0.62	<0.62	20.5	12.1	38.6	20.6	42	<0.62	0.05
Lu	7.84	8.08	6.52	7.9	6.42	6.65	3.8	5.3	4.05	5.89	0.022
Mo	1.69	2	2.23	2.36	2.07	2.17	1.98	1.98	2.3	1.96	31
Nb	4.65	7.74	4.67	6.31	<2.15	2.76	<2.15	<2.15	<2.15	3.05	0.31
Ni	628	643	525	678	572	531	297	338	701	961	12
Pb	20.4	<2.03	56.1	<2.03	17.6	53.4	33.6	<2.03	263	490	17
Rb	17.8	15.1	17.4	12.9	9.72	16.7	9.08	13.8	<2.03	43.8	82
Sb	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	<1.48	10.2	10.6	0.4
Sc	18.3	21.6	31.4	34.5	31.9	31.8	30.4	27.8	<1.48	<1.48	14
Se	12.7	12.3	<0.36	9.14	3.3	<0.36	<0.36	0.62	36.4	37.2	0.09
Sm	<1.62	<1.62	<1.62	5.31	<1.62	<1.62	12.4	<1.62	<0.36	2.43	4.7
Sn	8.13	8.6	8.21	7.19	7.84	7.66	8.83	7.19	<1.62	<1.62	2.1
Sr	23	31.4	41.4	43	56.4	50.4	61.7	45.5	7	8.68	320
Ta	3.5	3.17	1.89	2.99	2.41	2	1.38	1.28	105	53.9	0.9
Te	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	1.18	<0.16	1.3	2.11	-
Th	<0.88	<0.88	<0.88	<0.88	<0.88	<0.88	1.35	<0.88	<0.16	<0.16	10.5
Tl	7.31	6.17	4.84	5.99	4.97	4.82	2.4	3.82	<0.88	<0.88	0.9
U	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	<0.74	4	4	2.7
V	1 198	1 195	584	1 032	796	658	144	598	<0.74	<0.74	97
W	6.83	7.58	4.18	6.71	5.52	4.24	1.65	3.13	422	687	1.9
Y	4.28	3.55	6.17	2.9	5.36	6.49	5.3	8.77	2.94	4.75	21
Yb	40	37.5	23.8	31.5	28.1	23.2	6.58	14.8	5.67	4.33	2
Zn	3 131	971	1 919	622	304	1 573	<5.49	600	14.4	23.9	67
Zr	18	22.2	22.8	17.4	21	16.3	29.2	57.8	743	219	193

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile.

In order to assess whether any relationships exist between the oxides present in the material samples analysed, specific chemistry plots were assessed. The followings were generated in support of this geochemical assessment:

- Figure 11.2(a): MnO against CaO + MgO
- Figure 11.2(b): Fe_2O_3 and Al_2O_3 against Cr_2O_3
- Figure 11.2(c): TiO_2 against Al_2O_3
- Figure 11.2(d): V, Nd and Ni against Cr_2O_3
- Figure 11.2(e): Se and As against Cr_2O_3

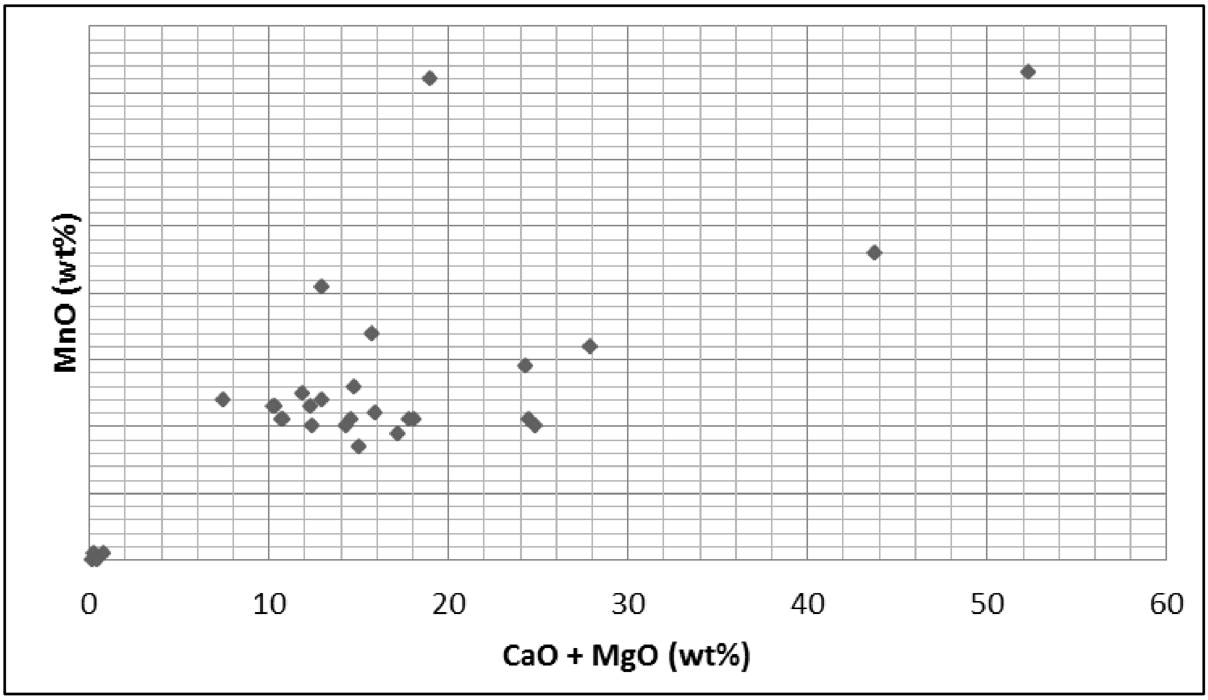


Figure 11.2(a): MnO against CaO + MgO

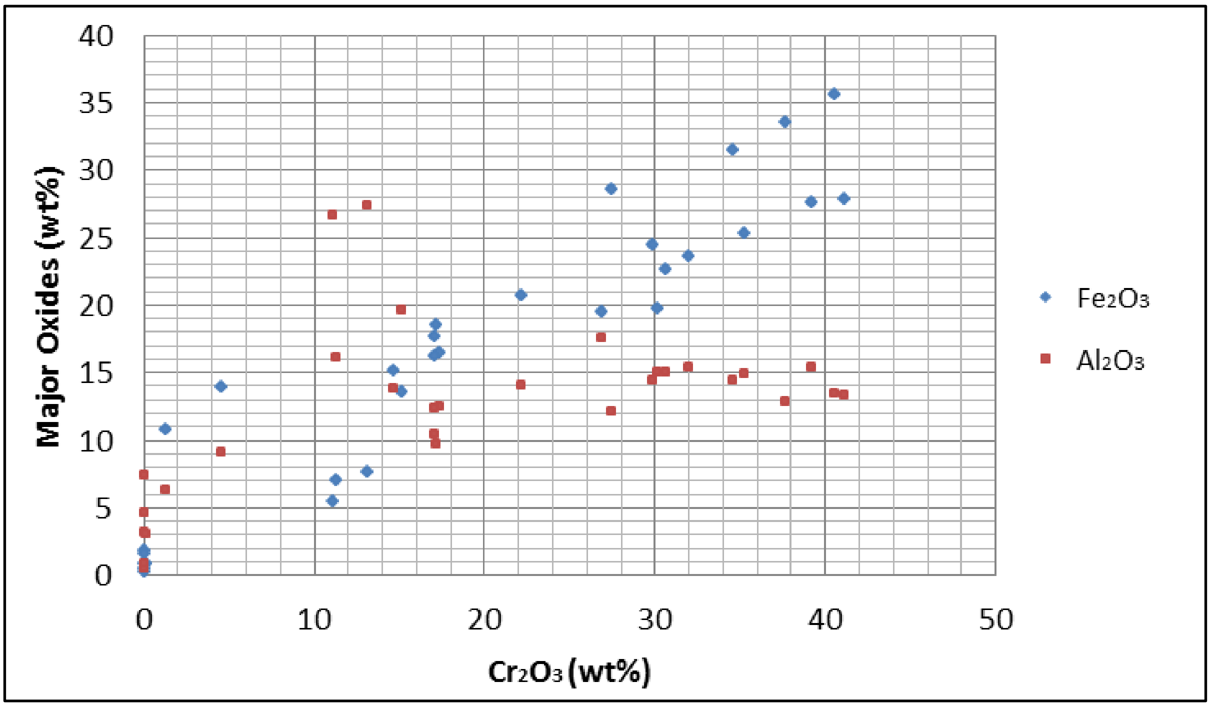


Figure 11.2(b): Fe_2O_3 and Al_2O_3 against Cr_2O_3

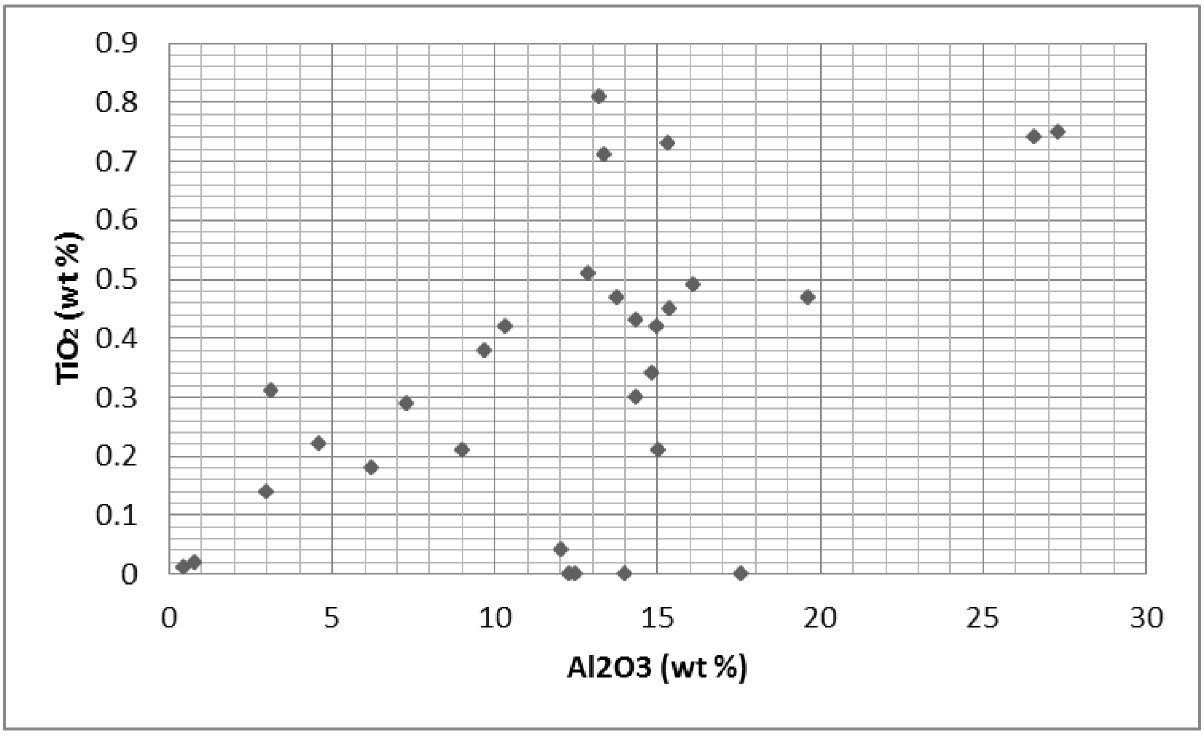


Figure 11.2(c): TiO_2 against Al_2O_3

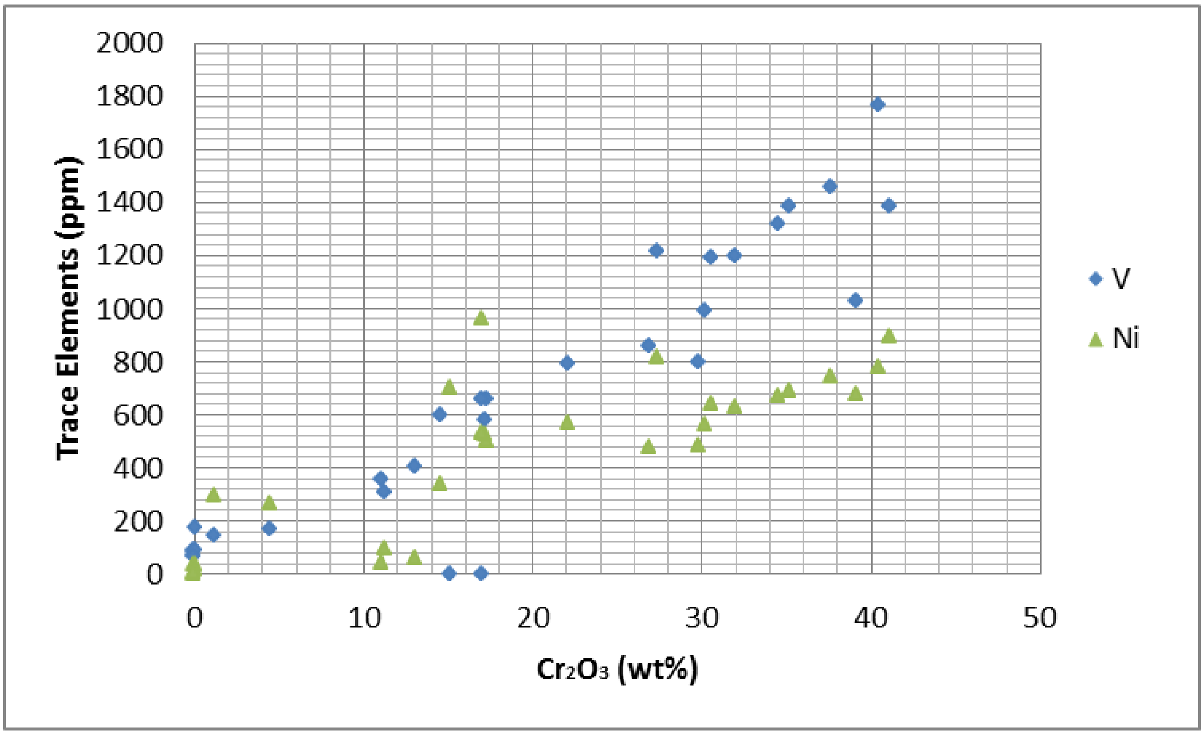


Figure 11.2(d): V, Nd and Ni against Cr_2O_3

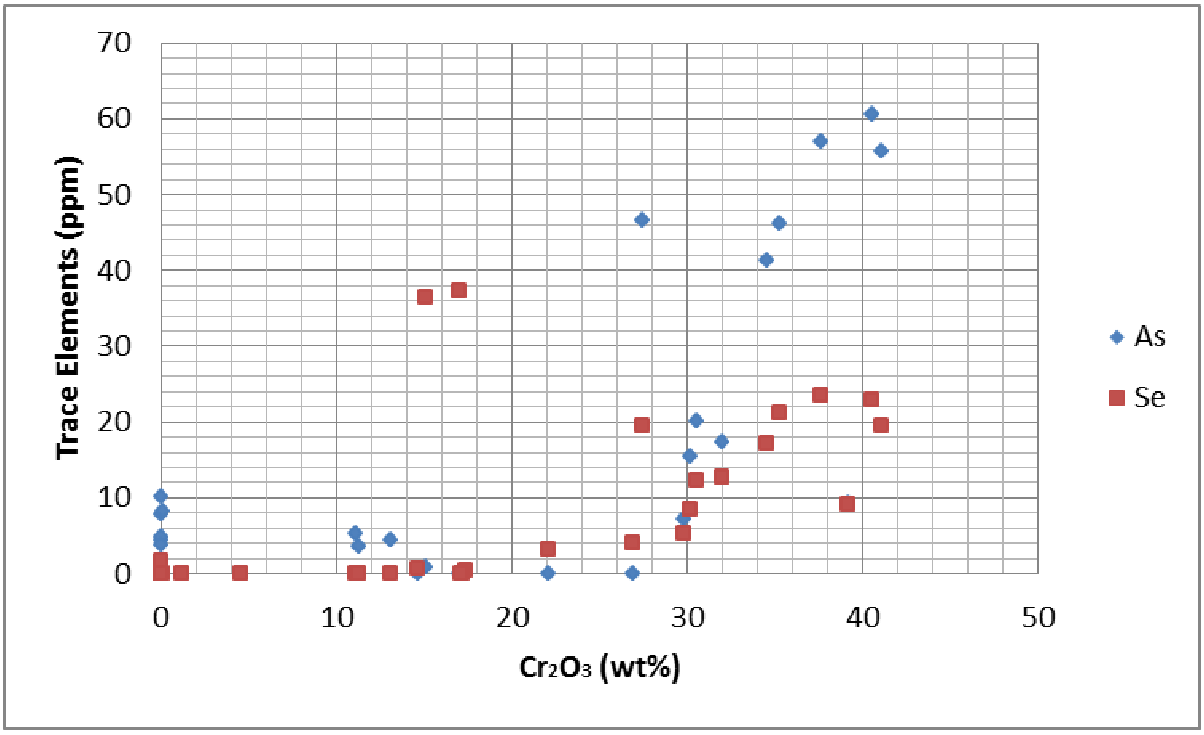


Figure 11.2(e): Se and As against Cr_2O_3

Based on the mineralogical and total element composition of the material samples analysed, the following comments have relevance:

- The unprocessed slag, slag fines and processed slag (HRM-12, HRM-17 and HRM-18) comprise primarily of spinel, amorphous minerals (probably Cr-Fe-Mg phases) and enstatite. The reworked slag samples also contain some minor concentrations of diopside and quartz.

  The slag samples have a resultant high Mg content especially because of the high spinel, enstatite and other Mg-minerals present. The samples also have a relatively high Al, Cr_2O_3 and Ca content. Al_2O_3 was essentially concentrated in the slag (waste) and decreased in the final product (see Figure 11.2(b)) and discussion further below). Although the SiO_2 is relatively higher than other oxides it is lowered with respect to the Average Upper Earth Crust (Rudnick and Gao, 2003). This is partly due to the low SiO_2 content of the original ore concentrate.

- The Coke Nuts (HRM-4) contains about 89% carbon (graphite) and 11% quartz according to the XRD results. The XRF results are probably more correct with 83% Loss on Ignition (LOI) of the sample. The remainder comprise primarily of SiO_2, Al_2O_3 and Fe_2O_3.

- The limestone (HRM-6) is comprised mostly of calcite (86%) with some minor dolomite (6%), mica (4%) and quartz (4%). The limestone has a high Loss on Ignition due to its CO_3 content. CaO is the dominant element in the limestone.

- The ore concentrate (HER-10 and HRM-11) samples comprised predominantly of chromite (89 - 91%) with some minor quartz and plagioclase. The total element composition is therefore almost totally comprised of Fe_2O_3, Cr_2O_3 with some minor Al_2O_3 and MgO.

- The pellets (HRM-22) mostly comprised of chromite (80%), some eskolaite (19%) with miner amounts of quartz and cristobalite. The total element composition is almost totally comprised of Fe_2O_3, Cr_2O_3 with some Al_2O_3, MgO and very small amounts of SiO_2.

- The quartzite (HRM-2) is comprised mostly of quartz (88%), plagioclase (10%) with some graphite, mica, kaolinite and magnetite. The total element composition is almost totally made up of SiO_2 (91%) with someAl_2O_3.

- The dolomite (HRM-1) is comprised of dolomite (86%), quartz (13%) and some traces of mica. The sample has therefore a high LOI of 39% with CaO, MgO and SiO_2 as the major oxides. MnO is slightly elevated in the samples relative to other samples. The relation between MnO and the CaO and MgO content of all material is discussed further below (and the relation is also depicted in Figure 11.2(a)).

- The ACP char (HRM-3) and anthracite (HRM-5) is comprised mostly of graphite (86%) and (63%) respectively with some quartz (11% - 18%) and small amounts of kaolinite. Anthracite contains about 13% of mica. Both samples have a high LOI of (73%) and (84%) respectively. The rest of the concentration is mostly made up of SiO_2 and Al_2O_3.

- The Sediment traps – at the process water dam (HRM-23) and OB dam (HRM-24) are comprised of chromite (57% and 65%) with some plagioclase, enstatite, quartz, clay and talc. The process dam sediment trap contains kaolinite clay and the OB dam has smectite clay minerals. The source water of these dams has high chromite content (as suspended material) as the water originates from plant and stockpile areas.

- The slimes (TSF) (HRM-13) are comprised of plagioclase (45%), chromite (19%), enstatite (14%), talc (6%), chloride (6%) with traces of smectite, quartz, calcite and mica. The total concentration indicates high SiO_2 (30%), Cr_2O_3 (17%), Fe_2O_3 (17%), MgO (14%) and Al_2O_3 (13%). Importantly, there is a higher concentration of CaO (4%) than Na_2O (0.85%).

  The high amounts of Ca-plagioclase are quite significant because it can relatively quickly weather to clays in relation to the other silicate minerals. This is supported by Bowen's reaction series. This will imply that tailings may potentially adsorb a significant part of any metals released onto the clays. The potential of the slimes (and slag) to produce clays must be further investigated. The fine clays will also slow the movement of water through the dams (and dump) and may increase instability issues.

- The MG-1 (HRM-8), MG-2 (HRM-9) and MG-4 (HRM-19) ore comprises mostly of chromite as expected (47%), (39%) and (40%) respectively with some plagioclase (19%), (24%) and (40%) respectively, enstatite (10%), (21%) and (13%) with small amounts of talc, spinel, smectite, chlorite, mica and calcite. The total element composition is therefore almost totally comprised of Cr_2O_3, Fe_2O_3 with some SiO_2, Al_2O_3 and MgO.

- The DMS Lumpy chrome ore (HRM-14) comprises mostly of plagioclase (46%), chromite (42%) with minor amounts of chlorite, calcite, enstatite, kaolinite, mica, quartz, smectite and talc. The total element composition is therefore almost totally made up of Cr_2O_3, Fe_2O_3 with some SiO_2, Al_2O_3 and MgO.

- The DMS waste (HRM-15) comprises mostly of enstatite (62%), plagioclase (26%) with minor amounts of quartz, smectite, spinel, talc, calcite, chlorite, chromite and mica. The total element composition is therefore almost totally comprised of SiO_2, MgO, Al_2O_3, Fe_2O_3, CaO and Cr_2O_3.

- The HFC Concentrate (HRM-16) comprises only of plagioclase (40%) and chromite (40%). The total element composition is therefore almost totally comprised of Cr_2O_3, Fe_2O_3 with some SiO_2, Al_2O_3 and MgO.

- The Return Material (HRM-21) comprises of chromite (64%), plagioclase (18%) and enstatite (12%) with small amounts of calcite, chlorite, quartz and talc. The total elemental composition therefore comprises almost totally of Cr_2O_3, Fe_2O_3 with some SiO_2, Al_2O_3 and MgO.

- The backfill samples at the rehabilitated pit and western backfill (HRM 25, HRM 26, HRM 27, HRM 28 and HRM-31) is mainly made up of chromite (23% - 49%), enstatite (5% - 19%) and plagioclase (9% - 31 %). The western backfill contains in contrast to the other 4 samples more plagioclase than enstatite. The western backfill also contains actinolite, diopside and muscovite which are not present in the other 4 samples. The other smaller minerals which are found in the backfill material consist of calcite, chlorite, kaolinite, mica, quartz, smectite and talc. The total concentration indicates low amounts Cr_2O_3 with high amounts of SiO_2, Al_2O_3, TiO_2, MnO and P_2O_5.

- The mining waste (HRM-29) is made up mostly of plagioclase (31%) with lesser chromite (9%) and amphibole, biotite, kaolinite, smectite and talc. The total concentration indicates high amounts of SiO_2 (55%), MgO (21%), Fe_2O_3 (11%) and Al_2O3 (6%).

- The grout plant material (HRM -30) is made up mostly of chromite (30%), quartz (22%), enstatite (15%), chlorite (10%) and plagioclase (9%) with small amounts of dolomite, magnetite and mica. The total concentration indicates high amounts of SiO_2 (37%), Cr_2O_3 (15%), Fe_2O_3 (15%), Al_2O_3 (14%) and MgO (12%).

- The mixed waste sample from the area around the OB plant (HRM-31) is made up mostly of enstatite (37%), chromite (22%) and plagioclase (19%) with small amounts of actinolite, chlorite, diopside, kaolinite, muscovite, quartz, smectite and talc. The total concentration indicates high amounts of SiO_2, Fe_2O_3, Cr_2O_3, MgO and Al_2O_3.

- MnO shows surprisingly no significant correlation with Fe_2O_3 and Cr_2O_3 but rather some excellent correlation with CaO + MgO especially at higher concentrations (see Figure 11.2(a)). This is probably due to the fact that MnO is relatively low in the original ore and some raw material like the dolomite and limestone contains much higher MnO than the concentrated ore material (HRM-10 and 11). Mn in general is also often elevated in carbonate rocks and may replace the Fe in carbonates for example siderite ($FeCO_3$).

- In the plant process Cr_2O_3 and Fe_2O3 are concentrated and Al_2O_3 typically decreased. The correlation of Fe2O3 and Al2O3 with Cr2O3 is depicted in Figure 11.2(b). Fe_2O_3 shows a positive correlation with both low and high Cr_2O_3 contents because these two elements often occur in the same mineral phases (e.g. chromite). Al_2O_3 shows no correlation with Cr_2O_3 at low Cr_2O_3 content but a definite negative correlation at higher Cr_2O_3 content. There is not a clear positive correlation between TiO_2 and Al_2O_3 is depicted in Figure 11.2(c).

- Several trace elements that are present in the concentrated ore (HRM-10 and HRM 11) also increase with the Cr_2O_3 content. V and Ni shows correlation with Cr_2O_3 as depicted in Figure 11.2(d). Cl is probably associated with the plant processes. As and Se shows a positive correlation with high Cr_2O_3 (see Figure 11.2(e)). This indicates that As and Se are essentially bonded with certain metals associated with the Cr_2O_3 phases and not associated with the sulphur (as often the case in sulphide containing rock).

It is important to note that an elevation of certain parameters above the Average Upper Crust values, determined by Rudnick and Gao (2003) is not an indication of the leachability of the trace elements and metals. The leachability of the elements and metals is further assessed by means of leaching tests, and is discussed in Section 11.4.

11.3 ACID BASE ACCOUNTING AND ACID GENERATION POTENTIAL

11.3.1 ABA Terminology and Screening Methods

Acid-Base Accounting (ABA) is a static test where the net potential of a rock or material in order to produce acidic drainage is assessed. This test is an important first order assessment of the potential leachate that could be expected from the material. A description of the different ABA components is given below:

- AP (Acid Potential) is determined by multiplying the %S with a factor of 31.25. The unit of AP is kg $CaCO_3$/t rock and indicates the theoretical amount of calcite neutralised by the acid produced;
- The NP (Neutralisation Potential) is determined by treating a material sample with a known excess of standardised hydrochloric or sulphuric acid (the sample and acid are heated to insure reaction completion). The paste is then back-titrated with standardised sodium hydroxide in order to determine the amount of unconsumed acid. NP is also expressed as kg $CaCO_3$/t rock as to represent the amount of calcite theoretically available to neutralize the acidic drainage;
- The Net Neutralizing Potential (NNP) is determined by subtracting AP from NP;

In order for the material to be classified in terms of their Acid Rock Drainage potential, the ABA results are screened in terms of its NNP, %S and NP:AP ratio as follows:

- A rock with NNP < 0 kg $CaCO_3$/t will theoretically have a net potential for acidic drainage. A rock with NNP > 0 kg $CaCO_3$/t rock will have a net potential for the neutralisation of acidic drainage. Because of the uncertainty related to the exposure of the carbonate minerals or the pyrite for reaction, the interpretation of whether a rock will actually be net acid generating or neutralizing is more complex. Research has shown that a range from -20 kg $CaCO_3$/t to 20 kg $CaCO_3$/t exists that is defined as a "grey" area in determining the net acid generation or neutralisation potential of a rock. Material with a NNP above this range is classified as Rock Type IV - No Potential for Acid Generation, and material with a NNP below this range as Rock Type I - Likely Acid Generating;
- Further screening criteria could be used that attempts to classify the rock in terms of its net potential for acid production or neutralisation. The screening methods given in Table 11.3(a) below, as proposed by Price (1997), use the NP:AP ratio to classify the rock in terms of its potential for acid generation;
- Soregaroli and Lawrence (1998) further states that samples with less than 0.3% sulphide sulphur are regarded as having insufficient oxidisable sulphides to sustain long term acid generation. Material with a %S below 0.3% is therefore classified as Rock Type IV - No Potential for Acid Generation, and material with a %S of above 0.3%, as Rock Type I - Likely Acid Generating.

Table 11.3(a): Screening Methods using the NP:AP Ratio (Price, 1997)

Potential for Acid Generation	NP:AP screening criteria	Comments
Rock Type I. Likely Acid Generating.	< 1:1	Likely AMD generating.
Rock Type II. Possibly Acid Generating.	1:1 – 2:1	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides.
Rock Type III. Low Potential for Acid Generation.	2:1 – 4:1	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficient reactive NP.
Rock Type IV. No Potential for Acid Generation.	>4:1	No further AMD testing required unless materials are to be used as a source of alkalinity.

11.3.2 NAG Test and Screening Method

In the Net Acid Generation (NAG) test hydrogen peroxide (H_2O_2) is used to oxidize sulphide minerals in order to predict the acid generation potential of the sample. The NAG test provides a direct assessment of the potential for a material to produce acid after a period of exposure (to a strong oxidant) and weathering. The test can be used to refine the results of the ABA predictions.

In general, the static NAG test involves the addition of 250 *ml* of 15% H_2O_2 to 2.5 *g* of sample in a 500 *ml* wide mouth conical flask, or equivalent. The sample is covered with a watch glass, and placed in a fumehood or well-ventilated area. Once "boiling" or effervescing ceases, the solution is allowed to cool to room temperature and the final pH (NAG pH) is determined. A quantitative estimation of the amount of net acidity remaining (the NAG capacity) in the sample is determined by titrating it with NaOH to pH 4.5 (and/or pH 7.0) to obtain the NAG Value.

In order to determine the acid generation potential of a sample, the screening method given in Table 11.3(b) of Miller et al. (1997) is used.

Table 11.3(b): NAG Test Screening Method (Edited from Miller *et al.*, 1997)

Rock Type	NAG pH	NAG Value (H_2SO_4 kg/t)	NNP ($CaCO_3$ kg/t)
Rock Type Ia. High Capacity Acid Forming.	< 4	> 10	Negative
Rock Type Ib. Lower Capacity Acid Forming.	< 4	≤ 10	-
Uncertain, possibly Ib.	< 4	> 10	Positive
Uncertain.	≥ 4	0	Negative (Reassess mineralogy)*
Rock Type IV. Non-acid Forming.	≥ 4	0	Positive

****If non- or low acid forming sulphides is dominant then Rock Type IV.***

11.3.3 ABA and NAG Test Results

The Acid-Base Accounting (ABA) and Net-Acid Generating (NAG) tests were performed by Waterlab (Pty) Ltd. The ABA and NAG test results are attached as APPENDIX IX to this report, and the test results are presented as follows:

- The ABA test results are presented in Table 11.3(c). The results above were screened as discussed in Section 11.3.1 as Rock Type I to IV;
- The average ABA results for the 3 carbonaceous samples is given in Table 11.3(d);
- The potential risk of the samples to generate AMD is presented in Table 11.3(e);
- The NAG test results are presented in Table 11.3(f); and
- The classification of the material samples in terms of %S and NP/AP is depicted on Figure 11.3(a).

Table 11.3(c): Acid Base Accounting (ABA) Results

Sample ID	Rock Type	Paste pH	Total %S	AP CaCO3 kg/t	NP CaCO3 kg/t	NNP $CaCO_3$ kg/t	NP/AP	Rock Type NNP	Rock Type %S	Rock Type NP/AP
HRM-3	ACP Char	8.00	0.53	17	9.16	-7.4	0.553	Uncertain	I	I
HRM-4	Coke Nuts	8.00	0.75	23	2.68	-21	0.114	I	I	I
HRM-5	Anthracite	6.00	0.86	27	3.4	-23	0.127	I	I	I
HRM-5 (Duplicate)	Anthracite	6.00	0.92	29	4.6	-24	0.16	I	I	I

Table 11.3(d): Average Acid Base Accounting (ABA) Results

Material	Number of samples	Total %S	AP $CaCO_3$ kg/t	NP $CaCO_3$ kg/t	NNP $CaCO_3$ kg/t	NP/AP	Rock Type NNP	Rock Type %S	Rock Type NP/AP
Coke, Anthracite & ACP Char	3	0.765	24	4.96	-18.85	0.2385	Uncertain	I	I

Table 11.3(e): Potential to Generate Acidic Drainage

Material	Number of samples	Rock Type (%S) I	Rock Type (NP/AP) I or II	Rock Type (%S) I	Rock Type (NP/AP) III or IV	%S 0.1 - 0.3	Rock Type (NP/AP) I or II	%S 0.1 - 0.3	Rock Type (NP/AP) III or IV	%S <0.1	Rock Type (NP/AP) I or II	%S <0.1	Rock Type (NP/AP) III or IV
Coke, Anthracite & ACP Char	3	3		0		0		0		0		0	
Potential for acid mine drainage		**High potential for acid generation. High salt load.**		Low to high potential for acid generation. Low to high salt load.		Low to medium potential for acid generation. Low to medium salt load.		Low potential for acid generation. Low salt load.		No potential for acidic drainage. Very low/no salt load.		No potential for acidic drainage. Very low/no salt load.	

Table 11.3(f): Net Acid Generation (NAG) Test Results

Sample ID	Description	NAG pH (H_2O_2)	*	NAG Value (H_2SO_4 kg/t)	NNP ($CaCO_3$ kg/t)	Rock Type
HRM-3	ACP Char	4.4		0.588	-7.4	Ib
HRM-4	Coke Nuts	4.2		0.392	-21	Ib
HRM-5	Anthracite	2.7		60	-23	Ia
HRM-5 (D)	Anthracite	2.6		62	-24	Ia

* High potential for acid generation and high salt load.

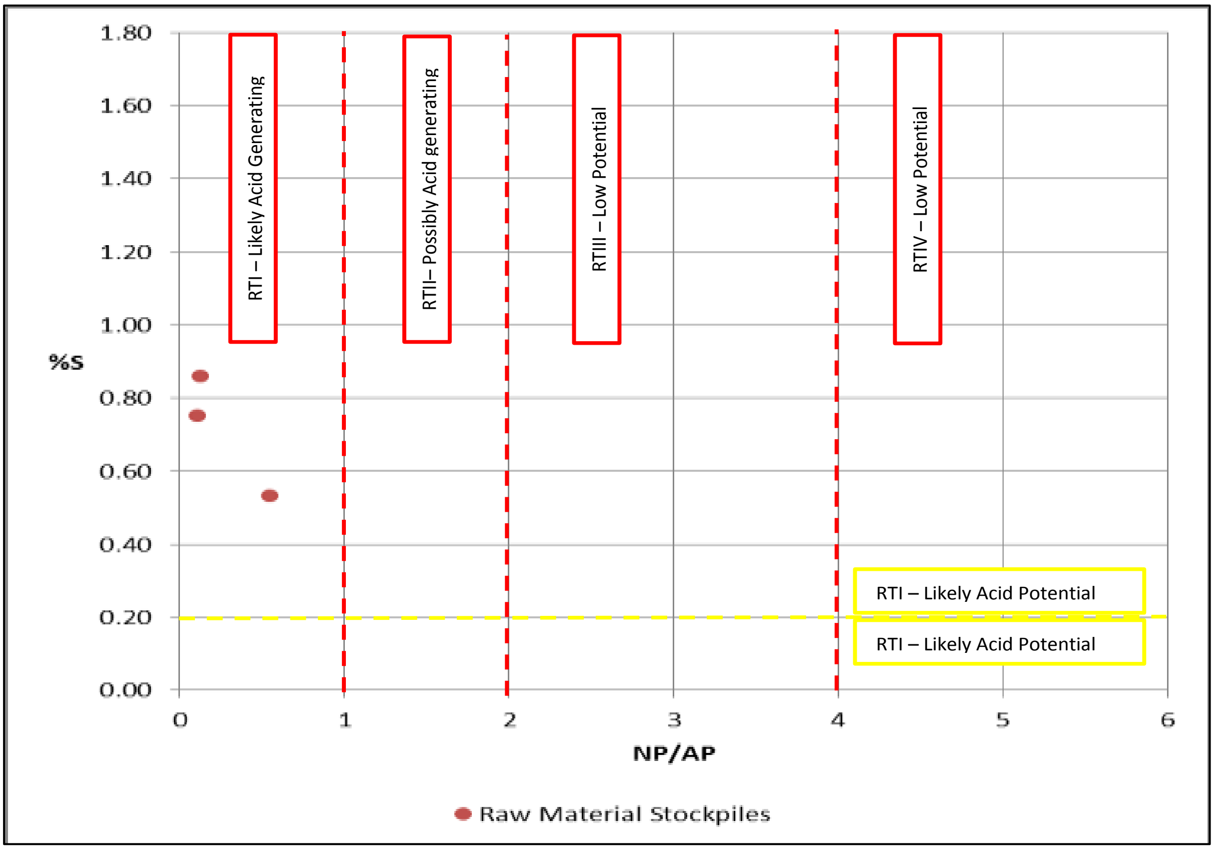


Figure 11.3(a): Classification of Carbonaceous Material in terms of %S and NP/AP

From the ABA and NAG test results the following observations are made:

- The total S% (determined by means of a leco analyser) was used to determine the Acid Potential (AP) of the rock. This is an overestimation as it assumes that all the sulphur in the rock will be acid-producing. Pyrite was the only sulphide detected in the rock through means of XRD. It was assumed that oxidation of pyrite will be the only contributor to acidity.

- The NP/AP indicates the potential for the rock to generate acid drainage, whereas the %S indicates whether this drainage will be over the long term. In Figure 11.3(a) the red lines indicate the acid production potential, whilst the yellow line indicate the long term acid generation potential.

- The 3 samples have a high %S (>0.765) with a resultant high Acid Potential (AP). The Neutralisation Potential (NP) of the samples is also much lower than the AP and therefore the samples will have a net potential to generate acid-mine drainage.

- The NAG test results confirm the acid potential of samples HRM-3 and HRM-4 and HRM-5.

- Overall, carbonaceous raw material has a large potential to generate acid over the medium to long-term. Some material has enough neutralisation potential not to generate acidic seepage over the short term (within a year). However, some material has little or no neutralisation potential and may therefore very quickly generate acidic seepage (after a few months). A high salt load will also be present per mass unit of the material. Whether a significant salt load will develop in the aquifer where the material is placed directly on the surface will also depend on the total mass of the material dumped. It is thus critical that the carbonaceous raw material be continually re-worked and not allowed a long residence (a couple of months) at the surface.

11.4 Reagent Water Leach

Reagent Water Leach analysis were undertaken on the 30 material samples collected at HERNIC. The Reagent water Leach Test results are attached as APPENDIX X in this report. The leachate generated from the **Reagent Water Leach Extract** were analysed for the following variables:

- Full Quantified ICP-MS analysis (Ag, Al, As, Au, B, Ba, Be, Bi, Ca*, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, Ir, K*, La, Li, Lu, Mg*, Mn, Mo, Na*, Nb, Nd, Ni, Os, P, Pb, Pd, Pr, Pt, Rb, Ru, Sb, Sc, Se, Si*, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr.)
- pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Ammonia, Total Alkalinity as $CaCO_3$, Bicarbonate Alkalinity as $CaCO_3$, Nitrate as N, Nitrite as N, Calcium, Chromium, Hexavalent Chrome as Cr^{6+}, Chloride, Magnesium, Sulphate, Ortho Phosphate, Sodium, Potassium, Silicon, Aluminium, Fluoride, Iron, Manganese and Total Cyanide.

The results for the major anions in the 1:20 Reagent Water Leach test are given in Table 11.4(a) and are compared to the Leachable Concentration Threshold (LCT) limits as specified in GNR635. The trace elemental concentrations are provided in Table 11.4(b).

Table 11.4(a): Major Anions in the 1:20 Reagent Water Extraction Test.

Sample Nr.	pH	EC (mS/m)	TDS (mg/l)	T.Alk (mg/l)	B.Alk (mg/l)	P.Alk (mg/l)	Cl (mg/l)	SO_4 (mg/l)	NO_3 (mg/l)	NO_2 (mg/l)	F (mg/l)	NH_4 (mg/l)	PO_4 (mg/l)	Cr^{6+} (mg/l)	CN (mg/l)
HRM-1	9.2	9.2	<10	40	24	8	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-2	6.2	0.5	<10	8	<5	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-3	8	14.1	74	40	<5	<5	<2	26	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-4	7.5	26.8	156	16	<5	<5	21	71	0.5	0.1	0.6	<0.1	<0.1	<0.010	<0.01
HRM-5	4.8	10.1	36	<5	<5	<5	<2	40	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-6	8.7	4.9	<10	24	16	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-8	8.1	5.2	30	28	<5	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-9	7.4	3.4	<10	20	<5	<5	<2	<2	0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-10	7.1	1.1	26	<5	<5	<5	<2	2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-11	7	2.4	14	8	<5	<5	<2	<2	0.3	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-12	7.4	2.0	<10	<5	<5	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-13	9	36.7	246	68	60	<5	11	66	4.7	<0.05	0.5	<0.1	<0.1	<0.010	<0.01
HRM-14	7.6	4.4	42	20	<5	<5	<2	<2	0.1	<0.05	<0.2	0.158	<0.1	<0.010	<0.01
HRM-15	7.7	5.8	62	24	<5	<5	<2	3	0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-16	7.3	3.0	<10	<5	<5	<5	<2	2	0.6	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-17	7.7	7.0	48	28	<5	<5	<2	2	0.4	<0.05	<0.2	<0.1	<0.1	0.076	<0.01
HRM-18	7.5	1.7	<10	12	<5	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-19	7.3	4.0	18	16	<5	<5	<2	<2	<0.1	<0.05	<0.2	0.3	<0.1	<0.010	<0.01
HRM-21	7.6	17.1	92	28	<5	<5	3	45	0.9	<0.05	0.2	<0.1	<0.1	<0.010	<0.01
HRM-22	6.6	2.7	<10	8	<5	<5	<2	3	0.1	<0.05	0.3	<0.1	<0.1	<0.010	<0.01
HRM-23	9	27.5	192	56	48	<5	5	51	1.8	<0.05	0.3	0.379	<0.1	* <0.010	<0.01
HRM-24	8.1	34.6	230	28	<5	<5	14	107	3.8	<0.05	0.2	<0.1	<0.1	* <0.010	<0.01
HRM-25	8.8	26.4	270	56	48	<5	3	55	1.1	<0.05	0.2	<0.1	<0.1	* <0.010	<0.01
HRM-26	7.7	6.4	16	24	<5	<5	<2	3	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-27	7.8	5.2	16	20	<5	<5	<2	2	0.2	<0.05	<0.2	0.154	<0.1	<0.010	<0.01
HRM-28	8.2	17.4	128	40	<5	<5	2	36	0.4	<0.05	0.2	<0.1	<0.1	<0.010	<0.01
HRM-29	8.2	4.3	62	20	<5	<5	<2	<2	<0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-30	7.9	5.1	54	24	<5	<5	<2	<2	0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-31	7.6	16.1	70	32	<5	<5	3	40	0.3	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
HRM-32	7.3	4.5	<10	20	<5	<5	<2	2	0.1	<0.05	<0.2	<0.1	<0.1	<0.010	<0.01
LCT0	-	-	1000	-	-	-	300	250	11	1.5	-	-	-	0.05	0.07
LCT1	-	-	12500	-	-	-	15000	12500	550	75	-	-	-	2.5	3.5
LCT2	-	-	25000	-	-	-	30000	25000	1100	150	-	-	-	5	7
LCT3	-	-	100000	-	-	-	120000	100000	4400	600	-	-	-	20	28

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 1 of 10)

Sample Id	Ag		Al		As		Au		B		Ba		Be	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.068	<0.001	<0.020
HRM-2	<0.001	<0.020	0.150	3.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.005	0.095	<0.001	<0.020
HRM-3	<0.001	<0.020	0.384	7.68	<0.001	<0.020	<0.001	<0.020	0.030	0.609	0.180	3.593	<0.001	<0.020
HRM-4	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	0.031	0.626	0.104	2.076	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.004	0.075	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.146	<0.001	<0.020
HRM-9	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.004	0.084	<0.001	<0.020
HRM-10	<0.001	<0.020	0.650	13.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.135	<0.001	<0.020
HRM-11	<0.001	<0.020	0.364	7.28	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.027	<0.001	<0.020
HRM-12	<0.001	<0.020	0.187	3.74	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.027	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.100	<2.00	0.003	0.067	<0.001	<0.020	0.071	1.415	0.017	0.340	<0.001	<0.020
HRM-14	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.058	<0.001	<0.020
HRM-15	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.138	<0.001	<0.020
HRM-16	<0.001	<0.020	0.148	2.96	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.023	<0.001	<0.020
HRM-17	<0.001	<0.020	1.039	20.78	<0.001	<0.020	<0.001	<0.020	0.006	0.117	0.003	0.051	<0.001	<0.020
HRM-18	<0.001	<0.020	0.296	5.92	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.022	<0.001	<0.020
HRM-19	<0.001	<0.020	0.548	10.96	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.006	0.120	<0.001	<0.020
HRM-21	<0.001	<0.020	0.150	3.00	<0.001	<0.020	<0.001	<0.020	0.017	0.343	0.010	0.191	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.002	0.031	<0.001	<0.020
HRM-23	<0.001	<0.020	<0.100	<2.00	0.001	0.022	<0.001	<0.020	0.040	0.794	0.012	0.237	<0.001	<0.020
HRM-24	<0.001	<0.020	<0.100	<2.00	0.002	0.041	<0.001	<0.020	0.032	0.632	0.038	0.754	<0.001	<0.020
HRM-25	<0.001	<0.020	<0.100	<2.00	0.002	0.048	<0.001	<0.020	0.016	0.318	0.020	0.400	<0.001	<0.020
HRM-26	<0.001	<0.020	0.144	2.88	<0.001	<0.020	<0.001	<0.020	0.004	0.077	0.008	0.158	<0.001	<0.020
HRM-27	<0.001	<0.020	0.489	9.78	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.006	0.113	<0.001	<0.020
HRM-28	<0.001	<0.020	<0.100	<2.00	0.002	0.031	<0.001	<0.020	0.016	0.316	0.030	0.600	<0.001	<0.020
HRM-29	<0.001	<0.020	0.114	2.28	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.005	0.095	<0.001	<0.020
HRM-30	<0.001	<0.020	0.142	2.84	<0.001	<0.020	<0.001	<0.020	0.001	0.030	0.007	0.134	<0.001	<0.020
HRM-31	<0.001	<0.020	1.132	22.64	<0.001	<0.020	<0.001	<0.020	0.016	0.318	0.013	0.263	<0.001	<0.020
HRM-32	<0.001	<0.020	0.412	8.24	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.134	<0.001	<0.020
TCT0	-	-	-	-	0.01	-	-	-	0.5	-	0.7	-	-	-
TCT1	-	-	-	-	0.5	-	-	-	25	-	35	-	-	-
TCT2	-	-	-	-	1	-	-	-	50	-	70	-	-	-
TCT3	-	-	-	-	4	-	-	-	200	-	280	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 2 of 10)

Sample Id	Bi		Ca		Cd		Ce		Co		Cr		Cs	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	7	140	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	<1	<20	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	<0.001	<0.020	19	380	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	<0.001	<0.020	25	500	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	<0.001	<0.020	3	60	<0.001	<0.020	<0.001	<0.020	0.001	0.022	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	6	120	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.026	<0.001	<0.020
HRM-9	<0.001	<0.020	2	40	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.141	<0.001	<0.020
HRM-10	<0.001	<0.020	<1	<20	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.047	0.948	<0.001	<0.020
HRM-11	<0.001	<0.020	2	40	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.064	1.272	<0.001	<0.020
HRM-12	<0.001	<0.020	1	20	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.009	0.174	<0.001	<0.020
HRM-13	<0.001	<0.020	3	60	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.009	0.171	<0.001	<0.020
HRM-14	<0.001	<0.020	2	40	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.012	0.243	<0.001	<0.020
HRM-15	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.002	0.049	<0.001	<0.020
HRM-16	<0.001	<0.020	2	40	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.028	0.564	<0.001	<0.020
HRM-17	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.122	2.450	<0.001	<0.020
HRM-18	<0.001	<0.020	<1	<20	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.018	0.364	<0.001	<0.020
HRM-19	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.125	2.509	<0.001	<0.020
HRM-21	<0.001	<0.020	6	120	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.027	0.539	<0.001	<0.020
HRM-22	<0.001	<0.020	2	40	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.020	0.408	<0.001	<0.020
HRM-23	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.027	0.538	<0.001	<0.020
HRM-24	<0.001	<0.020	14	280	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.022	0.445	<0.001	<0.020
HRM-25	<0.001	<0.020	7	140	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.008	0.159	<0.001	<0.020
HRM-26	<0.001	<0.020	3	60	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.016	0.312	<0.001	<0.020
HRM-27	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	0.002	0.032	0.106	2.126	<0.001	<0.020
HRM-28	<0.001	<0.020	7	140	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.009	0.177	<0.001	<0.020
HRM-29	<0.001	<0.020	4	80	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.069	<0.001	<0.020
HRM-30	<0.001	<0.020	5	100	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.019	0.385	<0.001	<0.020
HRM-31	<0.001	<0.020	6	120	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.044	0.872	<0.001	<0.020
HRM-32	<0.001	<0.020	3	60	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.234	4.680	<0.001	<0.020
TCT0	-	-	-	-	0.003	-	-	-	0.5	-	0.1	-	-	-
TCT1	-	-	-	-	0.15	-	-	-	25	-	5	-	-	-
TCT2	-	-	-	-	0.3	-	-	-	50	-	10	-	-	-
TCT3	-	-	-	-	1.2	-	-	-	200	-	40	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 3 of 10)

Sample Id	Cu		Dy		Er		Eu		Fe		Ga		Gd	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.001	0.021	<0.001	<0.020
HRM-2	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.001	0.022	<0.001	<0.020
HRM-3	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.048	0.964	<0.001	<0.020
HRM-4	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.028	0.560	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.002	0.040	<0.001	<0.020
HRM-9	0.001	0.030	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.282	5.640	0.001	0.028	<0.001	<0.020
HRM-10	0.004	0.088	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	1.057	21.140	0.002	0.040	<0.001	<0.020
HRM-11	0.005	0.109	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.397	7.940	<0.001	<0.020	<0.001	<0.020
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.043	0.860	0.006	0.118	<0.001	<0.020
HRM-14	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.170	3.400	<0.001	<0.020	<0.001	<0.020
HRM-15	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.002	0.038	<0.001	<0.020
HRM-16	0.004	0.077	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.184	3.680	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.757	15.140	0.001	0.025	<0.001	<0.020
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-19	0.004	0.090	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.765	15.300	0.002	0.035	<0.001	<0.020
HRM-21	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.234	4.680	0.005	0.103	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-23	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.051	1.020	0.008	0.169	<0.001	<0.020
HRM-24	0.001	0.022	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.011	0.217	<0.001	<0.020
HRM-25	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.006	0.116	<0.001	<0.020
HRM-26	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.308	6.160	0.002	0.049	<0.001	<0.020
HRM-27	0.002	0.045	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.953	19.060	0.002	0.037	<0.001	<0.020
HRM-28	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	<0.025	<0.500	0.008	0.169	<0.001	<0.020
HRM-29	0.001	0.029	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.155	3.100	0.002	0.032	<0.001	<0.020
HRM-30	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.181	3.620	0.002	0.048	<0.001	<0.020
HRM-31	0.003	0.058	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	1.290	25.800	0.004	0.082	<0.001	<0.020
HRM-32	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200	0.714	14.280	0.002	0.043	<0.001	<0.020
TCT0	2	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT1	100	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT2	200	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT3	800	-	-	-	-	-	-	-	-	-	-	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 4 of 10)

Sample Id	Ge		Hf		Hg		Ho		In		Ir		K	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-2	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.50	10
HRM-3	0.003	0.062	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-4	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	9.95	199
HRM-5	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-6	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1.22	24
HRM-8	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1.54	31
HRM-9	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-10	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-11	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-13	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	38.00	760
HRM-14	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2.41	48
HRM-15	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1.87	37
HRM-16	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-17	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	9.25	185
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-19	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-21	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	14.77	295
HRM-22	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.5	<10
HRM-23	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	29.00	580
HRM-24	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	15.00	300
HRM-25	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	20.00	400
HRM-26	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2.71	54
HRM-27	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1.53	31
HRM-28	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	13.00	260
HRM-29	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2.64	53
HRM-30	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2.47	49
HRM-31	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	5.08	102
HRM-32	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1.32	26
TCT0	-	-	-	-	0.006	-	-	-	-	-	-	-	-	-
TCT1	-	-	-	-	0.3	-	-	-	-	-	-	-	-	-
TCT2	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-
TCT3	-	-	-	-	2.4	-	-	-	-	-	-	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 5 of 10)

Sample Id	La		Li		Lu		Mg		Mn		Mo		Na	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	0.003	0.063	<0.001	<0.020	6	120	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-2	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-3	<0.001	<0.020	0.003	0.057	<0.001	<0.020	3	60	<0.025	<0.500	0.005	0.103	<1	<20
HRM-4	<0.001	<0.020	0.015	0.291	<0.001	<0.020	4	80	0.025	0.500	0.001	0.024	7	140
HRM-5	<0.001	<0.020	0.002	0.038	<0.001	<0.020	2	40	0.023	0.460	<0.001	<0.020	11	220
HRM-6	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-8	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	3	60	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-9	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2	40	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-10	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	0.033	0.660	<0.001	<0.020	<1	<20
HRM-11	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	1	20
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-13	<0.001	<0.020	0.008	0.158	<0.001	<0.020	2	40	<0.025	<0.500	0.003	0.061	45	900
HRM-14	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2	40	<0.025	<0.500	<0.001	<0.020	2	40
HRM-15	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	3	60	<0.025	<0.500	<0.001	<0.020	2	40
HRM-16	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	2	40
HRM-17	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	0.001	0.027	3	60
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1	20	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-19	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2	40	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-21	<0.001	<0.020	0.002	0.046	<0.001	<0.020	2	40	<0.025	<0.500	0.002	0.030	12	240
HRM-22	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<1	<20	<0.025	<0.500	<0.001	<0.020	1	20
HRM-23	<0.001	<0.020	0.005	0.104	<0.001	<0.020	1	20	<0.025	<0.500	0.003	0.067	28	560
HRM-24	<0.001	<0.020	0.001	0.024	<0.001	<0.020	7	140	<0.025	<0.500	0.009	0.186	28	560
HRM-25	<0.001	<0.020	0.002	0.049	<0.001	<0.020	5	100	<0.025	<0.500	0.004	0.076	25	500
HRM-26	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	3	60	<0.025	<0.500	<0.001	<0.020	4	80
HRM-27	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	4	80	0.026	0.520	<0.001	<0.020	2	40
HRM-28	<0.001	<0.020	0.001	0.026	<0.001	<0.020	5	100	0.027	0.540	0.002	0.048	12	240
HRM-29	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	1	20	<0.025	<0.500	<0.001	<0.020	<1	<20
HRM-30	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2	40	<0.025	<0.500	<0.001	<0.020	2	40
HRM-31	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	6	120	0.026	0.520	0.002	0.038	10	200
HRM-32	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	2	40	<0.025	<0.500	<0.001	<0.020	1	20
TCT0	-	-	-	-	-	-	-	-	0.5	-	0.07	-	-	-
TCT1	-	-	-	-	-	-	-	-	25	-	3.5	-	-	-
TCT2	-	-	-	-	-	-	-	-	50	-	7	-	-	-
TCT3	-	-	-	-	-	-	-	-	200	-	28	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 6 of 10)

Sample Id	Nb		Nd		Ni		Os		P		Pb		Pd	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.005	0.108	<0.001	<0.020	<0.001	<0.020
HRM-3	<0.001	<0.020	<0.001	<0.020	0.002	0.033	<0.001	<0.020	0.005	0.105	<0.001	<0.020	<0.001	<0.020
HRM-4	<0.001	<0.020	<0.001	<0.020	0.004	0.075	<0.001	<0.020	0.018	0.364	<0.001	<0.020	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.001	<0.020	0.002	0.033	<0.001	<0.020	0.002	0.032	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.001	<0.020	0.002	0.039	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	<0.001	<0.020	<0.001	<0.020	0.003	0.065	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	<0.001	<0.020	<0.001	<0.020	0.012	0.248	<0.001	<0.020	0.005	0.091	<0.001	<0.020	<0.001	<0.020
HRM-11	<0.001	<0.020	<0.001	<0.020	0.005	0.100	<0.001	<0.020	0.006	0.126	<0.001	<0.020	<0.001	<0.020
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.054	<0.001	<0.020	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.001	<0.020	0.003	0.055	<0.001	<0.020	0.079	1.583	<0.001	<0.020	<0.001	<0.020
HRM-14	<0.001	<0.020	<0.001	<0.020	0.002	0.046	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	<0.001	<0.020	<0.001	<0.020	0.001	0.029	<0.001	<0.020	0.001	0.023	<0.001	<0.020	<0.001	<0.020
HRM-16	<0.001	<0.020	<0.001	<0.020	0.003	0.065	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	<0.001	<0.020	0.007	0.143	<0.001	<0.020	0.003	0.054	<0.001	<0.020	<0.001	<0.020
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.005	0.105	<0.001	<0.020	<0.001	<0.020
HRM-19	<0.001	<0.020	<0.001	<0.020	0.009	0.178	<0.001	<0.020	0.008	0.158	<0.001	<0.020	<0.001	<0.020
HRM-21	<0.001	<0.020	<0.001	<0.020	0.003	0.054	<0.001	<0.020	0.006	0.122	<0.001	<0.020	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.001	<0.020	0.001	0.026	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	<0.001	<0.020	<0.001	<0.020	0.002	0.045	<0.001	<0.020	0.031	0.617	<0.001	<0.020	<0.001	<0.020
HRM-24	<0.001	<0.020	<0.001	<0.020	0.003	0.051	<0.001	<0.020	0.003	0.063	<0.001	<0.020	<0.001	<0.020
HRM-25	<0.001	<0.020	<0.001	<0.020	0.002	0.036	<0.001	<0.020	0.002	0.034	<0.001	<0.020	<0.001	<0.020
HRM-26	<0.001	<0.020	<0.001	<0.020	0.004	0.070	<0.001	<0.020	0.006	0.113	<0.001	<0.020	<0.001	<0.020
HRM-27	<0.001	<0.020	<0.001	<0.020	0.017	0.344	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	<0.001	<0.020	<0.001	<0.020	0.002	0.044	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	<0.001	<0.020	<0.001	<0.020	0.002	0.049	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	<0.001	<0.020	<0.001	<0.020	0.002	0.048	<0.001	<0.020	0.006	0.118	<0.001	<0.020	<0.001	<0.020
HRM-31	<0.001	<0.020	<0.001	<0.020	0.007	0.141	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-32	<0.001	<0.020	<0.001	<0.020	0.013	0.253	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
TCT0	-	-	-	-	0.07	-	-	-	-	-	0.01	-	-	-
TCT1	-	-	-	-	3.5	-	-	-	-	-	0.5	-	-	-
TCT2	-	-	-	-	7	-	-	-	-	-	1	-	-	-
TCT3	-	-	-	-	28	-	-	-	-	-	4	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 7 of 10)

Sample Id	Pr		Pt		Rb		Rh		Ru		Sb		Sc	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	<0.001	<0.020	0.001	0.028	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	<0.001	<0.020	<0.001	<0.020	0.001	0.022	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	<0.001	<0.020	<0.001	<0.020	0.087	1.733	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.001	<0.020	0.001	0.021	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.001	<0.020	0.004	0.083	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	<0.001	<0.020	<0.001	<0.020	0.002	0.049	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	<0.001	<0.020	<0.001	<0.020	0.001	0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.001	<0.020	0.070	1.401	<0.001	<0.020	<0.001	<0.020	0.001	0.027	<0.001	<0.020
HRM-14	<0.001	<0.020	<0.001	<0.020	0.004	0.085	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	<0.001	<0.020	<0.001	<0.020	0.003	0.069	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	<0.001	<0.020	<0.001	<0.020	0.001	0.029	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	<0.001	<0.020	0.014	0.278	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	<0.001	<0.020	<0.001	<0.020	0.002	0.040	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	<0.001	<0.020	<0.001	<0.020	0.042	0.846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.001	<0.020	0.001	0.022	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	<0.001	<0.020	<0.001	<0.020	0.094	1.875	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	<0.001	<0.020	<0.001	<0.020	0.015	0.303	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	<0.001	<0.020	<0.001	<0.020	0.032	0.634	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	<0.001	<0.020	<0.001	<0.020	0.002	0.044	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	<0.001	<0.020	<0.001	<0.020	0.004	0.071	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	<0.001	<0.020	<0.001	<0.020	0.021	0.421	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	<0.001	<0.020	<0.001	<0.020	0.012	0.230	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	<0.001	<0.020	<0.001	<0.020	0.002	0.048	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-31	<0.001	<0.020	<0.001	<0.020	0.006	0.111	-	-	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-32	<0.001	<0.020	<0.001	<0.020	0.003	0.059	-	-	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
TCT0	-	-	-	-	-	-	-	-	-	-	0.02	-	-	-
TCT1	-	-	-	-	-	-	-	-	-	-	1	-	-	-
TCT2	-	-	-	-	-	-	-	-	-	-	2	-	-	-
TCT3	-	-	-	-	-	-	-	-	-	-	8	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 8 of 10)

Sample Id	Se		Si		Sm		Sn		Sr		Ta		Tb	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	0.001	0.020	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.006	0.112	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	0.221	4.420	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	0.004	0.075	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.591	11.817	<0.001	<0.020	<0.001	<0.020
HRM-4	0.011	0.223	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.132	2.635	<0.001	<0.020	<0.001	<0.020
HRM-5	0.007	0.145	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.024	0.481	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.010	0.208	<0.001	<0.020	<0.001	<0.020
HRM-8	0.004	0.073	0.656	13.120	<0.001	<0.020	<0.001	<0.020	0.010	0.210	<0.001	<0.020	<0.001	<0.020
HRM-9	0.007	0.146	3.311	66.220	<0.001	<0.020	<0.001	<0.020	0.007	0.149	<0.001	<0.020	<0.001	<0.020
HRM-10	0.004	0.073	1.941	38.820	<0.001	<0.020	<0.001	<0.020	0.002	0.040	<0.001	<0.020	<0.001	<0.020
HRM-11	0.004	0.071	0.100	2.000	<0.001	<0.020	<0.001	<0.020	0.006	0.110	<0.001	<0.020	<0.001	<0.020
HRM-12	0.004	0.075	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.005	0.098	<0.001	<0.020	<0.001	<0.020
HRM-13	0.006	0.126	7.994	159.880	<0.001	<0.020	<0.001	<0.020	0.025	0.510	<0.001	<0.020	<0.001	<0.020
HRM-14	0.007	0.143	1.821	36.420	<0.001	<0.020	<0.001	<0.020	0.009	0.175	<0.001	<0.020	<0.001	<0.020
HRM-15	0.005	0.092	2.704	54.080	<0.001	<0.020	<0.001	<0.020	0.014	0.279	<0.001	<0.020	<0.001	<0.020
HRM-16	<0.001	<0.020	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.006	0.123	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	2.158	43.160	<0.001	<0.020	<0.001	<0.020	0.006	0.125	<0.001	<0.020	<0.001	<0.020
HRM-18	<0.001	<0.020	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.003	0.064	<0.001	<0.020	<0.001	<0.020
HRM-19	<0.001	<0.020	3.109	62.180	<0.001	<0.020	<0.001	<0.020	0.010	0.204	<0.001	<0.020	<0.001	<0.020
HRM-21	<0.001	<0.020	1.616	32.320	<0.001	<0.020	<0.001	<0.020	0.037	0.749	<0.001	<0.020	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.2	<4.0	<0.001	<0.020	<0.001	<0.020	0.009	0.171	<0.001	<0.020	<0.001	<0.020
HRM-23	0.009	0.172	2.327	46.540	<0.001	<0.020	<0.001	<0.020	0.027	0.544	<0.001	<0.020	<0.001	<0.020
HRM-24	0.005	0.093	1.934	38.680	<0.001	<0.020	<0.001	<0.020	0.083	1.662	<0.001	<0.020	<0.001	<0.020
HRM-25	0.007	0.137	4.967	99.340	<0.001	<0.020	<0.001	<0.020	0.040	0.795	<0.001	<0.020	<0.001	<0.020
HRM-26	<0.001	<0.020	2.255	45.100	<0.001	<0.020	<0.001	<0.020	0.015	0.296	<0.001	<0.020	<0.001	<0.020
HRM-27	0.003	0.059	2.436	48.720	<0.001	<0.020	<0.001	<0.020	0.015	0.296	<0.001	<0.020	<0.001	<0.020
HRM-28	0.012	0.231	4.125	82.500	<0.001	<0.020	<0.001	<0.020	0.039	0.784	<0.001	<0.020	<0.001	<0.020
HRM-29	0.007	0.138	2.440	48.800	<0.001	<0.020	<0.001	<0.020	0.008	0.150	<0.001	<0.020	<0.001	<0.020
HRM-30	0.005	0.092	1.520	30.400	<0.001	<0.020	<0.001	<0.020	0.014	0.289	<0.001	<0.020	<0.001	<0.020
HRM-31	<0.001	<0.020	6.416	128.320	<0.001	<0.020	<0.001	<0.020	0.033	0.650	<0.001	<0.020	<0.001	<0.020
HRM-32	0.002	0.043	3.093	61.860	<0.001	<0.020	<0.001	<0.020	0.008	0.154	<0.001	<0.020	<0.001	<0.020
TCT0	0.01	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT1	0.5	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
TCT3	4	-	-	-	-	-	-	-	-	-	-	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 9 of 10)

Sample Id	Te		Th		Ti		Tl		Tm		U		V	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	0.007	0.149	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	<0.001	<0.020	0.001	0.021	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	<0.001	<0.020	<0.001	<0.020	0.020	0.409	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.002	0.031
HRM-4	<0.001	<0.020	<0.001	<0.020	0.029	0.579	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.001	<0.020	0.004	0.083	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.001	<0.020	0.007	0.142	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.001	<0.020	0.005	0.093	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.019
HRM-9	<0.001	<0.020	<0.001	<0.020	0.003	0.066	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.063
HRM-10	<0.001	<0.020	<0.001	<0.020	0.015	0.292	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.026
HRM-11	<0.001	<0.020	<0.001	<0.020	0.009	0.170	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.001	0.020
HRM-12	<0.001	<0.020	<0.001	<0.020	0.003	0.055	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.001	<0.020	0.006	0.117	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.025	0.501
HRM-14	<0.001	<0.020	<0.001	<0.020	0.004	0.078	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.051
HRM-15	<0.001	<0.020	<0.001	<0.020	0.005	0.105	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.004	0.070
HRM-16	<0.001	<0.020	<0.001	<0.020	0.006	0.111	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	<0.001	<0.020	0.021	0.414	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.009	0.178
HRM-18	<0.001	<0.020	<0.001	<0.020	0.004	0.074	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	<0.001	<0.020	<0.001	<0.020	0.018	0.364	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.004	0.078
HRM-21	<0.001	<0.020	<0.001	<0.020	0.009	0.175	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.028	0.560
HRM-22	<0.001	<0.020	<0.001	<0.020	0.003	0.052	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.032	0.634
HRM-23	<0.001	<0.020	<0.001	<0.020	0.007	0.136	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.030	0.604
HRM-24	<0.001	<0.020	<0.001	<0.020	0.017	0.338	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.043	0.855
HRM-25	<0.001	<0.020	<0.001	<0.020	0.009	0.183	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.013	0.263
HRM-26	<0.001	<0.020	<0.001	<0.020	0.005	0.099	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.009	0.187
HRM-27	<0.001	<0.020	<0.001	<0.020	0.015	0.296	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.006	0.114
HRM-28	<0.001	<0.020	<0.001	<0.020	0.009	0.176	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.015	0.297
HRM-29	<0.001	<0.020	<0.001	<0.020	0.006	0.125	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.002	0.034
HRM-30	<0.001	<0.020	<0.001	<0.020	0.010	0.199	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.007	0.131
HRM-31	<0.001	<0.020	<0.001	<0.020	0.012	0.248	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.026	0.528
HRM-32	<0.001	<0.020	<0.001	<0.020	0.011	0.210	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.006	0.122
TCT0	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
TCT1	-	-	-	-	-	-	-	-	-	-	-	-	10	-
TCT2	-	-	-	-	-	-	-	-	-	-	-	-	20	-
TCT3	-	-	-	-	-	-	-	-	-	-	-	-	80	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.4(b): Trace elements analysed in the 1:20 Reagent Water Extraction Test (Table 10 of 10)

Sample Id	W		Y		Yb		Zn		Zr	
Unit	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
HRM-1	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.003	0.066	<0.001	<0.020
HRM-6	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.016	0.310	<0.001	<0.020
HRM-13	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.043	0.854	<0.001	<0.020
HRM-14	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.004	0.076	<0.001	<0.020
HRM-18	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.080	1.600	<0.001	<0.020
HRM-22	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.002	0.050	<0.001	<0.020
HRM-23	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.015	0.294	<0.001	<0.020
HRM-24	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.017	0.346	<0.001	<0.020
HRM-26	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.010	0.196	<0.001	<0.020
HRM-27	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.010	0.193	<0.001	<0.020
HRM-28	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.019	0.389	<0.001	<0.020
HRM-29	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.057	1.148	<0.001	<0.020
HRM-31	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.075	1.502	<0.001	<0.020
HRM-32	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020	0.014	0.286	<0.001	<0.020
TCT0	-	-	-	-	-	-	5	-	-	-
TCT1	-	-	-	-	-	-	250	-	-	-
TCT2	-	-	-	-	-	-	500	-	-	-
TCT3	-	-	-	-	-	-	2000	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Black = Raw Material Stockpile - Carbonaceous material, Brown = Raw Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile

11.5 Aqua Regia (Total Elemental Analysis)

The 16 waste samples collected were furthermore sent for Total Digestion (**Aqua Regia**) Analysis to assess the total elemental concentrations, the leachate of which was analysed for the following variables:

- Full Quantified ICP-MS analysis (*Ag, Al, As, Au, B, Ba, Be, Bi, Ca*, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe, Ga, Gd, Ge, Hf, Hg, Ho, In, Ir, K*, La, Li, Lu, Mg*, Mn, Mo, Na*, Nb, Nd, Ni, Os, P, Pb, Pd, Pr, Pt, Rb, Ru, Sb, Sc, Se, Si*, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm, U, V, W, Y, Yb, Zn, Zr.*)
- Total Hexavalent Chrome (Cr(VI))
- Total Fluoride
- Total Cyanide

The Aqua Regia analysis was done by Waterlab (Pty) Ltd with the results are attached as APPENDIX XI to this report. The results were scrutinised and compared to the Total Concentration Threshold (TCT) limits as specified in GNR635.

The ICP-MS results of the Cyanide, Fluoride and the Hexavalent Chrome are indicated in Table 11.5(a). The full quantified ICP-MS analysis results are provided in Table 11.5(b).

Table 11.5(a): ICP-MS Results of 1:400 Aqua Regia (Total Concentration) Test.

*Sample ID	CN	F	Cr^{6+}
Unit	mg/kg	mg/kg	mg/kg
HRM-12	<0.05	151	<5
HRM-13	<0.05	163	<5
HRM-15	<0.05	116	<5
HRM-17	<0.05	130	<5
HRM-18	<0.05	120	<5
HRM-21	<0.05	120	<5
HRM-23	<0.05	190	<5
HRM-24	<0.05	125	<5
HRM-25	<0.05	125	<5
HRM-26	<0.05	111	<5
HRM-27	<0.05	135	<5
HRM-28	<0.05	120	<5
HRM-29	<0.05	130	<5
HRM-30	<0.05	103	<5
HRM-31	<0.05	131	<5
HRM-32	<0.05	153	<5
TCT0	14	100	6.5
TCT1	10500	10000	500
TCT2	42000	40000	2000

* **Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Light Pink: Backfill Material, Purple: Unprocessed Slag Material, Light Purple: Waste Rock Stockpile**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 1 of 10)

*Sample Id	Unit	HRM-12	HRM-13	HRM-15	HRM-17	HRM-18	HRM-21	HRM-23	HRM-24	AUC	TCT0	TCT1	TCT3
Ag	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	2.31	-	-	-	-
Al	mg/l	115.00	50.00	68.00	78.00	120.00	41.00	87.00	56.00	-	-	-	-
	mg/kg	46000	20000	27200	31200	48000	16400	34800	22400	-	-	-	-
As	mg/l	0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	-	-	-	-
	mg/kg	0.429	1.615	<0.400	<0.400	<0.400	<0.400	<0.400	1.111	4.8	5.8	500	2000
Au	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
B	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	17	150	15000	60000
Ba	mg/l	0.58	0.28	0.16	0.46	0.50	0.06	0.10	0.16	-	-	-	-
	mg/kg	230.48	113.28	65.59	182.09	198.87	24.61	40.52	63.21	628	62.5	6250	25000
Be	mg/l	0.004	<0.001	0.001	0.002	0.005	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	1.428	<0.400	0.492	0.861	1.846	<0.400	<0.400	<0.400	-	-	-	-
Bi	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.68	-	-	-	-
Ca	mg/l	64.00	46.00	55.00	46.00	102.00	15.00	19.00	22.00	-	-	-	-
	mg/kg	25600	18400	22000	18400	40800	6000	7600	8800	-	-	-	-
Cd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.09	7.5	260	1040
Ce	mg/l	0.059	0.020	0.015	0.047	0.074	0.007	0.010	0.015	-	-	-	-
	mg/kg	23.45	7.86	6.15	18.95	29.80	2.74	4.02	6.06	-	-	-	-
Co	mg/l	0.14	0.10	0.16	0.11	0.13	0.09	0.32	0.13	-	-	-	-
	mg/kg	56.38	39.13	63.13	45.40	51.11	36.50	126.87	50.14	17.3	50	5000	20000
Cr	mg/l	29.00	22.00	10.00	40.00	28.00	60.00	246.00	76.00	-	-	-	-
	mg/kg	11600.00	8800.00	4000.00	16000.00	11200.00	24000.00	98400.00	30400.00	92	46000	800000	N /A
Cs	mg/l	0.001	0.002	<0.001	0.002	<0.001	0.001	0.002	0.002	-	-	-	-
	mg/kg	0.524	0.983	<0.400	0.635	<0.400	0.433	0.917	0.96	-	-	-	-

* **Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Purple: Unprocessed Slag Material.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 2 of 10)

*Sample Id	Unit	HRM-12	HRM-13	HRM-15	HRM-17	HRM-18	HRM-21	HRM-23	HRM-24	AUC	TCT0	TCT1	TCT3
Cu	mg/l	0.01	0.10	0.05	0.02	0.01	0.02	0.04	0.07				
	mg/kg	2.69	38.00	21.54	6.71	4.94	9.85	16.73	26.97	28	16	19500	78000
Dy	mg/l	0.00	0.00	0.00	0.00	0.00	<0.001	<0.001	0.00	-	-	-	-
	mg/kg	2	1	1	1	2	<0.400	<0.400	0	-	-	-	-
Er	mg/l	0.002	<0.001	0.001	0.002	0.003	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	0.968	<0.400	0.400	0.760	1.040	<0.400	<0.400	<0.400	-	-	-	-
Eu	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	-	-	-
	mg/kg	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	-	-	-	-
Fe	mg/l	81.00	97.00	140.00	81.00	88.00	92.00	206.00	114.00	-	-	-	-
	mg/kg	32400	38800	56000	32400	35200	36800	82400	45600	-	-	-	-
Ga	mg/l	0.192	0.147	0.057	0.165	0.177	0.046	0.120	0.077	-	-	-	-
	mg/kg	76.64	58.98	22.97	66.17	70.97	18.33	47.81	30.63	-	-	-	-
Gd	mg/l	0.004	0.001	0.002	0.003	0.005	<0.001	<0.001	0.001	-	-	-	-
	mg/kg	1.738	0.576	0.616	1.352	2.091	<0.400	<0.400	0.484	-	-	-	-
Ge	mg/l	<0.001	0.005	0.003	0.002	0.002	0.001	0.004	0.001	-	-	-	-
	mg/kg	<0.400	2.186	1.317	0.660	0.628	0.534	1.585	0.49	-	-	-	-
Hf	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	0.93	160	640
Ho	mg/l	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	0.406	<0.400	<0.400	<0.400	-	-	-	-
In	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ir	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
K	mg/l	12.29	8.57	2.06	9.67	5.24	1.59	3.49	2.87	-	-	-	-
	mg/kg	4916.80	3428.00	825.20	3868.80	2096.00	636.00	1394.00	1146.00	-	-	-	-

* Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Purple: Unprocessed Slag Material.

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 3 of 10)

*Sample Id	Unit	HRM-12	HRM-13	HRM-15	HRM-17	HRM-18	HRM-21	HRM-23	HRM-24	AUC	TCT0	TCT1	TCT3
La	mg/l	0.030	0.010	0.008	0.022	0.038	0.004	0.005	0.007	-	-	-	-
	mg/kg	11.83	3.86	3.12	8.95	15.12	1.41	1.97	2.97	-	-	-	-
Li	mg/l	0.020	0.011	0.008	0.015	0.036	0.004	0.008	0.009	-	-	-	-
	mg/kg	8	4	3	6	14	1	3	3	-	-	-	-
Lu	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Mg	mg/l	115.00	450.00	244.00	71.00	117.00	66.00	102.00	84.00	-	-	-	-
	mg/kg	46000.00	180000.00	97600.00	28400.00	46800.00	26400.00	40800.00	33600.00	-	-	-	-
Mn	mg/l	2.52	2.45	2.90	1.74	2.27	1.22	2.41	1.63	-	-	-	-
	mg/kg	1009.60	979.20	1158.00	695.20	909.60	487.20	965.20	650.00	632	1000	25000	100000
Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.46	1.1	40	1000	4000
Na	mg/l	5.00	9.00	7.00	3.00	4.00	2.00	3.00	4.00	-	-	-	-
	mg/kg	2000.00	3600.00	2800.00	1200.00	1600.00	800.00	1200.00	1600.00	-	-	-	-
Nb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Nd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ni	mg/l	0.92	1.29	1.71	0.88	0.88	0.85	2.24	1.28	-	-	-	-
	mg/kg	368.273	516.175	683.804	350.563	352.796	339.571	896.656	512.47	47	91	10600	42400
Os	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
P	mg/l	0.032	0.221	0.142	0.071	0.007	0.063	0.183	0.221	-	-	-	-
	mg/kg	12.653	88.527	56.969	28.597	2.605	25.216	73.119	88.47	-	-	-	-
Pb	mg/l	<0.001	0.06	0.00	0.01	0.00	0.03	0.07	0.03	-	-	-	-
	mg/kg	<0.400	23.333	1.494	3.755	0.459	10.903	27.961	10.60	17	20	1900	7600
Pd	mg/l	0.002	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.004	-	-	-	-
	mg/kg	0.933	0.469	<0.400	0.417	<0.400	<0.400	<0.400	1.63	-	-	-	-

* **Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Purple: Unprocessed Slag Material.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 4 of 10)

*Sample Id	Unit	HRM-12	HRM-13	HRM-15	HRM-17	HRM-18	HRM-21	HRM-23	HRM-24	AUC	TCT0	TCT1	TCT3
Pr	mg/l	0.008	0.002	0.002	0.006	0.011	0.001	0.001	0.002	-	-	-	-
	mg/kg	3.215	0.987	0.941	2.241	4.564	0.421	0.573	0.75	-	-	-	-
Pt	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Rb	mg/l	0.027	0.053	0.008	0.048	0.009	0.013	0.032	0.023	-	-	-	-
	mg/kg	10.864	21.058	3.005	19.177	3.781	5.055	12.863	9.39	-	-	-	-
Rh	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ru	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Sb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.92	0.4	10	75	300
Sc	mg/l	0.006	0.005	0.019	0.004	0.017	<0.001	<0.001	0.003	-	-	-	-
	mg/kg	2.575	2.115	7.502	1.425	6.968	<0.400	<0.400	1.08	-	-	-	-
Se	mg/l	0.06	0.07	0.03	0.08	0.03	0.06	0.06	0.07	-	-	-	-
	mg/kg	24.011	28.959	11.832	30.148	11.884	23.010	25.673	26.61	0.09	10	50	200
Si	mg/l	281.00	356.00	436.00	570.00	290.00	96.00	142.00	154.00	-	-	-	-
	mg/kg	112400	142400	174400	228000	116000	38400	56800	61600	-	-	-	-
Sm	mg/l	0.004	0.002	0.001	0.003	0.005	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	1.738	0.617	0.546	1.369	2.038	<0.400	<0.400	<0.400	-	-	-	-
Sn	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Sr	mg/l	0.218	0.188	0.166	0.171	0.276	0.058	0.088	0.114	-	-	-	-
	mg/kg	87.35	75.19	66.55	68.55	110.36	23.17	35.02	45.52	-	-	-	-
Ta	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Tb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Purple: Unprocessed Slag Material.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 5 of 10)

*Sample Id	Unit	HRM-12	HRM-13	HRM-15	HRM-17	HRM-18	HRM-21	HRM-23	HRM-24	AUC	TCT0	TCT1	TCT3
Te	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Th	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ti	mg/l	8.707	2.300	2.525	5.489	8.072	1.537	5.005	2.532	-	-	-	-
	mg/kg	3482.96	919.86	1009.96	2195.61	3228.99	614.65	2002.02	1012.85	-	-	-	-
Tl	mg/l	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	-	-	-	-
	mg/kg	<0.400	0.603	<0.400	<0.400	<0.400	<0.400	0.595	<0.400	-	-	-	-
Tm	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
U	mg/l	0.00	<0.001	<0.001	0.00	0.00	<0.001	<0.001	0.00	-	-	-	-
	mg/kg	1.549	<0.400	<0.400	0.864	1.671	<0.400	<0.400	0.54	-	-	-	-
V	mg/l	0.17	0.27	0.23	0.33	0.17	0.62	2.24	0.80	-	-	-	-
	mg/kg	68.82	107.71	91.44	133.87	69.86	249.98	894.84	321.63	97	150	2680	10720
W	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Y	mg/l	0.02	0.01	0.01	0.02	0.03	0.00	0.00	0.01	-	-	-	-
	mg/kg	8	3	4	8	11	2	2	3	-	-	-	-
Yb	mg/l	0.002	0.001	0.001	0.002	0.003	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	0.857	0.425	0.467	0.770	1.047	<0.400	<0.400	<0.400	-	-	-	-
Zn	mg/l	0.12	6.22	0.26	0.23	<0.001	2.14	8.13	1.30	-	-	-	-
	mg/kg	48.80	2489.74	103.27	91.18	<0.400	854.81	3253.48	518.12	67	240	160000	640000
Zr	mg/l	0.285	0.028	0.026	0.160	0.249	0.001	0.025	0.032	-	-	-	-
	mg/kg	113.97	11.06	10.46	63.87	99.54	0.49	10.11	12.91	-	-	-	-

*** Light Green = Waste Material Dump, Dark Green = Waste Material Stockpile, Orange = Raw and Waste Material Residue, Yellow = Slimes, Purple: Unprocessed Slag Material.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 6 of 10)

*Sample Id	Unit	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	AUC	TCT0	TCT1	TCT3
Ag	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	0.007	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	3.21	2.90	-	-	-	-
Al	mg/l	75.00	71.00	69.00	85.00	45.00	66.00	126.00	61.00	-	-	-	-
	mg/kg	30000	28400	27600	34000	18000	26400	50400	24400	-	-	-	-
As	mg/l	0.004	0.002	<0.001	0.004	0.002	<0.001	0.003	0.004	-	-	-	-
	mg/kg	1.649	0.996	<0.400	1.660	0.704	<0.400	1.344	1.550	4.8	5.8	500	2000
Au	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
B	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	17	150	15000	60000
Ba	mg/l	0.16	0.09	0.10	0.13	0.11	0.23	0.32	0.20	-	-	-	-
	mg/kg	64.28	37.32	41.87	51.58	43.50	90.92	126.23	79.05	628	62.5	6250	25000
Be	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.543	<0.400	-	-	-	-
Bi	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ca	mg/l	40.00	36.00	58.00	48.00	45.00	43.00	77.00	44.00	-	-	-	-
	mg/kg	16000	14400	23200	19200	18000	17200	30800	17600	-	-	-	-
Cd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.09	7.5	260	1040
Ce	mg/l	0.017	0.007	0.009	0.009	0.012	0.020	0.038	0.024	-	-	-	-
	mg/kg	6.85	2.86	3.70	3.71	4.92	8.15	15.12	9.77	-	-	-	-
Co	mg/l	0.12	0.19	0.10	0.17	0.23	0.11	0.18	0.23	-	-	-	-
	mg/kg	48.65	76.67	40.17	68.00	93.67	43.42	73.95	90.33	17.3	50	5000	20000
Cr	mg/l	39.00	109.00	29.00	59.00	4.43	42.00	87.00	78.00	-	-	-	-
	mg/kg	15600.00	43600.00	11600.00	23600.00	1770.66	16800.00	34800.00	31200.00	92	46000	800000	N /A
Cs	mg/l	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	-	-	-	-
	mg/kg	0.736	<0.400	<0.400	<0.400	<0.400	<0.400	0.59	<0.400	-	-	-	-

***Dark Green = Waste Material Stockpile, Light Pink: Backfill Material, Light Purple: Waste Rock Stockpile.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 7 of 10)

*Sample Id	Unit	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	AUC	TCT0	TCT1	TCT3
Cu	mg/l	0.11	0.07	0.07	0.09	0.03	0.04	0.07	0.05	-	-	-	-
	mg/kg	42.13	28.44	28.65	36.69	11.36	15.15	28.61	21.57	28	16	19500	78000
Dy	mg/l	0.00	<0.001	<0.001	<0.001	<0.001	0.00	0.00	0.00	-	-	-	-
	mg/kg	1	<0.400	<0.400	<0.400	<0.400	0	1	1	-	-	-	-
Er	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	-	-	-	-
	mg/kg	0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.77	0.55	-	-	-	-
Eu	mg/l	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	-	-	-	-
	mg/kg	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	<4.00	-	-	-	-
Fe	mg/l	126.00	139.00	83.00	140.00	135.00	82.00	142.00	152.00	-	-	-	-
	mg/kg	50400	55600	33200	56000	54000	32800	56800	60800	-	-	-	-
Ga	mg/l	0.082	0.050	0.038	0.065	0.035	0.077	0.125	0.077	-	-	-	-
	mg/kg	32.91	19.94	15.36	25.84	14.18	30.82	49.81	30.88	-	-	-	-
Gd	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.003	-	-	-	-
	mg/kg	0.565	<0.400	<0.400	<0.400	<0.400	0.527	1.232	1.153	-	-	-	-
Ge	mg/l	0.002	0.003	0.003	0.004	0.004	0.002	0.005	0.003	-	-	-	-
	mg/kg	0.948	1.002	1.070	1.521	1.453	0.646	1.89	1.00	-	-	-	-
Hf	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	0.868	<0.400	<0.400	-	-	-	-
Hg	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	0.93	160	640
Ho	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
In	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ir	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
K	mg/l	4.42	2.27	2.53	4.24	4.71	5.60	4.00	4.23	-	-	-	-
	mg/kg	1767.600	906.000	1012.000	1696.400	1885.200	2241.600	1600.40	1692.40	-	-	-	-

***Dark Green = Waste Material Stockpile, Light Pink: Backfill Material, Light Purple: Waste Rock Stockpile.**

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 8 of 10)

*Sample Id	Unit	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	AUC	TCT0	TCT1	TCT3
La	mg/l	0.009	0.003	0.004	0.004	0.005	0.008	0.019	0.011	-	-	-	-
	mg/kg	3.50	1.17	1.58	1.63	2.14	3.32	7.62	4.59	-	-	-	-
Li	mg/l	0.019	0.003	0.001	0.003	0.002	0.006	0.014	0.006	-	-	-	-
	mg/kg	8	1	0	1	1	2	6	2	-	-	-	-
Lu	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Mg	mg/l	189.00	111.00	120.00	181.00	211.00	88.00	107.00	182.00	-	-	-	-
	mg/kg	75600.00	44400.00	48000.00	72400.00	84400.00	35200.00	42800.00	72800.00	-	-	-	-
Mn	mg/l	2.36	1.98	1.58	2.74	3.87	1.81	2.53	2.85	-	-	-	-
	mg/kg	945.60	790.00	633.60	1094.80	1548.40	722.80	1010.40	1140.00	632	1000	25000	100000
Mo	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	1.1	40	1000	4000
Na	mg/l	5.00	7.00	8.00	8.00	8.00	5.00	9.00	7.00	-	-	-	-
	mg/kg	2000.00	2800.00	3200.00	3200.00	3200.00	2000.00	3600.00	2800.00	-	-	-	-
Nb	mg/l	<0.001	0.002	0.002	0.003	0.002	0.002	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	0.675	0.619	1.158	0.712	0.791	<0.400	<0.400	-	-	-	-
Nd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ni	mg/l	1.70	1.45	1.05	1.58	1.65	0.95	2.39	2.79	-	-	-	-
	mg/kg	678.808	579.096	418.155	631.302	659.456	378.220	957.72	1114.79	47	91	10600	42400
Os	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
P	mg/l	0.208	0.130	0.180	0.242	0.374	0.193	0.147	0.515	-	-	-	-
	mg/kg	83.033	51.980	72.015	96.651	149.559	77.114	58.71	205.97	-	-	-	-
Pb	mg/l	0.03	0.01	0.00	0.02	0.00	0.01	0.02	0.00	-	-	-	-
	mg/kg	13.500	3.035	1.270	7.935	1.726	3.130	8.23	1.99	17	20	1900	7600
Pd	mg/l	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	0.721	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-

***Dark Green = Waste Material Stockpile,** Light Pink: Backfill Material, Light Purple: Waste Rock Stockpile.

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 9 of 10)

*Sample Id	Unit	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	AUC	TCT0	TCT1	TCT3
Pr	mg/l	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.003	-	-	-	-
	mg/kg	0.941	0.787	0.962	0.840	0.997	1.557	1.71	1.14	-	-	-	-
Pt	mg/l	0.00	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	0.505	<0.400	<0.400	0.549	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Rb	mg/l	0.031	0.004	0.004	0.010	0.019	0.011	0.029	0.022	-	-	-	-
	mg/kg	12.506	1.703	1.433	3.820	7.639	4.369	11.43	8.78	-	-	-	-
Rh	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Ru	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Sb	mg/l	0.00	0.00	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	0.608	1.013	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	0.4	10	75	300
Sc	mg/l	0.002	0.016	0.016	0.022	0.033	0.018	0.039	0.052	-	-	-	-
	mg/kg	0.869	6.372	6.390	8.800	13.320	7.260	15.60	20.80	-	-	-	-
Se	mg/l	<0.001	0.04	0.01	0.13	0.02	0.02	0.04	0.04	-	-	-	-
	mg/kg	<0.400	17.448	3.103	**50.814**	6.049	9.020	15.60	15.56	0.09	10	50	200
Si	mg/l	313.00	243.00	326.00	370.00	587.00	497.00	251.00	215.00	-	-	-	-
	mg/kg	125200	97200	130400	148000	234800	198800	100400	86000	-	-	-	-
Sm	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.003	0.002	-	-	-	-
	mg/kg	0.514	<0.400	<0.400	<0.400	<0.400	0.527	1.24	0.89	-	-	-	-
Sn	mg/l	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	1.177	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Sr	mg/l	0.134	0.057	0.085	0.100	0.111	0.092	0.305	0.146	-	-	-	-
	mg/kg	53.44	22.65	33.91	39.98	44.59	36.63	122.06	58.31	-	-	-	-
Ta	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Tb	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-

*Dark Green = Waste Material Stockpile, Light Pink: Backfill Material, Light Purple: Waste Rock Stockpile.

Table 11.5(b): Full ICP-MS Quantification Results of 1:400 Aqua Regia (Total Concentration) Test (Table 10 of 10)

*Sample Id	Unit	HRM-25	HRM-26	HRM-27	HRM-28	HRM-29	HRM-30	HRM-31	HRM-32	AUC	TCT0	TCT1	TCT3
Te	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Th	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	0.452	<0.400	<0.400	-	-	-	-
Ti	mg/l	3.161	3.276	2.211	3.082	2.488	3.964	4.462	3.164	-	-	-	-
	mg/kg	1264.50	1310.21	884.33	1232.92	995.13	1585.76	1784.92	1265.48	-	-	-	-
Tl	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Tm	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
U	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	0.591	<0.400	<0.400	-	-	-	-
V	mg/l	0.40	1.07	0.32	0.63	0.24	0.39	0.79	0.78	-	-	-	-
	mg/kg	158.40	427.26	128.74	250.40	95.78	154.97	316.40	312.80	97	150	2680	10720
W	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	-	-
	mg/kg	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	<0.400	-	-	-	-
Y	mg/l	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	-	-	-	-
	mg/kg	4	1	1	2	2	2	7	6	-	-	-	-
Yb	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	-	-	-	-
	mg/kg	0.455	<0.400	<0.400	<0.400	<0.400	<0.400	0.80	0.80	-	-	-	-
Zn	mg/l	2.40	0.97	0.16	2.39	0.20	0.35	1.84	0.36	-	-	-	-
	mg/kg	959.12	388.17	63.86	954.77	79.85	141.90	737.21	144.45	67	240	160000	640000
Zr	mg/l	0.038	0.043	0.025	0.035	0.029	0.105	0.060	0.019	-	-	-	-
	mg/kg	15.35	17.06	10.12	13.87	11.56	42.19	24.00	7.60	-	-	-	-

*Dark Green = Waste Material Stockpile, Light Pink: Backfill Material, Light Purple: Waste Rock Stockpile.

12. WASTE CLASSIFICATION

12.1 PURPOSE AND REGULATIONS

The classification of the waste streams generated at HERNIC is done with reference to the Waste Classification and Management Regulations (GNR634, GNR635 and GNR636) as published by the Department of Environmental Affairs on 23 August 2013. The purpose of the Waste Classification and Management Regulations (GNR634, GNR635 and GNR636) are to:

- "*regulate the classification and management of waste in a manner which supports and implements the provisions of the Act [National Environmental Management: Waste Act (Act No.59 of 2008)];*
- *establish the mechanism and procedure for the listing of waste management activities that do not require a Waste Management Licence;*
- *prescribe requirements for the disposal of waste to landfill;*
- *prescribe requirements and timeframes for the management of certain wastes; and*
- *prescribe general duties of waste generators, transporters and managers*".

12.2 APPROACH

The waste material analysed was evaluated according to Government Notice Regulation (GNR) 635, National Environmental Management: Waste Act 59 of 2008: National Norms and Standards for the Assessment of Waste for Landfill Disposal (hereafter called GNR635);

It is indicated in Section 3(1) of Chapter 2 of GNR635 that in order "*to assess the waste for the purpose of disposal to landfill, the following are required –*

(a) identification of chemical substances present in the waste; and
(b) sampling and analysis to determine the total concentrations (TC) and leachable concentrations (LC) of the elements and chemical substances that have been identified in the waste and that are specified in Section 6 of these Norms and Standards."

Chapter 2 of GNR635 further states that,

(2) "*Within three (3) years of the date of commencement of the Regulations, all analyses of the TC and LC of elements and chemical substances in waste must be conducted by laboratories accredited by the South African National Accreditation System (SANAS) to conduct the particular techniques and analysis methods required."*

(3) "*The total concentration (TC) and leachable concentrations (LC) limits of the chemical substances in the waste must be compared to the threshold limits specified in section 6 of these Norms and Standards for total concentrations (TCT limits) and leachable concentrations (LCT limits) of specific elements and chemical substances."*

(4) "Based on the TC and LC limits of the elements and chemical substances in the waste exceeding the corresponding TCT and LCT limits respectively, the specific type of waste for disposal to landfill must be determined in terms of section 7 of these Norms and Standards";

The waste classification, undertaken as part of the material characterisation at HERNIC is undertaken with reference to and in fulfilment of the above. A summary of the waste classification undertaken at HERNIC is addressed in the sections that follow.

Total Concentration (TC) analysis

The Total Concentration (TC) is defined as the total concentration of a particular element or chemical substance in a waste, expressed as *mg/kg*. Section 4 of Chapter 2 of the Norms and Standards (GNR635) specifies that:

1) *"The TC of all the elements and chemicals substances specified in Section 6 of these Norms and Standards that are known to occur, likely to occur and can reasonably be expected to occur in the waste must be determined".*
2) *"The TC of elements and chemical substances in waste must be determined using techniques and analysis methods that will provide reliable, accurate and repeatable results of the TC of elements and chemical substances specified in Section 6 of these Norms and Standards".*

The TC's of the waste samples were determined by means of the X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF) as well as the Aqua Regia (Total Digestion) analyses methods and give a comprehensive range of elements and chemical substances identified in all the samples.

Leachable Concentration (LC Analysis)

The Leachable Concentration (LC) is defined as the leachable concentration of a particular element or chemical substance in a waste, expressed as mg/l. The LC's of the two samples were determined by means of the prescribed leaching tests amongst others. Section 5 of Chapter 2 of the Norms and Standards (GNR635) specifies that:

1) *"The LC of elements and chemical substances must be determined using the Australian Standard Leaching Procedure (AS 4439.1, 4439.2 and 4439.3).*

2) *The type of leaching fluid (Section 5.2 and 5.3 of AS4439.3) used in the leaching procedure must be selected as follows –*

   a) *Waste to be disposed of with, or waste that contains, putrescible wastes: Use 0.1M acetic acid solution with altered pH5.0 of pH2.9 determined as per section 7.5(a-e) of AS 4439.3;"*

   b) *Waste to be disposed of with non-putrescible wastes: Use a basic 0.1M sodium tetraborate decahydrate solution of pH9.2±0.1, as well as an acetic acid solution with pH 5.0 of pH2.9) determined as per section 7.5(a-e) of AS 4439.3: or*

   c) *Non-putrescible wastes to be disposed of without any other wastes: Use reagent water.*

3) *Existing LC results for elements and chemical subst5ances in wastes, which have been determined in terms of the Toxicity Characteristic Leaching Procedure (TCLP) leach test criteria of the minimum requirements for the handling, classification and Disposal of Hazardous Waste (2nd Edition, 1998; Department of Water Affairs and Forestry) prior to the regulations taking effect, may be utilised for comparison with the LCT limits in section 6 of these Norms and Standards to asses waste for the purpose of disposal of the waste landfill, for a period not exceeding three (3) years from the date of the publication of this notice."*

The LC's of the waste samples were determined by means of the Reagent Water Leach extract and analyses methods and give a comprehensive range of elements and chemical substances which could potentially leach from the samples.

Determining Waste Types for Landfill Disposal

- According to GNR 635 the particular type of waste destined for disposal to landfill, is determined as follows:
  - *"Wastes with any element or chemical substance concentration above the LCT3 or TCT2 limits (LC> LCT3 or TC> TCT2) are **Type 0 Wastes**;*
  - *Wastes with any element or chemical substance concentration above the LCT2 but below or equal to the LCT3 limits, or above the TCT1 but below or equal to the TCT2 limits (LCT2 < LC ≤ LCT3 or TCT1 <TC ≤ TCT2), are **Type 1 Wastes**;*
  - *Wastes with any element or chemical substance concentration above the LCT1 but below or equal to the LCT2 limits and all concentrations below or equal to the TCT1 limits (LCT1 < LC ≤ LCT2 and TC ≤ TCT1) are **Type 2 Wastes**;*
  - *Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0 < LC ≤ LCT1 and TC ≤ TCT1) are **Type 3 Wastes**;*
  - *Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC ≤ LCT0 and TC ≤ TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides, are **Type 4 Wastes** -*
  - *Notwithstanding the above, wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste;"*

- The TC of the material was also evaluated against the Average Upper Crust (AUC) of Rudnick and Gao (2003). The upper continental crust is the most accessible part of our planet and composition was determined by Rudnick and Gao (2003) from weighted averages of the compositions of rocks exposed at the surface; and

12.3 WASTE CLASSIFICATION RESULTS

Test results used for the waste classification are presented as follows:

- The results are tabulated in sections 11.4 and 11.5 of this report.
- Table 11.4(a) indicates the major elements and table 11.4(b) the trace elements as determined by Reagent Water Leach test.
- The results of the Reagent Water Leach test were compared to a Leachable Concentration Threshold (LCT) listed under section 6.2 of GNR635.
- Table 11.5(a) presents the total concentration of a spectrum of elements as determined by Aqua Regia (Total Digestion) analyses.
- The results of the Aqua Regia tests were compared to the average upper Crust (AUC) values as listed by Rudnick and Gao, 2003 as well as a Total Concentration Threshold (TCT) listed under section 6.1 of GNR635.

The distribution of the materials can be seen in Figure 12.3(a), whilst the classification distribution of the waste material assessed is indicated on Figure 12.3(b).

Summaries of the each of the waste classification results are addressed in the sub-sections that follow and provide an overview of the classification results.

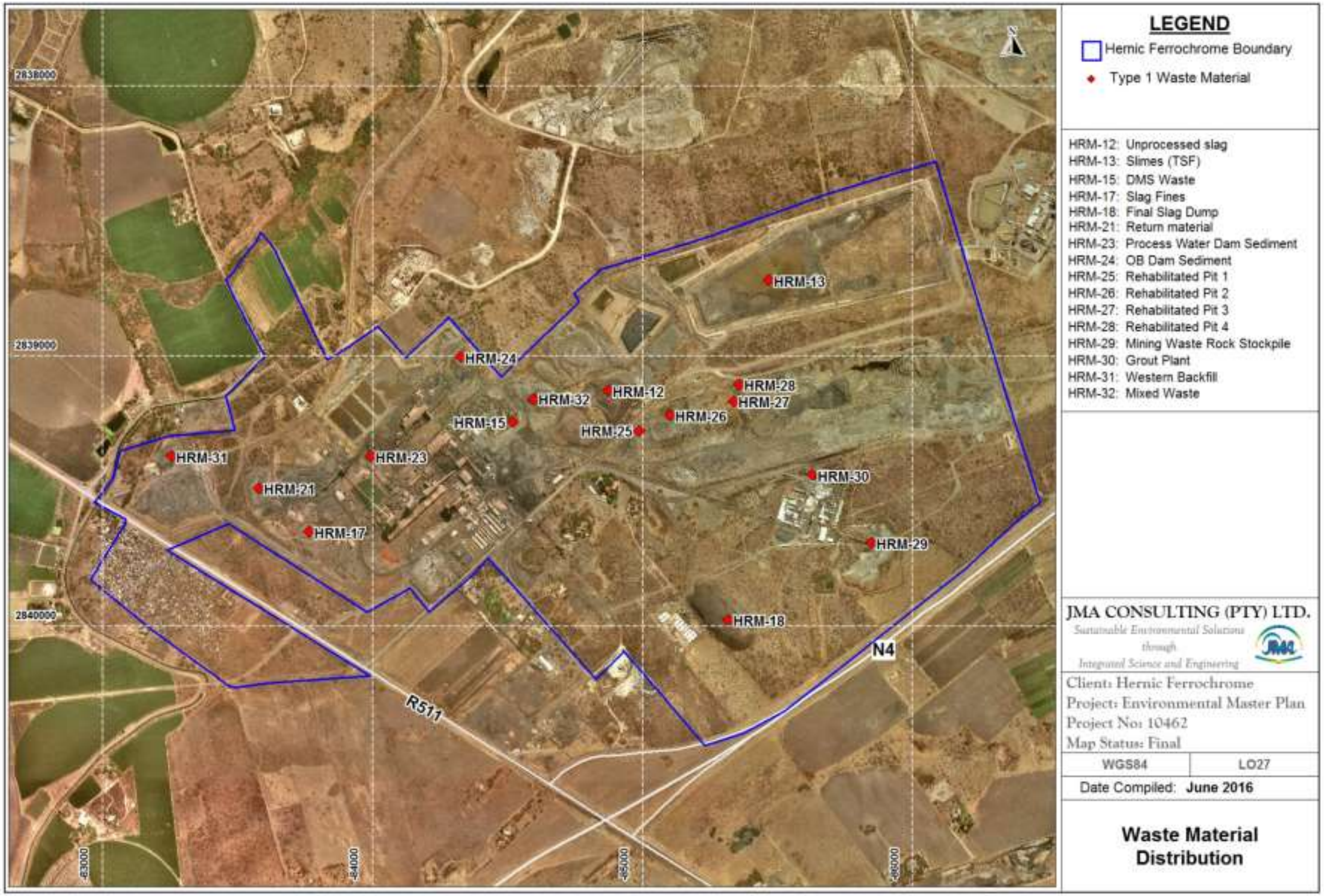


Figure 12.3(a): Waste Material Sampling Localities (16 Locations)

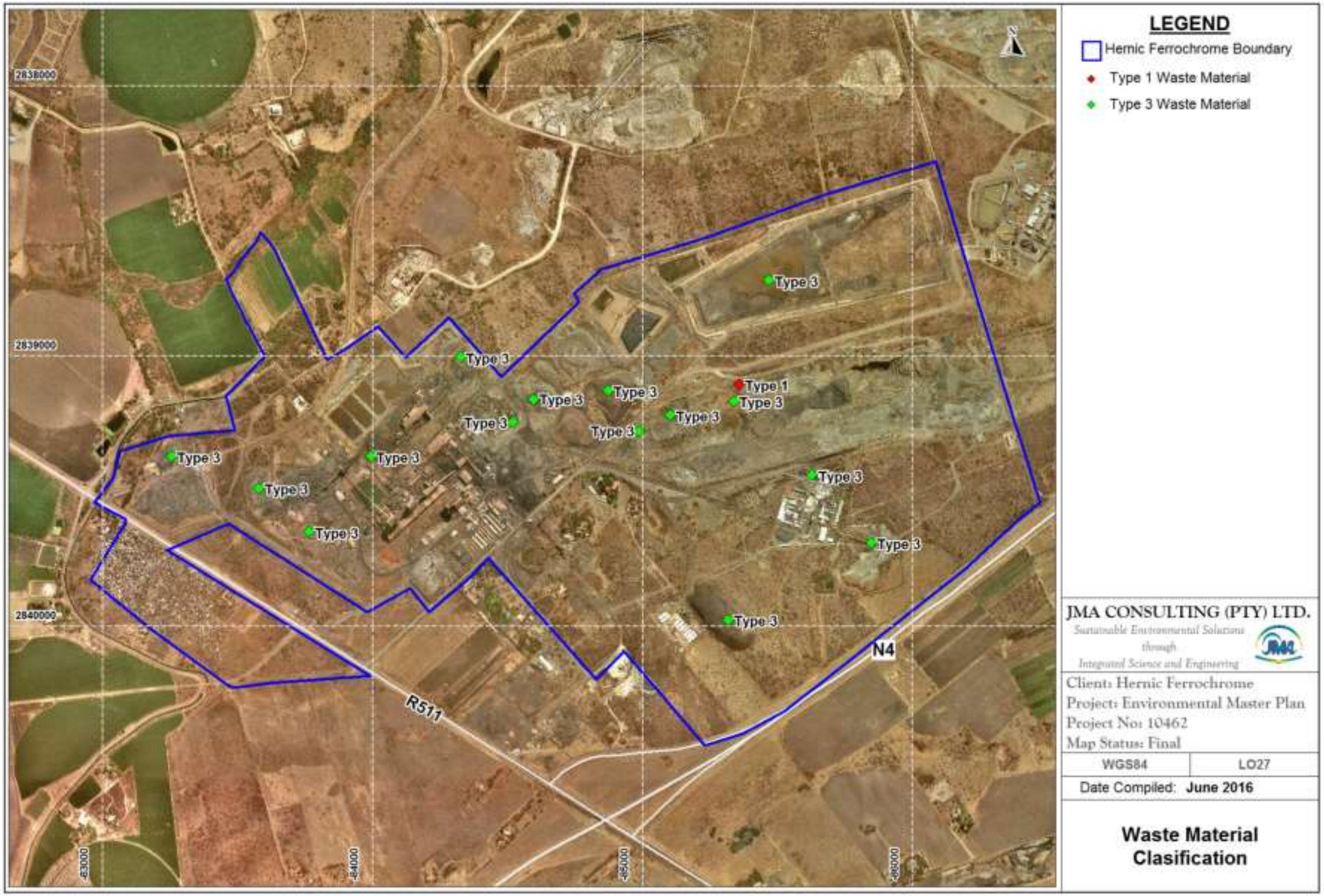


Figure 12.3(b): Waste Material Classification (16 Locations)

12.3.1 Unprocessed Slag (HRM-12)

None of the LC value tested, exceeded the LCT values. Five elements exceeded TCT0 as indicated in table 12.3.1(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.1(a): Unprocessed Slag Classification Summary

Sample:	Unprocessed Slag
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Co, Mn, Ni and Se
Elements >TCT1	-
Elements >TCT2	-

The unprocessed slag sample collected (HRM-12) is classified as a **Type 3** Waste.

12.3.2 Slimes (TSF) (HRM-13)

None of the LC value tested, exceeded the LCT values. Eight elements exceeded TCT0 as indicated in table 12.3.2(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.2(a): Slimes (TSF) Classification Summary

Sample:	Slimes (TSF)
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Co, Cu, Ni, Pb, Se and Zn
Elements >TCT1	-
Elements >TCT2	-

The Slimes (TSF) sample collected (HRM-13) is classified as a **Type 3** Waste.

12.3.3 DMS Waste (HRM-15)

None of the LC value tested, exceeded the LCT values. Seven elements exceeded TCT0 as indicated in table 12.3.3(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.3(a): DMS Waste Classification Summary

Sample:	DMS Waste
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Co, Cu, Mn, Ni and Se
Elements >TCT1	-
Elements >TCT2	-

The DMS Waste sample collected (HRM-15) is classified as a **Type 3** Waste.

12.3.4 Slag Fines (HRM-17)

Cr is the only element which exceeded the LCT0 values with four elements exceeding TCT0 as indicated in table 12.3.4(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to LCT1limits and all concentrations below or equal to the TC1limits are type 3 wastes";*

Table 12.3.4(a): Slag Fines Classification Summary

Sample:	Slag Fines
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	Cr
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Ni and Se
Elements >TCT1	-
Elements >TCT2	-

The Slag Fines sample collected (HRM-17) is classified as a **Type 3** Waste.

12.3.5 Final Slag Dump (HRM-18)

None of the LC value tested, exceeded the LCT values. Five elements exceeded TCT0 as indicated in table 12.3.5(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.5(a): Final Slag Dump Classification Summary

Sample:	Final Slag Dump
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Co, Ni and Se
Elements >TCT1	-
Elements >TCT2	-

The Final Slag Dump sample collected (HRM-18) is classified as a **Type 3** Waste.

12.3.6 Return Material (HRM-21)

None of the LC value tested, exceeded the LCT values. Five elements exceeded TCT0 as indicated in table 12.3.6(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.6(a): Return Material Classification Summary

Sample:	Return Material
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ni, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The Return Material sample collected (HRM-21) is classified as a **Type 3** Waste.

12.3.7 Process Water Dam Sediment (HRM-23)

None of the LC value tested, exceeded the LCT values. Nine elements exceeded TCT0 as indicated in table 12.3.7(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.7(a): Process Water Dam Sediment Classification Summary

Sample:	Process Water Dam Sediment
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Co, Cr, Cu, Ni, Pb, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The Process Water Dam Sediment sample collected (HRM-23) is classified as a **Type 3** Waste.

12.3.8 OB Dam Sediment (HRM-24)

None of the LC value tested, exceeded the LCT values. Eight elements exceeded TCT0 as indicated in table 12.3.8(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.8(a): OB Dam Sediment Slag Classification Summary

Sample:	OB Dam Sediment
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba Co, Cu, Ni, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The OB Dam Sediment sample collected (HRM-24) is classified as a **Type 3** Waste.

12.3.9 Rehabilitated Pit 1 (HRM-25)

None of the LC value tested, exceeded the LCT values. Seven elements exceeded TCT0 as indicated in table 12.3.9(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.9(a): Rehabilitated Pit 1 Classification Summary

Sample:	Rehabilitated Pit 1
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Cu, Ni, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The Rehabilitated Pit 1 sample collected (HRM-25) is classified as a **Type 3** Waste.

12.3.10 Rehabilitated Pit 2 (HRM-26)

None of the LC value tested, exceeded the LCT values. Seven elements exceeded TCT0 as indicated in table 12.3.10(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.10(a): Rehabilitated Pit 2 Classification Summary

Sample:	Rehabilitated Pit 2
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Co, Cu, Ni, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The Rehabilitated Pit 2 sample collected (HRM-26) is classified as a **Type 3** Waste.

12.3.11 Rehabilitated Pit 3 (HRM-27)

Cr is the only element which exceeded the LCT0 values with three elements exceeding TCT0 as indicated in table 12.3.11(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to LCT1 limits and all concentrations below or equal to the TC1limits are type 3 wastes";*

Table 12.3.11(a): Rehabilitated Pit 3 Classification Summary

Sample:	Rehabilitated Pit 3
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	Cr
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Cu and Ni
Elements >TCT1	-
Elements >TCT2	-

The Rehabilitated Pit 3 sample collected (HRM-27) is classified as a **Type 3** Waste.

12.3.12 Rehabilitated Pit 4 (HRM-28)

Se is the only element which exceeded the LCT0 values with seven elements exceeding TCT0 and one element **(Se) exceeding TCT1** as indicated in table 12.3.12(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT2 but below or equal to LCT3 limits,* ***or above the TCT1 but below or equal to the TCT2 limits are type 1 wastes****";*

Table 12.3.12(a): Rehabilitated Pit 4 Classification Summary

Sample:	Rehabilitated Pit 4
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	Se
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Co, Cu, Mn, Ni, V and Zn
Elements >TCT1	Se
Elements >TCT2	-

The Rehabilitated Pit 4 sample collected (HRM-28) is classified as a **Type 1** Waste.

12.3.13 Mining Waste Rock Stockpile (HRM-29)

None of the LC value tested, exceeded the LCT values. Four elements exceeded TCT0 as indicated in table 12.3.13(a). According to the GNR 635 the waste rock are classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.13(a): Mining Waste Rock Stockpile Classification Summary

Sample:	Mining Waste Rock Stockpile
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Co, Mn and Ni
Elements >TCT1	-
Elements >TCT2	-

The Mining Waste Rock Stockpile sample collected (HRM-29) is classified as a **Type 3** Waste.

12.3.14 Grout Plant (HRM-30)

None of the LC value tested, exceeded the LCT values. Four elements exceeded TCT0 as indicated in table 12.3.14(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.14(a): Unprocessed Slag Classification Summary

Sample:	Grout Plant
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Ni and V
Elements >TCT1	-
Elements >TCT2	-

The Ground Plant sample collected (HRM-30) is classified as a **Type 3** Waste.

12.3.15 Western Backfill (HRM-31)

None of the LC value tested, exceeded the LCT values. Nine elements exceeded TCT0 as indicated in table 12.3.15(a). According to the GNR 635 the waste material is classified as follows: *"...wastes with all element or chemical substance leachable concentration levels for metal ions and inorganic anions below or equal to the LCT0 limits are considered to be Type 3 Waste, irrespective of the total concentration of elements or chemical substances in the waste";*

Table 12.3.15(a): Western Backfill Classification Summary

Sample:	Western Backfill
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Co, Cu, Mn, Ni, Se, V and Zn
Elements >TCT1	-
Elements >TCT2	-

The Western Backfill sample collected (HRM-31) is classified as a **Type 3** Waste.

12.3.16 Mixed Waste (HRM-32)

Cr is the only element which exceeded the LCT0 values with eight elements exceeding TCT0 as indicated in table 12.3.16(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to LCT1 limits and all concentrations below or equal to the TC1 limits are type 3 wastes";*

Table 12.3.16(a): Mixed Waste Classification Summary

Sample:	Mixed Waste
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	Cr
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	F, Ba, Co, Cu, Mn, Ni, Se and V
Elements >TCT1	-
Elements >TCT2	-

The Mixed Waste sample collected (HRM-32) is classified as a **Type 3** Waste.

12.4 DISPOSAL OF MATERIAL

The following comments relate to the disposal of the material:

- A total of 15 of the 16 waste samples collected and analysed are classified as **Type 3** wastes. Only the rehabilitated pit sample 4 (HRM-28) is classified as a **Type 1** waste.

- The landfill disposal requirements for Type 3 wastes include the installation of a **Class C liner**. The Class C liner setup is depicted in Figure 12.4(a) overleaf.

  According to GNR 636: **"***Type 3 wastes may only be disposed of at a Class C landfill designed in accordance with section 3(1) and (2) of these norms and standards, or, subject to section 3(4) of these norms and standards, may be disposed of at a landfill site designed in accordance with the requirements for a GLB+ landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd ED., DWAF, 1998).*"

- The landfill disposal requirements for Type 1 wastes include the installation of a **Class A liner**. The Class A liner setup is depicted in Figure 12.4(b) overleaf.

  According to GNR 636: **"***Type 1 waste may only be disposed of at a Class A landfill designed in accordance with section 3(1) and (2) of these norms and standards, or, subject to section 3(4) of these norms and standards, may be disposed of at a landfill site designed in accordance with the requirements for a Hh / HH landfill as specified in the Minimum Requirements for Waste Disposal by Landfill (2nd ED., DWAF, 1998).*"

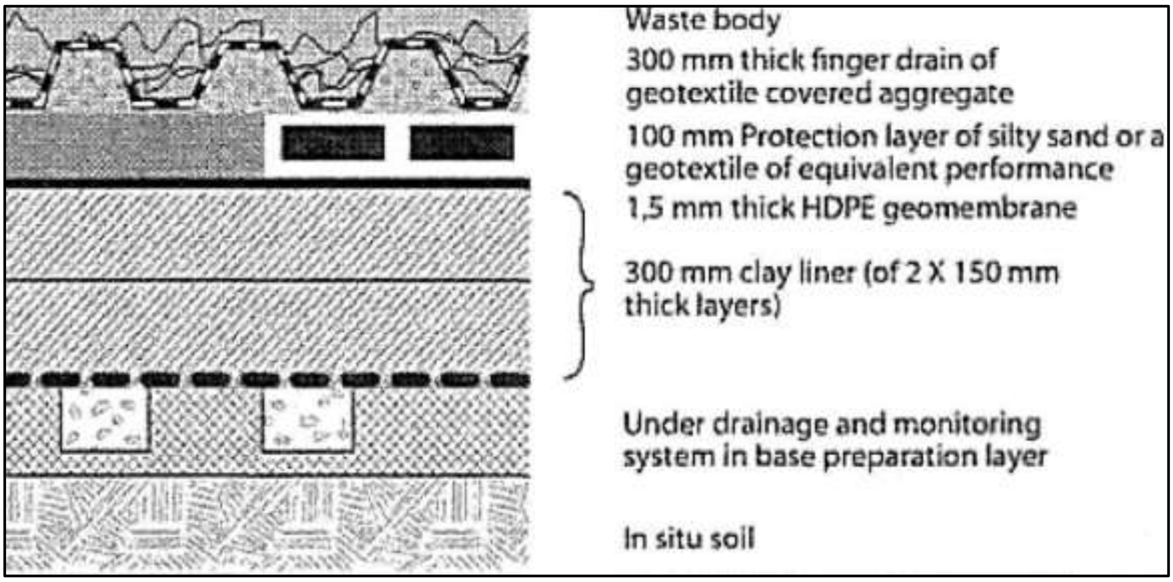


Figure 12.4(a): Class C Landfill Design (GNR 636)

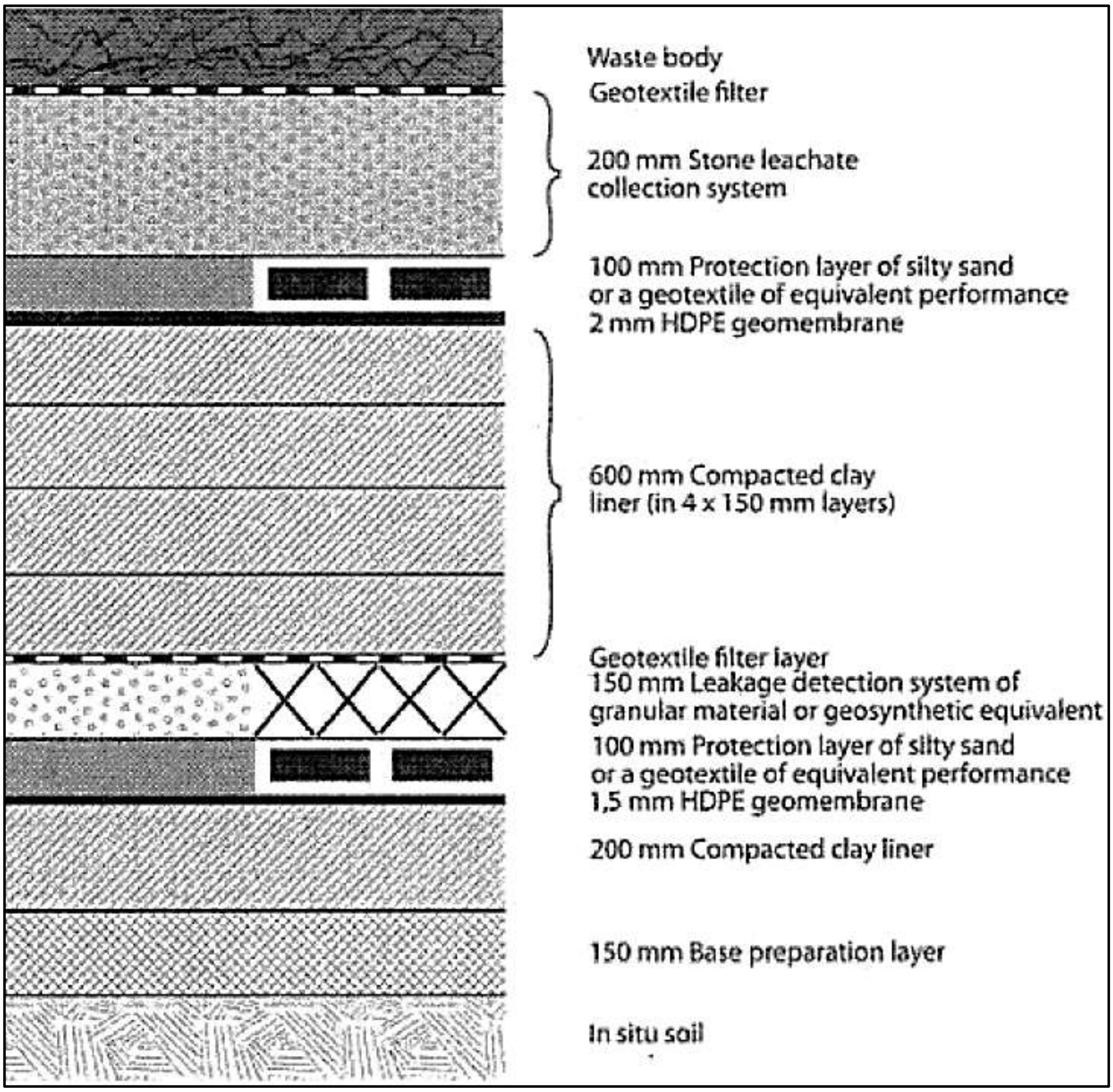


Figure 12.4(b): Class A Landfill Design (GNR 636)

13. SURFACE WATER QUALITY ASSESSMENT

13.1 SURFACE WATER SAMPLING

Based on the project description and site inventory, an initial surface water sampling plan was undertaken in order to assess the quality of the water contained within the respective surface water facilities, within the open pit as well as from several of the adjacent surface water bodies. A total of 13 surface water sampling points were located and collected for analytical testing. The surface water sampling field form is attached as APPENDIX XII to this report.

A description of each of the water samples collected is given in Table 13.1(a). The surface water sampling localities of all the points as well as the surface water sampling localities within the plant management area are depicted on Figure 13.1(a). Photographs of the surface water samples collected are shown in Table 13.1(b).

Table 13.1(a): Surface Water Sample Numbers and Descriptions

Sample Number	Latitude Longitude	Description	Water Type	Purpose
HSW-1	25° 39' 10.3" S 27° 50' 56.6" E	TSF Slimes Dam RWD	Process Water	Storage Facility For Process Decant Water
HSW-3	25° 39' 28.5" S 27° 50' 15.1" E	Storm Water Dam	Dirty Storm Water	Storage Facility for Storm Water Runoff
HSW-4	25° 39' 12.9" S 27° 50' 12.9" E	Process Water Dam	Process Water	Storage And Treatment Of Process Water
HSW-5	25° 39' 36.2" S 27° 50' 09.7" E	Drinking Water Dam	Hartbeespoort Irrigation Water	The Water Is Treated At The Water Treatment Plant And Distributed For Domestic Use
HSW-6	25° 39' 20.8" S 27° 50' 19.3" E	OB Plant Water Dam	Process Water	Reticulation Facility For Process And Storm Water From The OB Plant
HSW-7	25° 39' 48.1" S 27° 51' 13.4" E	Morula Dewatering Dam	Abstracted Groundwater	Additional Storage For The Dewatering Of Underground Workings
HSW-8	25° 39' 15.2" S 27° 50' 42.4" E	HH Return Water Dam	Process Water	Storage Facility For Process Decant Water
HSW-9	25° 39' 47.0" S 27° 50' 33.0" E	CRP Dam	Process Water	Reticulation Facility For Process And Storm Water From The CRP Facility
HSW-10	25° 39' 42.3" S 27° 50' 04.9" E	Slag Spiral Plant Sump	Process Water	Reticulation Facility For Process And Storm Water
HSW-11	25° 39' 24.6" S 27° 49' 54.7" E	Irrigation Canal	Hartbeespoort Irrigation Water	Isolated Irrigation Water Source From The Hartbeespoort Dam
HSW-16	25° 39' 23.5" S 27° 51' 17.3" E	Open Pit	Mine Water	Rain And Groundwater Will Be Pumped Away From The Pit
HSW-17	25° 39' 36.1" S 27° 51' 10.2" E	Grout Plant Sump	Process Water	Reticulation Facility For Process And Storm Water
HSW-18	25° 39' 21.8" S 27° 50' 09.7'' E	Emergency Dam	Dirty Storm Water	Capture And Store All Dirty Surface Storm Water Run-Off From The Alloys Plant Area

13.2 SURFACE WATER QUALITY

The surface water samples collected were not filtered in the field or the laboratory and were analysed by means of a full quantified ICP-MS analyses. The unfiltered total elemental concentrations are listed in Table 13.2(a) and have been assessed with regards to the acceptable drinking water quality limits set in SANS 241:2011.

Piper and Expanded Durov Diagrams were created for the surface water samples collected and are depicted as Figure 13.2(a) and Figure 13.2(b) respectively. The surface water time dependent chemistry report is attached as APPENDIX XIII to this report

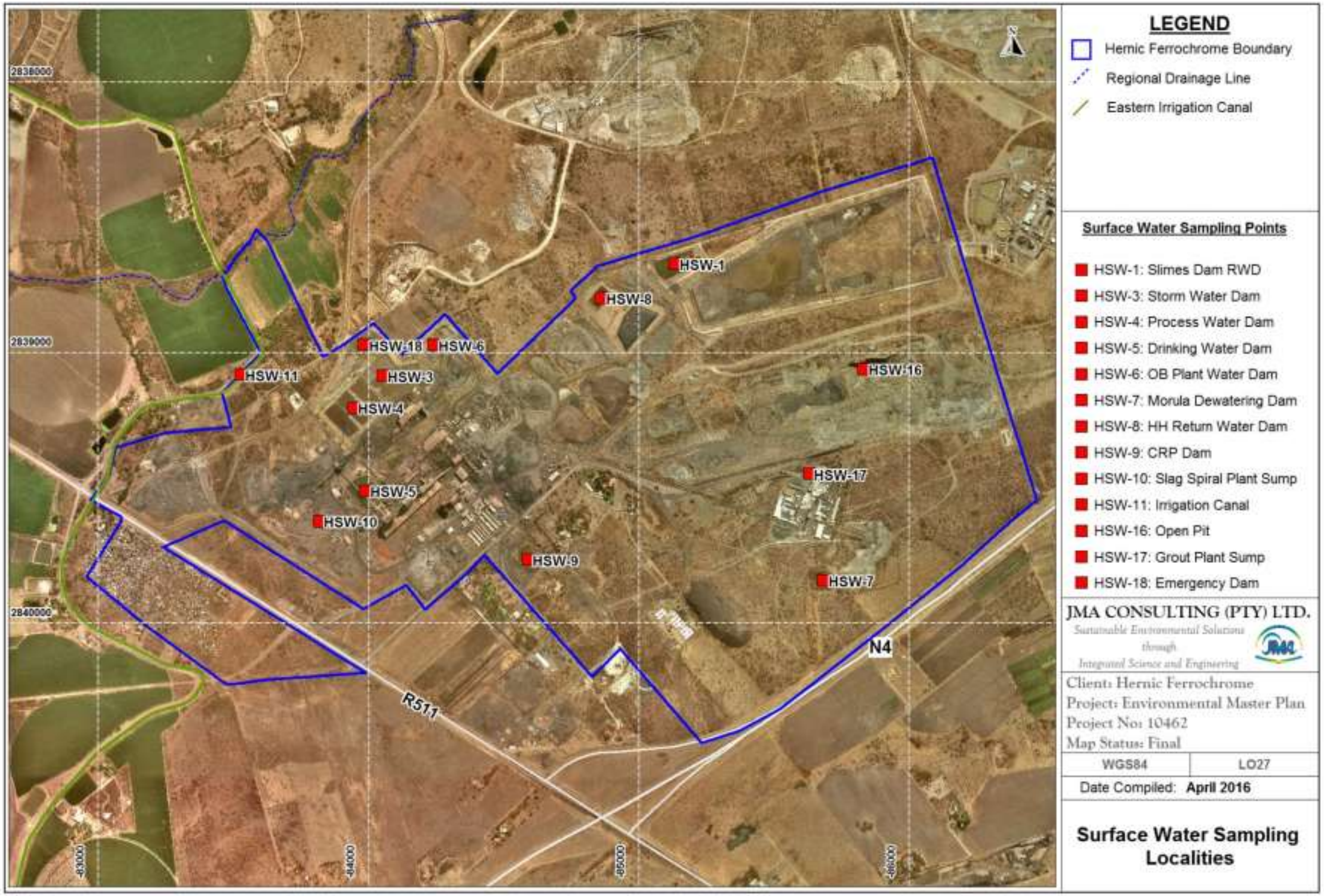


Figure 13.1(a): Surface Water Sampling Localities (13 Locations)

Table 13.1(b): Photographs of the Surface Water Samples Collected

Sample Number	HSW-1	HSW-3	HSW-4
Photo			
Description	**Slimes Dam RWD** (Process Water)	**Storm Water Dam** (Dirty Storm Water)	**Process Water Dam** (Process Water)
Sample Number	**HSW-5**	**HSW-6**	**HSW-7**
Photo			
Description	**Drinking Water Dam** (Hartbeespoort Dam Canal Water)	**OB Plant Water Dam** (Process Water)	**Morula Dewatering Dam** (Abstracted Groundwater)
Sample Number	**HSW-8**	**HSW-9**	**HSW-10**
Photo			
Description	**HH Return Water Dam** (Process Water)	**CRP Dam** (Process Water)	**Fine Fraction Slag Spiral Plant Sump** (Process Water)

Sample Number	HSW-11	HSW-16	HSW-17
Photo			
Description	**Irrigation Canal** (Hartbeespoort Dam Water)	**Open Pit** (Mine Water)	**Grout Plant Sump** (Process Water)
Sample Number	**HSW-18**		
Photo			
Description	**Emergency Dam** (Dirty Storm Water)		

Table 13.2(a): Surface Water Qualities (1 of 2)

Analyses in mg/ℓ	HSW-1	HSW-3	HSW-4	HSW-5	HSW-6	HSW-7	HSW-8	HSW-9	HSW-10	HSW-11	HSW-16	HSW-17	HSW-18	SANS 241:2006 Limits	SANS 241:2011 Limits	SANS 241:2015 Limits
pH	8.4	8.3	8.4	8	8.5	8.3	9.2	7.9	8.1	8.6	8.3	8.3	8.1	-	-	≥5 to ≤9.7
EC	325	333	422	60.6	320	98.7	2 954	344	293	53.8	91.4	43.8	114	-	-	≤170
TDS	2 244	2 356	2 966	356	2 202	640	20 814	2 680	2 088	300	560	280	708	-	-	≤1200
Ca	50	56	62	45	51	47	52	213	93	40	32	32	54	150-300	-	-
Mg	140	139	157	18	149	68	80	161	106	15	72	3	44	70-100	-	-
Na	327	350	379	48	327	64	5 099	292	275	44	51	34	97	-	-	≤200
K	228	241	397	13.1	227	9.1	3 574	143	213	9.2	15.5	25	41	50-100	-	-
T.Alk	524	368	624	160	464	268	212	144	248	156	316	52	228	-	-	-
Cl	226	245	267	47	236	54	7 735	299	210	39	29	25	75	-	-	≤300
SO_4	690	784	792	73	686	158	3 851	1 303	769	61	141	115	244	-	-	≤250 ≤500
Si	14.2	10.6	24	5.3	15.1	16.2	1.7	5.6	7.7	4.9	15	12.5	3.1	-	-	-
NO_3	48	57	107	1.9	48	11	20	34	48	0.4	6.7	<0.1	3.8	-	-	≤11
NO_2	26	25	29	1.2	27	0.1	5	6	19	0.3	0.2	<0.05	0.5	-	-	≤0.9
Al	<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	-	-	≤0.3
F	5.8	7.3	14	0.3	5.9	0.2	4.9	2.2	5.1	0.2	0.5	0.3	1.6	-	-	≤1.5
Fe	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	-	-	≤0.3 ≤2
Mn	0.068	<0.025	0.193	<0.025	0.06	<0.025	<0.025	0.066	0.173	<0.025	<0.025	<0.025	<0.025	-	-	≤0.1 ≤0.4
NH_4	9.9	1.1	26	1	11	0.1	0.9	2.6	4	2.4	0.3	0.1	0.4	-	-	≤1.5
Zn	0.027	0.046	0.038	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.033	<0.025	-	-	≤5
Cr	<0.025	<0.025	<0.025	<0.025	<0.025	0.075	3.2	<0.025	<0.025	<0.025	0.247	<0.025	<0.025	-	-	≤0.05
Cr^{6+}	<0.010	<0.010	<0.010	<0.010	<0.010	0.075	0.294	<0.010	<0.010	<0.010	0.247	<0.010	<0.010	-	-	-

Table 13.2(a): Surface Water Qualities (2 of 2)

Analyses in mg/ℓ	HSW-1	HSW-3	HSW-4	HSW-5	HSW-6	HSW-7	HSW-8	HSW-9	HSW-10	HSW-11	HSW-16	HSW-17	HSW-18	SANS 241:2006 Limits	SANS 241:2011 Limits	SANS 241:2015 Limits
Ag	<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	-	-	-
As	<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	-	-	≤0.01
Ba	0.076	0.116	0.062	0.035	0.093	0.039	0.054	0.077	<0.025	0.031	0.051	0.033	0.06	-	-	≤0.7
Bi	<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	-	-	-
B	0.313	0.318	0.429	0.037	0.293	0.067	0.736	0.191	0.238	0.036	0.103	0.292	0.118	-	-	≤2.4
Cd	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
Co	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	-	≤0.5	-
Cu	<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	-	-	≤2
Li	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.83	<0.025	<0.025	<0.025	<0.025	0.438	<0.025	-	-	-
Mo	<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	-	-	-
Ni	0.098	0.049	0.084	<0.025	0.079	<0.025	0.047	0.071	0.068	<0.025	<0.025	<0.025	<0.025	-	-	≤0.07
P	0.279	0.173	0.759	0.784	0.264	0.097	0.115	0.102	0.191	0.949	0.038	<0.025	0.052	-	-	-
Pb	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	-	-	≤0.01
PO_4	<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	-	-	-
Sb	<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	-	-	≤0.02
Se	<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	-	-	≤0.04
S	319	352	347	32	321	72	1 900	574	345	27	44	33	105	-	-	-
Sr	0.461	0.508	0.386	0.143	0.471	0.198	0.368	0.594	0.286	0.131	0.163	0.173	0.259	-	-	-
Ti	<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	-	-	-
V	0.081	0.078	0.08	<0.025	0.084	0.027	0.08	0.083	0.082	<0.025	0.025	<0.025	<0.025	-	≤0.2	-
% Balancing	99.8	98.5	99.6	99.7	97.2	100	97.1	99.4	98.8	99.7	98.1	97.9	98.3	-	-	

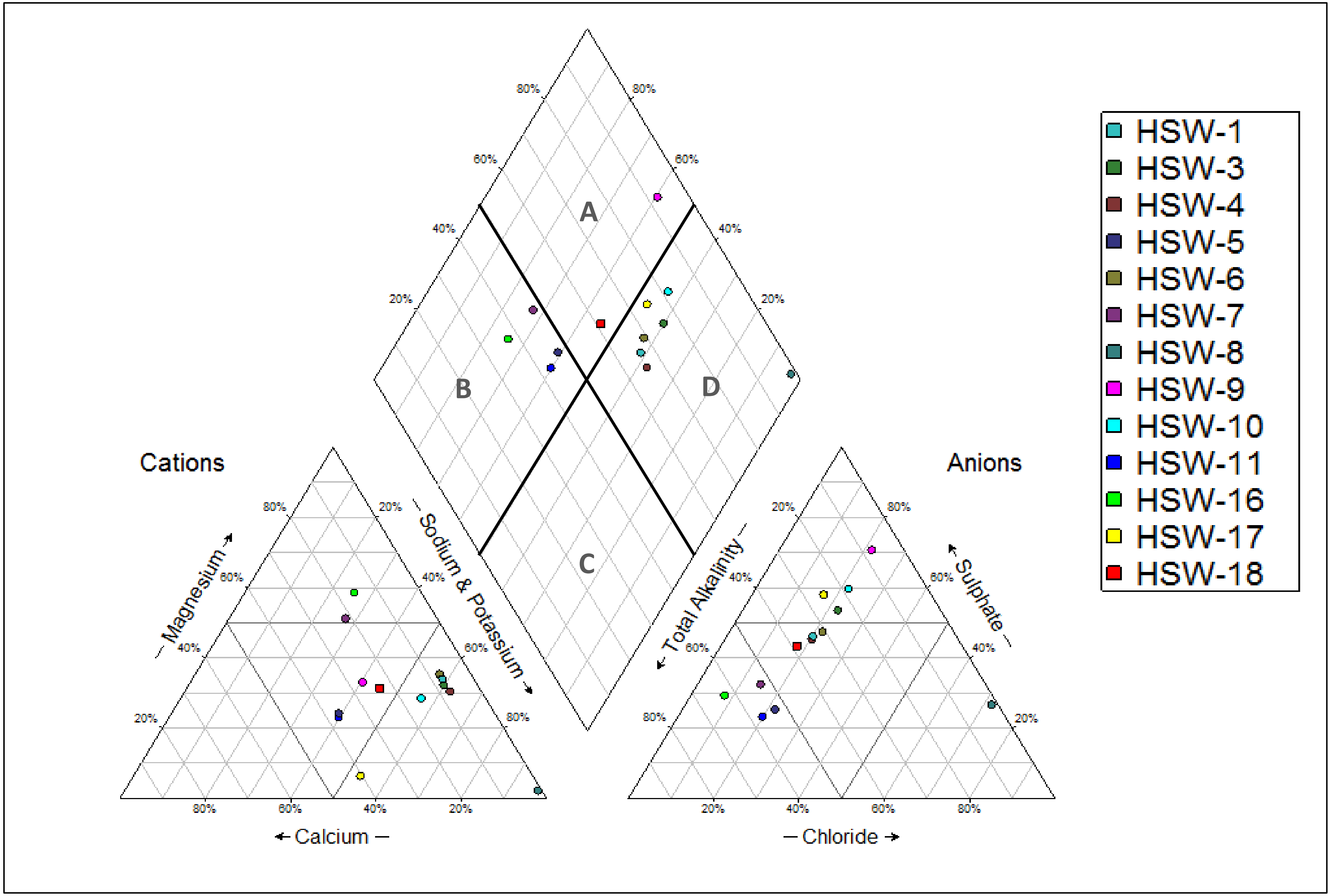


Figure 13.2(a): Piper Diagram – Surface Water Samples

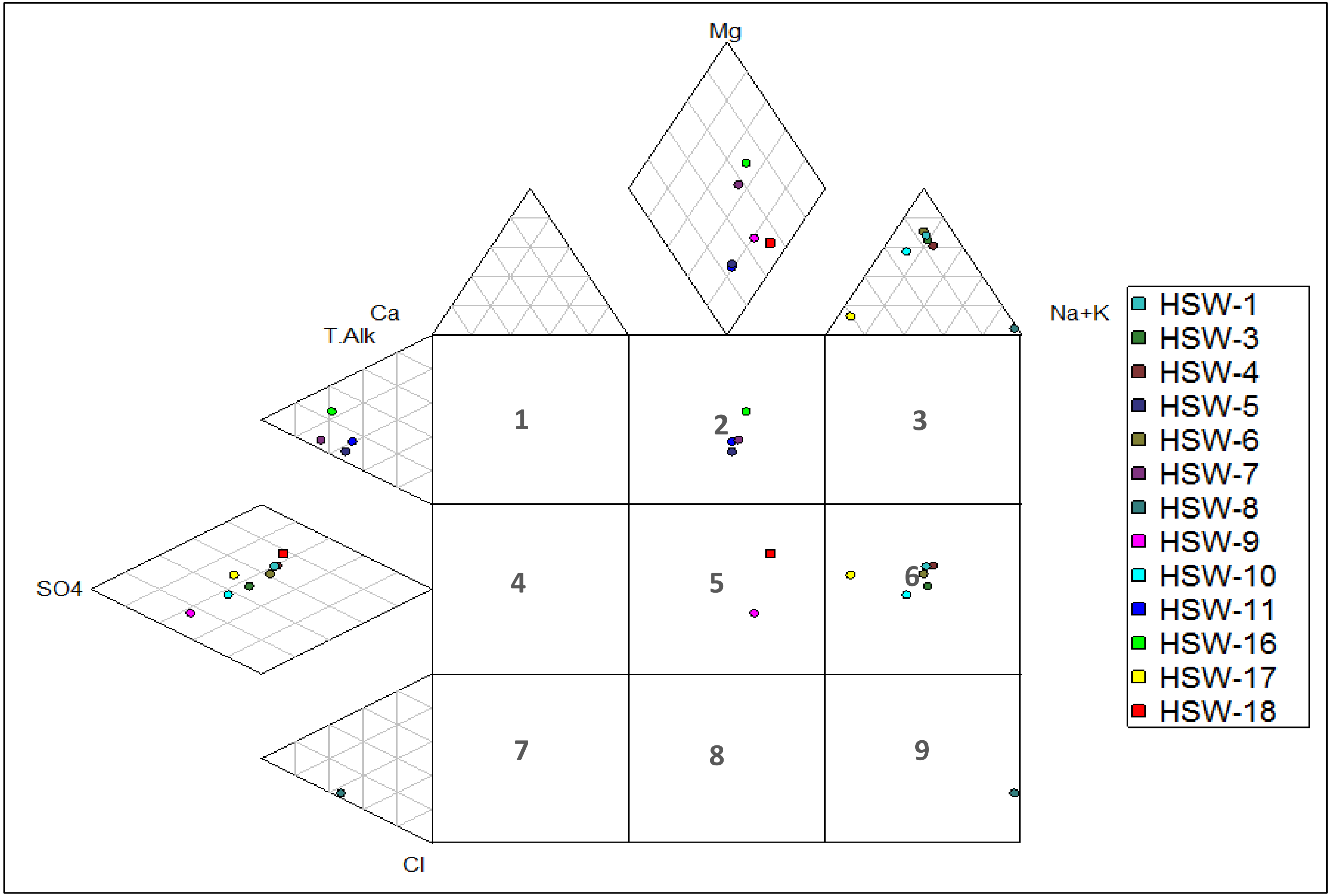


Figure 13.2(b): Expanded Durov Diagram – Surface Water Samples

The following comments are made with regards to the water sampled from the surface water containment facilities as well as the water sampled from the open pit and the Hartbeespoort Irrigation Canal):

- The water samples collected from the TSF Return Water Dam (HSW-1), Storm Water Dam (HSW-2), Process Water Dam (HSW-3), OB Plant Water Dam (HSW-6), HH Return Water Dam (HSW-8), Chrome Recovery Plant (CRP) dam (HSW-9) and at the Slag Spiral Plant Sump (HSW-10) all have elevated concentrations and could potentially have an adverse impact on the environment if the water is not contained within each of the respective facilities.
- Elevated levels of Cr(T) and Cr(VI) concentrations were recorded in the samples taken from the Morula Dewatering Dam (HSW-7), the HH Return Water Dam (HSW-8) as well as the water sampled from the Open Pit (HSW-16)

The Piper and Expanded Durov diagrams further indicate that:

- The water samples collected have scattered hydrochemical images.
- The water samples collected from the CRP Dam (HSW-9) and the Emergency Dam (HSW-18) are characterised by having a **Type A** hydrochemical image with the dominant cation being Mg and the dominant anion being SO_4.
- The water samples collected from the Drinking Water Dam (HSW-5), Morula Dewatering Dam (HSW-7), Hartbeespoort Irrigation Canal (HSW-11) and the Open Pit (HSW-16) are characterised by having a T**ype B** hydrochemical image with the dominant cation being Mg^{2+} and dominant anion being T.Alk. These water samples fall into Class 2 of the expanded Durov diagram and represent "*un-impacted*" surface water samples.
- The water samples collected from the TSF Slimes Dam Return Water Dam (HSW-1), Storm Water Dam (HSW-3), Process Water Dam (HSW-4), OB Plant Water Dam (HSW-6), HH Return Water Dam (HSW-8), Slag Spiral Plant Sump (HSW-10) and the Grout Plant Sump (HSW-17) are characterised by having a **Type D** hydrochemical image with the dominant cation being Na & K and dominant anion being SO_4. The Return Water Dam (HSW-8) has a slightly different signature with the dominant anion being Cl. These water samples fall into Class 6 (and Class 9) of the expanded Durov diagram and represent "*impacted*" surface water samples due to the increased salt concentrations in the water. It is of critical environmental importance that the water contained within these facilities is not released or spilled into the environment as it will have an adverse impact on the environmental resources.

13.3 SURFACE WATER QUALITY ASESSMENT / CLASSIFICATION

13.3.1 TSF Slimes Dam Return Water Dam

Four of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.1(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	TSF Slimes Dam RWD
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F, Cd, Ni and Pb
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the TSF Slimes Dam Return Water Dam (HSW-1) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.2 Storm Water Dam

Two of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.2(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	Storm Water Dam
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F and Pb
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Storm Water Dam (HSW-3) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.3 Process Water Dam

Three of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.3(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	Process Water Dam
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F, Ni and Pb
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Process Water Dam (HSW-4) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.4 Drinking Water Dam

None of the LC values tested, exceeded the LCT0 Standards. None of the elements exceeded TCT as indicated in table 13.3.4(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC≤LCT0 and TC≤TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides* (as stipulated in the GNR635)*, are Type 4 Wastes";*

Sample:	Drinking Water Dam
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Drinking Water Dam (HSW-5) is classified as **Type 4** according to GNR635 of the Waste Classification and Management Regulations.

13.3.5 OB Plant Water Dam

Two of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.5(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	OB Plant Water Dam
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F and Ni
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the OB Plant Water Dam (HSW-6) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.6 Morula Dewatering Dam

None of the LC values tested, exceeded the LCT0 Standards. None of the elements exceeded TCT as indicated in table 13.3.6(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC≤LCT0 and TC≤TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides* (as stipulated in the GNR635)*, are Type 4 Wastes";*

Sample:	Morula Dewatering Dam
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Morula Dewatering Dam (HSW-7) is classified as **Type 4** according to GNR635 of the Waste Classification and Management Regulations.

13.3.7 HH Return Water Dam

Five of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.7(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	**HH Return Water Dam**
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F, B, Cd, Pb and Se
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the HH Return Water Dam (HSW-8) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.8 CRP Dam

Three of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.8(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	**CRP Dam**
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F, Ni and Pb
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the CRP Dam (HSW-9) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.9 Slag Spiral Plant Sump

Two of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.9(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	Slag Spiral Plant Sump
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F and Pb
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Slag Spiral Plant Sump Dam (HSW-10) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

13.3.10 Open Pit

None of the LC values tested, exceeded the LCT0 Standards. None of the elements exceeded TCT as indicated in table 13.3.10(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC≤LCT0 and TC≤TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides* (as stipulated in the GNR635)*, are Type 4 Wastes";*

Sample:	Open Pit
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Open Pit (HSW-16) is classified as **Type 4** according to GNR635 of the Waste Classification and Management Regulations.

13.3.11 Grout Plant Sump

None of the LC values tested, exceeded the LCT0 Standards. None of the elements exceeded TCT as indicated in table 13.3.11(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with all element and chemical substance concentration levels for metal ions and inorganic anions below or equal to the LCT0 and TCT0 limits (LC≤LCT0 and TC≤TCT0), and with all chemical substance concentration levels also below the following total concentration limits for organics and pesticides* (as stipulated in the GNR635)*, are Type 4 Wastes";*

Sample:	**Grout Plant Sump**
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	-
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Grout Plant Sump (HSW-17) is classified as **Type 4** according to GNR635 of the Waste Classification and Management Regulations.

13.3.12 Emergency Dam

One of the LC values tested, exceeded the LCT0 values. None of the elements exceeded TCT as indicated in table 13.3.12(a). According to the GNR 635 the waste material is classified as follows: *"...Wastes with any element or chemical substance concentration above the LCT0 but below or equal to the LCT1 limits and all TC concentrations below or equal to the TCT1 limits (LCT0<LC≤LCT1 and TC≤ TCT1) are Type 3 Wastes";*

Sample:	**Emergency Dam**
Section 6.1, GNR635	Reagent Water Leach
Elements >LCT0	F
Elements >LCT1	-
Elements >LCT2	-
Elements >LCT3	-
Section 6.2, GNR635	Aqua Regia (Total Digestion)
Elements >TCT0	-
Elements >TCT1	-
Elements >TCT2	-

The water sampled from the Emergency Dam (HSW-18) is classified as **Type 3** according to GNR635 of the Waste Classification and Management Regulations.

14. REFERENCES

1. Department of Environmental Affairs (2013). National Environmental Management: Waste Act (Act No. 59 of 2008). Waste Classification and Management Regulations (GNR634). 23 August 2013.

2. Department of Environmental Affairs (2013). National Environmental Management: Waste Act (Act No. 59 of 2008). National Norms and Standards for the Assessment of Waste for Landfill Disposal (GNR635). 23 August 2013.

3. Department of Environmental Affairs (2013). National Environmental Management: Waste Act (Act No. 59 of 2008). National Norms and Standards for Disposal of Waste to Landfill (GNR636). 23 August 2013.

4. Miller, S., Robertson, A. and Donahue, T. (1997). Advances in Acid Drainage Prediction using the Net Acid Generation (NAG) Test. Proc. 4th International Conference on Acid Rock Drainage, Vancouver, BC, 0533-549.

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

6. National Environmental Management: Air Quality Act (Act No. 39 of 2004).

7. National Environmental Management: Waste Act (Act No. 59 of 2008).

8. National Water Act (Act No. 36 of 1998).

9. Price, W.A. (1997). DRAFT Guidelines and Recommended Methods for the prediction of Metal leaching and Acid Rock Drainage at Minesites in British Columbia. British Columbia Ministry of Employment and Investment, Energy and Minerals Division, Smithers, BC, p.143.

10. Soregaroli, B.A. and Lawrence, R.W. (1998). Update on Waste Characterisation Studies. Proc. Mine Design, Operations and Closure Conference, Polson, Montana.

RIAAN GROBBELAAR (Pr. Sci. Nat.)

Geohydrologist

Position: Director

Joined JMA: 2001

Qualifications:

M. Sc. (Cum Laude) Geohydrology, University of the Free State, 2001
B. Sc. (Hons) Geohydrology, University of the Free State, 1996
B. Sc. Geology, University of the Free State, 1995

Career:

- **November 2006:** Director at JMA Consulting (Pty) Ltd.
- **2004:** Associate at JMA Consulting (Pty) Ltd.
- **2003:** Senior Scientist at JMA Consulting (Pty) Ltd.
- **2001:** Joined JMA Consulting (Pty) Ltd. as Scientist
- **1996 – 2001:** Geohydrologist/Researcher, Institute for Ground Water Studies, UFS

Key Experience:

Riaan Grobbelaar is responsible for the overall Project Management, specifically for EIA's, Waste License Applications, Water Use License Applications, Process and Time Line Management, Project Technical Management (commissioning of specialist studies), and finally all the EIA/EMP Report Compilation including the full integration of all specialist studies into the EIA/EMP.

Professional Associations:

SACNASP – South African Council for Natural Scientific Professions
Ground Water Division
WISA – Water Institute of Southern Africa
IAIA – International Association for Impact Assessment

Contact Details:

Phone: +27 13 665 1788
Mobile: +27 82 452 1231
E-mail: riaan@jmaconsult.co.za

Selected Recent Relevant Projects:

- **Xstrata Alloys Boshoek Operation:** EMPr Amendment Project (2015)
- **Evraz Vametco:** EIA/EMPr Amendment (2015)
- **Samancor Chrome Ferrometals:** Environmental Authorizations (Water Use & Waste License) (2014)
- **Metmar Speciality Metals Brakpan:** Site Assessment. (2012)
- **Xstrata Alloys Wonderkop Operations:** EIA/EMPr Amendment, Water Use License and Waste License (2011)
- **Xstrata Alloys Rustenburg Works:** EIA/ EMP Water Use License and Waste License (2010)
- **Xstrata Alloys Lydenburg Works:** EMP Designs and EIA Process (2009)
- **Xstrata Rhovan Operations:** Addendum EMP & Waste License, Closure Plan. (2006)
- Various Monitoring and Audits Projects (Water monitoring, Water Use License Audits)

SHANE TURNER (Pr. Sci. Nat.)

Geohydrologist

Position: Director | Consulting Scientist

Joined JMA: 2009

Qualifications:

M.Sc. Geohydrology, University of the Free State, 2011
B.Sc. Hons. Geology, University of Stellenbosch, 2008
B.Sc. Geology: Earth Science, University of Stellenbosch, 2007

Career:

- **March 2016 – Present**
  Director | Consulting Scientist at JMA Consulting (Pty) Ltd.
- **March 2014 – February 2016**
  Senior Scientist - Geohydrologist at JMA Consulting (Pty) Ltd.
- **March 2012 – February 2014**
  Scientist - Geohydrologist at JMA Consulting (Pty) Ltd.
- **January 2009 – February 2012**
  Junior Scientist in Geohydrology at JMA Consulting (Pty) Ltd.

Key Experience:

Shane Turner specializes in the development of Integrated Water and Waste Management Plans, Geology and Groundwater Specialist Investigations, Water and Salt Balance Calculations as well as Integrated Water Use Licence and Amendment Applications for the mining and industrial sectors. Shane furthermore also focuses on the Process and Material Characterisation Investigations, Site Characterisation and Risk Assessments, the development of Geographic Information Systems as well as Surface Water and Groundwater Monitoring Systems.

Professional Associations:

Contact Details:

Phone: +27 13 665 1788
Mobile: +27 82 866 4125
E-mail: shane@jmaconsult.co.za

Selected Recent Relevant Projects:

- **Bosveld Phosphates (Pty) Ltd Phalaborwa Operations:** Integrated Water and Waste Management Plan (IWWMP), Integrated Water Use Licence and Amendment Applications, Water and Salt Balances.
- **Glencore Merafe Venture Boshoek Operations:** IWWMP, Integrated Water Use Licence and Amendment Applications, Geology & Groundwater Specialist Investigations, Process & Material Characterisation.
- **Anglo American Inyosi Coal – Kriel Colliery:** Groundwater Specialist Investigations.
- **Samancor Chrome Ltd Ferrometals:** Groundwater and Surface Water Monitoring Systems, Integrated Water Use Licence and Amendment Applications.
- **Sasol Mining (Pty) Ltd Borrow Pits:** Groundwater Specialist Investigation, Integrated Water Use Licence Application.
- **Metmar Speciality Metals Brakpan Site:** Site Characterisation and Risk Assessments, Groundwater and Surface Water Monitoring Systems.

RENé RADEMEYER (Pr. Sci. Nat.)

Ecologist

Position: Scientist

Joined JMA: 2012

Qualifications:

M.Sc. (Cum Laude) Ecology, University of Pretoria, 2009
B.Sc. Hons. Ecology, University of Pretoria, 2006
B.Sc. Ecology, University of Pretoria, 2005

Career:

- **May 2012 – Present**
  Scientist – Ecologist at JMA Consulting (Pty) Ltd.
- **July 2009 – April 2012**
  Environmental Practitioner at Clean Stream Scientific Services (Pty) Ltd.
- **January 2009 – June 2009**
  Intern at South African National Biodiversity Institute (SANBI)

Key Experience:

René Rademeyer is responsible for the compilation of Basic Assessment (BA) Reports, Scoping Reports, Environmental Impact Assessment (EIA) Reports, and Environmental Management Programme (EMP) Reports. She compiles Extract Reports in support of Waste Management Licence WML) Applications and furthermore assists in the development of Integrated Water and Waste Management Plans (IWWMP).

Professional Associations:

SACNASP
South African Council for Natural Scientific Professions

Contact Details:

Phone: +27 13 665 1788
Mobile: +27 82 556 8287
E-mail: rene@jmaconsult.co.za

Selected Recent Relevant Projects:

- **Glencore Operations South Africa (Pty) Ltd. Rhovan Mine:** BA Report
- **Bosveld Phosphates (Pty) Ltd. Phalaborwa Operations:** IWWMP
- **Samancor Chrome Ferrometals:** EIA and EMP Report and BA Report
- **Glencore Merafe Venture Operations Boshoek Smelter:** Scoping Report, EIA and EMP Report and Extract Report for WML Application
- **Glencore Operations South Africa (Pty) Ltd. Rustenburg Works:** Extract Report for WML Application
- **Sasol Mining (Pty) Ltd. Borrow Pits:** Scoping Report, EIA and EMP Report
- **Lusthof Colliery:** Scoping Report, EIA and EMP Report
- **EVRAZ Vametco:** Scoping Report, EIA and EMP Report and IWWMP

MICHAEL LOMBARD (Cand. Sci. Nat)

Geohydrologist

Position: Junior Scientist

Joined JMA: 2016

Qualifications:
BSc (Hons): Geology University of the Free State, 2015
BSc (Hons): Hydrogeology University of the Free State, 2014
BSc: Geology University of the Free State, 2013

Career:

February 2016 – Present
Junior Scientist - Hydrogeologist at JMA Consulting (Pty) Ltd.

October 2014 – January 2015
Production Geologist at NC Mine (Pty) Ltd.

Key Experience:

Michael Lombard specializes in the development of Groundwater and Geology Specialist Studies for the mining and industrial sectors. He is furthermore responsible for all JMA's field work, which consists of:

- *Stratigraphic Logging*
- *Aquifer Testing*
- *Hydrocensus*
- *Sampling*
- *Team Management*

He also assists with Risk Assessments as well as the development of various Geographic Information Systems & water monitoring programmes

Professional Associations:

SACNASP
South African Council for Natural Scientific Professions

GROUND WATER DIVISION
www.gwd.org.za

Selected Recent Relevant Projects:

- **Hernic Ferrochrome:** Geology and Groundwater Specialist Study inputs in support of the Addendum EMP, EIA, IWULA, IWWMP & Waste Licence Application.
- **Kriel (Anglo American):** Inputs into water balance for underground and open pit mining.
- **Kriel (Anglo American):** Groundwater Specialist Study inputs in support of the Addendum EMP, EIA, IWULA, IWWMP & Waste Licence Application.

Contact Details:

Phone: +27 13 665 1788
Mobile: +27 79 485 5233
E-mail: michael@jmaconsult.co.za

DMR 44

DEPARTMENT: MINERAL RESOURCES

REPUBLIC OF SOUTH AFRICA

AMENDMENT/VARIATION OF A MINING RIGHT

Granted in terms of section 102 of the Mineral and Petroleum Resources Development Act, 2002
(Act No. 28 of 2002)

nontsikelelo adonisi-kgame
Notary
johannesburg

Protocol No: 3 /2013
File Ref No

NW30/5/1/2/2/396MR

Application No

NOTARIAL DEED OF AMENDMENT/VARIATION OF A MINING RIGHT

BE IT HEREBY MADE KNOWN:

That on this the **24th** day of **May** in the year **2013** before me, **NONTSIKELELO ADONISI-KGAME**, Notary Public, duly sworn and admitted, residing and practising at **Sandton**, in the **Gauteng** Province of South Africa, and in the presence of the undersigned witnesses personally came and appeared;

Pieter Frederik Swart Regional Manager, **North West** of the Department of Mineral Resources, and as such in his/her capacity as the duly representative of:

THE MINISTER OF MINERAL RESOURCES

The said Regional Manager, being duly authorised thereto under and by virtue of a Power of Attorney granted by the Director-General or Deputy Director-General: Mineral Regulation of the Department of Mineral Resources on the **26th** day of the **April** in the year **2013** in terms of the powers delegated by the Minister in terms of section 103 (1) of the Mineral and Petroleum Resources Development Act, No 28 of 2002 ("the Act"),

nontsikelelo adonisi-kgame
Notary
Johannesburg

And

Johan Swanepoel in his/her personal capacity or as the company's **Joint Acting Chief Executive Officer** or a Close Corporation's member, and as such, the duly authorised representative of **Hernic Ferrochrome (Proprietary) Limited**, Identification /Registration number:

1	9	9	4	/	0	0	8	2	9	3	/	0	7	

(hereinafter together with his/her/its successors in title and assigns referred to as "the Holder"), the said representative, being duly authorised thereto under and by virtue of a Power of Attorney/resolution of directors/members of the Holder, signed or passed at **Brits** on the **23rd** day of **May** in the year **2013**, which power of attorney or certified copy of the resolution has this day been exhibited to me, the notary, and remain filed on record in my protocol with the minutes hereof.

THE MINISTER AND THE HOLDER DECLARED THAT:

WHEREAS	The State is the custodian of the nation's mineral and petroleum resources in terms of section 3 of the Act,
AND WHEREAS	In terms of clause 4 of the principal right, the terms of the right may not be amended/varied without the written consent of the Minister,
AND WHEREAS	the Holder has applied for the **amendment of the defined minerals in the right** ,
AND WHEREAS	The Minister has granted consent for the amendment/variation to the Holder, in terms of section 102 of the Act.

nontsikelelo adonis-kgame
Notary
johannesburg

NOW THEREFORE THESE PRESENTS WITNESS:

The Minister hereby grants the variation/amendment of the mining right executed on the **31st** day of **July** in the year **2012**, under Protocol **17/2012**, registered at the Mineral and Petroleum Titles Registration Office under **MPT 14/2013**, in respect of;

Certain: **portions 78, 105 (remaining extent), 135, 104, 143, 169, 170, 47 (remaining extent), 174 (remaining extent), remaining extent of portion 46 and the remaining extent of portion 100 of the farm De Kroon 444 JQ**

Situated: **North West** Magisterial/Administrative District of **Brits**

Measuring: **329,9599** hectares

(In case of various farms involved, a list must be attached and referred to as **ANNEXURE** _____);

Is hereby amended/ varied by the **amendment of the defined minerals to include platinum group metals (namely platinum, ruthenium, rhodium, palladium, osmium and iridium), gold ore, silver ore, nickel ore, copper ore, cobalt, vanadium, iron ore and rare group elements and the non metallic elements being sulphur, selenium and tellurium (in respect of Middle Group Chromitite seams) and sand manufactured from waste rocks .**

Now therefore the Minister grants the amendment/ variation of the principal right.

nontsikelelo adonisi-jame
Notary
johannesburg

Thus done and signed at **Klerksdorp** on the **24th** day of **May** in the year **2013** in the presence of the undersigned witnesses:

AS WITNESS:

____

____

For and on behalf of the Minister

AS WITNESS:

____

____

For and on behalf of the Holder

____

NOTARY PUBLIC

nontsikelelo adonisi-kgame
Notary
Johannesburg

HERNIC FERROCHROME (PTY) LTD

<u>NW 30/5/1/2/2/396MR</u>

AMENDMENT TO THE MINING WORK PROGRAMME

MORULABULT MINE

MARCH 2013

EXECUTIVE SUMMARY

Hernic Ferrochrome (Pty) Ltd has current mining right for various portions of the farm Krokodildrift 446 JQ by way of opencast mining and underground mining which is still in the development stage. Hernic Ferrochrome (Pty) Ltd now wishes to amend its mining *rights to include various minerals.*

Hernic Ferrochrome (Pty) Ltd has an operational ferrochrome smelting operation. Initially, opencast method has been used, and we are currently in a development stage to do underground mining . This underground mining will only be in full production towards the end of 2016. The additional tonnage mined from Bokfontein will form part of the larger future mining complex that will sustain a Life of Mine of 60 years.

The deposit forms part of the layered suite of the Bushveld Igneous Complex. Chromite is found in a tabular body approximately 1.3 m thick, referred to as the MG1 chromite seam. The ore seams dips at 17° to the north, extending over a strike distance of 5000m from west to east. The resource covers 6km of outcrop, with the MG reef extending to a maximum depth of 500 meters. Average dips are 17°to the north. The seam sub-outcrops under a layer of black turf approximately 1 m thick and extends to a depth of 500 m.

The end-user of Charge Chrome product in the world is Stainless steel producers, and the export will be 51% Far East and 49% Europe for the final product ferrochrome metal. The tailings concentrate will be extracted from current tailings arisings as well as through the re-mining of the old tailings storage facility (TSF), for PGMs at the recovery rate of 50% to be distributed to the third party platinum producers. In order to process the additional minerals from the old TSF and current arisings, Hernic is considering an on-site and off-site alternative.

Hernic Ferrochrome is a well-established mine, having commenced operations in 1996. Due to high demand of their chrome ore products the mine continuously operates at a sustainable levels, and the additional income generated from the PGM's processing will increase the sustainability levels. Hernic is fully aware of its obligations on SLP , environment, education and development programmes. This programmes are funded from the proceeds from the operations, and the proposed additional minerals are therefore considered essential to ensure continued income for the mine.

nontsikelelo adonisi-kgame
Notary
Johannesburg

a) FULL PARTICULARS OF THE APPLICANT

1.1 NAME OF COMPANY

Hernic Ferrochrome (Pty) Limited
Registration number: 1994/008293/07

1.2 PHYSICAL ADDRESS & POSTAL ADDRESS

Hernic Ferrochrome (Pty) Ltd

R/E of Portion 103
De Kroon 444 JQ
Brits

P.O. Box 4534
Brits
0250

1.3 TELEPHONE NUMBER, FAX NUMBER & E-MAIL ADDRESS

Tel: (012) 381-1100 Fax: (012) 381 1111
Cell: 076 779 5688 **Contact Person: Mr. Lemogang Pitsoe**
e-mail:

b) PLAN CONTEMPLATED IN REGULATION 2(2)

Attached is the plan as detailed in Regulation 2(2).

c) REGISTERED DESCRIPTION OF LAND OR AREA TO WHICH THE APPLICATION RELATES

The proposed application/amendment relates to the mining rights on various portions as covered by the Converted Mining Right NW30/5/1/2/2/396MR - see attached.

d) DETAILS OF IDENTIFIED MINERALS

1. MINERALS TO BE MINED

The following minerals will be mined: "chrome ore, platinum group metals (namely platinum, ruthenium, rhodium, palladium, osmium and iridium), gold ore, silver ore, nickel ore, copper ore, cobalt, rare group elements, vanadium and iron ore and the non metallic elements being sulphur, selenium and tellurium, and sand manufactured from waste rocks."

nontsikelelo adonis-kgame
Notary
johannesburg

2. LOCALITY OF THE MINERAL DEPOSIT

The ore body is located 10 kilometers south of Brits in the North West Province on the farm De Kroon 444JQ.

3. DESCRIPTION OF GEOLOGICAL STRUCTURE OF THE MINERAL

The deposit forms part of the layered suite of the Bushveld Igneous Complex. Chromite is found in a tabular body approximately 1.3 m thick, referred to as the MG1 chromite seam. The ore seams dips at 18° to the north, extending over a strike distance of 3000m from west to east.

4. SIZE OF DEPOSIT

The ore seams dips at 18° to the north, extending over a strike distance of 3000m from west to east.

5. DEPTH OF MINERAL BELOW SURFACE

The seam sub-outcrops under a layer of black turf approximately 1 m thick and extends to a depth of 450 m.

6. RESERVES, RESOURCES AND GRADES

Mining at De Kroon will be an underground mine and previously it utilised the opencast mining technique , therefore a large portion of the ore body has been mined. Below are two tables indicating the original resources and reserves and the current resources and reserves.

ORIGINAL ORE RESOURCE

CATEGORY	MILLION TONNES
MEASURED	28
INDICATED	44
INFERRED	30
TOTAL	102.3

ORIGINAL ORE RESERVE

CATEGORY	MILLION TONNES
MEASURED	31
INDICATED	54
INFERRED	0

TOTAL		85

The average estimated grade of the ore body is 38% Cr_2O_3 with Cr:Fe ratio of 1.47:1.

e) DETAILS OF MARKET FOR, THE MARKET'S REQUIREMENTS AND PRICING IN RESPECT OF, THE MINERAL CONCERNED

The mine is adjacent to the Hernic Ferrochrome plant. The production from the mine is supplied to the Ferrochrome plant. At present, the Plant production capacity is 420 000 tonnes per annum (tpa). The required chrome ore feed (ROM) is approximately 1 440 000 tpa. Note that, at full production, the De Kroon (308MR and 396MR) reserves will contribute approximately 960 000 tpa (approximately 65%) with the remaining 540 000 tpa (approximately 35%) derived from the Uitvalgrond reserves covered under 91MR.

The total production from the plant is exported with the target market Europe 37%; America 1% and Far East 62%. The prevailing market for Ferrochrome is the Stainless Steel Producers market, with current usage of 20 million tonnes per year with an expected growth between 15% and 30%. This is based on growth within the stainless steel market over the last 30 year, particularly the South African contribution towards the international market.

Hernic will not produce final metals for PGMs but the concentrate will be sold to the local PGMs producers/buyers. The producers/buyers utilize their refineries to produce the metals and then sell these metals. Selling arrangements - the exact details cannot be published as these arrangements are a matter of confidentiality and are still being negotiated, however, the buyers/producers will receive approximately 50% of the contained metal value.

f) DETAILS WITH REGARD TO THE APPLICABLE TIMEFRAMES AND SCHEDULING OF THE VARIOUS IMPLEMENTATION PHASES OF THE PROPOSED MINING OPERATION, AND A TECHNICALLY JUSTIFIED ESTIMATE OF THE PERIOD REQUIRED FOR THE MINING OF THE MINERAL DEPOSIT CONCERNED

Due to the outcropping of the mineral reserve, mining was initially conducted utilising opencast mining methonds. In 2002/2003, underground mining methodologies were initiated. The whole of the mining operations is conducted and being contracted to Newshelf Mining t/a JIC Mining Services, with Hernic supplying essential services such as surveying, engineering and over inspection. Based on the estimated remaining ore reserves, the life of mine calculations are as follows :

Ore reserve : 85 million tonnes
Production rate : 1 440 000 tonnes per annum
Remaining life of mine : 61 years

g) FINANCING PLAN

nontsikelelo adonis-kgari
Notary
johannesburg

i) **Details and costing of the mining technique, mining technology and production rates applicable to the mining operation**

- The proposed mining concept is to mine underground and open pit ores in the ratio 10 : 1 until June 2014. After June 2014 only underground ore will be mined. The reef consists of two seams with a waste parting. on average this reef band is about 2 meters thick.

- This total height of MG1 is 1.4 meters, which is ideal for the conventional mining whereas MG 2 reef is 2.8 meters and ideal for the operation of trackless equipment. Therefore mining at Bokfontein has been designed using mechanized methods and the conventional up/down dip techniques. Underground mining in the Bokfontein lease area is accessed by two 7 m wide declines extending down dip from a depth of 5 meters to a maximum depth of the mine.

- The technology to be used is the conventional bord and pillar methods, as used by the chrome mines. All development and stoping will be on reef and carried out by contractors. An average extraction rate of 80% has been achieved. Drilling is performed using a combination of hand held drills and drilling rigs. The blasted ore is trammed to the conveyor loading points using LHD's . This ore is then transported to a surface bin via strike and dip conveyors.

- Forecast of annual production rates. The underground average monthly production rate is 120 000 tons equating to 1.4 million tons per annum. The average open cast monthly production rate is 20 000 tons equating to 240 000 tons per annum, however the open cast reserve will be depleted by June 2014.

- All underground and open cast operations are performed by contactors, who are managed by Hernic staff.

- Costs applicable to mining operations. Refer to tables below

ANNUAL UNDERGROUND MINING COSTS

Fixed Costs	R 114 000 000
Variable Costs	R 252 000 000
Capital Costs	R 6 000 000
Total Costs	R 372 000 000

Notary
nontsikelelo adonis-kgare
Johannesburg

ii) Details and costing of the technological process applicable to the extraction and preparation of the mineral or minerals to comply with market requirements

- ROM is treated by crushing and screening prior to being beneficiated by a gravity separation plant (GSP). Lumpy material is further upgraded by using the DMS Plant. the fines are also upgraded by a Spiral Plant to Met grade Chrome. The material is then stockpiled for the Smelter.

- The input material is then fed into the Furnaces, where it is blended with other raw materials to reduce Chrome ore into Ferrochrome metal. Hot gases from the Smelter process provide energy for the pre-heater. which pre-heats the material to about 700° C. Pre heated materials are then fed into the Furnaces, where Oxygen and impurities are then removed from the Chrome ore and collected the Slag and a molten Ferrochrome is produced. After solidification, the metal is crushed, screened and then stockpiled for delivery.

- The slag, which is the main waste. is collected, cooled and crushed to recover metal entrained in the slag. Slag is used for building material and road building applications.

- The final tailings are thickened and pumped to a conventional tailings dam. The concentrate produced from the secondary circuit is thickened and sold to third parties for further processing. Within 18 months of getting the MR, Hernic should be able to process on site as the infrastructure is currently existing.

- The additional minerals will be extracted from current tailings arisings as well as through the re-mining of the old tailings storage facility (TSF). In order to process the additional minerals from the old TSF and current arisings, Hernic is considering an on-site and off-site alternative. The on-site alternative would entail processing the old TSF material and current arisings on-site (in which case an upgrade to the existing processing plant would be required). The off-site processing alternative would imply that old TSF material would be processed at third party processing facilities. With regards to the current arisings, should the off-site alternative be selected, tailings would be deposited on the tailings dam as is currently done and following this, Hernic would have access to extract these additional minerals at a later stage.

(iii) Details and costing of the technical skills and expertise and associated labour implications required to conduct the proposed mining operation

- The number of people who are employed at the Hernic operation is detailed in the table below

OPERATION	NUMBER
Open cast mining	220
Underground mining	700
Process Plant	500
Tailings dam	21
Security	37

nontsikelelo adonisi-kgame
Notary
johannesburg

Administration	40
Consultants	8
TOTAL	1526

- Respective skills requirements

Professionals :

- Mining Engineers
- Process Engineers
- Mechanical Engineers
- Electrical Engineers
- Geologists
- Rock Mechanics
- Accountants

Skilled :

- Mechanical and electrical artisans
- Instrumentation technicians
- Shift supervisors
- Clerks
- Safety officers
- Environmental officers

- Associated costs in respect of wages and salaries

OPERATION	COST R	
Open cast mining	R	20 000 000.00
Underground mining	R	31 000 000.00
Process Plant	R	36 000 000.00
Tailings dam	R	900 000.00
Security	R	4 000 000.00
Administration	R	34 000 000.00
Consultants	R	3 540 000.00
TOTAL	R	129 440 000.00

iv) Details and costing of regulatory requirements in terms of the Act and other applicable law, relevant to the proposed mining operation.

- List of applicable regulatory requirements

1 Royalty payments

2 Minerals and Energy Act

- Social and labour plan
- Conversion of right

nontsikelelo adonisi-kgame
Notary
johannesburg

- Sustained implementation

3 Environmental Management Program
4 Mine Health and Safety
5 Labour Act

- Costs associated with regulatory requirements

a) Royalty payments are only due for the remaining life of mine.
b) Minerals and Energy Act. The implementation of the social and labour will incur a total cost of approximately R120 000 per month
c) Environmental Management Programme (EMP)
    - Rehabilitation costs R200 000 per month liability costs and R150 000 per month ongoing costs
    - Ongoing environmental management costs associated with tailings dams. water monitoring, dust control are approximately R75 000 per month

d) Mine Health and Safety R200 000 per month

v) **Details regarding other relevant costing, capital expenditure requirements, and expected revenue applicable to the proposed mining operation.**

As the underground mine is not fully operational there are capital expenditure costs. The expected annual revenue is as follows :

2013–R210 million
2014 - R230 million
2015 - R300 million
2016 - R390 million

(iv) **Detailed cash flow forecast and valuation, excluding financing of the proposed mining operation, which forecast must also clearly indicate how the applicable regulatory costs will be accommodated therein**

Attached is the complete cash flow table including all requirements the NPV is R168 million with an IRR of 32% (This is as per market dynamics at time of preparation, a revised calculation will be submitted with every annual compliance report)

Please find revised production forecast for Bokfontein Block.

Full details will be disclosed as part of Hernic's annual compliance

(vii) Details regarding the applicant's resources or proposed mechanisms to finance the proposed mining operation, and details regarding the impact of such financing arrangements on the cash flow forecast

See attached annual report for financial statements and balance sheets. The funding will be received from the shareholders of Hernic, contained in the private and confidential Shareholders Agreement.

(viii) Provisions for the execution of the social and labour plan

OVERVIEW OF FINANCIAL PROVISIONS

In terms of Section 23(1) (e) "The Minister must grant a mining right if the applicant has provided financially and otherwise for the prescribed social and labour plan." This chapter will outline the manner in which Hernic's Mine will provide financially for each component of the Social and Labour Plan during the life of the mine. It should be highlighted that these assumptions are based on the current business status and plans being implemented at Hernic Mine currently and as the associated market and economic conditions surrounding the operations, may change, the need to up-date the financial provisions may arise. Where changes in these assumptions are required, they will be reported on in the annual SLP Report.

FINANCIAL PROVISION FOR HUMAN RESOURCE DEVELOPMENT PROGRAMMES

Whilst the exact breakdown of the financial provision for the Human Resource Development Programmes as outlined in Chapter 2, may change according to company needs and the evolving business plan during the life of the mine, approximately three percent (3%) of the total wage bill per annum will be committed for the programmes at Hernic Mine. Currently this amounts to approximately R1 000 000 per month for the mine's workforce (inclusive of the contractors workforce).

FINANCIAL PROVISION FOR LOCAL ECONOMIC DEVELOPMENT PROGRAMMES

In order to meet the scope of the Local Economic Development Programme as outlined in Chapter 3, Hernic Mine will commit 1.0% of its NPAT. This financial provision will meet the costs of the mine's participation in and implementation of various projects identified through the IDP process as well as the housing and nutrition programmes and the procurement progression plan.

FINANCIAL PROVISION FOR THE MANAGEMENT OF DOWNSCALING AND RETRENCHMENT PROGRAMMES

Over and above the financial provisions for the on-going Human Resource Development Programmes which will facilitate the on-going training of the workforce at Hernic Mine aimed at benefiting the workforce beyond the life of the mine, Hernic will commit one (1) month salary per employee for specific skills development training geared at directly assisting the employee in obtaining specific skills pertinent to their needs at the point of retrenchment. Any additional negotiations with regards to retrenchment packages will be carried out at the time of retrenchment and in line with the current legislation and best practice at that point in time.

nontsikelelo adonisi-kgame
Notary
Johannesburg

h) STATEMENT OF UNDERTAKING

I, **LEMOGANG PITSOE** the undersigned and duly authorized thereto by **HERNIC FERROCHROME (PTY) LTD** (Company) undertake to adhere to the information, requirements, commitments and conditions as set out in this social and labour plan.

Signed at **BRITS** on this **24th** day of **MARCH 2013**.

Signature of responsible person ______________________

Designation: **GENERAL MANAGER: MINING**

Approved

Signed at **BRITS** on this **24th** day of **MARCH 2013**.

Signature of responsible person ______________________

Contact Details ______________________

nontsikelelo adonisi-kgatle
Notary
johannesburg

DMR 44

DEPARTMENT: MINERAL RESOURCES

REPUBLIC OF SOUTH AFRICA

AMENDMENT/VARIATION OF A MINING RIGHT

Granted in terms of section 102 of the Mineral and Petroleum Resources Development Act, 2002
(Act No. 28 of 2002)

Protocol No: 4 /2013
File Ref No

NW30/5/1/2/2/308MR

Application No

NOTARIAL DEED OF AMENDMENT/VARIATION OF A MINING RIGHT

BE IT HEREBY MADE KNOWN:

That on this the **24th** day of **May** in the year **2013** before me, **NONTSIKELELO ADONISI-KGAME,** Notary Public, duly sworn and admitted, residing and practising at **Sandton**, in the **Gauteng** Province of South Africa, and in the presence of the undersigned witnesses personally came and appeared;

Pieter Frederik Swart Regional Manager, **North West** of the Department of Mineral Resources, and as such in his/her capacity as the duly representative of:

THE MINISTER OF MINERAL RESOURCES

The said Regional Manager, being duly authorised thereto under and by virtue of a Power of Attorney granted by the Director-General or Deputy Director-General: Mineral Regulation of the Department of Mineral Resources on the **26th** day of the **April** in the year **2013** in terms of the powers delegated by the Minister in terms of section 103 (1) of the Mineral and Petroleum Resources Development Act, No 28 of 2002 ("the Act"),

And

Johan Swanepoel in his/her personal capacity or as the company's **Joint Acting Chief Executive Officer** or a Close Corporation's member, and as such, the duly authorised representative of **Hernic Ferrochrome (Proprietary) Limited**, Identification /Registration number:

1	9	9	4	/	0	0	8	2	9	3	/	0	7	

(hereinafter together with his/her/its successors in title and assigns referred to as "the Holder"), the said representative, being duly authorised thereto under and by virtue of a Power of Attorney/resolution of directors/members of the Holder, signed or passed at **Brits** on the **23rd** day of **May** in the year **2013**, which power of attorney or certified copy of the resolution has this day been exhibited to me, the notary, and remain filed on record in my protocol with the minutes hereof.

THE MINISTER AND THE HOLDER DECLARED THAT:

WHEREAS The State is the custodian of the nation's mineral and petroleum resources in terms of section 3 of the Act,

AND WHEREAS In terms of clause 4 of the principal right, the terms of the right may not be amended/varied without the written consent of the Minister,

AND WHEREAS the Holder has applied for the **amendment of the defined minerals in the right** ,

AND WHEREAS The Minister has granted consent for the amendment/variation to the Holder, in terms of section 102 of the Act.

NOW THEREFORE THESE PRESENTS WITNESS:

The Minister hereby grants the variation/amendment of the mining right executed on the **26th** day of **June** in the year **2012**, under Protocol 15/2012, registered at the Mineral and Petroleum Titles Registration Office under **MPT 107/2012**, in respect of;

Certain: **Portions 51, 52, 122, 121, 123, 132, 115, 160, 159, 161, 157, 50, 49, 120, 119, 47, half share of the remaining portion of portion 48, portions 199, 168, 167, 166, 165 (portions of portion 47) all of the farm De Kroon 444 JQ (see attached amendments of various portions consolidated as per the land surveyor)**
Situated: **North West** Magisterial/Administrative District of **Brits**
Measuring: **329,9599** hectares

(In case of various farms involved, a list must be attached and referred to as **ANNEXURE** ______);

Is hereby amended/ varied by the **amendment of the defined minerals to include platinum group metals (namely platinum, ruthenium, rhodium, palladium, osmium and iridium), gold ore, silver ore, nickel ore, copper ore, cobalt, vanadium, iron ore and rare group elements and the non metallic elements being sulphur, selenium and tellurium (in respect of Middle Group Chromitite seams) and sand manufactured from waste rocks** .

Now therefore the Minister grants the amendment/ variation of the principal right.

Thus done and signed at **Klerksdorp** on the **24th** day of **May** in the year **2013** in the presence of the undersigned witnesses:

AS WITNESS:

For and on behalf of the Minister

AS WITNESS:

For and on behalf of the Holder

NOTARY PUBLIC

HERNIC FERROCHROME (PTY) LTD

NW30/5/1/2/2/308MR

AMENDMENT TO THE MINING WORK PROGRAMME

MORULABULT MINE

MARCH 2013

Nontsikelelo adonisi-kgame
Notary
Johannesburg

EXECUTIVE SUMMARY

Hernic Ferrochrome (Pty) Ltd has current mining right for various portions of the farm Krokodildrift 446 JQ by way of opencast mining and underground mining which is still in the development stage. Hernic Ferrochrome (Pty) Ltd now wishes to amend its mining rights to include various minerals.

Hernic Ferrochrome (Pty) Ltd has an operational ferrochrome smelling operation. Initially, opencast method has been used, and we are currently in a development stage to do underground mining . This underground mining will only be in full production towards the end of 2016. The additional tonnage mined from Bokfontein will form part of the larger future mining complex that will sustain a Life of Mine of 60 years.

The deposit forms part of the layered suite of the Bushveld Igneous Complex. Chromite is found in a tabular body approximately 1.3 m thick, referred to as the MG1 chromite seam. The ore seams dips at 17° to the north, extending over a strike distance of 5000m from west to east. The resource covers 6km of outcrop, with the MG reef extending to a maximum depth of 500 meters. Average dips are 17°to the north. The seam sub-outcrops under a layer of black turf approximately 1 m thick and extends to a depth of 500 m.

The end-user of Charge Chrome product in the world is Stainless steel producers, and the export will be 51% Far East and 49% Europe for the final product ferrochrome metal. The tailings concentrate will be extracted from current tailings arisings as well as through the re-mining of the old tailings storage facility (TSF), for PGMs at the recovery rate of 50% to be distributed to the third party platinum producers. In order to process the additional minerals from the old TSF and current arisings, Hernic is considering an on-site and off-site alternative.

Hernic Ferrochrome is a well-established mine, having commenced operations in 1996. Due to high demand of their chrome ore products the mine continuously operates at a sustainable levels, and the additional income generated from the PGM's processing will increase the sustainability levels. Hernic is fully aware of its obligations on SLP , environment, education and development programmes. This programmes are funded from the proceeds from the operations, and the proposed additional minerals are therefore considered essential to ensure continued income for the mine.

Pontsikelelo adonisi-Kgame
Notary
Johannesburg

a) FULL PARTICULARS OF THE APPLICANT

1.1 NAME OF COMPANY

Hernic Ferrochrome (Pty) Limited
Registration number: 1994/008293/07

1.2 PHYSICAL ADDRESS & POSTAL ADDRESS

Hernic Ferrochrome (Pty) Ltd

R/E of Portion 103
De Kroon 444 JQ
Brits

P.O. Box 4534
Brits
0250

1.3 TELEPHONE NUMBER, FAX NUMBER & E-MAIL ADDRESS

Tel: (012) 381-1100 Fax: (012) 381 1111
Cell: 076 779 5688 **Contact Person: Mr. Lemogang Pitsoe**
e-mail: [illegible]

b) PLAN CONTEMPLATED IN REGULATION 2(2)

Attached is the plan as detailed in Regulation 2(2).

c) REGISTERED DESCRIPTION OF LAND OR AREA TO WHICH THE APPLICATION RELATES

The proposed application/amendment relates to the mining rights on various portions as covered by the Mining Right NW30/5/1/2/2/308MR - see attached.

d) DETAILS OF IDENTIFIED MINERALS

1. MINERALS TO BE MINED

The following minerals will be mined: "chrome ore, platinum group metals (namely platinum, ruthenium, rhodium, palladium, osmium and iridium), gold ore, silver ore, nickel ore, copper ore, cobalt, rare group elements, vanadium and iron ore and the non metallic elements being sulphur, selenium and tellurium, and sand manufactured from waste rocks."

Notary
Johannesburg

2. LOCALITY OF THE MINERAL DEPOSIT

The ore body is located 10 kilometers south of Brits in the North West Province on the farm De Kroon 444JQ.

3. DESCRIPTION OF GEOLOGICAL STRUCTURE OF THE MINERAL

The deposit forms part of the layered suite of the Bushveld Igneous Complex. Chromite is found in a tabular body approximately 1.3 m thick, referred to as the MG1 chromite seam. The ore seams dips at 18° to the north, extending over a strike distance of 3000m from west to east.

4. SIZE OF DEPOSIT

The ore seams dips at 18° to the north, extending over a strike distance of 3000m from west to east.

5. DEPTH OF MINERAL BELOW SURFACE

The seam sub-outcrops under a layer of black turf approximately 1 m thick and extends to a depth of 450 m.

6. RESERVES, RESOURCES AND GRADES

Mining at De Kroon will utilise an underground mining techniques , therefore a large portion of the ore body has not been mined as yet. Below are two tables indicating the original resources and reserves and the current resources and reserves.

ORIGINAL ORE RESOURCE

CATEGORY	MILLION TONNES
MEASURED	28
INDICATED	44
INFERRED	30
TOTAL	102.3

ORIGINAL ORE RESERVE

CATEGORY	MILLION TONNES
MEASURED	31
INDICATED	54
INFERRED	0

nontsikelelo adonisi-kgame
Notary
johannesburg

TOTAL		85

The average estimated grade of the ore body is 38% Cr_2O_3 with Cr:Fe ratio of 1.47:1.

e) DETAILS OF MARKET FOR, THE MARKET'S REQUIREMENTS AND PRICING IN RESPECT OF, THE MINERAL CONCERNED

The mine is adjacent to the Hernic Ferrochrome plant. The production from the mine is supplied to the Ferrochrome plant. At present, the Plant production capacity is 420 000 tonnes per annum (tpa). The required chrome ore feed (ROM) is approximately 1 440 000 tpa. Note that, at full production, the De Kroon (308MR and 396MR)reserves will contribute approximately 960 000 tpa (approximately 65%) with the remaining 540 000 tpa (approximately 35%) derived from the Uitvalgrond reserves covered under 91MR.

The total production from the plant is exported with the target market Europe 37%; America 1% and Far East 62%. The prevailing market for Ferrochrome is the Stainless Steel Producers market, with current usage of 20 million tonnes per year with an expected growth between 15% and 30%. This is based on growth within the stainless steel market over the last 30 year, particularly the South African contribution towards the international market.

Hernic will not produce final metals for PGMs but the concentrate will be sold to the local PGMs producers/buyers. The producers/buyers utilize their refineries to produce the metals and then sell these metals. Selling arrangements - the exact details cannot be published as these arrangements are a matter of confidentiality and are still being negotiated, however, the buyers/producers will receive approximately 50% of the contained metal value.

f) DETAILS WITH REGARD TO THE APPLICABLE TIMEFRAMES AND SCHEDULING OF THE VARIOUS IMPLEMENTATION PHASES OF THE PROPOSED MINING OPERATION, AND A TECHNICALLY JUSTIFIED ESTIMATE OF THE PERIOD REQUIRED FOR THE MINING OF THE MINERAL DEPOSIT CONCERNED

Due to the outcropping of the mineral reserve, mining was initially conducted utilising opencast mining methods. In 2002/2003, underground mining methodologies were initiated. The whole of the mining operations is conducted and being contracted to Newshelf Mining t/a JIC Mining Services, with Hernic supplying essential services such as surveying, engineering and over inspection. Based on the estimated remaining ore reserves, the life of mine calculations are as follows :

Ore reserve : 85 million tonnes
Production rate : 1 440 000 tonnes per annum
Remaining life of mine : 61 years

g) FINANCING PLAN

nontsikelelo adonisi-kgame
Notary
Johannesburg

i) Details and costing of the mining technique, mining technology and production rates applicable to the mining operation

- The proposed mining concept is to mine underground and open pit ores in the ratio 10 : 1 until June 2014. After June 2014 only underground ore will be mined. The reef consists of two seams with a waste parting, on average this reef band is about 2 meters thick.

- This total height of MG1 is 1.4 meters, which is ideal for the conventional mining whereas MG 2 reef is 2.8 meters and ideal for the operation of trackless equipment. Therefore mining at Bokfontein has been designed using mechanized methods and the conventional up/down dip techniques. Underground mining in the Bokfontein lease area is accessed by two 7 m wide declines extending down dip from a depth of 5 meters to a maximum depth of the mine.

- The technology to be used is the conventional bord and pillar methods, as used by the chrome mines. All development and stoping will be on reef and carried out by contractors. An average extraction rate of 80% has been achieved. Drilling is performed using a combination of hand held drills and drilling rigs. The blasted ore is trammed to the conveyor loading points using LHD's . This ore is then transported to a surface bin via strike and dip conveyors.

- Forecast of annual production rates. The underground average monthly production rate is 120 000 tons equating to 1.4 million tons per annum. The average open cast monthly production rate is 20 000 tons equating to 240 000 tons per annum, however the open cast reserve will be depleted by June 2014.

- All underground and open cast operations are performed by contactors. who are managed by Hernic staff.

- Costs applicable to mining operations. Refer to tables below

ANNUAL UNDERGROUND MINING COSTS

Fixed Costs	R 114 000 000
Variable Costs	R 252 000 000
Capital Costs	R 6 000 000
Total Costs	R 372 000 000

nontsikelelo Madonisi-Kgame
Notary
Johannesburg

ii) Details and costing of the technological process applicable to the extraction and preparation of the mineral or minerals to comply with market requirements

- ROM is treated by crushing and screening prior to being beneficiated by a gravity separation plant (GSP). Lumpy material is further upgraded by using the DMS Plant. the fines are also upgraded by a Spiral Plant to Met grade Chrome. The material is then stockpiled for the Smelter.

- The input material is then fed into the Furnaces, where it is blended with other raw materials to reduce Chrome ore into Ferrochrome metal. Hot gases from the Smelter process provide energy for the pre-heater, which pre-heats the material to about 700° C. Pre healed materials are then fed into the Furnaces, where Oxygen and impurities are then removed from the Chrome ore and collected the Slag and a molten Ferrochrome is produced. After solidification, the metal is crushed, screened and then stockpiled for delivery.

- The slag, which is the main waste, is collected, cooled and crushed to recover metal entrained in the slag. Slag is used for building material and road building applications.

- The final tailings are thickened and pumped to a conventional tailings dam. The concentrate produced from the secondary circuit is thickened and sold to third parties for further processing. Within 18 months of getting the MR, Hernic should be able to process on site as the infrastructure is currently existing.

- The additional minerals will be extracted from current tailings arisings as well as through the re-mining of the old tailings storage facility (TSF). In order to process the additional minerals from the old TSF and current arisings, Hernic is considering an on-site and off-site alternative. The on-site alternative would entail processing the old TSF material and current arisings on-site (in which case an upgrade to the existing processing plant would be required). The off-site processing alternative would imply that old TSF material would be processed at third party processing facilities. With regards to the current arisings, should the off-site alternative be selected, tailings would be deposited on the tailings dam as is currently done and following this, Hernic would have access to extract these additional minerals at a later stage.

(iii) Details and costing of the technical skills and expertise and associated labour implications required to conduct the proposed mining operation

- The number of people who are employed at the Hernic operation is detailed in the table below

OPERATION	NUMBER
Open cast mining	220
Underground mining	700
Process Plant	500
Tailings dam	21
Security	37

Notary
Johannesburg

Administration	40
Consultants	8
TOTAL	1526

- Respective skills requirements

Professionals :

- Mining Engineers
- Process Engineers
- Mechanical Engineers
- Electrical Engineers
- Geologists
- Rock Mechanics
- Accountants

Skilled :

- Mechanical and electrical artisans
- Instrumentation technicians
- Shift supervisors
- Clerks
- Safety officers
- Environmental officers

- Associated costs in respect of wages and salaries

OPERATION	COST R	
Open cast mining	R	20 000 000.00
Underground mining	R	31 000 000.00
Process Plant	R	36 000 000.00
Tailings dam	R	900 000.00
Security	R	4 000 000.00
Administration	R	34 000 000.00
Consultants	R	3 540 000.00
TOTAL	R	129 440 000.00

iv) Details and costing of regulatory requirements in terms of the Act and other applicable law, relevant to the proposed mining operation.

- List of applicable regulatory requirements

1 Royalty payments

2 Minerals and Energy Act

- Social and labour plan
- Conversion of right

nontsikelelo adonisi-kgame Notary johannesburg

- Sustained implementation

3 Environmental Management Program
4 Mine Health and Safety
5 Labour Act

- Costs associated with regulatory requirements

a) Royalty payments are only due for the remaining life of mine.
b) Minerals and Energy Act. The implementation of the social and labour will incur a total cost of approximately R120 000 per month
c) Environmental Management Programme (EMP)
    - Rehabilitation costs R200 000 per month liability costs and R150 000 per month ongoing costs
    - Ongoing environmental management costs associated with tailings dams, water monitoring, dust control are approximately R75 000 per month

d) Mine Health and Safety R200 000 per month

v) Details regarding other relevant costing, capital expenditure requirements, and expected revenue applicable to the proposed mining operation.

As the underground mine is not fully operational there are capital expenditure costs. The expected annual revenue is as follows :

2013–R210 million
2014 - R230 million
2015 - R300 million
2016 - R390 million

(iv) Detailed cash flow forecast and valuation, excluding financing of the proposed mining operation, which forecast must also clearly indicate how the applicable regulatory costs will be accommodated therein

Attached is the complete cash flow table including all requirements the NPV is R168 million with an IRR of 32% (This is as per market dynamics at time of preparation, a revised calculation will be submitted with every annual compliance report)

Please find revised production forecast for Bokfontein Block.

Full details will be disclosed as part of Hernic's annual compliance

nontsikelelo madonisi-kgame
Notary
johannesburg

(vii) Details regarding the applicant's resources or proposed mechanisms to finance the proposed mining operation, and details regarding the impact of such financing arrangements on the cash flow forecast

See attached annual report for financial statements and balance sheets. The funding will be received from the shareholders of Hernic, contained in the private and confidential Shareholders Agreement.

(viii) Provisions for the execution of the social and labour plan

OVERVIEW OF FINANCIAL PROVISIONS

In terms of Section 23(1) (e) "The Minister must grant a mining right if the applicant has provided financially and otherwise for the prescribed social and labour plan." This chapter will outline the manner in which Hernic's Mine will provide financially for each component of the Social and Labour Plan during the life of the mine. It should be highlighted that these assumptions are based on the current business status and plans being implemented at Hernic Mine currently and as the associated market and economic conditions surrounding the operations, may change, the need to up-date the financial provisions may arise. Where changes in these assumptions are required, they will be reported on in the annual SLP Report.

FINANCIAL PROVISION FOR HUMAN RESOURCE DEVELOPMENT PROGRAMMES

Whilst the exact breakdown of the financial provision for the Human Resource Development Programmes as outlined in Chapter 2, may change according to company needs and the evolving business plan during the life of the mine, approximately three percent (3%) of the total wage bill per annum will be committed for the programmes at Hernic Mine. Currently this amounts to approximately R1 000 000 per month for the mine's workforce (inclusive of the contractors workforce).

FINANCIAL PROVISION FOR LOCAL ECONOMIC DEVELOPMENT PROGRAMMES

In order to meet the scope of the Local Economic Development Programme as outlined in Chapter 3, Hernic Mine will commit 1.0% of its NPAT. This financial provision will meet the costs of the mine's participation in and implementation of various projects identified through the IDP process as well as the housing and nutrition programmes and the procurement progression plan.

FINANCIAL PROVISION FOR THE MANAGEMENT OF DOWNSCALING AND RETRENCHMENT PROGRAMMES

Over and above the financial provisions for the on-going Human Resource Development Programmes which will facilitate the on-going training of the workforce at Hernic Mine aimed at benefiting the workforce beyond the life of the mine, Hernic will commit one (1) month salary per employee for specific skills development training geared at directly assisting the employee in obtaining specific skills pertinent to their needs at the point of retrenchment. Any additional negotiations with regards to retrenchment packages will be

nontsikelelo abonisi-kgame Notary johannesburg carried out at the time of retrenchment and in line with the current legislation and best practice at that point in time.

h) STATEMENT OF UNDERTAKING

I, **LEMOGANG PITSOE** the undersigned and duly authorized thereto by **HERNIC FERROCHROME (PTY) LTD** (Company) undertake to adhere to the information, requirements, commitments and conditions as set out in this social and labour plan.

Signed at **BRITS** on this **24th** day of **MARCH 2013**.

Signature of responsible person ______________________

Designation: **GENERAL MANAGER: MINING**

Approved

Signed at **BRITS** on this **24th** day of **MARCH 2013**.

Signature of responsible person ______________________

Contact Details 012 3511257 | 082 8802973

nontsikelelo adonisi-kgame Notary johannesburg

10.7 Authorisation to Abstract Water from the Hartbeespoort Government Water Scheme Canal

DW 0/1

DEPARTEMENT VAN WATERWESE EN BOSBOU
DEPARTMENT OF WATER AFFAIRS AND FORESTRY
REPUBLIEK VAN SUID-AFRIKA • REPUBLIC OF SOUTH AFRICA

Teleks:
Telex:

Faks No.:
Fax No.: 01211-30905

Telegram:

JB/cn/19

Verwysing:
Reference: H81/3/5

Navrae:
Enquiries: JJ BREEDT

Telefoon:
Telephone: 01211-30026

KANTOOR VAN DIE • OFFICE OF THE

GEBIEDSBESTUURDER
HARTBEESPOORT SWS
PRIVAAT SAK X352
HARTBEESPOORT
0216

16 JANUARIE 1995

Hernic Chrome (Pty) Ltd
Posbus 469
MOOINOOI
0325

MAGTIGING VIR DIE ONTTREKKING VAN WATER INGEVOLGE ARTIKEL 56(3) VAN DIE WATERWET, 1956

Hierby aangeheg vind u toestemming vir die onttrekking van water ingevolge Artikel 56(3) van die Waterwet.

U is geregtig om 'n totaal van 876 000 m^3 ongesuiwerde water uit die kanaal te onttrek vir industriële- en huishoudelike gebruik.

Die water mag slegs op gedeelte 47 van die plaas De Kroon 444 JQ aangewend word.

GEBIEDSBESTUURDER: BRITS

Rig asseblief alle korrespondensie aan die adres hierbo.
Please direct all correspondence to the above address.

avn/es/0008Q/49

ANNEXURE A

B159/1/2

HARTBEESPOORT GOVERNMENT WATER SCHEME

1. The constant availibility of water cannot be guaranteed and water restrictions during draught periods will also be impose on the applicant.

2. The applicant must provide for reservoir facilities for at least two weeks, should an emergency occurs.

3. The supply of water should coincide with scheme's operational process and should be arrange in close colaberation with the Local Area Manager, Brits.

4. The present scheduling of all water allocations for mining and industrial use, will be scraped.

5. Water must be re-used if at all possible.

6. The provision as set out in sections 12 and 21 of the Water Act, 1956, must be complied with.

06412/0003A DW 206

DEPARTMENT OF WATER AFFAIRS

CONDITIONS UNDER WHICH THE ABSTRACTION OF WATER IS AUTHORISED

1. Any water work used for the abstraction of water in terms of this authority, requires the prior approval of the Department's local representative and such approval will not be given unless the abstraction capacity of the water work is in reasonable proportion to the quantity of water authorised. For this purpose full particulars of the proposed water work must be furnished to the said representative.

2. The water work must be fitted with an effective self-registering meter at the consumer's expense, and the meter must be maintained in a satisfactory working condition by the consumer at his expense.

3. Officers of the Department will at all times have free access to the property and water work for supervision and control purposes.

4. The Department's local representative will issue the necessary instructions to the consumer with regard to the keeping of proper registers of water abstractions, and the owner must at all times comply with such instructions.

5. Accounts for water abstracted will be rendered monthly and must be paid within the period specified. Interest at the applicable rate is payable on any outstanding amount.

6. Such servitudes as may be necessary must be acquired by the consumer at his expense.

7. The Department accepts no liability for any damage, loss or inconvenience, of whatever nature, suffered as a result of -

   (a) a shortage of water;

   (b) inundation or flood;

   (c) siltation of the river or dam basin; and

   (d) the shifting of the water work in the event of a rise or drop in the water level of the river or dam.

8. The quality or suitability of the water for any purpose is not guaranteed.

9. The water abstracted in terms of this authority may be used for the authorised purposes only.

10. This authority is not a permanent, lawful right and is not transferable from one consumer to another or from one property to another.

11. This authority is subject to review and may at any time be withdrawn or replaced at the discretion of the Minister of Water Affairs after reasonable prior notice.

12. The abstraction of water in terms of this authority is subject to any such regulations or abatements as may at any time be published in respect of the Government Water Control Area concerned.

13. The consumer must take every possible precaution to the satisfaction of the Department, to prevent pollution of water.

14. The Department reserves the right to cancel this authority at short notice in the event of failure to comply with any of the said conditions or provisions.

avn/es/0008Q/47

Ref. no. B159/1/2 81/172892 (Z 28)

05 JAN 1995

REPUBLIC OF SOUTH AFRICA
DEPARTMENT OF WATER AFFAIRS AND FORESTRY

AUTHORITY FOR THE ABSTRACTION OF WATER

Authority no.: 68/2/94

Scheme: Hartbeespoort Government Water Scheme

Consumer: Hernic Chrome (Pty) Ltd

Address: P.O. Box 469, Mooinooi, 0325

is hereby authorised in terms of section 56(3) of the Water Act 1956, (Act 54 of 1956) to abstract a maximum of 876 000 cubic metres of unpurified water per annum from the canal for industrial and household purposes for use on Portion 47 of the farm De Kroon 444 JQ in the district of Brits.

A tariff in terms of section 66(1)(a) of the Water Act, 1956, and a levy in terms of section 11 of the Water Research Act, 1971 (Act 34 of 1971), as determined by the Minister from time to time will be imposed on the water abstracted.

A minimum tariff per metered water per month, as determined by the Minister from time to time will be imposed.

This authority is subject to the conditions as set out in the attached form DW 206 as well as the conditions as set out in Annexure A.

The local representative mentioned in the conditions is: Area Manager: Hartbeespoort Government Water Scheme, Private Bag X352, Hartbeespoort, 0216.

DIRECTOR-GENERAL

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Private Bag X313, Pretoria, 0001, Sedibeng Building, 185 Francis Baard Street, Pretoria,
Tel: (012) 336-7500, Fax: (012) 326-4472/ (012) 326-2715

LICENCE IN TERMS OF CHAPTER 4 OF THE NATIONAL WATER ACT, 1998 (ACT NO 36 OF 1998) (THE ACT)

I, ***Margaret-Ann Diedricks,*** in my capacity as Director-General in the Department of Water and Sanitation and acting under authority of the powers delegated to me by the Minister of Water and Sanitation, hereby authorise the following water uses in respect of this Licence.

SIGNED: ____________________

DATE: 18 December 2015

LICENCE NO: 03/A21J/ABGJ/4196
FILE NO: 27/2/2/A921/18/1

1. **Licensee :** **Hernic Ferrochrome Mine : Maroelabult Section**
   Postal Address: P.O. Box 4534
   Brits
   0250

2. **Water uses**

2.1 Section 21 (a) of the Act: Taking water from a water resource, subject to the conditions set out in Appendices I and II.

2.2 Section 21(b) of the Act: Storing water, subject to the conditions set out in Appendices I and III.

2.3 Section 21 (g) of the Act: Disposing of waste in a manner which may detrimentally impact on a water resource, subject to the conditions set out in Appendices I and IV.

2.4 Section 21 (j) of the Act: Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people, subject to the conditions set out in Appendices I and V

3. **Properties in respect of which this licence is issued**

Property	Title deed number
Portions 44, 105, 135	T17161/2004
Portion 47; 104;165	T24244/1995
Remainder of portion 103	T13996/1997
Portion 191	T162627/2007
Portion 303	T21864/2010
Portion 296	T133619/2005

B 06406

Remainder of portion 46	T65796/2001
Remainder of portion 200	T127417/1999
Remaining portion of 102	T135237/1999
Reminder of portion151,169	T152593/2007
Portion 132, 199.	T63200/2010
Portion 173,	T42667/2009
Portion 49; 50	T64689/2004
Portion 331	T13674/2006
Portion 267	T21864/2010
Portion 216	T30417/2003

4. Registered owner of the Properties

4.1 Hernic Ferrochrome Pty Ltd

5. Licence and Review Period

This licence is valid for a period of twenty (20) years from the date of issuance and it may be reviewed at an interval not more than five (5) years.

6. Definitions

"Any terms, words and expressions as defined in the National Water Act, 1998 (Act 36 of 1998) shall bear the same meaning when used in this licence."

"Department mean" Department of Water and Sanitation.

"The Provincial Head" means the Head of Provincial Operations: North West, Department of Water and Sanitation, Private Bag X357, Hartbeespoort, 0216.

"Responsible Authority" means the Department of Water and Sanitation or Catchment Management Agency.

"Report" refers to the report entitled:

i. Hydrological Report by Raison Grounter Consulting cc, dated December 2010;
ii. Environmental Impact Assessment Report by Environmental Assurance (Pty) Ltd dated April2011;
iii. Environmental Managment Plan by Metago Environmental Engineers (Pty) Ltd dated October 2010;
iv. Civil design drawings by C.V. Niekerk, dated February Hernic Ferrochrome Pty Ltd 2013;
v. Integrated Water Management Plan by Environmental Hydrogoelogical Consultants (Pty) Ltd dated April 2004.
vi. Groundwater Monitoring Report by Consult and Contracting Environmental Hydrogeologits, dated May 2011 and
vii. Groundwater Remediation Plan by Aqua Earth Consulting cc, dated July 2012 as well as all other related documentations and communication (emails, letters, verbal, etc) related thereto. .

7. Description of the activity

The licence authorises water use activities for taking of water, storing of water, disposing waste or wastewater and removing water found underground at Hernic Ferrochrome Mine (Pty) Ltd: Maroelabult Section located on different properties mentioned in item 3. Mineral deposit at Maroelabult Section consists of Middle Group 1 and Middle Group 2 ore seams using underground down dip mining methods. The run of mine produced at the mine is processed through the ore beneficiation (OB) plant to separate waste from the product. Lumpy chrome ore and chrome ore concentrate/fines are produced from the plant.

The chrome ore concentrate or fine ore is processed through the pelletising and sintering plant to produce sintered pellets. The pellets, lumpy ore and other raw materials reductants and fluxes are fed into the furnace to produce ferrochrome. The ferrochrome is then crushed and screened at the finished product for the correct sizing and specification, which is then shipped and transported by rail to customers for stainless steel making. The water uses activities fall within A21J Quaternary Catchment of Crocodile West and Marico Water Management Area.

APPENDIX I

General conditions for the licence

1. This licence is subject to all applicable provisions of the National Water Act, 1998 (Act 36 of 1998).

2. The responsibility for complying with the provisions of the licence is vested in the Licensee and not any other person or body.

3. The Licensee must immediately inform the Provincial Head or Responsible Authority of any change of name, address, premises and/or legal status.

4. If the property in respect of which this licence is issued is subdivided or consolidated, the Licensee must provide full details of all changes in respect of the properties to the Provincial Head or Responsible Authority of the Department within 60 days of the said change taking place.

5. If a water user association is established in the area to manage the resource, membership of the Licensee to this association is compulsory.

6. The Licensee shall be responsible for any water use charges or levies imposed by a responsible authority.

7. While effect must be given to the Reserve as determined in terms of the Act, where a desktop determination of the Reserve has been used in issuance of a licence, when a comprehensive determination of the Reserve has finally been made; it shall be given effect to.

8. The licence shall not be construed as exempting the Licensee from compliance with the provisions any other applicable Act, Ordinance, Regulation or By-law.

9. The licence and amendment of this licence are also subject to all the applicable procedural requirements and other applicable provisions of the Act, as amended from time to time.

10. The Licensee shall conduct an annual internal audit on compliance with the conditions of licence. A report on the audit shall be submitted to the Provincial Head or Responsible Authority within one month of the finalisation of the audit.

11. The Licensee shall appoint an independent external auditor to conduct an annual audit on compliance with the conditions of this licence. The first audit must be conducted within 3 (three) months of the date this licence and a report on the audit shall be submitted to the Provincial Head or Responsible Authority within one month of finalisation of the report.

12. Any incident that causes or may cause water pollution shall be reported to the Provincial Head or Responsible Authority or his/her designated representative within 24 hours.

13. Licensee shall use water efficiently to minimise total water intake, avoid usage of water where possible, implement "good" housekeeping and operating practices, and maximise the reuse /recycle of contaminated water.

14. If the Licensee is not the end user/beneficiary of the water use related infrastructure and will not be responsible for long term maintenance and management of the infrastructure, the Licensee must provide a programme for hand over to the successor-in-title including a brief management/maintenance plan and the agreement for infrastructure along with allocation of responsibilities, within three (3) months of the date of issuing of this licence.

15. The Department accepts no liability for any damage, loss or inconvenience, of whatever nature, suffered as a result of:

    15.1 shortage of water
    15.2 inundations or flood
    15.3 siltation of the resource; and
    15.4 required reserve releases.

16. The Licensee shall at all times, together with the conditions of this, licence adhere to the Regulations on use of water for mining and related activities aimed at the protection of water resources (GN 704, 4 June 1999).

17. The licensee shall submit motivation for using waste rock to backfilling open pits within six (6) months of the issuance of the licence. This shall be accompanied by pollution potential assessment Report of the waste rock.

APPENDIX II

Section 21 (a) of the Act: Taking water from a water resource

1. The Licensee is authorised to take a maximum quantity of water per annum from a borehole as detailed in Table 1.

Table 1: Section 21 (a) water use activity

Water Use Activity	Properties	Purpose	Volume(m^3/a)	Coordinates
Section 21(a)				
Taking water from water found underground	Portion 104 of the farm De Kroon 444 JQ	For reuse in the mining processes / operations	436 175 m^3/a	S 25°39′24.10 E 27°51′17.85
Taking water from Haartbeespoort Irrigation canal	Portion 303 of the farm De Kroon 444 JQ	For domestic, mining and industrial purposes at the mine industrial use as well as drinking water use	870 000 m^3/a	S 25°39′24.67 E 27°49′55.38
Taking water from the borehole HER-BH 1	Remaining Extent (R/E) of Portion 46 of the farm De Kroon 444 JQ	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression	21 902.92 m^3/a	S 25°39′45.90 E 27°50′22.23
Taking water from borehole HER- MA	Portion 46 of the farm De Kroon 444 JQ	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression	18 249.27 m^3/a	S 25°39′53.41 E 27°50′15.02
Taking water from borehole HER- MB	Portion 46of the farm De Kroon 444 JQ	Treating of contaminated groundwater for groundwater remediation purposes and dust suppression	7 297.81 m^3/a	S 25°39′52.21 E 27°50′15.00

2. The quantity of water authorised to be taken in terms of this licence may not be exceeded without prior authorisation by the Department.

3. This licence does not imply any guarantee that the said quantities and qualities of water will be available at present or at any time in the future.

4. The Licensee shall continually investigate new and emerging technologies and put into practice water efficient devices or apply technique for the efficient use of water containing waste, in an endeavour to conserve water at all times.

5. All water taken from the resource shall be measured as follows:

5.1 The daily quantity of water taken must be metered or gauged and the total recorded at the last day of each month; and

5.2 The Licensee shall keep record of all water taken and a copy of the records shall be forwarded to the Provincial Head or Responsible Authority each year with the annual water balance.

6. No water taken may be pumped, stored, diverted, or alienated for purposes other than intended in this licence, without written approval by the Department.

7. The Licensee shall install and monitor appropriate water measuring devices to measure the amount of water abstracted, received and/or consumed, as applicable to the infrastructure.

8. The Licensee shall ensure that all measuring devices are properly maintained and in good working order and must be easily accessible. This shall include a programme of checking, calibration, and/ or renewal of measuring devices.

9. The Licensee shall be responsible for any water use charges or levies, which may be imposed from time to time by the Department or responsible authority in terms of the Department's Raw Water Pricing Strategy.

APPENDIX III

Section 21 (b) of the Act: Storing of water

1. Storing of water

1.1. The Licensee is authorised to store water into the dams located on the properties and geographic location indicated in Table 2.

Table 2: Authorised water use activities

Water Use Activity	Properties	Purpose	Capacity(m^3)	Volume(m^3/a)	Coordinates
S21 (b)					
Storing water in drinking water dam	R/E of Portion 46 of the farm De Kroon 444 JQ	For domestic purposes	30 000 m^3	608 455 m^3/a	S 25°39´38.37 E 27°50´11.50

1.2. No additional storage works by means of which water can be impounded may be constructed on the property without the prior without prior authorisation by the Department.

2. Monitoring Requirements

2.1. Suitable measuring structures must be constructed to measure the flows entering and leaving the dam and this information must be available to the Provincial Head or Responsible Authority on request.

2.2. The Licensee shall establish a monitoring programme where in the date and time of monitoring in respect of each sample taken and shall be recorded together with the results of the analysis as well as other significant information (low flow, flooding, pollution incident, etc).

2.3. The water level in the dam and the quantity of water stored shall be recorded at the last day of each month.

3. Dam Safety Requirements

3.1 The operation and maintenance of all dam facilities classified as a dam with a safety risk, must be carried out under supervision of a Professional Civil Engineer, registered under the Engineering Profession of South Africa Act, 1990 (Act 114 of 1990).

3.2 All dams with a safety risk must be registered with the Department Dam Safety Office.

3.3 The Licensee shall supply any information, drawings, specifications, design assumptions, calculations, documents and test results when requested by the Provincial Head or Responsible Authority.

3.4 An approved professional person must be appointed to carry out a dam safety evaluation annually and must:

3.4.1 Consider whether the safety norms pertaining to the design, construction, monitoring, operation, performance and maintenance of the dam satisfy acceptable dam engineering practices.

3.4.2 Compile a report on the matters contemplated above according to the prescribed requirements and submit the signed and dated report to the owner of the dam within the prescribed period.

3.5 The Licensee is not exempted from compliance with the provisions of the Regulations published under Government Notice R. 139 of 24 February 2012, read with Chapter 12 of the Act.

4. Operation of Dams

4.1. The as-built drawing and specifications of all dams must be submitted to the Provincial Head or Responsible Authority for his/her records, after six months after completion of construction.

4.2. The Government reserves the right to construct storage works at any time in any stream and to store all surplus water reaching the dams and to control the allocation of such water.

4.3. The Licensee shall follow acceptable construction, maintenance and operational practices to ensure the consistent, effective and safe performance of the storage of water in the dam(s).

APPENDIX IV

Section 21 (g) of the act: Disposing of waste in a manner which may detrimentally impact on a water resource

1. CONSTRUCTION AND OPERATION

1.1 The Licensee shall carry out and complete all the activities, including the construction and operation of the facilities listed in Table 3, according to the Report and according to the final plans submitted with the Integrated Water Use Licence Application as approved by the Provincial Head or Responsible Authority.

Table 3: Waste water management facilities

Water Use Activity	Properties	Purpose	Capacity (m^3)/ Tonnages (p/a)/ Footprint Area	Volume (m^3/a ^{3})	Coordinates
S21 (g)					
Disposing of water found underground into Marula Dewatering Dam	R/E of Portion 103 of the farm De Kroon 444 JQ	For re-use in mining processes	12 000 m^3	580 685m^3/a	S 25°39´48.62 E 27°50´12.42
Disposing of waste water from ore beneficiation plant into ore beneficiation plant Return Water Dam	R/E of Portion 165 of the farm De Kroon 444 JQ	For reuse at the mine	25 000 m^3	420 115 m^3/a	S 25°39´21.29 E 27°50´20.15
Disposing of waste water from the processing plant into Process Water Dam	R/E of Portion 173 of the farm De Kroon 444 JQ	For reuse at the mine when required	76 000 m^3	1 840 450 m^3/a	S 25°39´28.24 E 27°50´10.81
Disposing of storm water into the Storm Water Pollution Dam	R/E of Portion 173 of the farm De Kroon 444 JQ	For re-use at the mine	38 000 m^3	150 380 m^3/a	S 25°39´23.81 E 27°50´13.89
Disposing of waste water from the tailing storage facility in the Return Water Dam	Portion 267 of the farm De Kroon 444 JQ	For re-use at the OB plant	24 000 m^3	2 058 235 m^3/a	S 25°39´11.15 E 27°50´52.14
Disposing of waste water from the chrome recovery plant into Chrome Recovery Plant Dam	Portion 216 of the farm De Kroon 444 JQ	For reuse at the chrome recovery plant	9 000 m^3	92 710 m^3/a	S 25°39´45.76 E 27°50´32.65

Water Use Activity	Properties	Purpose	Capacity (m^3)/ Tonnages (p/a)/ Footprint Area	Volume (m^3/a)	Coordinates
Disposing of return water from the new slimes dam into Slimes Return Water Dam	Portion 296 of the farm De Kroon 444 JQ	For evaporation	0.3ha	6 130 m^3/a	S 25°39´15.20 E 27°50´43.06
Disposing of slimes from bag filter plant into old slimes dam	R/E of Portion 46 of the farm De Kroon 444 JQ	Recovery of water and disposal of fines	0.36 ha	15 512m^3/a	S 25°39´45.96 E 27°50´24.12
Disposing of slimes from the bag filter plant into new slimes dam	Portion 296 of the farm De Kroon 444 JQ	Recovery of water and disposal of fines	4 ha	37 777m^3/a	S 25°39´18.44 E 27°50´46.78
Disposing of slag in the slag dump area	Portion 103 of the farm De Kroon 444 JQ	For recovery of metals at chrome recovery plant	4 ha	488 262.6 4m^3/a	S 25°39´52.69 E 27°50´58.23
Disposing of tailings in the Tailings Storage Facility from ore beneficiation plant	R/E of Portion 104 of the farm De Kroon 444 JQ	Storage of tailings	29.16 ha	5 303 627 m^3/a	S 25°39´13.08 E 27°51.13.38
Disposing of waste rock into Waste Rock Dump	R/E of Portion 104 of the farm De Kroon 444 JQ	For reuse-backfilling of the open pit void	0.3 ha	30 000 t/a	S 25°39´42.07 E 27°51´18.43
Disposing of coarse waste into Coarse Waste Dump	Portion 169 & 296 of the farm De Kroon 444 JQ	Temporary storage of coarse waste from the ore beneficiation plant	10 ha	523 871m^3/a	S 25°39´21.06 E 27°50´39.55
Backfilling of Open Pits with waste rock	R/E of Portion 103, 104 & 105, and Portion 135 of the farm De Kroon 444 JQ	For rehabilitation of the open pit	56 ha	680 000 m^3/a	S 25°39´24.10 E 27°51´17.85
Using purified waste water from	Portion 44 of the farm	For dust suppression		47 450.00 m^3/a	S: 25°65'96.7" E: 27°80'40.1"

Water Use Activity	Properties	Purpose	Capacity (m^3)/ Tonnages (p/a)/ Footprint Area	Volume (m^3/a ^{3})	Coordinates
contaminated boreholes	De Kroon 444 JQ	on the mine road			

1.2 The construction of the dam listed in Table 3 of must be carried out under the supervision of a professional Civil Engineer, registered under the Engineering Profession of South Africa Act, 1990 (Act 114 of 1990), as approved by the designer.

1.3 Within 30 days after the completion of the activities referred here in accordance with the relevant provisions of this licence, the Licensee shall in writing, under reference 27/2/2/A921/18/1, inform the Provincial Head or Responsible Authority thereof. This shall be accompanied by a signature of approval from the designer referred in Condition 1.2 that the construction was done according to the design plans referred to in the Report.

1.4 The Licensee must ensure that the disposal of the waste water and the operation and maintenance of the system are done according to the provisions in the Report.

1.5 The Licensee shall as well submit a set of as-built drawings to the Provincial Head or Responsible Authority of the waste facilities listed in Table 3.

1.6 The waste facilities listed in Table 3 shall be operated and maintained to have a minimum freeboard of 0.8 metres above full supply level and all other water systems related thereto shall be operated in such a manner that it is at all times capable of handling the 1:50 year flood-event on top of its mean operating level.

1.7 All the Pollution Control Dams (PCD) shall be lined with a composite (1,5 mm geo-membrane over 300 mm thick compacted clay) liner with a ballast layer on top of the geo-membrane which could be either by way of sand bags or a 200 mm thick soil layer.

2. QUALITY OF WATER CONTAINING WASTE TO BE DISPOSED

2.1 The Licensee shall submit the nature and the quality of the waste or water containing waste disposed off into all dirty water containment facilities as listed in Table 3.

3. MONITORING

3.1 The Licensee shall conduct ground water monitoring at the frequency and variables shown in Table 4 at the monitoring points shown in Table 5 and the results must be submitted to the Provincial Head or Responsible Authority on an annual basis.

3.2 Monitoring network shall be set up as an early warning system to detect any polluted seepage that might occur from the wastewater system.

3.3 If ground water pollution has occurred or may possibly occur, the licensee must conduct necessary investigations and implement additional monitoring and rehabilitation measures which must be to the satisfaction of the Provincial Head or Responsible Authority.

3.4 Monitoring boreholes shall be clearly marked and numbered, and must be equipped with lockable caps. The Department reserves the right to sample monitoring boreholes at any time and to analyse these samples, or to have samples taken and analysed.

Table 4: Groundwater monitoring variables and frequency

Variables/ Parameter	Frequency
pH	Quarterly
EC	Quarterly
TDS	Quarterly
Ca	Quarterly
Mg	Quarterly
Na	Quarterly
K	Quarterly
Cl	Quarterly
SO4	Quarterly
NO3asN	Quarterly
F	Quarterly
Al	Quarterly
Fe	Quarterly
Mn	Quarterly
Cr	Quarterly

Table 5: Ground water monitoring points

Locality	Description	X co-ordinate	Y co-ordinate
B1	North of mining	27º51´05.22	25º38´17.77
B2	West of mining	27º51´02.01	25º38´05.49
B3	East of mining	27º50´19.75	25º38´15.28
B4	East of mining	27º50´12.98	25º39´59.04
B5	At pan south of mining	27º49´54.01	25º39´50.04
B36	DWAF	27º49´53.00	25º39´51.98
B37	RAS SCHOOL old BH veld BH1	27º49´54.98	25º39´54.00
B38	Slimes dam BH1	27º50´24.00	25º39´45.00
B39	Slimes dam BH2	27º50´22.99	25º39´43.99
B40	Slimes dam BH3	27º50´21.01	25º39´48.99
41	Slimes dam BH4 (Hernic)	27º50´05.82	25º39´53.64

3.5 Licensee shall remove source of pollution within the three years that had been suggested by the Groundwater remediation plan report.

3.6 Licensee shall investigate source of nitrate pollution and if it is mine related activity at Maroelabult Section, Licensee shall start with clean up and preventative measures.

3.7 A yearly update of the phase approach remediation plan together with the surface and groundwater results must be reported to the Department.

3.8 The pollutant borehole should be closed for drinking purposes but should still operate as a monitoring borehole.

3.9 The mine must continue to provide the Ras School with potable drinking water until such a time that the Department declare the water potable and clean for drinking.

3.10 The Licensee shall conduct surface water monitoring on a monthly basis for water quality variables listed and frequency in Table 6 at the monitoring points shown in Table 7. The results must be submitted to the Provincial Head or Responsible Authority on a quarterly basis.

Table 6: Surface water monitoring variables and frequency

Surface water Variables	Frequency
Electrical Conductivity (mS/m)	Monthly
Sodium (mg/l)	Monthly
Magnesium (mg/l)	Monthly
Calcium (mg/l)	Monthly
Chloride (mg/l)	Monthly
Sulphate (mg/l)	Monthly
Nitrate (mg/l)	Monthly
Fluoride (mg/l)	Monthly
Iron mg/l)	Monthly
pH	Monthly
Total dissolved solids(mg/l)	Monthly
Potassium(mg/l)	Monthly
Chrome (IV) (mg/l)	Monthly

Table 7: Surface water quality sampling points

Locality	Description	X co-ordinate	Y co-ordinate
M1	Monitoring Point A-Upstream De Kroon Road Bridge	27°48'14.43"	25°42'57.0"
M2	Monitoring point B-Downstream Brits Pretoria Road	27°43'41.8"	25°42'49.8"
M3	Gravimax Concentrator RWD	27°44'40.5"	25°42'56.7"
M4	Process Water Dam	27°44'44.9"	25°42'42.5"
M5	Canal Water Dam	27°44'45.6"	25°42'28.2"
M6	Storm Water Containment Dam	27°45'35.10"	25°41'08.8"
M7	Sewage Effluent Pond	27°45'03.20"	25°41'50.22"

3.11 The date, time and monitoring point in respect of each sample taken shall be recorded together with the results of the analysis.

3.12 Monitoring points must not be changed prior to notification to and written approval by the Provincial Head or Responsible Authority.

3.13 Analysis shall be carried out in accordance with methods prescribed by and obtainable from the South African Bureau of Standards (SABS), in terms of the Standards Act, 1982 (Act 30 of 1982).

3.14 The methods of analysis shall not be changed without prior notification to and written approval by the Department.

4. WATER RESOURCE PROTECTION

4.1 The impact of the activities of the mine on the groundwater shall not exceed baseline groundwater quality as measured prior to mining activities as set out in Table 8.

Table 8: Baseline Groundwater Quality

Substance / Parameter	Maximum quality Baseline
pH	7-9
EC	260
TDS	1200
Ca	150-300
Mg	70-100
Na	200-400
K	50-100
Cl	200-600
SO4	400-600
NO3asN	10-20
F	1.0-1.5
Al	0.3-0.5
Fe	200-2000
Mn	0.1-1
Cr	100-500

6. STORMWATER MANAGEMENT

6.1 Stormwater leaving the Licensee's premises shall in no way be contaminated by any substance, whether such substance is a solid, liquid, vapour or gas or a combination thereof which is produced, used, stored, dumped or spilled on the premises.

6.2 Stormwater shall be diverted from the mine complex site and roads and shall be managed in such a manner as to disperse runoff and concentrating the storm-water flow.

6.3 Where necessary works must be constructed to attenuate the velocity of any storm-water discharge and to protect the banks of the affected watercourses.

6.4 Increased runoff due to vegetation clearance and/or soil compaction must be managed, and steps must be taken to ensure that stormwater does not lead to bank instability and excessive levels of silt entering the streams.

6.5 All storm-water that would naturally run across the pollution areas shall be diverted via channels and trapezoidal drains designed to contain the 1:50 year flood.

7. PLANT AREAS AND CONVEYANCES

7.1 Pollution caused by spills from the conveyances must be prevented through proper maintenance and effective protective measures especially near all stream crossings.

7.2 All reagent storage tanks and reaction units must be supplied with a bunded area built to the capacity of the facility and provided with sumps and pumps to return the spilled material back into the system. The system shall be maintained in a state of good repair and standby pumps must be provided.

7.3 Any hazardous substances must be handled according to the relevant legislation relating to the transport, storage and use of the substance.

7.4 Any access roads or temporary crossings must be:

7.4.1 non-erosive, structurally stable and shall not induce any flooding or safety hazard and
7.4.2 be repaired immediately to prevent further damage.

8. ACCESS CONTROL

8.1 Strict access procedures must be followed in order to gain access to the property. Access to the waste water containment facilities must be limited to authorised employees of the Licensee and their Contractors only.

8.2 Notices prohibiting unauthorised persons from entering the controlled access areas as well as internationally acceptable signs indicating the risks involved in case of an unauthorised entry must be displayed along the boundary fence of these areas.

9. CONTINGENCIES

9.1 Accurate and up-to-date records shall be kept of all system malfunctions resulting in non-compliance with the requirements of this licence. The records shall be available for inspection by the Provincial Head or Responsible Authority upon request. Such malfunctions shall be tabulated under the following headings with a full explanation of all the contributory circumstances:

9.1.1 operating errors
9.1.2 mechanical failures (including design, installation or maintenance)
9.1.3 environmental factors (e.g. flood)
9.1.4 loss of supply services (e.g. power failure) and
9.1.5 Other causes.

9.2 The Licensee must, within 24 hours, notify the Provincial Head or Responsible Authority of the occurrence or potential occurrence of any incident which has the potential to cause, or has caused water pollution, pollution of the environment, health risks or which is a contravention of the licence conditions.

9.3 The Licensee must, within 14 days, or a shorter period of time, as specified by the Provincial Head or Responsible Authority, from the occurrence or detection of any incident referred above, submit an action plan, which must include a detailed time schedule, to the satisfaction of the Provincial Head or Responsible Authority of measures taken to:

9.3.1 correct the impacts resulting from the incident
9.3.2 prevent the incident from causing any further impacts and prevent a recurrence of a similar incident.

10. INTEGRATED WATER AND WASTE MANAGEMENT

10.1 The Licensee must update an Integrated Water and Waste Management Plan (IWWMP), which must together with the updated Rehabilitation Strategy and Implementation Programme (RSIP), be submitted to the Provincial Head or Responsible Authority for approval within one (1) year from the date of issuance of this licence.

10.2 The IWWMP and RSIP shall thereafter be updated and submitted to the Provincial Head or Responsible Authority for approval, annually.

10.3 The Licensee must, at least 180 days prior to the intended closure of any facility, or any portion thereof, notify the Provincial Head or Responsible Authority of such intention and submit any final amendments to the IWWMP and RSIP as well as a final Closure Plan, for approval.

10.4 The Licensee shall make full financial provision for all investigations, designs, construction, operation and maintenance for a water treatment plant should it become a requirement as a long-term water management strategy.

11. WATER CONSERVATION AND WATER DEMAND MANAGEMENT (WC/WDM)

11.1 Licensee shall develop and submit a water conservation and demand management (WC/WDM) plan to the Provincial Head or Responsible Authority, which

11.1.1 quantify the water use efficiency of the activity;
11.1.2 contains the mine water management and water loss strategies and programs;
11.1.3 sets annual targets for improved water use efficiency for the mining activity, beneficiation and waste disposal practices and stipulates which measures will be implemented to achieve the targets on the mine;

11.2 Licensee shall update the WC/WDM plan on an annually basis and submit to the Provincial Head or Responsible Authority for approval.

11.3 Licensee shall report on annually basis the implementation of water conservation and water demand management measures including retrofitting with water efficient technologies and devices, reduction of total water demand, improvement in water use efficiency benchmarks and targets.

11.4 The Licensee shall establish and implement a continual process of raising awareness amongst itself, its workers and stakeholders with respect to Water Conservation/Water Demand Management initiatives.

12. REPORTING

12.1 The Licensee shall update the water balance annually and calculate the loads of waste emanating from the activities. The Licensee shall determine the contribution of their activities to the mass balance for the water resource and must furthermore co-operate with other water users in the catchment to determine the mass balance for the water resource reserve compliance point.

12.2 The Licensee shall submit the results of analysis for all monitoring requirements to the Provincial Head or Responsible Authority on a quarterly basis under the reference number 27/2/2/A921/18/1.

APPENDIX V

Section 21 (j) of the act: Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people

1. This licence authorises the removal, discharging or disposing of a maximum volume of water found underground for the efficient continuation of an activity as set out in Table 9.

Table 9: Section 21 (j) water use activities

Water Use Activity	Properties	Purpose	Volume(m^3/a)	Coordinates
S21 (j)				
Removing water from Morula Shaft Dewatering	Portion 104 of the farm De Kroon 444 JQ	For safe continuation of mining operation and re-use at the mine	436 175 m^3/a	S 25°39´24.10 E 27°51´17.85
Removing waste water from Morula Pit Dewatering	Portion 135 of the farm De Kroon 444 JQ	For reuse at the OB Plant	238 345 m^3/a	S 25°39´23.63 E 27°51´17.70

2. The quantity of the water authorised to be removed in terms of this licence may not be exceeded without prior authorisation by the Department.

3. The Licensee shall provide any water user whose water supply is impacted by the water use with potable water.

4. The quantity of water removed from underground must be metered and recorded on a daily basis.

5. Groundwater levels shall be monitored every six months (once in the beginning of the dry season and once in the beginning of the wet season), level measurements shall be reported in tabular and graphical formats indicating trends.

6. Self-registering flow meters must be installed in the delivery lines at easily accessible positions near the dewatering points.

7. The flow metering devices shall be maintained in a sound state of repair and calibrated by a competent person at intervals of not more than once in two (2) years. Calibration certificates shall be available for inspection by the Provincial Head or Responsible Authority or his/her representative upon request.

8. Calibration certificates in respect of the pumps must be submitted to the Provincial Head or Responsible Authority after installation thereof and thereafter at intervals of two years.

8 The date and time of monitoring in respect of each sample taken shall be recorded together with the results of the analysis.

10. Analysis shall be carried out in accordance with methods prescribed in condition 3.11 and 3.12 of appendix IV of this licence

11. The Provincial Head or Responsible Authority must be informed of any incident that may

lead to groundwater being disposed of contrary to the provisions of this license, by submitting a report containing the following information: -

11.1 Nature of the incident (e.g. operating malfunctions, mechanical failures, environmental factors, loss of supply services, etc)

11.2 Actions taken to rectify the situation and to prevent pollution or any other damage to the environment and

11.3 Measures to be taken to prevent re-occurrence of any similar incident.

12. The Licensee shall follow acceptable construction, maintenance and operational practices to ensure the consistent, effective and safe performance of the groundwater removal system.

13. Reasonable measures must be taken to provide for mechanical, electrical or operational failures and malfunctions of the underground water removal system.

[END OF LICENCE]

JMA Consulting (Pty) Ltd

15 Vickers Street
P O Box 883
Delmas 2210

Tel: (013) 665 1788
Fax: (013) 665 2364

Material Sampling Field Form

"Sustainable Environmental Solutions through Integrated Science and Engineering "

Sample No:	HRM - 1	**Description:**	Dolomite	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 40"S	**Hole Depth (m)**
Sampling Time:	14:12	**Longitude:**	27° 50' 29.9"E	Stockpile

Sample No:	HRM - 2	**Description:**	Quartzite	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 39.9"S	**Hole Depth (m)**
Sampling Time:	14:23	**Longitude:**	27° 50' 29.2"E	Stockpile

Sample No:	HRM - 3	**Description:**	ACP Char	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 38.7"S	**Hole Depth (m)**
Sampling Time:	15;09	**Longitude:**	27° 50' 32.4"E	Stockpile

Sample No:	HRM - 4	**Description:**	Coke Nuts	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 37.8"S	**Hole Depth (m)**
Sampling Time:	15:22	**Longitude:**	27° 50' 32.1"E	Stockpile

Sample No:	HRM - 5	**Description:**	Anthracite	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 40.3"S	**Hole Depth (m)**
Sampling Time:	15:32	**Longitude:**	27° 50' 32.5"E	Stockpile

Sample No:	HRM - 6	**Description:**	Limestone	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 34.6"S	**Hole Depth (m)**
Sampling Time:	15:48	**Longitude:**	27° 50' 29.9"E	Stockpile

Sample No:	HRM - 8	**Description:**	MG - 1 Ore	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 31.6"S	**Hole Depth (m)**
Sampling Time:	16:07	**Longitude:**	27° 50' 31.6"E	Stockpile

Sample No:	HRM - 9	**Description:**	MG - 2 Ore	
Sampling Date:	25/02/2016	**Latitude:**	25° 39' 30.1"S	**Hole Depth (m)**
Sampling Time:	16:16	**Longitude:**	27° 50' 33.5"E	Stockpile

Sample No:	HRM - 10	**Description:**	Chem Stof Conc	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 33.5"S	**Hole Depth (m)**
Sampling Time:	09:10	**Longitude:**	27° 50' 30.1"E	Stockpile

Sample No:	HRM - 11	**Description:**	UG - 2 Conc	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 34.2"S	**Hole Depth (m)**
Sampling Time:	09:18	**Longitude:**	27° 50' 29.3"E	Stockpile

Sample No:	HRM - 12	**Description:**	Unprocessed slag	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 27.3"S	**Hole Depth (m)**
Sampling Time:	09:29	**Longitude:**	27° 50' 37.9"E	Stockpile

JMA Consulting (Pty) Ltd
15 Vickers Street
P O Box 883
Delmas 2210
Tel: (013) 665 1788
Fax: (013) 665 2364

Material Sampling Field Form

"Sustainable Environmental Solutions through Integrated Science and Engineering "

Sample No:	HRM - 13	**Description:**	Slimes (TSF)	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 14.5"S	**Hole Depth (m)**
Sampling Time:	09:54	**Longitude:**	27° 50' 53.1"E	Stockpile

Sample No:	HRM - 14	**Description:**	DMS Lumpy (10x30) Chrome Ore	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 29.9"S	**Hole Depth (m)**
Sampling Time:	10:36	**Longitude:**	27° 50' 30.2"E	Stockpile

Sample No:	HRM - 15	**Description:**	DMS Waste	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 29.83"S	**Hole Depth (m)**
Sampling Time:	10:38	**Longitude:**	27° 50' 30.27"E	Stockpile

Sample No:	HRM - 16	**Description:**	HFC Concentrate	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 24.07"S	**Hole Depth (m)**
Sampling Time:	10:50	**Longitude:**	27° 50' 24.13"E	Stockpile

Sample No:	HRM - 17	**Description:**	Slag Fines	
Sampling Date:	26/02/2016	**Latitude:**	25° 39' 41.5"S	**Hole Depth (m)**
Sampling Time:	12:02	**Longitude:**	27° 50' 02.3"E	Stockpile

Sample No:	HRM - 18	**Description:**	Final Slag Dump	
Sampling Date:	1/3/2016	**Latitude:**	25° 39' 49.14"S	**Hole Depth (m)**
Sampling Time:	16:48	**Longitude:**	27° 50' 54.3"E	Stockpile

Sample No:	HRM - 19	**Description:**	MG 4	
Sampling Date:	2/3/2016	**Latitude:**	25° 39' 24.2"S	**Hole Depth (m)**
Sampling Time:	12:26	**Longitude:**	27° 51' 13.6"E	Stockpile

Sample No:	HRM - 21	**Description:**	Return material	
Sampling Date:	2/3/2016	**Latitude:**	25° 39' 36.6"S	**Hole Depth (m)**
Sampling Time:	13:54	**Longitude:**	27° 49' 55.1"E	Stockpile

Sample No:	HRM - 22	**Description:**	Pellets	
Sampling Date:	2/3/2016	**Latitude:**	25° 39' 31.88"S	**Hole Depth (m)**
Sampling Time:	14:10	**Longitude:**	27° 50' 11.3"E	Stockpile

Sample No:	HRM - 23	**Description:**	Process water dam sediment	
Sampling Date:	2/3/2016	**Latitude:**	25° 39' 33.6"S	**Hole Depth (m)**
Sampling Time:	14:17	**Longitude:**	27° 50' 11.2"E	Stockpile

Sample No:	HRM - 24	**Description:**	OB dam sediment	
Sampling Date:	2/3/2016	**Latitude:**	25° 39' 22.63"S	**Hole Depth (m)**
Sampling Time:	15:10	**Longitude:**	27° 50' 23.6"E	Stockpile

JMA Consulting (Pty) Ltd

15 Vickers Street
P O Box 883
Delmas 2210

Tel: (013) 665 1788
Fax: (013) 665 2364

Material Sampling Field Form

"Sustainable Environmental Solutions through Integrated Science and Engineering "

Sample No:	HRM - 25	**Description:**	Rehabilitated Pit 1	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 31.16"S	**Hole Depth (m)**
Sampling Time:	10:25	**Longitude:**	27° 50' 47.6"E	Stockpile

Sample No:	HRM - 26	**Description:**	Rehabilitated Pit 2	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 28.94"S	**Hole Depth (m)**
Sampling Time:	10:48	**Longitude:**	27° 50' 51.3"E	Stockpile

Sample No:	HRM - 27	**Description:**	Rehabilitated Pit 3	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 26.8"S	**Hole Depth (m)**
Sampling Time:	11:23	**Longitude:**	27° 50' 59.7"E	Stockpile

Sample No:	HRM - 28	**Description:**	Rehabilitated Pit 4	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 25"S	**Hole Depth (m)**
Sampling Time:	11:35	**Longitude:**	27° 51' 1.7"E	Stockpile

Sample No:	HRM - 29	**Description:**	Mining Waste Rock Stockpile	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 45.06"S	**Hole Depth (m)**
Sampling Time:	12:25	**Longitude:**	27° 51' 17.3"E	Stockpile

Sample No:	HRM - 30	**Description:**	Grout plant	
Sampling Date:	3/3/2016	**Latitude:**	25° 39' 36.21"S	**Hole Depth (m)**
Sampling Time:	12:01	**Longitude:**	27° 51' 10.39"E	Stockpile

Sample No:	HRM - 31	**Description:**	Western Backfill	
Sampling Date:	30/03/2016	**Latitude:**	25° 39' 35.3"S	**Hole Depth (m)**
Sampling Time:	13:29	**Longitude:**	27° 49' 44.4"E	2m

Sample No:	HRM - 32	**Description:**	Mixed Waste	
Sampling Date:	30/03/2016	**Latitude:**	25° 39' 28.6"S	**Hole Depth (m)**
Sampling Time:	14:03	**Longitude:**	27° 50' 26.3"E	Stockpile

Dr Sabine Verryn

m: 083 548 0586
f: 086 565 7368
e: sabine.verryn@xrd.co.za

XRD Analytical and Consulting cc
75 Kafue Street, Lynnwood Glen,
0081, South Africa

CLIENT: Shane Turner (JMA Consulting (Pty) Ltd)

DATE: 06 April 2016

SAMPLES: 28 Samples (JMA10462/ST/02)

ANALYSIS: Qualitative and quantitative XRD

After Splitting and Milling, the material submitted was scanned using a using a back loading preparation method.
Samples HRM 12, 17 and 18 were scanned after addition of 20 % Si and micronizing in a McCrone micronizing mill for quantitative determination of amorphous content.

They were analysed with a PANalytical Empyrean diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software.

The relative phase amounts (weight %) were estimated using the Rietveld method.

Comment:

- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown.
- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group
- Traces of additional phases may be present.
- Some sample seem to contain organic carbon, this is represented by the phase "graphite", quantification is, however, not as accurate as shown.
- Samples HRM 15, 26 and 27 may contain traces of amphibole.
- Amorphous phases, if present, were not taken into consideration during quantification – except for the above mentioned samples.

Quantification results are also attached as JMA16-1.xlsx

If you have any further queries, kindly contact me.

Verryn.

Dr. Sabine Verryn (Pr.Sci.Nat)

Samples will be stored for 3 months after which they will be discarded.

	Quartz	Dolomite	Mica									
HRM_1	13.16	86.5	0.33									
	Quartz	Plagioclase	Mica	Hematite	Magnetite	Kaolinite						
HRM_2	87.64	10.03	0.55	1.05	0.36	0.37						
	Quartz	Graphite	Kaolinite									
HRM_3	10.76	85.78	3.46									
	Quartz	Graphite	Kaolinite									
HRM_4	11.04	88.96	0									
	Quartz	Graphite	Kaolinite	Mica	Calcite							
HRM_5	17.8	63.41	5.36	13	0.42							
	Calcite	Dolomite	Quartz	Mica								
HRM_6	85.88	5.98	4.13	4								
	Chromite	spinel	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_8	46.91	4.44	18.88	5.55	4.64	0.74	1.53	1.02	0.63	5.88	9.76	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Dolomite	Mica	Quartz		calcite	Chlorite	Enstatite
HRM_9	38.99	23.66	7.79	1.16	0	0.32	0.82	0.46		0.9	4.6	21.31
	Chromite	Plagioclase	Enstatite									
HRM_10	90.77	7.5	1.73									
	Chromite	Plagioclase	Enstatite									
HRM_11	88.84	7.98	3.18									
	Spinel	Enstatite	Amorphous									
HRM_12	34.03	13.79	52.18									
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite		
HRM_13	19.46	45.41	6.21	3.15	0	1.22	2.98	1.37	5.77	14.43		
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite		
HRM_14	41.47	45.67	3.48	0.69	0.74	0.76	0.38	0.6	2.24	3.97		
	Chromite	spinel	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_15	4.04	0.47	25.62	3.53	0.98	0	0.77	1.56	0.61	0.4	62.03	

	Chromite	Plagioclase									
HRM_16	78.86	5.81									
	Spinel	Enstatite	Quartz	Diopside	Amorphous						
HRM_17	13.16	12.25	39.3	2.68	32.61						
	Spinel	Enstatite	Quartz	Diopside	Amorphous						
HRM_18	32.23	12.17	1.26	6.89	47.46						
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Dolomite	Mica	Quartz	calcite	Chlorite	Enstatite
HRM_19	40.17	40.46	2.78	0.01	0	0.36	0.6	1.31	0.77	0.63	12.91
	Chromite	Plagioclase	Talc	Quartz	calcite	Chlorite	Enstatite				
HRM_21	64.24	0	18.35	3.04	1.11	0.61	0.31	12.34			
	Chromite	Eskolaite	Quartz	Cristobalite							
HRM_22	80.17	18.51	0.55	0.77							
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_23	57.01	17.1	6.12	0	1.24	1.4	3.58	0	0.61	12.95	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_24	65.43	13.86	4.74	0	0	1.11	2.25	0.3	0.93	11.37	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_25	32.97	9.3	8.64	17.15	0.19	3.26	2.84	1.48	12.46	11.69	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_26	49.05	10.25	7.23	5.74	1.53	1.06	2.67	1.32	7.83	13.32	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_27	42.33	11.81	7.35	5.04	2.52	1.64	2.29	1.27	6.87	18.87	
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Mica	Quartz	calcite	Chlorite	Enstatite	
HRM_28	37.97	11.31	8.95	5.77	2.85	1.89	3.07	2.04	9.07	16.68	
	Quartz	Enstatite	Plagioclase	Amphibole	Talc	Mica	Kaolinite				
HRM_29	8.86	47.65	33.48	5.9	1.97	2.03	0.11				
	Chromite	Plagioclase	Talc	Smectite	Kaolinite	Dolomite	Mica	Quartz	calcite	Chlorite	Enstatite
HRM_30	30.12	8.83	6.45	5.8	0.08	0.14	2.5	21.91	0	9.61	14.56

0 = n.d. – not detected above the detection limit of 1-3 weight per cent

Ideal Mineral Composition	
Calcite	CaCO3
Talc	Mg3Si4O10(OH)2
Enstatite	(Mg,Fe)SiO3
Plagioclase	(Na,Ca)(Si,Al)4O8
Dolomite	Ca Mg (C O3)2
Kaolinite	Al2 Si2 O5 (OH)4
Hematte	Fe2O3
Mica	K Al2 ((OH)2 Al Si3 O10)
Kaolinite	Al2 Si2 O5 (OH)4
Quartz	SiO2
Smectite (Montmorillonite)	(Na,Ca)0,3(Al,Mg)2Si4O10(OH)2•n(H2O)
Chromite	Fe++Cr2O4
Chlorite	(Mg,Fe)5Al(AlSi3O10)(OH)8
Mica	K0.7 Al2 ((OH)2 Al Si3 O10)
Cristobalite	SiO2
Eskolaite	Cr23

Dr Sabine Verryn

m: 083 548 0586
f: 086 565 7368
e: sabine.verryn@xrd.co.za

XRD Analytical and Consulting cc
75 Kafue Street, Lynnwood Glen,
0081, South Africa

CLIENT: Shane Turner (JMA Consulting (Pty) Ltd)

DATE: 14 April 2016

SAMPLES: 7 Samples (JMA10462/ST/08)

ANALYSIS: Qualitative and quantitative XRD

After Splitting and Milling, the material submitted was scanned using a using a back loading preparation method.

They were analysed with a PANalytical Empyrean diffractometer with PIXcel detector and fixed slits with Fe filtered Co-Kα radiation. The phases were identified using X'Pert Highscore plus software.

The relative phase amounts (weight %) were estimated using the Rietveld method.

Comment:

- Due to preferred orientation and crystallite size effects, results may not be as accurate as shown. Smectite may be underestimated.
- In case the results do not correspond to results of other analytical techniques, please let me know for further fine tuning of XRD results.
- Mineral names may not reflect the actual compositions of minerals identified, but rather the mineral group
- Traces of additional phases may be present.
- Amorphous phases, if present, were not taken into consideration during quantification

Quantification results are also attached as JMA16-2.xlsx

If you have any further queries, kindly contact me.

Dr. Sabine Verryn (Pr.Sci.Nat)

Samples will be stored for 3 months after which they will be discarded.

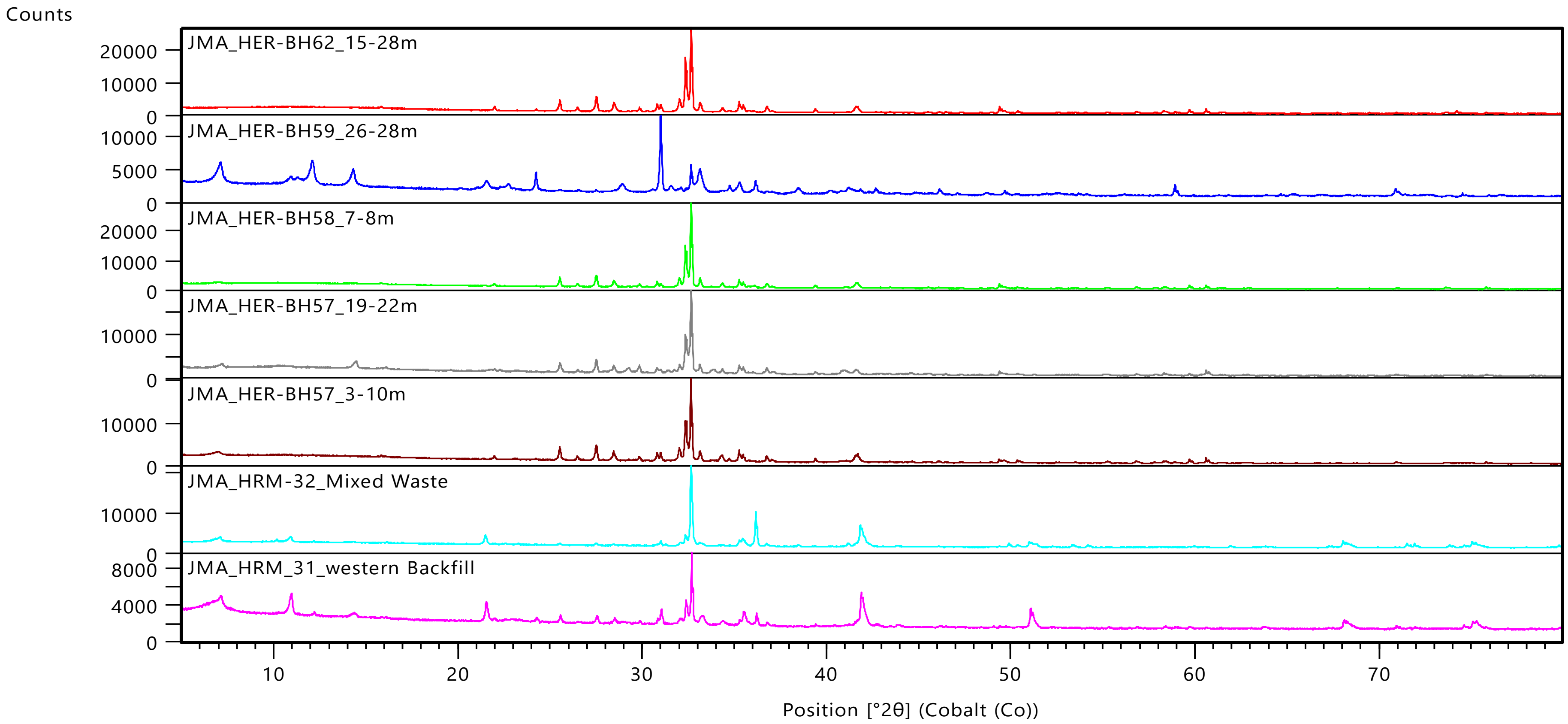
	HER-BH57_ 3-10m		HER-BH57_ 19-22m		HER-BH58_ 7-8m		HER-BH59_ 26-28m
Plagioclase	87.58	**Chlorite**	8.47	**Plagioclase**	92.86	**Actinolite**	27.32
Quartz	2.9	**Diopside**	3.98	**Quartz**	1.73	**Chlorite**	6.83
Smectite	9.53	**Enstatite**	3.66	**Smectite**	5.4	**Diopside**	11.33
		Illite	11.79			**Enstatite**	8.23
		Kaolinite	3.67			**Kaolinite**	4.01
		Plagioclase	65.18			**Plagioclase**	5.46
		Quartz	0.42			**Quartz**	15.69
		Smectite	2.82			**Smectite**	11.43
						Talc	9.69

	HER-BH62_ 15-28m		HRM_31_ western Backfill		HRM-32_ Mixed Waste
Diopside	5.71	**Actinolite**	2.16	**Actinolite**	1.65
Plagioclase	91.2	**Chlorite**	3.64	**Chlorite**	1.48
Quartz	3.09	**Chromite**	23.07	**Chromite**	22.23
		Diopside	4.02	**Diopside**	3.19
		Enstatite	5.48	**Enstatite**	36.68
		Kaolinite	2.46	**Kaolinite**	0.85
		Muscovite	0.96	**Muscovite**	0.71
		Plagioclase	30.67	**Plagioclase**	19.31
		Quartz	3.42	**Quartz**	1.63
		Smectite	7.88	**Smectite**	3.21
		Talc	16.24	**Talc**	9.05

Ideal Mineral Composition

Talc	Mg3Si4O10(OH)2
Enstatite	(Mg,Fe)SiO3
Plagioclase	(Na,Ca)(Si,Al)4O8
Kaolinite	Al2 Si2 O5 (OH)4
Muscovite/ Illite	K Al2 ((OH)2 Al Si3 O10)
Quartz	SiO2
Smectite (Montmorillonite)	(Na,Ca)0,3(Al,Mg)2Si4O10(OH)2•n(H2O)
Chromite	Fe++Cr2O4
Chlorite	(Mg,Fe)5Al(AlSi3O10)(OH)8
Actinolite	Ca2(Mg,Fe)5Si8O22(OH)2
Diopside	CaMgSi2O6

XRD Analytical and Consulting cc



Limitation of Liability: Although every effort is made to provide reliable and accurate results, by use of the results the client agrees that "XRD Analytical and Consulting cc" and/or its staff can only be held liable for the cost of the analysis.

Test Certificate

Project Information			
Project number 1126	Report number 1126_1	Report date 31 March 2016	Pages 11

Customer Information	
Customer XRD Analytical & Consulting cc	Contact person Sabine Verryn
Address 75 Kafue Street Lynnwood Glen Pretoria 0001	Email Sabine.verryn@xrd.co.za Telephone 0835480586 Fax None Order number None

Contents

1 Sample List

Sci-Ba Sample ID	Customer Sample ID	Comment
1126:1	HRM-1	Sample arrived milled. Integrity is good.
1126:2	HRM-2	Sample arrived milled. Integrity is good.
1126:3	HRM-3	Sample arrived milled. Integrity is good.
1126:4	HRM-4	Sample arrived milled. Integrity is good.
1126:5	HRM-5	Sample arrived milled. Integrity is good.
1126:6	HRM-6	Sample arrived milled. Integrity is good.
1126:8	HRM-8	Sample arrived milled. Integrity is good.
1126:9	HRM-9	Sample arrived milled. Integrity is good.
1126:10	HRM-10	Sample arrived milled. Integrity is good.
1126:11	HRM-11	Sample arrived milled. Integrity is good.
1126:12	HRM-12	Sample arrived milled. Integrity is good.
1126:13	HRM-13	Sample arrived milled. Integrity is good.
1126:14	HRM-14	Sample arrived milled. Integrity is good.
1126:15	HRM-15	Sample arrived milled. Integrity is good.
1126:16	HRM-16	Sample arrived milled. Integrity is good.
1126:17	HRM-17	Sample arrived milled. Integrity is good.
1126:18	HRM-18	Sample arrived milled. Integrity is good.
1126:19	HRM-19	Sample arrived milled. Integrity is good.

Sci-Ba Sample ID	Customer Sample ID	Comment
1126:21	HRM-21	Sample arrived milled. Integrity is good.
1126:22	HRM-22	Sample arrived milled. Integrity is good.
1126:23	HRM-23	Sample arrived milled. Integrity is good.
1126:24	HRM-24	Sample arrived milled. Integrity is good.
1126:25	HRM-25	Sample arrived milled. Integrity is good.
1126:26	HRM-26	Sample arrived milled. Integrity is good.
1126:27	HRM-27	Sample arrived milled. Integrity is good.
1126:28	HRM-28	Sample arrived milled. Integrity is good.
1126:29	HRM-29	Sample arrived milled. Integrity is good.
1126:30	HRM-30	Sample arrived milled. Integrity is good.

* There are no samples HRM-7 or HRM-20.

2 XRF01 - Major Analysis by XRF

Determinand	Analyte	Unit	HRM-1	HRM-2	HRM-3	HRM-4	HRM-5
Silica	SiO_2	% g/g	15.43	91.15	12.85	10.36	9.76
Titanium	TiO_2	% g/g	0.01	0.22	0.29	0.31	0.14
Aluminium	Al_2O_3	% g/g	0.51	4.66	7.35	3.18	3.04
Iron	Fe_2O_3	% g/g	0.86	1.89	0.22	1.62	0.89
Manganese	MnO	% g/g	0.46	<0.01	0.01	0.01	0.00
Magnesium	MgO	% g/g	16.86	0.08	0.31	0.10	0.15
Calcium	CaO	% g/g	26.90	0.12	0.47	0.20	0.31
Sodium	Na_2O	% g/g	0.02	0.58	0.02	0.01	0.08
Potassium	K_2O	% g/g	0.08	0.66	0.14	0.17	0.23
Phosphorous	P_2O_5	% g/g	0.05	0.08	0.02	0.04	0.02
Chromium	Cr_2O_3	% g/g	0.05	0.04	0.02	0.07	0.10
Sulphur	SO_3	% g/g	0.02	0.04	0.01	0.01	0.04
Loss on Ignition (1000 °C)	LOI	% g/g	39.11	0.60	73.45	82.55	84.30
Total	Total	% g/g	100.39	100.24	99.34	100.84	99.39
Loss of Moisture (105 °C)	H_2O-	% g/g	0.03	0.13	4.20	2.22	0.32

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-6	HRM-8	HRM-9	HRM-10	HRM-11
Silica	SiO_2	% g/g	2.83	17.70	16.36	3.55	4.17
Titanium	TiO_2	% g/g	0.02	0.21	0.30	0.71	0.81
Aluminium	Al_2O_3	% g/g	0.82	15.06	14.38	13.40	13.27
Iron	Fe_2O_3	% g/g	0.45	19.69	24.41	35.60	27.82
Manganese	MnO	% g/g	0.73	0.22	0.21	0.24	0.23
Magnesium	MgO	% g/g	2.50	13.56	12.77	7.07	9.85
Calcium	CaO	% g/g	49.79	2.38	1.82	0.37	0.48
Sodium	Na_2O	% g/g	<0.01	<0.01	0.14	<0.01	<0.01
Potassium	K_2O	% g/g	0.39	0.14	<0.01	0.03	0.02
Phosphorous	P_2O_5	% g/g	<0.01	0.01	0.01	<0.01	<0.01
Chromium	Cr_2O_3	% g/g	0.01	30.20	29.83	40.54	41.14
Sulphur	SO_3	% g/g	0.01	0.03	0.03	<0.01	0.01
Loss on Ignition (1000 °C)	LOI	% g/g	41.41	0.16	-0.14	-1.50	1.78
Total	Total	% g/g	99.10	99.45	100.19	<0.01	99.07
Loss of Moisture (105 °C)	H_2O-	% g/g	0.15	0.10	0.09	0.05	0.02

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-12	HRM-13	HRM-14	HRM-15	HRM-16
Silica	SiO_2	% g/g	28.66	30.36	9.04	45.45	16.92
Titanium	TiO_2	% g/g	0.74	<0.01	0.43	0.21	0.04
Aluminium	Al_2O_3	% g/g	26.60	12.54	14.39	9.08	12.09
Iron	Fe_2O_3	% g/g	5.46	16.53	31.47	13.90	28.54
Manganese	MnO	% g/g	0.29	0.21	0.21	0.21	0.20
Magnesium	MgO	% g/g	19.35	14.03	9.13	19.66	11.77
Calcium	CaO	% g/g	4.94	4.03	1.60	4.83	2.51
Sodium	Na_2O	% g/g	3.60	0.85	<0.01	0.52	<0.01
Potassium	K_2O	% g/g	0.64	0.21	0.06	0.16	0.02
Phosphorous	P_2O_5	% g/g	0.02	0.02	0.01	0.04	0.01
Chromium	Cr_2O_3	% g/g	11.09	17.36	34.57	4.56	27.46
Sulphur	SO_3	% g/g	0.20	0.06	0.01	0.06	0.03
Loss on Ignition (1000 °C)	LOI	% g/g	-1.55	-6.97	-0.91	0.85	-1.18
Total	Total	% g/g	100.22	100.13	100.10	99.56	97.89
Loss of Moisture (105 °C)	H_2O-	% g/g	0.17	10.94	0.46	0.03	0.02

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-17	HRM-18	HRM-19	HRM-21	HRM-22
Silica	SiO_2	% g/g	50.14	22.53	21.28	10.21	6.38
Titanium	TiO_2	% g/g	0.49	0.75	<0.01	0.34	0.51
Aluminium	Al_2O_3	% g/g	16.17	27.35	17.60	14.88	12.90
Iron	Fe_2O_3	% g/g	7.02	7.60	19.53	25.32	33.56
Manganese	MnO	% g/g	0.20	0.32	0.17	0.25	0.23
Magnesium	MgO	% g/g	9.18	21.42	11.60	10.88	9.94
Calcium	CaO	% g/g	3.20	6.50	3.39	1.03	0.30
Sodium	Na_2O	% g/g	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	K_2O	% g/g	0.55	0.29	0.04	0.05	<0.01
Phosphorous	P_2O_5	% g/g	0.02	0.03	0.01	0.01	<0.01
Chromium	Cr_2O_3	% g/g	11.33	13.13	26.91	35.25	37.64
Sulphur	SO_3	% g/g	0.09	0.15	0.04	0.01	0.01
Loss on Ignition (1000 °C)	LOI	% g/g	-0.27	-1.75	-0.07	1.12	-0.49
Total	Total	% g/g	99.18	98.28	100.21	99.04	100.47
Loss of Moisture (105 °C)	H_2O-	% g/g	1.07	0.01	0.07	0.12	0.01

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-23	HRM-24	HRM-25	HRM-26	HRM-27
Silica	SiO_2	% g/g	12.74	14.21	31.49	4.35	24.11
Titanium	TiO_2	% g/g	0.45	0.42	0.38	0.73	<0.01
Aluminium	Al_2O_3	% g/g	15.40	15.02	9.74	15.37	14.03
Iron	Fe_2O_3	% g/g	23.60	22.64	18.52	27.64	20.74
Manganese	MnO	% g/g	0.24	0.23	0.34	0.21	0.19
Magnesium	MgO	% g/g	11.32	10.52	13.14	10.64	13.44
Calcium	CaO	% g/g	1.66	1.78	2.61	0.13	3.72
Sodium	Na_2O	% g/g	<0.01	<0.01	<0.01	<0.01	<0.01
Potassium	K_2O	% g/g	0.20	0.16	0.40	<0.01	0.09
Phosphorous	P_2O_5	% g/g	0.01	0.01	0.29	<0.01	0.01
Chromium	Cr_2O_3	% g/g	31.99	30.60	17.21	39.18	22.14
Sulphur	SO_3	% g/g	0.02	0.02	0.32	<0.01	0.05
Loss on Ignition (1000 °C)	LOI	% g/g	1.88	3.52	5.95	2.07	1.99
Total	Total	% g/g	99.03	98.72	100.74	99.86	100.09
Loss of Moisture (105 °C)	H_2O-	% g/g	0.05	0.01	0.37	0.05	-0.01

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-28	HRM-29	HRM-30		
Silica	SiO_2	% g/g	29.90	54.99	36.69		
Titanium	TiO_2	% g/g	<0.01	0.18	0.47		
Aluminium	Al_2O_3	% g/g	12.34	6.26	13.80		
Iron	Fe_2O_3	% g/g	16.27	10.84	15.14		
Manganese	MnO	% g/g	0.21	0.20	0.26		
Magnesium	MgO	% g/g	13.81	20.70	11.73		
Calcium	CaO	% g/g	3.97	4.19	3.00		
Sodium	Na_2O	% g/g	<0.01	0.43	0.13		
Potassium	K_2O	% g/g	0.21	0.16	0.29		
Phosphorous	P_2O_5	% g/g	0.02	0.04	0.05		
Chromium	Cr_2O_3	% g/g	17.10	1.25	14.63		
Sulphur	SO_3	% g/g	0.05	0.04	0.08		
Loss on Ignition (1000 °C)	LOI	% g/g	5.20	1.16	1.76		
Total	Total	% g/g	99.04	100.42	98.08		
Loss of Moisture (105 °C)	H_2O-	% g/g	0.18	-0.01	0.05		

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	Standard Uncertainty (95% CL)	Limit of Detection
Silica	SiO_2	% g/g	0.86	1.44
Titanium	TiO_2	% g/g	0.0075	0.013
Aluminium	Al_2O_3	% g/g	0.45	0.76
Iron	Fe_2O_3	% g/g	0.33	0.56
Manganese	MnO	% g/g	0.016	0.027
Magnesium	MgO	% g/g	0.48	0.80
Calcium	CaO	% g/g	0.18	0.31
Sodium	Na_2O	% g/g	0.11	0.18
Potassium	K_2O	% g/g	0.16	0.27
Phosphorous	P_2O_5	% g/g	0.11	0.19
Chromium	Cr_2O_3	% g/g	0.06	0.10
Sulphur	SO_3	% g/g	0.24	0.40

3 XRF02 – Trace Element Analysis by XRF

Determinand	Analyte	Unit	HRM-1	HRM-2	HRM-3	HRM-4	HRM-5
Arsenic	As	mg/kg	4.57	4.92	10.1	7.97	8.37
Barium	Ba	mg/kg	37.0	97.0	85.2	42.8	65.9
Bismuth	Bi	mg/kg	1.73	1.48	1.35	1.54	1.49
Cadmium	Cd	mg/kg	<3.04	<3.04	<3.04	<3.04	<3.04
Cerium	Ce	mg/kg	4.07	37.9	57.9	69.5	12.6
Chlorine	Cl	mg/kg	206	146	126	253	401
Cobalt	Co	mg/kg	6.35	<0.56	49.3	<0.56	<0.56
Caesium	Cs	mg/kg	1.12	1.06	1.21	1.15	1.14
Copper	Cu	mg/kg	<4.19	<4.19	14.5	<4.19	<4.19
Gallium	Ga	mg/kg	<3.21	5.31	11.1	22.4	7.40
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	6.37	6.18	6.47	6.35	6.37
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	107	94.4	98.5	76.7	85.0
Lutetium	Lu	mg/kg	1.47	1.60	1.79	1.91	1.61
Molybdenum	Mo	mg/kg	2.19	1.23	2.11	0.70	2.31
Niobium	Nb	mg/kg	<2.15	<2.15	<2.15	7.30	<2.15
Nickel	Ni	mg/kg	<5.14	9.41	36.8	38.2	18.6
Lead	Pb	mg/kg	<2.03	<2.03	<2.03	<2.03	<2.03
Rubidium	Rb	mg/kg	6.85	25.7	9.90	12.6	13.0
Antimony	Sb	mg/kg	<1.48	<1.48	<1.48	<1.48	<1.48
Scandium	Sc	mg/kg	108	13.7	16.2	15.2	16.3
Selenium	Se	mg/kg	<0.36	<0.36	<0.36	1.63	<0.36
Samarium	Sm	mg/kg	5.36	9.73	12.0	14.2	11.8
Tin	Sn	mg/kg	2.69	3.03	3.56	6.24	4.99
Strontium	Sr	mg/kg	9.79	17.3	68.4	46.0	57.7
Tantalum	Ta	mg/kg	1.03	1.02	0.52	0.60	0.93
Tellurium	Te	mg/kg	4.21	<0.16	<0.16	0.24	<0.16
Thorium	Th	mg/kg	<0.88	3.59	5.96	1.92	1.17
Thallium	Tl	mg/kg	2.59	2.49	2.16	2.25	2.24
Uranium	U	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Vanadium	V	mg/kg	74.3	83.1	91.5	177	93.9
Tungsten	W	mg/kg	1.00	0.75	0.73	0.78	0.84
Yttrium	Y	mg/kg	4.18	14.4	33.2	21.3	9.98
Ytterbium	Yb	mg/kg	3.54	1.84	<1.05	1.65	2.28
Zinc	Zn	mg/kg	<5.49	<5.49	74.0	<5.49	<5.49
Zirconium	Zr	mg/kg	<1.47	238	72.9	194	37.0

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-6	HRM-8	HRM-9	HRM-10	HRM-11
Arsenic	As	mg/kg	3.86	15.4	7.14	60.6	55.7
Barium	Ba	mg/kg	40.9	76.3	80.2	39.3	31.5
Bismuth	Bi	mg/kg	1.49	3.14	<0.68	<0.68	<0.68
Cadmium	Cd	mg/kg	8.91	<3.04	<3.04	<3.04	16.0
Cerium	Ce	mg/kg	<3.08	<3.08	<3.08	<3.08	<3.08
Chlorine	Cl	mg/kg	169	111	130	86.6	101
Cobalt	Co	mg/kg	29.9	225	<0.56	235	182
Caesium	Cs	mg/kg	1.10	1.19	1.30	1.36	1.25
Copper	Cu	mg/kg	<4.19	<4.19	4.96	<4.19	<4.19
Gallium	Ga	mg/kg	<3.21	<3.21	<3.21	<3.21	<3.21
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	6.38	5.58	5.98	5.27	5.40
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	77.7	<0.62	9.88	<0.62	9.28
Lutetium	Lu	mg/kg	1.29	6.24	5.65	8.37	8.28
Molybdenum	Mo	mg/kg	2.30	1.19	2.01	1.56	1.75
Niobium	Nb	mg/kg	2.47	5.32	2.83	8.27	7.43
Nickel	Ni	mg/kg	9.37	563	483	784	897
Lead	Pb	mg/kg	<2.03	<2.03	<2.03	<2.03	<2.03
Rubidium	Rb	mg/kg	10.4	11.6	7.89	12.6	9.44
Antimony	Sb	mg/kg	1.82	<1.48	<1.48	<1.48	6.30
Scandium	Sc	mg/kg	141	30.7	24.7	12.4	14.1
Selenium	Se	mg/kg	<0.36	8.42	5.33	22.8	19.6
Samarium	Sm	mg/kg	3.47	<1.62	<1.62	20.0	15.6
Tin	Sn	mg/kg	1.66	7.28	8.96	8.92	8.72
Strontium	Sr	mg/kg	28.4	43.7	32.2	8.84	3.69
Tantalum	Ta	mg/kg	0.82	2.29	2.47	2.56	3.00
Tellurium	Te	mg/kg	<0.16	<0.16	<0.16	<0.16	<0.16
Thorium	Th	mg/kg	<0.88	<0.88	<0.88	<0.88	<0.88
Thallium	Tl	mg/kg	2.50	5.43	5.32	3.96	2.73
Uranium	U	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Vanadium	V	mg/kg	65.4	991	802	1 767	1 388
Tungsten	W	mg/kg	0.98	6.21	5.36	7.95	6.73
Yttrium	Y	mg/kg	3.67	3.80	4.10	<0.97	1.46
Ytterbium	Yb	mg/kg	3.29	28.5	24.8	38.6	32.7
Zinc	Zn	mg/kg	<5.49	525	255	720	576
Zirconium	Zr	mg/kg	<1.47	26.4	3.29	10.2	4.08

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-12	HRM-13	HRM-14	HRM-15	HRM-16
Arsenic	As	mg/kg	5.24	<0.43	41.3	<0.43	46.7
Barium	Ba	mg/kg	149	108	47.3	72.7	26.0
Bismuth	Bi	mg/kg	4.12	4.71	<0.68	1.31	<0.68
Cadmium	Cd	mg/kg	<3.04	7.92	<3.04	<3.04	<3.04
Cerium	Ce	mg/kg	27.6	<3.08	<3.08	<3.08	<3.08
Chlorine	Cl	mg/kg	105	172	111	147	109
Cobalt	Co	mg/kg	<0.56	101	301	<0.56	69.4
Caesium	Cs	mg/kg	1.18	1.26	1.29	1.08	1.37
Copper	Cu	mg/kg	<4.19	28.5	<4.19	<4.19	<4.19
Gallium	Ga	mg/kg	<3.21	<3.21	<3.21	<3.21	<3.21
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	6.30	5.93	5.22	6.28	5.63
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	41.4	1.32	39.3	34.2	<0.62
Lutetium	Lu	mg/kg	2.42	5.78	7.76	3.48	7.49
Molybdenum	Mo	mg/kg	1.23	2.11	1.75	2.11	1.78
Niobium	Nb	mg/kg	<2.15	4.13	5.93	<2.15	4.50
Nickel	Ni	mg/kg	40.8	501	670	269	819
Lead	Pb	mg/kg	<2.03	45.4	<2.03	8.75	<2.03
Rubidium	Rb	mg/kg	17.9	21.9	12.2	8.12	8.73
Antimony	Sb	mg/kg	1.68	3.41	<1.48	1.81	<1.48
Scandium	Sc	mg/kg	29.9	32.3	22.9	27.4	16.9
Selenium	Se	mg/kg	<0.36	0.48	17.2	<0.36	19.6
Samarium	Sm	mg/kg	<1.62	<1.62	5.81	7.12	21.3
Tin	Sn	mg/kg	3.92	7.41	8.21	8.64	9.37
Strontium	Sr	mg/kg	68.3	60.6	33.9	67.1	4.36
Tantalum	Ta	mg/kg	1.01	2.56	4.27	1.32	3.90
Tellurium	Te	mg/kg	<0.16	<0.16	<0.16	<0.16	<0.16
Thorium	Th	mg/kg	<0.88	<0.88	<0.88	<0.88	<0.88
Thallium	Tl	mg/kg	2.78	5.86	4.83	2.96	3.53
Uranium	U	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Vanadium	V	mg/kg	360	659	1 320	171	1 219
Tungsten	W	mg/kg	1.41	4.47	7.15	1.91	6.65
Yttrium	Y	mg/kg	14.2	7.13	<0.97	5.05	1.40
Ytterbium	Yb	mg/kg	5.54	28.3	33.7	7.66	32.7
Zinc	Zn	mg/kg	<5.49	2 638	547	<5.49	505
Zirconium	Zr	mg/kg	102	19.2	3.66	6.02	2.14

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-17	HRM-18	HRM-19	HRM-21	HRM-22
Arsenic	As	mg/kg	3.66	4.52	<0.43	46.1	57.0
Barium	Ba	mg/kg	136	139	63.5	72.2	65.6
Bismuth	Bi	mg/kg	3.32	4.33	3.62	<0.68	<0.68
Cadmium	Cd	mg/kg	<3.04	21.4	<3.04	39.6	<3.04
Cerium	Ce	mg/kg	<3.08	14.4	13.3	<3.08	<3.08
Chlorine	Cl	mg/kg	123	105	129	113	89.1
Cobalt	Co	mg/kg	<0.56	<0.56	41.0	313	205
Caesium	Cs	mg/kg	1.16	1.15	1.19	1.32	1.43
Copper	Cu	mg/kg	<4.19	<4.19	<4.19	<4.19	<4.19
Gallium	Ga	mg/kg	<3.21	<3.21	<3.21	<3.21	<3.21
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	6.26	6.29	5.66	5.78	5.82
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	48.2	62.8	<0.62	<0.62	<0.62
Lutetium	Lu	mg/kg	2.70	2.59	6.30	9.07	9.67
Molybdenum	Mo	mg/kg	1.39	1.27	1.86	1.67	1.81
Niobium	Nb	mg/kg	<2.15	<2.15	3.43	8.08	7.45
Nickel	Ni	mg/kg	94.6	62.3	480	693	743
Lead	Pb	mg/kg	<2.03	<2.03	<2.03	<2.03	<2.03
Rubidium	Rb	mg/kg	16.9	9.14	9.91	15.4	11.3
Antimony	Sb	mg/kg	2.22	2.04	<1.48	3.82	<1.48
Scandium	Sc	mg/kg	23.1	34.6	37.2	16.3	13.9
Selenium	Se	mg/kg	<0.36	<0.36	3.98	21.3	23.6
Samarium	Sm	mg/kg	<1.62	<1.62	<1.62	8.17	18.5
Tin	Sn	mg/kg	4.93	4.19	8.12	7.55	8.98
Strontium	Sr	mg/kg	43.0	60.7	66.1	18.1	11.1
Tantalum	Ta	mg/kg	0.95	0.77	2.42	3.47	2.85
Tellurium	Te	mg/kg	<0.16	<0.16	<0.16	<0.16	<0.16
Thorium	Th	mg/kg	<0.88	<0.88	<0.88	<0.88	<0.88
Thallium	Tl	mg/kg	3.21	3.37	4.71	5.09	4.50
Uranium	U	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Vanadium	V	mg/kg	309	404	863	1 385	1 461
Tungsten	W	mg/kg	1.60	1.50	5.05	7.64	7.46
Yttrium	Y	mg/kg	11.3	14.0	4.34	2.10	<0.97
Ytterbium	Yb	mg/kg	6.99	5.98	25.1	37.7	34.2
Zinc	Zn	mg/kg	49.1	15.7	302	1 579	731
Zirconium	Zr	mg/kg	106	80.8	14.1	18.3	15.4

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-23	HRM-24	HRM-25	HRM-26	HRM-27
Arsenic	As	mg/kg	17.3	20.1	<0.43	9.28	<0.43
Barium	Ba	mg/kg	48.3	102	82.2	116	87.8
Bismuth	Bi	mg/kg	<0.68	<0.68	1.95	<0.68	4.17
Cadmium	Cd	mg/kg	<3.04	<3.04	<3.04	<3.04	<3.04
Cerium	Ce	mg/kg	<3.08	<3.08	<3.08	<3.08	<3.08
Chlorine	Cl	mg/kg	146	209	157	120	143
Cobalt	Co	mg/kg	206	207	32.0	236	92.3
Caesium	Cs	mg/kg	1.48	1.33	1.23	1.29	1.25
Copper	Cu	mg/kg	6.00	11.6	24.6	8.93	20.5
Gallium	Ga	mg/kg	<3.21	<3.21	<3.21	<3.21	<3.21
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	5.35	5.45	5.81	5.68	5.73
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	<0.62	<0.62	<0.62	<0.62	20.5
Lutetium	Lu	mg/kg	7.84	8.08	6.52	7.90	6.42
Molybdenum	Mo	mg/kg	1.69	2.00	2.23	2.36	2.07
Niobium	Nb	mg/kg	4.65	7.74	4.67	6.31	<2.15
Nickel	Ni	mg/kg	628	643	525	678	572
Lead	Pb	mg/kg	20.4	<2.03	56.1	<2.03	17.6
Rubidium	Rb	mg/kg	17.8	15.1	17.4	12.9	9.72
Antimony	Sb	mg/kg	<1.48	<1.48	<1.48	<1.48	<1.48
Scandium	Sc	mg/kg	18.3	21.6	31.4	34.5	31.9
Selenium	Se	mg/kg	12.7	12.3	<0.36	9.14	3.30
Samarium	Sm	mg/kg	<1.62	<1.62	<1.62	5.31	<1.62
Tin	Sn	mg/kg	8.13	8.60	8.21	7.19	7.84
Strontium	Sr	mg/kg	23.0	31.4	41.4	43.0	56.4
Tantalum	Ta	mg/kg	3.50	3.17	1.89	2.99	2.41
Tellurium	Te	mg/kg	<0.16	<0.16	<0.16	<0.16	<0.16
Thorium	Th	mg/kg	<0.88	<0.88	<0.88	<0.88	<0.88
Thallium	Tl	mg/kg	7.31	6.17	4.84	5.99	4.97
Uranium	U	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Vanadium	V	mg/kg	1 198	1 195	584	1 032	796
Tungsten	W	mg/kg	6.83	7.58	4.18	6.71	5.52
Yttrium	Y	mg/kg	4.28	3.55	6.17	2.90	5.36
Ytterbium	Yb	mg/kg	40.0	37.5	23.8	31.5	28.1
Zinc	Zn	mg/kg	3 131	971	1 919	622	304
Zirconium	Zr	mg/kg	18.0	22.2	22.8	17.4	21.0

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HRM-28	HRM-29	HRM-30		
Arsenic	As	mg/kg	<0.43	<0.43	<0.43		
Barium	Ba	mg/kg	93.7	79.1	102		
Bismuth	Bi	mg/kg	2.68	1.04	4.04		
Cadmium	Cd	mg/kg	<3.04	3.27	<3.04		
Cerium	Ce	mg/kg	<3.08	36.2	<3.08		
Chlorine	Cl	mg/kg	137	178	124		
Cobalt	Co	mg/kg	65.0	<0.56	7.78		
Caesium	Cs	mg/kg	1.26	1.11	1.14		
Copper	Cu	mg/kg	21.8	<4.19	<4.19		
Gallium	Ga	mg/kg	<3.21	9.40	<3.21		
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50		
Hafnium	Hf	mg/kg	6.04	6.28	6.23		
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00		
Lanthanum	La	mg/kg	12.1	38.6	20.6		
Lutetium	Lu	mg/kg	6.65	3.80	5.30		
Molybdenum	Mo	mg/kg	2.17	1.98	1.98		
Niobium	Nb	mg/kg	2.76	<2.15	<2.15		
Nickel	Ni	mg/kg	531	297	338		
Lead	Pb	mg/kg	53.4	33.6	<2.03		
Rubidium	Rb	mg/kg	16.7	9.08	13.8		
Antimony	Sb	mg/kg	<1.48	<1.48	<1.48		
Scandium	Sc	mg/kg	31.8	30.4	27.8		
Selenium	Se	mg/kg	<0.36	<0.36	0.62		
Samarium	Sm	mg/kg	<1.62	12.4	<1.62		
Tin	Sn	mg/kg	7.66	8.83	7.19		
Strontium	Sr	mg/kg	50.4	61.7	45.5		
Tantalum	Ta	mg/kg	2.00	1.38	1.28		
Tellurium	Te	mg/kg	<0.16	1.18	<0.16		
Thorium	Th	mg/kg	<0.88	1.35	<0.88		
Thallium	Tl	mg/kg	4.82	2.40	3.82		
Uranium	U	mg/kg	<0.74	<0.74	<0.74		
Vanadium	V	mg/kg	658	144	598		
Tungsten	W	mg/kg	4.24	1.65	3.13		
Yttrium	Y	mg/kg	6.49	5.30	8.77		
Ytterbium	Yb	mg/kg	23.2	6.58	14.8		
Zinc	Zn	mg/kg	1 573	<5.49	600		
Zirconium	Zr	mg/kg	16.3	29.2	57.8		

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	Standard Uncertainty (95% CL)	Limit of Detection
Arsenic	As	mg/kg	8.72	14.7
Barium	Ba	mg/kg	15.5	26.1
Bismuth	Bi	mg/kg	4.42	7.44
Cadmium	Cd	mg/kg	2.80	4.72
Cerium	Ce	mg/kg	23.7	39.9
Chlorine	Cl	mg/kg	32.6	19.4
Cobalt	Co	mg/kg	14.9	25.1
Caesium	Cs	mg/kg	2.19	3.69
Copper	Cu	mg/kg	7.65	12.9
Gallium	Ga	mg/kg	2.29	3.86
Germanium	Ge	mg/kg	0.27	0.45
Hafnium	Hf	mg/kg	3.89	6.55
Lanthanum	La	mg/kg	9.69	16.3
Lutetium	Lu	mg/kg	0.27	0.46
Molybdenum	Mo	mg/kg	3.38	5.69
Niobium	Nb	mg/kg	1.81	3.04
Nickel	Ni	mg/kg	11.8	7.00
Lead	Pb	mg/kg	34.8	58.5
Rubidium	Rb	mg/kg	19.1	32.1
Antimony	Sb	mg/kg	9.06	15.3
Scandium	Sc	mg/kg	6.12	10.3
Selenium	Se	mg/kg	1.80	3.02
Samarium	Sm	mg/kg	20.4	34.3
Tin	Sn	mg/kg	3.95	6.64
Strontium	Sr	mg/kg	11.3	19.0
Tantalum	Ta	mg/kg	0.65	1.10
Tellurium	Te	mg/kg	0.047	0.028
Thorium	Th	mg/kg	4.59	7.72
Thallium	Tl	mg/kg	2.32	3.91
Uranium	U	mg/kg	1.48	2.49
Vanadium	V	mg/kg	6.56	11.05
Tungsten	W	mg/kg	2.25	3.80
Yttrium	Y	mg/kg	7.77	13.1
Ytterbium	Yb	mg/kg	18.5	31.1
Zinc	Zn	mg/kg	14.6	24.6
Zirconium	Zr	mg/kg	7.82	13.2

SCI-BA
LABORATORIES AND SCIENTIFIC CONSULTANTS

(+27) 21 418 0325 (+27) 21 418 0325 sci-ba www.sci-ba.co.za

Test Certificate

Project Information			
Project number 1137	Report number 1137_1	Report date 25 April 2016	Pages 6

Customer Information	
Customer XRD Analytical & Consulting cc	Contact person Sabine Verryn
Address 75 Kafue Street Lynnwood Glen Pretoria 0001	Email Sabine.verryn@xrd.co.za Telephone 0835480586 Fax None Order number None

Contents

1 Sample List

Sci-Ba Sample ID	Customer Sample ID	Comment
1137:1	HRM-31 Western Backfill (1)	Sample arrived milled. Integrity is good.
1137:2	HRM 32 Mixed Waste (2)	Sample arrived milled. Integrity is good.
1137:3	HER-BH57 3-10m (3)	Sample arrived milled. Integrity is good.
1137:4	HER-BH57 19-22m (4)	Sample arrived milled. Integrity is good.
1137:5	HER-BH58 7-8m (5)	Sample arrived milled. Integrity is good.
1137:6	HER-BH59 26-28m (6)	Sample arrived milled. Integrity is good.
1137:7	HER-BH62 15-28m (7)	Sample arrived milled. Integrity is good.

2 XRF01 - Major Analysis by XRF

Determinand	Analyte	Unit	HER-BH57 3-10m (3)	HER-BH57 19-22m (4)	HER-BH58 7-8m (5)	HER-BH59 26-28m (6)	HER-BH62 15-28m (7)
Silica	SiO_2	% g/g	45.80	49.31	46.95	52.71	49.87
Titanium	TiO_2	% g/g	0.21	0.11	0.11	0.20	0.12
Aluminium	Al_2O_3	% g/g	26.91	27.37	27.13	5.16	28.11
Iron	Fe_2O_3	% g/g	4.64	2.82	3.73	14.50	3.18
Manganese	MnO	% g/g	0.04	<0.027	0.03	0.25	<0.027
Magnesium	MgO	% g/g	1.06	1.19	1.65	14.72	1.33
Calcium	CaO	% g/g	13.69	13.11	14.55	7.59	14.16
Sodium	Na_2O	% g/g	2.47	2.81	2.23	0.18	2.30
Potassium	K_2O	% g/g	0.28	0.45	<0.27	<0.27	0.27
Phosphorous	P_2O_5	% g/g	<0.19	<0.19	<0.19	<0.19	<0.19
Chromium	Cr_2O_3	% g/g	2.66	0.14	0.92	1.46	<0.1
Sulphur	SO_3	% g/g	<0.4	<0.4	<0.4	<0.4	<0.4
Loss on Ignition (1000 °C)	LOI	% g/g	2.21	2.59	1.10	3.20	0.35
Total	Total	% g/g	<0.4	<0.4	<0.4	<0.4	<0.4
Loss of Moisture (105 °C)	H_2O-	% g/g	0.79	0.45	0.37	0.84	0.10

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	Standard Uncertainty (95% CL)	Limit of Detection
Silica	SiO_2	% g/g	0.86	1.44
Titanium	TiO_2	% g/g	0.0075	0.013
Aluminium	Al_2O_3	% g/g	0.45	0.76
Iron	Fe_2O_3	% g/g	0.33	0.56
Manganese	MnO	% g/g	0.016	0.027
Magnesium	MgO	% g/g	0.48	0.80
Calcium	CaO	% g/g	0.18	0.31
Sodium	Na_2O	% g/g	0.11	0.18
Potassium	K_2O	% g/g	0.16	0.27
Phosphorous	P_2O_5	% g/g	0.11	0.19
Chromium	Cr_2O_3	% g/g	0.06	0.10
Sulphur	SO_3	% g/g	0.24	0.40

3 TM-006

Determinand	Analyte	Unit	HRM-31 Western Backfill (1)	HRM 32 Mixed Waste (2)			
Silica	SiO_2	% g/g	29.83	31.70			
Titanium	TiO_2	% g/g	0.47	0.42			
Aluminium	Al_2O_3	% g/g	19.67	10.39			
Iron	Fe_2O_3	% g/g	13.60	17.69			
Manganese	MnO	% g/g	0.41	0.72			
Magnesium	MgO	% g/g	8.00	16.68			
Calcium	CaO	% g/g	4.93	2.32			
Sodium	Na_2O	% g/g	<0.18	2.47			
Potassium	K_2O	% g/g	1.07	0.40			
Phosphorous	P_2O_5	% g/g	<0.19	<0.19			
Chromium	Cr_2O_3	% g/g	15.14	17.06			
Sulphur	SO_3	% g/g	<0.4	<0.4			
Loss on Ignition (1000 °C)	LOI	% g/g	-14.17	0.01			
Total	Total	% g/g	<0.4	<0.4			
Loss of Moisture (105 °C)	H_2O-	% g/g	19.96	0.35			

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	Standard Uncertainty (95% CL)	Limit of Detection
Silica	SiO_2	% g/g	0.027	0.2
Titanium	TiO_2	% g/g	0.007	0.002
Aluminium	Al_2O_3	% g/g	0.025	0.30
Iron	Fe_2O_3	% g/g	0.003	0.02
Manganese	MnO	% g/g	0.002	0.02
Magnesium	MgO	% g/g	0.082	0.40
Calcium	CaO	% g/g	0.003	0.03
Sodium	Na_2O	% g/g	0.135	0.02
Potassium	K_2O	% g/g	0.012	0.02
Phosphorous	P_2O_5	% g/g	0.001	0.01
Chromium	Cr_2O_3	% g/g	0.002	0.01
Sulphur	SO_3	% g/g	0.002	0.004

4 XRF02 – Trace Element Analysis by XRF

Determinand	Analyte	Unit	HRM-31 Western Backfill (1)	HRM 32 Mixed Waste (2)	HER-BH57 3-10m (3)	HER-BH57 19-22m (4)	HER-BH58 7-8m (5)
Arsenic	As	mg/kg	0.78	<0.43	2.93	3.30	4.47
Barium	Ba	mg/kg	80.6	83.5	97.5	200	78.6
Bismuth	Bi	mg/kg	3.74	3.93	1.74	1.53	2.20
Cadmium	Cd	mg/kg	<3.04	<3.04	<3.04	<3.04	<3.04
Cerium	Ce	mg/kg	18.1	<3.08	<3.08	<3.08	<3.08
Chlorine	Cl	mg/kg	135	140	147	155	148
Cobalt	Co	mg/kg	<0.56	23.4	<0.56	<0.56	<0.56
Caesium	Cs	mg/kg	1.17	1.19	0.98	1.05	1.02
Copper	Cu	mg/kg	<4.19	<4.19	<4.19	<4.19	<4.19
Gallium	Ga	mg/kg	<3.21	<3.21	8.99	16.7	12.2
Germanium	Ge	mg/kg	<0.50	<0.50	<0.50	<0.50	<0.50
Hafnium	Hf	mg/kg	6.25	5.62	6.28	6.35	6.26
Mercury	Hg	mg/kg	<1.00	<1.00	<1.00	<1.00	<1.00
Lanthanum	La	mg/kg	41.6	<0.62	88.6	89.2	87.4
Lutetium	Lu	mg/kg	4.05	5.89	1.99	1.87	1.93
Molybdenum	Mo	mg/kg	2.30	1.96	2.39	2.18	2.25
Niobium	Nb	mg/kg	<2.15	3.05	<2.15	<2.15	<2.15
Nickel	Ni	mg/kg	701	961	121	43.3	87.1
Lead	Pb	mg/kg	263	490	38.8	23.7	35.3
Rubidium	Rb	mg/kg	<2.03	43.8	<2.03	<2.03	<2.03
Antimony	Sb	mg/kg	10.2	10.6	7.72	14.6	5.00
Scandium	Sc	mg/kg	<1.48	<1.48	<1.48	2.23	1.56
Selenium	Se	mg/kg	36.4	37.2	43.8	49.2	50.4
Samarium	Sm	mg/kg	<0.36	2.43	<0.36	<0.36	<0.36
Tin	Sn	mg/kg	<1.62	<1.62	6.17	6.92	5.68
Strontium	Sr	mg/kg	7.46	8.68	3.39	3.13	3.30
Tantalum	Ta	mg/kg	105	53.9	302	356	314
Tellurium	Te	mg/kg	1.30	2.11	0.91	0.77	0.92
Thorium	Th	mg/kg	<0.16	<0.16	14.8	17.5	18.3
Thallium	Tl	mg/kg	<0.88	<0.88	<0.88	<0.88	<0.88
Uranium	U	mg/kg	3.51	4.01	2.50	2.34	2.40
Vanadium	V	mg/kg	<0.74	<0.74	<0.74	<0.74	<0.74
Tungsten	W	mg/kg	422	687	160	94.4	113
Yttrium	Y	mg/kg	2.94	4.75	1.01	1.03	0.98
Ytterbium	Yb	mg/kg	5.67	4.33	6.18	5.64	5.76
Zinc	Zn	mg/kg	14.4	23.9	3.18	3.41	2.86
Zirconium	Zr	mg/kg	743	219	<5.49	<5.49	<5.49

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	HER-BH59 26-28m (6)	HER-BH62 15-28m (7)			
Arsenic	As	mg/kg	<0.43	4.25			
Barium	Ba	mg/kg	59.9	91.4			
Bismuth	Bi	mg/kg	1.53	1.58			
Cadmium	Cd	mg/kg	<3.04	18.2			
Cerium	Ce	mg/kg	21.2	<3.08			
Chlorine	Cl	mg/kg	133	168			
Cobalt	Co	mg/kg	<0.56	<0.56			
Caesium	Cs	mg/kg	1.13	1.06			
Copper	Cu	mg/kg	<4.19	<4.19			
Gallium	Ga	mg/kg	10.2	16.5			
Germanium	Ge	mg/kg	<0.50	<0.50			
Hafnium	Hf	mg/kg	6.17	6.37			
Mercury	Hg	mg/kg	<1.00	<1.00			
Lanthanum	La	mg/kg	37.4	96.2			
Lutetium	Lu	mg/kg	4.09	1.80			
Molybdenum	Mo	mg/kg	2.21	2.15			
Niobium	Nb	mg/kg	<2.15	<2.15			
Nickel	Ni	mg/kg	87.7	55.3			
Lead	Pb	mg/kg	295	25.3			
Rubidium	Rb	mg/kg	47.4	<2.03			
Antimony	Sb	mg/kg	5.92	8.41			
Scandium	Sc	mg/kg	2.29	<1.48			
Selenium	Se	mg/kg	33.7	49.1			
Samarium	Sm	mg/kg	<0.36	<0.36			
Tin	Sn	mg/kg	10.4	9.48			
Strontium	Sr	mg/kg	9.24	3.42			
Tantalum	Ta	mg/kg	23.3	308			
Tellurium	Te	mg/kg	0.98	1.00			
Thorium	Th	mg/kg	7.81	18.1			
Thallium	Tl	mg/kg	<0.88	<0.88			
Uranium	U	mg/kg	2.10	2.46			
Vanadium	V	mg/kg	<0.74	<0.74			
Tungsten	W	mg/kg	148	89.9			
Yttrium	Y	mg/kg	1.56	0.91			
Ytterbium	Yb	mg/kg	6.42	6.59			
Zinc	Zn	mg/kg	6.26	2.73			
Zirconium	Zr	mg/kg	<5.49	<5.49			

Notes: % g/g is equivalent to wt %; mg/kg is equivalent to ppm; n.d. = not determined; bold italicised font represents semi-quantitative data; * represents measurements reported in % g/g or wt%.

Determinand	Analyte	Unit	Standard Uncertainty (95% CL)	Limit of Detection
Arsenic	As	mg/kg	8.72	14.7
Barium	Ba	mg/kg	15.5	26.1
Bismuth	Bi	mg/kg	4.42	7.44
Cadmium	Cd	mg/kg	2.80	4.72
Cerium	Ce	mg/kg	23.7	39.9
Chlorine	Cl	mg/kg	32.6	19.4
Cobalt	Co	mg/kg	14.9	25.1
Caesium	Cs	mg/kg	2.19	3.69
Copper	Cu	mg/kg	7.65	12.9
Gallium	Ga	mg/kg	2.29	3.86
Germanium	Ge	mg/kg	0.27	0.45
Hafnium	Hf	mg/kg	3.89	6.55
Lanthanum	La	mg/kg	9.69	16.3
Lutetium	Lu	mg/kg	0.27	0.46
Molybdenum	Mo	mg/kg	3.38	5.69
Niobium	Nb	mg/kg	1.81	3.04
Nickel	Ni	mg/kg	11.8	7.00
Lead	Pb	mg/kg	34.8	58.5
Rubidium	Rb	mg/kg	19.1	32.1
Antimony	Sb	mg/kg	9.06	15.3
Scandium	Sc	mg/kg	6.12	10.3
Selenium	Se	mg/kg	1.80	3.02
Samarium	Sm	mg/kg	20.4	34.3
Tin	Sn	mg/kg	3.95	6.64
Strontium	Sr	mg/kg	11.3	19.0
Tantalum	Ta	mg/kg	0.65	1.10
Tellurium	Te	mg/kg	0.047	0.028
Thorium	Th	mg/kg	4.59	7.72
Thallium	Tl	mg/kg	2.32	3.91
Uranium	U	mg/kg	1.48	2.49
Vanadium	V	mg/kg	6.56	11.05
Tungsten	W	mg/kg	2.25	3.80
Yttrium	Y	mg/kg	7.77	13.1
Ytterbium	Yb	mg/kg	18.5	31.1
Zinc	Zn	mg/kg	14.6	24.6
Zirconium	Zr	mg/kg	7.82	13.2

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2016-03-17
Project number: 131
Report number: 58229
Date completed: 2016-04-26
Order number: JMA 10462/ST/01

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 013 665 1788
Fax: 013 665 2364
Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Cell: 082 866 4125

Acid – Base Accounting Modified Sobek (EPA-600)	Sample Identification			
	HRM-3	HRM-4	HRM-5	HRM-5
Sample Number	**1843**	**1844**	**1845**	**1845 D**
Paste pH	8.0	8.0	6.0	6.0
Total Sulphur (%) (LECO)	0.53	0.75	0.86	0.92
Acid Potential (AP) (kg/t)	17	23	27	29
Neutralization Potential (NP)	9.16	2.68	3.40	4.60
Nett Neutralization Potential (NNP)	-7.40	-21	-23	-24
Neutralising Potential Ratio (NPR) (NP : AP)	0.553	0.114	0.127	0.160
Rock Type	I	I	I	I

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

Please refer to Appendix **(p.2)** for a Terminology of terms and guidelines for rock classification

E. Pelser
Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2016-03-17 **Date completed: 2016-04-26**
Project number: 131 **Report number: 58229** **Order number: JMA 10462/ST/01**

Client name: JMA Consulting **Contact person: Shane Turner**
Address: P O Box 883, Delmas, 2210 **Email: shane@jmaconsult.co.za**
Telephone: 013 665 1788 **Fax: 013 665 2364** **Cell: 082 866 4125**

APPENDIX : TERMINOLOGY AND ROCK CLASSIFICATION

TERMINOLOGY (SYNONYMS)

- Acid Potential (AP) ; *Synonyms*: Maximum Potential Acidity (MPA)
  Method: Total S(%) (Leco Analyzer) x 31.25
- Neutralization Potential (NP) ; *Synonyms:* Gross Neutralization Potential (GNP) ; *Syn*: Acid Neutralization Capacity (ANC) (The capacity of a sample to consume acid)
  Method: Fizz Test ; Acid-Base Titration (Sobek & Modified Sobek (Lawrence) Methods)
- Nett Neutralization Potential (NNP) ; *Synonyms:* Nett Acid Production Potential (NAPP)
  Calculation: NNP = NP – AP ; NAPP = ANC – MPA
- Neutralising Potential Ratio (NPR)
  Calculation: NPR = NP : AP

CLASSIFICATION ACCORDING TO NETT NEUTRALISING POTENTIAL (NNP)

If NNP (NP – AP) < 0, the sample has the potential to generate acid
If NNP (NP – AP) > 0, the sample has the potential to neutralise acid produced

Any sample with NNP < 20 is potentiall acid-generating, and any sample with NNP > -20 might not generate acid (Usher *et al*., 2003)

ROCK CLASSIFICATION

TYPE I	Potentially Acid Forming	Total S(%) > 0.25% and NP:AP ratio 1:1 or less
TYPE II	Intermediate	Total S(%) > 0.25% and NP:AP ratio 1:3 or less
TYPE III	Non-Acid Forming	Total S(%) < 0.25% and NP:AP ratio 1:3 or greater

E. Pelser
Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2016-03-17
Project number: 131 **Report number: 58229**
Date completed: 2016-04-26
Order number: JMA 10462/ST/01

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 013 665 1788 **Fax: 013 665 2364**
Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Cell: 082 866 4125

CLASSIFICATION ACCORDING TO NEUTRALISING POTENTIAL RATIO (NPR)

Guidelines for screening criteria based on ABA (Price *et al*., 1997 ; Usher *et al*., 2003)

Potential for ARD	Initial NPR Screening Criteria	Comments
Likely	**< 1:1**	Likely AMD generating
Possibly	**1:1 – 2:1**	Possibly AMD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	**2:1 – 4:1**	Not potentially AMD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	**>4:1**	No further AMD testing required unless materials are to be used as a source of alkalinity

CLASSIFICATION ACCORDING TO SULPHUR CONTENT (%S) AND NEUTRALISING POTENTIAL RATIO (NPR)

For sustainable long-term acid generation, at least 0.3% Sulphide-S is needed. Values below this can yield acidity but it is likely to be only of short-term significance. From these facts, and using the NPR values, a number of rules can be derived:

1) Samples with less than 0.3% Sulphide-S are regarded as having insufficient oxidisable Sulphide-S to sustain acid generation.
2) NPR ratios of >4:1 are considered to have enough neutralising capacity.
3) NPR ratios of 3:1 to 1:1 are consider inconclusive.
4) NPR ratios below 1:1 with Sulphide-S above 3% are potentially acid-generating. (Soregaroli & Lawrence, 1998 ; Usher *et al*., 2003)

E. Pelser
Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
ACID – BASE ACCOUNTING
EPA-600 MODIFIED SOBEK METHOD

Date received: 2016-03-17 | **Date completed: 2016-04-26**
Project number: 131 | **Report number: 58229** | **Order number: JMA 10462/ST/01**

Client name: JMA Consulting | **Contact person: Shane Turner**
Address: P O Box 883, Delmas, 2210 | **Email: shane@jmaconsult.co.za**
Telephone: 013 665 1788 | **Fax: 013 665 2364** | **Cell: 082 866 4125**

REFERENCES

LAWRENCE, R.W. & WANG, Y. 1997. **Determination of Neutralization Potential in the Prediction of Acid Rock Drainage**. Proc. 4th International Conference on Acid Rock Drainage. Vancouver. BC. pp. 449 – 464.

PRICE, W.A., MORIN, K. & HUTT, N. 1997. **Guidelines for the prediction of Acid Rock Drainage and Metal leaching for mines in British Columbia** : Part 11. Recommended procedures for static and kinetic testing. In: Proceedings of the Fourth International Conference on Acid Rock Drainage. Vol 1. May 31 – June 6. Vancouver, BC., pp. 15 – 30.

SOBEK, A.A., SCHULLER, W.A., FREEMAN, J.R. & SMITH, R.M. 1978. **Field and laboratory methods applicable to overburdens and minesoils**. EPA-600/2-78-054. USEPA. Cincinnati. Ohio.

SOREGAROLI, B.A. & LAWRENCE, R.W. 1998. Update on waste Characterisation Studies. Proc. Mine Design, Operations and Closure Conference. Polson, Montana.

USHER, B.H., CRUYWAGEN, L-M., DE NECKER, E. & HODGSON, F.D.I. 2003. **Acid-Base : Accounting, Techniques and Evaluation (ABATE): Recommended Methods for Conducting and Interpreting Analytical Geochemical Assessments at Opencast Collieries in South Africa.** Water Research Commission Report No 1055/2/03. Pretoria.

ENVIRONMENT AUSTRALIA. 1997. **Managing Sulphidic Mine Wastes and Acid Drainage**.

E. Pelser
Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES
NET ACID GENERATION

Date received: 2016-03-17
Project number: 131
Report number: 58229
Date completed: 2016-04-26
Order number: JMA 10462/ST/01

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 013 665 1788
Fax: 013 665 2364
Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Cell: 082 866 4125

Net Acid Generation	Sample Identification: pH 4.5			
	HRM-3	HRM-4	HRM-5	HRM-5
Sample Number	**1843**	**1844**	**1845**	**1845 D**
NAG pH: (H_2O_2)	4.4	4.2	2.7	2.6
NAG (kg H_2SO_4 / t)	0.588	0.392	60	62

Net Acid Generation	Sample Identification: pH 7			
	HRM-3	HRM-4	HRM-5	HRM-5
Sample Number	**1843**	**1844**	**1845**	**1845 D**
NAG pH: (H_2O_2)	4.5	4.6	4.5	4.5
NAG (kg H_2SO_4 / t)	15	0.784	41	40

Notes:
- Samples analysed with Single Addition NAG test as per Prediction Manual For Drainage Chemistry from Sulphidic Geological Materials MEND Report 1.20.1.
- Please let me know if results do not correspond to other data.

E. Pelser
Geochemistry Project Manager (Acting)

WATERLAB

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

Prelim-CERTIFICATE OF ANALYSES

TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received:	2016/03/17		**Date completed:**	
Project number:	131	Report number: 58229	**Order number:**	JMA 10462/ST/01

Client name:	JMA Consulting	**Contact person:**	Shane Turner
Address:	P O Box 883, Delmas, 2210	**Email:**	shane@jmaconsult.co.za
Telephone:	0136651788	**Cell:**	0828664125

Analyses	HRM-1 Dolomite		HRM-2 Quartzite		HRM-3 Char		HRM-4 Coke		HRM-5 Anthracite	
Sample Number	1841		1842		1843		1844		1845	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water		Distilled Water		Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50		50		50		50	
Volume Used (mℓ)	1000		1000		1000		1000		1000	
pH Value at 25˚C	9.2		6.2		8.0		7.5		4.8	
Electrical Conductivity in mS/m at 25˚C	9.2		0.5		14.1		26.8		10.1	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Total Dissolved Solids at 180 ˚C	<10	<200	<10	<200	74	1480	156	3120	36	720
Total Alkalinity as CaCO3	40	800	8	160	40	800	16	320	<5	<100
Bicarbonate Alkalinity as CaCO3 (calc)	24	480	<5	<100	<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	8	160	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	<2	<40	<2	<40	<2	<40	21	420	<2	<40
Sulphate as SO4	<2	<40	<2	<40	26	520	71	1420	40	800
Nitrate as N	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	0.5	10	<0.1	<2.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	0.1	2.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	0.6	12	<0.2	<4.0
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		See attached report		See attached report		See attached report	
Net Acid Generation	-----		-----		See attached report		See attached report		See attached report	

Analyses	HRM-6 Limestone		HRM-8 MG-1 Chromite Ore		HRM-9 MG-2 Chromite Ore		HRM-10 Chemstof (Chromite) Concentrate		HRM-11 UG-2 (Chromite) Concentrate	
Sample Number	1846		1847		1848		1849		1850	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water		Distilled Water		Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50		50		50		50	
Volume Used (mℓ)	1000		1000		1000		1000		1000	
pH Value at 25˚C	8.7		8.1		7.4		7.1		7.0	
Electrical Conductivity in mS/m at 25˚C	4.9		5.2		3.4		1.1		2.4	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Total Dissolved Solids at 180 ˚C	<10	<200	30	600	<10	<200	26	520	14	280
Total Alkalinity as CaCO3	24	480	28	560	20	400	<5	<100	8	160
Bicarbonate Alkalinity as CaCO3 (calc)	16	320	<5	<100	<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	<2	<40	<2	<40	<2	<40	<2	<40	<2	<40
Sulphate as SO4	<2	<40	<2	<40	<2	<40	2	40	<2	<40
Nitrate as N	<0.1	<2.0	<0.1	<2.0	0.1	2.0	<0.1	<2.0	0.3	6.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	* <0.010	* <0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		-----		-----		-----	
Net Acid Generation	-----		-----		-----		-----		-----	

Analyses	HRM-12 Unprocessed Slag	HRM-13 Slimes (TSF Facility)	HRM-14 DSM Lumpy	HRM-15 DMS Waste	HRM-16 HFC (Chromite) Concentrate
Sample Number	1851	1852	1853	1854	1855
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water	Distilled Water	Distilled Water	Distilled Water	Distilled Water

Dry Mass Used (g)	**50**		**50**		**50**		**50**		**50**	
Volume Used (mℓ)	**1000**		**1000**		**1000**		**1000**		**1000**	
pH Value at 25˚C	7.4		9.0		7.6		7.7		7.3	
Electrical Conductivity in mS/m at 25˚C	2.0		36.7		4.4		5.8		3.0	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Dissolved Solids at 180 ˚C	<10	<200	246	4920	42	840	62	1240	<10	<200
Total Alkalinity as CaCO3	<5	<100	68	1360	20	400	24	480	<5	<100
Bicarbonate Alkalinity as CaCO3 (calc)	<5	<100	To follow		<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	<2	<40	11	220	<2	<40	<2	<40	<2	<40
Sulphate as SO4	<2	<40	66	1320	<2	<40	3	60	2	40
Nitrate as N	<0.1	<2.0	4.7	94	0.1	2.0	0.1	2.0	0.6	12
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	0.5	10	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	0.158	3.2	<0.1	<2.0	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		-----		-----		-----	
Net Acid Generation	-----		-----		-----		-----		-----	

Analyses	**HRM-17 Slag Fines**		**HRM-18 Final Slag Dump**		**HRM-19 MG-4 (Chromite) Ore**		**HRM-21 Return Material**		**HRM-22 Pellets**	
Sample Number	**1856**		**1857**		**1858**		**1859**		**1860**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**Distilled Water**		**Distilled Water**		**Distilled Water**		**Distilled Water**		**Distilled Water**	
Dry Mass Used (g)	**50**		**50**		**50**		**50**		**50**	
Volume Used (mℓ)	**1000**		**1000**		**1000**		**1000**		**1000**	
pH Value at 25˚C	7.7		7.5		7.3		7.6		6.6	
Electrical Conductivity in mS/m at 25˚C	7.0		1.7		4.0		17.1		2.7	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Dissolved Solids at 180 ˚C	48	960	<10	<200	18	360	92	1840	<10	<200
Total Alkalinity as CaCO3	28	560	12	240	16	320	28	560	8	160
Bicarbonate Alkalinity as CaCO3 (calc)	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	<2	<40	<2	<40	<2	<40	3	60.0	<2	<40
Sulphate as SO4	2	40	<2	<40	<2	<40	45	900	3	60
Nitrate as N	0.4	8.0	<0.1	<2.0	<0.1	<2.0	0.9	18	0.1	2.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	0.2	4.0	0.3	6
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	0.3	6.0	<0.1	<2.0	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	0.076	1.52	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		-----		-----		-----	
Net Acid Generation	-----		-----		-----		-----		-----	

Analyses	**HRM-23 Process Water Dam Sediment**		**HRM-24 OB Dam Sediment**		**HRM-25 Rehabilitated Open Pit #1**		**HRM-26 Rehabilitated Open Pit #2**		**HRM-27 Rehabilitated Open Pit #3**	
Sample Number	**1861**		**1862**		**1863**		**1864**		**1865**	
TCLP / Acid Rain / Distilled Water / H_2O_2	**Distilled Water**		**Distilled Water**		**Distilled Water**		**Distilled Water**		**Distilled Water**	
Dry Mass Used (g)	**50**		**50**		**50**		**50**		**50**	
Volume Used (mℓ)	**1000**		**1000**		**1000**		**1000**		**1000**	
pH Value at 25˚C	9.0		8.1		8.8		7.7		7.8	
Electrical Conductivity in mS/m at 25˚C	27.5		34.6		26.4		6.4		5.2	
Inorganic Anions	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**	**mg/ℓ**	**mg/kg**
Total Dissolved Solids at 180 ˚C	192	3840	230	4600	270	5400	16	320	16	320
Total Alkalinity as CaCO3	56	1120	28	560	56	1120	24	480	20	400
Bicarbonate Alkalinity as CaCO3 (calc)	To follow		<5	<100	To follow		<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	5	100	14	280.0	3	60	<2	<40	<2	<40
Sulphate as SO4	51	1020	107	2140	55	1100	3	60	2	40
Nitrate as N	1.8	36	3.8	76	1.1	22	<0.1	<2.0	0.2	4.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	0.3	6.0	0.2	4.0	0.2	4.0	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	0.379	7.6	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	0.154	3.1
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	* <0.010	* <0.200	* <0.010	* <0.200	* <0.010	* <0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		-----		-----		-----	
Net Acid Generation	-----		-----		-----		-----		-----	

Analyses	HRM-28 Rehabilitated Open Pit #4		HRM-29 Morula Mine Waste Rock Stockpile		HRM-30 Morula Grout Plant Material	
Sample Number	1866		1867		1868	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50		50	
Volume Used (mℓ)	1000		1000		1000	
pH Value at 25˚C	8.2		8.2		7.9	
Electrical Conductivity in mS/m at 25˚C	17.4		4.3		5.1	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Total Dissolved Solids at 180 ˚C	128	2560	62	1240	54	1080
Total Alkalinity as CaCO3	40	800	20	400	24	480
Bicarbonate Alkalinity as CaCO3 (calc)	<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100
Chloride as Cl	2	40.0	<2	<40	<2	<40
Sulphate as SO4	36	720	<2	<40	<2	<40
Nitrate as N	0.4	8.0	<0.1	<2.0	0.1	2.0
Nitrite as N	<0.05	<1.0	<0.05	<1.0	<0.05	<1.0
Fluoride as F	0.2	4.0	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW	
Acid Base Accounting	-----		-----		-----	
Net Acid Generation	-----		-----		-----	

[s] = Subcontracted

* = Absorbtion value due to sample turbidity

E. Pelser

Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD
CERTIFICATE OF ANALYSES
ICP-MS FULL QUANTITATIVE ANALYSIS

Date received: 2016/03/17
Project number: 131
Date completed: 2016/04/26
Report number: 58229

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 013 665 1788
Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Fax: 0136652364

Extract	Sample Mass (g)	Volume (ml)	Factor
Distilled Water	50	1000	20

Sample Id	Sample Number	Ag	Ag	Al	Al	As	As
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	0.150	3.00	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	0.384	7.68	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	0.650	13	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	0.364	7.28	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	0.187	3.74	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.100	<2.00	0.003	0.067
HRM-14	1853	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	0.148	2.96	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	1.04	21	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	0.296	5.92	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	0.548	11	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	0.150	3.00	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.100	<2.00	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.100	<2.00	0.001	0.022
HRM-24	1862	<0.001	<0.020	<0.100	<2.00	0.002	0.041
HRM-25	1863	<0.001	<0.020	<0.100	<2.00	0.002	0.048
HRM-26	1864	<0.001	<0.020	0.144	2.88	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	0.489	9.78	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.100	<2.00	0.002	0.031
HRM-29	1867	<0.001	<0.020	0.114	2.28	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	0.142	2.84	<0.001	<0.020

Sample Id	Sample Number	Au	Au	B	B	Ba	Ba
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	0.003	0.068
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	0.005	0.095
HRM-3	1843	<0.001	<0.020	0.030	0.609	0.180	3.59
HRM-4	1844	<0.001	<0.020	0.031	0.626	0.104	2.08
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	0.004	0.075
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	0.007	0.146
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	0.004	0.084
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	0.007	0.135
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	0.001	0.027
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	0.001	0.027
HRM-13	1852	<0.001	<0.020	0.071	1.41	0.017	0.340
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	0.003	0.058
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	0.007	0.138
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	0.001	0.023
HRM-17	1856	<0.001	<0.020	0.006	0.117	0.003	0.051
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	0.001	0.022
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	0.006	0.120
HRM-21	1859	<0.001	<0.020	0.017	0.343	0.010	0.191
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	0.002	0.031
HRM-23	1861	<0.001	<0.020	0.040	0.794	0.012	0.237
HRM-24	1862	<0.001	<0.020	0.032	0.632	0.038	0.754
HRM-25	1863	<0.001	<0.020	0.016	0.318	0.020	0.400
HRM-26	1864	<0.001	<0.020	0.004	0.077	0.008	0.158
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	0.006	0.113
HRM-28	1866	<0.001	<0.020	0.016	0.316	0.030	0.600
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	0.005	0.095
HRM-30	1868	<0.001	<0.020	0.001	0.030	0.007	0.134

Sample Id	Sample Number	Be	Be	Bi	Bi	Ca	Ca
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<1	<20
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	7	140
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<1	<20
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	19	380
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	25	500
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	3	60
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	6	120
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	4	80
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	2	40
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<1	<20
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	2	40
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	1	20
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	3	60
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	2	40
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	4	80
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	2	40
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	4	80
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<1	<20
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	4	80
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	6	120
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	2	40
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	4	80
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	14	280
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	7	140
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	3	60
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	4	80
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	7	140
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	4	80
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	5	100

Sample Id	Sample Number	Cd	Cd	Ce	Ce	Co	Co
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	0.001	0.022
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	0.002	0.032
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Cr	Cr	Cs	Cs	Cu	Cu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	0.001	0.026	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	0.007	0.141	<0.001	<0.020	0.001	0.030
HRM-10	1849	0.047	0.948	<0.001	<0.020	0.004	0.088
HRM-11	1850	0.064	1.27	<0.001	<0.020	0.005	0.109
HRM-12	1851	0.009	0.174	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	0.009	0.171	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	0.012	0.243	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	0.002	0.049	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	0.028	0.564	<0.001	<0.020	0.004	0.077
HRM-17	1856	0.122	2.45	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	0.018	0.364	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	0.125	2.51	<0.001	<0.020	0.004	0.090
HRM-21	1859	0.027	0.539	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	0.020	0.408	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	0.027	0.538	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	0.022	0.445	<0.001	<0.020	0.001	0.022
HRM-25	1863	0.008	0.159	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	0.016	0.312	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	0.106	2.13	<0.001	<0.020	0.002	0.045
HRM-28	1866	0.009	0.177	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	0.003	0.069	<0.001	<0.020	0.001	0.029
HRM-30	1868	0.019	0.385	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Dy	Dy	Er	Er	Eu	Eu
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.010	<0.200

Sample Id	Sample Number	Fe	Fe	Ga	Ga	Gd	Gd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.025	<0.500	0.001	0.021	<0.001	<0.020
HRM-2	1842	<0.025	<0.500	0.001	0.022	<0.001	<0.020
HRM-3	1843	<0.025	<0.500	0.048	0.964	<0.001	<0.020
HRM-4	1844	<0.025	<0.500	0.028	0.560	<0.001	<0.020
HRM-5	1845	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.025	<0.500	0.002	0.040	<0.001	<0.020
HRM-9	1848	0.282	5.64	0.001	0.028	<0.001	<0.020
HRM-10	1849	1.06	21	0.002	0.040	<0.001	<0.020
HRM-11	1850	0.397	7.94	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	0.043	0.860	0.006	0.118	<0.001	<0.020
HRM-14	1853	0.170	3.40	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.025	<0.500	0.002	0.038	<0.001	<0.020
HRM-16	1855	0.184	3.68	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	0.757	15	0.001	0.025	<0.001	<0.020
HRM-18	1857	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	0.765	15	0.002	0.035	<0.001	<0.020
HRM-21	1859	0.234	4.68	0.005	0.103	<0.001	<0.020
HRM-22	1860	<0.025	<0.500	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	0.051	1.02	0.008	0.169	<0.001	<0.020
HRM-24	1862	<0.025	<0.500	0.011	0.217	<0.001	<0.020
HRM-25	1863	<0.025	<0.500	0.006	0.116	<0.001	<0.020
HRM-26	1864	0.308	6.16	0.002	0.049	<0.001	<0.020
HRM-27	1865	0.953	19	0.002	0.037	<0.001	<0.020
HRM-28	1866	<0.025	<0.500	0.008	0.169	<0.001	<0.020
HRM-29	1867	0.155	3.10	0.002	0.032	<0.001	<0.020
HRM-30	1868	0.181	3.62	0.002	0.048	<0.001	<0.020

Sample Id	Sample Number	Ge	Ge	Hf	Hf	Hg	Hg
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	0.003	0.062	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Ho	Ho	In	In	Ir	Ir
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	K	K	La	La	Li	Li
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.5	<10	<0.001	<0.020	0.003	0.063
HRM-2	1842	0.5	10	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.5	<10	<0.001	<0.020	0.003	0.057
HRM-4	1844	9.9	199	<0.001	<0.020	0.015	0.291
HRM-5	1845	<0.5	<10	<0.001	<0.020	0.002	0.038
HRM-6	1846	1.2	24	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	1.5	31	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	38	760	<0.001	<0.020	0.008	0.158
HRM-14	1853	2.4	48	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	1.9	37	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	9.2	185	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	15	295	<0.001	<0.020	0.002	0.046
HRM-22	1860	<0.5	<10	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	29	580	<0.001	<0.020	0.005	0.104
HRM-24	1862	15	300	<0.001	<0.020	0.001	0.024
HRM-25	1863	20	400	<0.001	<0.020	0.002	0.049
HRM-26	1864	2.7	54	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	1.5	31	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	13	260	<0.001	<0.020	0.001	0.026
HRM-29	1867	2.6	53	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	2.5	49	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Lu	Lu	Mg	Mg	Mn	Mn
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-1	1841	<0.001	<0.020	6	120	<0.025	<0.500
HRM-2	1842	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-3	1843	<0.001	<0.020	3	60	<0.025	<0.500
HRM-4	1844	<0.001	<0.020	4	80	0.025	0.500
HRM-5	1845	<0.001	<0.020	2	40	0.023	0.460
HRM-6	1846	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-8	1847	<0.001	<0.020	3	60	<0.025	<0.500
HRM-9	1848	<0.001	<0.020	2	40	<0.025	<0.500
HRM-10	1849	<0.001	<0.020	<1	<20	0.033	0.660
HRM-11	1850	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-12	1851	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-13	1852	<0.001	<0.020	2	40	<0.025	<0.500
HRM-14	1853	<0.001	<0.020	2	40	<0.025	<0.500
HRM-15	1854	<0.001	<0.020	3	60	<0.025	<0.500
HRM-16	1855	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-17	1856	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-18	1857	<0.001	<0.020	1	20	<0.025	<0.500
HRM-19	1858	<0.001	<0.020	2	40	<0.025	<0.500
HRM-21	1859	<0.001	<0.020	2	40	<0.025	<0.500
HRM-22	1860	<0.001	<0.020	<1	<20	<0.025	<0.500
HRM-23	1861	<0.001	<0.020	1	20	<0.025	<0.500
HRM-24	1862	<0.001	<0.020	7	140	<0.025	<0.500
HRM-25	1863	<0.001	<0.020	5	100	<0.025	<0.500
HRM-26	1864	<0.001	<0.020	3	60	<0.025	<0.500
HRM-27	1865	<0.001	<0.020	4	80	0.026	0.520
HRM-28	1866	<0.001	<0.020	5	100	0.027	0.540
HRM-29	1867	<0.001	<0.020	1	20	<0.025	<0.500
HRM-30	1868	<0.001	<0.020	2	40	<0.025	<0.500

Sample Id	Sample Number	Mo	Mo	Na	Na	Nb	Nd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-3	1843	0.005	0.103	<1	<20	<0.001	<0.020
HRM-4	1844	0.001	0.024	7	140	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	11	220	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	1	20	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-13	1852	0.003	0.061	45	900	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	2	40	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	2	40	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	2	40	<0.001	<0.020
HRM-17	1856	0.001	0.027	3	60	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-21	1859	0.002	0.030	12	240	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	1	20	<0.001	<0.020
HRM-23	1861	0.003	0.067	28	560	<0.001	<0.020
HRM-24	1862	0.009	0.186	28	560	<0.001	<0.020
HRM-25	1863	0.004	0.076	25	500	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	4	80	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	2	40	<0.001	<0.020
HRM-28	1866	0.002	0.048	12	240	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<1	<20	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	2	40	<0.001	<0.020

Sample Id	Sample Number	Nd	Nd	Ni	Ni	Os	Os
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	0.002	0.033	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	0.004	0.075	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	0.002	0.033	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	0.002	0.039	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	0.003	0.065	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	0.012	0.248	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	0.005	0.100	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	0.003	0.055	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	0.002	0.046	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	0.001	0.029	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	0.003	0.065	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	0.007	0.143	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	0.009	0.178	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	0.003	0.054	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	0.001	0.026	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	0.002	0.045	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	0.003	0.051	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	0.002	0.036	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	0.004	0.070	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	0.017	0.344	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	0.002	0.044	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	0.002	0.049	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	0.002	0.048	<0.001	<0.020

Sample Id	Sample Number	P	P	Pb	Pb	Pd	Pd
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	0.005	0.108	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	0.005	0.105	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	0.018	0.364	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	0.002	0.032	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	0.005	0.091	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	0.006	0.126	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	0.003	0.054	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	0.079	1.58	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	0.001	0.023	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	0.003	0.054	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	0.005	0.105	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	0.008	0.158	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	0.006	0.122	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	0.031	0.617	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	0.003	0.063	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	0.002	0.034	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	0.006	0.113	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	0.006	0.118	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Pr	Pr	Pt	Pt	Rb	Rb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	0.001	0.028
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	0.001	0.022
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	0.087	1.73
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	0.001	0.021
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	0.004	0.083
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	0.002	0.049
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	0.001	0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	0.070	1.40
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	0.004	0.085
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	0.003	0.069
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	0.001	0.029
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	0.014	0.278
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	0.002	0.040
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	0.042	0.846
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	0.001	0.022
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	0.094	1.87
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	0.015	0.303
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	0.032	0.634
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	0.002	0.044
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	0.004	0.071
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	0.021	0.421
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	0.012	0.230
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	0.002	0.048

Sample Id	Sample Number	Rh	Rh	Ru	Ru	Sb	Sb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	0.001	0.027
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Sc	Sc	Se	Se	Si	Si
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
HRM-1	1841	<0.001	<0.020	0.001	0.020	<0.2	<4.0
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	0.2	4.4
HRM-3	1843	<0.001	<0.020	0.004	0.075	<0.2	<4.0
HRM-4	1844	<0.001	<0.020	0.011	0.223	<0.2	<4.0
HRM-5	1845	<0.001	<0.020	0.007	0.145	<0.2	<4.0
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
HRM-8	1847	<0.001	<0.020	0.004	0.073	0.7	13.1
HRM-9	1848	<0.001	<0.020	0.007	0.146	3.3	66
HRM-10	1849	<0.001	<0.020	0.004	0.073	1.9	39
HRM-11	1850	<0.001	<0.020	0.004	0.071	0.1	2.0
HRM-12	1851	<0.001	<0.020	0.004	0.075	<0.2	<4.0
HRM-13	1852	<0.001	<0.020	0.006	0.126	8.0	160
HRM-14	1853	<0.001	<0.020	0.007	0.143	1.8	36
HRM-15	1854	<0.001	<0.020	0.005	0.092	2.7	54
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	2.2	43
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	3.1	62
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	1.6	32
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.2	<4.0
HRM-23	1861	<0.001	<0.020	0.009	0.172	2.3	47
HRM-24	1862	<0.001	<0.020	0.005	0.093	1.9	39
HRM-25	1863	<0.001	<0.020	0.007	0.137	5.0	99
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	2.3	45
HRM-27	1865	<0.001	<0.020	0.003	0.059	2.4	49
HRM-28	1866	<0.001	<0.020	0.012	0.231	4.1	83
HRM-29	1867	<0.001	<0.020	0.007	0.138	2.4	49
HRM-30	1868	<0.001	<0.020	0.005	0.092	1.5	30

Sample Id	Sample Number	Sm	Sm	Sn	Sn	Sr	Sr
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	0.006	0.112
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	0.591	12
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	0.132	2.63
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	0.024	0.481
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	0.010	0.208
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	0.010	0.210
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	0.007	0.149
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	0.002	0.040
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	0.006	0.110
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	0.005	0.098
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	0.025	0.510
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	0.009	0.175
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	0.014	0.279
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	0.006	0.123
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	0.006	0.125
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	0.003	0.064
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	0.010	0.204
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	0.037	0.749
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	0.009	0.171
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	0.027	0.544
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	0.083	1.66
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	0.040	0.795
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	0.015	0.296
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	0.015	0.296
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	0.039	0.784
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	0.008	0.150
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	0.014	0.289

Sample Id	Sample Number	Ta	Ta	Tb	Tb	Te	Te
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Th	Th	Ti	Ti	Tl	Tl
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	0.007	0.149	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	0.001	0.021	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	0.020	0.409	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	0.029	0.579	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	0.004	0.083	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	0.007	0.142	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	0.005	0.093	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	0.003	0.066	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	0.015	0.292	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	0.009	0.170	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	0.003	0.055	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	0.006	0.117	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	0.004	0.078	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	0.005	0.105	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	0.006	0.111	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	0.021	0.414	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	0.004	0.074	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	0.018	0.364	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	0.009	0.175	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	0.003	0.052	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	0.007	0.136	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	0.017	0.338	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	0.009	0.183	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	0.005	0.099	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	0.015	0.296	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	0.009	0.176	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	0.006	0.125	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	0.010	0.199	<0.001	<0.020

Sample Id	Sample Number	Tm	Tm	U	U	V	V
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	0.002	0.031
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	0.001	0.019
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	0.003	0.063
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	0.001	0.026
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	0.001	0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	0.025	0.501
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	0.003	0.051
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	0.004	0.070
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	0.009	0.178
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	0.004	0.078
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	0.028	0.560
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	0.032	0.634
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	0.030	0.604
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	0.043	0.855
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	0.013	0.263
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	0.009	0.187
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	0.006	0.114
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	0.015	0.297
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	0.002	0.034
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	0.007	0.131

Sample Id	Sample Number	W	W	Y	Y	Yb	Yb
		mg/l	mg/kg	mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-13	1852	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-22	1860	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-23	1861	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-26	1864	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-27	1865	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-28	1866	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	<0.001	<0.020	<0.001	<0.020	<0.001	<0.020

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.020	<0.001	<0.020
HRM-1	1841	<0.001	<0.020	<0.001	<0.020
HRM-2	1842	<0.001	<0.020	<0.001	<0.020
HRM-3	1843	<0.001	<0.020	<0.001	<0.020
HRM-4	1844	<0.001	<0.020	<0.001	<0.020
HRM-5	1845	0.003	0.066	<0.001	<0.020
HRM-6	1846	<0.001	<0.020	<0.001	<0.020
HRM-8	1847	<0.001	<0.020	<0.001	<0.020
HRM-9	1848	<0.001	<0.020	<0.001	<0.020
HRM-10	1849	<0.001	<0.020	<0.001	<0.020
HRM-11	1850	<0.001	<0.020	<0.001	<0.020
HRM-12	1851	0.016	0.310	<0.001	<0.020
HRM-13	1852	0.043	0.854	<0.001	<0.020
HRM-14	1853	<0.001	<0.020	<0.001	<0.020
HRM-15	1854	<0.001	<0.020	<0.001	<0.020
HRM-16	1855	<0.001	<0.020	<0.001	<0.020
HRM-17	1856	0.004	0.076	<0.001	<0.020
HRM-18	1857	<0.001	<0.020	<0.001	<0.020
HRM-19	1858	<0.001	<0.020	<0.001	<0.020
HRM-21	1859	0.080	1.60	<0.001	<0.020
HRM-22	1860	0.002	0.050	<0.001	<0.020
HRM-23	1861	0.015	0.294	<0.001	<0.020
HRM-24	1862	<0.001	<0.020	<0.001	<0.020
HRM-25	1863	0.017	0.346	<0.001	<0.020
HRM-26	1864	0.010	0.196	<0.001	<0.020
HRM-27	1865	0.010	0.193	<0.001	<0.020
HRM-28	1866	0.019	0.389	<0.001	<0.020
HRM-29	1867	<0.001	<0.020	<0.001	<0.020
HRM-30	1868	0.057	1.15	<0.001	<0.020

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TCLP / ACID RAIN / DISTILLED WATER EXTRACTIONS

Date received:	2016/04/04	**Date completed:**	2016/05/04
Project number:	131 **Report number:** 58512	**Order number:**	JMA 10462/ST/07
Client name:	JMA Consulting	**Contact person:**	Shane Turner
Address:	P O Box 883, Delmas, 2210	**Email:**	shane@jmaconsult.co.za
Telephone:	0136651788	**Cell:**	0828664125

Analyses	HRM-31 Western Backfill		HRM-32 Mixed Waste		HER-BH57 3 - 10 m		HER-BH57 19 - 22 m		HER-BH58 7 – 8 m	
Sample Number	2901		2902		2903		2904		2905	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water		Distilled Water		Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50		50		50		50	
Volume Used (mℓ)	1000		1000		1000		1000		1000	
pH Value at 25˚C	7.6		7.3		7.7		7.2		7.7	
Electrical Conductivity in mS/m at 25˚C	16.1		4.5		6.5		3.6		5.6	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Total Dissolved Solids at 180 ˚C	70	1400	<10	<200	<10	<200	<10	<200	<10	<200
Total Alkalinity as CaCO3	32	640	20	400	36	720	20	400	24	480
Bicarbonate Alkalinity as CaCO3 (calc)	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100	<5	<100	<5	<100	<5	<100
Chloride as Cl	3	60	<2	<40	<2	<40	<2	<40	<2	<40
Sulphate as SO4	40	800	2	40	2	40	2	40	<2	<40
Nitrate as NO3	0.3	6.0	0.1	2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Nitrite as NO2	<0.05	<1.00	<0.05	<1.00	<0.05	<1.00	<0.05	<1.00	<0.05	<1.00
Fluoride as F	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	<0.1	<2.0	<0.1	<2.0	0.1	2.0	<0.1	<2.0	0.1	2
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW		See tab ICP DW	

Analyses	HER-BH59 26 – 28 m		HER-BH62 15 – 28 m	
Sample Number	2906		2907	
TCLP / Acid Rain / Distilled Water / H_2O_2	Distilled Water		Distilled Water	
Dry Mass Used (g)	50		50	
Volume Used (mℓ)	1000		1000	
pH Value at 25˚C	7.9		7.5	
Electrical Conductivity in mS/m at 25˚C	5.4		4.2	
Inorganic Anions	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Total Dissolved Solids at 180 ˚C	<10	<200	<10	<200
Total Alkalinity as CaCO3	24	480	16	320
Bicarbonate Alkalinity as CaCO3 (calc)	<5	<100	<5	<100
P-Alkalinity as CaCO3	<5	<100	<5	<100
Chloride as Cl	<2	<40	3	60
Sulphate as SO4	3	60	<2	<40
Nitrate as NO3	<0.1	<2.0	<0.1	<2.0
Nitrite as NO2	<0.05	<1.00	<0.05	<1.00
Fluoride as F	<0.2	<4.0	<0.2	<4.0
Free & Saline Ammonia as N	0.1	2	<0.1	<2.0
Ortho-Phosphate as P	<0.1	<2.0	<0.1	<2.0
Hexavalent Chromium as Cr6+	<0.010	<0.200	<0.010	<0.200
Total Cyanide as CN	<0.01	<0.20	<0.01	<0.20
Full ICP-MS Quant	See tab ICP DW		See tab ICP DW	

[s]=subcontracted

E. Pelser

Geochemistry Project Manager (Acting)

WATERLAB (PTY) LTD

CERTIFICATE OF ANALYSES

ICP-MS FULL QUANTITATIVE ANALYSIS

Date received:	2016/04/04
Project number:	131

Client name:	JMA Consulting
Address:	P O Box 883, Delmas, 2210
Telephone:	013 665 1788

Extract	Sample Mass (g)	Volume (ml)	Factor
Distilled Water	50	1000	20

Sample Id	Sample Number	Ag	Ag	Al
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.100
HRM-31 Western Backfill	2901	<0.001	<0.020	1.13
HRM-32 Mixed Waste	2902	<0.001	<0.020	0.412
HER-BH57 3 - 10 m	2903	<0.001	<0.020	0.436
HER-BH57 19 - 22 m	2904	<0.001	<0.020	2.03
HER-BH58 7 – 8 m	2905	0.001	0.023	2.02
HER-BH59 26 – 28 m	2906	<0.001	<0.020	1.34
HER-BH62 15 – 28 m	2907	<0.001	<0.020	1.16

Sample Id	Sample Number	Au	Au	B
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	0.016
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Be	Be	Bi
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Cd	Cd	Ce

		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Cr	Cr	Cs
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	0.044	0.872	<0.001
HRM-32 Mixed Waste	2902	0.234	4.68	<0.001
HER-BH57 3 - 10 m	2903	0.001	0.024	<0.001
HER-BH57 19 - 22 m	2904	0.004	0.074	<0.001
HER-BH58 7 – 8 m	2905	0.003	0.064	<0.001
HER-BH59 26 – 28 m	2906	0.017	0.342	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Dy	Dy	Er
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Fe	Fe	Ga
		mg/l	mg/kg	mg/l
Det Limit		<0.025	<0.500	<0.001
HRM-31 Western Backfill	2901	1.29	26	0.004
HRM-32 Mixed Waste	2902	0.714	14	0.002
HER-BH57 3 - 10 m	2903	0.110	2.20	0.001
HER-BH57 19 - 22 m	2904	0.602	12	0.001
HER-BH58 7 – 8 m	2905	0.394	7.88	0.002
HER-BH59 26 – 28 m	2906	2.39	48	<0.001
HER-BH62 15 – 28 m	2907	0.086	1.72	<0.001

Sample Id	Sample Number	Ge	Ge	Hf
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001

HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Ho	Ho	In
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	K	K	La
		mg/l	mg/kg	mg/l
Det Limit		<0.5	<10	<0.001
HRM-31 Western Backfill	2901	5.1	102	<0.001
HRM-32 Mixed Waste	2902	1.3	26	<0.001
HER-BH57 3 - 10 m	2903	<0.5	<10	<0.001
HER-BH57 19 - 22 m	2904	<0.5	<10	<0.001
HER-BH58 7 – 8 m	2905	<0.5	<10	<0.001
HER-BH59 26 – 28 m	2906	<0.5	<10	<0.001
HER-BH62 15 – 28 m	2907	<0.5	<10	<0.001

Sample Id	Sample Number	Lu	Lu	Mg
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<1
HRM-31 Western Backfill	2901	<0.001	<0.020	6
HRM-32 Mixed Waste	2902	<0.001	<0.020	2
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<1
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<1
HER-BH58 7 – 8 m	2905	<0.001	<0.020	1
HER-BH59 26 – 28 m	2906	<0.001	<0.020	5
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<1

Sample Id	Sample Number	Mo	Mo	Na
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<1
HRM-31 Western Backfill	2901	0.002	0.038	10
HRM-32 Mixed Waste	2902	<0.001	<0.020	1
HER-BH57 3 - 10 m	2903	<0.001	<0.020	5
HER-BH57 19 - 22 m	2904	0.003	0.050	2
HER-BH58 7 – 8 m	2905	<0.001	<0.020	1
HER-BH59 26 – 28 m	2906	<0.001	<0.020	1

HER-BH62 15 – 28 m	2907	<0.001	<0.020	2

Sample Id	Sample Number	Nd	Nd	Ni
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	0.007
HRM-32 Mixed Waste	2902	<0.001	<0.020	0.013
HER-BH57 3 - 10 m	2903	<0.001	<0.020	0.003
HER-BH57 19 - 22 m	2904	<0.001	<0.020	0.006
HER-BH58 7 – 8 m	2905	<0.001	<0.020	0.004
HER-BH59 26 – 28 m	2906	<0.001	<0.020	0.010
HER-BH62 15 – 28 m	2907	<0.001	<0.020	0.001

Sample Id	Sample Number	P	P	Pb
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Pr	Pr	Pt
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Ru	Ru	Sb
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Se	Se	Si
		mg/l	mg/kg	mg/l

Det Limit		<0.001	<0.020	<0.2
HRM-31 Western Backfill	2901	<0.001	<0.020	6.4
HRM-32 Mixed Waste	2902	0.002	0.043	3.1
HER-BH57 3 - 10 m	2903	<0.001	<0.020	3.1
HER-BH57 19 - 22 m	2904	<0.001	<0.020	4.2
HER-BH58 7 – 8 m	2905	<0.001	<0.020	4.5
HER-BH59 26 – 28 m	2906	0.002	0.048	6.1
HER-BH62 15 – 28 m	2907	<0.001	<0.020	1.9

Sample Id	Sample Number	Sn	Sn	Sr
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	0.033
HRM-32 Mixed Waste	2902	<0.001	<0.020	0.008
HER-BH57 3 - 10 m	2903	<0.001	<0.020	0.033
HER-BH57 19 - 22 m	2904	<0.001	<0.020	0.017
HER-BH58 7 – 8 m	2905	<0.001	<0.020	0.044
HER-BH59 26 – 28 m	2906	<0.001	<0.020	0.017
HER-BH62 15 – 28 m	2907	<0.001	<0.020	0.008

Sample Id	Sample Number	Tb	Tb	Te
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Ti	Ti	Tl
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	0.012	0.248	<0.001
HRM-32 Mixed Waste	2902	0.011	0.210	<0.001
HER-BH57 3 - 10 m	2903	0.005	0.103	<0.001
HER-BH57 19 - 22 m	2904	0.009	0.174	<0.001
HER-BH58 7 – 8 m	2905	0.009	0.187	<0.001
HER-BH59 26 – 28 m	2906	0.008	0.159	<0.001
HER-BH62 15 – 28 m	2907	0.005	0.101	<0.001

Sample Id	Sample Number	U	U	V
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	0.026
HRM-32 Mixed Waste	2902	<0.001	<0.020	0.006
HER-BH57 3 - 10 m	2903	<0.001	<0.020	0.004

HER-BH57 19 - 22 m	2904	<0.001	<0.020	0.003
HER-BH58 7 – 8 m	2905	<0.001	<0.020	0.003
HER-BH59 26 – 28 m	2906	<0.001	<0.020	0.007
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Y	Y	Yb
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.020	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.020	<0.001
HER-BH57 3 - 10 m	2903	<0.001	<0.020	<0.001
HER-BH57 19 - 22 m	2904	<0.001	<0.020	<0.001
HER-BH58 7 – 8 m	2905	<0.001	<0.020	<0.001
HER-BH59 26 – 28 m	2906	<0.001	<0.020	<0.001
HER-BH62 15 – 28 m	2907	<0.001	<0.020	<0.001

Sample Id	Sample Number	Zr	Zr
		mg/l	mg/kg
Det Limit		<0.001	<0.020
HRM-31 Western Backfill	2901	<0.001	<0.020
HRM-32 Mixed Waste	2902	<0.001	<0.020
HER-BH57 3 - 10 m	2903	<0.001	<0.020
HER-BH57 19 - 22 m	2904	<0.001	<0.020
HER-BH58 7 – 8 m	2905	<0.001	<0.020
HER-BH59 26 – 28 m	2906	<0.001	<0.020
HER-BH62 15 – 28 m	2907	<0.001	<0.020

Date completed:	**2016/05/04**
Report number:	**58512**

Contact person:	**Shane Turner**
Email:	**shane@jmaconsult.co.za**
Fax:	**0136652364**

Al	As	As
mg/kg	mg/l	mg/kg
<2.00	<0.001	<0.020
23	<0.001	<0.020
8.24	<0.001	<0.020
8.72	<0.001	<0.020
41	<0.001	<0.020
40	<0.001	<0.020
27	<0.001	<0.020
23	<0.001	<0.020

B	Ba	Ba
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
0.318	0.013	0.263
<0.020	0.007	0.134
<0.020	0.005	0.101
<0.020	0.004	0.076
<0.020	0.006	0.118
<0.020	0.001	0.028
<0.020	0.001	0.020

Bi	Ca	Ca
mg/kg	mg/l	mg/kg
<0.020	<1	<20
<0.020	6	120
<0.020	3	60
<0.020	5	100
<0.020	3	60
<0.020	8	160
<0.020	3	60
<0.020	4	80

Ce	Co	Co

mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	0.001	0.027
<0.020	<0.001	<0.020

Cs	Cu	Cu
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	0.003	0.058
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

Er	Eu	Eu
mg/kg	mg/l	mg/kg
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200
<0.020	<0.010	<0.200

Ga	Gd	Gd
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
0.082	<0.001	<0.020
0.043	<0.001	<0.020
0.029	<0.001	<0.020
0.029	<0.001	<0.020
0.035	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

Hf	Hg	Hg
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

In	Ir	Ir
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

La	Li	Li
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	0.001	0.027

Mg	Mn	Mn
mg/kg	mg/l	mg/kg
<20	<0.025	<0.500
120	0.026	0.520
40	<0.025	<0.500
<20	<0.025	<0.500
<20	<0.025	<0.500
21	<0.025	<0.500
103	0.038	0.760
<20	<0.025	<0.500

Na	Nb	Nd
mg/kg	mg/l	mg/kg
<20	<0.001	<0.020
200	<0.001	<0.020
20	<0.001	<0.020
100	<0.001	<0.020
40	<0.001	<0.020
20	<0.001	<0.020
20	<0.001	<0.020

40	<0.001	<0.020

Ni	Os	Os
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
0.141	<0.001	<0.020
0.253	<0.001	<0.020
0.050	<0.001	<0.020
0.122	<0.001	<0.020
0.070	<0.001	<0.020
0.206	<0.001	<0.020
0.022	<0.001	<0.020

Pb	Pd	Pd
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

Pt	Rb	Rb
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	0.006	0.111
<0.020	0.003	0.059
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	0.001	0.024

Sb	Sc	Sc
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

Si	Sm	Sm
mg/kg	mg/l	mg/kg

<4.0	<0.001	<0.020
128	<0.001	<0.020
62	<0.001	<0.020
63	<0.001	<0.020
85	<0.001	<0.020
90	<0.001	<0.020
123	<0.001	<0.020
37	<0.001	<0.020

Sr	Ta	Ta
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
0.650	<0.001	<0.020
0.154	<0.001	<0.020
0.660	<0.001	<0.020
0.333	<0.001	<0.020
0.876	<0.001	<0.020
0.350	<0.001	<0.020
0.167	<0.001	<0.020

Te	Th	Th
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

Tl	Tm	Tm
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020
<0.020	<0.001	<0.020

V	W	W
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
0.528	<0.001	<0.020
0.122	<0.001	<0.020
0.088	<0.001	<0.020

0.056	<0.001	<0.020
0.065	<0.001	<0.020
0.130	<0.001	<0.020
<0.020	<0.001	<0.020

Yb	Zn	Zn
mg/kg	mg/l	mg/kg
<0.020	<0.001	<0.020
<0.020	0.075	1.50
<0.020	0.014	0.286
<0.020	<0.001	<0.020
<0.020	0.002	0.037
<0.020	0.002	0.044
<0.020	0.005	0.105
<0.020	<0.001	<0.020

WATERLAB

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TOTALS

Date received:	2016/03/17		**Date completed:**	2016/04/28
Project number:	131	**Report number:** 58229	**Order number:**	JMA 10462/ST/01
Client name:	JMA Consulting		**Contact person:**	Shane Turner
Address:	P O Box 883, Delmas, 2210		**Email:**	shane@jmaconsult.co.za
Telephone:	0136651788		**Cell:**	0828664125

Analyses	HRM-12 Unprocessed Slag		HRM-13 Slimes (TSF Facility)		HRM-15 DMS Waste		HRM-17 Slag Fines		HRM-18 Final Slag Dump	
Sample Number	1851		1852		1854		1856		1857	
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0.25		0.25		0.25		0.25		0.25	
Volume Used (mℓ)	100		100		100		100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Full ICP-MS Quant	See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion	
Total Cyanide as CN	---	<0.05	---	<0.05	---	<0.05	---	<0.05	---	<0.05
Total Fluoride [s]	---	151	---	163	---	116	---	130	---	120
Total Hexavalent Chromium as Cr^{6+} [s]	---	<5	---	<5	---	<5	---	<5	---	<5

Analyses	HRM-21 Return Material		HRM-23 Process Water Dam Sediment		HRM-24 OB Dam Sediment		HRM-25 Rehabilitated Open Pit #1		HRM-26 Rehabilitated Open Pit #2	
Sample Number	1859		1861		1862		1863		1864	
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0.25		0.25		0.25		0.25		0.25	
Volume Used (mℓ)	100		100		100		100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Full ICP-MS Quant	See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion	
Total Cyanide as CN	---	<0.05	---	<0.05	---	<0.05	---	<0.05	---	<0.05
Total Fluoride [s]	---	120	---	190	---	125	---	125	---	111
Total Hexavalent Chromium as Cr^{6+} [s]	---	<5	---	<5	---	<5	---	<5	---	<5

Analyses	HRM-27 Rehabilitated Open Pit #3		HRM-28 Rehabilitated Open Pit #4		HRM-29 Morula Mine Waste Rock Stockpile		HRM-30 Morula Grout Plant Material	
Sample Number	1865		1866		1867		1868	
Digestion	HNO3 : HF		HNO3 : HF		HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0.25		0.25		0.25		0.25	
Volume Used (mℓ)	100		100		100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Full ICP-MS Quant	See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion		See tab ICP Digestion	
Total Cyanide as CN	---	<0.05	---	<0.05	---	<0.05	---	<0.05
Total Fluoride [s]	---	135	---	120	---	130	---	103
Total Hexavalent Chromium as Cr^{6+} [s]	---	<5	---	<5	---	<5	---	<5

[s]=subcontracted

E. Pelser
Geochemistry Project Manager (Acting)

CERTIFICATE OF ANALYSES
ICP-MS QUANTITATIVE ANALYSIS

Date received:	2016/03/17	**Date completed:**	
Project number:	131	**Report number:**	

Client name:	JMA Consulting	**Contact person:**	
Address:	P O Box 883, Delmas, 2210	**Email:**	
Telephone:	013 665 1788	**Fax:**	

Extract	Sample Mass (g)	Volume (ml)	Factor
HNO3 : HF	0.25	100	400

Sample Id	Sample Number	Ag	Ag	Al	Al
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.100	<40
HRM-12	1851	<0.001	<0.400	115	46000
HRM-13	1852	<0.001	<0.400	50	20000
HRM-15	1854	<0.001	<0.400	68	27200
HRM-17	1856	<0.001	<0.400	78	31200
HRM-18	1857	<0.001	<0.400	120	48000
HRM-21	1859	<0.001	<0.400	41	16400
HRM-23	1861	<0.001	<0.400	87	34800
HRM-24	1862	0.006	2.31	56	22400
HRM-25	1863	<0.001	<0.400	75	30000
HRM-26	1864	<0.001	<0.400	71	28400
HRM-27	1865	<0.001	<0.400	69	27600
HRM-28	1866	<0.001	<0.400	85	34000
HRM-29	1867	<0.001	<0.400	45	18000
HRM-30	1868	<0.001	<0.400	66	26400

Sample Id	Sample Number	Au	Au	B	B
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	<0.001	<0.400
HRM-13	1852	<0.001	<0.400	<0.001	<0.400
HRM-15	1854	<0.001	<0.400	<0.001	<0.400
HRM-17	1856	<0.001	<0.400	<0.001	<0.400
HRM-18	1857	<0.001	<0.400	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	<0.001	<0.400
HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Be	Be	Bi	Bi
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.004	1.43	<0.001	<0.400
HRM-13	1852	<0.001	<0.400	<0.001	<0.400

HRM-15	1854	0.001	0.492	<0.001	<0.400
HRM-17	1856	0.002	0.861	<0.001	<0.400
HRM-18	1857	0.005	1.85	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	0.002	0.684
HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Cd	Cd	Ce	Ce
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	0.059	23
HRM-13	1852	<0.001	<0.400	0.020	7.86
HRM-15	1854	<0.001	<0.400	0.015	6.15
HRM-17	1856	<0.001	<0.400	0.047	19
HRM-18	1857	<0.001	<0.400	0.074	30
HRM-21	1859	<0.001	<0.400	0.007	2.74
HRM-23	1861	<0.001	<0.400	0.010	4.02
HRM-24	1862	<0.001	<0.400	0.015	6.06
HRM-25	1863	<0.001	<0.400	0.017	6.85
HRM-26	1864	<0.001	<0.400	0.007	2.86
HRM-27	1865	<0.001	<0.400	0.009	3.70
HRM-28	1866	<0.001	<0.400	0.009	3.71
HRM-29	1867	<0.001	<0.400	0.012	4.92
HRM-30	1868	<0.001	<0.400	0.020	8.15

Sample Id	Sample Number	Cr	Cr	Cs	Cs
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	29	11600	0.001	0.524
HRM-13	1852	22	8800	0.002	0.983
HRM-15	1854	10	4000	<0.001	<0.400
HRM-17	1856	40	16000	0.002	0.635
HRM-18	1857	28	11200	<0.001	<0.400
HRM-21	1859	60	24000	0.001	0.433
HRM-23	1861	246	98400	0.002	0.917
HRM-24	1862	76	30400	0.002	0.962
HRM-25	1863	39	15600	0.002	0.736
HRM-26	1864	109	43600	<0.001	<0.400
HRM-27	1865	29	11600	<0.001	<0.400
HRM-28	1866	59	23600	<0.001	<0.400
HRM-29	1867	4.43	1771	<0.001	<0.400
HRM-30	1868	42	16800	<0.001	<0.400

Sample Id	Sample Number	Dy	Dy	Er	Er
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.004	1.57	0.002	0.968
HRM-13	1852	0.002	0.609	<0.001	<0.400
HRM-15	1854	0.002	0.662	0.001	0.400

HRM-17	1856	0.003	1.23	0.002	0.760
HRM-18	1857	0.005	1.93	0.003	1.04
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	0.001	0.493	<0.001	<0.400
HRM-25	1863	0.002	0.616	0.001	0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	0.001	0.406	<0.001	<0.400

Sample Id	Sample Number	Fe	Fe	Ga	Ga
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.025	<10	<0.001	<0.400
HRM-12	1851	81	32400	0.192	77
HRM-13	1852	97	38800	0.147	59
HRM-15	1854	140	56000	0.057	23
HRM-17	1856	81	32400	0.165	66
HRM-18	1857	88	35200	0.177	71
HRM-21	1859	92	36800	0.046	18
HRM-23	1861	206	82400	0.120	48
HRM-24	1862	114	45600	0.077	31
HRM-25	1863	126	50400	0.082	33
HRM-26	1864	139	55600	0.050	20
HRM-27	1865	83	33200	0.038	15
HRM-28	1866	140	56000	0.065	26
HRM-29	1867	135	54000	0.035	14
HRM-30	1868	82	32800	0.077	31

Sample Id	Sample Number	Ge	Ge	Hf	Hf
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	<0.001	<0.400
HRM-13	1852	0.005	2.19	<0.001	<0.400
HRM-15	1854	0.003	1.32	<0.001	<0.400
HRM-17	1856	0.002	0.660	<0.001	<0.400
HRM-18	1857	0.002	0.628	<0.001	<0.400
HRM-21	1859	0.001	0.534	<0.001	<0.400
HRM-23	1861	0.004	1.59	<0.001	<0.400
HRM-24	1862	0.001	0.494	<0.001	<0.400
HRM-25	1863	0.002	0.948	<0.001	<0.400
HRM-26	1864	0.003	1.00	<0.001	<0.400
HRM-27	1865	0.003	1.07	<0.001	<0.400
HRM-28	1866	0.004	1.52	<0.001	<0.400
HRM-29	1867	0.004	1.45	<0.001	<0.400
HRM-30	1868	0.002	0.646	0.002	0.868

Sample Id	Sample Number	Ho	Ho	In	In
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	<0.001	<0.400
HRM-13	1852	<0.001	<0.400	<0.001	<0.400
HRM-15	1854	<0.001	<0.400	<0.001	<0.400
HRM-17	1856	<0.001	<0.400	<0.001	<0.400

HRM-18	1857	0.001	0.406	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	<0.001	<0.400
HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	K	K	La	La
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.5	<200	<0.001	<0.400
HRM-12	1851	12.3	4917	0.030	12
HRM-13	1852	8.6	3428	0.010	3.86
HRM-15	1854	2.1	825	0.008	3.12
HRM-17	1856	9.7	3869	0.022	8.95
HRM-18	1857	5.2	2096	0.038	15
HRM-21	1859	1.6	636	0.004	1.41
HRM-23	1861	3.5	1394	0.005	1.97
HRM-24	1862	2.9	1146	0.007	2.97
HRM-25	1863	4.4	1768	0.009	3.50
HRM-26	1864	2.3	906	0.003	1.17
HRM-27	1865	2.5	1012	0.004	1.58
HRM-28	1866	4.2	1696	0.004	1.63
HRM-29	1867	4.7	1885	0.005	2.14
HRM-30	1868	5.6	2242	0.008	3.32

Sample Id	Sample Number	Lu	Lu	Mg	Mg
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400
HRM-12	1851	<0.001	<0.400	115	46000
HRM-13	1852	<0.001	<0.400	450	180000
HRM-15	1854	<0.001	<0.400	244	97600
HRM-17	1856	<0.001	<0.400	71	28400
HRM-18	1857	<0.001	<0.400	117	46800
HRM-21	1859	<0.001	<0.400	66	26400
HRM-23	1861	<0.001	<0.400	102	40800
HRM-24	1862	<0.001	<0.400	84	33600
HRM-25	1863	<0.001	<0.400	189	75600
HRM-26	1864	<0.001	<0.400	111	44400
HRM-27	1865	<0.001	<0.400	120	48000
HRM-28	1866	<0.001	<0.400	181	72400
HRM-29	1867	<0.001	<0.400	211	84400
HRM-30	1868	<0.001	<0.400	88	35200

Sample Id	Sample Number	Mo	Mo	Na	Na
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<1	<400
HRM-12	1851	<0.001	<0.400	5	2000
HRM-13	1852	<0.001	<0.400	9	3600
HRM-15	1854	<0.001	<0.400	7	2800
HRM-17	1856	<0.001	<0.400	3	1200
HRM-18	1857	<0.001	<0.400	4	1600

HRM-21	1859	<0.001	<0.400	2	800
HRM-23	1861	<0.001	<0.400	3	1200
HRM-24	1862	0.001	0.457	4	1600
HRM-25	1863	<0.001	<0.400	5	2000
HRM-26	1864	<0.001	<0.400	7	2800
HRM-27	1865	<0.001	<0.400	8	3200
HRM-28	1866	<0.001	<0.400	8	3200
HRM-29	1867	<0.001	<0.400	8	3200
HRM-30	1868	<0.001	<0.400	5	2000

Sample Id	Sample Number	Nd	Nd	Ni	Ni
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	0.921	368
HRM-13	1852	<0.001	<0.400	1.29	516
HRM-15	1854	<0.001	<0.400	1.71	684
HRM-17	1856	<0.001	<0.400	0.876	351
HRM-18	1857	<0.001	<0.400	0.882	353
HRM-21	1859	<0.001	<0.400	0.849	340
HRM-23	1861	<0.001	<0.400	2.24	897
HRM-24	1862	<0.001	<0.400	1.28	512
HRM-25	1863	<0.001	<0.400	1.70	679
HRM-26	1864	<0.001	<0.400	1.45	579
HRM-27	1865	<0.001	<0.400	1.05	418
HRM-28	1866	<0.001	<0.400	1.58	631
HRM-29	1867	<0.001	<0.400	1.65	659
HRM-30	1868	<0.001	<0.400	0.946	378

Sample Id	Sample Number	P	P	Pb	Pb
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.032	13	<0.001	<0.400
HRM-13	1852	0.221	89	0.058	23
HRM-15	1854	0.142	57	0.004	1.49
HRM-17	1856	0.071	29	0.009	3.75
HRM-18	1857	0.007	2.61	0.001	0.459
HRM-21	1859	0.063	25	0.027	11
HRM-23	1861	0.183	73	0.070	28
HRM-24	1862	0.221	88	0.027	11
HRM-25	1863	0.208	83	0.034	13
HRM-26	1864	0.130	52	0.008	3.04
HRM-27	1865	0.180	72	0.003	1.27
HRM-28	1866	0.242	97	0.020	7.93
HRM-29	1867	0.374	150	0.004	1.73
HRM-30	1868	0.193	77	0.008	3.13

Sample Id	Sample Number	Pr	Pr	Pt	Pt
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.008	3.21	<0.001	<0.400
HRM-13	1852	0.002	0.987	<0.001	<0.400
HRM-15	1854	0.002	0.941	<0.001	<0.400
HRM-17	1856	0.006	2.24	<0.001	<0.400
HRM-18	1857	0.011	4.56	<0.001	<0.400
HRM-21	1859	0.001	0.421	<0.001	<0.400

HRM-23	1861	0.001	0.573	<0.001	<0.400
HRM-24	1862	0.002	0.748	<0.001	<0.400
HRM-25	1863	0.002	0.941	0.001	0.505
HRM-26	1864	0.002	0.787	<0.001	<0.400
HRM-27	1865	0.002	0.962	<0.001	<0.400
HRM-28	1866	0.002	0.840	0.001	0.549
HRM-29	1867	0.002	0.997	<0.001	<0.400
HRM-30	1868	0.004	1.56	<0.001	<0.400

Sample Id	Sample Number	Rh	Rh	Ru	Ru
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	<0.001	<0.400
HRM-13	1852	<0.001	<0.400	<0.001	<0.400
HRM-15	1854	<0.001	<0.400	<0.001	<0.400
HRM-17	1856	<0.001	<0.400	<0.001	<0.400
HRM-18	1857	<0.001	<0.400	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	<0.001	<0.400
HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Sc	Sc	Se	Se
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.006	2.57	0.060	24
HRM-13	1852	0.005	2.11	0.072	29
HRM-15	1854	0.019	7.50	0.030	12
HRM-17	1856	0.004	1.42	0.075	30
HRM-18	1857	0.017	6.97	0.030	12
HRM-21	1859	<0.001	<0.400	0.058	23
HRM-23	1861	<0.001	<0.400	0.064	26
HRM-24	1862	0.003	1.08	0.067	27
HRM-25	1863	0.002	0.869	<0.001	<0.400
HRM-26	1864	0.016	6.37	0.044	17
HRM-27	1865	0.016	6.39	0.008	3.10
HRM-28	1866	0.022	8.80	0.127	51
HRM-29	1867	0.033	13	0.015	6.05
HRM-30	1868	0.018	7.26	0.023	9.02

Sample Id	Sample Number	Sm	Sm	Sn	Sn
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.004	1.74	<0.001	<0.400
HRM-13	1852	0.002	0.617	<0.001	<0.400
HRM-15	1854	0.001	0.546	<0.001	<0.400
HRM-17	1856	0.003	1.37	<0.001	<0.400
HRM-18	1857	0.005	2.04	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400

HRM-24	1862	<0.001	<0.400	<0.001	<0.400
HRM-25	1863	0.001	0.514	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	0.003	1.18
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	0.001	0.527	<0.001	<0.400

Sample Id	Sample Number	Ta	Ta	Tb	Tb
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	<0.001	<0.400
HRM-13	1852	<0.001	<0.400	<0.001	<0.400
HRM-15	1854	<0.001	<0.400	<0.001	<0.400
HRM-17	1856	<0.001	<0.400	<0.001	<0.400
HRM-18	1857	<0.001	<0.400	<0.001	<0.400
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	<0.001	<0.400
HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	<0.001	<0.400

Sample Id	Sample Number	Th	Th	Ti	Ti
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	8.71	3483
HRM-13	1852	<0.001	<0.400	2.30	920
HRM-15	1854	<0.001	<0.400	2.52	1010
HRM-17	1856	<0.001	<0.400	5.49	2196
HRM-18	1857	<0.001	<0.400	8.07	3229
HRM-21	1859	<0.001	<0.400	1.54	615
HRM-23	1861	<0.001	<0.400	5.01	2002
HRM-24	1862	<0.001	<0.400	2.53	1013
HRM-25	1863	<0.001	<0.400	3.16	1264
HRM-26	1864	<0.001	<0.400	3.28	1310
HRM-27	1865	<0.001	<0.400	2.21	884
HRM-28	1866	<0.001	<0.400	3.08	1233
HRM-29	1867	<0.001	<0.400	2.49	995
HRM-30	1868	0.001	0.452	3.96	1586

Sample Id	Sample Number	Tm	Tm	U	U
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	0.004	1.55
HRM-13	1852	<0.001	<0.400	<0.001	<0.400
HRM-15	1854	<0.001	<0.400	<0.001	<0.400
HRM-17	1856	<0.001	<0.400	0.002	0.864
HRM-18	1857	<0.001	<0.400	0.004	1.67
HRM-21	1859	<0.001	<0.400	<0.001	<0.400
HRM-23	1861	<0.001	<0.400	<0.001	<0.400
HRM-24	1862	<0.001	<0.400	0.001	0.544

HRM-25	1863	<0.001	<0.400	<0.001	<0.400
HRM-26	1864	<0.001	<0.400	<0.001	<0.400
HRM-27	1865	<0.001	<0.400	<0.001	<0.400
HRM-28	1866	<0.001	<0.400	<0.001	<0.400
HRM-29	1867	<0.001	<0.400	<0.001	<0.400
HRM-30	1868	<0.001	<0.400	0.001	0.591

Sample Id	Sample Number	W	W	Y	Y
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	<0.001	<0.400	0.021	8.37
HRM-13	1852	<0.001	<0.400	0.009	3.48
HRM-15	1854	<0.001	<0.400	0.010	4.19
HRM-17	1856	<0.001	<0.400	0.021	8.22
HRM-18	1857	<0.001	<0.400	0.027	11
HRM-21	1859	<0.001	<0.400	0.004	1.56
HRM-23	1861	<0.001	<0.400	0.005	1.99
HRM-24	1862	<0.001	<0.400	0.006	2.58
HRM-25	1863	<0.001	<0.400	0.010	3.93
HRM-26	1864	<0.001	<0.400	0.003	1.05
HRM-27	1865	<0.001	<0.400	0.003	1.31
HRM-28	1866	<0.001	<0.400	0.004	1.63
HRM-29	1867	<0.001	<0.400	0.004	1.69
HRM-30	1868	<0.001	<0.400	0.005	2.10

Sample Id	Sample Number	Zn	Zn	Zr	Zr
		mg/l	mg/kg	mg/l	mg/kg
Det Limit		<0.001	<0.400	<0.001	<0.400
HRM-12	1851	0.122	49	0.285	114
HRM-13	1852	6.22	2490	0.028	11
HRM-15	1854	0.258	103	0.026	10
HRM-17	1856	0.228	91	0.160	64
HRM-18	1857	<0.001	<0.400	0.249	100
HRM-21	1859	2.14	855	0.001	0.493
HRM-23	1861	8.13	3253	0.025	10
HRM-24	1862	1.30	518	0.032	13
HRM-25	1863	2.40	959	0.038	15
HRM-26	1864	0.970	388	0.043	17
HRM-27	1865	0.160	64	0.025	10
HRM-28	1866	2.39	955	0.035	14
HRM-29	1867	0.200	80	0.029	12
HRM-30	1868	0.355	142	0.105	42

2016/04/26

58229

Shane Turner
shane@jmaconsult.co.za
0136652364

As	As
mg/l	mg/kg
<0.001	<0.400
0.001	0.429
0.004	1.61
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.003	1.11
0.004	1.65
0.002	0.996
<0.001	<0.400
0.004	1.66
0.002	0.704
<0.001	<0.400

Ba	Ba
mg/l	mg/kg
<0.001	<0.400
0.576	230
0.283	113
0.164	66
0.455	182
0.497	199
0.062	25
0.101	41
0.158	63
0.161	64
0.093	37
0.105	42
0.129	52
0.109	43
0.227	91

Ca	Ca
mg/l	mg/kg
<1	<400
64	25600
46	18400

55	22000
46	18400
102	40800
15	6000
19	7600
22	8800
40	16000
36	14400
58	23200
48	19200
45	18000
43	17200

Co	Co
mg/l	mg/kg
<0.001	<0.400
0.141	56
0.098	39
0.158	63
0.114	45
0.128	51
0.091	37
0.317	127
0.125	50
0.122	49
0.192	77
0.100	40
0.170	68
0.234	94
0.109	43

Cu	Cu
mg/l	mg/kg
<0.001	<0.400
0.007	2.69
0.095	38
0.054	22
0.017	6.71
0.012	4.94
0.025	10
0.042	17
0.067	27
0.105	42
0.071	28
0.072	29
0.092	37
0.028	11
0.038	15

Eu	Eu
mg/l	mg/kg
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00

<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00
<0.010	<4.00

Gd	Gd
mg/l	mg/kg
<0.001	<0.400
0.004	1.74
0.001	0.576
0.002	0.616
0.003	1.35
0.005	2.09
<0.001	<0.400
<0.001	<0.400
0.001	0.484
0.001	0.565
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.001	0.527

Hg	Hg
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Ir	Ir
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Li	Li
mg/l	mg/kg
<0.001	<0.400
0.020	8.00
0.011	4.49
0.008	3.10
0.015	5.93
0.036	14
0.004	1.50
0.008	3.00
0.009	3.45
0.019	7.73
0.003	1.10
0.001	0.490
0.003	1.10
0.002	0.701
0.006	2.36

Mn	Mn
mg/l	mg/kg
<0.025	<10
2.52	1010
2.45	979
2.90	1158
1.74	695
2.27	910
1.22	487
2.41	965
1.63	650
2.36	946
1.98	790
1.58	634
2.74	1095
3.87	1548
1.81	723

Nb	Nb
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.002	0.675
0.002	0.619
0.003	1.16
0.002	0.712
0.002	0.791

Os	Os
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Pd	Pd
mg/l	mg/kg
<0.001	<0.400
0.002	0.933
0.001	0.469
<0.001	<0.400
0.001	0.417
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.004	1.63
0.002	0.721
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Rb	Rb
mg/l	mg/kg
<0.001	<0.400
0.027	11
0.053	21
0.008	3.01
0.048	19
0.009	3.78
0.013	5.05

0.032	13
0.023	9.39
0.031	13
0.004	1.70
0.004	1.43
0.010	3.82
0.019	7.64
0.011	4.37

Sb	Sb
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.002	0.918
0.002	0.608
0.003	1.01
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Si	Si
mg/l	mg/kg
<0.2	<80
281	112400
356	142400
436	174400
570	228000
290	116000
96	38400
142	56800
154	61600
313	125200
243	97200
326	130400
370	148000
587	234800
497	198800

Sr	Sr
mg/l	mg/kg
<0.001	<0.400
0.218	87
0.188	75
0.166	67
0.171	69
0.276	110
0.058	23
0.088	35

0.114	46
0.134	53
0.057	23
0.085	34
0.100	40
0.111	45
0.092	37

Te	Te
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

Tl	Tl
mg/l	mg/kg
<0.001	<0.400
<0.001	<0.400
0.002	0.603
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.001	0.595
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

V	V
mg/l	mg/kg
<0.001	<0.400
0.172	69
0.269	108
0.229	91
0.335	134
0.175	70
0.625	250
2.24	895
0.804	322

0.396	158
1.07	427
0.322	129
0.626	250
0.239	96
0.387	155

Yb	Yb
mg/l	mg/kg
<0.001	<0.400
0.002	0.857
0.001	0.425
0.001	0.467
0.002	0.770
0.003	1.05
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
0.001	0.455
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400
<0.001	<0.400

WATERLAB

WATERLAB (PTY) LTD

23B De Havilland Crescent
Persequor Techno Park,
Meiring Naudé Road, Pretoria
P.O. Box 283, 0020

Telephone: +2712 – 349 – 1066
Facsimile: +2712 – 349 – 2064
Email: accounts@waterlab.co.za

CERTIFICATE OF ANALYSES

TOTALS

Date received: 2016/04/04
Project number: 131
Report number: 58512
Date completed: 2016/05/04
Order number: JMA 10462/ST/07

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 0136651788
Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Cell: 0828664125

Analyses	HRM-31 Western Backfill		HRM-32 Mixed Waste	
Sample Number	2901		2902	
Digestion	HNO3 : HF		HNO3 : HF	
Dry Mass Used (g)	0.25		0.25	
Volume Used (mℓ)	100		100	
Units	mg/ℓ	mg/kg	mg/ℓ	mg/kg
Full ICP-MS Quant	See tab ICP Digestion		See tab ICP Digestion	
Total Cyanide as CN	---	<0.05	---	<0.05
Total Fluoride [s]	---	131	---	153
Total Hexavalent Chromium as Cr^{6+} [s]	---	<5	---	<5

[s]=subcontracted

E. Pelser
Geochemistry Project Manager (Acting)

CERTIFICATE OF ANALYSES
ICP-MS QUANTITATIVE ANALYSIS

Date received: 2016/04/04
Project number: 131

Client name: JMA Consulting
Address: P O Box 883, Delmas, 2210
Telephone: 013 665 1788

Extract	Sample Mass (g)	Volume (ml)	Factor
HNO3 : HF	0.25	100	400

Sample Id	Sample Number	Ag	Ag	Al
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.100
HRM-31 Western Backfill	2901	0.008	3.21	126
HRM-32 Mixed Waste	2902	0.007	2.90	61

Sample Id	Sample Number	Au	Au	B
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	Be	Be	Bi
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	0.001	0.543	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	Cd	Cd	Ce
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	0.038
HRM-32 Mixed Waste	2902	<0.001	<0.400	0.024

Sample Id	Sample Number	Cr	Cr	Cs
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	87	34800	0.001
HRM-32 Mixed Waste	2902	78	31200	<0.001

Sample Id	Sample Number	Dy	Dy	Er
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	0.003	1.10	0.002

HRM-32 Mixed Waste	2902	0.002	0.857	0.001

Sample Id	Sample Number	Fe	Fe	Ga
		mg/l	mg/kg	mg/l
Det Limit		<0.025	<10	<0.001
HRM-31 Western Backfill	2901	142	56800	0.125
HRM-32 Mixed Waste	2902	152	60800	0.077

Sample Id	Sample Number	Ge	Ge	Hf
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	0.005	1.89	<0.001
HRM-32 Mixed Waste	2902	0.003	1.00	<0.001

Sample Id	Sample Number	Ho	Ho	In
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	K	K	La
		mg/l	mg/kg	mg/l
Det Limit		<0.5	<200	<0.001
HRM-31 Western Backfill	2901	4.0	1600	0.019
HRM-32 Mixed Waste	2902	4.2	1692	0.011

Sample Id	Sample Number	Lu	Lu	Mg
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<1
HRM-31 Western Backfill	2901	<0.001	<0.400	107
HRM-32 Mixed Waste	2902	<0.001	<0.400	182

Sample Id	Sample Number	Mo	Mo	Na
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<1
HRM-31 Western Backfill	2901	<0.001	<0.400	9
HRM-32 Mixed Waste	2902	<0.001	<0.400	7

Sample Id	Sample Number	Nd	Nd	Ni
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	2.39
HRM-32 Mixed Waste	2902	<0.001	<0.400	2.79

Sample Id	Sample Number	P	P	Pb
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001

HRM-31 Western Backfill	2901	0.147	59	0.021
HRM-32 Mixed Waste	2902	0.515	206	0.005

Sample Id	Sample Number	Pr	Pr	Pt
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.020	<0.001
HRM-31 Western Backfill	2901	0.004	1.71	<0.001
HRM-32 Mixed Waste	2902	0.003	1.14	<0.001

Sample Id	Sample Number	Rh	Rh	Ru
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	Sc	Sc	Se
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	0.039	16	0.039
HRM-32 Mixed Waste	2902	0.052	21	0.039

Sample Id	Sample Number	Sm	Sm	Sn
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	0.003	1.24	<0.001
HRM-32 Mixed Waste	2902	0.002	0.889	<0.001

Sample Id	Sample Number	Ta	Ta	Tb
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	Th	Th	Ti
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	4.46
HRM-32 Mixed Waste	2902	<0.001	<0.400	3.16

Sample Id	Sample Number	Tm	Tm	U
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	<0.001
HRM-32 Mixed Waste	2902	<0.001	<0.400	<0.001

Sample Id	Sample Number	W	W	Y
		mg/l	mg/kg	mg/l

Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	<0.001	<0.400	0.017
HRM-32 Mixed Waste	2902	<0.001	<0.400	0.014

Sample Id	Sample Number	Zn	Zn	Zr
		mg/l	mg/kg	mg/l
Det Limit		<0.001	<0.400	<0.001
HRM-31 Western Backfill	2901	1.84	737	0.060
HRM-32 Mixed Waste	2902	0.361	144	0.019

Date completed: 2016/05/04
Report number: 58512

Contact person: Shane Turner
Email: shane@jmaconsult.co.za
Fax: 0136652364

Al	As	As
mg/kg	mg/l	mg/kg
<40	<0.001	<0.400
50400	0.003	1.34
24400	0.004	1.55

B	Ba	Ba
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	0.316	126
<0.400	0.198	79

Bi	Ca	Ca
mg/kg	mg/l	mg/kg
<0.400	<1	<400
<0.400	77	30800
<0.400	44	17600

Ce	Co	Co
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
15	0.185	74
10	0.226	90

Cs	Cu	Cu
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
0.591	0.072	29
<0.400	0.054	22

Er	Eu	Eu
mg/kg	mg/l	mg/kg
<0.400	<0.010	<4.00
0.765	<0.010	<4.00

0.545	<0.010	<4.00

Ga	Gd	Gd
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
50	0.003	1.23
31	0.003	1.15

Hf	Hg	Hg
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400

In	Ir	Ir
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400

La	Li	Li
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
7.62	0.014	5.78
4.59	0.006	2.37

Mg	Mn	Mn
mg/kg	mg/l	mg/kg
<400	<0.025	<10
42800	2.53	1010
72800	2.85	1140

Na	Nb	Nb
mg/kg	mg/l	mg/kg
<400	<0.001	<0.400
3600	<0.001	<0.400
2800	<0.001	<0.400

Ni	Os	Os
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
958	<0.001	<0.400
1115	<0.001	<0.400

Pb	Pd	Pd
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400

8.23	<0.001	<0.400
1.99	<0.001	<0.400

Pt	Rb	Rb
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	0.029	11
<0.400	0.022	8.78

Ru	Sb	Sb
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400

Se	Si	Si
mg/kg	mg/l	mg/kg
<0.400	<0.2	80
16	251	100400
16	215	86000

Sn	Sr	Sr
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	0.305	122
<0.400	0.146	58

Tb	Te	Te
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400
<0.400	<0.001	<0.400

Ti	Tl	Tl
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
1785	<0.001	<0.400
1265	<0.001	<0.400

U	V	V
mg/kg	mg/l	mg/kg
<0.400	<0.001	<0.400
<0.400	0.791	316
<0.400	0.782	313

Y	Yb	Yb
mg/kg	mg/l	mg/kg

<0.400	<0.001	<0.400
6.80	0.002	0.800
5.60	0.002	0.800

Zr
mg/kg
<0.400
24
7.60

JMA Consulting (Pty) Ltd

"Sustainable Environmental Solutions through integrated Science and Engineering"

15 Vickers Street
Delmas
P O Box 883
Delmas, 2210
Tel (013) 665 1788

Surface Water Sampling Field Form: Hernic Ferrochrome (JMA10462)

SAMPLING POINT INFO		SAMPLE TYPE	SAMPLING METHOD	LEVEL INFO			STATUS			COORDINATES		COMMENTS
SAMPLE NO	SAMPLING DEPTH (m)			DATE (YYMMDD)	TIME (HH:MM)	DAM LEVEL / RIVER STATUS	STATUS	PHOTO (Y/N)	SAMPLED (Y/N)	LATITUDE	LONGITUDE	OTHER
HSW-1	Surface	L	C	2016/02/26	10:16	-	G	Y	Y	25° 39' 10.3" S	27° 50' 56.6" E	Slimes Dam RWD
HSW-2	Surface	L	C	2016/02/26	10:59	-	G	Y	N	25° 39' 25.5" S	27° 50' 18.8" E	Storm Water Dam
HSW-3	Surface	L	C	2016/02/26	11:12	-	G	Y	Y	25° 39' 28.5" S	27° 50' 15.1" E	Storm Water Dam
HSW-4	Surface	L	C	2016/02/26	11:22	-	G	Y	Y	25° 39' 12.9" S	27° 50' 12.9" E	Process Water Dam
HSW-5	Surface	L	C	2016/02/26	11:33	-	G	Y	Y	25° 39' 36.2" S	27° 50' 09.7" E	Drinking Water Dam
HSW-6	Surface	L	C	2016/02/26	11:48	-	G	Y	Y	25° 39' 20.8" S	27° 50' 19.3" E	OB Plant Water Dam
HSW-7	Surface	L	C	2016/02/26	13:22	-	G	Y	Y	25° 39' 48.1" S	27° 51' 13.4" E	Morula Dewatering Dam
HSW-8	Surface	L	C	2016/02/29	09:31	-	G	Y	Y	25° 39' 15.2" S	27° 50' 42.4" E	HH Return Water Dam
HSW-9	Surface	L	C	2016/03/01	08:36	-	G	Y	Y	25° 39' 47.0" S	27° 50' 33.0" E	CRP Dam
HSW-10	Surface	X	C	2016/03/02	15:31	-	G	Y	Y	25° 39' 42.3" S	27° 50' 04.9" E	Slag Spiral Plant Sump
HSW-11	Surface	C	C	2016/03/03	14:44	-	G	Y	Y	25° 39' 24.6" S	27° 49' 54.7" E	Irrigation Canal
HSW-12	Surface	V	C	2016/03/03	14:51	-	G	Y	Y	25° 39' 12.4" S	27° 49' 52.1" E	Tributary - Midstream
HSW-13	Surface	V	C	2016/03/03	15:09	-	G	Y	Y	25° 38' 27.0" S	27° 50' 38.5" E	Tributary - Downstream
HSW-14	Surface	V	C	2016/03/03	15:42	-	G	Y	Y	25° 39' 21.6" S	27° 49' 01.2" E	Tribuatory - Upstream
HSW-15	Surface	L	C	2016/03/03	16:25	-	G	Y	Y	25° 39' 15.8" S	27° 50' 06.2" E	Northern Farmers Dam
HSW-16	Surface	L	C	2016/03/04	13:09	-	G	Y	Y	25° 39' 23.5" S	27° 51' 17.3" E	Open Pit
HSW-17	Surface	L	C	2016/03/07	11:52	-	G	Y	Y	25° 39' 36.1" S	27° 51' 10.2" E	Grout Plant Sump
HSW-18	Surface	L	C	2016/03/30	12:47	-	G	Y	Y	25° 39' 21.8" S	27° 50' 09.7" E	Emergency Dam

NOTES:

Sampled by:	Shane Turner, Michael Lombard, Cas Erasmus	**Lab prescribed sample preservation (10% HNO_3):**		No
Relinquished by:	**Received by:**	**Date:**	**Time:**	**Laboratory name:**
Shane Turner	Mandy van der Heyde	15/03/2016	07:30	Waterlab (Pty) Ltd

SAMPLE TYPE:
- B - BOREHOLE
- C - CANAL
- D - DRINKING WATER
- E - EFFLUENT
- F - FOUNTAINS
- G - SEDIMENT
- K - SEWAGE
- L - PAN, DAM, LAKE
- U - SEEPAGE
- V - RIVERS & STREAMS
- X - OTHER

- A - AIRLIFT
- B - BAIL
- P - PUMP
- C - BOTTLE

TIME DEPENDENT CHEMISTRY REPORT

Date compiled: 2016/07/04

Site Identifier: 2527DB00001 **Number:** HSW-1 **Site Name:** SLIMES DAM RETURN WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-1	L	20160226	1016	8.4	325 ‡	2244 ‡	50	140 ‡	327 ‡	228 ‡	14.2	524	226	690 ‡	48 ‡	5.8 ‡	< 0.1	0.043	0.068

Site Identifier: 2527DB00003 **Number:** HSW-3 **Site Name:** PLANT STORM WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-3	L	20160226	1112	8.3	333 ‡	2356 ‡	56	139 ‡	350 ‡	241 ‡	10.6	368	245	784 ‡	57 ‡	7.3 ‡	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00004 **Number:** HSW-4 **Site Name:** PROCESS WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-4	L	20160226	1122	8.4	422 ‡	2966 ‡	62	157 ‡	379 ‡	397 ‡	24	624	267	792 ‡	107 ‡	14 ‡	< 0.1	0.099	0.193 †

Site Identifier: 2527DB00005 **Number:** HSW-5 **Site Name:** DRINKING WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-5	L	20160226	1133	8	60.6	356	45	18	48	13.1	5.3	160	47	73	1.9	0.3	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00006 **Number:** HSW-6 **Site Name:** OB PLANT WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-6	L	20160226	1148	8.5	320 ‡	2202 ‡	51	149 ‡	327 ‡	227 ‡	15.1	464	236	686 ‡	48 ‡	5.9 ‡	< 0.1	< 0.025	0.06

Site Identifier: 2527DB00007 **Number:** HSW-7 **Site Name:** MORULA DEWATERING DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-7	L	20160226	1322	8.3	98.7	640	47	68	64	9.1	16.2	268	54	158	11 †	0.2	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00008 **Number:** HSW-8 **Site Name:** HH RETURN WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-8	L	20160229	0931	9.2	2954 ‡	20814 ‡	52	80 †	5099 ‡	3574 ‡	1.7	212	7735 ‡	3851 ‡	20 †	4.9 ‡	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00009 **Number:** HSW-9 **Site Name:** CHROME RECOVERY PLANT DIRTY WATER DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-9	L	20160301	0836	7.9	344 ‡	2680 ‡	213 †	161 ‡	292 ‡	143 ‡	5.6	144	299	1303 ‡	34 ‡	2.2 ‡	< 0.1	< 0.025	0.066

Site Identifier: 2527DB00010 **Number:** HSW-10 **Site Name:** SLAG SPIRAL PLANT SUMP

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-10	X	20160302	1531	8.1	293 ‡	2088 ‡	93	106 ‡	275 ‡	213 ‡	7.7	248	210	769 ‡	48 ‡	5.1 ‡	< 0.1	0.134	0.173 †

Site Identifier: 2527DB00011 **Number:** HSW-11 **Site Name:** EASTERN HARTEBEESPOORT IRRIGATION CANAL

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-11	C	20160303	1444	8.6	53.8	300	40	15	44	9.2	4.9	156	39	61	0.4	0.2	< 0.1	< 0.025	< 0.025

Chemistry Standard: SANS241:2015 Drinking Water S
† Value exceeds recommended maximum limit
‡ Value exceeds maximum allowable limit
! Value exceeds recommended minimum limit
¡ Value exceeds minimim allowable limit

Concentrations in [mg/l] where applicable
EC [mS/m]
Nitrate as N

Sample Type Code Explanation:
B: Borehole
C: Canal
D: Drinking water
E: Effluent
F: Fountains
K: Sewage
L: Dam, Pan, Lake
O: Organic
P: Pressed or pellet

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

TIME DEPENDENT CHEMISTRY REPORT

Date compiled: 2016/07/04

Site Identifier: 2527DB00012 **Number:** HSW-12 **Site Name:** TRIBUTARY - MIDSTREAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-12	V	20160303	1451	8.2	130	842	69	78 †	88	4.7	17.9	296	118	183	19 †	0.2	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00013 **Number:** HSW-13 **Site Name:** TRIBUTARY - DOWNSTREAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-13	V	20160303	1509	8.2	119	766	59	62	96	3.1	17.4	220	119	147	27 ‡	0.2	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00014 **Number:** HSW-14 **Site Name:** TRIBUTARY - UPSTREAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-14	V	20160303	1542	8.2	130	858	74	88 †	84	4	18.4	344	113	187	15 †	0.2	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00015 **Number:** HSW-15 **Site Name:** NORTHERN FARMERS DAM

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-15	L	20160303	1625	8	56	312	41	15	40	10.6	5.3	172	45	42	< 0.1	0.2	< 0.1	0.03	0.193 †

Site Identifier: 2527DB00016 **Number:** HSW-16 **Site Name:** OPEN PIT

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-16	L	20160304	1309	8.3	91.4	560	32	72 †	51	15.5	15	316	29	141	6.7	0.5	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00017 **Number:** HSW-17 **Site Name:** GROUT PLANT SUMP

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-17	L	20160307	1152	8.3	43.8	280	32	3	34	25	12.5	52	25	115	< 0.1	0.3	< 0.1	< 0.025	< 0.025

Site Identifier: 2527DB00018 **Number:** HSW-18 **Site Name:**

Samp. Nr./Type		Date/Time samp.		pH	EC	TDS	Ca	Mg	Na	K	Si	T. Alk.	Cl	SO4	NO3 as N	F	Al	Fe	Mn
HSW-18	L	20160330	1247	8.1	114	708	54	44	97	41	3.1	228	75	244	3.8	1.6 ‡	< 0.1	< 0.025	< 0.025

Chemistry Standard: SANS241:2015 Drinking Water S Concentrations in [mg/l] where applicable
† Value exceeds recommended maximum limit EC [mS/m]
‡ Value exceeds maximum allowable limit Nitrate as N
! Value exceeds recommended minimum limit
¡ Value exceeds minimim allowable limit

Sample Type Code Explanation:
B: Borehole
C: Canal
D: Drinking water
E: Effluent
F: Fountains
K: Sewage
L: Dam, Pan, Lake
O: Organic
P: Pressed or pellet

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

TIME DEPENDENT CHEMISTRY REPORT

Date compiled: 2016/07/04

Site Identifier: 2527DB00001 **Number:** HSW-1 **Site Name:** SLIMES DAM RETURN WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-1 L	20160226 1016	9.9 ‡	26 ‡	< 0.1	319	0.313	< 0.01	< 0.02	< 0.025	< 0.01	0.057 ‡	0.027	< 0.025	0.098 ‡	< 0.025	< 0.025	0.025

Site Identifier: 2527DB00003 **Number:** HSW-3 **Site Name:** PLANT STORM WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-3 L	20160226 1112	1.1	25 ‡	< 0.1	352	0.318	< 0.01	< 0.02	< 0.025	< 0.01	0.031 ‡	0.046	< 0.025	0.049	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00004 **Number:** HSW-4 **Site Name:** PROCESS WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-4 L	20160226 1122	26 ‡	29 ‡	0.1	347	0.429	< 0.01	< 0.02	< 0.025	< 0.01	0.045 ‡	0.038	< 0.025	0.084 ‡	< 0.025	< 0.025	0.025

Site Identifier: 2527DB00005 **Number:** HSW-5 **Site Name:** DRINKING WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-5 L	20160226 1133	1	1.2 ‡	0.7	32	0.037	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00006 **Number:** HSW-6 **Site Name:** OB PLANT WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-6 L	20160226 1148	11 ‡	27 ‡	< 0.1	321	0.293	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	0.079 ‡	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00007 **Number:** HSW-7 **Site Name:** MORULA DEWATERING DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-7 L	20160226 1322	0.1	0.1	< 0.1	72	0.067	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	0.075 ‡	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00008 **Number:** HSW-8 **Site Name:** HH RETURN WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-8 L	20160229 0931	0.9	5 ‡	< 0.1	1900	0.736	< 0.01	< 0.02	< 0.025	< 0.01	0.049 ‡	< 0.025	3.2 ‡	0.047	< 0.025	0.133	< 0.025

Site Identifier: 2527DB00009 **Number:** HSW-9 **Site Name:** CHROME RECOVERY PLANT DIRTY WATER DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-9 L	20160301 0836	2.6 ‡	6 ‡	< 0.1	574	0.191	< 0.01	< 0.02	< 0.025	< 0.01	0.035 ‡	< 0.025	< 0.025	0.071 ‡	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00010 **Number:** HSW-10 **Site Name:** SLAG SPIRAL PLANT SUMP

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-10 X	20160302 1531	4 ‡	19 ‡	< 0.1	345	0.238	< 0.01	< 0.02	< 0.025	< 0.01	0.035 ‡	< 0.025	< 0.025	0.068	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00011 **Number:** HSW-11 **Site Name:** EASTERN HARTEBEESPOORT IRRIGATION CANAL

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-11 C	20160303 1444	2.4 ‡	0.3	0.9	27	0.036	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Chemistry Standard: SANS241:2015 Drinking Water S
† Value exceeds recommended maximum limit
‡ Value exceeds maximum allowable limit
! Value exceeds recommended minimum limit
¡ Value exceeds minimim allowable limit

Concentrations in [mg/l] where applicable
Ammonia as N

Sample Type Code Explanation:
B: Borehole
C: Canal
D: Drinking water
E: Effluent
F: Fountains
K: Sewage
L: Dam, Pan, Lake
O: Organic
P: Pressed or pellet

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

TIME DEPENDENT CHEMISTRY REPORT Date compiled: 2016/07/04

Site Identifier: 2527DB00012 **Number:** HSW-12 **Site Name:** TRIBUTARY - MIDSTREAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-12 V	20160303 1451	0.2	< 0.05	< 0.1	82	0.043	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00013 **Number:** HSW-13 **Site Name:** TRIBUTARY - DOWNSTREAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-13 V	20160303 1509	0.2	< 0.05	< 0.1	49	0.07	< 0.01	< 0.02	< 0.025	0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00014 **Number:** HSW-14 **Site Name:** TRIBUTARY - UPSTREAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-14 V	20160303 1542	0.1	< 0.05	< 0.1	66	0.075	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00015 **Number:** HSW-15 **Site Name:** NORTHERN FARMERS DAM

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-15 L	20160303 1625	3.2 ‡	< 0.05	1.1	16	0.056	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00016 **Number:** HSW-16 **Site Name:** OPEN PIT

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-16 L	20160304 1309	0.3	0.2	< 0.1	44	0.103	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	0.247 ‡	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00017 **Number:** HSW-17 **Site Name:** GROUT PLANT SUMP

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-17 L	20160307 1152	0.1	< 0.05	< 0.1	33	0.292	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	0.033	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Site Identifier: 2527DB00018 **Number:** HSW-18 **Site Name:**

Samp. Nr./Type	Date/Time samp.	NH4 as N	NO2 as N	PO4	S	B	As	Sb	Bi	Cu	Pb	Zn	Cr	Ni	Ti	Mo	Co
HSW-18 L	20160330 1247	0.4	0.5	< 0.1	105	0.118	< 0.01	< 0.02	< 0.025	< 0.01	< 0.01	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025	< 0.025

Chemistry Standard: SANS241:2015 Drinking Water S Concentrations in [mg/l] where applicable
† Value exceeds recommended maximum limit Ammonia as N
‡ Value exceeds maximum allowable limit
! Value exceeds recommended minimum limit
¡ Value exceeds minimim allowable limit

Sample Type Code Explanation:
B: Borehole
C: Canal
D: Drinking water
E: Effluent
F: Fountains
K: Sewage
L: Dam, Pan, Lake
O: Organic
P: Pressed or pellet

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

TIME DEPENDENT CHEMISTRY REPORT

Date compiled: 2016/07/04

Site Identifier: 2527DB00001 **Number:** HSW-1 **Site Name:** SLIMES DAM RETURN WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-1	L	20160226	1016	0.076	0.461	0.004 ‡	< 0.025	< 0.025	0.081	< 0.01	

Site Identifier: 2527DB00003 **Number:** HSW-3 **Site Name:** PLANT STORM WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-3	L	20160226	1112	0.116	0.508	< 0.003	< 0.025	< 0.025	0.078	< 0.01	

Site Identifier: 2527DB00004 **Number:** HSW-4 **Site Name:** PROCESS WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-4	L	20160226	1122	0.062	0.386	< 0.003	< 0.025	< 0.025	0.08	< 0.01	

Site Identifier: 2527DB00005 **Number:** HSW-5 **Site Name:** DRINKING WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-5	L	20160226	1133	0.035	0.143	< 0.003	< 0.025	< 0.025	< 0.025	< 0.01	

Site Identifier: 2527DB00006 **Number:** HSW-6 **Site Name:** OB PLANT WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-6	L	20160226	1148	0.093	0.471	< 0.003	< 0.025	< 0.025	0.084	< 0.01	

Site Identifier: 2527DB00007 **Number:** HSW-7 **Site Name:** MORULA DEWATERING DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-7	L	20160226	1322	0.039	0.198	< 0.003	< 0.025	< 0.025	0.027	< 0.01	

Site Identifier: 2527DB00008 **Number:** HSW-8 **Site Name:** HH RETURN WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-8	L	20160229	0931	0.054	0.368	0.004 ‡	0.83	< 0.025	0.08	0.068 ‡	

Site Identifier: 2527DB00009 **Number:** HSW-9 **Site Name:** CHROME RECOVERY PLANT DIRTY WATER DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-9	L	20160301	0836	0.077	0.594	< 0.003	< 0.025	< 0.025	0.083	< 0.01	

Site Identifier: 2527DB00010 **Number:** HSW-10 **Site Name:** SLAG SPIRAL PLANT SUMP

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-10	X	20160302	1531	< 0.025	0.286	< 0.003	< 0.025	< 0.025	0.082	< 0.01	

Site Identifier: 2527DB00011 **Number:** HSW-11 **Site Name:** EASTERN HARTEBEESPOORT IRRIGATION CANAL

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-11	C	20160303	1444	0.031	0.131	< 0.003	< 0.025	< 0.025	< 0.025	< 0.01	

Chemistry Standard: SANS241:2015 Drinking Water SConcentrations in [mg/l] where applicable
† Value exceeds recommended maximum limit
‡ Value exceeds maximum allowable limit
! Value exceeds recommended minimum limit
¡ Value exceeds minimim allowable limit

Sample Type Code Explanation:
B: Borehole
C: Canal
D: Drinking water
E: Effluent
F: Fountains
K: Sewage
L: Dam, Pan, Lake
O: Organic
P: Pressed or pellet

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

TIME DEPENDENT CHEMISTRY REPORT Date compiled: 2016/07/04

Site Identifier: 2527DB00012 **Number:** HSW-12 **Site Name:** TRIBUTARY - MIDSTREAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-12	V	20160303	1451	0.054	0.359	< 0.003	< 0.025	< 0.025	0.041	< 0.01	

Site Identifier: 2527DB00013 **Number:** HSW-13 **Site Name:** TRIBUTARY - DOWNSTREAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-13	V	20160303	1509	0.065	0.268	< 0.003	< 0.025	< 0.025	0.039	< 0.01	

Site Identifier: 2527DB00014 **Number:** HSW-14 **Site Name:** TRIBUTARY - UPSTREAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-14	V	20160303	1542	0.059	0.396	< 0.003	< 0.025	< 0.025	0.043	< 0.01	

Site Identifier: 2527DB00015 **Number:** HSW-15 **Site Name:** NORTHERN FARMERS DAM

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-15	L	20160303	1625	0.037	0.13	< 0.003	< 0.025	< 0.025	< 0.025	< 0.01	

Site Identifier: 2527DB00016 **Number:** HSW-16 **Site Name:** OPEN PIT

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-16	L	20160304	1309	0.051	0.163	< 0.003	< 0.025	< 0.025	0.025	< 0.01	

Site Identifier: 2527DB00017 **Number:** HSW-17 **Site Name:** GROUT PLANT SUMP

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-17	L	20160307	1152	0.033	0.173	< 0.003	0.438	< 0.025	< 0.025	< 0.01	

Site Identifier: 2527DB00018 **Number:** HSW-18 **Site Name:**

Samp. Nr./Type		Date/Time samp.		Ba	Sr	Cd	Li	Ag	V	Se	Be
HSW-18	L	20160330	1247	0.06	0.259	< 0.003	< 0.025	< 0.025	0.028	< 0.01	< 0.025

JMA Consulting (Pty) Ltd
P O Box 883
Delmas
2210
Tel: (013) 665 1788
www.jmaconsult.co.za

CO ORDINATE LIST

MANHOLES

POINT	X+	Y-
MH1	2838214.598	86106.308
MH2	2838205.854	86103.483
MH3	2838183.940	86096.413
MH4	2838059.999	86056.559
MH5	2838069.023	86027.231
MH6	2838091.427	85953.887
MH7	2838113.639	85881.815
MH8	2838129.772	85829.252
MH9	2838157.581	85738.049
MH10	2838177.582	85672.526
MH11	2838209.124	85570.111
MH12	2838247.019	85508.306
MH13	2838282.616	85450.356
MH14	2838325.531	85380.494
MH15	2838364.787	85316.588
MH16	2838418.244	85229.564
MH17	2838449.777	85178.230
MH18	2838497.707	85196.597
MH19	2838544.501	85214.582
MH20	2838593.986	85233.349
MH21	2838609.198	85239.322
MH22	2838626.405	85272.755
MH23	2838586.129	85442.363
MH24	2838572.848	85500.041
MH25	2838545.678	85626.044

PENSTOCK

POINT	X+	Y-
PS1	2838405.861	85526.267
PS2	2838365.293	85501.298
PS3	2838336.687	85483.660
PS4	2838292.987	85883.105
PS5	2838244.267	85866.984
PS6	2838191.151	85849.398

DECANT OUTLET

POINT	X+	Y-
DO1	2838382.222	85107.099

SPILTTER BOX

POINT	X+	Y-
SB1	2838396.565	85264.854

CO ORDINATE LIST

BLANKET DRAIN

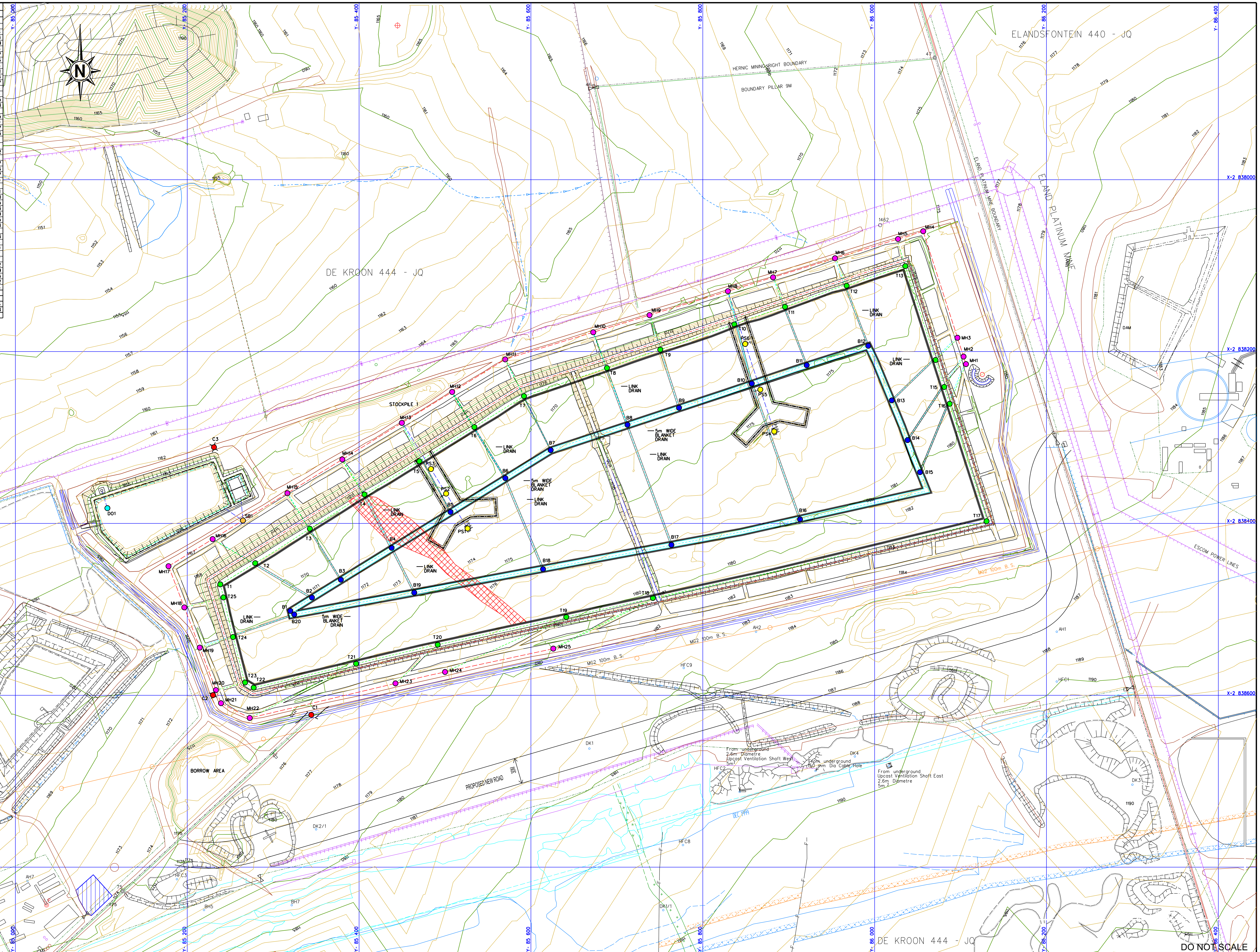
POINT	X+	Y-
B1	2838501.819	85319.987
B2	2838486.269	85345.168
B3	2838465.512	85378.784
B4	2838426.107	85442.599
B5	2838386.703	85506.413
B6	2838347.298	85570.227
B7	2838314.721	85622.986
B8	2838285.206	85712.363
B9	2838263.372	85778.481
B10	2838239.485	85850.244
B11	2838215.884	85920.947
B12	2838193.260	85992.613
B13	2838256.771	86019.953
B14	2838303.047	86038.325
B15	2838340.377	86052.778
B16	2838395.162	85913.130
B17	2838424.956	85763.535
B18	2838453.228	85614.080
B19	2838480.533	85464.237
B20	2838505.945	85324.536

LINK DRAINS

POINT	X+	Y-
T1	2838470.901	85238.442
T2	2838446.259	85279.111
T3	2838406.184	85342.737
T4	2838366.332	85406.276
T5	2838327.680	85470.237
T6	2838287.937	85534.160
T7	2838251.935	85591.932
T8	2838219.164	85688.451
T9	2838196.821	85753.780
T10	2838168.394	85836.725
T11	2838147.934	85895.703
T12	2838123.440	85967.459
T13	2838100.578	86035.755
T14	2838209.830	86070.928
T15	2838241.193	86081.018
T16	2838260.793	86087.323
T17	2838397.448	86130.286
T18	2838486.768	85741.940
T19	2838508.924	85641.092
T20	2838541.118	85491.497
T21	2838563.186	85396.542
T22	2838591.091	85277.359
T23	2838585.169	85267.325
T24	2838532.166	85253.282
T25	2838486.160	85242.156

CULVERTS

POINT	X+	Y-
C1	2838622.794	85344.416
C2	2838599.753	85229.978
C3	2838311.352	85231.135



A0

REV	BY	DATE	DESCRIPTION
Z	LDK	JUNE 2012	AS BUILT

DRG.No.	REFERENCE DRAWINGS	DRG.No.	REFERENCE DRAWINGS

APPROVED BY

NAME	QUALIFICATION & REG. No.	SIGNATURE	DATE
R.A. COOPER	PROFESSIONAL ENGINEER 950008		AUG 2012
L De KONING	PROFESSIONAL ENGINEER 20120163		AUG 2012

Stefanutti Stocks Mining Services
a division of Stefanutti Stocks (Pty) Ltd
Reg No. 2003/022221/07
Stratford Office Park (Block 6 & 7),
Cnr. Cedar Ave & Valley Rd, Broadacres, South Africa
PO Box 783697, Sandton, 2146, South Africa
Tel : +27 11 705 1111
Fax : +27 11 705 1908
ECMP
Stefanutti Stocks

CLIENT: HERNIC FERROCHROME

TITLE: MAROELABULT TAILINGS STORAGE FACILITY DRAINAGE SETTING OUT CO-ORDINATES

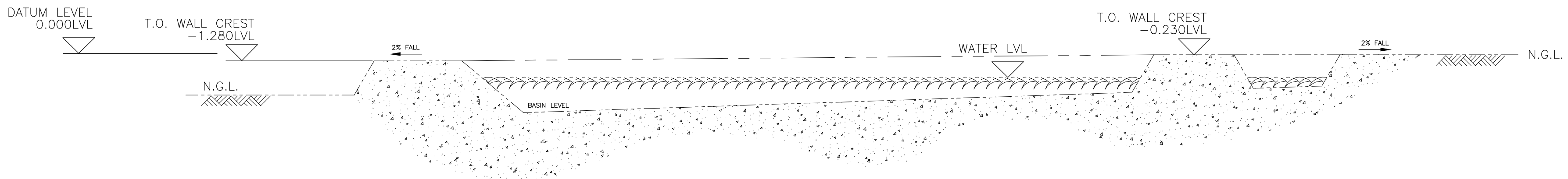
	BY	DATE
DESIGNED	LDK	JUN 2012
DRAWN	S.Q.	JUN 2012
CHECKED	LdK	AUG 2012

SCALE 1:1500

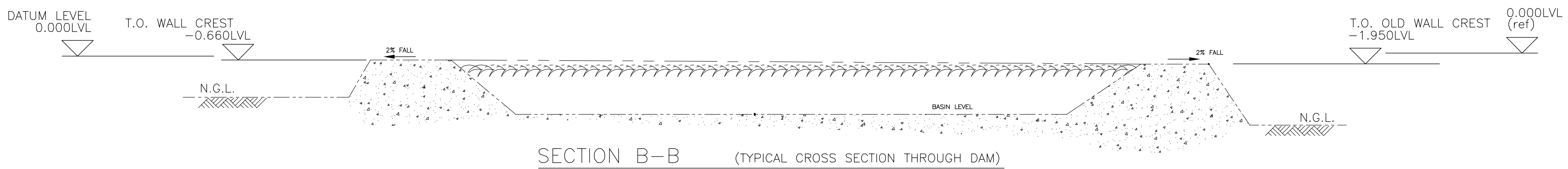
DRAWING No. T1022-104

REVISION Z

DO NOT SCALE



SECTION A–A (TYPICAL CROSS SECTION THROUGH DAM)

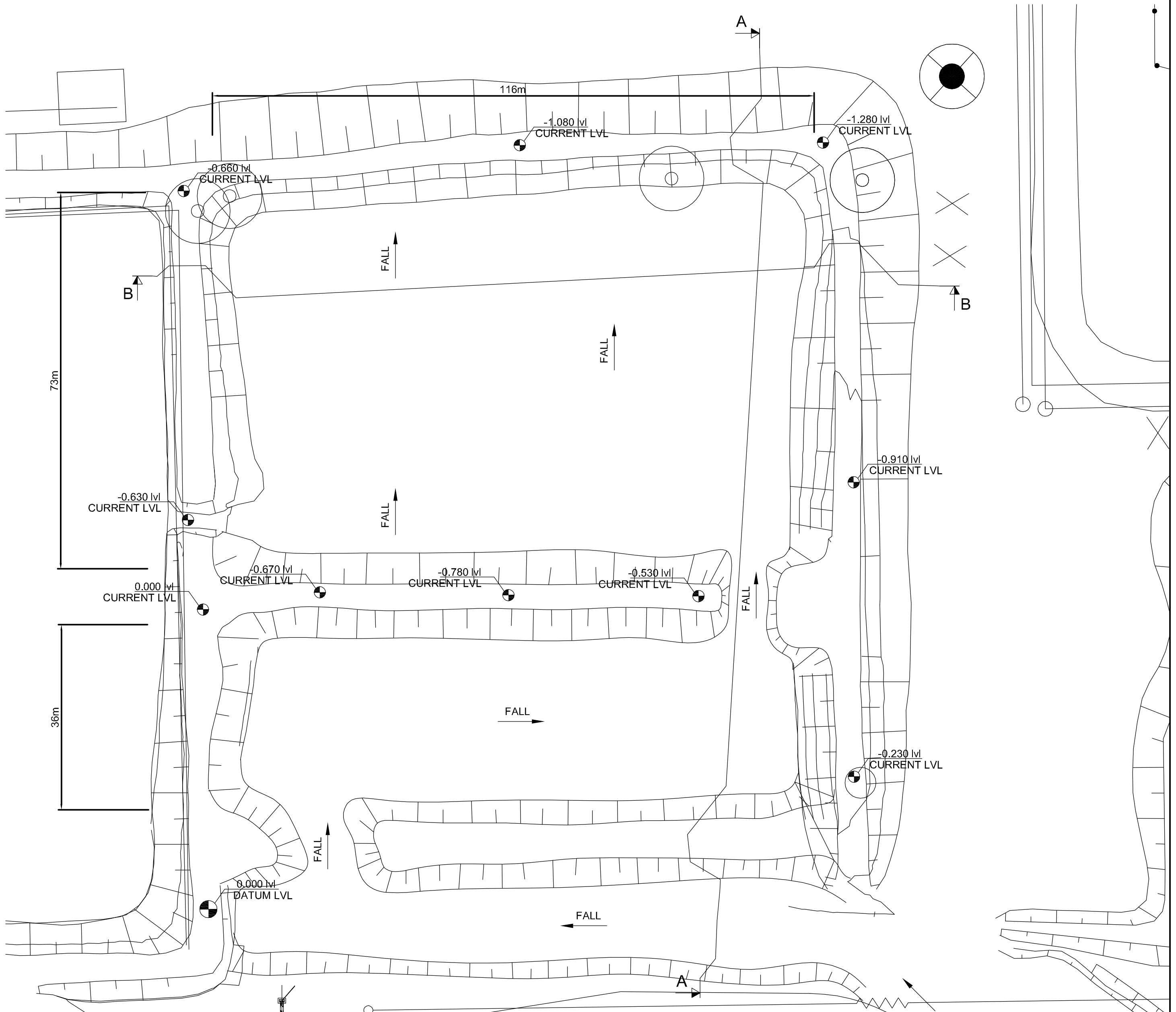


SECTION B–B (TYPICAL CROSS SECTION THROUGH DAM)

NOTE:

VOLUME OFF WATER AT +–3M DEEP = 38 000 m^3

COMPACTION = IN SITU MATERIAL TO BE RIPED, SCARIFY & RECOMPACTED TO 95% MOD AASHTO.
EXISTING FILL TO HAVE MINIMUM DENSITY OF 93% MOD AASHTO.



J.A. Rutkiewicz

APPROVAL

CHECKED		DATE 22.2.2011
PR. ENG.		DATE 22.2.2011

DRAWING No.	TITLE

REFERENCE DRAWINGS

DESCRIPTION	REV	DATE	BY	CHD	APPR.

REVISIONS

DESCRIPTION	REV	DATE	BY	CHD	APPR.
ISSUED FOR APROVAL	0	22.2.11	AO	JAR	JAR

REVISIONS

HERNIC FERROCHROME

P.O. Box. 4534
Brits
0250
Tel: 012–381 1100
Fax: 012–381 1111
E–mail: plant@hernic.co.za

DRAWN BY: A.Oosthuizen
DATE: 10/02/2011
CHECKED BY:
DATE:

APPROVAL

TITLE	SIGNATURE	DATE
MAINTANANCE MANAGER	O.T. KANIS	22.2.11
PLANT ENGINEER	J. MOSTERT	22.2.11

DRAWING TITLE
GENERAL PLANT & INFRASTRUCTURE
STORM WATER DAM LAYOUT

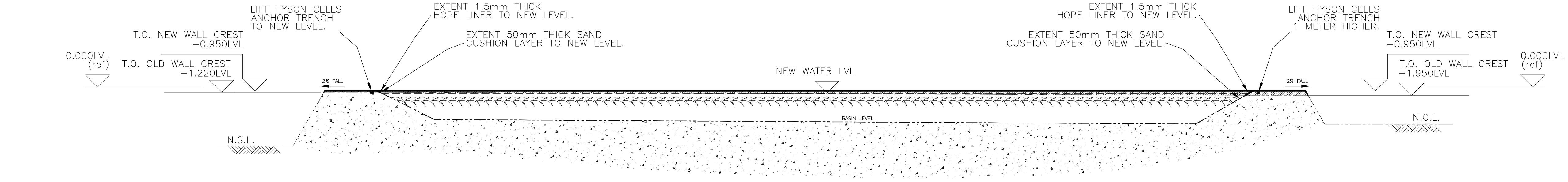
JOB No. 00–21–0156

SCALE.

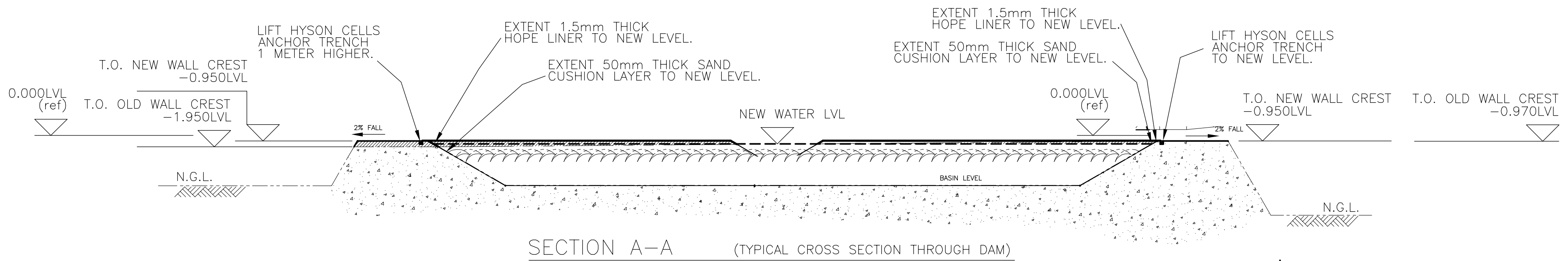
DRAWING NUMBER: 00–21–037 (AREA CODE – CLASS CODE – DOCUMENT NUMBER)

REV. 0

A1



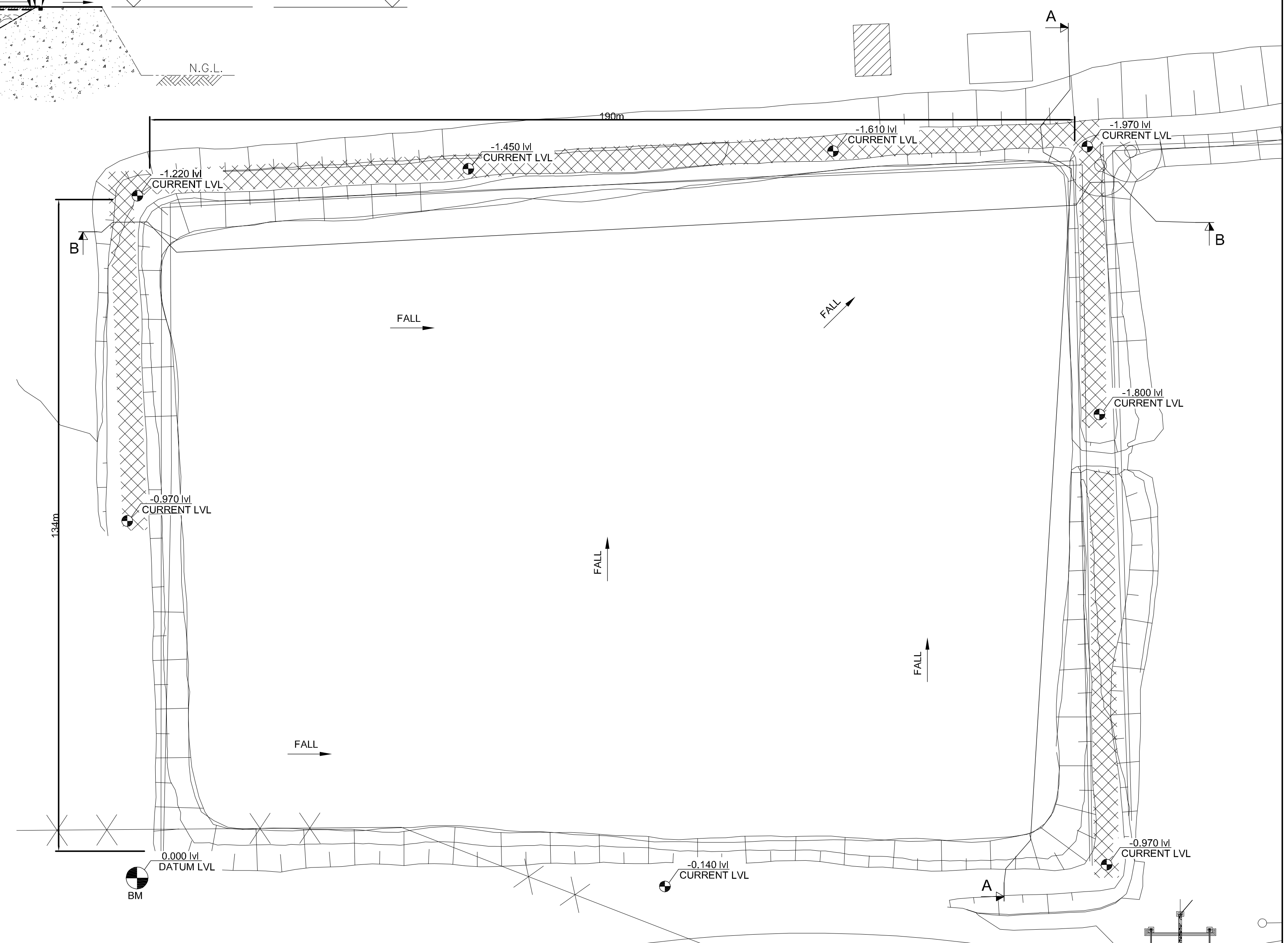
SECTION B–B (TYPICAL CROSS SECTION THROUGH DAM)



SECTION A–A (TYPICAL CROSS SECTION THROUGH DAM)

NOTE:

VOLUME m^3 = 1200 m^3
VOLUME OFF WATER AT +-3M DEEP= 76 000 m^3
COMPACTION = IN SITU MATERIAL TO BE RIPED, SCARIFY & RECOMPACTED TO 95% MOD AASHTO.
EXISTING FILL TO HAVE MINIMUM DENSITY OF 93% MOD AASHTO.



J.A. Rutkiewicz
Consulting Structural and Civil Engineer

APPROVAL

CHECKED		DATE 22.2.2011
PR. ENG.		DATE 22.2.2011

DRAWING No.	TITLE

REFERENCE DRAWINGS

DESCRIPTION	REV	DATE	BY	CHD	APPR.

REVISIONS

DESCRIPTION	REV	DATE	BY	CHD	APPR.
ISSUED FOR APROVAL	0	22.2.11	AO	JAR	JAR

REVISIONS

HERNIC FERROCHROME
P.O. Box. 4534
Brits
0250
Tel: 012-381 1100
Fax: 012-381 1111
E-mail: plant@hernic.co.za

DRAWN BY: A.Oosthuizen
DATE: 28/01/2011
CHECKED BY:
DATE:

APPROVAL

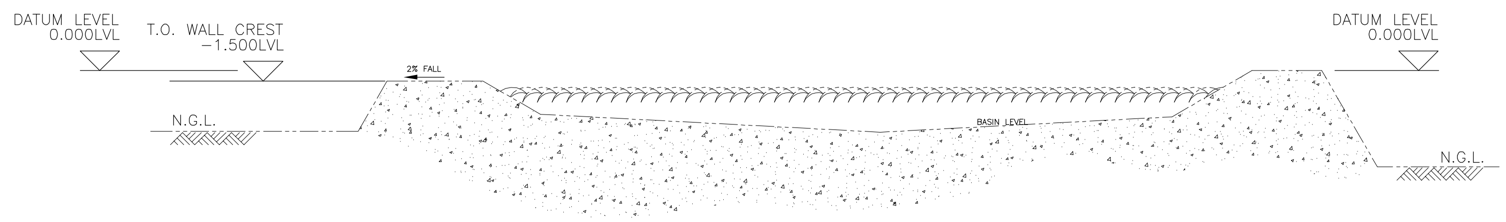
TITLE	SIGNATURE	DATE
MAINTANANCE MANAGER	O.T. KANIS	22.2.11
PLANT ENGINEER	J. MOSTERT	22.2.11

DRAWING TITLE
GENERAL PLANT & INFRASTRUCTURE
PROCESS WATER DAM LAYOUT

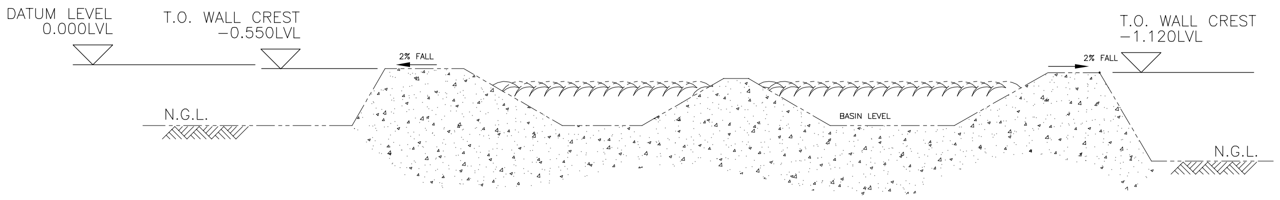
JOB No. 00–21–0156
SCALE.

DRAWING NUMBER: 00–21–036 (AREA CODE – CLASS CODE – DOCUMENT NUMBER)
REV.

A1



SECTION A–A (TYPICAL CROSS SECTION THROUGH DAM)

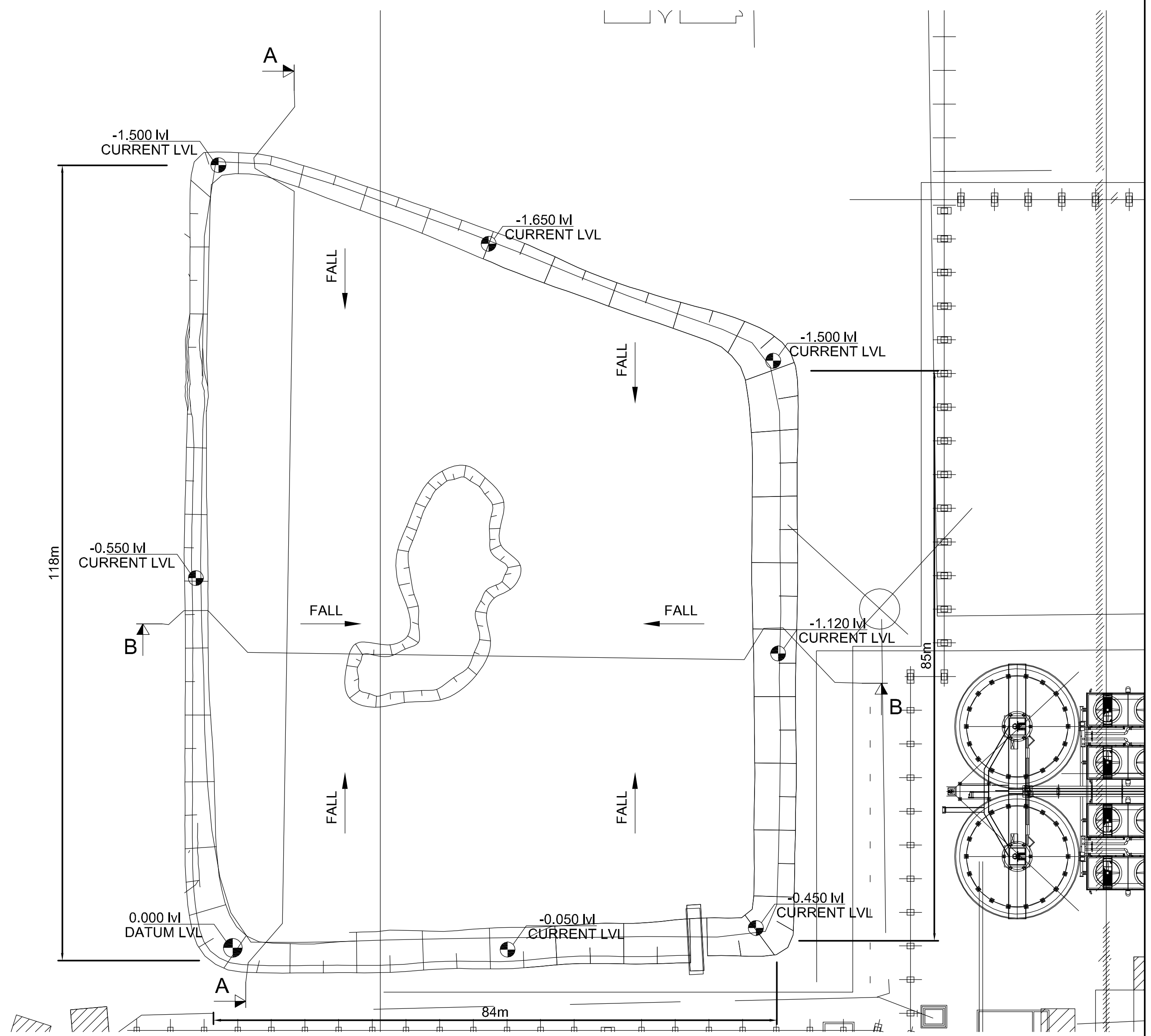


SECTION B–B (TYPICAL CROSS SECTION THROUGH DAM)

NOTE:

VOLUME OFF WATER AT +−3.5M DEEP= 30 000m^3

COMPACTION = IN SITU MATERIAL TO BE RIPED, SCARIFY & RECOMPACTED TO 95% MOD AASHTO.
EXISTING FILL TO HAVE MINIMUM DENSITY OF 93% MOD AASHTO.



APPROVAL

J.A. Rutkewicz
Consulting Structural and Civil Engineer

CHECKED		DATE 22.2.2011
PR. ENG.		DATE 22.2.2011

DRAWING No.	TITLE

REFERENCE DRAWINGS

DESCRIPTION	REV	DATE	BY	CHD	APPR.

REVISIONS

DESCRIPTION	REV	DATE	BY	CHD	APPR.
ISSUED FOR APROVAL	0	22.2.11	AO	JAR	JAR

REVISIONS

HERNIC FERROCHROME

P.O. Box. 4534
Brits
0250
Tel: 012−381 1100
Fax: 012−381 1111
E−mail: plant@hernic.co.za

DRAWN BY: A.Oosthuizen
DATE: 09/02/2011
CHECKED BY:
DATE:

APPROVAL

TITLE	SIGNATURE	DATE
MAINTANANCE MANAGER	O.T. KANIS	22.2.11
PLANT ENGINEER	J. MOSTERT	22.2.11

DRAWING TITLE

GENERAL PLANT & INFRASTRUCTURE

DRINKING WATER DAM LAYOUT

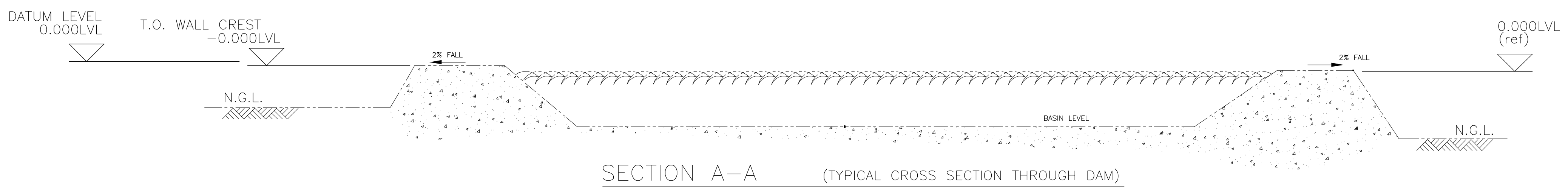
JOB No. 00−21−0156

SCALE.

DRAWING NUMBER: 00−21−035 (AREA CODE / CLASS CODE / DOCUMENT NUMBER)

REV. 0

A1

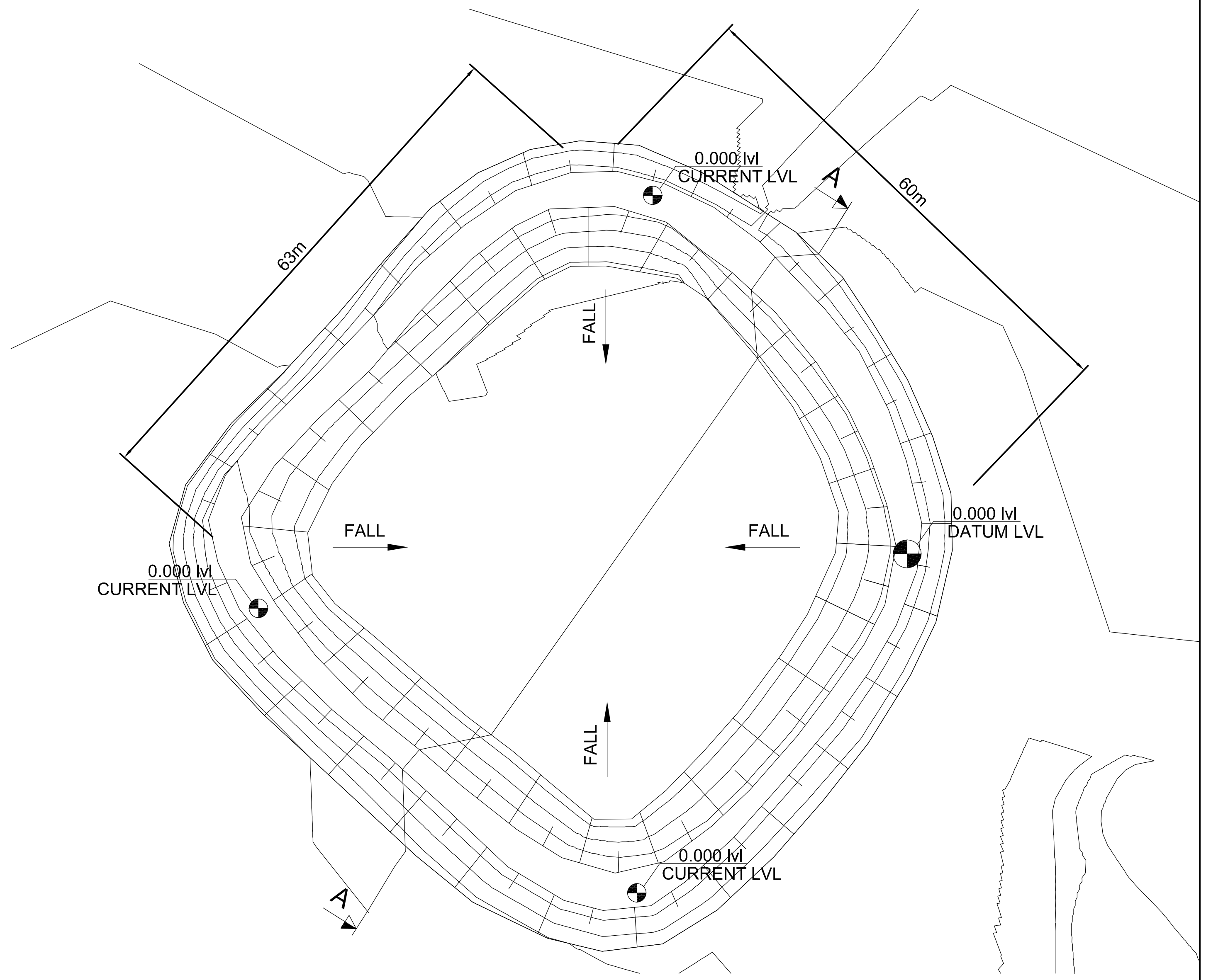


SECTION A–A (TYPICAL CROSS SECTION THROUGH DAM)

NOTE:

VOLUME OFF WATER AT +–3M DEEP = 12 000 m^3

COMPACTION = IN SITU MATERIAL TO BE RIPED, SCARIFY & RECOMPACTED TO 95% MOD AASHTO.
EXISTING FILL TO HAVE MINIMUM DENSITY OF 93% MOD AASHTO.



J.A. Rutkiewicz
Consulting Structural and Civil Engineer

APPROVAL

CHECKED		DATE 22.2.2011
PR. ENG.		DATE 22.2.2011

DRAWING No.	TITLE

REFERENCE DRAWINGS

DESCRIPTION	REV	DATE	BY	CHD	APPR.

REVISIONS

DESCRIPTION	REV	DATE	BY	CHD	APPR.
ISSUED FOR APROVAL	0	22.2.11	AO	JAR	JAR

REVISIONS

HERNIC FERROCHROME

P.O. Box. 4534
Brits
0250
Tel: 012–381 1100
Fax: 012–381 1111
E–mail: plant@hernic.co.za

DRAWN BY: A.Oosthuizen
DATE: 10/02/2011
CHECKED BY:
DATE:

APPROVAL

TITLE	SIGNATURE	DATE
MAINTANANCE MANAGER	O.T. KANIS	22.2.11
PLANT ENGINEER	J. MOSTERT	22.2.11

DRAWING TITLE

GENERAL PLANT & INFRASTRUCTURE
HERNIC UNDER GROUND MINE WASTE
WATER DAM LAYOUT

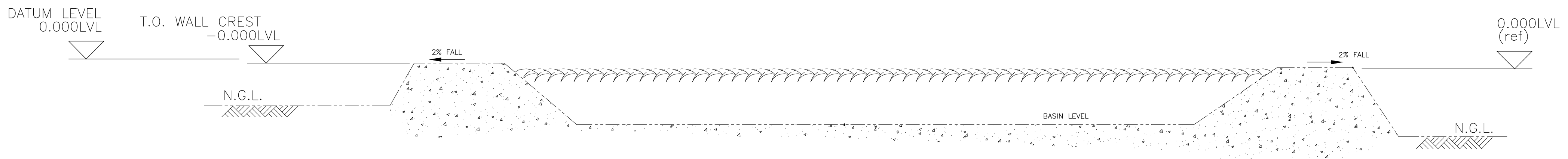
JOB No. 00–21–0156

SCALE.

DRAWING NUMBER: 00–21–039 (AREA CODE – CLASS CODE – DOCUMENT NUMBER)

REV. 0

A1

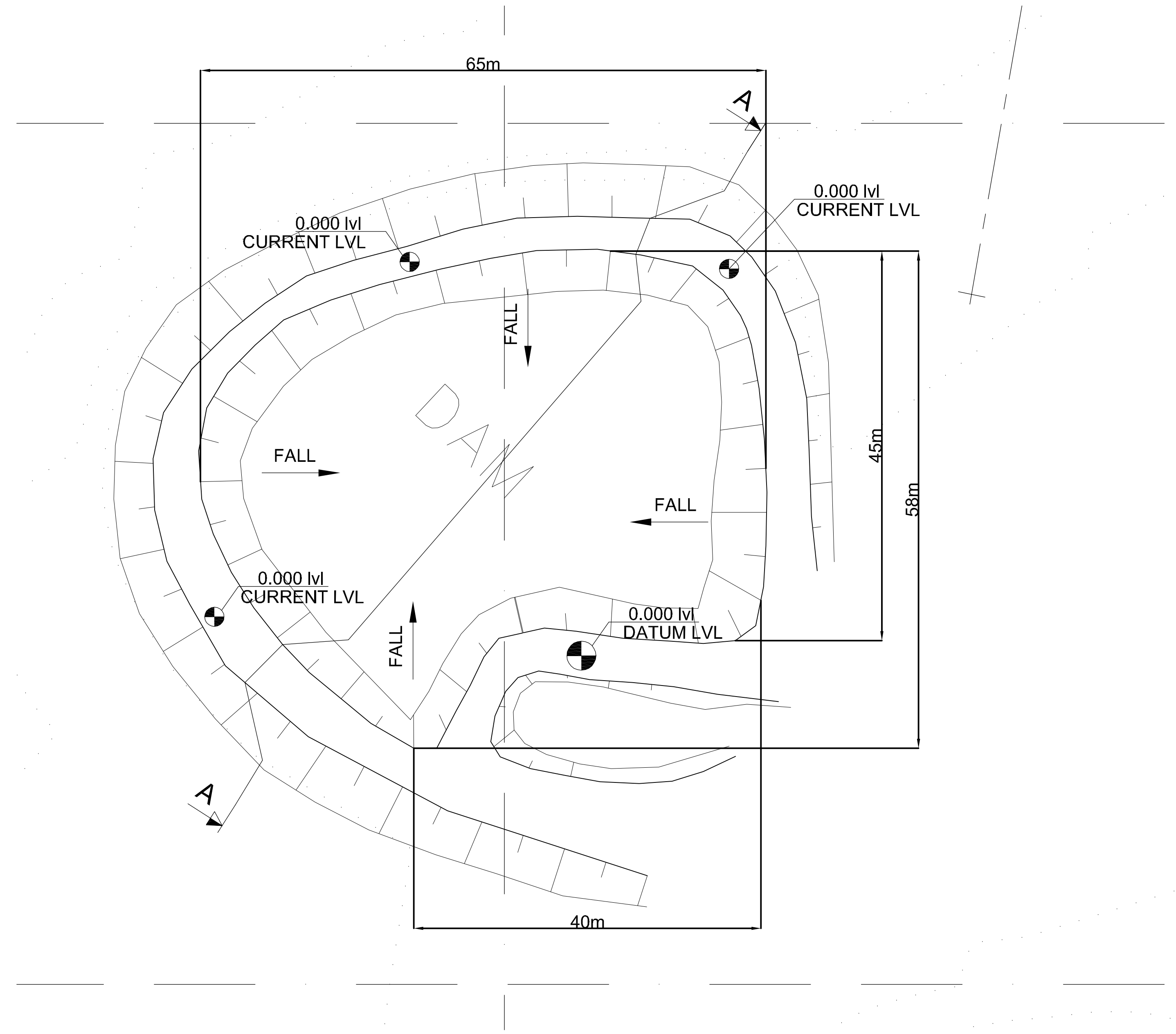


SECTION A–A (TYPICAL CROSS SECTION THROUGH DAM)

NOTE:

VOLUME OFF WATER AT +–3M DEEP = 9 000 m^3

COMPACTION = IN SITU MATERIAL TO BE RIPED, SCARIFY & RECOMPACTED TO 95% MOD AASHTO.
EXISTING FILL TO HAVE MINIMUM DENSITY OF 93% MOD AASHTO.



								ISSUED FOR APPROVAL	0	5.5.11	CVN	JAR	JAR
DRAWING No.	TITLE	DESCRIPTION	REV	DATE	BY	CHD	APPR.	DESCRIPTION	REV	DATE	BY	CHD	APPR.
REFERENCE DRAWINGS		REVISIONS						REVISIONS					

APPROVAL

J.A. Rutkiewicz
Consulting Structural and Civil Engineer

CHECKED — DATE 5.5.2011
PR. ENG. — DATE 5.5.2011

HERNIC FERROCHROME
P.O. Box. 4534
Brits
0250
Tel: 012–381 1100
Fax: 012–381 1111
E–mail: plant@hernic.co.za

DRAWN BY: A.Oosthuizen
DATE: 05/05/2011
CHECKED BY:
DATE:

APPROVAL		
TITLE	SIGNATURE	DATE
MAINTANANCE MANAGER	O.T. KANIS	5.5.11
PLANT ENGINEER	J. MOSTERT	5.5.11

DRAWING TITLE
GENERAL PLANT & INFRASTRUCTURE
HERNIC CRP WATER DAM LAYOUT

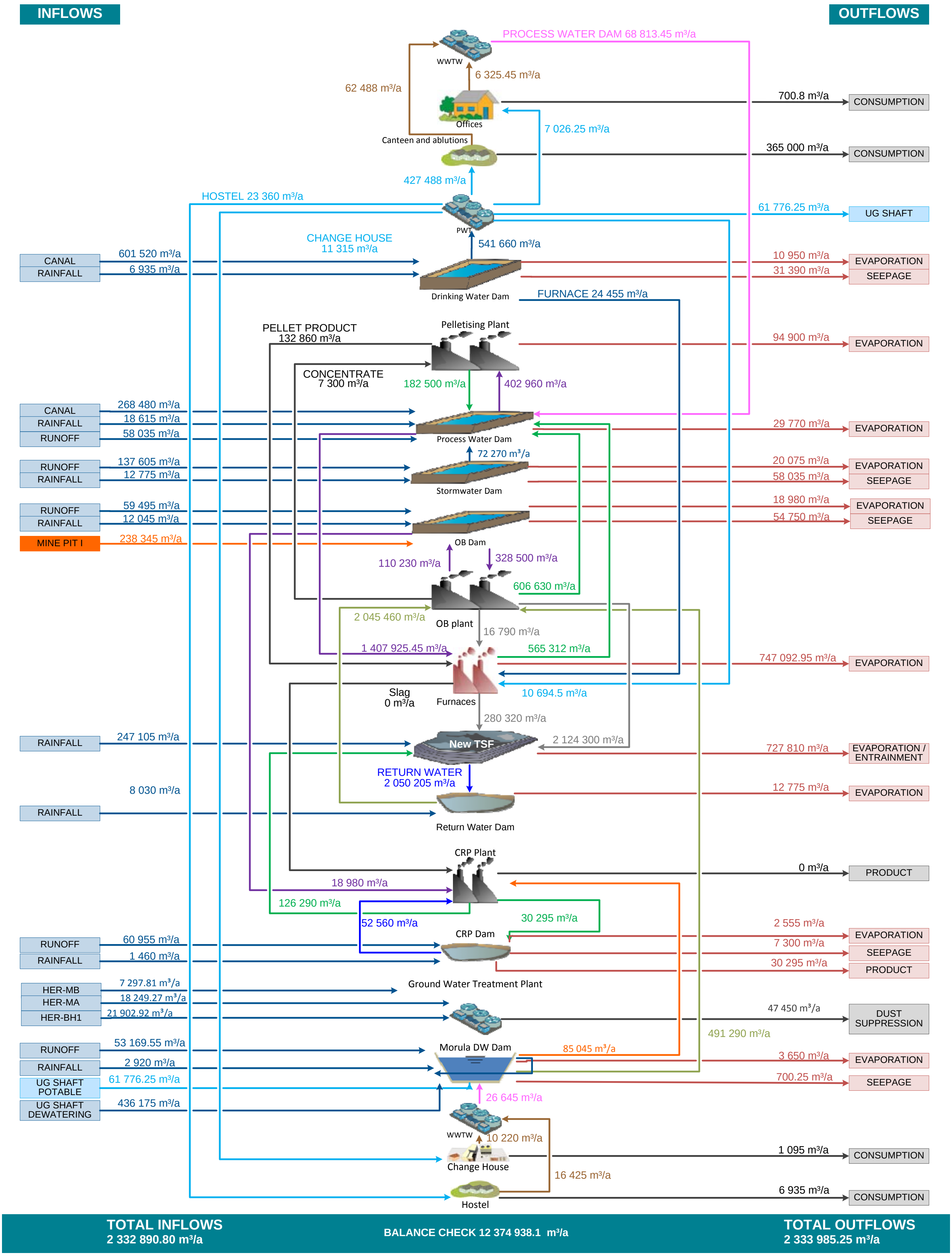
JOB No. 00–21–0156
SCALE.

DRAWING NUMBER: 00–21–040 (AREA CODE / CLASS CODE / DOCUMENT NUMBER)
REV. 0

A1

HERNIC MORULA WATER BALANCE

Mean annual flow rates



APPENDIX 8(A)

SHEQ Toolbox Talk Forum Programme for 2017

Month	**Topic**
January 2017	Waste Segregation
February 2017	Dust Management
March 2017	Water Conservation
April 2017	Air Pollution
May 2017	Reporting Environmental Incidents
June 2017	Caring for the Environment
July 2017	Waste Management
August 2017	Water Pollution
September 2017	Noise Pollution
October 2017	Environmental Awareness
November 2017	Alien Plants
December 2017	Erosion Control