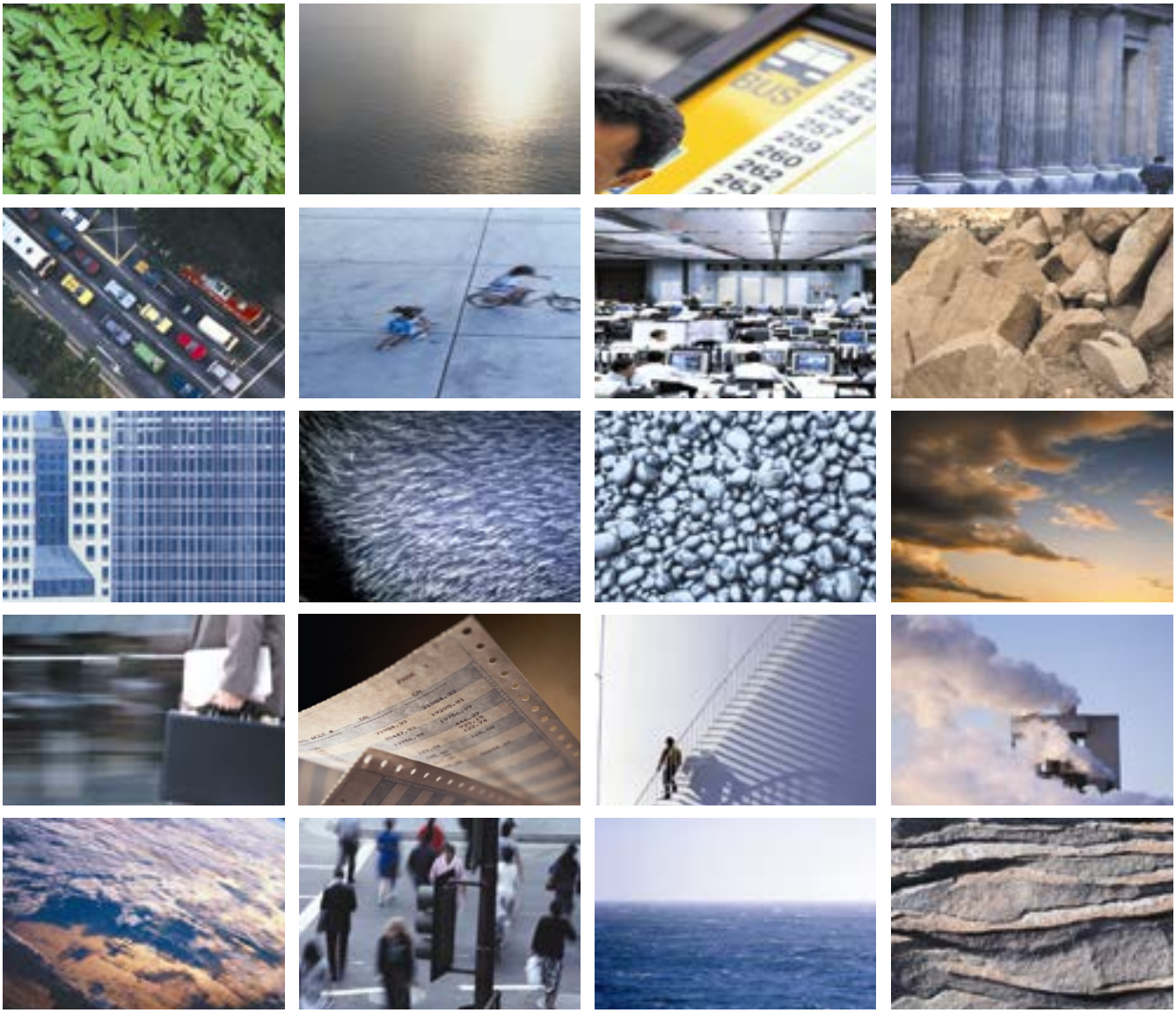
ANNEXURE-I

ENVIRONMENTAL MANAGEMENT PROGRAM



Draft Environmental Management Programme for the Gamsberg Zinc Mine and Associated Infrastructure in the Northern Cape

Black Mountain Mining (Pty) Ltd

May 2013

www.erm.com

Revision Description Sheet

Rev.	Section / Para.	Revision Description

CONTENTS

ABBREVIATIONS

AEL	Atmospheric Emissions License
BMM	Black Mountain Mining (Pty) Ltd
CEMPr	Construction Environmental Management Programme
DEA	Department of Environmental Affairs
DENC	Department of Environment and Nature Conservation
DMR	Department of Mineral Resources
DWA	Department of Water Affairs
EA	Environmental Authorisation
ECO	Environmental Control Officer
ELC	Environmental Liaison Committee
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
HNC	Heritage Northern Cape
MPRDA	Minerals and Petroleum Resources Development Act (28 of 2002)
NCNCA	Northern Cape Nature conservation Act (No 9 of 2009)
NEMA	National Environmental Management Act (107 of 1998)
NEM: AQA	National Environmental Management: Air Quality Act (39 of 2008)
NEM: BA	National Environmental Management Act: Biodiversity Act (10 of 2004)
NEM: WA	National Environmental Management: Waste Act (59 of 2008)
NFA	National forestry Act (30 of 1998)
NHRA	National Heritage Resources Act (25 of 1999)
NWA	National Water Act (36 of 1998)
OEMPr	Operational Environmental Management Programme
OHS	Occupational Health and Safety Act (85 of 1998)
SAHRA	South African Heritage Resource Agency - the statutory national body responsible for heritage resource management.
WML	Waste Management License

Bund: Enclosure under / around a storage facility to contain any spillage.

Batch plant: Site for the large-scale mixing and production of concrete or plaster, and associated equipment and materials.

Contractor: The principal persons /company undertaking the construction of the Development.

- The main contractor as engaged by the Developer;
- Selected subcontractors; and
- Any other contractor from time to time engaged by the Developer directly in connection with the construction part of the Works.

Contaminated water: Water contaminated by the Contractor's activities, e.g. concrete water and runoff from plant/ personnel wash areas.

Construction camp: The area designated for all temporary site offices, storage sheds and areas, parking areas, maintenance workshops, staff welfare facilities, accommodation, etc.

Construction Environmental Management Programme (CEMPr): The construction phase Environmental Management Programme, containing the Environmental Specifications for Civil and Building Works, also forming part of the civils and building contract documentation.

Engineer: A person representing the Developer on site and who is responsible for the technical and contractual implementation of the works to be undertaken. This is usually the engineer, but may be any other person, such as an architect or project manager, authorized by the Developer to fulfil this role.

Environment: The surroundings within which humans exist and that are made up of the land, water and atmosphere of the earth, *viz*.:

- micro-organisms, plant and animal life;
- any part or combination of the above and the inter-relationships among and between them; and
- the physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

Environmental Education Programme: An environmental education course for the Contractor's management staff and labour force, which informs them

of the requirements of the CEMPr. The ECO will present and co-ordinate such courses.

Environmental Control Officer (ECO): The individual or company appointed by the Developer to ensure the implementation of the CEMPr and suitable environmental management practices on site for the duration of the construction phase of the project.

Environmental Liaison Committee (ELC): The committee responsible for implementing, amending and monitoring the application of the OEMPr. This shall be made up of representatives of the facility management and local authority.

Method Statement: A written submission by the Contractor to the Engineer and ECO in response to the Specifications or a request by the Engineer, setting out the plant, materials, labour and method the Contractor proposes using to carry out an activity, identified by the relevant specification or the Engineer when requesting the Method Statement, in such detail that the Engineer is enabled to assess whether the Contractor's proposal is in accordance with the Specifications and/or will produce results in accordance with the Specifications.

The Method Statement shall cover applicable details with regard to:

- construction procedures;
- materials and plant to be used;
- transport of materials and plant to and from site;
- how the plant/ material will be moved while on site;
- how and where material will be stored;
- the containment (or action to be taken if containment is not possible) of leaks or spills of any liquid or material that may occur;
- timing and location of activities;
- compliance/ non-compliance with the Specifications; and
- any other information deemed necessary by the Engineer.

No Go Areas: Areas identified as being environmentally sensitive in some manner and delineated on plan, and on the site with pegs or fencing, and which are out of bounds to unauthorised persons. Authorisation must be obtained prior to entry.

Operational Environmental Management Programme (OEMPr): The operation phase Environmental Management Programme, containing the Environmental Specifications for the ongoing maintenance and operational activities, also forming part of the contract documentation.

Potentially hazardous substance: A substance which, in the reasonable opinion of the Engineer, can have a deleterious effect on the environment.

Reasonable: Means, unless the context indicates otherwise, reasonable in the opinion of the Engineer after he has consulted with a person, not an employee of the Employer, suitably experienced in "environmental implementation plans" and "environmental management programmes" (both as defined in the National Environmental Management Act (No 107, 1998)).

Site: The boundary and extent of Development works and infrastructure, including any areas off the main site on which works are to be carried out in order to allow the Development to proceed successfully.

Solid waste: Means all solid waste, including construction debris, chemical waste, excess cement/ concrete, packaging materials, timber, tins and cans, drums, wire, nails, food and domestic waste (e.g. plastic packets and wrappers).

Specification: A technical description of the standards of materials and workmanship that the Contractor is to use in the Works to be executed, the performance of the Works when completed and the manner in which payment is to be made.

Works: The construction operations and all related and incidental works, such as site works, earthworks, installation of services, rehabilitation etc., in connection with the execution and carrying to completion of the Development.

Top material: This refers to any surface material in the construction area, whether it be soil, fine material or stones including vegetation.

Topsoil: Means the top 300 mm of soil and may include vegetation and rocks.

This Environmental Management Programme (1) (EMPr) is the mechanism by which Black Mountain Mining (herein referred to as BMM), a subsidiary of Vedanta Resources Plc., shall manage the significant environmental impacts associated with the Gamsberg zinc mine (referred to as the "Project"), situated near the town of Aggeneys, in the Northern Cape (refer to Locality Map in *Figure 1.1* below). It is intended that this EMP will serve both as a checklist and framework to effectively manage the implementation of all environmental mitigation actions and monitoring requirements.

This EMPr has been prepared in line with the requirements of the Vedanta's corporate standards, which provides the overarching guidance to the company for controlling and managing its construction, operational and decommissioning environmental impacts and aspects. Furthermore, Vedanta's Technical Standards on Environmental Management is to ensure that BMM manage the impacts to the environment through effective management systems and processes and that work towards improving our environmental performance. This technical standard is aligned with IFC Performance Standards (2012).

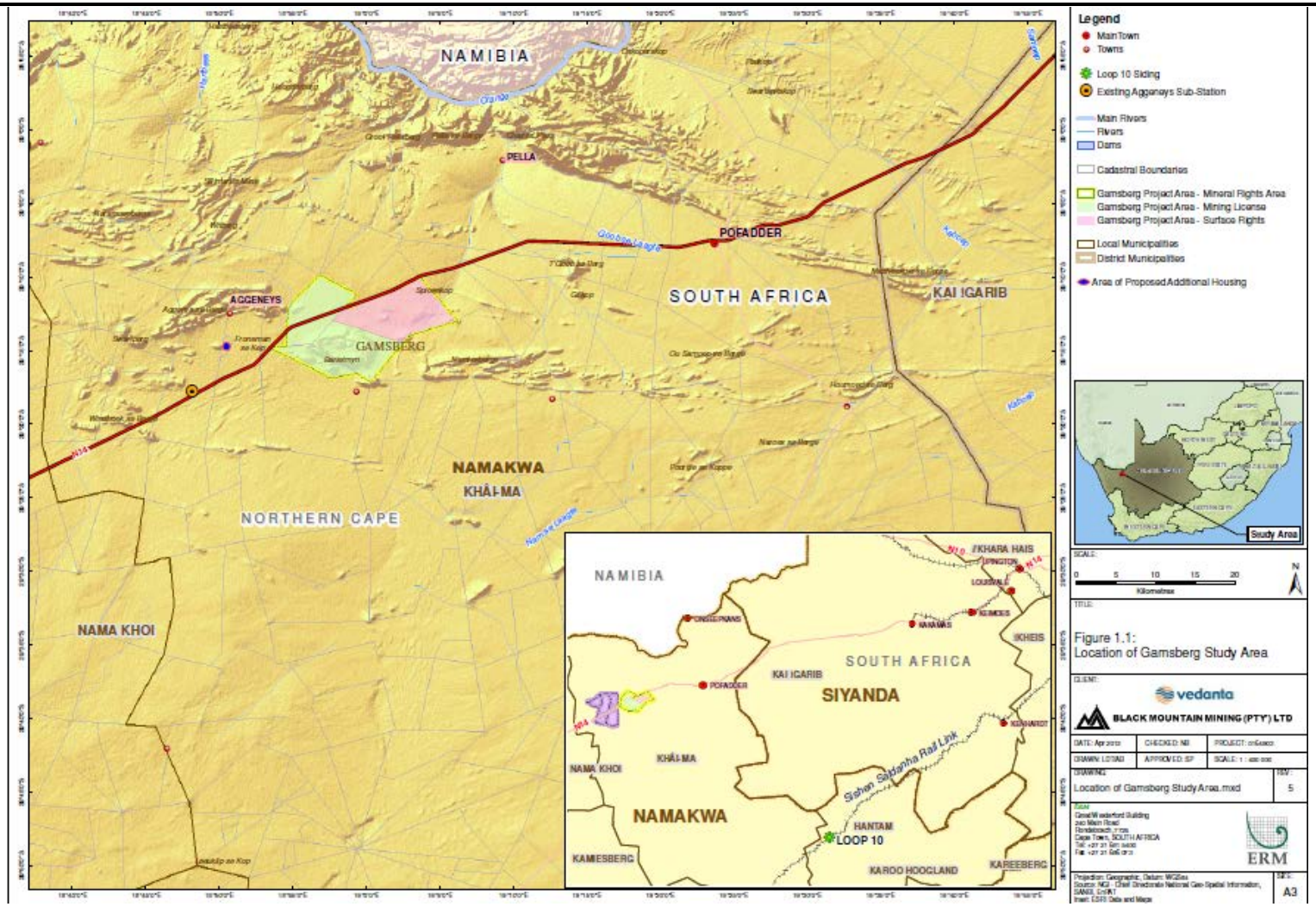
Compliance with the South African legislation and regulation is equally a foundation of this document as well as referencing applicable international standards such as the International Finance Corporation (IFC) Performance Standards and related Guidelines.

This EMPr relates specifically to the technical environmental aspects/impacts associated with currently 'permitted' activities associated with the Project, as described in this document. Chapter 2 provides a detailed description of the project activities and areas covered by this EMPr, which in summary include, *inter alia*:

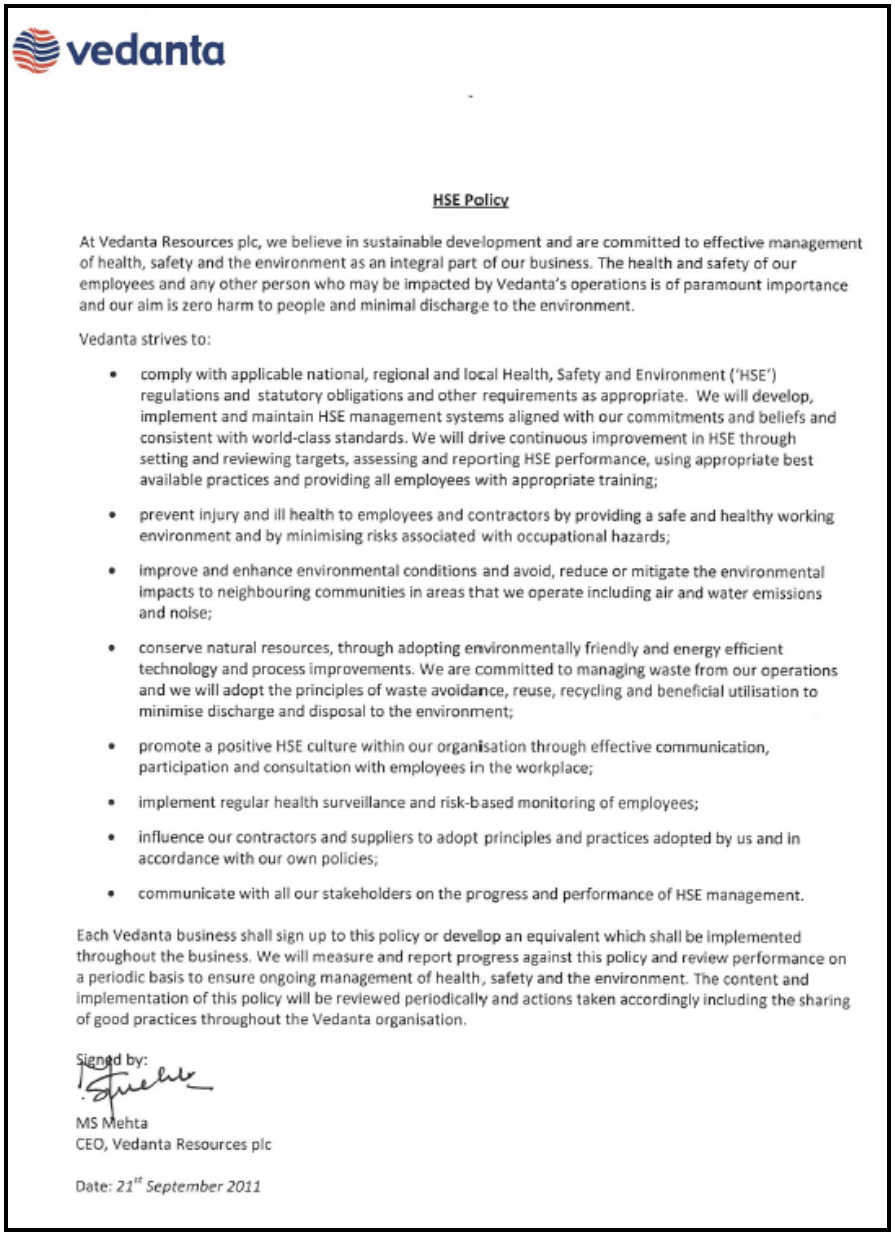
- Open pit area, including associated haul roads;
- Zinc concentrator plant and associated infrastructure (storage dams, access roads etc.);
- Closed conveyor system;
- Management of waste streams, including domestic waste from the operations and camp site, waste rock and tailings facility.
- Transport of zinc ore concentrate to the transhipment point for export; and
- Support infrastructure and activities such as the contractor camp, maintenance facilities, engineering workshops etc.

(1) Please note that a separate Social Management Plan has not been developed. This EMPr includes mitigation and management measures related to the social environment as well.

Figure 1.1 Locality Map



Vedanta Health, Safety and Environment (HSE) Policy will act as the guiding framework for the implementation of this EMPr. The Policy is presented below:



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HSE Policy

At Vedanta Resources plc, we believe in sustainable development and are committed to effective management of health, safety and the environment as an integral part of our business. The health and safety of our employees and any other person who may be impacted by Vedanta's operations is of paramount importance and our aim is zero harm to people and minimal discharge to the environment.

Vedanta strives to:

- comply with applicable national, regional and local Health, Safety and Environment ('HSE') regulations and statutory obligations and other requirements as appropriate. We will develop, implement and maintain HSE management systems aligned with our commitments and beliefs and consistent with world-class standards. We will drive continuous improvement in HSE through setting and reviewing targets, assessing and reporting HSE performance, using appropriate best available practices and providing all employees with appropriate training;
- prevent injury and ill health to employees and contractors by providing a safe and healthy working environment and by minimising risks associated with occupational hazards;
- improve and enhance environmental conditions and avoid, reduce or mitigate the environmental impacts to neighbouring communities in areas that we operate including air and water emissions and noise;
- conserve natural resources, through adopting environmentally friendly and energy efficient technology and process improvements. We are committed to managing waste from our operations and we will adopt the principles of waste avoidance, reuse, recycling and beneficial utilisation to minimise discharge and disposal to the environment;
- promote a positive HSE culture within our organisation through effective communication, participation and consultation with employees in the workplace;
- implement regular health surveillance and risk-based monitoring of employees;
- influence our contractors and suppliers to adopt principles and practices adopted by us and in accordance with our own policies;
- communicate with all our stakeholders on the progress and performance of HSE management.

Each Vedanta business shall sign up to this policy or develop an equivalent which shall be implemented throughout the business. We will measure and report progress against this policy and review performance on a periodic basis to ensure ongoing management of health, safety and the environment. The content and implementation of this policy will be reviewed periodically and actions taken accordingly including the sharing of good practices throughout the Vedanta organisation.

Signed by:

MS Mehta
CEO, Vedanta Resources plc

Date: *21st September 2011*

1.1 PROJECT RESPONSIBILITY AND MANAGEMENT FRAMEWORK

In 1988, Anglo American Corporation acquired BMM and completed prefeasibility and feasibility investigations in order to explore the viability of mining the Gamsberg zinc deposit. The feasibility investigations included an ESIA which addressed the open pit mine development together with all associated infrastructure. The necessary approvals for the mining right and associated EMPr were obtained in 2001. An amendment to this EMPr was approved in 2002 to mine a small part of the deposit, underground. An additional amendment was made to the EMPr in 2009 for surface exploration along the north eastern section of Gamsberg.

Apart for the abovementioned EMPr, all other approvals obtained previously by Anglo American have lapsed. Vedanta Resource Plc. has acquired the BMM in 2012, from Anglo American Corporation.

Although BMM is the applicant for this Project, the prescribed standards and policies of Vedanta Resources (as the parent company) were used to inform the ESIA process and the EMPr.

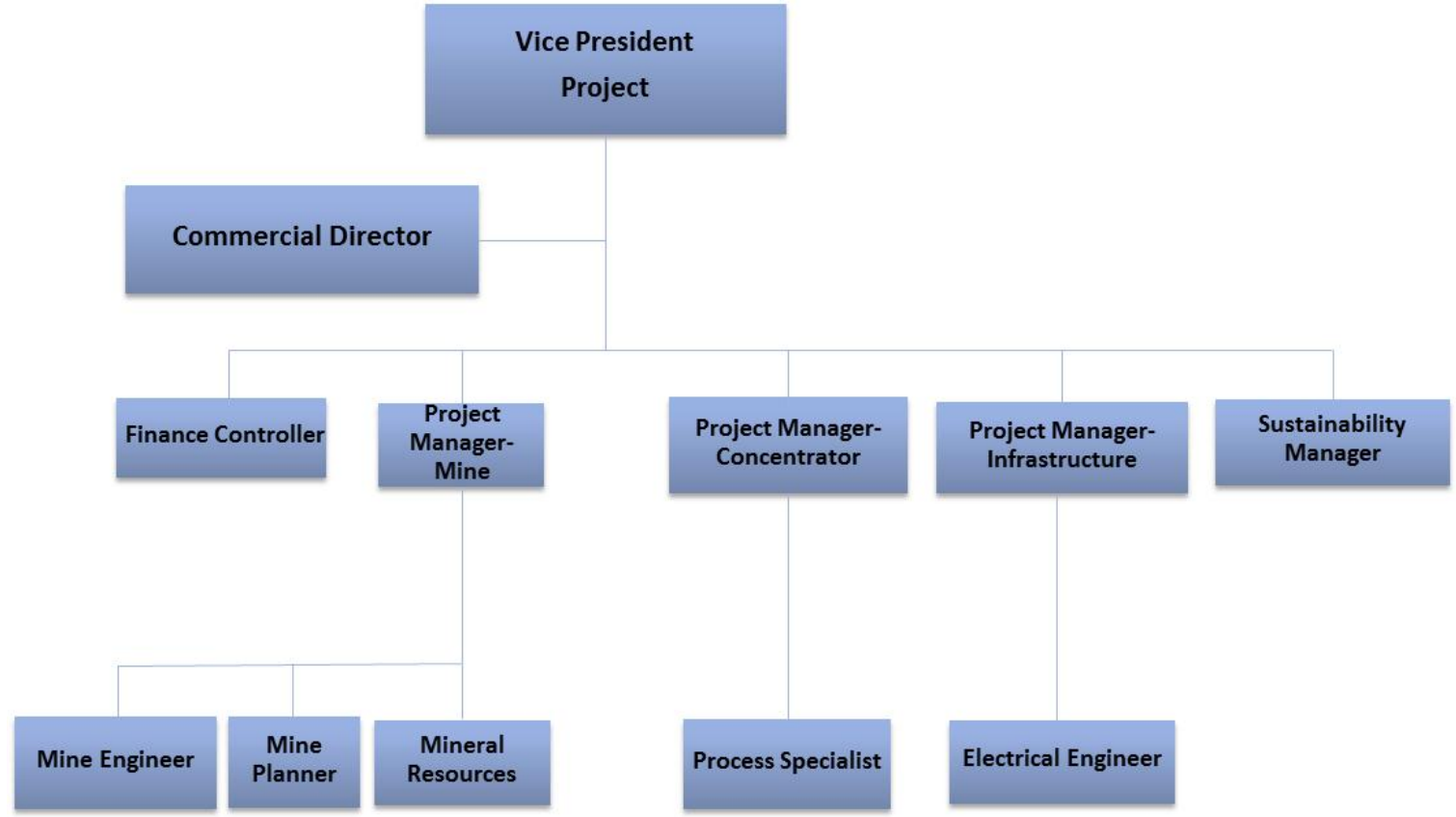
Vedanta Resources Plc. has developed a suite of environmental policies to guide the company's activities with respect to environmental management. Copies of Vedanta's Environmental and Social Policies are attached as *Annex B* of this EMPr. The policies strive to align with IFC Performance Standards (2012), thus achieving international good practice. The following is a list (1) of Vedanta's environmental polices developed and incorporated into this EMPr:

- Biodiversity Policy;
- Energy and Carbon Policy;
- HIV/ AID Policy;
- Health, Safety and Environment Policy;
- Human Rights Policy;
- Social Policy; and
- Water Management Policy.

BMM, together with Vedanta Resources Plc., are responsible for implementation (and updating if required) of this EMPr at the various stages of the project planning, construction, operation and decommissioning. A detailed team organogram for this Project is presented below.

(1) A more detailed description of the relevant policies and standards are contained in Chapter 2 the ESIA Report, and associated Annex's.

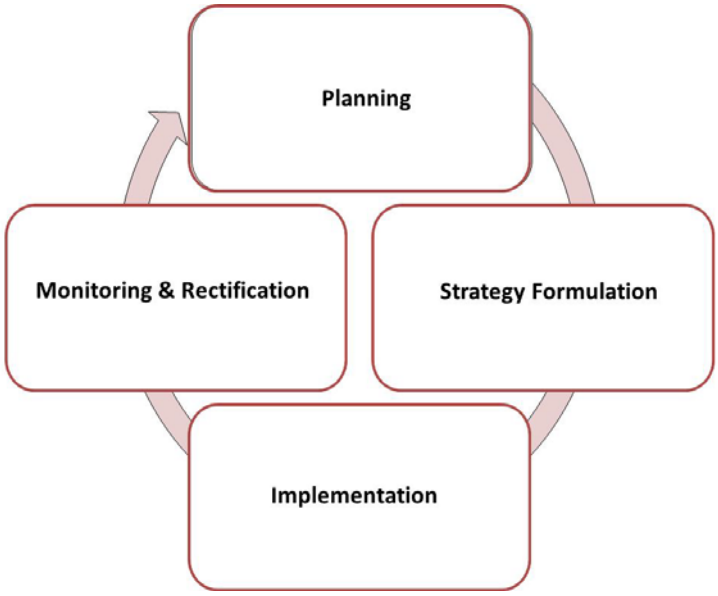
Figure 1.2 Project Organogram



The management approach adopted for this Project is one of continual improvement, including planning, implementation, corrective actions and management review:

- The Planning phase considers the Environmental (and other) policies which provide the framework and platform from which the Project is conducted;
- The strategy formulation considers the specific plans, objectives and expected outcomes;
- The implementation phase involves the development and execution of the required processes, guidelines, procedures, instructions, relating to operational control, training and awareness etc.;
- The checking and corrective action phase of the process involves the application of the strategy and supporting processes to all key operational management processes to ensure compliance with the policy and applicable legislation and also identify areas of non-conformity; and
- The management review phase of the cycle involves an organised and structured performance review of all aspects of the business cycle with the ultimate goal of identifying areas for further environmental performance improvement and the setting of appropriate, achievable and measurable objectives and targets to achieve the identified performance improvements. Monitoring of the sites activities and comparing performance against compliance criteria and targets (i.e. key performance indicators) will be a key driver of improvement within the Project. This will take many forms, including audits of project activities and areas of operation and from direct monitoring of the environment (e.g. groundwater quality and levels, noise, dust, etc.). It is critical that the necessary data is not only collected but also analysed for compliance (e.g. regulatory standards), trends and accuracy.

Figure 1.3 Environmental Management Cycle



Source: Adapted from Vedanta Resources Sustainable Development Strategy (Endemic Vision, 2013)

This process to monitor and evaluate will enable BMM to make management decisions based on actual performance against expectations and make informed decisions about whether the environmental objectives are being achieved. Modifications to the project implementation/management/systems can then be made based on an informed understanding of the Project's performance and where improvements are required. A proactive monitoring and evaluation program will aid BMM in identifying potential issues early in the project life; reducing potential impacts and increasing the likelihood of success for mitigation plans/actions should they be required. The planning and management will be applied to achieve the mitigation and control of the environmental impacts (and aspects) identified for this Project.

1.2 OBJECTIVES OF THE EMPR

The aim of an EMPr is to facilitate appropriate bio-physical and socio-economic environmental controls during all phases of the project. To achieve this, the EMPr must make recommendations for the planning and design (pre-construction/design phase), specify the limitations the contractor must abide by during construction, detail the issues that should be taken cognisance of and indicate specific actions that must be undertaken so as to mitigate all impacts identified and assessed in the ESIA. The EMPr thus specifies the framework within which the contractor(s) must carry out the construction activities. An operational and decommissioning phase management plan is also included in the EMPr and specifies the framework within which the

developer must carry out the operations during the life of mine and during the decommissioning phases of the development.

In addition, the EMPr provides a clear indication of the environmental and social management requirements of each of the role players involved during the construction, operational and decommissioning phases of the Project. Guidance for the implementation of the EMPr is provided, including the management of method statements which are required to be implemented to achieve compliance with the Environmental Specifications. Corrective actions in the event of non-compliance with the EMPr are also defined.

The EMPr is required in order to:

- assist in ensuring continuing compliance with South African legislation, Black Mountain Mining's Environmental Health and Safety Policy and international good practice;
- provide a mechanism for ensuring that measures identified in the ESIA Report designed to mitigate potentially adverse impacts, are implemented;
- provide a framework for mitigating impacts that may be unforeseen or unidentified until construction is underway;
- provide assurance to regulators and stakeholders that their requirements with respect to environmental and socio-economic performance will be met; and
- provide a framework for compliance auditing and inspection programs.

The EMPr will remain a draft document until it has been updated with the conditions stipulated in the environmental authorisation. From then onwards it is intended to be a living document that The overall EMPr contains sections that specifically deal with the design and planning phase, the construction phase (Construction EMPr), the operational phase (Operational EMPr) and decommissioning and closure plans. This document will address both bio-physical and socio-economic aspects, and present these within the various phases of the Project.

1.3 LEGISLATIVE REQUIREMENTS FOR AN EMPR

In light of the nature of the Project, the following legislation, *inter alia* (1), are identified to be applicable:

(1) Please note that other applicable legislation, including the National Forest Act, Water Services Act, Northern Cape Nature Conservation Act, Occupational, Health and Safety Act are inherently incorporated into this document.

- National Environmental Management Act (107 of 1998) (NEMA);
- Minerals and Petroleum Resources Development Act (28 of 2002) (MPRDA);
- National Heritage Resources Act (25 of 1999) (NHRA);
- National Environmental Management: Air Quality Act (39 of 2008) (NEM:AQA);
- National Environmental Management Act: Biodiversity Act (10 of 2004) (NEM:BA);
- National Environmental Management: Waste Act (59 of 2008) (NEM:WA); and
- National Water Act (36 of 1998) (NWA).

Despite the applicability of a suite of legislation, the NEMA and MPRDA are the primary pieces of legislation that govern the content, structure and approach to this EMPr. However, specific mitigation and management requirements in terms of the remaining aforementioned pieces of legislation will be met in this EMPr as well.

The specific legal requirements for an EMPr, as per the NEMA and MPRDA, are presented below, for ease of reference.

1.3.1 National Environmental Management Act (107 of 1998) (NEMA)

In terms of Section 24 (n) of the NEMA, an EMPr is required. Section 33 of the EIA Regulation R543 (2010) outlines specific requirements for the compilation of an EMPr. The specific requirements in terms of the EIA Regulation R543 are as follows:

Table 1.1 Content of draft environmental management programme (Section 33 of the EIA Regulations R543)

Relevant Section		Requirements	Applicable Section in EMPr
33		A draft environmental management programme must comply with section 24N of the Act and include –	
33 (a)		details of –	
	(i)	the person who prepared the environmental management programme; and	Section 1.4
	(ii)	the expertise of that person to prepare an environmental management programme	Section 1.4
33 (b)		information on any proposed management or mitigation measures that will be taken to address the environmental impacts that have been identified in a report contemplated by these Regulations, including environmental impacts or objectives in respect of –	Chapter 2
	(i)	planning and design;	Chapter 2
	(ii)	pre-construction and construction activities;	Chapter 2

Relevant Section		Requirements	Applicable Section in EMPr
	(iii)	operation or undertaking of the activity	Chapter 2
	(iv)	rehabilitation of the environment; and	Chapter 2
	(v)	closure, where relevant.	Chapter 2
33 (c)		a detailed description of the aspects of the activity that are covered by the draft environmental management programme;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
33 (d)		an identification of the persons who will be responsible for the implementation of the measures contemplated in paragraph (b)	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
33 (e)		proposed mechanisms for monitoring compliance with and performance assessment against the environmental management programme and reporting thereon;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
33 (f)		as far as is reasonably practicable, measures to rehabilitate the environment affected by the undertaking of any listed activity or specified activity to its natural or predetermined state or to a land use which conforms to the generally accepted principle of sustainable development, including, where appropriate, concurrent or progressive rehabilitation measures	Chapter 7 (closure and decommissioning)
33 (g)		a description of the manner in which it intends to—	
	(i)	modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(ii)	remedy the cause of pollution or degradation and migration of pollutants	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(iii)	comply with any prescribed environmental management standards or practices;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(iv)	comply with any applicable provisions of the Act regarding closure, where applicable;	Chapter 7.
	(v)	comply with any provisions of the Act regarding financial provisions for rehabilitation, where applicable;	Chapter 7

Relevant Section		Requirements	Applicable Section in EMPr
33 (h)		time periods within which the measures contemplated in the environmental management programme must be implemented;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
33 (i)		the process for managing any environmental damage, pollution, pumping and treatment of extraneous water or ecological degradation as a result of undertaking a listed activity;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
33 (j)		an environmental awareness plan describing the manner in which—	
	(i)	the applicant intends to inform his or her employees of any environmental risk which may result from their work; and	
	(ii)	risks must be dealt with in order to avoid pollution or the degradation of the environment;	
33 (k)		where appropriate, closure plans, including closure objectives.	Chapter 7

1.3.2 Minerals and Petroleum Resources Development Act (28 of 2002) (MPRDA)

Together with the EIA requirements outlined above, this EMPr also meets the specific requirements for the MPRDA. Section 37 of the MPRDA outlines the general requirements for an EMPr, which is tabulated below:

Table 1.2 EMPr and EMP requirements in terms of Section 39 of the MPRDA

Relevant Section		Requirements	Applicable Section in EMPr
39 (1)		Every person who has applied for a mining right in terms of section 22 must conduct an environmental impact assessment and submit an environmental management programme within 180 days of the date on which he or she is notified by the Regional Manager to do so.	This EMPr is attached as an Annex to the ESIA Report.
39 (2)		Any person who applies for a reconnaissance permission, prospecting right or mining permit must submit an environmental management plan as prescribed.	Not applicable. EMPr is being produced for mining right.
39 (3)		An applicant who prepares an environmental management programme or an environmental management plan must-	
	(a)	establish baseline information concerning the affected environment to determine protection, remedial measures and environmental management objectives;	Chapter 2
	(b)	investigate, assess and evaluate the impact of his or her proposed prospecting or mining operations on-	
	(b) (i)	the environment;	Chapter 2

Relevant Section		Requirements	Applicable Section in EMPr
	(b) (ii)	the socio-economic conditions of any person who might be directly affected by the prospecting or mining operation; and	Chapter 2
	(b) (iii)	any national estate referred to in section 3(2) of the National Heritage Resources Act, 1999 (Act No. 25 of 1999), with the exception of the national estate contemplated in section 3(2)(i)(vi) and (vii) of that Act;	Chapter 2
	(c)	develop an environmental awareness plan describing the manner in which the applicant intends to inform his or her employees of any environmental risks which may result from their work and the manner in which the risks must be dealt with in order to avoid pollution or the degradation of the environment; and	
	(d)	describe the manner in which he or she intends to--	
	(d) (i)	modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(d) (ii)	contain or remedy the cause of pollution or degradation and migration of pollutants; and	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(d) (iii)	comply with any prescribed waste standard or management standards or practices	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.

Sections 51 and 52 of the Mineral and Petroleum Resources Development Regulation (2004) outlines the specific requirements for an EMPr and EMP respectively, and must be considered in conjunction with the MPRDA itself. The specific requirements for the Mineral and Petroleum Resources Development Regulation is tabulated below:

Table 1.3 Section 51 and 52 of the Mineral and Petroleum Resources Development Regulation (2004)

Relevant Section		Requirements	Applicable Section in EMPr
Section 51: Environmental Management Programme			
51		An environmental management programme contemplated in section 39(1) of the Act must include the following:	
51 (a)		A description of the environmental objectives and specific goals for-	Chapter 2
	(i)	mine closure;	Chapter 7

Relevant Section		Requirements	Applicable Section in EMPr
	(ii)	the management of identified environmental impacts emanating from the proposed mining operation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(iii)	the socio-economic conditions as identified in the social and labour plan; and	Chapter 2
	(iv)	historical and cultural aspects, if applicable;	Chapter 2
51 (b)		an outline of the implementation programme which must include -	
	(i)	a description of the appropriate technical and management options chosen for each environmental impact, socio-economic condition and historical and cultural aspects for each phase of the mining operation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(ii)	action to achieve the objectives and specific goals contemplated in paragraph (a) which must include a time schedule of actions to be undertaken to implement mitigatory measures for the prevention, management and remediation of each environmental impact, socio-economic condition and historical and aspects for each phase of the mining operation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(iii)	procedures for environmental related emergencies and remediation;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(iv)	planned monitoring and environmental management programme performance assessment;	This divided between pre-construction, construction, operation and closure/decommissioning. This is contained in Chapters, 4, 5, 6 and 7.
	(v)	financial provision in relation to the execution of the environmental management programme which must include-	Chapter 7
	(v) (aa)	the determination of the quantum of the financial provision contemplated in 54; and	Chapter 7
	(v) (bb)	details of the method providing for financial provision contemplated in regulation 53;	Chapter 7
	(vi)	an environmental awareness plan contemplated in section 39(3)(c) of the Act;	
	(vii)	all supporting information and specialist reports that must be attached as appendices to the environmental management programme; and	All specialist reports are attached as Annex's to the Main ESIA Report.
	(viii)	an undertaking by the applicant to comply with the provisions of the Act and regulations thereto	

This EMPr is designed to meet the aforementioned legislative requirements, together with the associated requirements of secondary legislation and good practice. The structure of the EMPr is presented below.

1.4 STRUCTURE OF THE EMPR

Table 1.4 Components of the EMPr

Section	Heading	Content
Section1	Introduction	Provides background information regarding the site, the proposed Development and the legislative framework.
Section 2	Summary of ESIA Process	Provides a summary of the affected environment, specialist studies undertaken, stakeholder engagement process and findings of the detailed impact assessment.
Section 3	Implementation of the EMPr	Provides details of the communication and organisational structures within which the EMPr will be implemented, responsibilities of key role players, and provides the terms of reference for the ECO.
Section 4	Environmental Management Specifications for Pre-construction Phase	Provides environmental specifications for pre-construction phase
Section 5	Environmental Management Specifications for Construction Phase (CEMPr)	Provides all construction phase environmental management requirements applicable to the principal construction contractors, and their subcontractors.
Section 6	Environmental Management Specifications for Operational Phase (OEMPr)	Provides all operational phase environmental management requirements applicable to applicant and any sub-contractors.
Section 7	Environmental Management Specifications for Decommissioning and Closure Phase.	Provides all decommissioning phase environmental management requirements applicable to applicant and any sub-contractors.
Section 8	Conclusion and Way forward	Concludes the requirements for the Project and outlines the way forward for the applicant.

1.5 EXPERTISE OF ESIA TEAM

ERM is a global environmental consulting firm employing over 4,000 specialists in over 140 offices across 40 countries. ERM Southern Africa in turn is one of the largest environmental consulting firms in the region, with extensive experience in South Africa and several other African countries.

A list of the ESIA project team is tabulate below, together with the associated qualifications and relevant experience:

Table 1.5 Expertise of ESIA Project Team

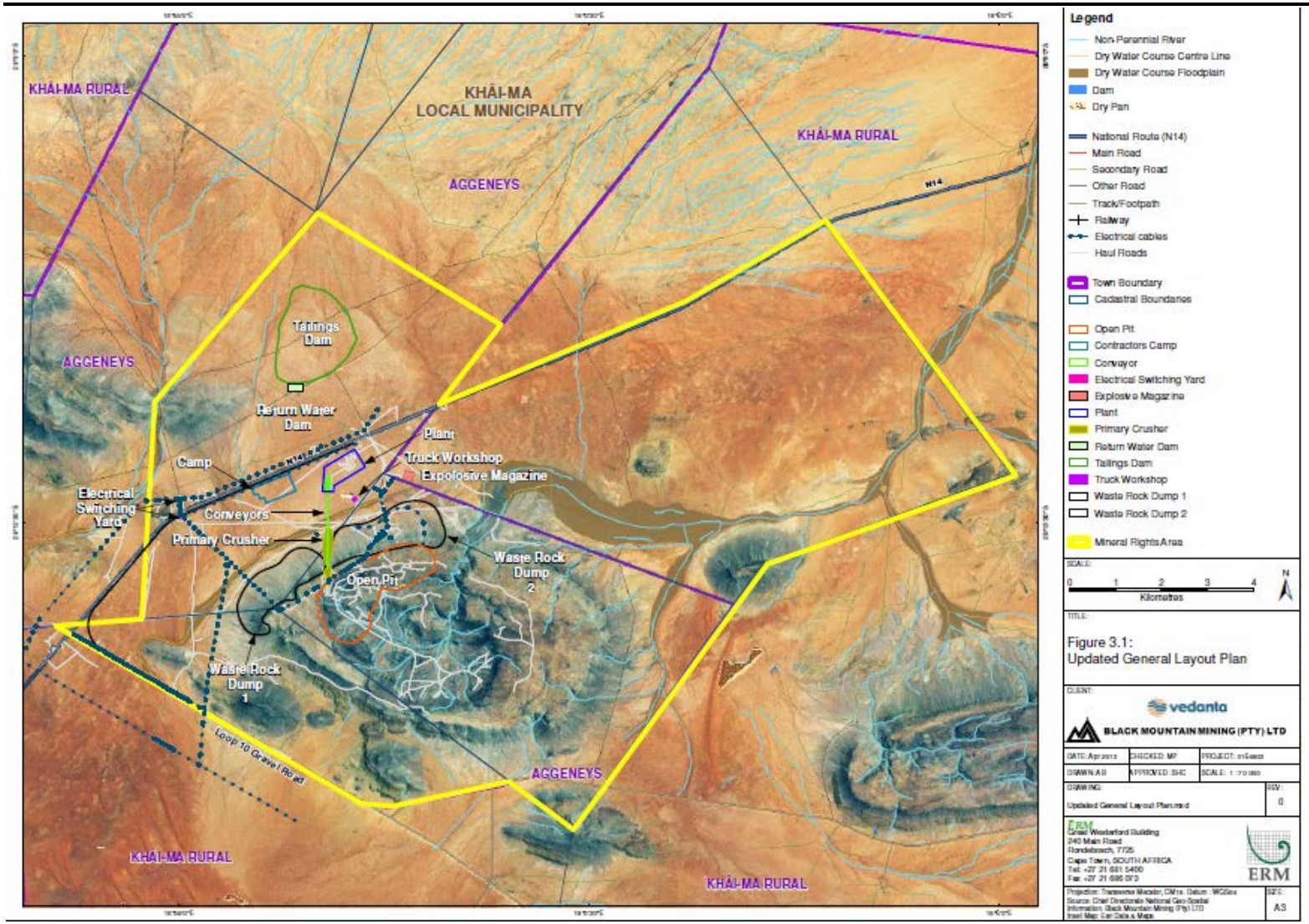
Stuart Heather-Clark	Partner in Charge:	• BSc Civil Engineering – Univ. of Cape Town (1992) • MPhil. Environ Science – Univ. of Cape Town (1996). EAPSA Certification.	Stuart Heather-Clark is a Partner in the Impact Assessment and Planning Team within ERM Southern Africa based in Cape Town, South Africa. Mr Heather-Clark's has over 17 years of experience in industrial, oil & gas and infrastructure related ESIA and Strategic Environmental Assessments (SEA) throughout Africa. His experience has afforded him a sound understanding of the sustainability issues facing development in Africa. He has been involved in a number of internationally funded projects in Cameroon, Ethiopia, Zambia, Tanzania, Angola, Botswana, Namibia, Uganda and Mozambique. All of these projects involved interaction with lenders, developers, local stakeholders, including NGO's, government officials and local communities. Mr Heather-Clark has an in-depth understanding of the Equator Principles and IFC performance Standards.
Tania Swanepoel	Project Manager:	• BSc Hons (Engineering & Environmental Geology), University of Pretoria, 2000. • BSc Hons (Geology and Geohydrology), University of the Western Cape, 1997. • BSc (Geology, Mathematics) , University of the Western Cape, 1996. Registered Natural Scientist (Pr Sci Nat).	Tania Swanepoel is a Principal Consultant in the Impact Assessment and Planning team based in Cape Town, South Africa. Tania has over thirteen years of broad based environmental experience. Her experience includes environmental impact assessments, management plans, public participation, environmental site investigations, pollution risk assessments, remedial system monitoring, geotechnical investigations, groundwater monitoring and rural water supply & sanitation studies.

BMM intends to establish the Gamsberg mine near the town of Aggeneys, in the Northern Cape (refer to *Figure 1.1* above). The Project will result in the generation of a waste rock dump, tailings dam, mine machinery fleet and workshops. A concentrator plant with resultant stockpile areas and supporting infrastructure such as water supply, laboratories, sewage works and office complex will also be established to process the mined ore. An additional 1000 houses will be constructed within the town of Aggeneys, linking the existing northern and southern township.

Upon processing the zinc ore, the concentrate will be transported to the Port of Saldanha, via two options. A portion of the product will be trucked to the Port of Saldanha (via the N14, N7), with the remainder of the product railed to the Port (via the Loop 10 siding along the Sishen-Saldanha railway line).

Based on environmental sensitivities identified during the Scoping and Impact Assessment phase of the Project, the project layout was finalised (refer to *Figure 2.1* below). Cognizance was taken of the mitigation hierarchy, with the application of the *avoidance* to all environmental sensitivities identified. For sensitivities that could not be avoided, due to technical and financial limitation, the reminder of the mitigation hierarchy was applied in terms of abatement, mitigation and compensation.

Figure 2.1 Final Layout Plan



A detailed Project description chapter has been included into the ESIA Report (refer to *Chapter 3* of the ESIA). For ease of reference, a summary table reflecting all project infrastructure is presented below. Due to the magnitude of the Project, the project infrastructure is divided between construction (*Table 2.1*) and operational phase project infrastructure (*Table 2.2*).

Table 2.1 Summary table of construction phase project infrastructure

Project component	Location	Specification/ Detail
Construction Phase components		
Bulk Requirements	Water: Off take from existing bulk supply pipeline between Pella and Aggeneys.	• 2,000 m^3 of water per day required. • Sourced from the Orange River via an off take pipe of 5 km that extends from the Pella Water Board water pipeline, located to the north of the N14. • The off take pipe will be 550 -750 mm in diameter and will be constructed aboveground from the discharge point to the mine, except for the section that crosses the N14. • The off-take pipe covers an area of 0.5 hectares. • 1 reservoir located along this pipeline. It will be located near to the plant construction site. • The construction footprint of the pipeline is 1000 m^2
	Power:	• The construction phase is expected to require a temporary 4 MVA supply point on the existing Gamsberg 11kV line using 21 million kilowatts hour per year. • The electricity will be supplied to the construction site via a 5km overhead line and 4 x 500kVA miniature substations. • One of the substations will be in a fixed position at the construction camp and the other 3 will be movable units on the construction site. One miniature substation has a footprint of about 4m^2.
	Sewage: Located near the Contractors Camp	• There will be one sewage plant constructed common for the construction and operation
	Fuels and lubricants: Located within the contractors camp	Fuel: • 50 m^2 bund area • Total storage of 100 m^3 per day Lubricants: • 10 m^2 bund area • Total storage of 20 m^3
Construction Camp	Adjacent to the N14	A total area of 2 to 4 hectares, including the following facilities: o Workshop o Office complex o Truck yard and vehicle parking o Washing and servicing of equipment o Potential for storm-water capture and

		re-use
Temporary Staff Housing	Located within the contractors camp	• 5 000 construction jobs over a 30 month period • Total area of approx. 30 hectares • Total of 500 units • 0.2 Million kW-hours per annum • Bulk water requirement of 250 m^3 of water/day
Waste Management Facilities	Contractors' camp	Two separate contractors employed to collect and dispose domestic and hazardous wastes. Domestic wastes: • Paper and plastics will be recycling • Disposed of at a registered landfill facility –Existing landfill facility at BMM will be used • Industrial waste include steel, packaging material and material off-cuts • Total area of 200 m^2 Hazardous wastes: • Mainly oil contaminated wastes • Storage facility capacity – 0.5 hectares • Disposed of at a registered hazardous landfill facility • Collected and disposed of once in a month • Total area of 100 m^2

Table 2.2 Summary table of operational phase project infrastructure

Project Component	Location	Specification/ Detail
Operational Phase: On-site Mine Infrastructure		
Open Pit Zinc Mine	On the Northern side of the Inselberg running from the West of the Kloof to South-West.	Maximum pit dimensions: • Total area of approx. 330 hectares • Depth approx. 650 m • Slope angles – 45 to 53 degrees
Crusher	Located on the flat surface of the proposed V-cut access road of the northern slopes of the Inselberg. Approximately 70m from the top of the Inselberg.	• Total processing capacity of 10 000 000 tons per annum (tpa) • Total height of crusher 35 m above ground level • Total area of 0.1 hectares
Concentrator Plant	Located between N14 and the Inselberg.	• 10 000 000 tap ore treatment capacity • 40 m high • A total number of 4 dust extraction vents that are approximately 30m high • Total area of 45 hectares
Tailings Dam	Located approximately 2 km north of the Gamsberg Inselberg, along the northern border of the N14.	• Final height of 70 m high • Cover a total area of 280 hectares • Total storage capacity of 132 million tonnes
Waste Rock Dump	Located on the North side of the Inselberg.	• Final capacity of 1.5 billion tonnes • Total final area of 490 hectares • Total final height of 215 m • Waste rock slopes with an average slope angle of 35 degrees
Two Modular	One sewage treatment plant	• Processing capacity of 600 m^3 per day

Sewage Plants	will be located near to the Concentrator mineral processing plant.	• It will service an expected workforce of 2500 people • Generate 480 m^3 of treated effluent per day • Treated effluent will be used for dust suppression and plantation • Produce 1500 tons of sludge per month • Sludge will be used in the rehabilitation purposes
	Expansion of existing Aggeneys wastewater treatment works.	• Proposed total treatment capacity of 1000 m^3 per day • Generate 800 m^3 of treated effluent • Effluent will be used for plantation • Generate 2500 tons of sludge per month. • Sludge will be used in the rehabilitation purposes
Sewerage collection sump	Near the Concentrator Plant	• Expected to service mine work force of approximately 140 people • Total capacity of 70 m^3 (7 days storage) • Total area of 40 m^2
Treated sewage effluent dam	Located near Sewage treatment plant	• 7 day capacity • HDPE lined pond • Total depth of 5m • Total height above ground is maximum 1.5 m • Total storage capacity of 1200 m^3 • Total area of approx. 250 m^2
Salvage Yard	Located within the Plant.	• Total footprint of 750 m^2 • Total storage capacity of 1800 m^3 for general wastes • Maximum height of 3 m
Domestic Waste Facility	Located within the Plant.	• Total footprint of 100m^2 • Total capacity of 150 m^3 • Maximum height of 2 m • Waste to be disposed of at the designated site.
Temporary Hazardous Waste Management Facility	Located within the Plant.	• Storage capacity of 100 m^3 • Total area of 150 m^2 • Maximum height of 2 m • All hazardous waste collected will be transferred to the Vissershok hazardous waste disposal facility.
Internal Haul and Mine Area Roads	All haul and mine area roads are depicted on the map.	• 10 km of internal haul and mine area roads • All haul roads, including the pit access road, is 45 m wide gravel road • All mine roads would be 10 m wide • Slope angles of roads not more than 10 degrees • Gravel road, compacted with surface material • Total footprint area of internal haul and mine area roads 55 Ha • Surface material sourced from suitable overburden material and/or available burrow pits at Lemoenplaas

		• Length and width of any buffer areas, stormwater infrastructure, fencing etc. (i.e. any associated infrastructure) • An existing approach road towards Western side of the Inselberg will be widened to 12 m width (including 2m shoulder on either side) as approach for start-up activities. Main & permanent approach road will be constructed from Northern side, once the permission is granted.
Plant Area Roads	Plant area roads are located on the map.	• 4 km of total plant area road • 6 m and 8 m wide, depending on function • The construction footprint of the plant roads is maximum 12 m wide • Total area of off-road parking 5000 m² • Access tracks for inspection and maintenance: Total area of 1000 m²
Material Laydown and Storage Area	Located within the Plant.	• Total area of 2,500 m^2
Equipment and Engineering Workshops	Workshop one located within the Plant.	• Total area of 1 Ha
	Workshop two (heavy duty workshop) located between the process plant and waste rock dump sites, along the plains.	• Total area of 1.5 Ha
Ore Stockpiles	In-pit open stockpile area (prior to primary crushing). Location reflected on layout plan.	• Total area of 1 Ha • Maximum height of 4 m
	Open stockpile area located within the Plant (prior to secondary crushing).	• There is no secondary crushing
	Ore stockpiles (4 Nos – two ore, blended ore and one concentrate) area located within the Plant.	• Maximum height of 20 m • Width of 54 m • Length of 90 m for high grade, 72 m for low grade and 60 m for blended.
	Zinc concentrate stockpile located within the Plant.	• Storage capacity of 7 days • Total area of 0.25 Ha • Maximum stockpile height of 12 m • 50 m in length
Administrative Office Block	Located within the Plant.	• Total area of 1,500 m^2 • Maximum height of 12 m • Expected to contain more than 100 employees, working 7 days a week
Control Rooms	Control room 1: Located within the Plant.	• Total area of approximately 300 m² • Maximum height of 12 m
Equipment Wash Area	Located within the Plant.	• Total area of 750 m² • 45,000 m^3 of water will be required annually • The water will be sourced from recycled water reservoirs only
Explosives Storage Area and Ammonium Nitrate	Located on the North of Inselberg, in the plain area.	• Total area of 20 hectares • Total height of 12m • 2 x 85 ton Emulsion silos and 2 x 50 ton

and Emulsion Silos		silos
Parking Area	Located adjacent to the Plant.	• Total area of 5,000 m² • The material to tar the road will be sourced from waste rock / borrow pit • It will accommodate 300-350 vehicles
Stormwater Management Infrastructure	Storm water dam to be constructed adjacent to and south of the Plant and along the western foothills of the Inselberg.	• There will be one storm water dam • Total storage capacity will be 5000 m³ • Each dam cover a total area of 1000 m² • Wall height above ground of 3 m (Partially below ground)
Bulk Storage Tank Farms	Adjacent to the Plant as reflected on the layout plan.	• Store 100 m³ of diesel and petrol • Total area of 400 m² (fuel, oil and lubricants storage area) • 2 fuel supply points
	Located adjacent to the mine workshop area (Fuel, oil & lubricant storage) as depicted on the layout plan.	• Store 500 m³ of diesel • Total area of 2,500 m² • 6 re-fueling bays • 5,000 litres of lubricants • Total area of 1,000 m²
Medical clinic	Located within the Plant.	• Total area of 80 m² • Total height of 6 m • Result in production of hazardous wastes of 5-6 kg per month
Internal Conveyor System	From the Primary crusher located at open pit to the northern face of the Inselberg up to the stockpiles	• Closed system; • The conveyor will be 2 m wide and approximately 2.5 km long.
Raw water Storage Dam	Located within the Plant.	• 1 dam • Storage capacity of 25, 000 m³ • Wall height of 4.5 m • Source of water: Orange River, via the Pella Water Board water supply system.
Process Water Dam	Located within the Plant.	• A total number of 1 dam • Storage capacity of 25,000 m³ • Wall height of 4.5m • Sources of process water: recycled water from the plant, treated water and make-up water from raw water dam
Dust Suppression Tank	Located in the plain area adjacent to the plant.	• There will be one metallic/concrete tank • Storage capacity of 1,000m³ • Max height of 4.5m • Source of water: raw water dam
Fire Control System	Water from raw water storage dam is pumped to a clean water tank. From there it will be pumped to the fire hydrant pipe network	• There will be a tank with a storage capacity of 2000 m³ • Wall height of 5m • Source of water: raw water dam
Return water dams	Located between the tailings dam and N14	• Three pollution control dams to be constructed adjacent to the tailings facility. • A total cumulative storage capacity of 25 000 m³. • Three meters high dam wall and cover a total area of half hectare. • HDPE lined.
Entrance and Exit	Main entrance/exit point	• Main entrance/exit point: Total width of

Points	will be Located along the southern border of the N14. Second entrance/exit point will be located along the western border of the inselberg, leading onto the existing Loop 10 gravel road.	45 m; Tar road. • Second entrance/exit: Total width of 15 m; Compacted gravel road • Surface material sourced from existing borrow pit located north of the inselberg.
Security and induction training areas	Near the main entrance, along the southern border of the N14.	• Security single storey building, covering a total area of approximately 120 m² • Induction training area covering a total area of approximately 500 m²
Operational Phase: Off-site Mine Infrastructure		
Power Infrastructure Including Sub-stations and Distribution Lines	Two sub-stations along the northern and southern border of the N14 and two connecting distribution lines.	• The 220kV/66V substation will cover a total area of 2 hectares and reach a total height of 8 m • 66 kV/11kV sub-station • The 660kV/11KV substation will cover a total area of 1 hectares and reach a total height of 8 m • Two 66 kV distribution lines • The connecting distribution lines will extend 3 km and require 12 pylons, with a span length of 6m each. • The distribution lines will cover a total distance of 10 km and total footprint of 2 Ha.
Operational Phase Housing	Located in the town of Aggeneys, between the northern and southern township.	• An additional 1000 houses • Will cover a total area of 100 hectares • Require 12 Million kW-hour of power per annum • Generation of approximately 1 200 m³ of additional sewage per day • Requires 1500 m³ of water per day (sourced from Orange River)
Transport Corridor:	Extends from proposed mine to Saldanha Bay Port, via two transport options.	<u>Option 1:</u> • Truck via the N14 and N7 to Saldanha Bay Port. • No. of trucks required per day: Phase 1 = 30; Phase 2 = 30; Phase 3 = 45. <u>Option 2:</u> • Concentrate will be trucked 160 km along the Loop 10 Gravel Road to Loop 10 siding and then loaded onto the Sishen-Saldanha Railway Line during phases 2 and 3. • No. of trucks required per day: Phase 2 = 30; Phase 3 = 45.
Loop 10	Infrastructure for the storage and handling of zinc concentrate will be required at Loop 10	BMM has an existing offloading facility at Loop 10 siding. The existing storage shed at the siding covers a total area of 2000 m² and has a total height of 10 m. It is anticipated that additional facilities, located within the existing disturbed footprint will accommodate Phase 2 volumes of zinc concentrate generated by Gamsberg. However, due to the expected volumes at

		Phase 3 of production (500 000 Mtpa), additional infrastructure will be required at BMM's existing Loop 10 siding facility, which is as follows: • Truck unloading and wash station; • Truck Loading Facilities and Equipment (324nos of 67ton trucks per week); • Truck Cue/Parking; • Concentrate Storage Facility; • Support Facilities/offices/lab; • Rail Wagon Loading Facilities and Equipment; and • Rail Yard/Storage.

3 DESCRIPTION OF AFFECTED ENVIRONMENT

The following sections provide a brief summary of the affected environment. This is followed by the list of specialist assessments completed, public consultation efforts and a summary of impacts assessed. A detailed list of applicable environmental legislation is contained in *Section 1.2* above.

Note that the following is an abbreviated version of information. Should further detail regarding the ESIA be required, please refer to the ESIA Report.

3.1 AREA OF INFLUENCE

The Project is located within the Northern Cape Province and the NDM, along the N14 national road which bisects BMM's mining license area (refer to *Figure 1.1*). The Project is situated wholly in the Khai Ma LM, approximately 45 km to the west of Pofadder and 120 km to the east of Springbok. The Gamsberg Inselberg itself is located approximately 33 km south of the Orange River, South Africa's longest river and an important river in the Northern Cape Province.

3.2 SUMMARY OF KEY ENVIRONMENTAL ASPECTS

3.2.1 *Climate and topography*

The Northern Cape Province is characterised as a dry region, with portions of the Kalahari Dessert falling within the province. Rainfall patterns for the towns of Aggeneys and Pella are similar, with Springbok (and to a lesser extent Pofadder) receiving far greater volumes of monthly average rainfall. The Gamsberg region receives more than 75% of its rainfall from January to June annually (i.e. approximately 68 mm), with the months of January and April averaging the highest rainfall. On average, no rainfall is experienced during the month of September.

The local topography is mainly characterised with undulating plains, containing low growing shrubby vegetation and grasses. The surrounding plains are approximately 750 – 900 meters above mean sea level (mamsl), with the highest areas of the Gamsberg inselberg varying between 1100 – 1150 mamsl. The Gamsberg inselberg is approximately 7.2 km east – west and approximately 4.6 km north – south. Erosion along the top of the inselberg has resulted in the creation of a basin within the feature, which subsequently varies between 60 – 70 m below the rim of the inselberg.

3.2.2 Water Sources

The northern section of the Project area drains into the Orange River Basin, whereas the southern section drains into a catchment referred to as an endoreic area, (i.e. an interior catchment that doesn't feed out into the ocean) (SRK Consulting, 2010). The Orange River basin is considered to be the largest river basin in South Africa with a total catchment area of approximately 1 000 000 km^2 (www.dwa.gov.za, 2012). Approximately 600 000 km^2 of the total catchment area is located inside the Republic of South Africa (refer to *Figure 4.1* below). The remainder of the catchment area is spread across Lesotho, Botswana and Namibia.

Groundwater is mainly found within secondary fractured-rock aquifers and tends to be found along fractures within hydraulically isolated rocks of low permeability, which are commonly found in the surrounding areas. According to the baseline report, the transmissivity of the fractured aquifers is considered to be low (SRK Consulting, 2010).

3.2.3 Ecological Habitat

The Gamsberg inselberg sits within what is termed the Bushmanland Inselberg Region (BIR), which includes all the large, quartzite-capped inselbergs located in the northern Bushmanland plains in South Africa. The BIR is said to cover a total area of about 6 300km2 (Desmet, 2010). The BIR extends through the boundary between summer and winter rainfall systems in Southern Africa. Based on this location, the vegetation found on the plains and along the warmer north-facing slopes is characteristic of the Nama Karoo Biome whereas that of cooler higher-elevation plains and south-facing slopes is characteristic of the Succulent Karoo Biome. The overlap of these biomes makes these inselbergs a unique feature, thus forming the fundamental difference of these inselbergs as compared to other inselbergs found elsewhere in the Nama Karoo. Due to erratic rainfall experienced during different seasons, summer and winter rainfall flora can co-exist in this region, and thus contributing to its unique value.

The vegetation found on these inselbergs forms a distinct centre of plant endemism located within the larger Eastern Gariep Centre of Endemism (Desmet, 2010), which includes the Orange River valley between Vioolsdrif and Pofadder/Onseepkans. As there are a number of species identified that is considered to be endemic to the Bushmanland inselbergs and the BIR itself, the region has been termed "Bushmanland Inselberg Centre of Endemism" or sometimes the "Gamsberg Centre of Endemism".

Based on the field work and observations undertaken, it was confirmed that no Red Data invertebrate species were identified in the Gamsberg region (Groundtruth, 2010). This was said to unlikely change through further investigations as most of the Red Data invertebrates in South Africa are butterfly's, with none of which expected to occur in the Gamsberg region. The

region is known however to accommodate a suite of reptilian, avi-faunal, vertebrate and invertebrate species.

Based on the results of the sampling undertaken at the four sites, the aquatic ecology at Gamsberg was characterised as a "poor ecological" state. However, as there were no symptoms of water quality/river heath degradation, it is suspected that the "poor" ecological state is directly attributed to the fact that samples were taken from stagnant pools of water. As the pools were identified as stagnant, nutrients (or other water quality parameters) have likely accumulated over a period of time and is subsequently of a concentrate state.

3.2.4 Socio-economic

The Northern Cape is characterised by an extreme disparity in wealth, with 44.7 % of the population earning less than 9.8 % of the income. The unequal income distribution has severely hampered development (1). Migration patterns suggest that there has been economic decline in the area, as people have been leaving the area in search of opportunities in other Provinces such as the Western Cape, Gauteng and Eastern Cape Provinces. Rapid population growth has given rise to a very young population structure.

Rising levels of unemployment and the increase in the economically inactive population has resulted in increased pressure on the diminishing employed population and a high dependency on the State for support. The mining sector continues to be the dominant economic sector although recent trends in the sector show the sector to be in decline. This is evident from the mine closures in the District (eg Kleinsee and Steinkopf). Provision of services and infrastructure continues to be a challenge. This is exacerbated by the highly dispersed distribution of settlements.

The significance of economic impacts is often highly dependent on the environment or context within which they occur. For example, job creation in a small local community with a stagnating economy will be far more significant than it would be in a larger community with a healthy economy.

The Northern Cape Province recorded the lowest average annual growth rate between 2001 and 2011. This figure relates to approximately 2.4 %, compared to the national growth rate of 4.0 % over the same period (2). Despite this, the contribution of the Northern Cape economy to the national GDP has remained constant at between 2 and 2.2 %, throughout the period 1996 to 2011. This indicates that the province has kept pace with economic growth in general but has not experienced accelerated economic development.

(1) Northern Cape Provincial Growth and Development Strategy (NCPGDS), July 2011.
(2)Stats SA, 2012, ' Gross Domestic Product: Annual Estimates 2002-2011, Regional Estimates 2002-2011 - Third Quarter 2012', Statistical Release P0441, Pretoria.

From a sector perspective, mining was the biggest contributing sector with 27 % contribution to GGP. To illustrate the national importance of the Northern Cape mining sector, in 1998 the Province produced around 37 % of South Africa's diamond output, 44 % of its zinc, 70 % of its silver, 84 % of its iron-ore, 93 % of its lead and 99 % of its manganese (1). Mining is followed by general government services at 13 %; finance, real estate and business services at 12 %; and wholesale, retail and motor trade including catering and accommodation at 10 %. Tourism is of growing importance in the NDM with the main attraction being the wild flower displays which occur from August to October annually (2).

A detailed review of the socio-economic context of the impact region is provided in Chapter 6 of the ESIA Report.

(1) Black Mountain Mining, 2010, Gamsberg Zinc Project: Final Social-Economic Baseline Report, Report no.:396036/5 (prepared by SRK Consulting).
(2) Stats SA, 2012, ' Gross Domestic Product: Annual Estimates 2002-2011, Regional Estimates 2002-2011 - Third Quarter 2012', Statistical Release P0441, Pretoria.

Based on the outcomes of the Scoping Report, a number of key issues were identified to have a potentially significant impact on the bio-physical and/ or socio-economic environment. For ease of reference, all specialist studies undertaken are tabulated below, for ease of reference:

Table 4.1 Specialist studies completed for ESIA process

Name	Company	Expertise
Dr David Morris	McGregor Museum	Heritage and Archaeology
Mr John Pether	Private Consultant	Palaeontology
Mr Bertie Phillips	Kantey & Templer	Traffic
Mr Graham A Young	Newtown Landscape Architects	Visual
Mr Demos Dracoulides	DDA Environmental Engineers	Noise & Vibration and Air Quality
Dr Mark Graham	GroundTruth	Fauna (terrestrial, aquatic and avi-fauna) (on-site mine infrastructure)
Dr Phillip Desmet	Private Consultant	Terrestrial and aquatic flora (on-site mine infrastructure)
Dr Hugo Van Zyl	Independent Economic Researcher	Macro-economics
Dr David Baldwin	Private Consultant	Waste Classification and Management
Mr Simon Todd	Simon Todd Consulting	General ecologist (terrestrial and aquatic biodiversity) (off-site infrastructure)
Mr Stefan Muller	ERM	Hydrogeology
Mr Stewart Whyte	ERM	Geochemistry
Mr Fred de Villiers	HHO	Hydrology
Ms Mariam January	ERM	Social Specialist
Ms Lisa Constable	ERM	Climate Change and Green House Gas Emissions

A detailed summary of the findings of each specialist study, including copies of the full specialist reports, are included in the ESIA Report.

Potential impacts that have been identified and assessed in the ESIA Report, is as follows:

- Impact on traffic in the region;
- Impact of noise and vibration;
- Impact on air quality (including dust);
- Impact of waste management;
- Impact of geochemical processes (ARD and metal leachate);

- Impact on hydrogeology;
- Impact on hydrology;
- Impact on climate change and GHG emissions;
- Impact on terrestrial and aquatic flora (on-site infrastructure);
- Impact on terrestrial, aquatic and avi-fauna (on-site infrastructure);
- Impact on general ecology (off-site infrastructure);
- Impact on heritage, archaeology and palaeontology;
- Impact on the social environment;
- Impact on the visual environment; and
- Impact on the economic environment.

4.1 SUMMARY OF IMPACT ASSESSMENT

It is acknowledged that the Project will be developed in a sensitive biophysical environment, where the interdependencies of groundwater, surface water and ecological functioning of the Gamsberg inselberg will be important to understand. While the biophysical environmental is sensitive, the socio-economic environment is such that the Project could result in significant socio-economic benefits at a local, district and provincial levels in an environment of high unemployment, low levels of education and several other socio-economic challenges.

Table 4.2 Summary of impact assessment (pre & post mitigation)

NEGLIGIBLE (-ve)
MINOR (-ve)
MODERATE (-ve)
MAJOR (-ve)
MINOR (+ve)
MODERATE (+ve)
MAJOR (+ve)

	Construction Phase		Operational Phase		Decommissioning Phase	
Primary/Secondary Impact	Pre-mitigation Significance	Residual Impact Significance	Pre-mitigation Significance	Residual Impact Significance	Pre-mitigation Significance	Residual Impact Significance
Biophysical Impacts						
Impact on Air Quality						
Impact on Air Quality	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	MINOR (-ve)	MINOR (-ve)	N/A	N/A
Impact on Groundwater						
Impact of Drawdown on Groundwater Resource	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	MODERATE (-ve)	MODERATE (-ve)	MODERATE (-ve)	MODERATE (-ve)
Impact of Drawdown on Groundwater Users	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	MODERATE (-ve)	NEGLIGIBLE (-ve)
Impact on Groundwater Quality	MINOR (-ve)	NEGLIGIBLE (-ve)	MODERATE (-ve)	MODERATE (-ve) to MINOR (-ve)	MODERATE (-ve)	MODERATE (-ve) to MINOR (-ve)
Impact of Water Quality on Groundwater Users	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Impact on Biodiversity						
Habitat Loss Caused by the Mine Footprint and Associated Activities	MAJOR (-ve)	MODERATE (-ve) to MAJOR (-ve)	MAJOR (-ve)	MODERATE (-ve) to MAJOR (-ve)	MAJOR (-ve)	MODERATE (-ve) to MAJOR (-ve)
Impacts Resulting from Habitat Degradation from Dust Deposition	MODERATE (-ve)	MODERATE (-ve)	MAJOR (-ve) (Low confidence)	MAJOR (-ve) (Low confidence)	MODERATE (-ve) (Low confidence)	MODERATE (-ve) (Low confidence)
Impacts on Habitat resulting from Groundwater Drawdown	MAJOR (-ve)	MODERATE (-ve)	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)
Impacts Arising from Habitat Fragmentation	MODERATE (-ve)	MODERATE (-ve)	MAJOR (-ve)	MODERATE (-ve)	MAJOR (-ve)	MODERATE (-ve)
Impacts on Species Diversity as a result of Mining-related Activities	MODERATE (-ve)	MINOR (-ve)	MAJOR (-ve)	MODERATE (-ve)	MAJOR (-ve)	MODERATE (-ve)
Impacts from Encroachment of Alien Species	MODERATE (-ve)	MODERATE (-ve)	MODERATE (-ve)	NEGLIGIBLE (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)
Impacts of Human Influx on Biodiversity	MODERATE (-ve)	MINOR (-ve)	MINOR (-ve)	MINOR (+ve)	MINOR (-ve)	MINOR (+ve)
Impact on Surface hydrology						
Removal and alteration of natural water courses	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Impact of reduced peak runoff and discharge volumes on water courses	MODERATE (+ve)	MODERATE (+ve)	MODERATE (+ve)	MODERATE (+ve)	MODERATE (+ve)	MODERATE (+ve)
Impact of Reduction in Mean Annual Runoff on Downstream Surface Water Resources	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Impact of Increased Sediment Yield on Surface Water Quality	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Impact of Increased Pollutant Load on Surface Water Quality	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Noise and Vibration Impacts						
Noise and Vibration Impacts	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	N/A	N/A
Impact on Climate Change and GHG emissions						
Impact of Project GHG Emissions on South Africa's National Emissions	N/A	N/A	MODERATE (-ve)	MINOR (-ve)	N/A	N/A

Socio-Economic Impacts

Impact on Economic Environment						
Impacts linked to Project expenditure	MODERATE (+ve)	MAJOR (+ve)	MODERATE (+ve)	MAJOR (+ve)	MAJOR (-ve)	MODERATE (-ve)
Impacts on key macro-economic variables	NEGLIGIBLE	NEGLIGIBLE	MAJOR (+ve)	MAJOR (+ve)	MAJOR (-ve)	MAJOR (-ve)
Impacts on tourism	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve) TO MAJOR (-ve)	MODERATE (-ve)	MINOR (+ve)	MODERATE (+ve)
Impacts on surrounding land uses	MODERATE (-ve)	MINOR (-ve) TO MODERATE (-ve)	MODERATE (-ve)	MINOR (-ve) TO MODERATE (-ve)	MINOR (+ve)	MINOR (+ve) TO MODERATE (+ve)
Impacts on municipal services	MODERATE (-ve)	MODERATE (+ve)	MODERATE (-ve)	MODERATE (+ve)	MODERATE (-ve)	MODERATE (-ve)
Impact on Social Environmental						
Employment opportunities	MODERATE (+ve)	MAJOR (+ve)	MODERATE (+ve)	MAJOR (+ve)	MAJOR (-ve)	MODERATE (-ve)
Training and skills development	MINOR (+ve)	MODERATE (+ve)	MINOR (+ve)	MODERATE (+ve)	MINOR (+ve)	MODERATE (+ve)
Procurement and services	MODERATE (+ve)	MAJOR (+ve)	MODERATE (+ve)	MAJOR (+ve)	N/A	N/A
Economic diversification	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)	MAJOR (-ve)	MODERATE (-ve)
Unmet Expectations and Potential for Social Unrest	MAJOR (-ve)	MINOR (-ve) to MODERATE (-ve)	MAJOR (-ve)	MINOR (-ve) to MODERATE (-ve)	N/A	N/A
Increased Pressure on Infrastructure and Services (Direct)	MINOR (-ve)	NEGLIGIBLE (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)	MODERATE (-ve)	MINOR (-ve)
Road Infrastructure and Transport (Direct)	MODERATE (-ve)	MINOR (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Health Impacts: Communicable diseases	MAJOR (-ve)	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	MINOR (-ve) to NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Health Impacts: Road traffic accidents	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Impact in Relations between Locals and In-migrants	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Impact on Social Pathologies	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)
Impact on Sense of Place	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Local Cultural and Social Values	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)	MINOR (+ve)
Increased Pressure on Infrastructure and Services (Indirect resulting from Influx)	MINOR (-ve)	MINOR (-ve)	MINOR (-ve)	MINOR (-ve)	MINOR (-ve)	MINOR (-ve)
Communicable Diseases (Indirect resulting from Influx)	MAJOR (-ve)	MODERATE (-ve)	MODERATE (-ve)	MINOR (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)
	MAJOR (-ve)	MODERATE (-ve)	MINOR (-ve) to MODERATE (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)
Impact on Visual Resources						
Impact on the Aesthetic Value of the Landscape	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)	MAJOR (-ve)
Impact on Traffic and Transport						
Impact on Traffic and Transport Networks	MINOR (-ve)	NEGLIGIBLE (-ve)	MINOR (-ve)	MINOR (-ve)	MINOR (-ve)	NEGLIGIBLE (-ve)
Impact on heritage, Palaeontology and Archaeology						
Impact on Archaeology	MAJOR (-ve)	MODERATE (-ve)	MAJOR (-ve)	MODERATE (-ve)	N/A	N/A
Impact on Cultural Heritage and Sense of Place	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)	MODERATE (-ve)	MINOR (-ve)
Impact on Palaeontology	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	NEGLIGIBLE (-ve)	N/A	N/A

4.2 *PUBLIC PARTICIPATION PROCESS*

The public participation process (PPP) has been designed to comply with the regulatory requirements set out in the NEMA, NEM:WA, NEM:AQA, NEM:BA, MPRDA and NWA, as well as international good practice. The PPP is also aligned with the International Finance Corporation (IFC) which is recognised as international good practice.

4.2.1 *Objectives of public participation*

The PPP has been designed to achieve the following objectives:

- To ensure that stakeholders are well informed about the proposed development;
- To provide a broad set of stakeholders sufficient opportunity to engage and provide input and suggestions on the Project;
- To verify that stakeholder issues have been accurately recorded;
- To draw on local knowledge in the process of identifying environmental and social issues associated with the Project, and to involve stakeholders in identifying ways in which these can be addressed; and
- To comply with the legal requirements and international good practice.

A summary of the stakeholder engagement processes undertaken as part of the ESIA process is tabulated below:

Table 4.3 Summary of public participation activities

Activity	Details
Initial consultation	
Meeting with authorities.	Provision of information and general discussion around the Gamsberg Project. The following authorities were consulted on 10 July 2012: • Department of Mineral Resources (DMR); • Department of Environment and Nature Conservation (DENC); and • Department of Water Affairs (DWA).
Meeting with key stakeholders.	Provision of information and general discussion around the Gamsberg Project. The following key stakeholders were consulted on 20 and 21 June 2012: • Pella Local Municipality and community leaders (20 June, Pella); • South African National Botanical Institute (SANBI) (20 June, Springbok); • Khai-Ma Local and Namakwa District Municipalities (21 June, Pofadder); and • Pofadder Landbou Vereniging (21 June, Pofadder).
Identification of stakeholders.	Stakeholder database which includes interested and affected parties from various sectors of society including directly affected and adjacent landowners in and around the Project area.
Pre-Scoping Phase	
Distribution of Project announcement letter and Background Information Document	BID and announcement documentation emailed and posted to stakeholders on 30 July 2012. (Registration period of 30 days: 30 July – 29 August 2012).

(BID).	
Placing of adverts.	Afrikaans adverts were placed in the Die Plattelander (3 August 2012), Die Namakwalander (3 August 2012), Eland (8 August 2012), Die Burger West (5 August 2011) newspapers and English adverts were placed in the Die Gemsbok (3 August 2012).
Putting up of site notices.	Eight Afrikaans and eight English site notices were put up at the Project area, local libraries, municipal offices and frequently visited shops or recreational venues Pella, Aggeneys and Pofadder: • Gamsberg Project area; • Aggeneys Kaffee; • Aggeneys Recreation Hall; • Black Mountain Main Building Aggeneys; • Pella Library; • Pella Municipal Office; • Pofadder Library; and • Pofadder Municipal Office.
Meetings with relevant stakeholders.	Meetings and telephonic consultations were conducted with the following stakeholders in mid-August 2012: • Landowners/farmers telephonic consultations (27 July); • Environmental NGOs telephonic consultations (8 August); • Pofadder Landbou Vereniging meeting (15 August, Pofadder); • Conservation South Africa, SANBI and NAGO meeting (16 August, Springbok); and • Khai-Ma Local Municipality meeting (16 August, Pofadder).
Obtained comments from stakeholders.	Comments, issues of concern and suggestions received from stakeholders are included in the Final Scoping Report.
Scoping Phase	
Announcement of DSR.	Draft Scoping Report announcement letter sent to all I&APs on the database on 9 November 2012. An English and Afrikaans adverts was placed in the following newspapers: • Die Gemsbok • Die Plattelander • Die Namakwalander • Eland • Die Burger West • Express Northern Cape
Making Draft Scoping Report available to I&APs.	Draft Scoping Report in English, a Non-Technical Summary in English and Afrikaans accompanying documents were placed at the following public places within the Project area:

	• Pofadder Public Library • Pofadder Local Municipal Offices • Springbok Municipal Offices • Springbok Library • Aggeneys Public Library • Pella Public Library and Local Municipality • Project website
Draft Scoping Report available for I&AP review	The Draft Scoping Report was made available for a 30 day period for I&AP review from the 9 November – 14 December 2012.
Stakeholder meetings to present Draft Scoping Report.	Details of public meetings undertaken during the Scoping Phase are as follows: - **Pofadder Community Hall** **27 November 2012** **16:00 – 18:00** - **Pella Community Hall** - **28 November 2012** - **16:00 – 18:00** - **Aggeneys Recreational Club** - **29 November 2012** - **16:00 – 18:00** Details of focus group meetings undertaken during the Scoping Phase are as follows: - **Pofadder Landbou Community Hall** - **Pofadder Farmers Association** **28 November 2012** **10:00 – 12:00** - **Conservation South Africa Offices** - **Social and Environmental Non-Governmental Organisations** - **28 November 2012** - **16:00 – 18:00**
Obtain comments from stakeholders on the Draft Scoping Report.	Comments, issues of concern and suggestions received from stakeholders during the Draft Scoping Report public review period were captured in the Comment and Response Report. These comments were addressed in the Final Scoping Report, which was distributed for a public comment period.
Making Final Scoping Report available to I&APs	The Final Scoping Report was simultaneously submitted to the competent authority and made available to I&APs for a 21 day comment period (from 14 January 2013 to the 4 February 2013). During this time the public could submit their comments directly to DENC.
ESIA Phase	
Announcement of Draft ESIA report.	A Draft ESIA report announcement letter was sent to all I&APs on the database on in April 2013. Adverts placed in the following newspapers: • Die Gemsbok

	• Die Plattelander • Die Namakwalander • Eland • Die Burger West • Express Northern Cape
Making Draft ESIA report available to I&APs.	The Draft ESIA report in English, a Non-Technical Summary in English and Afrikaans accompanying documents were placed at the following public places within the Project area: • Pofadder Public Library • Pofadder Local Municipal Offices • Springbok Municipal Offices • Springbok Library • Aggeneys Public Library • Pella Public Library and Local Municipality • Project website
Making the Draft ESIA Report available to I&APs	The Draft ESIA report and associated documents were placed on the following website: wwww.erm.com/Gamsberg
Stakeholder meetings.	Public meetings are scheduled from 13 to 17 May.
Obtain comments from stakeholders.	Comments, issues of concern and suggestions received from stakeholders on the Draft ESIA Report will be captured in the Comment and Response Report (in the Final ESIA), which will also be made available to I&APs. The Comment and Response Report will also be distributed to all I&APs who submitted comment.
Making ESIA Report available to I&Ps	The Final ESIA Report was simultaneously submitted to competent authority and made available to I&APs. A public review period of 21 days was provided for I&APs to provide comments directly to DENC.

5 IMPLEMENTATION OF THE EMPR

5.1 INTRODUCTION

This document describes mitigation measures in detail, and is partly prescriptive in identifying specific people or organisations to undertake specific tasks in order to ensure that impacts on the bio-physical and socio-economic environment are minimised during the lifecycle of this project. The EMPr is applicable to all works comprising the pre-construction, construction, operation and decommissioning of the Project. It is an open-ended document implying that information gained during pre-construction, construction, operational, decommissioning and closure activities and/or monitoring of procedures on site could lead to changes in the EMPr.

The appointed Environmental Control Officer (ECO) will monitor compliance with the construction EMPr and other Conditions of Approval as they relate to environmental matters. This EMPr gives direction and guidance to all responsible parties. The responsible parties are expected to co-operate closely to minimise or avoid unnecessary environmental impacts. The mitigation hierarchy must be abided to, when implementing this EMPr. The mitigation hierarchy is contained below, for ease of reference:

Figure 5.1 Mitigation hierarchy

- **Avoid at Source; Reduce at Source:** avoiding or reducing at source through the design of the Project (e.g., avoiding by siting or re-routing activity away from sensitive areas or reducing by restricting the working area or changing the time of the activity).
- **Abate on Site:** add something to the design to abate the impact (e.g., pollution control equipment, traffic controls, perimeter screening and landscaping).
- **Abate at Receptor:** if an impact cannot be abated on-site then control measures can be implemented off-site (e.g., noise barriers to reduce noise impact at a nearby residence or fencing to prevent animals straying onto the site).
- **Repair or Remedy***:* some impacts involve unavoidable damage to a resource (e.g. agricultural land and forestry due to creating access, work camps or materials storage areas) and these impacts can be addressed through repair, restoration or reinstatement measures.
- **Compensate in Kind; Compensate Through Other Means:** where other mitigation approaches are not possible or fully effective, then compensation for loss, damage and disturbance might be appropriate (e.g., planting to replace damaged vegetation, financial compensation for damaged crops or providing community facilities for loss of fisheries access, recreation and amenity space).

The Contractor is obliged to inform the ECO immediately of events that may cause serious environmental damage or breach the requirements of the EMPr. The ECO in turn will immediately inform the site Engineer and BMM and, if necessary the Local, Provincial and or National Authority, of such events (depending on the nature of the event).

5.2 LEGAL OBLIGATIONS

Obligations imposed by the EMPr are legally binding in terms of environmental statutory legislation (i.e. the Environmental Authorization in terms of the National Environmental Management Act No.107 of 1998, as amended) and in terms of amendments to the Particular Conditions of Contract that pertain to this project.

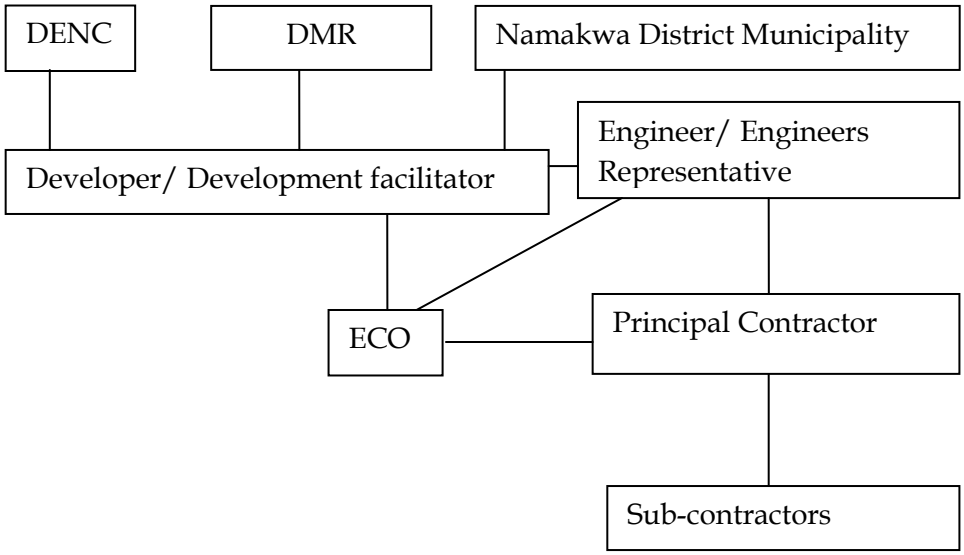
The requirements of this EMPr do not release the Developer from the requirements of any other legislation that may be applicable to the project.

5.3 ROLES AND RESPONSIBILITIES

The key role-players during the construction phase of the Project, for the purposes of environmental management on site, include but are not limited to: the Developer (BMM), the Engineer, the main Contractors (direct appointments including civil works contractor, building contractor, landscape contractor etc.), the ECO, and representatives of the relevant Authority/ies.

Details of the responsibilities of each of the key role-players have been provided below. Lines of communication and reporting between the various parties are also illustrated below.

Figure 5.2 Roles and Responsibilities



5.3.1 The Developer

For the purpose of this document, "the Developer" and its appointed facilitators refers to those to whom permission has been granted to proceed with the Project (i.e. BMM), and who is thus ultimately responsible for compliance with all conditions of approval of the Development or any aspect thereof by any authority.

With respect to the **pre-construction phase** of the Development, the Developer is to:

- Implement the recommendations outlined in the pre-construction EMPr; and
- Implement as many recommendations as possible that will lessen the total environmental impact of the proposed Development from the design stage, through to construction and ultimately the operational phase.

With respect to the **construction phase** of the Development, the Developer is to:

- Ensure that all relevant approvals and permits have been obtained prior to the start of construction activities on site;
- Ensure that the EMPr has been approved by DENC and DMR prior to the start of construction activities on site;
- Ensure that DENC has been notified of the date on which construction activities will be starting, prior to commencement of the activity;
- Ensure that all conditions of approval have been complied with;

- Appoint all the required specialists to make input into the pre-construction/design phase (refer to *Section 6.3)*; and
- Appoint a suitably qualified and experienced ECO prior to the start of construction activities on site, and for the duration of the construction phase.

With respect to the **operational phase** of the Development, the developer is to:

- Ensure that operation of the zinc mine is undertaken in line with the requirements of the operational phase EMPr; and
- Continuously seek to improve any negative environmental impacts which result from the operational phase.

5.3.2 Site Engineer

For the purposes of this document, "Site Engineer" refers to the engineer for the Development, or any other person authorised by the Developer, to be responsible for the technical and contractual implementation of the works to be undertaken.

The responsibilities of the Site Engineer are to:

- Ensure that the requirements as set out in this EMPr and by the relevant Authorities are adhered to and implemented;
- Assist the ECO in ensuring that the conditions of the Construction EMPr are being adhered to and promptly issuing instructions requested by the ECO, to the Contractor. All site instructions relating to environmental matters issued by the Engineer are to be copied to the ECO;
- Assist the ECO in making decisions and finding solutions to environmental problems that may arise during the construction phase;
- Review and approve construction method statements with input from the ECO;
- Order the removal of person(s) and/or equipment not complying with the specifications (as required by the ECO or otherwise); and
- Provide input into the ECO's ongoing internal review of the EMPr.

5.3.3 The Contractor

For the purposes of this document "The Contractor" refers to any directly appointed (by the Developer) company or individual undertaking the implementation of the works.

The Contractor is to:

- Ensure implementation of all applicable Environmental Specifications, including all additional requirements related to approved method statements, during all works on site.
- Ensure that all of its sub-contractors', employees, suppliers, agents etc. are fully aware of the environmental requirements detailed in the Environmental Specifications;
- Liaise closely with the Engineer and the ECO and ensure that the works on site are conducted in an environmentally controlled manner;
- Inform the Engineer as well as the ECO should environmental conditions on site deteriorate, e.g. dumping, pollution, littering and damage to vegetation; and
- Carry out instructions issued by the Engineer, on request of the ECO, required to fulfil his/her compliance with the Construction EMPr.

5.3.4 Environmental Control Officer

During the construction phase of the project, the ECO is to:

- Ensure that the Contractor has a copy of the Construction EMPr and all agreed method statements;
- Undertake weekly site inspections (frequency may change as required, depending on the activity) to audit compliance of all parties with the requirements of the Construction EMPr;
- Advise/recommend on actions or issues impacting on the environment to the Engineer, who shall issue any required Site Instructions to the Contractor;
- Environmentally educate and raise the awareness of the Contractor and his/her staff as to the sensitivity of the site and to facilitate the spread of the correct attitude during works on site;
- Review and approve construction/landscape method statements together with the Engineer/Landscaper (when applicable);
- Assist the Contractor in finding environmentally responsible solutions to problems;
- Recommend to the Engineer the removal of person(s) and/or equipment not complying with the Specifications;
- Undertake photographic monitoring of the construction site;
- Keep records of all activities/ incidents concerning the environment on site in a Site Diary;
- Complete temporary and permanent site closure checklists;
- Compile and maintain a complaints register;
- Take immediate action on site to stop works where significant and irreparable damage is being inflicted on the environment, and to inform

the Engineer, BMM and relevant authorities immediately of the occurrence and action taken; and

- Undertake a continual internal review of the EMPr and make recommendations regarding its updating to the Engineer and Developer.

The ECO has the authority to recommend to DENC that works be stopped, if in his/her opinion serious harm to, or impact on the environment is imminent, is likely to occur or has occurred and such actual or potential harm or impact is in contravention of the EMPr, and which is, or may be, caused by construction or related works.

Upon failure by the Contractor or Contractor's employee to show adequate consideration to the environmental aspects of this contract, the ECO may recommend to the Engineer and the project management team to have the Contractor's representative or any employee(s) removed from the site or work suspended until the matter is remedied. No extension of time will be considered in the case of such suspensions and all costs will be borne by the Contractor.

The ECO shall keep a Site Diary in which events and concerns of environmental significance are to be recorded. The ECO will compile a monthly report of such events, concerns, public complaints and general compliance of the Contractor with the construction phase of the EMPr. This report will be submitted to the Engineer and if required, to DENC, DMR and the Namakwa District Municipality. The ECO is also required to attend regular site meetings of the project management team to report on environmental issues and to minute the requirements that emerge.

The ECO will be responsible for the compilation of a final completion checklist for the project, completed when all construction works related to the project have terminated and the site has been cleared of all construction related debris, materials or equipment not forming part of the permanent works. This checklist will audit the Contractor's compliance with the construction phase of the EMPr throughout the duration of the construction phase and, together with a final written report, will be submitted to DENC, DMR and the Namakwa District Municipality in order to achieve "environmental closure" for the construction phase of the project.

5.4 SITE MEETINGS DURING THE CONSTRUCTION PHASE

The ECO is required to attend regular site meetings of the project management team to facilitate the transfer of information and to update all parties on the environmental compliance of the project as a whole, and minute the consequential requirements.

The ECO will present a summary report, outlining the main construction activities that relate to the environment, at this meeting. The minutes of these meetings will form part of the construction phase EMPr records. These minutes will reflect environmental queries, agreed actions and dates of eventual compliance by the Contractor.

The following people should attend these meetings:

- BMM representative;
- Engineer;
- ECO; and
- Contractor(s) representative.

5.5 ENVIRONMENTAL AWARENESS PROGRAMME

The Contractor, in consultation with the ECO, shall arrange for a presentation to site staff to familiarise them with the environmental aspects of the construction phase of the EMPr within seven days from the commencement date of construction. This presentation should take cognizance of the level of education, designation and language preferences of the staff. General site staff would commonly receive a basic environmental awareness course highlighting general environmental "do's and don'ts" and how they relate to the site. Management on site, e.g. site agents and foremen, who require more detailed knowledge about the environmental sensitivities on site and the contents and application of the construction phase of the EMPr document itself, will benefit from a separate presentation dealing with these issues. The ECO may call upon the services of a specialist environmental education translator should this be required.

5.6 METHOD STATEMENTS

The Contractor shall provide Method Statements for approval by the ECO and the Engineer prior to work commencing on aspects of the project deemed or identified to be of greater risk to the environment and/or which may not be covered in sufficient detail in the construction phase of the EMPr, when called upon to do so by the Engineer or ECO.

A Method Statement is a "live document" in that modifications are negotiated between the Contractor and the ECO/Engineering team, as circumstances unfold. All Method Statements will form part of the construction phase of the EMPr documentation and are subject to all terms and conditions contained within the construction phase of the EMPr.

Note that a Method Statement is a starting point for understanding the nature of the intended actions to be carried out and allows for all parties to review and understand the procedures to be followed in order to minimise risk of harm to the environment.

Changes to, and adaptations of, Method Statements can be implemented with the prior consent of all parties.

A Method Statement describes the scope of the intended work in a step-by-step description, in order for the ECO and the Engineer to understand the Contractor's intentions. This will enable them to assist in devising any mitigation measures, which would minimize environmental impact during these tasks.

For each instance where it is requested that the Contractor submit a Method Statement to the satisfaction of the Engineer and ECO, the format should clearly indicate the following:

- *What* - a brief description of the work to be undertaken;
- *How* - a detailed description of the process of work, methods and materials;
- *Where* - a description/sketch map of the locality of work (if applicable);
- *When* - the sequencing of actions with due commencement dates and completion date estimates;
- *Who* – The person responsible for undertaking the works described in the Method Statement; and
- *Why* – a description of why the activity is required.

All Method Statements are to be to the satisfaction of the ECO, Engineer and, where practical and deemed necessary, should be endorsed as being acceptable by the environmental representative of the DENC and DMR.

A list of some of the Method Statements that the Contractor may need to submit during the course of the construction contract has been provided in Section 4, along with an indication of those which the ECO may require the Contractor to provide prior to the start of works on site (see *Appendix 1* for a Method Statement Template).

5.7 ECO DIARY ENTRIES

The ECO will maintain a site diary that relates to environmental issues as they occur on site for record keeping purposes. Comments from this diary will form part of reports presented at site meetings by the ECO.

5.8 SITE MEMO ENTRIES

Site memos, stipulating recommended actions required to improve compliance with the construction phase of the EMPr by the contractor, will be issued by the ECO to the Engineer, who in turn will ensure that the Contractor is informed of the said instruction.

Comments made by the ECO in the Site Memo book are advisory and all consequential Site Instructions required may only be issued by the Engineer. Site Memos will also be used for the issuing of stop work orders for the purposes of immediately halting any particular activity(ies) of the Contractor deemed to pose immediate and serious risk of unnecessary damage to the environment.

5.9 GRIEVANCE MECHANISM

Any disputes or disagreements between role players on site (with regard to environmental management) will firstly be referred to the Engineer during the construction phase, or to a DENC environmental officer during the operational phase. If no resolution on the matter is possible during the construction phase, the matter will be elevated to DENC for clarification.

BMM should develop a grievance procedure to ensure fair and prompt resolution of problems arising from the Project. The grievance procedure should be underpinned by the following principles and commitments:

- Implement a transparent grievance procedure, and disseminate key information to directly impacted stakeholders;
- Seek to resolve all grievances timeously; and
- Maintain full written records of each grievance case and the associated process of resolution and outcome for transparent, external reporting.

The responsibility for resolution of grievances will lie with BMM and its Contractors.

5.10 COMMUNITY RELATIONS

BMM should continue to engage with stakeholders throughout the project construction and operation. Communication with local communities and other local stakeholders will be a key part of this engagement process and is one where BMM and the Contractor will need to work closely together during

the construction period. Development of a Community Engagement Plan (CEP) is important to facilitate this communication.

The objectives of communication and liaison with local communities are the following:

- To provide residents in the direct and indirect vicinity of the Development and other interested stakeholders with regular information on the progress of work and its implications;
- To monitor implementation of mitigation measures and the impact of construction on communities via direct monitoring and feedback from those affected, in order to ensure that mitigation measures are implemented and the mitigation objectives achieved; and
- To manage any disputes between BMM, the Contractors and Interested and Affected Parties.

5.11 SOCIAL RESPONSIBILITIES

The Developer and Contractors shall encourage and implement wherever possible the procurement of locally based labour, skills and materials, in line with BMM's existing Procurement Plan.

6 PLANNING AND DESIGN PHASE EMPR

6.1 SCOPE

This section covers the mitigation measures and recommendations that may be considered in the pre-construction and design stage of the project.

6.2 APPLICATION

This specification covers the requirements for mitigating the impact on the environment during the detailed design phase of the Project.

6.3 PRE-CONSTRUCTION REQUIREMENTS

6.3.1 TSF Liner Requirements

The ESIA and specialist recommendation with regards to reducing the impact the TSF may have on groundwater quality is to construct a natural liner system as specified by the design engineers beneath the TSF. The detailed specifications of the liner system requirements will be agreed upon by the Department of Water Affairs and be in line with the conditions of the Water Use License.

The detailed design of the TSF liner system will be informed by the following during the final design phase:

- Permeability testing of the subsurface in the area of the TSF; and
- Geophysical investigations.

6.3.2 Refinement of Design

The preferred site layout may be refined, based on the completion of detailed design. Regardless of the extent of changes made to the current design, the applicant must engage with the DENC to determine if the refinements to the design are considered substantive. The DENC will determine whether the refinements warrant additional public engagement and revisions to the current ESIA Report and associated EMPr.

Explosives Magazine

Based on recommendations from the Hydrologist, it was requested that the location of the explosives magazine storage area be relocated from the top of the inselberg (due to the proximity of three watercourses). During the ESIA process, BMM agreed that the explosives magazine area would be relocated to the plains, between the N14 and inselberg, outside of any watercourses. This

design refinement has therefore already been accommodated in the final layout as presented in the ESIA report.

Floodline Determination

Lastly, the hydrologist requested that an in-depth floodline determination study be undertaken, once the detailed surveying is complete, of all major watercourses in the affected mining license area. Based on the findings of this study, project infrastructure location must be refined to remain outside the 1:100 year floodline of watercourses.

Waste Rock Dump

The extremities of the waste rock dump may still be adjusted, where technically feasible through discussions with the botanist and engineering team. The results of this will not change the significance ratings on the impact assessment and may require some fine adjustments to the residual impact and resultant offsets. This will be finalised in the offset report.

Consider designing and constructing a rock dump comprising only quartzite rock to fill the remaining portion of the western kloof thereby shielding the main kloof from any direct impacts of mining activities in the pit. Careful placement of this barrier must be defined with input from a qualified botanist prior to the placement of the rock.

Consider designing and constructing a rock-dump (or berm), where technically feasible, in the crater to the south and south-eastern side of the pit to shield the remainder of the basin/crater from mining activities. The berm should be constructed to the same elevation as the plateau comprising a non-acid leaching rock core and a quartzite rock outer layer. Careful placement of this barrier must be defined with input from a qualified botanist and the engineering team prior to the placement of rock.

Associated with the two above mitigations, the botanist will work with the engineering team to consider the design and construction of appropriate structures to deal with erosion, storm water and dirty water within the crater.

6.3.3 Biodiversity Offsetting Process

It is the responsibility of BMM to ensure that the Biodiversity Offset process is finalised and mutually agreed to with the relevant authorities and stakeholders (i.e. DENC and NGO's), prior to commencement of construction. Proof of agreement of the finalisation of the biodiversity offset is required. All relevant stakeholders of the biodiversity offset process must be notified, two weeks prior of commencement of construction. If any further issues arise around the biodiversity offset, these would need to be addressed to the mutual agreement of the relevant stakeholders, before construction may commence.

6.3.4 Permit Requirements

Activities undertaken during site preparation, construction and operation may require additional permits, over and above the Environmental Authorisation. BMM is responsible for ensuring that they hold the necessary permits in order to comply with national and local regulations. Additional permit requirements that may be required are described below.

National Water Act

There are licensing procedures that need to be followed for particular "water uses". Water uses that may be of relevance to the Development include the following:

- Taking of water from a water resource, including a water course, surface water, estuary or aquifer (i.e. borehole);
- altering the bed, banks, course or characteristics of a water course; and/or
- impeding or diverting of a flow in a water course.

Under the National Water Act (No 36 of 1998), either a General Authorisation or a Water Use Licence may be required for the project.

National Environmental Management: Biodiversity Act

The NEM:BA identifies a number of plant species that, if removed, require a permit prior to proceeding.

The Botanical Impact Assessment undertaken as part of this ESIA process confirmed that there are a number of species identified on site which will require a permit in terms of the Biodiversity Act. A permit application will need to be submitted to the Provincial Department of Environment and Nature Conservation for approval, before proceeding with the activity. This Permit Application must be accompanied by a detailed Biodiversity Management Plan. A detailed BMP will be developed as part of this EMP and cover the following aspects / requirements:

- Appropriate management of the set aside conservation area.
- The set aside conservation area under the control of the mine will be maintained in a good ecological state through controlled access, prohibition on livestock grazing and proactive management.
- An Alien Plant Control Plan to prioritise the species for control and present the most effective control measures based on available technology and levels of infestation.

- Continued scientific research of ecological habitat (including fauna and flora) will be required. The regional importance of the unnamed ant species identified on the inselberg, will need to be completed, prior to commencement of construction. BMM will explore additional research areas to help feed into the current gaps present on the ecological habitat of the affected region.

- Search and Rescue operations to capture and translocate faunal species that are not able to escape prior to any land clearing exercises.

- Translocation of plants will be considered under the following circumstances:

    - Translocation only from areas about to be destroyed through clearing of vegetation cover;

    - For research purposes (e.g. to botanical gardens);

    - For landscaping purposes around the mine;

    - Species with very limited numbers and of high conservation value will be translocated within the Gamsberg.

    - In some cases translocated plants will be used to restore degraded habitat within the offset area.

- Any clearing within or close to watercourse or wetland vegetation communities will employ adequate erosion and sedimentation mitigation measures to ensure that aquatic ecosystems are not impacted and vegetation is not affected.

- Design and construct the southern approach road within the available flat surface, cutting of the slope should be limited to areas where the available surface does not allow for the required surface width. Berms should be constructed with materials cut from the slope and rocks rolling down the slope are to be kept to a minimum.

National Forestry Act

The National Forests Act (84 of 1998) (NFA) deals with the protection of trees. The Minister is required to annually publish a list of all species protected under Section 12. No person may undertake any of the following restricted activities involving a listed tree species, except under licence granted by the Minister:

- cut, disturb, damage, destroy or remove any listed tree species; or
- collect, remove, transport, export, purchase, sell, donate or in any other manner acquire or dispose of any listed tree species.

Applications for such activities shall be made to the responsible official in the Northern Cape Province.

Northern Cape Nature Conservation Act

Consideration will also be given to the Northern Cape Nature Conservation Act (NCNCA), which came into force on 21 January 2010 and which repealed the Ordinance on Nature Conservation in the Northern Cape. NCNCA prescribes restricted activities in relation to specially protected plants and animals species for which licencing is required. NCNCA furthermore prescribes prohibited acts in relation to invasive species, as well as restricted activities in relation to certain damage causing animals for which licenses are required.

A number of protected tree (i.e. *Acacia erioloba* – Camel Thorn) and faunal species have been identified to occur within the proposed Project area. To the extent that licences are required in terms of the NCNCA, these should be obtained.

National Heritage Resources Act (25 of 1999)

The protection and management of South Africa's heritage resources is controlled by the National Heritage Resources Act (NHRA). The objective of the NHRA is to introduce an integrated system for the management of national heritage resources.

In terms of the NHRA, prior to the destruction, translocation or trade of archaeological and/ or paleontological artefacts, a permit is required from the heritage authorities (Heritage Northern Cape) prior to commencement of construction. Based on the recommendations from the Archaeologist, a phase 2 archaeological mitigation plan needs to be approved by the South African Heritage Resources Agency and the mitigation implemented, prior to commencement of construction. A suitably qualified archaeologist must be appointed to undertake the Phase 2 salvage mitigation measures.

Furthermore, additional investigation into the potential massacre sites is recommended to confirm if, indeed, there is a tie with the mine site and the San people.

6.3.5 Tender Documentation

BMM shall ensure that this EMPr is included within the tender documents for all Contractors tendering to undertake any aspects of the construction phase of the project.

In the adjudication of any tenders to undertake any aspect of the construction or operation of the proposed project, BMM (or BMM agent in this regard)

must ensure that the costs of compliance with the EMPr have been adequately allowed for within the winning tender.

6.3.6 Additional Pre – Construction Requirements

- Clearly delineate and cordon off all no-go areas, as identified by the ECO.
- Notify DENC, DEA, DWA and DMR prior to commencement of construction, as per the Environmental Authorisation.
- A variety of plans (as outlined below) must be developed prior to the commencement of construction, to identify and avoid work-related accidents. These plans must be aligned with the existing plans compiled by BMM and Vedanta Resources plc.
- BMM must establish a suite of policies (as outlined below) to guide the various phases of the Project. These policies must be aligned with the existing plans compiled by BMM and Vedanta Resources plc.
- A Code of Conduct must be developed for all workers (BMM and Contractors including their workers) directly related to the project. The objective of the code of conduct is to limit, where possible, social ills brought about by the construction and operation of the Project.

6.4 DESIGN AND PLANNING COMPLIANCE

In order to ensure compliance with environmental legislation and good practice guidelines, the following actions are applicable to the planning and design phase for the Project. The persons responsible for implementation of the actions are listed in the table below, the majority of which are the responsibility of BMM and/ or associated contractors.

6.4.1 Generic design and planning requirements:

Table 6.1 below is a generic list of design and planning considerations. This is followed by *Table 6.2* for waste management design consideration.

Table 6.1 Generic list of design and planning considerations

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
1.	Stakeholder engagement	Notify all registered Interested and Affected Parties of Environmental Authorisation (EA).	1.1	Notify all registered I&APs and key stakeholders, via letters of notification and advertising of the opportunity for appeal of the Environmental Authorisation.	Notices sent to relevant parties on the stakeholder database. List of those to whom it was sent on file.	ERM	Within the number of DENC-required days from the issuing of the Environmental Authorisation.
2.	Permit Requirements	Ensure compliance with, *inter alia*, the following legal requirements: 1. Minerals and Petroleum Resources Development Act 2. National Environmental Management Act 3. National Environmental Management: Waste Act 4. National Environmental Management: Biodiversity Act 5. National forestry Act 6. Northern Cape Nature Conservation Act 7. National Heritage	2.1	Obtain all relevant permit and licences, prior to commencement of construction.	Proof of Permits to be kept on-site.	BMM	Prior to construction

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
		Resources Act 8. National Water Act Note that the license issued in terms of the National Environmental Management: Air Quality Act will only be issued, after commencement of operation.					
3.	Finalisation of EMPr and Contractor Compliance Standards	Update EMPr with EA conditions and other requirements as set out by the Department of Mineral Resources and Water Affairs and Environment and Nature conservation.	3.1	Incorporate additional mitigation measures specified by the relevant authorities into the EMPr and Contractor Compliance Standards.	EMPr and Contractor Compliance Standards.	BMM	Prior to construction
4.	Notification to DENC: Director of Compliance Monitoring	Ensure that DENC, DEA, DWA and DMR are notified of commencement date.	4.1	Notify DENC, DMR and DEA prior to commencement of construction.	Proof of communication	BMM	14-days in advance of commencement of construction.
		Keep DENC and DMR informed of any aspects of non-compliance with EMPr or EA.	4.2	Notify DENC, DMR and DEA with reasons if any provisions of the EMPr or EA cannot be implemented, and provide alternative.	Letter of notification	BMM	Prior to construction
		Keep all authorities informed of current contact details of applicant.	4.3	Notify DENC, DEA, DMR and DWA of any change of contact details of the applicant.	Letter of notification	BMM	Prior to construction
		Keep DENC informed of	4.4	Submit the name and contact details of the	Letter of notification	BMM	Prior to construction

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
		contact details of ECO		appointed ECO prior to construction			
5.	Subsidiary Plans	Develop Subsidiary Plans to minimise environmental and social risks	5.1	The following subsidiary plans will need to be in place prior to construction, and apply to both the construction and operational phases of the Project. Specialist input will be required for, as indicated below: • Biodiversity Management Plan (qualified botanist required) • Health and Safety Plan • Traffic Management Plan • HIV Policy and Awareness Plan • Rehabilitation Plan • Policy for assessing damages and losses to resources • Recruitment Policy • Procurement Policy • Code of Conduct • Grievance Mechanism • Community Engagement Plan • Waste Management Plan (Waste management specialist required) • Emergency Plan • Storm water management plan • Grievance procedure • Tailings Management Plan • Comprehensive water balance plan • Groundwater Monitoring Plan (Hydrogeologist) • Soil erosion and sediment control	Copies of plans to be kept on-site.	BMM	Prior to construction

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				management plan • Air quality monitoring plan, including dust suppression (air quality specialist required) • Phase 2 archaeological mitigation plan (Archaeological specialist required) • Soil contamination and management plan • Health and safety plan (include requirements in terms of the Operational, Health and Safety Act) • Groundwater monitoring plan, for implementation prior to construction. • Stakeholder Consultation and Engagement Plan • Local contractor and supplier policy These are referred to below, where relevant. These plans should be aligned with BMM and Vedanta existing Plans, which in turn demonstrates alignment with IFC requirements.			
6.	Procurement of Services and Tender Procedures	Ensure that procurement of local, regional and national services is maximised:	6.1	Establish a procurement policy which sets reasonable targets for the procurement of goods and services from South African residents /suppliers, particularly local residents as far as possible.	Procurement policy	BMM	Prior to construction
			6.2	Procurement should advertise tenders in local and national newspapers.	Proof of advertisements		
			6.3	Procurement processes should identify and	Proof of BIDs considered.		

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				encourage bids from local suppliers.			
			6.4	Adopt transparent adjudication process for local suppliers.	Demonstrate robust reasons for selecting/not selecting local suppliers		
			6.5	The conditions of the contract between BMM and the subcontractor will include requirements for local Enterprise Development addressing the following identified opportunities, whenever possible: • Electrical system: there will be a requirement for the electrical contractor to make use of local electrical companies for certain elements of the installation of the electrical system. • Security: there will be a contractual requirement for the security service contractor to subcontract the provision of local security staff to a local company. If such a company does not exist, then the requirement will be for the security service contractor to establish such a subcontractor. • BMM will include requirements for local employment in the contracts that they establish with subcontractors and encourage all contractors recruit in accordance with the BMM recruitment policy (as proposed above) and RFP	Proof of conditions of contract Copies of contract for proof.		

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				documents.			
			6.6	BMM will work with the Local Municipality, community representatives and NGOs to identify suppliers with the appropriate level of capacity to supply goods and services over the operational lifetime of the project (specifically BBBEE companies).			
			6.7	BMM to work closely with the suppliers to provide the requisite training to the workers. The training provided will focus on Development of local skills.			
			6.8	BMM to ensure that the appointed project contractors and suppliers have access to Health, Safety, Environmental and Quality training as required by the Project. This will help to ensure that they have future opportunities to provide goods and services to the sector.	Proof of training (signed records required).		
7.	Employment & Recruitment	Ensure that employment of local people is maximised and that societal expectations are managed in terms of employment opportunities.	7.1	BMM will work closely with the relevant local authorities, community representatives and NGOs to ensure that the use of local labour is maximised. This should include: • sourcing and using available skills/ employment databases that the local authorities may have;	Meeting minutes / advertisements	BMM	Prior to construction

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				• where no database is available, BMM to establish a database in consultation with the Khai Ma Local Municipality, community representatives and NGOs (this database will be shared with contractors); and • advertising employment opportunities through the Local Municipality and using local media.			
			7.2	Ensure that the appointed project contractors and suppliers have access to Health, Safety, Environmental and Quality training as required by the project.	Signed records of Health and Safety training undertaken.		
			7.3	BMM will establish a recruitment policy which will encourage the employment of local residents from the IYLM. The policy will be aligned with the requirements of the DoE as stipulated in the RFP Documents and, where possible, BMM will strive to exceed these requirements.	Recruitment Policy		
			7.4	The Recruitment Policy will also promote the employment of women to ensure that gender equality is attained as defined in the Employment Equity Act (No 55 of 1998).	Proof of compliance with the Employment Equity Act.		
			7.5	BMM will notify identified representatives of the Local Municipality of the specific jobs and the skills required for the project.	Proof of notification		

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				This will give the local population time prior to the commencement of construction to attain the relevant skills/qualifications to be employable on the project.			
			7.6	BMM will initiate training and skills Development programmes prior to the commencement of construction, as a means of ensuring that members of the local workforce are up-skilled and can be employed on the project.	Training material and records		
			7.7	The recruitment policy must be aligned with the existing policy for BMM and Vedanta.			
			7.8	In order meet unmet expectations of employment opportunities, BMM must implement the following measures, wherever possible: • BMM will keep the communities regularly informed of on-going Project activities through the ward councillors and community leaders. Method and frequency to be defined in the above-mentioned stakeholder consultation and engagement plan. • All concerns regarding jobs and other expectations will be addressed in accordance to the grievance procedure			

PLANNING AND DESIGN PHASE							
Aspect		**Objective**	**Actions to be undertaken to Mitigate Environmental Impact**		**Parameters for Monitoring**	**Responsibility**	**Frequency / Timing**
#	**Description of Aspect**		**#**	**Commitment / Actions Required / Key Controls**			
				- clearly advertise criteria for skills and experience needed for available jobs through local, regional and national media; and clearly advertise experience, quality and volume requirements from the supply chain. • Consult with local community leaders/members to ensure the Project is fulfilling commitments to participation including in training, employment, community benefits package, and monitoring activities and outcomes. • Ensure a high standard of environmental management and monitoring, including participative monitoring with community groups. • The Project will clearly communicate information on safety standards and practices, and respond quickly to community questions as they arise.			

6.4.2 Waste management and classification design and planning requirements

Table 6.2 Waste management design and planning considerations.

Unit / Source	Description	Waste Type/Composition	Preferred Management Option(s)	Alternative Management Option(s)
1. Construction Phase				
Construction Wastes	Metal Scrap	Steel, wood, rubber & plastic & tyre scrap Electrical cable scrap	Recycle/Recover	Dispose to General Waste Landfill
	Building Rubble	Cement Bags, bricks, cut-offs, hardened cement etc	Recycle, reuse, if possible	Dispose to General Waste Landfill
	Paint	Waste Paint, "Empty" Containers	Recycle to "Collect-a-Can"	Dry out/Solidify and Dispose to General Waste Landfill
	Fuels	Spillage, Contaminated Soil	See Sections 6 and Below	
	Lubricating Oil and Grease	Used oil and grease, oil filters, oily rags, etc		
	Sewage Treatment	Activated Sludge		
	Health care risk waste	Used bandages, plasters, syringes, Sanitary Towels, and Pads etc.		
	Hazardous Packaging:	Drums, Plastic and Paper Bags, "Empty" Containers of Cleaning Agents		
	Batteries	Vehicle Batteries Batteries from electrical equipment, e.g. cell phones, torches		
2. Mining				
Waste Rock	Residue Rock, Soil, etc.	Natural material from the mining area.	Dispose to Rock Dump in accordance to Requirements	Use to back fill open pit workings, if permitted
Drilling Oils	Soluble petroleum oils	Soluble oil can be considered potentially hazardous if it enters the ground and surface water	Temporary storage on-site followed by disposal at Vissershok, Cape Town.	Dispose any residual Oil and packaging to an HH Landfill
Explosives	Ammonium Nitrate Fuel Oil (ANFO)	Classed as SANS 10228/GHS 10234 Class 1 Waste, Explosive, when not de-sensitized.	The spilled over explosives would be collected and used in the void bore hole (stemming) just above the ANFO fill.	Small amounts can be treated with water and disposed to hazardous waste landfill
Crusher Dusts	Rock dusts	Spillage, Dust from extractors	Process in flotation plant if possible	Dispose to Tailings Dam

Unit / Source	Description	Waste Type/Composition	Preferred Management Option(s)	Alternative Management Option(s)
Petroleum Wastes	Diesel, Petrol	Spillage, Contaminated Soil	See Section Below	
Oil and Grease	Vehicle lubricants	Used oil, oil filters, oily rags, empty oil cans, etc.		
3. Processing – Flotation Plant				
Carbon Flotation:				
Depressants	1. Zinc Sulphate 2. Calcium / Sodium Cyanide	Solid Residues and dissolved Zn and Cyanide	The spillage will be transferred to PCD. Liquid will be recycled suitably and the solid part will be taken back into the circuit.	The reagent and plant bund areas will be designed so that the volume contained will be 110% of total tankage volume.
Frothers	Anionic or non-ionic Detergents	Waste material, spillages, empty containers and tailings	The spillage will be transferred to PCD. Liquid will be recycled suitably and the solid part will be taken back into the circuit.	As above
Lead Flotation				
Frother	Anionic or non-ionic Detergents	Waste material, spillages, empty containers and tailings	The spillage will be transferred to PCD. Liquid will be recycled suitably and the solid part will be taken back into the circuit. All empty drums and containers will be sent back to the suppliers for safe disposal.	As above
Collector	Sodium ethyl xanthate	Waste material, spillages, empty containers and tailings	The spillage will be transferred to PCD. Liquid will be recycled suitably and the solid part will be taken back into the	As above

Unit / Source	Description	Waste Type/Composition	Preferred Management Option(s)	Alternative Management Option(s)
			circuit. All empty drums and containers will be sent back to the suppliers for safe disposal.	
Zinc Flotation and Zinc Concentrate Flotation				
Activator	Copper sulphate	Waste material, spillages, empty containers and tailings	The spillage will be transferred to PCD. Liquid will be recycled suitably and the solid part will be taken back into the circuit. All empty drums and containers will be sent back to the suppliers for safe disposal.	As above
pH Modifier - lime	Calcium oxide/hydroxide	Waste Lime, spillages, empty bags, etc.	Utilise to raise pH of tailings before discharge to dam. All empty drums and containers will be sent back to the suppliers for safe disposal.	High pH wastes, pH>12, should not be disposed to landfill. Can be used to neutralise acid wastes at an HH landfill.
Collector	Sodium ethyl xanthate	Waste material, spillages, empty containers and tailings	Oxidise xanthate using hydrogen peroxide: Effluent to tailings dam and solid residues to HH Landfill. All empty drums and containers will be sent back to the suppliers for safe disposal.	

Unit / Source	Description	Waste Type/Composition	Preferred Management Option(s)	Alternative Management Option(s)
Ore (in Open) and Concentrate (under Cover) Stockpile Pads				
Spillage and Sweepings??		The ore and concentrate both contain heavy metals and sulphides: spillages, sweepings, etc.	Recover values or dispose to Tailings Dam	
4. Flotation Plant - Other				
Chemicals	Redundant Chemicals, Reject Products,	Various – see above	Recycle, if possible	Dispose to Hazardous Waste Landfill, if permitted
Laboratory	Laboratory Waste	Waste Samples Waste or redundant chemicals	Dispose to HH Landfill	See text
5. Maintenance including Vehicle Wash Bay				
Effluent Treatment System	Oily Sludge	Oily waste from Workshops, Maintenance Yard, Sludge from Vehicle Wash Bay	Oil recovery – ROSE Foundation.	Treatment/Disposal to Hazardous Waste Landfill, if permitted
	Oily Wastes	"Empty" oil cans, oily rags	Oily Cans to Recycling, Oily Rags to Landfill, if permitted or alternatively to Vissershok.	
	Scrap Tyres and rubber waste	Scrap tyres from cars, trucks plus conveyer belt waste.	Utilise/Recover to manufacture rubber product	Landfill of tyres whole or quartered may be prohibited: see text.
Fuel Storage	Diesel, petrol	Spillage, Contaminated Soil	Bio-remediate in-situ or at BMM site. Alternatively to Vissershok site.	Dispose to HH Landfill, if permitted
6. Tailings Dam				
Tailings	Residues from flotation process.	Contains heavy metals, iron, cadmium, zinc, lead, copper, manganese, etc. plus high amount of sulphur as the sulphide. Classed as significant environmental risk.	Dispose to tailings Dam, ensure pH of 8 to 9 to minimise possibility of acid mine drainage.	

Unit / Source	Description	Waste Type/Composition	Preferred Management Option(s)	Alternative Management Option(s)
7. Effluent Treatment System				
	Bio Sludge	Activated Sludge	Agricultural Use Compost	Treatment/Disposal to Landfill, if permitted
	Water Treatment Sludge	Mainly Inorganic Solids	Could be used in the manufacture of clay bricks	Treatment/Disposal to HH Landfill, if permitted
7. Plant and Office Buildings				
	Office waste	Non-hazardous Paper, packaging waste, plastics	Recycle where possible.	Treatment/Disposal of Residues to General Waste Landfill
	Garden waste	Green waste from gardens	Compost	Excess and non-compostable material, dispose to General Waste Landfill.
	Empty Metal Containers	Soft drink cans, paint cans, empty oil cans, etc.	Recycle to Collect-a-Can	Dispose to licensed to General Waste Landfill, if permitted.
	Batteries	Lead-acid Batteries from Vehicles Dry Batteries, e.g. from cell phones, torches and other equipment.	Lead-Acid Batteries recycle Dry Batteries recycle if possible.	Treatment/Disposal of Residues to Landfill, if permitted: see text.
	Waste Electric and Electronic Equipment (WEEE)	Lamps Other, e.g. computers, Cell Phones	Recycle through licensed WEEE management company.	Incinerate
	Cleaning Materials	Hazardous Packaging: Drums, Plastic and Paper Bags, "Empty" Containers of Cleaning Agents, Aerosols, Pesticides, etc.	Clean and recycle if possible. Use principles of the Responsible Packaging Management Association of South Africa (www.rpmasa.org.za)	Dispose to Licensed General or Hazardous Waste Landfill

7 CONSTRUCTION ENVIRONMENTAL MANAGEMENT PROGRAMME (CEMPR)

7.1 SCOPE

This Specification covers the requirements for controlling the impact on the environment of all construction activities for the Project. All construction activities shall observe the requirements of this specification as well as any relevant environmental legislation and in so doing shall be undertaken in such a manner as to minimise impacts on the natural and social environment.

Although the construction period is expected to last for 36 - 42 months, it must be noted that construction related activities are directly linked to the production ramp up of the mine. BMM intends to construct the Gamsberg mine, with a zinc concentrate production capacity of only 0.335 million tons per annum (i.e. Phase 1 of the ramp up). Once the proposed mine achieves this production capacity, the construction phase will commence again to then achieve a zinc concentrate production capacity of only 0.67 million tons per annum (tpa) (i.e. Phase 2 of the ramp up). Note that while construction continues to achieve Phase 2 production levels, the operational phase for Phase 1 (0.335 million tpa) will commence.

Following this, the final construction phase will commence to then achieve a zinc concentrate production capacity of 1 million tpa (i.e. Phase 3 of the ramp up). Note that it will take on average, two years to achieve each phase of the ramp up of the production capacity. It is anticipated that full production (i.e. Phase 3) will take approximately 6 years to achieve, with construction activities occurring in-between.

7.2 APPLICATION

This Specification contains clauses that are generally applicable to the undertaking of civil engineering works in areas where it is necessary to impose pro-active controls on the extent to which the construction activities impact on the environment. The roles and responsibilities in terms of the application and implementation of this Specification have been outlined in *Section 4.2* above.

7.3 METHOD STATEMENTS

Any Method Statement required by the Engineer or the Environmental Specification shall be produced within such reasonable time as the Engineer shall specify or as required by the Specification. The Contractor shall not commence the activity until the Method Statement has been approved and

shall, except in the case of emergency activities, allow a period of two weeks for approval of the Method Statement by the Engineer. Such approval shall not unreasonably be withheld.

The Engineer or ECO may request a Method Statement for any activity they believe may impact on the environment. The Engineer in consultation with the ECO may also require changes to a Method Statement if the proposal does not comply with the Specification or, if in the reasonable opinion of the Engineer, the proposal may result in, or carry a greater than reasonable risk of, damage to the environment in excess of that permitted by the Specifications. Approved Method Statements shall be readily available on the site and shall be communicated to all relevant personnel. The Contractor shall carry out the Works in accordance with the approved Method Statement. Approval of the Method Statement shall not absolve the Contractor from any of his/her obligations or responsibilities in terms of the Contract.

The following Method Statements shall be provided by the Contractor and submitted to the Engineer and ECO at least 7 working days before site establishment. The content of the Method Statement must be agreed to with the ECO and site engineer, and *Section 6.5* above provides an explanation of what these documents must contain.

- Logistics for the environmental awareness course for all the Contractors employees.
- Emergency procedures for fire, accidental leaks and spillages of hazardous materials including:
    - who shall be notified in the event of an emergency, including contact numbers for the relevant local authority,
    - where and how any hazardous spills will be disposed of,
    - the size of spillage which the emergency procedures could contain,
    - location of all emergency equipment and an indication of how regularly the emergency equipment will be checked to ensure that it is working properly.

- Location and layout of the construction camp in the form of a plan showing offices, stores for fuels, hazardous substances, vehicle parking, access point, equipment cleaning areas and staff toilet placement.
- Location, layout and preparation of cement / concrete batching facilities including the methods employed for the mixing of concrete and the management of runoff water for such areas. An indication shall be given of how concrete spoil will be minimised and cleared.
- Method of undertaking earthworks, including spoil management, erosion.
- Measures for the suppression of dust and noise emissions.
- Method statement for the establishment of no-go areas, specifically with regard to the manner in which sensitive ecological habitat will be avoided.
- Method of undertaking blasting during pre-stripping (if required).

- Location of stormwater management measures and visual representation of mechanisms to manage clean and dirty water separation.
- Management measures to be undertaken in instances where traffic flows may be interrupted.
- Extent of areas to be cleared, the method of clearing and the preparation for this clearing so as to ensure minimisation of exposed areas.
- Measures to be put in place during temporary closure periods, e.g. December holidays.
- Measures to be put in place to limit sediment deposition into the Kloof and waterbodies.

Note that the contractor may only commence with any activity if a Method Statement which has been approved by the ECO and site engineer is in place.

7.3.1 Environmental Awareness Training

The logistics for the environmental awareness training course, together with the subject matter, would need to be outlined into a method statement. This will include, *inter alia*, the number of attendees, material to be distributed and procedures to record and verify attendance.

7.3.2 Temporary Construction Camp and Site Division

The location, layout and method of establishment of the temporary contractor camp (including all buildings, offices, lay down yards, vehicle washing areas, fuel storage areas, batching areas and other infrastructure required for the construction of the project).

7.3.3 Vegetation Clearing

Method of vegetation clearing during site establishment and disposal procedure for cleared material.

7.3.4 Access/Haul Routes

Details, including a drawing, showing where and how the access points and routes will be located and managed, including traffic safety measures.

7.3.5 Fuel Storage and Use

The design, location and construction of the fuel storage area, for the filling and dispensing from storage tanks and management of drip trays.

7.3.6 Solid Waste Management

Expected solid waste types, quantities, methods of recycling to be employed, monitoring and record keeping procedures, staff responsible for the oversight

of waste management and recycling and frequency of collection and disposal of the non-recycled component, as well as location of disposal sites.

7.3.7 Contaminated Water

Methods of minimising, controlling, collecting and disposing of contaminated water, including stormwater run-off.

7.3.8 Hazardous Substances

Details of any hazardous substances / materials to be used, together with the transport, storage, handling and disposal procedures for the substances.

7.3.9 Cement and Concrete Batching

Location, layout and preparation of cement/ concrete mixing areas including the methods employed for the mixing of concrete, and particularly the containment of runoff water from such areas, as well as the method of transportation of concrete.

Batching to be undertaken on a smooth, impermeable surface and which is sloped towards a sump collection point. All wastewater generated from the batching area shall be collected and disposed of via the contaminated wastewater management system.

7.3.10 Emergency Procedures and Equipment

Emergency procedures for fire, accidental leaks and spillages of hazardous substances (including fuel and oil). Include details of risk reduction measures to be implemented, such as fire fighting equipment, fire prevention procedures and spill kits (materials and compounds used to reduce the extent of spills and to breakdown or encapsulate hydrocarbons). The contractor will also outline the type of emergency equipment required on site, as well as the servicing requirements to ensure correctly functioning equipment.

Other Method Statements required by the Engineer and ECO during the course of construction are to be provided by the Contractor a minimum of 14 working days prior to commencement of the works or activities to which they apply (these activities may not commence on site before these Method Statements have been approved except in the case of emergency activities).

7.3.11 Erosion and Sedimentation Control

The proposed methods of sedimentation and erosion control for bulk earthworks in particular and the remainder of the construction period, in order to ensure the prevention of sedimentation of water courses and storm-water infrastructure.

7.3.12 Blasting

A detailed method statement will need to be compiled for all blasting activities related to the construction phase. This method statement must reflect the timing, regularity, means of notification of surrounding receptors and proof of legislative requirements that govern blasting.

7.3.13 Traffic management

The contractor must compile a method statement for the transportation of abnormal loads, or transport related activities that will impact on surrounding traffic flows. The method statement must indicate timing of potential disruption/ road closures, means of notification of surrounding road users, proof of correspondence from the relevant traffic authorities and drawings of any potential changes to the existing road layout.

7.4 SITE ESTABLISHMENT

7.4.1 Site Division

The Contractor shall restrict all his activities, materials, equipment and personnel to within the area specified, and shall restrict his activities to only those areas that are necessary to undertake the works.

A Method Statement detailing the layout and method of establishment of the temporary construction camp, all buildings, offices, lay down areas, fuel storage areas, batching areas and other infrastructure required for the running of the project shall be submitted.

Disturbed areas rather than pristine or intact landscape areas should preferably be used for the temporary construction camp.

7.4.2 Site Demarcation

The Contractor shall erect and maintain permanent and/ or temporary fences of the type and in the locations directed by the Engineer. Such fences shall, if so specified, be erected before undertaking designated activities. The temporary construction camp, material stores and lay-down areas should be screened and sited as far away as possible from the local roads.

7.4.3 Site Clearance

Topsoil

Given the conditions on top of the Gamsberg, there is generally very little topsoil if any at all. Ideally, only about the top 30cm should be used. In some situations this generates too little to redistribute effectively afterwards, and a

little more is taken, but this has a negative effect on the recovery achieved when it is reapplied. Also, the biological activity of stored topsoil declines over time and it should not be stored for more than a few months and the benefit of putting it aside declines substantially after about 6 months. However if stored for an extended period of time no natural regeneration from the soil-stored seed bank can be expected. Due to the arid nature of the impacted environment, topsoil will not be retained for re-use during the construction phase of the Project.

7.4.4 Access Routes/ Haul Roads

The Contractor shall control the movement of all vehicles including that of his suppliers so that they remain on designated routes, are distributed so as not to cause an undue concentration of traffic and that all relevant laws are complied with. In addition, such vehicles shall be so routed and operated as to minimise disruption to regular users of the routes not on the site. The vehicles of the Contractor and his suppliers shall not exceed a speed of 30 km/h on gravel or earth roads on site and within 500 m of the site.

During construction, arrangements and routes for abnormal loads (if required) must be agreed in advance with the relevant authorities and the appropriate permit must be obtained for the use of public roads. Lastly, dust suppression measures must be applied to all gravel roads, especially during period of strong winds.

7.5 GENERAL REQUIREMENTS

7.5.1 Materials Handling, Use and Storage

The Contractor shall ensure that any delivery drivers are informed of all procedures and restrictions (including "no go" areas) required to comply with the Specifications. The Contractor shall ensure that these delivery drivers are supervised during off loading, by someone with an adequate understanding of the requirements of the Specifications.

Materials shall be appropriately secured to ensure safe passage between destinations. Loads including, but not limited to, sand, stone chips, fine vegetation, refuse, paper and cement, shall have appropriate cover to prevent them spilling from the vehicle during transit. The Contractor shall be responsible for any clean-up resulting from the failure by his employees or suppliers to properly secure transported materials.

All manufactured and/ or imported material shall be stored within the Contractor's temporary construction camp. All lay down areas outside of the temporary construction camp shall be subject to the Engineer's approval.

All building materials should be stored at least 50 m away from aquatic ecosystems and the areas bunded appropriately such that there will be no runoff from these areas towards aquatic systems. All building materials should be removed after construction.

7.5.2 Fuel (Petrol and Diesel) and Oils (Heavy fuel oils included)

All fuel is to be stored within a demarcated area in the Contractor's temporary construction camp. No refuelling of vehicles or machinery is to take place outside of this demarcated area unless authorised by the Engineer. The Engineer shall be advised of the area that the Contractor intends using for the storage of fuel.

The Contractor shall ensure that all liquid fuels (petrol and diesel) are stored in tanks with lids, which are kept firmly shut. Only empty and externally clean tanks may be stored on the bare ground. All empty and externally dirty tanks shall be sealed and stored in an area where the ground has been protected.

Tanks containing fuels shall be situated on a smooth impermeable surface (plastic or concrete) base with a bund (if plastic, it must have sand on top to prevent perishing) to contain any possible spills and prevent infiltration of fuel into the ground. The impermeable lining shall extend to the crest of the bund and the volume inside the bund shall make up 110 percent of the total capacity of all the storage tanks.

The floor of the bund shall be sloped towards an oil trap or sump to enable any spilled fuel to be removed. An Enretech or similar hydrocarbon absorption/remediation product approved by the ECO shall be installed in the sump to reduce the risk of pollution. Bulk fuel storage and bunded areas shall have overhead cover to prevent rain from entering the bunded area. The Contractor shall keep fuel under lock and key at all times.

If fuel is dispensed from 210 litre drums, the proper dispensing equipment shall be used, and the drum shall not be tipped in order to dispense fuel. The dispensing mechanism used to dispense fuel from the drums shall be stored in a waterproof container when not in use.

During fuel tanker delivery, the tanker driver must be present at all times during offloading of product. An emergency cut-off switch must be installed to immediately stop fuel delivery should an accident occur. An anti-flash nozzle must be installed at the end of the vent pipe with a fuel dispenser equipped with an automatic cut-off switch to prevent fuel tank overfills.

No smoking shall be allowed in the vicinity of the stores. Symbolic safety signs depicting "No Smoking", "No Naked Lights" and "Danger" are to be provided, and are to conform to the requirement of SABS 1186. The volume

capacity of the tank shall be displayed. The product contained within the tank shall be clearly identified using the emergency information system detailed in SABS 0232 Part 1. Any electrical or petrol-driven pump shall be equipped and positioned so as not to cause any danger of ignition of the product.

Areas for storage of fuels and other flammable materials shall comply with standard fire safety regulations and may require the approval of the Municipal Fire Prevention Officer.

The Contractor shall ensure that there is adequate fire-fighting equipment at the fuel stores.

Where reasonably practical, vehicles and equipment shall be refuelled at a designated re-fuelling area or at the workshop as applicable. If it is not reasonably practical then the surface under the temporary refuelling area shall be protected against pollution and drip trays used to the reasonable satisfaction of the Engineer prior to any refuelling activities. The Contractor shall ensure that there is always a supply of appropriate material readily available to absorb/ breakdown and where possible be designed to encapsulate minor hydrocarbon spillage. The quantity of such materials shall be able to handle a minimum of 210 litre of hydrocarbon liquid spill. This material must be approved by the Engineer prior to any refuelling or maintenance activities.

7.5.3 Solid Waste Management

For the purposes of these Environmental Specifications, solid waste includes all debris and waste (e.g. litter, food waste, hardware discards, vegetation and tree stumps, building rubble, etc.), including hazardous waste (e.g. oils) resulting from any construction activities on site.

The Contractor shall be responsible for the establishment of a waste control system (Waste Management Plan) that is acceptable to the Engineer and ECO, and a method statement is required in this regard. The contractor shall keep detailed records of all waste removed from site. The waste management hierarchy (as presented below) must be adopted, when managing waste produced onsite.

Figure 7.1 Waste management hierarchy

(*Source: http://www.zerowaste.sa.gov.au*)

The contractor must then provide proof of recycling or legal disposal at a registered landfill site (disposal certificates). No refuse or waste material will be disposed of by burying on site. The specific disposal requirements of wastes will be informed by the relevant hazard rating, as this will determine the landfill requirements.

Refuse Control

The Contractor shall provide labourers to clean up the Contractor's temporary construction camp and working areas on a daily basis.

Litter and waste materials (excluding rubble and hazardous waste materials) shall be disposed of into scavenger- and weather-proof bins. The Contractor shall provide sufficient bins with lids on site to store the waste produced on a daily basis. In order to facilitate recycling it is recommended that a number of bins be provided at each location, and that such bins be clearly marked according to the category of waste being recycled (e.g. paper, metals, plastics, glass, etc.) Bins shall not be allowed to become overfull and shall be emptied a minimum of once daily. The waste may be temporarily stored on site in a central waste area that is weatherproof and scavenger-proof, and which the Engineer has approved. The Contractor shall then remove the refuse collected from the Site at least once a week. Any refuse not being re-cycled must be disposed of at a registered waste disposal facility.

The Contractor shall ensure that waste and surplus food, food packaging and organic waste are not deposited by employees anywhere on the site except in refuse bins.

Empty Cement Bags

Empty cement bags must be collected from the construction area by the end of every day and before rain events and shall be stored in bins that are either placed under cover or fitted with lids. This prevents the bags getting wet and the cement powder leaching into the environment.

Hazardous Waste

Petroleum, chemicals, and other harmful and hazardous wastes are to be stored in enclosed and bunded areas. The location of these sites is to be approved by the Engineer and the ECO. These wastes shall be disposed of at a registered hazardous waste disposal site. The Contractor shall submit copies of receipts from such waste disposal sites to the Engineer and ECO as proof of proper disposal. The storage, handling and disposal of hazardous waste are also controlled through other relevant legislation which must be complied with, e.g. the Occupational Health & Safety Act.

Builders rubble

The Contractor shall provide labourers to clean up the Contractor's camp and working areas of rubble generated in the course of construction work, at least once a week.

Rubble shall be temporarily stockpiled in a waste skip or a central stockpile. Any rubble not being recycled (e.g. sent for crushing) or reused shall be removed from site and disposed of at an approved landfill site as soon as it constitutes a practical load for removal and before temporary closure of the site (e.g. over builders holidays). No plastics, shrink wrap, paint buckets or any other debris that does not constitute clean building rubble, shall be stored at such stockpile sites.

7.5.4 Ablution Facilities

Washing, whether of the person or of personal effects, and acts of excretion and urination are strictly prohibited other than at the facilities provided. Latrine and ablution facilities and first-aid services shall comply with the regulations of the local authority concerned and shall be maintained in a clean and sanitary condition to the satisfaction of the Engineer.

The Contractor shall provide suitable sanitary arrangements at the Contractor’s temporary construction camp and approved points around the designated work area to allow easy access for all employees on site. Project

staff are not permitted to commence with work on a site without suitable toilet facilities available for them.

Sanitary facilities shall be located within 100 m from any point of work, but not closer than 50 m to any water body. One chemical toilet is to be provided on site for every 15 contract personnel at each working area. These toilets must have doors and locks and shall be secured to prevent them blowing over. Toilet paper shall be provided.

The Contractor shall ensure that suitable sanitation facilities are provided for or by all his sub-contractors on site.

Toilets are to be emptied prior to builders' holidays. The contractor shall ensure that no spillage occurs when the toilets are cleaned or emptied and that the contents are removed from site. Discharge of waste from toilets into the environment and burial of waste is strictly prohibited.

The Contractor shall keep the toilets in a clean, neat and hygienic condition. If the Contractor fails to provide and/or maintain all site sanitation facilities in a clean and hygienic condition, the Engineer may order the Contractor to suspend any or all work on the site until these requirements are met. No payment shall be made for any delays or disruption of the Works caused thereby nor shall extensions of time be granted for such delays.

7.5.5 Eating Areas

The Contractor shall designate eating areas to the approval of the Engineer, which shall be clearly demarcated. Sufficient bins, as specified in 4.5.3, shall be present in this area. Any cooking on site shall be done on well-maintained gas cookers with fire extinguishers present.

7.5.6 Drinking Water

The Contractor shall ensure that drinking water is available for all staff on site. If no potable water source is available on site, then the Contractor shall import drinking water to the site.

7.5.7 Contaminated Water

Potential pollutants of any kind and in any form shall be kept, stored, and used in such a manner that any escape can be contained and the water table not endangered. Water containing such pollutants as cements, concrete, lime, chemicals, fuels and hydrocarbons shall be contained and discharged into an impermeable storage facility for removal from the site or for recycling. This particularly applies to water emanating from concrete batching plants and concrete swills, and to runoff from fuel depots, workshops and truck washing areas.

Wash down areas shall be placed and constructed in such a manner so as to ensure that the surrounding areas are not polluted. The Contractor shall notify the Engineer immediately of any pollution incidents on Site.
If construction areas are to be dewatered (e.g. after rains), this water must first be pumped into a settlement area, and not directly into a natural ecosystem.

A Method Statement shall be required for all wash areas where hydrocarbon and hazardous materials or other pollutants are expected to be used. This includes, but is not limited to, vehicle washing, workshop wash bays and paint equipment cleaning. Wash areas for domestic use shall ensure that the disposal of contaminated "grey" water is sanctioned by the Engineer.

7.5.8 Hazardous Substances

Hazardous chemical substances (as defined in the Regulations for Hazardous Chemical Substances) used during construction shall be stored in secondary containers. The relevant Material Safety Data Sheets (MSDS) shall be available on Site. Procedures detailed in the MSDS shall be followed in the event of an emergency situation.

If potentially hazardous substances are to be stored on site, the Contractor shall provide a Method Statement detailing the substances/ materials to be used, together with the storage, handling and disposal procedures of the materials.

No paint products and chemical additives and cleaners such as thinners and turpentine, may be disposed of on Site. Brush / roller washing facilities shall be established to the satisfaction of the Engineer. A Method Statement, approved by the Engineer, is required for such washing activities.

7.5.9 Site Structures

The Contractor shall supply and maintain adequate and suitable sheds for the storage of materials. Sheds for the storage of materials that may deteriorate or corrode if exposed to the weather shall be weatherproof, adequately ventilated and provided with raised floors.

All site establishment components (as well as equipment) shall be positioned to limit visual intrusion on neighbours and the size of the area disturbed. The type and colour of roofing and cladding materials comprising the Contractor's temporary structures shall be selected to reduce reflection. The Contractor's camp shall be fenced with a fence of at least 1.8 m high, and the camp area shall be screened via the attachment of shade cloth to the fence surrounding the site camp.

7.5.10 Lights

The Contractor shall ensure that any lighting installed on site for related activities does not interfere/impact with road traffic or cause a reasonably avoidable disturbance to the surrounding road users or community members.

7.5.11 Workshop, Equipment Maintenance and Storage

Where practical, all maintenance of plant on Site shall be performed in the workshop. If it is necessary to do maintenance outside of the workshop area, the Contractor shall obtain the approval of the Engineer prior to commencing activities.

The Contractor shall ensure that in his workshop and other plant maintenance facilities, including those areas where, after obtaining the Engineer's approval, the Contractor carries out emergency plant maintenance, there is no contamination of the soil or vegetation. The workshop shall have a smooth impermeable floor either constructed of concrete or thick plastic covered with sufficient sand to protect the plastic from damage. If constructed of concrete the floor shall be bunded and sloped towards an oil trap or sump to contain any spillages of substances (e.g. oil). A Method Statement detailing the design and construction of the workshop must be submitted.

When servicing equipment, drip trays shall be used to collect the waste oil and other lubricants. Drip trays shall also be provided in construction areas for stationary plant (such as compressors) and for "parked" plant (such as scrapers, loaders, vehicles). All wastes collected into the drip trays shall be collected in a bunded area and disposed of into a hazardous waste facility, as and when required.

All vehicles and equipment shall be kept in good working order and serviced regularly. Leaking equipment shall be repaired immediately or be removed from the Site.

The washing of equipment shall be restricted to preventative maintenance requirements only. All washing shall be undertaken in wash bays within the workshop or maintenance areas, and these areas must be equipped with a suitable impermeable floor and sump/oil trap. The use of detergents for washing shall be restricted to low phosphate and nitrate containing and low sudsing-type detergents.

7.5.12 Noise

The Contractor shall limit noise levels (e.g. install and maintain silencers/mufflers on machinery). When working in any areas within audible distance of residents, the Contractor shall provide and use suitable and effective silencing devices for pneumatic tools and other plant that would

otherwise cause a noise level exceeding 85 dB(A) during excavations and other work.

Appropriate directional and intensity settings are to be maintained on all hooters and sirens.

No amplified music shall be allowed on site. The use of radios, tape recorders, compact disc players, television sets, etc., shall not be permitted unless the volume is kept sufficiently low as to avoid any intrusion on members of the public within range. The Contractor shall not use sound amplification equipment on Site unless in emergency situations.

The Contractor's attention is drawn to the Noise Regulations as promulgated in terms of the Environment Conservation Act, relevant Local Authority bylaws and South African National Standards 10103 and Occupational Health and Safety requirements.

7.5.13 Environmental Awareness Training

Environmental awareness training sessions shall be run for all personnel on site. Two types of course shall be run, one for the Contractor's and Subcontractor's management and one for all site staff and labourers. Courses shall be run in the morning during normal working hours at a suitable venue provided by the Contractor. All attendees shall remain for the duration of the course and sign an attendance register on completion that clearly indicates participant's names, a copy of which shall be handed to the Engineer.

All staff is to attend an initial presentation of approximately 45 minutes, and approximately half an hour a month thereafter for the duration of the contract shall be allowed for employees to attend any follow-up lectures, should such follow-up lectures be deemed necessary by the ECO. If staff goes on an extended period of absence, the environmental awareness training course must be undertaken, upon their return. In addition, all new staff and sub-contractors as well as employees that spend more than one day a week or four days in a month, to attend the environmental education session prior to commencement of work on site. The Contractor shall supply the ECO with a monthly report indicating the number of employees that will be present on site during the following month and any changes in this number that may occur during the month.

No more than 30 people shall attend each course and the cost, venue and logistics for this/ these course/s shall be for the Developer's responsibility. The ECO shall keep a register of all personnel attending the Environmental awareness training sessions.

Notwithstanding the specific provisions of this clause, it is incumbent upon the Contractor to convey the sentiments of the EMPr to all personnel involved

with the works. Please note *Appendix 2* of the EMPr contains a template Environmental Awareness Poster.

Training for management and foremen

The environmental awareness training session for management shall include all management and foremen. The session, which will be presented by the ECO, will be of approximately one-hour duration. The initial session shall be undertaken not less than seven days prior to commencement of work on site. Subsequent sessions shall be held as and when required.

Training course for site staff and labour

The environmental awareness training session for site staff and labour shall be presented by the ECO. The course will be approximately 45 minutes long. The course shall be run not more than seven days after commencement of work on site with sufficient sessions to accommodate all available personnel. Subsequent sessions shall be held as and when required.

7.5.14 Contractor's Environmental Officer

The Contractor shall designate a permanent onsite employee as the Environmental Officer who shall be responsible for undertaking a daily site inspection to monitor compliance with this Specification. The Contractor shall submit the name of the Contractor's Environmental Officer to the Engineer and ECO for approval seven days prior to the date of the environmental awareness training course.

7.5.15 "No go" Areas

The demarcated buffer areas around the heritage sites, pans on site and other identified ecological sensitive areas are to be "no go" areas. The Contractor shall ensure that, insofar as he has the authority, no person, machinery, equipment or material enters the "no go" areas at any time.

7.5.16 Construction Personnel Information Posters

The Contractor shall erect and maintain information posters for the information of his employees depicting actions to be taken to ensure compliance with aspects of the Specifications. Such posters shall be erected at the eating areas and any other locations specified by the Engineer. A template poster is attached in *Appendix 2.*

7.5.17 Fire Control

No fires may be lit on site. Any fires which occur, shall be reported to the Engineer immediately. Smoking shall not be permitted in those areas where it is a fire hazard. Such areas shall include the workshop and fuel storage areas

and any areas where the vegetation or other material is such as to make viable the rapid spread of an initial flame. In terms of the National Environmental Management: Air Quality Act (39 of 2004), burning is not permitted as a disposal method, unless authorised by the DENC: Air Quality Directorate responsible for the implementation of the National Environmental Management: Air Quality Act. The Contractor shall appoint a Fire Officer who shall be responsible for ensuring immediate and appropriate actions in the event of a fire and shall ensure that employees are aware of the procedure to be followed. The Contractor shall forward the name of the Fire Officer to the Engineer for his approval seven days prior to the date of the environmental awareness training course.

The Contractor shall ensure that there is basic fire fighting equipment available on Site at all times.

7.5.18 Concrete and Cement Work

Cement powder has a high pH value. Spillage of dry cement powder and concrete slurry will affect both soil and water pH adversely. Careless handling of cement products resulting in spillage can have detrimental effects on the surrounding environment.

The location of the batching area (including the location of cement stores and sand and aggregate stockpiles) shall be indicated on the Site layout plan and approved by the ECO. A Method Statement indicating the layout and preparation of this facility is required in this regard.

Cement is to be stored in a secure weatherproof location to avoid contamination of the environment and wastage.

All runoff from batching areas shall be strictly controlled so that contaminated water does not enter storm water, or groundwater. Plastering boards and mixing trays should be used at all mixing and supply points. Cleaning of equipment and flushing of mixers shall not result in pollution of the surrounding environment.

Suitable screening and containment shall be in place to prevent windblown contamination associated with bulk cement silos, loading and batching.
All visible remains of excess concrete shall be physically removed to an approved waste site on completion of the plaster or concrete pour section and disposed of.

7.5.19 Emergency Procedures

The Contractor shall submit Method Statements covering the procedures for the following emergencies:

Fire

The Contractor shall advise the relevant authority of a fire as soon as one starts and shall not wait until he can no longer control it. The Contractor shall ensure that his employees are aware of the procedure to be followed in the event of a fire.

Accidental leaks and spillages

The Contractor shall ensure that his employees are aware of the procedure to be followed for dealing with spills and leaks, which shall include notifying the Engineer and the relevant authorities. The Contractor shall ensure that the necessary materials and equipment for dealing with spills and leaks is available on Site at all times. Treatment and remediation of the spill areas shall be undertaken to the reasonable satisfaction of the Engineer. In the event of a spill, the source of the spillage shall be isolated, and the spillage contained, provided it is safe to do so. The area shall be cordoned off and secured.

7.5.20 Safety

The Contractor shall at all times observe proper and adequate safety precautions on the Site. Telephone numbers of emergency services, including the local fire fighting service, shall be posted conspicuously in the Contractor's office near the telephone. Detailed emergency procedures must be kept on-site, and all staff must be subject to the necessary training.

No unauthorised firearms are permitted on Site.

The Occupational Health and Safety Act (No 85 of 1993) and in particular the requirements of the Construction Regulations issued in July 2003, must be complied with.

7.5.21 Security

With the possible exception of any security staff who may be required to be present overnight at the Contractor's temporary construction camp, no personnel will be permitted to live on the mine. Security staff must be provided with heating and cooking facilities (in order that they do not need to light fires), and access to toilet facilities and communication equipment.

Any security lighting at the Contractor's temporary construction camp is to be placed in such a way as to not cause a nuisance to residents of the area and traffic on adjacent roads.

7.5.22 Community Relations

The Contractor shall erect and maintain information boards in the position, quantity, design and dimensions specified. Such boards shall include contact

details which members of the public can use to register complaints, in accordance with details provided by the Engineer.

All interactions with the surrounding community shall be undertaken in terms of the Community Engagement Plan developed by BMM in terms of *Section 5.10* of this document.

The Contractor shall keep a "Complaints Register" on Site. The Register shall contain all contact details of the person who made the complaint, and information regarding the complaint itself. All grievances raised shall be dealt with in accordance with the BMM Grievance Procedure which is to be developed in accordance with *Section 5.10* of this document.

7.5.23 Protection of Natural Features

The Contractor shall not deface, paint, damage or mark any natural features (e.g. rock formations) situated in or around the Site for survey or other purposes unless agreed beforehand with the Engineer. Any features affected by the Contractor in contravention of this clause shall be restored/ rehabilitated to the satisfaction of the Engineer.

The Contractor shall not permit his employees to make use of any natural water sources (e.g. springs, streams and open water bodies) for the purposes of swimming, personal washing and the washing of machinery or clothes.

7.5.24 Protection of Flora and Fauna

Except to the extent necessary for the carrying out of the Works, flora shall not be removed, damaged or disturbed nor shall any vegetation be planted. Trapping, poisoning and/ or shooting of animals is strictly forbidden. No domestic pets or livestock are permitted on the mining license area during the construction phase. Where the use of herbicides, pesticides and other poisonous substances has been specified, the Contractor shall submit a Method Statement.

7.5.25 Erosion and Sedimentation Control

The Contractor shall take all reasonable measures to limit erosion and sedimentation due to the construction activities. Where erosion and/or sedimentation, whether on or off the Site, occurs despite the Contractor complying with the foregoing, rectification shall be carried out in accordance with details specified by the Engineer. Where erosion and/or sedimentation occur due to the fault of the Contractor, rectification shall be carried out to the reasonable requirements of the Engineer.

Any runnels or erosion channels developed during the construction period or during the maintenance period shall be backfilled and compacted.

Stabilisation to prevent and control erosion of cleared areas shall be actively managed. Consideration and provision shall be made for various methods, namely, brush-cut packing, mulch or chip cover, straw stabilising (at a rate of one bale/square metre and rotorvated into the top 100 mm of the completed earthworks), watering, soil binders and anti-erosion compounds, mechanical cover or packing structures (e.g. hessian cover).

Traffic and movement over stabilised areas shall be restricted and controlled, and damage to any stabilised area shall be repaired and maintained to the satisfaction of the Engineer.

7.5.26 Aesthetics

The Contractor shall take reasonable measures to ensure that construction activities do not have an unreasonable impact on the aesthetics of the area. Waste facilities shall be enclosed and not visible to road users of the N14.

7.5.27 Dust Control

The Contractor shall take all reasonable measures to minimise the generation of dust as a result of construction activities to the satisfaction of the Engineer and ECO. Dust control measures may include the stabilisation of disturbed areas via the rotorvation of straw into the soil surface. In extreme instances, the use of specific chemical dust suppressant additives such as "*Dustex*" may be necessary in order to limit dust generation from haul roads.

During high wind conditions, the Contractor shall comply with the Engineer's instructions regarding dust-suppression measures. The Engineer may request the temporary cessation of all construction activities where wind speeds are unacceptably high, and until such time as wind speeds return to acceptable levels.

7.5.28 Pollution

The Contractor shall take all reasonable measures to minimise any dust nuisance, pollution of streams and inconvenience to or interference with the public (or others) as a result of the execution of the Works. A method statement may be required in this regard as determined by the Engineer and ECO.

If in emergency situations as mentioned above washing of vehicles and machinery is required on site, this should not take place within 50 m from any watercourse. All machinery should be regularly checked for leaks. No runoff shall enter any watercourse.

7.5.29 Working Hours

Working hours in terms of the planning approval shall be adhered to. If works are to take place outside of normal working hours, the ECO, Engineer and adjacent landowners are to be notified and disturbance to the surrounding residents or land users is to be prevented. The Engineer will, where required, in turn notify the Local Authority of work done outside of normal working hours.

7.5.30 Excavation and Trenching

During excavation and trenching activities, care is to be taken to ensure that the stockpiling of top material is kept separate from sub-soils. Top material thus saved is to be replaced as top material and is to be the final layer when back-filling. The Contractor shall reinstate all working areas to the satisfaction of the Engineer.

Areas opened for trenching should be restricted to the minimum required to be worked in and closed up in a working day or as dictated by technical requirements such as length of pipe or cable, in order to prevent them from posing safety hazards to people, traffic and animals and to prevent rainwater erosion. Trenches left exposed for more than one day shall be barricaded, subject to approval by the site engineer and ECO. Trenches shall be re-filled to the same level as (or slightly higher, to allow for settlement) the surrounding land surface to minimise erosion. Excess soil shall be stockpiled in an appropriate manner. No stockpiling must occur within 50 m of a water course.

In the event of material removed during trenching being excessive after backfilling or being unsuitable as overburden, the excess material must be removed from the construction site to a site agreed upon by the Engineer and, where applicable, the Local Authority

7.5.31 Stockpiling

The engineer will identify suitable areas for stockpiling of all materials. Each stockpile may not exceed 2 m in height and cover a minimum footprint. The required precautions must be taken to prevent erosion or compaction of stockpiles. The top materials shall not be left for a period exceeding 6 months. If unavoidable, the topsoil must be analysed and if necessary, upgraded before placement.

7.5.32 Temporary Site Closure

If the Site is closed for a period exceeding one week, a checklist procedure shall be carried out by the Contractor in consultation with the ECO. Contractor's Safety Officers (in terms of the Occupational Health and Safety Act) are to check the Site and report to the Engineer regarding the following:

Fuels / flammables / hazardous materials stores:

- Ensure fuel stores are as low in volume as possible;
- No leaks;
- Outlet secure / locked;
- Bund empty;
- Fire extinguisher serviced and accessible;
- Secure area from accidental damage, e.g. vehicle collision;
- Emergency and Management telephone numbers to be available and displayed; and
- Adequate ventilation.

Other:

- All trenches and manholes secured;
- Fencing and barriers in place per the Occupational Health and Safety Act (No 85 of 1993);
- Notice boards applicable and secured;
- Security persons briefed and have facility for contact;
- Night hazards checked, e.g. reflectors, lighting, traffic signage;
- Fire hazards identified – local authority notified of any potential threats, e.g. large brush stockpiles, fuels etc.;
- Pipe stockpile wedged / secured;
- Scaffolds secure; and
- Inspection schedule and log by security or contracts staff.

The ECO is to check and report to the Engineer regarding the following issues:

- Wind and dust mitigation in place, e.g. straw, brush packs, irrigation;
- Slopes and stockpiles at stable angle;
- Landscape areas watering schedules and supply secured;
- Fuels/hazardous substances stores secure;
- Cement and materials stores secured;
- Toilets empty and secured;
- Refuse bins empty and lids secured;
- Bunding clean and treated, e.g. Spill Sorb or Enretech #1 powder;
- Drip trays empty and secure; and
- Structures vulnerable to high winds secure.

The Contractor is to ensure that all temporary closure requirements are met before leaving the Site.

7.6 SITE CLEAN UP AND REHABILITATION

7.6.1 Site Clean Up

The Contractor shall ensure that all temporary structures, equipment, materials, waste and facilities used for construction purposes are removed upon completion of the project. The site clean-up shall be to the satisfaction of the Engineer and the ECO.

7.6.2 Rehabilitation

Where appropriate, the Contractor shall employ a suitably qualified person (a botanist with experience in the Namakwa Bushmanland Region) to suggest and implement rehabilitation measures for areas damaged by construction activities but that will not be utilised during the operational level. The Contractor shall be responsible for rehabilitating areas identified by the ECO and the Engineer, or recommended by the aforementioned botanist. The Contractor's procedure for rehabilitation shall be approved by the ECO and the Engineer and, where required, the Local Authority's environmental representative.

7.7 TOLERANCES

Environmental management is concerned not only with the final results of the Contractor's operations to carry out the Works but also with the control of how those operations are carried out. Tolerance with respect to environmental matters applies not only to the finished product but also to the standard of the day-to-day operations required to complete the Works.
It is thus required that the Contractor shall comply with the environmental requirements on an ongoing basis and any failure on his part to do so will entitle the Engineer to certify the imposition of a fine subject to the details set out in the Environmental Specification.

7.8 MEASUREMENT AND PAYMENT

7.8.1 Basic Principles

Except as noted below and as per the Scheduled Items, no separate measurement and payment will be made to cover the costs of complying with the provisions of this Specification and such costs shall be deemed to be covered by the rates tendered for the items as contained in the Schedule of Quantities, as completed by the Contractor when submitting his tender.

Some of the important cost items have been listed below to assist the Contractor in making provision for implementation of the Specifications:

a) Protection of stock piles from blowing or washing away: The spraying or covering of stockpiles, including the supply of the spray or cover material or vegetation, as required.

b) Storage of fuel and oils: The supply, construction, installation, transport, upkeep and removal of all facilities required for storage and management of fuel and oils.

c) Cement-laden water management: The supply, construction, installation, transport, upkeep and removal of all facilities required for the management of wastewater from concrete operations.

d) Contaminated water management: The supply, construction, installation, transport, upkeep and removal of all facilities required for managing contaminated water.

e) Storm water and flood management: The supply, construction, installation, transport, upkeep and removal of all facilities required for managing storm water run-off from the site and protection of works from flooding.

f) Bunding and management of run-off from workshop areas and supply of drip trays for stationary and "parked" plant: The supply, construction, installation, transport, upkeep and removal of all facilities required for bunding and managing the run-off from workshop areas as well as all drip trays required.

g) Dust management: The supply, application, transport, upkeep and removal of all materials required to ensure that dust is adequately controlled.

h) Solid waste management: The supply, application, transport, upkeep and removal of all materials required to ensure that solid waste is adequately controlled in accordance with the specification (including the recycling program).

i) Fire Control: The supply, transport, upkeep and removal of all material required for fire control.

j) Eating areas: The supply, construction, installation, transport, upkeep and removal at the end of the construction of all eating areas structures.

k) Ablutions: The supply, maintenance, regular emptying and removal of toilets.

l) Site demarcation: The supply, installation and removal at the end of the construction of all temporary fences.

m) Vegetation protection: The supply, installation and removal at the end of the construction of all vegetation protection fences.

7.8.2 Scheduled Items

a) Provision of venue and staff attendance at the environmental awareness training courses:

The provision of a venue and attendance at the environmental training courses will be measured as a lump sum. The sum shall cover all costs incurred by the Contractor in providing the venue and facilities and in ensuring the attendance of all relevant employees and sub-contractors at the training.

b) Method Statements: Additional Work:
No separate measurement and payment will be made for the provision of Method Statements where the Engineer requires a change on the basis of his opinion that the proposal may result in, or carry a greater than warranted risk of, damage to the environment, in excess of that warranted by the Specifications. In cases of additional work being required, provided it could not reasonably have been foreseen by an experienced contractor, it shall be valued in accordance with GCC 90 Clause 40.

A stated sum is provided in the Schedule of Quantities to cover payment for such additional work.

7.9 CONSTRUCTION PHASE COMPLIANCE: SUMMARY TABLES

Each individual Construction EMPr outlines proposed management strategies in accordance with proposed performance criteria for specified acceptable levels of environmental and social performance. The construction EMPr identifies:

- Project activities that result in environmental impacts;
- potential impacts on environmental and social values;
- mitigation strategies;
- relevant monitoring;
- appropriate indicators and performance criteria;
- reporting requirements;
- appropriate corrective actions should an undesirable impact or unforeseen levels of impact occur; and
- responsible person/s for corrective actions and way forward.

The structure of the construction EMPr is outlined in ***Error! Reference source not found.***.

Table 7.1 ESMP Structure

Activity	The project activity that would result in an impact to an element.
Element/Issue	The element/issues that are to be managed (as it affects environmental and social values).
Policy/Objective	The policy or management objective that applies to each element.
Performance Criteria	Measurable performance criteria (outcomes) for each element.
Implementation Strategy	The strategies, tasks or action program (to nominated operational design standards) that will be implemented to achieve the performance criteria.

Monitoring	The monitoring requirements to measure actual performance (i.e. specified limits to pre-selected indicators of change).
Auditing	The auditing requirements to demonstrate implementation of agreed environmental management strategies and compliance with agreed performance criteria.
Reporting	Format and timing for reporting and auditing of monitoring results.
Corrective Action	The action (options) to be implemented in case a performance requirement is not reached
Responsible person/ s	The person responsible for the corrective action (including staff authority, responsibility and management structure).

Each element/ impact is separated into an individual section, with tabulated requirements for the construction phase. Each element/ impact will include a description of the aforementioned criteria and related requirements.

7.10 AIR QUALITY AND DUST

Table 7.2 Air Quality and Dust

Management of Air Quality	
Activity and Element	Construction activities, including pre-stripping, establishment of roads, contractor areas and excavation will result in the generation of dust.
Policy	The aim is to minimise dust impacts to surrounding sensitive habitats and human receptors.
Performance Criteria	• Remain within the applicable air quality standards (i.e. SANS 1929 residential guidelines of 600 mg/m^2/ day and South African National Ambient Air Quality Standards) for dust deposition, at the time of construction. • Respond to complaints received from adjacent landowners and road users of the N14.
Implementation Strategy	• Regular maintenance of vehicles to reduce emission levels. • Consult with and advise any residents or landowners who may likely be impacted by temporary dust emissions before activities start. • Develop a detailed dust monitoring plan specifically for construction targeting areas in the vicinity of sensitive habitats on site (with a suitably qualified ecologist), and in addition at the site boundary. • Activity sites and access roads shall be watered or dust suppressant applied as required to minimise the potential for nuisance due to dust. • Watering frequency will be increased during periods of high risk (e.g. high winds). • A "no burning" policy will be implemented. • Visual inspection will be undertaken to confirm no dust plumes over the N14 during high wind conditions or dust generating activities. Should visible dust plumes cross the N14, the Environmental Control Officer (ECO), together with the site

Management of Air Quality	
	engineer must notify the Environmental Manager.
Monitoring and Auditing	• Vehicles maintenance records must be kept. • Record will be kept of air quality related complaints received. • Ambient dust monitoring must be undertaken at a frequency in-line with the dust monitoring plan and biodiversity monitoring plan. • Based on results from dust monitoring, mitigation measures must be refined and adapted to respond to climatic conditions and complaints received. This will be reached in agreement with the ECO and site engineer. Botanical and air quality specialist input may be brought in, as and when required. • The ECO must record all instances of non-compliance with on-site burning policy and record in the monthly ECO report. • Any visual confirmation of dust plumes over the N14 must be recorded in the monthly ECO Report.
Reporting and Corrective Action	• Records of all monitoring and auditing activities will be kept, with results included into the Monthly ECO Report, which must be submitted to the Department of Environment and Nature Conservation (DENC). • Recommendations and corrective actions arising from ECO inspections and reviews will be agreed to with the site engineer, before proceeding. • Non-compliance and incident reports will be reviewed and closed out by the ECO and site engineer. All non-compliances to be submitted to DENC for their records.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.11 HYDROLOGY

Table 7.3 Hydrology

Management of Hydrology	
Activity and Element	The construction of Project related infrastructure would result in the diversion of water courses, changes to sediment load and potential deterioration to water quality.
Policy	To prevent the potential impacts associated with erosion and to prevent the release of contaminants that may adversely affect surface water quality.
Performance Criteria	• Avoidance of release of contaminants or unacceptable sediment release to surface waters features. • Any disturbances or crossings of to watercourses must be aligned with the water use license issued by the Department of Water Affairs.
Implementation Strategy	• Implement dust suppression plan and stormwater management plan. • An Operation Manual is required for each Pollution Control Dam (PCD) and wastewater treatment works. The purpose of the manuals is to provide guidelines to the operators for the safe operation and maintenance of these facilities during its lifespan. • During construction, the surface water runoff from the dirty areas must be captured, and wherever possible reused, in the construction process. Pollution control dams must be utilised

Management of Hydrology	
	and dirty runoff should be directed towards these dams through a well-designed system of berms and channels. The dams should be designed to avoid sediment deposition through the use of silt traps. • All areas where hydrocarbons, such as oils and petroleum fuels are handled or stored should be bunded and strictly controlled to minimise the risk of accidental spillages. • All relevant personnel trained in appropriate handling of spill materials and spill prevention. • The construction process must remain outside of set-aside areas as outlined by the biodiversity management plan. • Installation of temporary drainage works (channels and bunds) where required for sediment and erosion control and around construction sites. • Use of pumps to maintain dry working conditions in temporary excavations, rather than constructing temporary open channels for gravity drainage of temporary excavations where gravity channelling is not acceptable. • Stockpiles will not be located within the 1:100 year floodline of a watercourse. • In cases where traversing a watercourse is unavoidable, the clearance path will, where practical, be designed in order to limit the extent of disturbance. • Works in the vicinity of a watercourse or drainage line will be subject to a method statement, layout/design plan approved by the ECO and site engineer before works commence. Upon completion of construction, the bed and banks of the affected watercourse must be reinstated. • Keep the work area to a minimum to limit ground disturbance. • Where appropriate, install temporary sediment basins to capture sediment laden runoff from site. • Provide bunding around stockpiles to prevent the material from being washed away, where required. • Inspect, and if required, reinstate all existing erosion-control structures after storm/heavy rain events.
Monitoring and Auditing	• Weekly monitoring of construction activities to ensure that no watercourses are unnecessarily impacted/ disturbed. • Rehabilitated watercourses will be monitored by the ECO to ensure no erosion or sediment deposition is occurring. • The integrity of storage facilities for hazardous substances, dangerous goods and waste holding areas will be controlled by sealed or bunded areas that will be routinely inspected by the ECO. • Conduct weekly inspections of all erosion control structures to ensure they are operating efficiently. Additional inspections should be conducted after storm events.
Reporting and Corrective Action	• Records of all monitoring and auditing activities will be kept, with results included into the Monthly ECO Report, which is to be submitted to the DENC and Department of Water Affairs (DWA). • Recommendations and corrective actions arising from ECO inspections and reviews will be agreed to with the site engineer, before proceeding. • Complaints relating to water quality or quantity from downstream users will be responded to and reported to DENC and DWA, if required. This will be recorded within the monthly ECO Report. • Non-compliance and incident reports will be reviewed and closed out by the ECO and site engineer.

Management of Hydrology	
	• • The ECO must notify DWA of any deviations from the conditions of the water use license.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.12 HYDROGEOLOGY

Table 7.4 Hydrogeology

Management of Hydrogeology	
Activity	Construction activities may result in the contamination of land that may impact groundwater quality.
Policy	To minimise impacts to groundwater quality and quantity.
Performance Criteria	• To limit impacts to groundwater quality to within the mining license area. • To avoid negatively impacting on groundwater levels of surrounding users. • Remain in alignment with the water use license issued by the DWA.
Implementation Strategy	• Implement groundwater monitoring plan (i.e. this should be the continuation of the groundwater monitoring undertaken prior to construction, at receptor locations recommended by a hydrogeologist). • Develop and implement a grievance procedure to address and respond to groundwater related grievances in a timely manner so that the receptors are never without a reliable water source. • Ensure that the storage of all hazardous substances and dangerous good (including hydrocarbons) are stored in bunded areas, to prevent run-off and infiltration during tank failures. • Construction equipment is to be serviced regularly, to prevent oil spills. • A spill response plan must be in place, and employees must be trained accordingly. • All vehicle servicing must be undertaken in a bunded area.
Monitoring and Auditing	• Records and reports related to the implementation of the groundwater monitoring plan will be kept and findings recorded in the Monthly ECO Report, if available. • All complaints received must be responded to and impacts to surrounding groundwater users and corrective actions must be agreed to with the landowner and BMM. Should agreement not be reached, the matter must be referred to the DWA for consideration. • All conditions outlined in the water use license must be adhered to.
Reporting and Corrective Action	• Records of monitoring and auditing activities will be stored on-site, with results included into the Monthly ECO Report. • Recommendations and corrective actions arising from ECO inspections and reviews will be agreed to with the site engineer, before proceeding. • Complaints relating to groundwater quality or quantity from surrounding users will be responded to and further investigations carried out and reported to the DENC and DWA, if required. This will be recorded within the monthly ECO Report as well.

Management of Hydrogeology	
	• Non-compliance and incident reports will be reviewed and closed out by the ECO and site engineer. All non-compliances with regard to hydrogeology to be submitted to DENC and DWA for their records.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.13 BIODIVERSITY MANAGEMENT

Table 7.5 Biodiversity Management

Biodiversity Management Plan	
Activity	Establishing the mine infrastructure, particularly excavation of the pit, blasting and processing ore would result in the loss of biodiversity.
Policy	Aim of mitigation is to conserve all forms of biodiversity with an emphasis on irreplaceable habitats, threatened and rare species through reducing the residual impact. This must be aligned with Vedanta Biodiversity Policy, thus improving conservation and minimising biodiversity impacts.
Performance Criteria	Objectives of the mitigation are to facilitate development of a Biodiversity Management Plan (BMP) and reduce the impacts of loss and fragmentation of habitats, reduction of species diversity and spread of alien and invasive species. These mitigation measures must be implemented, in conjunction with a botanical and faunal specialist.
Implementation Strategy	• A detailed Biodiversity Management Plan (BMP) will be developed to ensure that the proposed onsite (excluding offsets) avoidance, minimisation and rehabilitation measures associated with mine construction, operation and closure are consolidated for effective implementation and subsequent auditing. The plan will, in broad terms, include: o Optimal approach to management of the mine property and mine controlled areas including setting aside a large conservation area within these areas; o Approach towards implementing controlled access to the mine property and mine controlled areas; o Management measures to ensure protection and appropriate management of the biodiversity features on the mine property and mine controlled areas involving: o Avoidance of any forms of fire within the area; o Wildlife management plan focused on management of the medium to large faunal species and their habitat requirements to avoid habitat destruction through overgrazing; o Flora and fauna translocation plan from areas prior to disturbance when appropriate; o An ecological rehabilitation programme for impacted areas; o Independent monitoring and ongoing inventory development of

	the mine property's biological and physical environments to inform adaptive management measures and/or corrective action as required; o Alien and invasive species control program; o General awareness training will be done as part of the mine induction to inform all staff and contractors of the sensitivities of the biodiversity aspects of the mine and surrounds and appropriate environmental work-place etiquette; o The BMP will consider means of avoiding and mitigating "foot print" creep. o Measures to manage emergency, accident or upset conditions where biodiversity may be adversely affected. • The following activities will be prohibited by staff and contractors: o Hunting of wildlife within the mine property or mine controlled areas; o Purchase, sale or transport of any wildlife products from local communities or passing traders; o Collection of any plants or animals or products thereof for consumption, medicinal use, cultivation or keeping as pets; o Keeping pets within the Gamsberg mine property, either domestic animals such as cats or dogs, or native wildlife; o Intentional killing of any animals including snakes, lizards, birds or other animals; o All forms of off-road driving. • There will be no grazing of livestock within the set aside conservation area. • Occasional patrolling of the mine property and mine controlled areas will be conducted by the mine security to watch for evidence of prohibited activities. *Mine Footprint related measures* • Clearly demarcate areas of high conservation with appropriate barriers and signage to ensure no unnecessary encroachment occurs. • Any infringements or encroachment will be reported and appropriate penalties are to be enforced on the staff member or contractor. • The footprint of short-duration activities during construction, operation and decommissioning phases of the mine and the projects outside of the BMM mine concession will be minimised. • Linear infrastructure (e.g. roads, powerlines and pipelines) should be grouped where possible to follow the same route adjacent to one another. • Design and construct the southern approach road within the available flat surface, cutting of the slope should be limited to areas

where the available surface does not allow for the required surface width. Berms should be constructed with materials cut from the slope and rocks rolling down the slope are to be kept to a minimum.

- No access of personnel to areas outside the disturbed areas, unless prior approval gained from the relevant manager or ECO.

Groundwater drawdown related measures

The following approaches will be implemented:

- Artificial drinking water in appropriate areas within the inselberg basin throughout the year for wildlife that is currently dependent on current water of the Kloof. The methods of water provision can be varied, but needs to be accessible to a range of medium to large wildlife species. Water can be provided in a similar manner to that used for livestock in the greater area, will a ball valve maintaining a large container in a medium to full state at all times. This must be done once natural water sources have disappeared as a result of the predicted groundwater drawdown to determine the necessity and use of the service to local wildlife.
- Seasonal provision of water in natural pools in appropriate wetland habitat locations for frog species and aquatic fauna to complete their breeding cycles. Surface water flows through the kloof during the rainy season may be sufficient, however if not, then a quantity of water, approximately equal to the volume of a large bowser truck used for dust suppression should be released at intervals to maintain some pools of water in the upper part of the kloof. Small pools should be maintained for a period of approximately four to six weeks during the normal rainy season. The required frequency of water delivery would depend on the prevailing weather, the extent to which water infiltrates into the soil and use by wildlife and vegetation. Optimal points of delivery will need to be found where a lasting presence is achieved, and an adaptive management approach followed towards determining the required frequency of delivery. The success of water provision to stimulate frog breeding and maintaining aquatic fauna must be shown through monitoring to justify future water provisioning programmes.

Habitat fragmentation related measures

- Small areas of natural vegetation will be maintained wherever possible as islands for the refuge of species within the mine footprint to facilitate the movement of species through disturbed areas.
- Fencing of the set aside conservation area will be maintained in a good state in the form of livestock fences that allow unrestricted movement of small and medium-sized wildlife.
- Gates will be locked gates and no entry signs prominently displayed.
- Locally indigenous plant species will be used in landscaping projects around offices and mine facilities.

Recommendations for protecting or enhancing species diversity

- Trenches and pits that are excavated for pipelines, cabling etc will be backfilled as soon as practically possible to avoid acting as a trap for small fauna.
- Artificial barriers to species movements will be minimized and

Biodiversity Management Plan	
	avoided where possible, and measures taken to reduce their fragmentation impacts. • Night lighting for the plant and security purposes will be kept to a minimum and both inward and downward facing to minimise the disturbance to the movement of nocturnal species. • It is recommended that low pressure sodium vapour lights/or LED lights should be used with wavelengths of limited attractiveness to insects. • Escape routes for fauna will be provided within pitfall features and concreted drainage lines, and potentially dangerous situations inspected regularly to save trapped species. • Check trenches for trapped fauna before backfilling. • All new power line infrastructure will be bird-friendly in configuration and adequately insulated to minimise the loss of raptors and other large birds. • Speed restrictions as per applicable standards will be enforced on all roads within the mine properties and mine controlled areas to minimise the incidence of faunal road kills. • Driver training will be provided to sensitise them to the importance of avoiding faunal road kills and the mine site, within the mine properties and on public roads. • Trained mine personnel with capacity to safely capture and translocate dangerous snakes will be available at all times. • Efforts will be supported to promote an appreciation of biodiversity features of the mine property and mine controlled areas among staff, contractors and their dependents. *Alien control measures* • Only approved indigenous species will be used for all workplace landscaping projects. • The introduction of foreign plant species onto the mine site and associated projects will be controlled. • Presence of alien fauna, such as feral dogs and cats that threaten the local ecology will be monitored. Ethical control measures will be implemented if an increase in their presence is detected. • Routine monitoring conducted to identify any new incidence of weed infestation. • Provision of information for personnel on the identification of declared weeds • Stockpile areas and haul roads required will be clearly defined, so that weed establishment and the potential spread of plant diseases may be contained. Stockpiles will be developed in previously cleared areas, with adequate open-spaces buffers, where possible.
Monitoring, Auditing and further studies	*Monitoring of ecological dust impacts* • Dust monitoring of sensitive habitat must be undertaken in alignment with the air quality monitoring requirements, outlined above. • Monitoring of sensitive ecological receptors (particularly in response to dust) will be implemented and include the following considerations: o A competent botanist will be contracted to oversee the monitoring programme; o Monitoring will be conducted monthly.

Biodiversity Management Plan	
	o Permanent monitoring plots will be established within sensitive habitats at high risk of loss of important plant species from dust deposition; o Threshold levels of loss of individual plants will be determined and actions to be followed in the event of exceeding these levels. • Monitoring will be undertaken in line with the BMP.
Reporting and Corrective Action	*General* • Records of all monitoring and auditing activities will be kept, with results included into the Monthly ECO Report, which is to be submitted to the DENC. • Recommendations and corrective actions arising from ECO inspections and reviews will be agreed to with the site engineer, before proceeding. • Biodiversity related complaints from surrounding users will be responded to with further investigations carried out and reporting to the DENC and DWA, as required. This will be recorded within the monthly ECO Report as well. • Non-compliance and incident reports will be reviewed and closed out by the ECO and site engineer. All non-compliances with regard to hydrogeology to be submitted to DENC and DWA for their records.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.14 NOISE AND VIBRATION

Table 7.6 Noise and Vibration

Noise and Vibration Management Plan	
Activity	The construction phase would result in the generation of noise and vibration through the use of blasting and heavy duty equipment.
Policy	To construct in a manner that minimises the impact of noise and vibrations on surrounding properties.
Performance Criteria	• No exceedence of SAN 10103 of noise at sensitive receptors. • Respond to noise and vibration related complaints received from residents and landholders and implement mitigation measures. • Consultation with potentially affected sensitive receptors, prior to commencement of construction. • Respond to all complaints.
Implementation Strategy	• Implement environmental noise and vibration monitoring along site boundaries and at four selected locations within farm houses closest to the mine and the Loop 10 road on an annual basis with more frequent targeted monitoring at sensitive receptors, if required. • Ensure all noise complaints are responded to and recorded by the ECO. • Ensure that all machinery and equipment is well maintained in good working order. • Regular maintenance of vehicle servicing is required. The intervals

Noise and Vibration Management Plan	
	will vary based on the vehicle and approved by the site engineer.
Monitoring and Auditing	• ECO to review vehicle servicing records. • Public or neighbours' complaints relating to noise and vibration will be recorded and responded to. • Record noise and vibration monitoring results.
Reporting and Corrective Action	• Complaints relating to noise will be addressed promptly, with further investigations and reporting to the ECO and site engineer, if required. • Routine work reports with maintenance records will be recorded and reviewed by each supervisor or manager. • All works that deviate from normal operating conditions will be reported and action initiated (including reporting to relevant agencies where this is warranted/required) to prevent a recurrence of the incident. • Non-compliance and incident reports will be reviewed and closed out by senior management. • Regular reviews, recommendations and corrective actions shall be implemented.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.15 SOCIAL

Table 7.7 Social (mitigation measures)

Social Mitigation and Enhancement Measures	
Activity	Construction of the Project would result in increase in demand to municipal services, result in an influx of in-migrants, social ills and communicable diseases. The Project will also result in an increase in training and skills development, procurement and employment opportunities.
Policy	To construct in a manner that promotes sustainable development in line with Vedanta's Social Policy.
Performance Criteria	Objectives of the mitigation and enhancement measures are to limit social impacts and enhance benefits associated with the construction of the Project, respectively.
Implementation Strategy	*General* • Adjacent landowners will be notified of construction, two weeks prior to commencement. • BMM will implement a grievance procedure that is easily accessible to stakeholders, through which complaints related to contractor or employee road use infringements (e.g. speeding, accidents) can be lodged and responded to. Key steps of the grievance mechanism include: o Circulation of contact details of 'grievance officer' or other key contact; o Awareness raising among local communities (including all directly affected and neighbouring farmers) regarding the grievance procedure and how it works; and o Establishment of a grievance register to be updated by BMM,

Social Mitigation and Enhancement Measures	
	including all responses. • BMM, in partnership with the local municipality, local education and training NGOs and Community Based Organisations, will develop a Training Plan that enhances skills in the area in line with the Project's Social and Labour Plan. The Plan should: o Identify the skills gaps (between existing skills and Project needs) and initiate mechanisms to train local people to meet the Project's needs; o Identify the particular needs of the youth and women, based on feedback from stakeholders; and o Prioritise the youth and women for training programs. • BMM will develop and implement a detailed Stakeholder Consultation and Engagement Plan (SCEP), prior to commencement of construction, which identifies all stakeholders, defines methods and frequency for engagement and defines responsibility for these activities. This plan should be updated on an annual basis. • BMM and its appointed contractors are to develop an induction programme and a Code of Conduct for all workers directly or indirectly employed by the Project. The Code of Conduct is to form part of induction of all employees related to the Project and it is to be signed by each employee, prior to construction. All employees and sub-contractors will adhere to the Code of Conduct. If workers are found to be in contravention of the Code of Conduct, which they have signed, they will face disciplinary procedures. If the breach of the code of conduct warrants a dismissal, the dismissal must comply with the South African labour legislation. The Code of Conduct should be available in all relevant languages and at a minimum, English, Afrikaans and Setswana. The Code of Conduct should address the following aspects as a minimum: • respect for local residents; • respect for farm infrastructure and agricultural activities; • no unauthorised taking of natural resources; • respect for the natural environment and no littering or illegal dumping; • zero tolerance of illegal activities by Project related employees including: soliciting prostitutes; illegal sale and purchase of alcohol; sale, purchase or consume drugs; illegal gambling or fighting; and engaging in sexual acts with minors; • compliance with the traffic regulations on site and all road traffic regulations; and • description of disciplinary measures for infringement of the Code of Conduct and company rules. • Implement mitigation measures stipulated to enhance the levels of employment, skills development and procurement in the Local Municipality (LM) and Namakwa District Municipality (NDM) giving priority to vulnerable groups such as women, and ensuring that the youth are empowered to maximise these opportunities.

Social Mitigation and Enhancement Measures	

	Employment
	• Implement provisions set out in terms of the prescribed recruitment and human resources management policy for the Project.
	• BMM will partner with the NDM and Local Municipality to establish a labour centre. The centre will focus on the following services:
	  • Posting of employment opportunities;
	  • Compilation of a database of the local and regional labour force (skilled, semi-skilled and skilled); and
	  • Providing basic training (including labour laws and financial management training). The training course will be targeted mainly to people from the NDM and LM.
	• All contractors will be required to recruit and manage personnel in terms of BMM's recruitment and human resources management policy.
	• BMM will provide all its local workers with induction/orientation. As part of the orientation process, brochures will be provided on financial management and the country's labour laws. The brochure must be in the local languages spoken by employees, simple and easy to understand.
	
	Training and Skills Development
	• BMM will implement a skills and development training programme;
	• All capacity building and skills development initiatives and commitments for core and non-core mining skills (including sustainable alternative livelihoods) will be defined as commitments in the Mine's Social and Labour Plan (SLP).
	• BMM will support the development of literacy enhancement programmes for the local community, in coordination with the local authorities, as part of the community development plans.
	• BMM will provide local and national scholarships throughout the life of the project to recognised public and private universities for courses that are related to both core and non-core mining skills.
	• BMM will implement a bursary scheme aimed at members from the local community.
	• On-the-job performance and training will be monitored through performance reviews. Training needs will be identified and provided on an on-going basis to foster continuous learning during the construction phase, which can feed into the operational phase.
	
	Procurement and Services
	• BMM will assist with building supplier capability in line with their SLP. This may entail the following, wherever possible:
	  • Audit of suppliers in the LM and NDM;
	  • Undertake skills survey to identify skills gaps and development needs;
	  • Develop a supplier training programme; and
	  • Target vulnerable groups to benefit from the supplier training initiative.
	• As part of the tendering process, BMM will encourage large companies to demonstrate how they will partner with local or regional companies to jointly supply a service if it is not possible to split a contract.
	• Through a tendering process, the Project will invite recognised

Social Mitigation and Enhancement Measures	

	national and international organisations, institutions or NGOs to prepare and implement a programme for training, promoting and supporting entrepreneurship and small business development.
	
	Economic Diversification
	• BMM will assist relevant authorities to update their local economic development plans for the LM and NDM.
	• BMM will support the relevant authorities as far as possible in implementing selected components of the local economic development plans.
	
	Unmet Expectations and Associated Social Unrest
	• BMM will keep the communities regularly informed of on-going Project activities through the ward councillors and community leaders. Method and frequency of communications to be defined in the above-mentioned SCEP.
	• Concerns regarding jobs and other expectations will be addressed in accordance with the grievance procedure.
	• Maximise local employment and procurement.
	• Clearly advertise criteria for skills and experience needed for available jobs through local, regional and national media; and clearly advertise experience, quality and volume requirements from the supply chain.
	
	Health
	• Support the Provincial Department of Health in their awareness raising campaigns related to communicable diseases, wherever possible.
	• All contractors and BMM employees will adhere to the Code of Conduct, which will include a zero tolerance of illegal activities by personnel including: prostitution; illegal sale or purchase of alcohol; sale, purchase or consumption of drugs; illegal gambling and/ fighting. Any employee or contractor found in violation of the Code shall face a disciplinary hearing which may result in dismissal.
	• BMM will roll out the HIV/AIDS and TB programmes.
	  • Initiatives shall address the symptoms as well as behaviour change issues around the transmission and infection of HIV/AIDS as well as other sexually transmitted infections.
	  • Programs will need to be developed and carried out in partnership with health services (at various levels) and will not be the sole responsibility of BMM, but of the local government and NGOs operating in the area.
	
	Relations between Locals and In-migrants
	• BMM will assist government in developing the following documentation in order to better manage migration into the area, prior to commencement of the construction phase:
	  • A Migration Situation Analysis Report: this report will show the migration trend of the Local and District municipalities as well as the Province over the past five years. This report is to be updated every five years.
	  • A Regional Migration Plan: this plan will outline strategies, programmes and measures to be implemented in order to better manage the levels of migration into the

Social Mitigation and Enhancement Measures	
	LM and NDM. • A Migration Monitoring Programme: this program will outline steps needed to effectively monitor the migration trends. • BMM will communicate with the local communities on all aspects where the community stand to benefit from the Project. • When tensions over a specific issue reach a point where social unrest between the local community and the migrants is imminent, BMM will work with relevant stakeholders and proactively intervene to avoid social unrest. *Social Pathologies* • BMM to support SAPS through working with Provincial structures to ensure that the appropriate number of police are deployed to the area in line with the expected increase in the population size. • BMM will ensure that their security personnel work in close collaboration with the police to monitor any illegal activity. • The movement of workers on and off the site should be closely managed and monitored by BMM/contractors. In this regard the contractors should be responsible for making the necessary arrangements for transporting workers to and from site on a daily basis. • BMM/contractor will make necessary arrangements to enable workers from outside the area to return home over weekends and or on a regular basis during their respective employment contracts. Contractors will also make the necessary arrangements to ensure that all non-local workers are transported back to their place of residence once their phase is completed. *Sense of Place* • Mitigation measures linked to impacts on air quality, noise and vibration, botanical and visual impacts will be implemented to limit the change to the sense of place. • BMM will encourage local employment opportunities (where possible) during the construction phase and are offered training which will make them more employable. • BMM will invest in and promote sustainable projects, training and education to help communities to develop alternative livelihoods and to ensure that economic dependence on the Project is limited in line with the SLP. • BMM to facilitate cultural or sporting events to encourage interaction between employees and communities including migrants and locals. *Infrastructure and Services* • BMM will identify appropriate Local Economic Development (LED) projects in accordance with their Social and Labour Plan (SLP). It is envisaged that these projects will incorporate the following categories: • Infrastructure development; • Poverty alleviation; and • Skills development.
Monitoring and Auditing	• Proof of notification and grievance procedure to be kept on-site, during construction. • Code of Conduct to be kept on-site. • Signed records of all training and skills development courses

Social Mitigation and Enhancement Measures	
	completed, on the job training and induction training will be provided to the ECO, for inclusion into the Monthly Audit Report. • Proof of advertisement of employment opportunities. • Proof of implementation of HIV/AIDS and TB programmes. • Incidences of social unrest must be monitored, and if required, recorded into the Monthly ECO Report. • Proof of cultural or sporting events, and sustainable projects, training and education to help communities to develop alternative livelihoods must be provided to the ECO and then DENC and DMR during the operational phase.
Reporting and Corrective Action	• Records of all monitoring and auditing activities will be kept, with results reported by the ECO to the DENC, on a quarterly basis. • Recommendations and corrective actions arising from monthly ECO audits, inspections and reviews will be implemented in conjunction with the site engineer. • Non-compliance and incident reports will be reviewed and closed out by the Environmental Manager.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.16 ECONOMIC

Table 7.8 Economic mitigation and enhancement measures

Economic Mitigation and Enhancement Measures	
Activity	The construction phase of the project will result in increased expenditure/investment, net foreign exchange and tax earnings outflows while negative impacts resulting from the Project may be associated with tourism potential, impact adjacent land values and increase strain on municipal services.
Policy	The aim is to minimise the negative impacts on tourism potential of the area, reduce impacts associated with reduction in adjacent land values and reduce demand/ dependency on municipal services while enhancing the economic benefits associated with the Project.
Performance Criteria	• To enhance potential employment opportunities in the local communities associated with the construction phase of the Project. • Increase the potential for the use of local contractors and suppliers. • Ensure that local and district municipal costs are not increased, resulting from increased demand on municipal services. • To reduce the impacts of dust, lighting, visibility of project infrastructure and loss of conservation worthy vegetation. • Reduce demand (from Project employees) on municipal services.
Implementation Strategy	• Early notification to surrounding landowners and the nearby communities of Aggeneys, Pella and Pofadder of the commencement of construction. • Implement employment equity plan, recruitment and procurement policy and local contractor and supplier policy. • Provide training prior to construction, to maximise employees from local communities. • Work in collaboration with Local and District Municipality to align local economic development initiatives and mine opportunities, as well as reduce increased demand on municipal services through

Economic Mitigation and Enhancement Measures	
	joint efforts to meet the requirements of the mine and associated employees. • Early notification to surrounding landowners and the nearby communities of Aggeneys, Pella and Pofadder of the commencement of construction.
Monitoring and Auditing	• Copy of employment equity plan, recruitment and procurement policy and local contractor and supplier policy to be kept on-site. • Contractual documents will be used to verify level of local employment. • Proof of notifications to stakeholders to be kept on-site.
Reporting and Corrective Action	• BMM must submit verification of the use of local employees, suppliers and contractors (including if targets have been met) to DMR. If targets have not been met, a detailed motivation must be provided. • Proof of notification and on the job training must be included into the monthly ECO Report. • BMM must distribute minutes of meeting of the employment forum, once every three months.
Responsibility	BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.17 HERITAGE, ARCHAEOLOGY AND PALAEONTOLOGY

Table 7.9 Heritage, Archaeology and Palaeontology

Heritage, Archaeology and Palaeontology Management Plan	
Activity	Construction activities related to excavation and utilisation of heavy duty equipment will result in the destruction of artefacts of heritage, archaeological and paleontological value. Areas of sensitivity are contained below.
Policy	Avoid or mitigate impacts on indigenous cultural/ heritage values, or artefacts of archaeological and paleontological value.
Performance Criteria	• Preventing the loss of artefacts of importance. • Implementing effective mitigation for the salvage of artefacts of importance. • Compliance with policies and procedures set out in the Record of Decision issued by the South African Heritage Resources Agency.
Implementation Strategy	• Minimise the development footprint to only what is actually needed. • The sites SG1, SG4 and SG7 are to be considered as "no-go" areas, and are to be cordoned off to avoid any direct impacts. A suitably qualified archaeologist must be appointed to assist with delineating the sensitive areas to ensure avoidance. A Map of the SG sites is contained below, for ease of reference. • Restrict all construction activities to designated working areas with all work areas and access areas clearly marked and signposted. • Immediately report any heritage trace that may come to light during the construction phase. • The suspected gravesite, located to the south west of the inselberg adjacent to Loop 10 gravel road, is to be defined as a No-Go area during the construction phase. • Physical salvage of sites would need to take place before commencement of the construction phases.

Heritage, Archaeology and Palaeontology Management Plan	
	• Further investigation of the possible massacre site SG7 and possibly associated archaeological sites SG3 and SG4 (not expected to be impacted) on the south side of Gamsberg is recommended in order to ensure adequate protection of this sensitive zone.
Monitoring and Auditing	• During construction phase, all excavated areas must be monitored for presence of any artefacts of cultural/ heritage, archaeological or paleontological value. • The ECO must inspect newly opened trenches for potential presence of artefacts. • Weekly visual inspections required to ensure that sites SG1, 4 and 7 are not impacted during construction.
Reporting and Corrective Action	• The ECO must record all instances of artefacts of importance identified in the monthly audit report. • If any traces of heritage, archaeological or paleontological value are revealed, SAHRA must be notified, a suitably qualified archaeologist must be appointed. All construction work around the area in question must cease, until approved by SAHRA to proceed. • If significant fossils are found, an appropriately qualified palaeontologist will investigate, and if required, a permit will be obtained to recover and preserve the paleontological resources for scientific purposes before work can be commenced again.
Responsibility	• BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

Figure 7.2 Location of no-go areas during construction

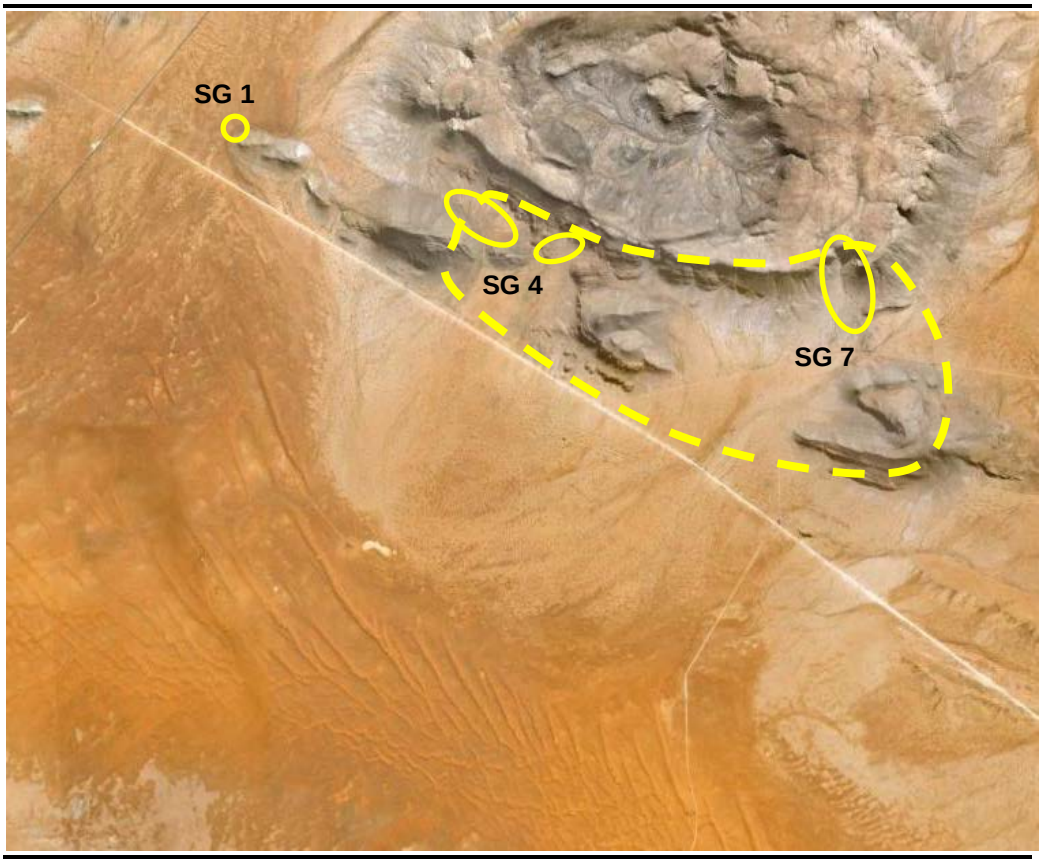
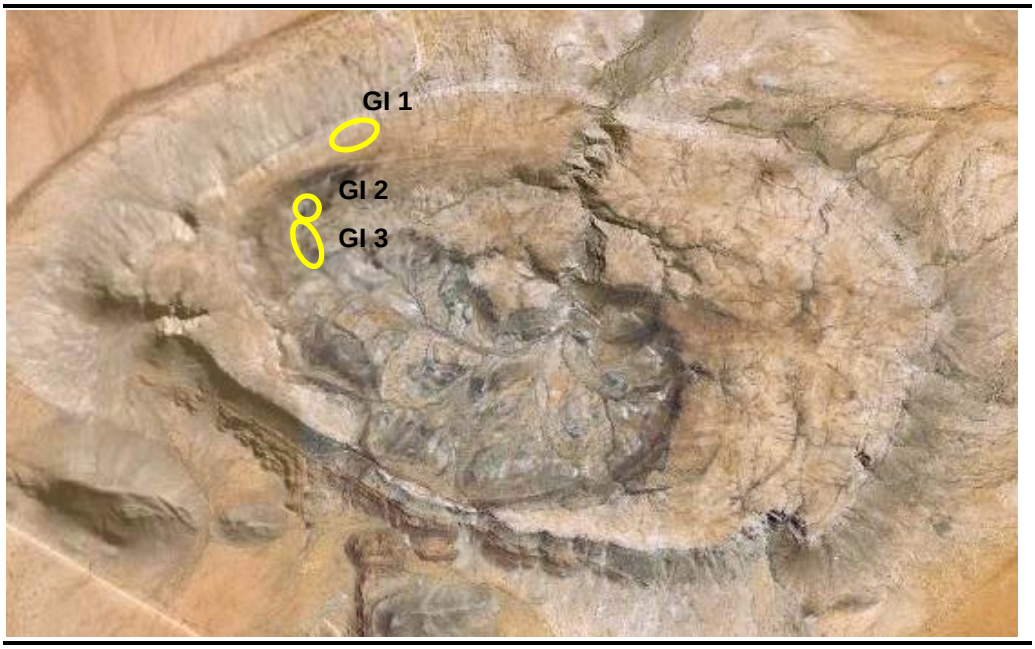


Figure 7.3 Location of site subject to Phase 2 Archaeological Mitigation



7.18 VISUAL AMENITY AND LIGHTING

Table 7.10 Visual amenity and lighting

Visual amenity and lighting	
Activity	The construction phase will result in a change to the visual landscape, through the generation of dust, physical activities, project infrastructure and lighting.
Policy	• To minimise impacts on visual impacts associated with the Project and associated infrastructure. • To reduce as much as practicable lighting impacts on sensitive receptors, including adjacent landowners and N14 and Loop 10 road users.
Performance Criteria	• Respond to all complaints regarding visual amenity and lighting and, where feasible, implement mitigation measures. • Consultation with potentially affected sensitive receptors, prior to construction. • Dust suppression measures will be implemented in line with the air quality recommendations.
Implementation Strategy	<u>Construction of plant and associated infrastructure</u> • It is proposed that as little vegetation as possible be removed from building and infrastructure areas. • Paint buildings and structures with colours that reflect and compliment the natural colours of the surrounding landscape. • To further reduce the potential of glare, the external surfaces of buildings and structures should be articulated or textured to create an interplay of light and shade. • Minimise amount of vegetation and topsoil should be removed from the Project area. • Ensure that conveyor belts are designed to follow the natural

Visual amenity and lighting	
	contours of the land to avoid extensive cut or fill areas, as far as possible. The negative effect of night lighting, glare and spotlight effects can be mitigated using the following methods, as far as technical safe: • Install light fixtures that provide precisely directed illumination to reduce light 'spillage' beyond the immediate surrounds of the project structures and activities. • Avoid high pole top flood and security lighting around the support infrastructure and areas of activity e.g. roads. • To reduce the amount of glare, external surfaces of buildings and other structures should be articulated or textured to increase the interplay of light and shade. <u>Landscaping</u> • Natural vegetation should be retained as far as possible, keeping clearing of vegetation as close as possible to the footprint of structures and activities. • An ecological approach to landscaping is recommended. <u>Access and Haul Roads</u> • Where paved surfaces are required, paving materials with a colour that would complement the natural colours and textures of the area shall be used. This should be explored as far as reasonable possible.
Monitoring and Auditing	• Lighting will be monitored to ensure that it meets the aim of reducing excessive leakage. • Review of the complaints received. • Monitoring dust generation and cleanliness of site.
Reporting and Corrective Action	• All complaints received will be addressed. • Any complaints received, together with the suggested mitigation measures must be recorded in the ECO monthly audit report.
Responsibility	• BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

7.19 TRAFFIC AND TRANSPORT

Table 7.11 Traffic and Transport

Traffic and Transport Management Plan	
Activity	The construction phase would result in the generation of traffic on the N7, N14 and access road to the town of Aggeneys.
Policy	• To reduce traffic impacts to surrounding landowners and road users, during the construction phase.
Performance Criteria	• Minimal traffic-related complaints and incidents. • To minimise impacts on road pavements, or where this is not practicable, to negotiate appropriate contributions or upgrades to road pavement impacts with relevant authorities.
Implementation Strategy	• Obtain relevant approval/s from SANRAL prior to commencement of construction. • Implement traffic management plan.

Traffic and Transport Management Plan	
	• Prepare the intersection of the N14 and the access to the site with the appropriate construction warning signs and road markings. • Restrict all construction activities to designated working areas with all work areas and access areas clearly marked and signposted. • Car pooling and bus services will be implemented where possible to minimise worker journeys. • Dangerous goods will be transported along preferred routes in accordance with relevant legislation. • The transport of oversize loads will be restricted to non-peak periods, in line with traffic authority requirements. • Clear signs and signals will be installed on-site and at all entrance/exit points to the mine to guide traffic movement and increase traffic safety. • Vehicles will observe on-site traffic regulations. • Impacts and subsequent rehabilitation requirements on road pavements will be negotiated with the relevant authorities. • Where necessary, and in consultation with the relevant authorities, road sections (e.g. intersections) may be upgraded. • Construction in road reserves will be planned to minimise disruption and maximise safety of road users.
Monitoring and Auditing	• The number of incidents or complaints received in relation to project traffic will be monitored. • Visual inspection of road quality at the entrance to the Gamsberg mine and N14, as well as at the N14 and access road to Aggeneys.
Reporting and Corrective Action	• The occurrence of any traffic incidents or complaints will be recorded by the relevant ECO monthly audit report and reported to the site engineer. • All traffic incidents involving Project personnel will be reported to the ECO and site engineer and must be thoroughly investigated. • In the event of a complaint/incident or failure to comply with requirements, relevant corrective action will be taken.
Responsibility	• BMM is responsible for the appointment of the ECO and requirements outlined above. These requirements must be fulfilled by the ECO, together with the site engineer and input from BMM.

ANNEXURE-II

GEOTECHNICAL INVESTIGATION REPORT

- *Site Investigations*
- *Slope Stability*
- *Rock Mechanics*
- *Soil Mechanics*
- *Foundations*
- *Borrow Pits and Materials*
- *Roads*
- *Groundwater*
- *NHBRC*
- *Geotechnical Instrumentation*

Gamsberg Mine, Aggeneys, Northern Cape: Process Plant & Tailings Dam: Geotechnical Investigation Report

Client: Geomech Africa (Pty) Ltd

Reference: 15-549R04

Dated: 25 February 2016

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Gamsberg Mine, Aggeneys, Northern Cape: Process Plant & Tailings Dam: Geotechnical Investigation Report

Reference: 15-549R04 **Dated: 25 February 2016**

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Gamsberg Mine, Aggeneys, Northern Cape: Process Plant & Tailings Dam: Geotechnical Investigation Report

Reference: 15-549R04 **Date: 25 February 2016**

EXECUTIVE SUMMARY

This report presents the findings of an additional foundation investigation for the Gamsberg Mine process plant and tailings dam to be constructed just east of Aggeneys in the Northern Cape. The mine processing plant will comprise a number of different elements including a slag mill, ball mill, primary crusher and jaw crusher.

This report has been commissioned to provide information on in situ ground conditions and appropriate foundation methods, with the supplement of previous drilling and geotechnical ground information obtained during the feasibility investigation (AMEC, 2013). ***This report includes the borehole logs, test pit profiles, laboratory test results and geophysical survey.***

The site is underlain by a thin layer of wind-blown sand, duricrete, talus, nodular calcrete, hardpan calcrete, residuum and weathered bedrock of either gneiss or schist with sporadic occurrences of angular quartz talus or sheetflood flow deposit. Weathered bedrock was encountered at between 1.5 m and 10.5 m below surface at an average depth of 6.2 m below surface.

The borehole logs, test pit profiles, in situ and laboratory test results and geophysical survey do not show any untoward constraints to the proposed construction of the process plant or tailings dam, except at boreholes P11, P15 and P18 where loose conditions were encountered to a maximum depth of 3 m below surface. ***In general, however, the transported, pedogenic and residual soils are well cemented and consolidated to form a reliable foundation horizon for conventional pad or strip foundations with and allowable foundation bearing pressures up to 300 kPa.***

The ERT results show unconsolidated material to an average depth of 9 m in the plant area and approximately 5 m in the tailing area.

Shallow weathered bedrock or hardpan calcrete may impede the installation of services to 1.5 m depth in isolated areas.

The surficial materials are considered excellent as a construction material and qualify as at least subbase and even basecourse for some layers. However, these materials are also mildly corrosive to corrosive and thus standard precautionary measures to protect steel reinforcing and metal piping should be taken where necessary.

The foundation conditions are considered adequate for the envisaged loads, except in the areas of BH's P11, P15 and P18, where loose conditions were encountered to a maximum depth of 3 m below surface.

Definitions and Abbreviations

Commercial:

GCS Geotechnical	Groundwater Consulting Services (Pty) Ltd Geotechnical

Technical:

CH	Chainage (metres)
mbgl	metres below ground level
masl	metres above sea level
NGL	Natural Ground Level
FL	Foundation Level
BH	Borehole
SPT	Standard Penetration Test
N	SPT N value (blows per 300 mm)
TLB	Tractor-mounted Loader Backhoe
TP	Test Pit
DCP	Dynamic Cone Penetrometer
EABC	Estimated Allowable Bearing Capacity
G1-G10	Standard classification of natural road building materials (TRH 14)
CBR	California Bearing Ratio
MDD	Maximum Dry Density (kg/m3)
MADD	Modified AASHTO Dry Density
OMC	Optimum moisture Content (%)
PI	Plasticity Index
LL	Liquid Limit
LS	Linear Shrinkage
RMR	Rock Mass Rating
GSI	Geological Strength Index
m_i	Hoek-Brown Constant (origin & texture dependent)
RQD	Rock Quality Designation (%)
FF	Fracture frequency
UCS	Unconfined Compressive Strength (MPa)
C (c')	Cohesion (kPa) – total stress and (effective stress)
Φ (Φ')	Friction Angle (degrees) – total stress and (effective stress)
Kv	Modulus of Subgrade Reaction (MN/mm or kPa/mm)
CFA	Continuous Flight Auger (pile type)
DCI	Driven Cast In situ (pile type)
C_v	Coefficient of Consolidation (m^2/yr)
M_v	Modulus of Compressibility (m^2/MN)
MC1	Moisture Content Before Test (%)
MC2	Moisture Content After Test (%)
ρ	Dry Density (kg/m^3)
VSR	Very soft rock
SR	Soft rock
MHR	Medium hard rock
HR	Hard rock
VHR	Very hard rock

Gamsberg Mine, Aggeneys, Northern Cape: Process Plant & Tailings Dam: Geotechnical Investigation Report

Reference: 15-549R04 **Date: 25 February 2016**

1. INTRODUCTION & TERMS OF REFERENCE

Mr Grant Rijsmus of Geomech Africa (Pty) Ltd, requested ***GCS Geotechnical*** to provide a cost estimate to carry out geotechnical professional services to assist in the completion of the additional foundation investigation for the construction of the new process plant and tailings dam for the newly developed Gamsberg Mine near Aggeneys in the Northern Cape. The professional services were itemized in a BOQ and consisted of the following:

- Logging and photographing of 21No boreholes including RQD
- Profiling of 5No test pits
- Sampling of test pits (soil) and boreholes (rock) and testing in laboratory
- Collation of ERT
- Preparation of a report presenting all the results and a comparison with the previous investigation results

The site is located approximately 12km northeast of the town of Aggeneys and approximately 60km west of the town of Pofadder in the Northern Cape.

This report presents the findings of the additional geotechnical investigation carried out specifically for the foundations of the main elements of the process plant and access roads, and supersedes the feasibility study (AMEC, 2013).

2. AVAILABLE INFORMATION

The following information was drawn upon for the purposes of this report:

- Published geological map at 1:250 000 scale (2918 Pofadder), dated 1990
- AMEC feasibility study (2013)
- Waste rock dump ground stability borehole logs (Black Mountain Mining, 2013)
- Calcrete mapping study by University of Free State
- Coordinates of the proposed 27No boreholes and 5No plate load tests
- Drawing showing boring locations

3. SITE DESCRIPTION

The proposed site is located approximately 12km east of the town of Aggeneys and approximately 60km west of the town of Pofadder in the Northern Cape.

The site is affected by numerous shallow non-perennial drainage paths traversing the site in a south-east and north east direction. There are a number of groundwater monitoring boreholes located on the site. The site falls within the Nama-Karoo biome characterised by low shrub land and grasses. A locality and site plan are attached as Figure 1.

3.1 Gamsberg Processing Plant Site Layout

The positions of the proposed processing plant and boreholes designated P1 through P24 are observed on the layout plan provided. The coordinates of the boreholes, positioned by the client, designated P1 through P24 are provided below. The coordinates of the boreholes as well as the ground elevations as provided by the client, were located on the ground by means of hand-held GPS are provided below:

Table 3-1: Summary of Borehole Positions

WTG Position	X coordinate	Y coordinate	Z (masl)	Status
Plant Site				
P1	3 335.45	3 234 306.60	929.43	Drilled
P2	3 542.95	3 234 405.86	935.96	Removed
P3	3 805.98	3 233 435.02	920.00	Drilled
P4	3 836.11	3 233 371.78	920.00	Drilled
P5	3 458.93	3 234 092.08	920.00	Drilled
P6	3 902.86	3 233 257.61	920.00	Drilled
P7	3 944.50	3 233 201.89	919.90	Drilled
P8	3 978.17	3 233 155.75	919.55	Drilled
P9	3 966.06	3 233 113.83	919.89	Drilled
P10	4 026.26	3 233 138.09	919.38	Drilled
P11	3 864.53	3 233 046.45	920.54	Drilled
P12	4 037.94	3 233 025.78	920.81	Drilled
P13	3 942.00	3 232 836.88	923.13	Drilled
P14	4 079.27	3 233 342.06	917.36	Drilled
P15	4 041.53	3 233 252.21	918.25	Drilled
P16	4 215.85	3 233 228.84	917.96	Drilled
P17	4 197.88	3 233 151.57	919.09	Drilled
P18	4 204.17	3 233 311.51	916.75	Drilled
P19	4 300.31	3 233 318.70	916.60	Drilled
P20	4 296.71	3 233 244.12	917.70	Removed
Tailings				
P21	3 155.93	3 233 921.34	920.00	Removed
P22	5 592.10	3 231 173.54	941.00	Drilled
P23	4 711.88	3 230 507.64	944.50	Removed
P23A	5 116.37	3 230 440.75	942.00	Drilled
P24	5 842.91	3 230 678.82	942.12	Drilled
P25	5 160.68	3 230 056.47	947.17	Removed
P26	5 531.60	3 229 388.30	954.37	Removed
P27	4 814.90	3 229 354.54	952.72	Removed

3.2 Topography & Climate

The area is essentially flat altered only by very shallow drainage paths. The general ground fall is towards the south east at a gradient of approximately 1:140. Mean annual precipitation is approximately 83 mm (WR, 2005).

4. REGIONAL GEOLOGY

The following broad scale geological units were encountered during the investigation. Angular quartz talus or sheetflood deposit, schist and gneiss of the Hotson Formation, Bushmanland Group and Koeipoort Gneiss of the Gladkop Metamorphic Suite. Secondary pedogenic surface deposits of calcrete and sand of the Kalahari Group are also abundantly represented. Recent alluvial deposits appear to be absent or very thin in the dry surface river channels.

Structurally, the regional area is influenced by the Zuurwater and Rozynbosch thrust faults.

4.1 Schist and Gneiss

The schist and gneiss was formed approximately 2 000 Ma. They comprise an orangey pinkish streaked dark and light grey, closely to medium jointed, foliated, very soft to soft occasionally medium hard rock. Foulkes (2014) refers to a geological model proposed by Stadler (2003) in which the orogenesis of the zinc and copper deposits of Gamsberg were formed during intense rift faulting subsequent to the marine deposition of partly consolidated clastic rocks.

4.2 Kalahari Group

The Kalahari Group is the most extensive body of terrestrial sediments in Southern Africa and covers most parts of central and northern Botswana, parts of eastern Zambia and occurs in other southern African countries. The deposits formed in inland basins created during the break-up of Gondwanaland and subsequent tectonic uplifts.

The older units generally have a fluvial origin and consist of gravels interlayered with calcareous clays. Aeolian deposits, informally termed Kalahari sand, form the upper unit of the Kalahari Group and cover most of the underlying sediments.

Pedocretes in the form of calcrete (calcium carbonate cementing agent) and silcrete (silica cementing agent) typically occur at the base of the Aeolian sands. Calcrete may be in the form of sandy limestone or calcareous sand or gravel. Silcretisation of the sandy limestone is known to occur in many locations (Johnson et al., 2006).

4.3 Recent Alluvial Sediments

Alluvial sediments deposited by the non-perennial streams were distinguished from the Kalahari Group sediments by a lack of pedogenic alteration or signs of consolidation. The sediments typically consisted of fine to medium-grained sand and was encountered in all the boreholes and test pits.

4.4 Quartz Talus or Sheetflood Deposit

This unit comprises a reddish brown, fine- to coarse-grained clastic altered rock with varying degrees of weathering.

5. CLIMATE

The climatic regime plays a fundamental role in rock weathering and the development of a soil profile. The climate in the Northern Cape is generally semi-arid to arid and the Aggeneys area receives a mean annual precipitation of approximately 83 mm (DWA, 2005) per annum.

Weinert (1964) demonstrated that mechanical weathering is the predominant mode of weathering where his climatic "N-value" is more than 20 as here in Aggeneys (N=21).

6. FIELDWORK

The fieldwork was completed on 16 November 2015. The relevant borehole, test pit and plate load tests and electrical resistivity tests (ERT) positions are shown on Figure 2.

6.1 Rotary-cored Boreholes

Twenty one vertical diamond rotary-cored boreholes have been completed during the investigation.

The holes were drilled to between 4.5 m and 19.5 m at an average depth of 12.7 m.

Table 6-1: Summary of Foundation Conditions at 1.5 & 3.0 mbgl

BH No	Ground Elevation (masl)	Final depth (mbgl)	Rock Type at 1.5 mbgl	Rock Type at 3.0 mbgl
Plant site				
P1	929.43	15	Medium hard calcrete	Quartz gravel
P3	920.00	12.1	Very dense clayey sand	Extremely weak talus or sheetflood deposit
P4	920.00	12.1	Very dense clayey sand	Very dense clayey sand
P5	920.00	9	Quartz gravel	Quartz gravel
P6	920.00	12.1	Very dense clayey sand	Very dense clayey sand
P7	919.90	14.3	Very dense clayey sand	Very dense clayey sand
P8	919.55	16.6	Clayey sand	Very dense clayey sand
P9	919.89	14.5	Medium dense clayey sand	Medium dense clayey sand
P10	919.38	14.6	Very dense sand	Very dense sand
P11	920.54	19.5	Loose sand	Medium dense clayey sand
P12	920.81	13.6	Very dense sandy clay	Very dense clayey sand
P13	923.13	13.6	Very dense clayey sand	Very dense clayey sand
P14	917.36	13.6	Dense clayey gravel	Dense slightly clayey sand
P15	918.25	13.5	Medium hard calcrete	Loose clayey sand
P16	917.96	12	Medium dense clayey sand	Dense clayey sand
P17	919.09	12	Medium dense clayey sand	Medium dense clayey sand
P18	916.75	9	Silty sand	Medium dense clayey sand
P19	916.60	14.6	Very dense clayey sand	Very soft talus or sheetflood deposit
Tailings Dam				
P22	941	10.6	Dense clayey gravelly sand	Very soft talus or sheetflood deposit
P23A	942	4.5	Soft rock gneiss	Medium hard rock gneiss
P24	942.12	9.9	Very soft rock gneiss	Soft rock gneiss

The locations of the boreholes were set out by survey and in part by hand held GPS.

6.1.1 Drilling Method

The boreholes were drilled using NWD-4 drilling equipment with a NXC size starting barrel, to produce a borehole of 76mm diameter for core sampling and in situ testing. Standard Penetrometer Testing was conducted from 1.5m in regular intervals until test refusal was achieved. Temporary casing was installed to stabilise the upper unconsolidated portion of the boreholes to prevent collapse of the boreholes during drilling.

The drilling system uses a double tube core barrel with a solid inner tube.

The drilling was undertaken with the aid of a commercial drilling fluid additive sold under the brand name Ezeemix produced by SAMCHEM. Ezeemix is a biodegradable polymer that increases the viscosity of the drilling fluid and aids side wall stability and sample return.

6.1.2 Core Logging

The soil and rock cores obtained during the drilling were profiled by one of ***GCS Geotechnical'***s engineering geologists under the supervision of the author (***GCS Geotechnical*** project specialist) in accordance with the accepted South African standards. Soils were described according to the method of Jennings et al (1973) and the rock core in accordance with the Core Logging Committee of SA.

In addition to the primary description of the rock mass, the borehole logs include parameters for core recovery, rock quality designation (RQD) and fracture frequency.

The RQD provided in the borehole logs was recorded per drill run and is defined as the total length of individual intact core greater than 100mm expressed as a percentage of the drill run length. The RQD was measured along the central axis of the core.

Fracture frequency is obtained by counting the number of natural fractures that occur per metre length of core. Where the fracture frequency exceeded 20 fractures per metre "+20" was recorded in the borehole logs. The fracture frequency was measured after the core had been handled to assess the integrity of the re-cemented joints and fractures.

6.2 Standard Penetration Tests (SPT)

Standard penetration tests (SPT's) were undertaken in the boreholes in the unconsolidated overburden material initially at 1m intervals until refusal was obtained. The SPT apparatus consisted of an automated 63.5kg hammer falling a distance of 760mm onto a string of rods attached to a standard split spoon sampler (Raymond Spoon). The number of blows per six increments of 75mm is recorded. The upper 150mm (i.e. the first two blow counts) are considered disturbed and are discarded. The sum of the blow counts for the remaining 300mm is recorded as the SPT N-value.

Refusal was recorded when the blow count exceeded 25 blows per 75mm, which corresponds to an SPT N-value in excess of 100.

The SPT N-values are summarised in Table 6-2 below and included in the borehole logs (Appendix A).

Table 6-2: Summary of SPT Results

BH No	Start depth (mbgl)	SPT N-value	Consistency	EABC (kPa)	Material
Plant Area					
P3	1.5	77	Very Dense	>300	Clayey SAND
	3.1	Ref	Very dense	>400	CWR
	4.6	58	Very dense	>300	Clayey SAND
	6.1	Ref	Very dense	>300	Clayey SAND
P4	1.5	77	Very dense	>300	Clayey SAND
	3.1	68	Very dense	>300	Clayey SAND
P6	1.5	61	Very dense	>300	Clayey SAND
	3.1	Ref	Very dense	>300	Clayey SAND
	4.6	Ref	Very dense	>400	HWR
P7	1.6	56	Very dense	>300	Clayey SAND
	2.9	77	Very dense	>300	Clayey SAND
	4.5	Ref	Very dense	>300	Clayey SAND
	6.0	Ref	Very dense	>400	CWR
	7.5	Ref	Very dense	>400	CWR
	9.1	Ref	Very dense	>400	CWR
	10.6	Ref	Very dense	>400	CWR
P8	1.6	44	Dense	250-300	Clayey SAND
	3.1	Ref	Very dense	>300	Clayey SAND
	4.6	Ref	Very dense	>400	CWR
	7.6	Ref	Very dense	250-300	Fine SAND
	10.6	Ref	Very dense	>400	CWR
P9	1.8	22	Medium dense	100-200	Clayey SAND
	3.0	28	Medium dense	100-200	Clayey SAND
	4.5	24	Medium dense	100-200	Clayey SAND
	6.0	38	Dense	200-300	Clayey SAND
	7.5	Ref	Very dense	>300	Clayey SAND
P10	1.5	Ref	Very dense	>300	Fine SAND
	3.1	Ref	Very dense	>300	Fine SAND
	4.6	Ref	Very dense	>300	Clayey SAND
P11	1.9	7	Loose	50-75	Silty SAND
	3.0	13	Medium dense	150-200	Clayey SAND
	4.5	11	Medium dense	150-200	Clayey SAND
	6.0	18	Medium dense	150-200	Clayey SAND
	7.5	Ref	Very dense	>400	CWR
P12	1.5	52	Very dense	>300	Clayey SAND
	3.1	62	Very dense	>300	Clayey SAND
	4.5	Ref	Very dense	>300	Clayey SAND
	6.1	Ref	Very dense	>300	Clayey SAND
	7.6	Ref	Very dense	>300	Clayey SAND
	9.1	Ref	Very dense	>400	CWR
P13	2.1	42	Dense	200-300	Clayey SAND
	3.1	54	Very dense	>300	Clayey SAND
	4.6	53	Very dense	>300	Clayey SAND
	6.1	52	Very dense	>400	Gravely SAND
	9.1	Ref	Very dense	>400	Gravely SAND
P14	1.5	45	Dense	300-400	Clayey GRAVEL
	3.1	47	Dense	300-400	Clayey GRAVEL

BH No	Start depth (mbgl)	SPT N-value	Consistency	EABC (kPa)	Material
	4.6	Ref	Very dense	>300	Clayey SAND
	6.1	Ref	Very dense	>300	Clayey SAND
	7.6	Ref	Very dense	>300	Clayey SAND
P15	3.0	6	Loose	75-100	Clayey SAND
	4.5	Ref	Very dense	>300	Clayey SAND
P16	1.8	15	Medium dense	200-250	Clayey SAND
	3.0	39	Dense	300-350	Clayey SAND
	4.5	12	Medium dense	200-250	Clayey SAND
	6.0	12	Medium dense	200-250	Clayey SAND
	7.5	Ref	Very dense	>300	Clayey SAND
P17	1.5	26	Medium dense	100-250	Clayey SAND
	3.0	14	Medium dense	100-250	Clayey SAND
	4.5	Ref	Very dense	>300	Clayey SAND
P18	1.6	8	Loose	75-100	Clayey SAND
	3.0	29	Medium dense	200-250	Clayey SAND
	4.5	Ref	Very dense	>400	CWR
P19	1.5	55	Very dense	>300	Clayey SAND
	3.0	Ref	Very dense	>400	CWR
Tailings Dam					
P22	1.5	47	Dense	300-400	Clayey GRAVEL
P24	1.5	Ref	Very dense	>400	CWR

***EABC = estimated allowable bearing capacity**
**** CWR = completely weathered rock, HWR = highly weathered rock**

Based on the above SPT results and values less than N=10 or loose consistency, the areas represented by BH's P11, P15 and P18 are cause for concern. Loose conditions were encountered at these borehole sites to a maximum depth of 3 m. These areas will require further investigation to determine the best foundation solution.

6.3 Test Pits

Five test pits were excavated to facilitate the plate load testing, profiling and sampling. The full test pit profiles are included in Appendix B.

A number of bulk samples were recovered and tested at the Simlab laboratory in Kimberley and the remainder were sent to Soillab in Pretoria. The results are included in the Appendices.

6.4 Plate Load Tests

Nine plate load tests were carried out in five test pits excavated across the plant site and tailings site facility. It was proposed that two plate load tests would be conducted at different depths in each test pit, achievable in test pits P3, P19, P23-24 and P25, with P1 only having one test. The plate load test data sheets have been included in Appendix E.

The main purpose of the plate load tests is to determine certain in situ geomechanical parameters such as elastic modulus, shear modulus, modulus of subgrade reaction and ultimate bearing capacity. The following is a summary of the test results:

Table 6.4-1: Summary of Plate Load Test Results

TP No	Depth (m)	Strength Modulae				Site
		Elastic (MPa)	Shear (MPa)	K* (kPa/mm)	UBC** (kPa)	
Talus						
PLT 1	0.46	86.6	43.3	121	>450	Plant
Calcrete						
PLT3	1.35	57.8	28.9	162	>450	Plant
PLT19	0.6	22.0	11.0	62	>450	Plant
PLT23/24	0.35	79.8	39.9	223	>450	Tailings
Residual Talus or Sheetflood Deposit						
PT19	1.7	40.9	20.5	110	>450	Plant
VSR Schist						
PLT25	0.7	139.6	69.8	300	>450	Tailings
PLT25	1.7	42.9	21.5	100	>450	Tailings

***K = modulus of subgrade reaction**
****UBC – ultimate bearing capacity**

The following equations and relationships have been used to determine the strength modulae from the graphs:

Elastic Modulus:

$E = \Pi.r.\sigma.(1-\gamma^2)/2\rho$

Modulus of Subgrade Reaction:

$K = E/B.(1-\gamma^2).Iw$ or $2E/\Pi.(1-\gamma^2).r$

6.5 Electrical Resistivity Tests (ERT)

Three electrical resistivity tomography (ERT) were carried out on the plant site and one at the tailing site facility. The primary aim of the geophysical survey was to characterise the subsurface material properties to identify adequate foundation depths for the mine processing plant and tailings site facility. The ERT survey was conducted using the Wenner configuration as opposed to the Wenner-Schlumberger configuration due to the very dry and loose conditions encountered. The coordinates are summarised below:

Traverse	Start Coordinates		End Coordinates	
	Latitude	Longitude	Latitude	Longitude
Plant Site				
1	-29.2166	18.9578	-29.2157	18.95938
2	-29.2153	18.95823	-29.2167	18.95926
3	-29.2158	18.95769	-29.2173	18.95876
Tailings Site				
4	-29.1978	18.94253	-29.1979	18.9446

The ERT system uses a series of electrodes along a straight line attached to a multi-core cable (e.g., 100 m long cable). A DC or slowly varying AC current is artificially injected into the Earth through a series of grounded current electrodes and the resulting potential measurements made at a number of grounded potential electrode pairs. This information (injected current and the measured potential) is then used to identify subsurface apparent resistivity. The test results are included in Appendix D:

Essentially, the results in the plant area (traverses 1 to 3) show unconsolidated material (low resistivity < 83Ωm) to an average depth of 9 m below surface with a sharp transition into weathered bedrock at this depth (>179 Ωm). At the tailings dam site this transition depth is estimated at 5 m below surface.

7. LABORATORY TESTING

Laboratory testing has been completed on the soil samples from the test pits and selected core samples from some of the boreholes. A summary of the available UCS test results for this investigation is presented below:

Table 7-1a: Summary of Available UCS Test Results

BH No	Depth (m-m)	UCS (MPa)	Classification
Talus or Sheetflood Deposit			
P4	4.24-4.38	2.6	Very soft rock
P4	7.10-7.33	2.4	Very soft rock
P8	3.83-4.04	1.9	Very soft rock
P9	9.80-9.96	4.8	Soft rock
P10	6.15-6.26	0.6	Less than very soft rock
P12	9.86-10.0	3.9	Soft rock
P15	9.13-9.31	3.4	Soft rock
P18	5.14-5.27	7.1	Soft rock
Altered Schist			
P12	12.08-12.30	32.8	Hard rock
P15	11.02-11.21	4.1	Soft rock

The results of the soil tests are summarised below:

Table 7-1b: Summary of Foundation Indicators

TP	Depth (m-m)	LL	PI	GM	CBR* (%)	Classifications		
						TRH14	PRA	USCS
Residual Talus or Sheetflood Deposit								
PLT1	0.0-0.68	NP	NP	2.03	60+	G4	A.1.b	SM
PLT3	0.0-0.4	NP	NP	1.28	36+	G6	A.2.4	SM
PLT19	0.0-0.35	NP	NP	1.29	36+	G6	A.2.4	SM
P08	1.5-1.6	39	13	1.25	20	G6	A.6	SC

***CBR for 93% MADD**

Specific test results for compaction characteristics are as follows:

Table 7-1c: Summary of Compaction Test Results

TP	Depth (m-m)	MDD (kg/m3)	OMC (%)	Swell (%)	CBR (%)				
					90	93	95	98	100
Residual Talus or Sheetflood Deposit									
PLT1	0.0-0.68	2238	6.9	0.05	17	26	36	57	78
PLT19	0.0-0.35	2141	7.0	0.72	34	50	66	98	129
PLT19	0.35-1.3	2127	7.4	0.18	36	58	80	129	177
Calcrete gravel									
PLT19	1.3-2.1	2126	7.0	0.24	22	36	49	79	109
PLT23-24	0.2-0.5	2082	9.6	0.02	41	63	83	127	169
Colluvium									
PLT23-24	0.0-0.2	2084	7.0	0.06	17	27	37	60	83
Duricrete									
PLT25	0.0-0.5	2041	9.7	0.00	17	27	36	56	75
Schist - Very soft rock									
PLT25	0.6-1.3	1996	7.9	0.02	39	61	82	127	170

MDD = maximum dry density
OMC = optimum moisture content

Table 7-1d: Summary of Shear Box Test Results (Residual Talus)

TP	Depth (m-m)	MC (%)	Cohesion (kPa)	Phi (°)
P08	1.5-1.6	12.9	8	35
P09	1.5-1.8	16.3	8	38
P18	1.5-1.63	26.8	5	31

A single collapse potential test (single oedometer saturated at 200 kPa) in the residual quartzite showed a collapse potential of just 1.4% with a dry density of 1366 kg/m3, initial and final moisture contents of 11% and 16.4% respectively.

8. ROCKMASS CHARACTERISTICS

Using the rock strength results and rockmass structure (fracture spacing, RQD and condition of joints) from the core logging, it is possible to provide an estimate of the Rock Mass Rating (RMR) proposed by Bieniawski (1974). From this rating it is also possible to calculate the Geological Strength Index (GSI) as proposed by Hoek & Brown (1997) using the following relationship:

GSI = RMR-5

The RMR is estimated using the range of geomechanical parameters obtained from the borehole logs and laboratory testing as follows:

Table 8-1a: Summary of RMR Parameters & Values (Talus)

RMR Parameter	Value Range & (average)	Rating & (average)
UCS	1.9-7.1 (3.8)	1-2 (1)
RQD	0-100 (39)	3-20 (12)
Spacing of joints	10-100 (55)	8-15 (12)
Condition of joints	Slightly to very rough	10-30 (20)
Water	Dry (default)	0
TOTAL		***22-67 (45)***

Table 8-1b: Summary of RMR Parameters & Values (Schist)

RMR Parameter	Value Range & (average)	Rating & (average)
UCS	1.9-7.1 (3.8)	1-2 (1)
RQD	6-83 (56)	3-17 (10)
Spacing of joints	30-100 (65)	10-15 (13)
Condition of joints	Slightly to very rough	10-25 (18)
Water	Dry (default)	0
TOTAL		***24-59 (42)***

The range and average total suggests a poor (Class IV) to good (Class II) rock mass class range with an average of fair (Class III) rock mass class.

In order to apply the GSI methodology, the RMR needs to be reduced by 5 and thus the GSI range is 17 to 62 with an average of 37. These range and average values can be used, together with the Hoek-Brown constant which is dependent on the rock type, origin and texture (grain size) of the intact rock. For the basalt the Hoek-Brown constant (mi) is 4 to 8.

Once these input values are entered into the spreadsheet, the output values for the strength and deformation values of the basalt rockmass are as follows:

Table 8-2a: Summary of Rockmass Values (average to maximum) (Talus)

Input Parameters			Output Values			
GSI	UCS (MPa)	mi	Ø (°)	C (MPa)	E (MPa)	E (GPa)
40-62	1.9-7.1	4-8	21-32	0.05-0.39	0.16-1.4	0.78-5.3

Ø = rockmass friction angle
C = rockmass cohesion
σ = rockmass compressive strength
E = rockmass deformation modulus

Table 8-2b: Summary of Rockmass Values (average to maximum) (Schist)

Input Parameters			Output Values			
GSI	UCS (MPa)	mi	Ø (°)	C (MPa)	σ (MPa)	E (GPa)
37-54	1.9-7.1	4-8	21-30	0.05-0.31	0.15-1.09	0.67-3.3

Ø = rockmass friction angle
C = rockmass cohesion
σ = rockmass compressive strength
E = rockmass deformation modulus

Therefore, the minimum allowable bearing capacity of the rockmass at depth is 150 kPa to 1 MPa. However, the minimum safe allowable bearing capacity as measured in situ by various methods (plate load and SPT) have shown the minimum allowable bearing capacity to be in the region of 300 to 450+ kPa.

9. GROUNDWATER LEVELS

Standpipe piezometers were installed in three boreholes in order to allow for the monitoring of the groundwater levels, however due to the depth of the regional groundwater table exceeding the depth of the current investigation boreholes, no groundwater levels were recorded.

10. SEISMICITY

The seismic intensity of the area is VI (MMS) with a 10% probability of being exceeded in 100 years (Fernandez et al, 1977). The probability of liquefaction is considered marginal with a peak horizontal acceleration of 50 to 100 cm/s2 (Welland, 2002). However, the latest provisional seismic hazard map shows a peak ground acceleration of 0.05g with a 10% probability of exceedance in 50 years (CGS, 2003).

SANS 10160 (2009) suggests that values of peak horizontal acceleration of less than 0.1g do not warrant the inclusion of additional seismic loading in foundation design.

11. FOUNDATION RECOMMENDATIONS

The results of the drilling, test pitting, in situ testing and laboratory testing suggests that conventional pad or strip foundations can be placed at nominal depth at a bearing pressure of 300 kPa over most of the site.

However, structures proposed in the vicinity of boreholes P11, 15 and 18 will require deeper than normal foundation excavations to approximately 3 m below surface. Provided these temporary excavations are battered back to a safe angle (at least 1:1 recommended) or temporarily shored by planking and props, then conventional pad or strip foundations can be placed at this depth at 300 kPa allowable bearing pressure.

It is recommended that adequate site supervision of earthworks and foundations be included in the tender documentation.

12. SUMMARY OF BOREHOLE LOGS

A summary of the borehole logs indicating the depth at which bedrock was encountered is provided in Table 9-1. The full borehole logs are included in Appendix A.

The geology underlying the site is relatively uniform. A typical profile contains a thin aeolian, colluvial or talus horizon, underlain by calcrete and residual quartzite followed by either weathered schist or gneiss bedrock.

Calcrete was observed (P1, P9, P10, P13, P14, P15, P16, P19, P22, P24) varying in form from sand, gravels, cobbles and boulders, to hardpan calcrete of soft to medium hard rock strength. It was found in most instances as a thin horizon at or close to surface, very rarely exceeding 2 m depth.

Cemented talus or sheetflood deposit was observed in all boreholes with the exception of P24. It was generally found as a dense to very dense soil with sporadic horizons of completely to highly weathered very soft to soft rock. It was encountered between surface and 13.4 m (P19) with an average depth of 9.3 m.

Schist and gneiss was encountered in all boreholes from an average depth of 6.2 m below surface with a minimum of 1.5 m and a maximum of 10.5 m below surface. It was generally found to be highly to moderately weathered very soft to medium hard rock strength.

The majority of the rock was found to be closely to very widely jointed and fractured, with up to three sets being recorded. The joints are oriented sub-horizontal to sub-vertical, with the intersection of these creating a jointed rock mass, in some instances greater than 20 joints per meter.

The cemented talus of sheetflood deposit generally becomes less weathered with depth, however horizons of very soft to soft rock were observed within the unconsolidated soils.

Evidence of major fault planes of shearing were not observed in any of the boreholes. However, areas of low core recovery (<50%) could be indications of highly weathered, low strength zones.

Table 10-1: Summary of Borehole Logs

BH No	Collar elevation (masl)	Bedrock level (mbgl)	Elevation of bedrock level (masl)
P1	929.43	5.8	923.63
P3	920.00	9.35	910.65
P4	920.00	3.65	916.35
P5	920.00	5.93	914.07
P6	920.00	3.68	916.32
P7	919.90	4.78	915.12
P8	919.55	8.0	911.55
P9	919.89	8.88	911.01
P10	919.38	6.08	913.30
P11	920.54	10.5	910.04
P12	920.81	7.73	913.08
P13	923.13	10.28	912.85
P14	917.36	9.53	907.83
P15	918.25	9.0	909.25
P16	917.96	8.0	909.96
P17	919.09	6.26	912.83
P18	916.75	4.65	912.10
P19	916.60	2.76	913.84
P22	941.00	2.0	939.00
P23A	942.00	1.0	941.00
P24	942.12	1.5	940.62

The average bedrock depth is 6.2 mbgl (916.88 masl) with a minimum and maximum of 1.5 mbgl at borehole P24 and 10.5 mbgl at borehole P11 with a difference of 9 m.

25 February 2016

For ***GCS Geotechnical***

GAMSBERG PLANT
APPENDIX A
Borehole Logs

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	11/11/2015
Client:	Geomechanics	Borehole end date:	12/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	929.43
Geologist:	SK	Coordinates:	-3335.45
Borehole No.:	P1		-3234306.6
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	NXC	100	0	0									W5	1.26	Reddish brown speckled white, silty sandy **GRAVEL**. Ferrigenous Duricrust/Talus NOTE 1)Gravels comprise fine to coarse grained, angular to sub-angular quartz			929
1	NXC	88	20	0									W5	1.82	Light grey blotched light brown, completely weathered, fine to very coarse grained, fractured, very well cemented becoming poorly cemented with depth, **medium hard rock becoming very soft rock with depth**. Calcrete			928
2	NWD4	69	29	0									W5	3.2	Light pinkish grey, very poorly cemented, calcretized, clayey **GRAVEL**. Residual Calcrete NOTE 1) Gravels comprise angular to sub-angular fine to coarse grained quartz			927
3																		
4	NWD4	62	31	9			+20						W4-W5	4.54	Light grey, completely to highly weathered, fine to very coarse grained, fractured, calcretized, **very soft to medium hard rock**. Quartzite NOTE 1) Completely weathered fractured rock from 4.14-4.54 m			926
5	NWD4	57	10	0									W5	5.8	Reddish brown, very poorly cemented, partially calcretized, clayey fine to medium **SAND** with abundant gravel. Fault breccia NOTE 1) Gravels comprise fine grained angular to sub-rounded quartz and agglomerations			925
6	NWD4	84	84	13			11	J1	30-40	M	PLA	MRJ	W4-W5					924
7							+20											923
8	NWD4	61	33	6			+20	J2	60-70	M-W	PLA	RJ			Orange dark grey streaked dark and light grey, completely to highly weathered, closely jointed to fractured, fine to coarse grained, **very soft to soft rock**. Biotite-rich Schist NOTE 1) Completely weathered rock from 7.74-7.80 m; 8.06-9.26 m; 10.5-10.6 m and 11.71-11.87 m 2) Zone of completely weathered clay-rich, friable, extremely to very soft rock from 9.4-9.9 m 3) Very soft rock from 10.6-11.71 m			922
9							+20											921
10	NWD4	63	28	10			+20	J3	0-10	M-W	PLA	RJ						920
11							+20											919
12	NWD4	49	29	15			+20	J3	0-10	M	IRR/PLA	MRJ	W3-W5	11.87				918
13	NWD4	70	70	19			+20	J4	80-90	W	STE/PLA	MRJ			Light grey, pink and orange, completely to moderately weathered, closely to medium jointed, fine grained, **very soft to medium hard rock**. Quarzitic Gneiss NOTE 1) Completely weathered rock from 13.5-14.3 m and 14.85-15.0 m			917
14	NWD4	83	93	6			+20	J2	60-70	W	PLA	MRJ						916
15														15				915

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P1**

GCS Geotechnical Engineering
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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	06/11/2015
Client:	Geomechanics	Borehole end date:	07/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920
Geologist:	SK	Coordinates:	-3805.98
Borehole No.:	P3		-3233435.02
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description
0	Auger	50	0	0									W5	0.6	Dry, reddish brown, silty clayey fine **SAND** with minor medium to coarse sand. Colluvium
1	NXC	63	0	0									W5		Light pinkish brown mottled white, very dense, moderately cemented, partially calcretized, clayey fine **SAND** with minor medium sand and gravels. Calcretized Fault breccia
2	SPT	100	0	0	N=77									2.08	NOTE 1) Gravels comprise sub-angular to sub-rounded fine to coarse grained quartz from 0.6-0.93 m
3	NWD4	30	12	0			+20	J1	0-10	M	IRR	RJ	W4-W5	3.23	Reddish brown to light pinkish brown, completely to highly weathered, fine to medium grained, medium jointed, poorly to moderately cemented, **extremely weak to very soft rock**. Fault breccia
	SPT	33	0	0	REF										
4	NWD4	74	0	0									W5		Reddish brown, very dense to extremely soft rock, poorly cemented, clayey fine to medium **SAND** with minor gravels. Fault breccia
5	SPT	100	0	0	N=58										NOTE 1) Gravels comprise sub-rounded to angular, fine to coarse grained quartz and agglomerations
	NWD4	60	0	0											
6	SPT	67	0	0	REF										
7	NWD4	69	0	0										7.47	
8	NWD4	77	17	0									W5		Reddish brown, poorly to moderately cemented, slightly clayey medium grained **SAND** with abundant fine to medium gravels. Fault breccia
9														9	NOTE 1) Zone of moderately cemented very soft rock from 7.58-7.72 m
							10						W4	9.35	2) Gravels comprise sub-rounded to sub-angular fine to medium quartz and agglomerations
10	NWD4	83	71	38			4	J1	0-10	M	IRR	RJ	W4-W5		White, highly weathered, closely jointed to fractured, very fine grained, **very soft rock**. Mudstone
							15	J2	20-30	W	IRR	RJ			Reddish brown speckled light grey, completely becoming highly weathered, fine to medium grained, medium to widely jointed, well cemented, **very soft to soft rock**. Fault breccia
11	NWD4	103	103	7				J1	0-10	W	IRR	SRJ-R		10.96	NOTE 1) Zone of completely weathered soft rock from 9.35-9.60 m
							11	J3	10-20	M	PLA	J SRJ-MRJ	W4-W5		
12								J4	30-40	W	PLA	SRJ		12.08	Light grey streaked greenish brown and dark grey, completely becoming highly weathered, fine to medium grained, medium jointed, foliated, **very soft to soft rock**. Biotite-rich Gneiss
13															NOTE 1) Thick joint infill comprising biotite from 11.10-11.15 m and 11.39-11.41 m

Lithology

Samples: UCS 1 at 10.16-10.34 m

Elevation (mamsl): 920, 919, 918, 917, 916, 915, 914, 913, 912, 911, 910, 909, 908, 907

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P3**

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Project:	Gamsberg Mine	Borehole start date:	06/11/2015
Client:	Geomechanics	Borehole end date:	06/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920
Geologist:	SK	Coordinates:	-3836.11
Borehole No.:	P4		-3233371.78
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	91	0	0									W5		Creamish brown, very dense, clayey fine **SAND** with minor medium and coarse sand. Colluvium NOTE 1) Partially calcretized and weakly cemented from 1.50-1.70 m			920
1	SPT	100	0	0	N=77									1.7				919
2	NWD4	48	0	0									W5		Creamish brown, very dense, well sorted, slightly clayey fine to medium **SAND**. Aeolian NOTE 1) Homogenous horizon with rounded predominantly quartz grains			918
3	SPT	100	0	0	N=68									3.08				917
4	NWD4	100	88	38			11	J1	0-10	C-M	IRR	RJ	W5	3.65	Light reddish brown, very dense, clayey fine **SAND** with abundant gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained sub-rounded to angular quartz		UCS 1 at 4.24-4.38 m	916
5	NWD4	47	32	27			+20								Reddish brown speckled black, completely weathered, fine to coarse grained, medium jointed, moderately cemented, **very soft rock**. Fault breccia NOTE 1) Partially cemented residual soil from 4.58-4.94 m			915
6							7	J2	30-40	W	PLA	VRJ						914
7	NWD4	60	60	60			5	J1	0-10	M-W	IRR	RJ	W3-W4	6.74	Reddish brown speckled dark and light grey, highly to moderately weathered, fine to coarse grained, medium to widely jointed, very well cemented, **very soft to soft rock**. Fault breccia		UCS 2 at 7.10-7.33 m	913
8	NWD4	100	100	80			8											912
9							9	J2	30-40	W	PLA	RJ						911
10	NWD4	82	78	39			10	J1	0-10	W	IRR	RJ		9.93				910
11	NWD4	103	103	47			10	J2	30-40	W	IRR	VRJ	W3-W4		Brown streaked and blotched white, highly to moderately weathered, very fine to coarse grained, widely jointed, very well cemented, **very soft to medium hard rock**. Fault breccia NOTE 1) Zones of soft rock from 10.35-10.48 m; 10.58-10.61 m; 10.92-11.17 m and 11.29-11.56 m		UCS 3 at 10.83-11.03 m	909
								J3	20-30	W	IRR	RJ		11.56				
12							9	J2	30-40	M	PLA	SRJ	W4					908
								J1	0-10	W	IRR	RJ		12.08	Dark grey streaked light grey blotched white, highly weathered, closely to medium jointed, fine to medium grained, foliated, **very soft rock**. Biotite-rich Schist			

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P4**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	10/11/2015
Client:	Geomechanics	Borehole end date:	11/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920
Geologist:	SK	Coordinates:	-3458.93
Borehole No.:	P5		-3234092.08
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0																		920
0.5	NXC	67	0	0														919.5
1	NXC	55	0	0														919
1.5																		918.5
2	NWD4	53	0	0														918
2.5																		917.5
3																		917
3.5	NWD4	55	0	0														916.5
4																		916
4.5																		915.5
5	NWD4	70	4	0														915
5.5													W5		Reddish brown blotched light grey, presumed very dense becoming dense with depth, poorly cemented, calcretized, clayey **GRAVEL**. Fault breccia NOTE 1) Gravels comprise fine to coarse grained sub-angular to sub-rounded quartz			914.5
6														5.93				914
6.5	NWD4	100	77	8			+20	J1	10-20	M	PLA	MRJ	W5		Light brown streaked orange speckled black, completely weathered, closely jointed, fine to medium grained, calcretized, **very weak rock**. Quarzitic Gneiss NOTE 1) Residual soil from 6.08-6.23 m; 6.38-6.50 m and 6.86-7.0 m			913.5
7								J2	20-30	W	PLA	RJ		7				913
7.5							+20	J1	10-20	C-M	PLA	RJ	W2-W3		Light pinkish brown speckled cream and dark grey, moderately to slightly weathered, closely to medium jointed, fine to medium grained, **at least medium hard rock**. Quarzitic Gneiss NOTE 1) Closely jointed completely weathered rock with clayey sandy infill from 7.18-7.22 m and 7.95-8.0 m			912.5
8	NWD4	100	100	40				J2	20-30	M	PLA	RJ						912
8.5							13	J3	50-60	W	IRR/STE	RJ						911.5
9								J4	30-40	W	IRR/STE	RJ		9				911

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P5**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	05/11/2015
Client:	Geomechanics	Borehole end date:	06/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920
Geologist:	SK	Coordinates:	-3902.86
Borehole No.:	P6		-3233257.61
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5		Light reddish brown speckled light grey, very dense becoming very soft rock, very poorly cemented becoming poorly cemented, partially calcretized, clayey fine to medium grained **SAND** with minor gravels. Fault breccia			920
1	Auger	100	0	0														919
	SPT	100	0	0	N=61													
2	NWD4	88	0	0														918
3	SPT	100	0	0	REF													917
	NWD4	100	61	44										3.68				
4							8											916
	SPT	8	0	0	REF		4	J1	0-10	W	IRR/PLA	RJ						
5	NWD4	90	90	90														915
6							7						W4		Light pinkish brown speckled light and dark grey, highly weathered, fine to medium grained, medium to widely jointed, moderately becoming well cemented, calcretized, **very soft rock**. Fault breccia			914
7	NWD4	104	104	73			6	J2	20-30	W	PLA/UND	RJ						913
8	NWD4	99	99	87			5							8.55				912
9							6											911
10	NWD4	92	92	92			4	J1	0-10	VW	PLA	RJ	W3-W4		Light brown speckled light grey, highly to moderately weathered, fine to very coarse grained, widely jointed, very well cemented, calcretized, **soft rock**. Fault breccia			910
11	NWD4	100	100	80			8							11.1				909
								J2	20-30	C	PLA	SJ	W4		Light and dark streaked grey, highly weathered, fine to medium grained, closely to widely jointed, foliated, **very soft to soft rock**. Biotite-rich Schist			
12							15	J3	20-30	W	UND	MRJ		12.08	NOTE 1) Completely weathered rock from 11.83-11.93 m			908

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P6**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	29/10/2015
Client:	Geomechanics	Borehole end date:	30/10/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	919.9
Geologist:	SK	Coordinates:	-3944.5
Borehole No.:	P7		-3233201.89
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5	0.6	Reddish brown, slightly clayey medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise fine grained sub-angular quartz			919
1	NXC	100	0	0														
	Shelby	100	0	0													Shelby Tube at 1.50-1.64 m	
2	SPT	100	0	0	N=56													918
	NWD4	100	0	0									W5		Light pinkish brown mottled cream, very dense, very poorly becoming moderately cemented with depth, partially calcretized, clayey fine to medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained sub-rounded to sub-angular quartz			
3	SPT	100	0	0	N=77													917
4	NWD4	75	0	0														916
	SPT	67	0	0	REF									4.78				
5	NWD4	57	57	38			4											915
6	SPT	100	30	0	REF		+20										UCS 1 at 5.98-6.28 m	914
7	NWD4	67	25	0			+20	J1	0-10	M-W	IRR/PLA	RJ	W4-W5		Reddish brown speckled light grey, completely to highly weathered, fine to coarse grained, medium to widely jointed, moderately to well cemented, calcretized, **very soft rock**. Fault breccia NOTE 1) Completely weathered rock and residual soil from 6.97-7.21 m; 9.83-10.21 m and 10.45-10.52 m		UCS 2 at 7.48-7.60 m	913
	SPT	100	58	0	REF													
8	NWD4	52	52	13			+20											912
9	SPT	100	100	0	REF		+20											911
10	NWD4	85	66	39			15							10.63				910
11	SPT	100	100	0	REF		3	J1	0-10	W	IRR/PLA	RJ	W3-W4		Light greyish brown speckled dark grey, highly to moderately weathered, fine to coarse grained, widely jointed, very well cemented, calcretized, **soft rock**. Fault breccia			909
	NWD4	100	100	96										11.85			UCS 3 at 10.63-10.78 m	
12							18	J1	0-10	C	PLA	MRJ	W4		Dark grey streaked light grey blotched light grey, highly weathered, fine to medium grained, closely to medium jointed, foliated, **very soft to soft rock**. Biotite-rich Schist NOTE 1) Completely weathered rock to residual soil from 12.91-13.02 m 2) Closely jointed rock from 13.42-13.63 m 3) Zone of quartzite from 13.99-14.02 m and 14.16-14.28			908
13	NWD4	100	100	17			+20											907
								J2	10-20	C	PLA	MRJ						
14	NWD4	97	97	57			5							14.28				906

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
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RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: P7

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	31/10/2015
Client:	Geomechanics	Borehole end date:	01/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	919.55
Geologist:	SK	Coordinates:	-3978.17
Borehole No.:	P8		-3233155.75
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5	1.5	Reddish brown blotched pink, clayey fine to medium grained **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise sub-rounded fine to medium grained quartz 2) Pockets of clayey material present 3) Decaying vegetation interspersed through horizon		Shelby Tube at 1.50-1.60 m	919
1	Auger	100	0	0														
2	Shelby	100	0	0	N=44													918
	SPT	100	0	0														
3	NWD4	26	0	0									W5	3.52	Reddish brown speckled light pink, dense becoming very dense, very poorly cemented, clayey fine to medium **SAND** with occasional gravels. Fault breccia			917
	SPT	100	0	0	REF													
4	NWD4	100	92	48			7	J1	0-15	W	IRR	RJ	W4-W5				UCS 1 at 3.83-4.04 m	916
	SPT	100	100	0	REF		12	J2	40-50	W	IRR	RJ			Reddish brown speckled light and dark grey, completely to highly weathered, widely jointed, medium grained, **very soft to soft rock**. Fault breccia			915
5	NWD4	57	57	27			4											
6														6.08				914
7	NWD4	84	0	0									W5	8	Reddish brown becoming pinkish brown, very dense, very poorly cemented, fine to medium **SAND**. Fault breccia			913
	SPT	100	0	0	REF													912
8	NWD4	20	15	15			+20	J1	0-15	W	IRR	RJ	W4-W5					
9							+20											911
10	NWD4	30	14	0			+20	J3	20-30	W	IRR	RJ			Light reddish brown, completely to highly weathered, fine to medium grained, closely to medium jointed, **very soft to soft rock**. Fault breccia NOTE 1) Interspersed zones of extremely soft to soft rock throughout			910
	SPT	100	0	0	REF													909
11	NWD4	121	121	100			6	J1	0-15	W	PLA/UND	RJ	W4-W5	10.93	Light brown speckled cream, highly weathered, fine to very coarse grained, medium to widely jointed, well cemented, **soft rock.** Fault breccia NOTE 1) Interface zone between breccia and gneiss from 11.70-12.13 m		UCS 2 at 11.53-11.75 m	908
12								J4	50-60	W	IRR	RJ		12.13				
13	NWD4	100	100	22			8	J1	0-15	W	PLA	MRJ	W3-W4					907
							19											906
14	NWD4	78	78	27			10	J5	30-40	C	PLA	SRJ			Light grey speckled and streaked dark grey, highly to moderately weathered, closely jointed, fine to medium grained, foliated, **soft to medium hard rock**. Biotite-rich Gneiss NOTE 1) Zone of completely weathered rock from 14.89-14.91 m			905
15																		
16	NWD4	104	104	57			9	J6	70-80	W	IRR	RJ		16.63			UCS 3 at 15.75-15.93 m	904
							5											903

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: P8

GCS Geotechnical Engineering

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	03/11/2015
Client:	Geomechanics	Borehole end date:	04/11/20105
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	919.89
Geologist:	SK	Coordinates:	-3966.06
Borehole No.:	P9		-3233113.83
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	NXC	100	50	0									W4-W5	0.2	Creamish brown, completely to highly weathered, fractured, very fine grained, **medium hard rock**. Calcrete			919
1	NXC	86	0	0														
	NXC	55	13	0														
2	Shelby	100	0	0													Shelby Tube at 1.50-1.80 m	918
	SPT	56	0	0	N=22													
	NWD4	51	0	0														917
3	SPT	67	0	0	N=28													
4	NWD4	100	0	0											Reddish brown blotched dark grey and cream, medium dense becoming very dense, very weakly cemented, partially calcretized, clayey fine to medium **SAND** with sporadic gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained rounded to sub-angular quartz and nodular calcrete accretions sporadically distributed throughout			916
	SPT	58	0	0	N=24													
5	NWD4	74	0	0									W5					915
6	SPT	49	0	0	N=38													
7	NWD4	100	0	0														913
	SPT	100	0	0	REF													
8	NWD4	81	0	0														912
9	NWD4	73	73	39			9	J1	0-10	W	IRR/PLA	RJ	W5	8.88	Reddish brown speckled light and dark grey, completely weathered, fine to medium grained, closely to medium jointed, moderately cemented, calcretized, **very soft rock**. Fault breccia NOTE 1) Zone of residual soil from 11.45-11.72 m		UCS 1 at 9.80-9.96 m	911
10							8											910
11	NWD4	55	49	0			+20											909
12	NWD4	77	77	44			11											908
13							11	J1	0-10	M	IRR	RJ	W4-W5	12.7	Dark grey streaked light grey, completely to highly weathered, fine to medium grained, closely to medium jointed, partially calcretized, foliated, **soft rock**. Biotite-rich Gneiss NOTE 1) Zones of completely weathered rock from 12.80-12.94 m and 14.40-14.50 m		UCS 2 at 12.49-12.63 m	907
14	NWD4	75	62	0			+20	J2	20-30	W	PLA	MRJ		14.5				906

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
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RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P9**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	02/11/2015
Client:	Geomechanics	Borehole end date:	03/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	919.38
Geologist:	SK	Coordinates:	-4026.26
Borehole No.:	P10		-3233138.09
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	NXC	38	38	0									W4	0.6	Light grey, highly weathered, very fine grained, fractured, **at least medium hard rock.** Hardpan Calcrete			919
1	NXC	33	0	0									W5	1.5	Light grey blotched reddish brown, very dense, partially calcretized, fine **SAND** with abundant gravel. Fault breccia NOTE 1) Gravels comprise fine to coarse sub-rounded to sub-angular quartz			918
	SPT	71	0	0	REF													
2	NWD4	88	0	0									W5		Reddish brown speckled white, very dense, very weakly cemented, fine to medium **SAND** with minor gravels. Fault breccia			917
3	SPT	100	0	0	REF									3.38	NOTE 1) Gravels comprise fine to medium sub-angular to sub-rounded quartz 2) Localized concretization sporadically distributed throughout horizon			916
4	NWD4	60	60	0									W5		Reddish brown, very dense to extremely soft rock, weakly to moderately cemented, clayey fine to medium **SAND** with abundant gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained angular cemented breccia			915
5	SPT	100	0	0	REF													914
	NWD4	67	26	0										6.08	2) Extremely soft rock from 3.58-3.98 m and 5.40-5.75 m			
6																		913
7	NWD4	57	53	31			+20	J1	0-10	M	IRR	RJ	W4-W5					
							9								Reddish brown speckled black and cream, completely to highly weathered, fine to medium grained, moderately cemented, medium jointed, **very soft rock**. Fault breccia NOTE 1) Completely weathered fractured zones from 6.99-7.09 m; 8.58-8.78 m; 8.93-9.08; 9.95-10.03 m and 10.43-10.58 m 2) Clayey cement			912
8	NWD4	100	72	9			+20	J2	10-20	W	IRR	RJ						911
9	NWD4	91	60	15			+20	J3	40-50	W	IRR	VRJ						910
10							10							10.58				909
11	NWD4	100	100	89				J1	0-10	W	IRR	RJ	W4		Light brown speckled dark grey, highly weathered, fine to coarse grained, widely jointed, **soft to medium hard rock**. Fault breccia NOTE 1) Softens quickly with addition of water 2) Clayey cement			908
							5							11.51				
12								J1	0-10	M	PLA	SRJ						907
13	NWD4	90	90	35			13						W4		Dark grey streaked light grey blotched white, highly weathered, fine to medium grained, foliated, closely to medium jointed, **soft rock**. Biotite-rich Gneiss			906
14	NWD4	100	100	22			14	J2	10-20	M	PLA	SRJ						
							6							14.58				905

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
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RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P10**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	04/11/2015
Client:	Geomechanics	Borehole end date:	05/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920.54
Geologist:	SK	Coordinates:	-3864.53
Borehole No.:	P11		-3233046.45
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5		Light pinkish brown, loose, fine grained **SAND** with minor gravel. Fault breccia NOTE 1) Gravels comprise fine to medium sub-rounded quartz		Shelby Tube at 1.50-1.90	920
1																		
2	Shelby	100	0	0														919
	SPT	100	0	0	N=7													
	NWD4	57	0	0														918
3	SPT	56	0	0	N=13									2.91				
													W5		Light yellowish to light reddish brown, medium dense, clayey fine to medium **SAND** with abundant gravels. Fault breccia NOTE 1) Gravels comprise medium grained sub-angular to sub-rounded matrix supported quartz			917
4	NWD4	62	0	0										3.72				
													W5		Reddish brown, medium dense, very poorly cemented, clayey fine to medium **SAND** with trace gravels. Fault breccia			916
	SPT	51	0	0	N=11									5.12				
5	NWD4	48	29	14			+20	J1	10-20	W	IRR	RJ	W4-W5		Reddish brown, completely to highly weathered, fine to medium grained, widely jointed, poorly cemented, **very soft rock**. Fault breccia			915
														5.9				
6	SPT	49	0	0	N=18								W5		Reddish brown, medium dense, very poorly cemented, clayey fine to medium **SAND**. Fault breccia			914
														6.48				
7	NWD4	79	73	35			10	J1	10-20	W	IRR	RJ						
	SPT	80	0	0	REF													913
8	NWD4	78	61	19			12						W4-W5		Reddish brown speckled dark grey blotched cream, completely to highly weathered, medium jointed, fine to medium grained, poorly to moderately cemented, **very soft to soft rock**. Fault breccia NOTE 1) Zone of completely weathered rock from 8.55-8.74 m		UCS 1 at 7.93-8.07 m	
																		912
9							+20	J2	0-10	W	IRR	RJ						
10	NWD4	72	31	7			+20							10.07				911
													W5	10.5	Reddish brown, poorly cemented, clayey fine to medium grained **SAND**. Fault breccia			
11	NWD4	100	100	40			10	J2	0-10	M-W	IRR	RJ	W4		Reddish brown blotched cream, highly weathered, fine to medium grained, medium jointed, moderately cemented, **very soft to soft rock**. Fault breccia			910
12							13							11.22			UCS 2 at 11.02-11.19 m	
13	NWD4	80	80	35			6	J1	0-10	M-W	PLA	MRJ						909
																	UCS 5 at 12.92-13.10 m	908
14	NWD4	79	79	25			13											907
15							13								Streaked light grey and dark greenish brown, highly weathered, fine to medium grained, closely to medium jointed, foliated, **soft to medium hard rock**. Biotite-rich Gneiss NOTE 1) Zones of completely weathered rock from 11.33-11.38 m; 11.90-12.0 m; 13.43-13.5 m; 16.63-16.66 m and 19.41-19.5 m 2) Zones of medium hard rock from 14.02-14.47 m; 15.56-15.82 m and 17.37-17.94 m		UCS 3 at 14.56-14.76 m	906
16	NWD4	100	100	52			15	J2	10-20	W	IRR	RJ	W4				UCS 6 at 15.66-15.99 m	905
17	NWD4	77	77	14			9											904
18							12	J3	30-40	W	PLA	MRJ						903
19	NWD4	68	63	12			10							19.5			UCS 4 at 18.5-18.64 m	902

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: P11

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	03/11/2015
Client:	Geomechanics	Borehole end date:	04/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	920.81
Geologist:	SK	Coordinates:	-4037.94
Borehole No.:	P12		-3233025.78
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5	0.9	Reddish brown, slightly clayey fine to medium **SAND**. Aeolian			920
1	Auger	100	0	0														
	SPT	100	0	0	N=56													919
2	NWD4	57	0	0														
	SPT	100	0	0	N=62													918
3	NWD4	59	0	0														
	SPT	100	0	0	REF													917
4	NWD4	78	0	0									W5		Light pinkish brown, very dense, friable, poorly cemented, sandy clay becoming clayey fine to medium **SAND**. Fault breccia NOTE 1) Horizon comprises a fining upwards sequence 2)Decrease in clay content with depth			
	SPT	100	0	0	REF													916
5	NWD4	58	0	0														
	SPT	100	0	0	REF													915
6	NWD4	96	82	9			+20	J1	0-10	M	IRR	RJ						
	SPT	100	0	0	REF													914
7	NWD4	100	100	44			15	J2	20-30	M	IRR	RJ	W4-W5	7.73	Orange brown speckled light and dark grey, completely to highly weathered, closely to very closely jointed, medium grained, poorly becoming moderately cemented, friable, mulched, **very soft rock**. Fault breccia NOTE 1) Appearance of an open grain structure 2) Zone of completely weathered rock from 8.60-8.82 m			913
8	NWD4	77	77	59			8	J1	0-10	M	IRR	RJ						
								J2	20-30	W	IRR	RJ	W4-W5	9.4	Light orange brown speckled light grey, highly weathered, fine to medium grained with occasional very coarse grains, moderately to well cemented, closely to medium jointed, mulched, **very soft to soft rock**. Fault breccia NOTE 1) Appearance of open grain structure		UCS 1 at 9.86-10.0 m	912
9							5	J3	40-50	W	IRR	RJ		11.33				911
10							4	J1	0-10	W	IRR	RJ	W3		Light grey streaked dark grey and white blotched white, moderately weathered, fine to medium grained, widely jointed, **soft to medium hard rock**. Brecciated Biotite-rich Schist		UCS 4 at 11.49-11.73 m UCS 2 at 12.08-12.30 m	910
11							4	J4	10-20	W	UND	SRJ		13.58			UCS 3 at 12.79-12.99 m	909
12																		908
13																		

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
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JOINT ROUGHNESS
SJ-smooth joint
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MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P12**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	04/11/2015
Client:	Geomechanics	Borehole end date:	05/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	923.13
Geologist:	SK	Coordinates:	-3942
Borehole No.:	P13		-3232836.88
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	NXC	50	33	0			6						W3	0.7	Light pinkish brown, moderately weathered, fractured, very fine to coarse grained, **at least medium hard rock**. Calcrete NOTE 1) Calcrete comprises angular fine to coarse grained quartz grains cemented within a clayey matrix			-9999
1	NXC	73	0	0									W5	1.4	Reddish brown speckled white, possible open grain structure, clayey medium to coarse grained **SAND** with minor gravel. Fault breccia NOTE 1) Gravels comprise fine to medium grained sub-angular to sub-rounded quartz		Shelby Tube at 1.5-2.05 m	-10000
2	Shelby	100	0	0														-10001
	SPT	100	0	0	N=42													
3	NWD4	100	0	0									W5					-10002
	SPT	100	0	0	N=54													
4	NWD4	138	0	0											Light reddish brown speckled black and white, very dense, very weakly cemented, fractured, partially open grain structure, clayey fine to medium grained **SAND** with minor gravel. Fault breccia			-10003
	SPT	100	0	0	N=53													
5	NWD4	52	0	0										5.03				-10004
6	SPT	100	0	0	N=52													-10005
7	NWD4	46	0	0									W5		Light reddish brown, very dense, pin holed, very weakly cemented, slightly clayey fine to medium **SAND** with gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained angular to sub-angular quartz			-10006
	SPT	100	0	0	REF													
8	NWD4	47	0	0														-10007
9	SPT	100	0	0	REF													-10008
10	NWD4	85	18	0										10.28				-10009
11	NWD4	73	73	9			+20	J1	0-10	C-M	PLA/I RR	RJ	W4-W5		Light grey and white streaked greenish brown, completely to highly weathered, closely to medium jointed, fine to medium grained, foliated, **medium hard rock**. Gneiss NOTE 1) Biotite present in trace amounts 2) Highly fractured from 10.41-10.58 m 3) Quartz vein observed from 12.34-12.38 m			-10010
12							14	J2	50-60	M	PLA	RJ					UCS 1 at 11.71-11.84 m UCS 2 at 12.08-12.21 m UCS 3 at 12.46-12.66 m	-10011
								J3	80-90	W	PLA	RJ		12.38				
13	NWD4	87	87	31			+20	J2	50-60	C-M	PLA	SJ	W4		Light greyish brown streaked dark grey, highly weathered, closely jointed, very fine grained, foliated, **very soft rock**. Biotite Gneiss			-10012
							5	J4	20-30	M-W	PLA	SJ		13.58	NOTE 1) Zone of completely weathered rock from 12.96-13.58 m			
14																		-10013

ROCK FABRIC
MF-massive
BF-bedded
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SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
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JOINT SPACING
VC-very closely jointed
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JOINT ROUGHNESS
SJ-smooth joint
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MRJ-medium rough joint
RJ-rough joint
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JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P13**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	09/11/2015
Client:	Geomechanics	Borehole end date:	09/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	917.36
Geologist:	SK	Coordinates:	-4079.27
Borehole No.:	P14		-3233342.06
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	33	0	0									W5	0.9	Reddish brown, slightly clayey fine to medium grained **SAND**. Fault breccia NOTE 1) Roots present			917
1	NXC	100	60	0									W4	1.22	Light grey, highly weathered, fine to medium grained, fractured, **medium hard rock**. Nodular Calcrete			916
	SPT	100	0	0	N=45								W5	1.95	Light greyish brown, dense, clayey sandy **GRAVEL**. Residual Calcrete NOTE 1) Gravels comprise fine to coarse grained sub-rounded predominantly quartz			915
2	NWD4	82	0	0									W5	3.53	Reddish brown becoming light brown, partially calcretized, dense, very poorly cemented, slightly clayey fine to medium grained **SAND**. Fault breccia NOTE 1) Homogenous horizon			914
3	SPT	100	0	0	N=47								W5	4.73	Reddish brown mottled cream, very dense, partially calcretized, clayey fine **SAND**. Fault breccia NOTE 1) Occasional medium and coarse sand			913
4	NWD4	95	0	0														912
	SPT	100	0	0	REF													
5	NWD4	52	0	0														911
	SPT	100	0	0	REF													
6	NWD4	75	0	0									W5		Light brown, very dense, partially calcretized slightly clayey fine to medium **SAND** with trace gravel. Fault breccia NOTE 1) Gravels comprise fine grained rounded quartz 2) Homogenous horizon			910
	SPT	100	0	0	REF													
7	NWD4	76	0	0														909
8														8.93				
	NWD4	37	37	0			+20	J1	10-20	M	PLA	SRJ	W5	9.53	Reddish brown, moderately cemented, calcretized, clayey fine to medium grained **SAND** with abundant gravels. Fault breccia NOTE 1) Gravels comprise sub-angular fine to coarse calcrete agglomerations			908
9																		907
10	NWD4	47	47	0			+20	J2	70-80	W	IRR	RJ	W4-W5		Light green speckled dark grey, completely to highly weathered, fine to coarse grained, foliated, fractured, **very soft to medium hard rock**. Quarzitic Biotite-rich Schist NOTE 1) Completely weathered fractured rock from 9.53-10.54 m; 10.67-10.74 m; 11.01-11.20 m and 13.44-13.49 m 2) Quartzite from 12.08-12.82 m			906
11							+20	J3	40-50	W	IRR/PLA	RJ						905
12	NWD4	71	71	6			14	J4	0-10	M	IRR/PLA	RJ		13.58				904
13																		

Undisturbed SPT sample at 6.08-3.31 m

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P14**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	05/11/2015
Client:	Geomechanics	Borehole end date:	06/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	918.25
Geologist:	SK	Coordinates:	-4041.53
Borehole No.:	P15		-3233252.21
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	NXC	77	0	0									W5	0.7	Light reddish brown, gravelly fine to medium grained **SAND** with cobbles. Aeolian NOTE 1) Gravels and cobbles comprise angular fine to coarse grained calcrete			918
1	NXC	83	33	0			10	J1	10-20	M	IRR	RJ	W4	1.5	Light grey blotched brown, highly weathered, fractured, very fine grained, **medium hard rock**. Calcrete			917
2	NWD4	52	0	0									W5		Reddish brown speckled cream, loose, clayey fine to medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise sub-rounded fine to medium quartz			916
3	SPT	67	0	0	N=6													
4	NWD4	60	0	0										3.81				915
	SPT	77	0	0	REF								W5		Reddish brown speckled white and light grey, very dense, partially calcretized, very weakly cemented, clayey fine to medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise sub-rounded fine to medium quartz			914
5	NWD4	100	0	0														913
6	NWD4	92	13	13			+20	J1	10-20	M	IRR	RJ	W4	6	Light brown speckled dark and light grey, highly weathered, fine to medium grained, friable, medium jointed, **very soft rock**. Fault breccia NOTE 1) Completely weathered rock from 6.54-6.63 m			912
7								J2	80-90	W	IRR	RJ						
								J3	30-40	W	IRR	RJ		7.22				911
8	NWD4	76	0	0									W5		Reddish brown speckled white and dark grey, very dense, partially calcretized, very weakly cemented, clayey gravelly fine to medium grained **SAND**. Fault breccia NOTE 1) Gravels comprise angular fine grained quartz			910
9														9				
10	NWD4	100	100	77			6	J1	10-20	W	IRR	RJ	W4		Light creamish brown speckled light and dark grey, highly weathered, widely jointed, friable, fine to medium grained, cemented, **very soft rock**. Fault breccia		UCS 1 at 9.13-9.31 m	909
							6	J3	30-40	W	IRR	RJ						908
11	NWD4	100	100	75										10.84				
							8	J1	10-20	W	IRR	RJ	W4-W5		Streaked light and dark grey, highly to moderately weathered, medium jointed, fine to medium grained, **soft rock**. Biotite-rich Schist		UCS 2 at 11.02-11.21 m	907
								J3	30-40	W	IRR	RJ						
12								J4	50-60	VW	PLA	SRJ		12				
	NWD4	83	48	6			+20	J1	10-20	M	IRR	RJ	W4-W5		Light grey speckled brown, completely to highly weathered, fine to medium grained, very closely to medium jointed, **very soft to soft rock**. Biotite-rich Schist NOTE 1) Zones of completely weathered rock from 12.14-12.25 m; 12.59-12.95 m and 13.40-13.50 m			906
13								J2	80-90	W	IRR	RJ						
							+20	J3	30-40	W	IRR	RJ		13.5				905

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P15**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	07/11/2015
Client:	Geomechanics	Borehole end date:	09/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	917.96
Geologist:	SK	Coordinates:	-4215.85
Borehole No.:	P16		-3233228.84
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description
0	Auger	100	0	0									W5	1.05	Reddish brown, clayey fine to medium **SAND**. Fault breccia NOTE 1) Clay pockets sporadically distributed throughout (approximate diameter 10-20 mm) 2) Roots present
1	NXC	90	50	0			5	J1	0-10	M	IRR	RJ	W4	1.29	Creamish brown, highly weathered, fractured, medium jointed, fine to coarse grained, **soft rock**. Calcrete
	Shelby	100	0	0											
2	SPT	100	0	0	N=15										
	NWD4	100	0	0											
3	SPT	67	0	0	N=39										
	NWD4	57	9	0									W5		Reddish brown blotched light grey, medium dense to dense, very poorly cemented, partially calcretized, clayey fine to medium grained **SAND** with pockets of gravels. Fault breccia NOTE 1) Gravels comprise fine to medium sub-rounded matrix supported quartz 2) Clayey cement 3) Zone of very soft poorly cemented breccia from 5.73-6.0 m
4	SPT	67	0	0	N=12										
5	NWD4	70	19	0											
6	SPT	67	0	0	N=12									6.45	
	NWD4	55	0	0									W5		Dark brown speckled dark grey, very dense, clayey fine grained **SAND**. Residual Gneiss NOTE 1) Biotite rich horizon
7	SPT	80	0	0	REF									8	
8	NWD4	57	28	0			15	J1	10-20	M	PLA	SRJ	W4-W5		Streaked light and dark grey, completely to highly weathered, fine to medium grained, medium grained, foliated, **very soft rock**. Biotite-rich Gneiss NOTE 1) Zones of completely weathered rock from 10.33-10.37 m and 9.62-9.70 m
9							10	J2	30-40	W	PLA	MRJ			
10	NWD4	72	68	9										10.28	
							14	J2	30-40	W	IRR	RJ	W3-W4		Streaked light and dark grey, highly to moderately weathered, fine to medium grained, medium to widely jointed, foliated, **soft rock**. Biotite-rich Gneiss
11	NWD4	100	100	23				J3	20-30	M	PLA	SRJ			
							15	J4	40-50	W	IRR	MRJ			
12														12	

Lithology: Shelby Tube at 1.50-1.75 m

Samples

Elevation (mamsl): 917, 916, 915, 914, 913, 912, 911, 910, 909, 908, 907, 906

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P16**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	06/11/2015
Client:	Geomechanics	Borehole end date:	07/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	919.09
Geologist:	SK	Coordinates:	-4197.88
Borehole No.:	P17		-3233151.57
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	60	0	0									W5	1.43	Reddish brown, slightly clayey fine to medium grained **SAND**. Fault breccia NOTE 1) Minor vegetation present			919
1	SPT	71	0	0	N=26													918
2	NWD4	100	0	0									W5		Reddish brown occasionally speckled black and white, medium dense becoming very dense with depth, very weakly cemented, clayey fine to medium grained **SAND** with sporadic pockets of gravel. Fault breccia NOTE 1) Gravels comprise sub-rounded fine to coarse grained quartz 2) Zone of very well cemented extremely soft rock from 6.0-6.26 m			917
3	SPT	62	0	0	N=14													916
4	NWD4	66	0	0														915
5	SPT	80	0	0	REF													914
	NWD4	74	0	0														
6	NWD4	93	60	0			+20	J1	0-10	M	IRR	MRJ	W5	6.26	Dark grey streaked and speckled dark brown and gold, completely weathered, fine to medium grained, closely jointed, foliated, **extremely soft to very soft rock**. Biotite-rich Gneiss NOTE 1) Zones of residual gneissic soil from 6.26-6.49 m and 6.73-7.03 m			913
7							14											912
8	NWD4	107	107	24			18	J1	0-10	C	IRR	MRJ	W4	8.06	Light grey streaked dark grey speckled dark grey and pink, highly weathered, fine to medium grained, closely jointed, foliated, **very soft rock**. Biotite-rich Granite-Gneiss NOTE 1) Veins of quartz approximately 20 mm thickness from 8.98-9.0 m			911
9																		910
10	NWD4	97	97	23			16											909
11	NWD4	100	100	9			+20	J2	10-20	M	PLA	MRJ						908
12							18							12				

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P17**

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Project:	Gamsberg Mine	Borehole start date:	09/11/2015
Client:	Geomechanics	Borehole end date:	09/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	916.75
Geologist:	SK	Coordinates:	-4204.17
Borehole No.:	P18		-3233311.51
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description
0	Auger	100	0	0									W5		Light pinkish brown, silty fine grained **SAND** with minor gravels. Aeolian NOTE 1) Gravels comprise fine grained sub-angular to angular quartz and calcrete
1	Shelby	100	0	0										1.57	
2	SPT	73	0	0	N=8								W5		Light reddish brown, medium dense, very poorly cemented, clayey fine to medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise fine grained sub-angular to sub-rounded quartz
	NWD4	100	35	0										2.68	
3								J1	0-10	C-M	IRR	RJ	W5	3	Light reddish brown, completely weathered, fine to medium grained, closely to medium jointed, poorly cemented, partially calcretized, **very soft rock**. Fault breccia
	SPT	89	0	0	N=29										
4	NWD4	86	0	0									W5		
	SPT	100	0	0	REF									4.65	
5								J2	20-30	W	IRR	RJ	W5	5.08	Reddish brown, medium dense becoming very dense, very poorly cemented, partially calcretized, clayey fine to medium **SAND**. Fault breccia
	NWD4	100	100	21			+20	J1	0-10	M	IRR	VRJ	W4-W5	5.84	Reddish brown speckled white, completely weathered, fine to coarse grained, fractured, partially calcretized, moderately cemented, **very soft rock**. Quarzitic fault breccia NOTE 1) Significant amount of clay throughout horizon
6							+20								
	NWD4	47	47	0			+20						W5		Dark and light grey speckled black and white, completely to highly weathered, medium jointed, fine to coarse grained, moderately to well cemented, **very soft to soft rock**. Fault breccia NOTE 1) Interface between breccia and schist 2) Highly weathered rock from 5.08-5.40 m
7							+20								
	NWD4	43	43	0			+20	J1	0-10	C	IRR	MRJ	W3-W4	8	
8							7	J3	50-60	M	IRR/PLA	MRJ		9	Dark grey speckled and streaked light grey, completely weathered, closely jointed, fine to medium grained, foliated, **very soft rock**. Biotite-rich Schist NOTE 1) Residual soil from 6.07-6.16 m; 7.15-7.23 m; 7.30-7.36 m and 7.41-7.50 m
9															Light grey, highly to moderately weathered, closely jointed, fine to medium grained, **medium hard rock**. Quartzite
10															
11															

Lithology

Samples: Shelby Tube at 1.50-1.63 m; UCS 1 at 5.14-5.27 m

Elevation (mamsl): 916, 915, 914, 913, 912, 911, 910, 909, 908, 907, 906

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P18**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	13/11/2015
Client:	Geomechanics	Borehole end date:	14/11/2015
Location:	Aggeneys	Date logged:	15/11/2015
Project No.:	15-549	Elevation (mamsl):	916.6
Geologist:	SK	Coordinates:	-4300.31
Borehole No.:	P19		-3233318.7
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0	Auger	100	0	0									W5	0.5	Reddish brown, silty fine to medium **SAND**. Colluvium NOTE 1) Minor rootlets present			916
1													W5	1.5	Light creamish brown, very dense, clayey fine to medium **SAND** with minor gravels. Calcrete NOTE 1) Gravels comprise angular to sub-angular fine grained calcrete accretions			915
2	SPT	100	0	0	N=55								W5	2.76	Reddish brown speckled light grey, very dense, poorly cemented, partially calcretized, clayey fine to coarse grained **SAND** with abundant gravels. Fault breccia NOTE 1) Gravels comprise fine to coarse grained sub-angular to sub-rounded quartz and agglomerations			914
3	NWD4	66	44	0														
	SPT	100	0	0	REF		18	J1	0-10	M	IRR	RJ	W4-W5					913
4	NWD4	100	100	48			+20								Reddish brown speckled dark grey, completely to highly weathered, fine to coarse grained, medium jointed, moderately cemented, calcretized, **very soft rock**. Fault breccia NOTE 1) Completely weathered rock from 4.29-4.37 m and 6.27-6.31 m			912
5	NWD4	100	100	47			8	J2	20-30	W	IRR/PLA	RJ						911
6	NWD4	100	77	33			+20							6.46				910
7								J1	0-10	M	IRR/PLA	RJ	W5		Reddish brown, completely weathered, fine to coarse grained, closely to medium jointed, fractured, poorly cemented, calcretized, **extremely soft rock**. Fault breccia NOTE 1) Fine to medium sandy infill along joints within horizon			
							+20	J3	30-40	M	IRR	RJ		7.17				909
8	NWD4	100	82	29				J1	0-10	W	IRR/PLA	RJ	W4-W5					
							+20	J1	0-10	M	IRR/PLA	RJ	W5	8.33	Reddish brown speckled dark grey, completely to highly weathered, fine to coarse grained, medium to widely jointed, moderately cemented, calcretized, **very soft rock**. Fault breccia			908
9	NWD4	100	100	66				J2	20-30	M	IRR	RJ		9.22				
10							+20	J1	0-10	W	IRR/PLA	RJ	W4		Reddish brown, completely weathered, fine to coarse grained, fractured, poorly cemented, calcretized, **extremely soft rock**. Fault breccia			907
							6							10.9				906
11	NWD4	97	90	69			8	J4	10-20	C-M	IRR/PLA	RJ	W4		Reddish brown speckled light and dark grey, highly weathered, fine to coarse grained, medium to widely jointed, well cemented, calcretized, **very soft rock**. Fault breccia			905
12								J3	30-40	M	IRR/PLA	MRJ						
	NWD4	100	100	97			10	J1	0-10	W	IRR	RJ		12.32	Reddish brown and streaked dark grey, highly weathered, closely to medium jointed, fine to coarse grained, moderately to well cemented, calcretized, **very soft rock**. Fault breccia NOTE 1) Transition between breccia and schist 2) Completely weathered rock from 11.86-12.0 m			904
13								J1	0-10	W	IRR	VRJ	W4					
							11							13.43				903
14	NWD4	100	100	10				J1	0-10	C-M	PLA	MRJ	W4		Light grey streaked grey, highly weathered, fine to medium grained, medium to widely jointed, very well cemented, foliated, **very soft to soft rock**. Calcretized fault breccia			
							9	J4	10-20	C-M	PLA	SRJ		14.63				902
15															Dark grey streaked light grey, highly weathered, fine to medium grained, closely to medium jointed, foliated, **very soft to soft rock**. Biotite-rich Schist			
16																		901

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
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CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P19**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	12/11/2015
Client:	Geomechanics	Borehole end date:	12/11/2015
Location:	Aggeneys	Date logged:	13/11/2015
Project No.:	15-549	Elevation (mamsl):	941
Geologist:	SK	Coordinates:	-5592.1
Borehole No.:	P22		-3231173.54
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0													W5	0.89	Light grey and reddish brown, very well cemented, slightly clayey fine to medium sandy **GRAVEL,COBBLES and BOULDERS**. Calcrete NOTE 1) Gravels, cobbles and boulders comprised of fine grained rounded calcrete 2) Reddish slightly clayey sand found between larger particles			941
0.5	NXC	53	34	0									W5	2				940.5
1	NXC	55	13	0									W5	2.3				940
1.5	SPT	100	0	0	N=47										Light greyish brown, dense, poorly cemented, clayey **GRAVEL** becoming a clayey gravelly fine SAND. Nodular Calcrete NOTE 1) Gravels comprise fine to medium sub-rounded to sub-angular calcrete nodules			939.5
2																		939
2.5	NWD4	71	40	20			7	J1	[0-10	W	IRR/PLA	RJ						938.5
3																		938
3.5	NWD4	67	67	48			4						W3-W5					937.5
4								J2	20-30	M	IRR	RJ			Reddish brown, moderately cemented, partially calcretized, clayey fine to medium **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise sub-angular fine grained quartz			937
4.5							9											936.5
5	NWD4	75	75	15										5.28				936
5.5							15	J1	0-10	M	IRR	RJ			Reddish brown speckled light grey, completely to moderately weathered, fine to very coarse grained, medium to widely jointed, well cemented, **very soft to soft rock**. Fault breccia NOTE 1) Completely weathered rock and residual soil from 4.52-4.71 m and 5.15-5.18 m			935.5
6																		935
6.5	NWD4	50	50	0			+20	J2	20-30	M	IRR	RJ	W5					934.5
7																		934
7.5														7.58	Light grey speckled dark grey, completely weathered, fine to medium grained, closely to medium jointed, **soft to medium hard rock**. Quartzite NOTE 1) Residual material from 6.81-6.85 m; 6.20-6.25 m and 7.28-7.58 m			933.5
8	NWD4	97	97	33			12	J1	0-10	W	IRR/PLA	MRJ						933
8.5							11	J2	20-30	M	PLA/UND	SRJ	W3-W4		Light pink speckled dark and light grey, highly to moderately weathered, fine to medium grained, closely to medium jointed, partially foliated, **medium hard rock**. Quarzitic Gneiss NOTE 1) Highly fractured quartz vein from 8.05-8.10 m; 8.23-8.29 m; 10.35-10.39 m and 10.55-10.58 m			932.5
9																		932
9.5	NWD4	97	97	59			9	J3	40-50	C	PLA	MRJ						931.5
10																		931
10.5														10.58				930.5

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
GF-gneissose
LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
M-medium jointed
W-widely jointed
VW-very widely jointed

JOINT ROUGHNESS
SJ-smooth joint
SRJ-slighty rough joint
MRJ-medium rough joint
RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P22**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	13/11/2015
Client:	Geomechanics	Borehole end date:	13/11/2015
Location:	Aggeneys	Date logged:	15/11/2015
Project No.:	15-549	Elevation (mamsl):	942
Geologist:	SK	Coordinates:	-5116.36637
Borehole No.:	P23A		-3230440.748
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0																		942
0.4	NXC	100	0	0									W5	1	Reddish brown, slightly clayey fine to medium grained **SAND** with minor gravels. Fault breccia NOTE 1) Gravels comprise fine to medium sub-angular quartz 2) Vegetation observed throughout horizon			941.6
0.8																		941.2
1.2	NXC	78	60	18			+20	J1	30-40	M	PLA	RJ						940.8
1.6								J2	50-60	W	PLA	MRJ	W4		Light grey streaked dark grey, highly weathered, closely to medium jointed, fine to medium grained, foliated, **soft to medium hard rock**. Gneiss NOTE 1) Closely jointed rock from 1.50-1.80 m 2) Fractured zone from 2.53-2.82 m			940.4
2	NWD4	65	65	10														940
2.4							+20	J3	0-10	W	PLA	MRJ						939.6
2.8														3				939.2
3.2							4	J3	0-10	W	PLA	RJ	W3					938.8
3.6	NWD4	100	100	88											Light grey streaked dark grey, moderately weathered, fine to medium grained, very widely jointed, foliated, **medium hard rock**. Gneiss			938.4
4																		938
4.4							3	J4	40-50	W	PLA	MRJ		4.5				937.6

ROCK FABRIC
MF-massive
BF-bedded
FF-foliated
CF-cleaved
SF-schistose
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LF-laminated

GRAIN SIZE
FG-fine grained
MG-medium grained
CG-coarse grained

JOINT SPACING
VC-very closely jointed
C-closely jointed
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JOINT ROUGHNESS
SJ-smooth joint
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RJ-rough joint
VRJ-very rough joint

JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
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MHR-medium hard rock
SR-soft rock
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Borehole No.: **P23A**

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GEOMECHANICS

Project:	Gamsberg Mine	Borehole start date:	12/11/2015
Client:	Geomechanics	Borehole end date:	13/11/2015
Location:	Aggeneys	Date logged:	15/11/2015
Project No.:	15-549	Elevation (mamsl):	942.12
Geologist:	SK	Coordinates:	-5842.91
Borehole No.:	P24		-3230678.82
Contractor:	Geomech Africa		

Depth (m)	Drilling method	Material Recovery (%)	Core Recovery (%)	RQD (%)	SPT-N Value	UCS (MPa)	Fracture Frequency	Joint set No.	Joint inclination (deg.)	Joint spacing	Joint shape	Joint roughness	Weath-ering (%)	Depth (m)	Lithology Description	Lithology	Samples	Elevation (mamsl)
0													W5	0.8	Light brown and light grey, very well cemented, fine to coarse grained **GRAVEL**. Nodular Calcrete NOTE 1) Gravels comprise sub-angular to sub-rounded fine to coarse calcrete accretions			942
0.5	NXC	45	0	0														
1	NXC	47	0	0									W5	1.5	Light reddish brown, slightly clayey fine to medium **SAND**. Aeolian NOTE 1) Homogenous horizon			941.5
1.5	SPT	100	0	0	REF													941
2	NWD4	44	44	0				J1	20-30	C-M	PLA	MRJ	W4-W5					940.5
2.5														2.98	Light greyish brown streaked dark grey, completely to highly weathered, fine to medium grained, closely jointed, foliated, **very soft to soft rock**. Gneiss NOTE 1) Quartz vein from 2.80-2.95 m			940
3																		939.5
3.5	NWD4	80	80	27			+20	J1	20-30	C-W	PLA	MRJ	W3-W4					939
4								J2	50-60	W	PLA	MRJ						938.5
4.5							13											938
5	NWD4	100	100	40				J3	30-40	W	PLA	MRJ						937.5
5.5							20							5.38	Light grey streaked dark grey, highly to moderately weathered, fine to medium grained, closely to medium jointed, foliated, **soft rock**. Gneiss NOTE 1) Quartz vein from 3.78-4.05 m; 4.76-4.82 m and 5.07-5.37 m 2) Closely jointed rock from 4.52-4.58 m			937
6								J1	20-30	C	PLA	MRJ						936.5
6.5	NWD4	93	93	59			+20											936
7																		935.5
7.5							10	J2	50-60	W	PLA	MRJ	W3		Light grey streaked dark grey, moderately weathered, fine to medium grained, closely to widely jointed, foliated, **medium hard rock**. Gneiss NOTE 1) Closely jointed rock from 6.08-6.22 m; 7.51-7.58 m and 7.79-7.84 m			935
8	NWD4	100	100	64														934.5
8.5							16											934
9								J3	30-40	W	PLA	MRJ						933.5
9.5	NWD4	79	79	61			8											933
														9.88				932.5

ROCK FABRIC
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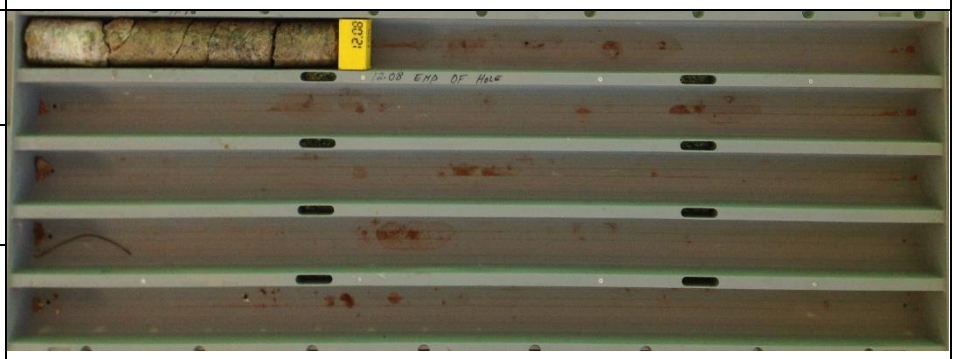
JOINT SHAPE
CUR-curvilinear
PLA-planar
UND-undulating
STE-stepped
IRR-irregular

ROCK HARDNESS
EHR-extremely hard rock
VHR-very hard rock
HR-hard rock
MHR-medium hard rock
SR-soft rock
VSR-very soft rock

Borehole No.: **P24**

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P01	Date Logged: 14/11/2015	Project No.: 15-549
Box No.: 1 of 3 Depth (m): 0.0-6.25		
Box No.: 2 of 3 Depth (m): 6.25-13.0		
Box No.: 3 of 3 Depth (m): 13.0-14.0		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P03	Date Logged: 12/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.38		
Box No.: 2 of 3		
Depth (m): 6.38-11.78		
Box No.: 3 of 3		
Depth (m): 11.78-12.08		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P04	Date : 12/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.08		
Box No.: 2 of 3		
Depth (m): 6.08-11.57		
Box No.: 3 of 3		
Depth (m): 11.57-12.08		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P05	Date Logged: 14/11/2015	Project No.: 15-549
Box No.: 1 of 2		
Depth (m): 0.0-7.0		
Box No.: 2 of 2		
Depth (m): 7.0-9.0		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P06	Date Logged: 13/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-4.58		
Box No.: 2 of 3		
Depth (m): 4.58-8.95		
Box No.: 3 of 3		
Depth (m): 8.95-12.08		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P07	Date Logged: 14/11/2015	Project No.: 15-549
Box No.: 1 of 4 Depth (m): 0.0-3.99		
Box No.: 2 of 4 Depth (m): 3.99-9.94		
Box No.: 3 of 4 Depth (m): 9.94-13.63		
Box No.: 4 of 4 Depth (m): 13.63-14.28		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P08	Date Logged: 11/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.13		
Box No.: 2 of 3		
Depth (m): 6.13-12.63		
Box No.: 3 of 3		
Depth (m): 12.63-16.63		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P09	Date Logged: 12/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-5.36		
Box No.: 2 of 3		
Depth (m): 5.36-10.5		
Box No.: 3 of 3		
Depth (m): 10.5-14.5		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P10	Date Logged: 12/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.08		
Box No.: 2 of 3		
Depth (m): 6.08-11.34		
Box No.: 3 of 3		
Depth (m): 11.34-14.58		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P11	Date Logged: 11/11/2015	Project No.: 15-549
Box No.: 1 of 4		
Depth (m): 0.0-6.0		
Box No.: 2 of 4		
Depth (m): 6.0-11.47		
Box No.: 3 of 4		
Depth (m): 11.47-16.5		
Box No.: 4 of 4		
Depth (m): 16.5-18.5		

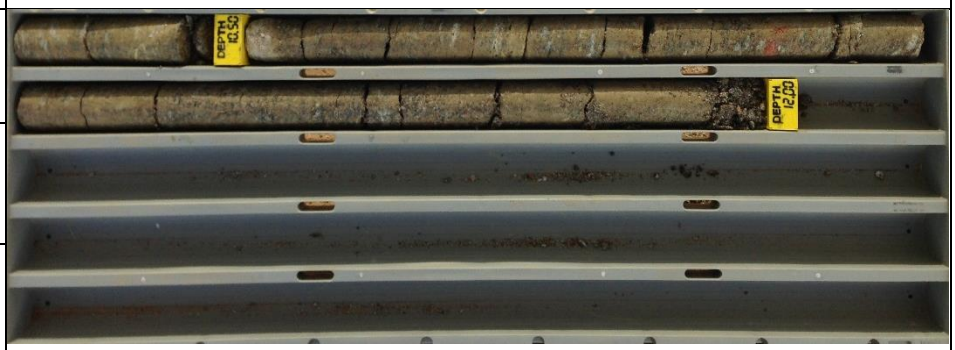
PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P12	Date Logged: 10/11/2015	Project No.: 15-549
Box No.: 1 of 3 Depth (m): 0.0-6.08		
Box No.: 2 of 3 Depth (m): 6.08-10.90		
Box No.: 3 of 3 Depth (m): 10.90-13.58		

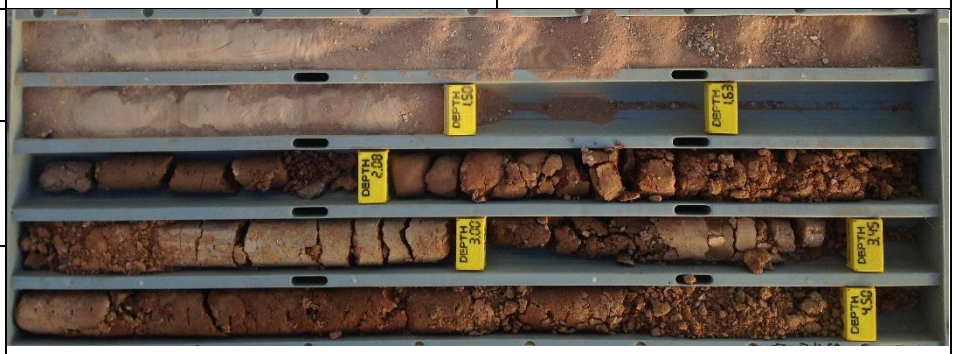
PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P13	Date Logged: 11/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.08		
Box No.: 2 of 3		
Depth (m): 6.08-12.08		
Box No.: 3 of 3		
Depth (m): 12.08-13.58		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P14	Date Logged: 14/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.08		
Box No.: 2 of 3		
Depth (m): 6.08-12.21		
Box No.: 3 of 3		
Depth (m): 12.21-13.58		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P15	Date Logged: 10/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-6.0		
Box No.: 2 of 3		
Depth (m): 6.0-11.21		
Box No.: 3 of 3		
Depth (m): 11.21-13.5		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P16	Date Logged: 11/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-4.95		
Box No.: 2 of 3		
Depth (m): 4.95-11.19		
Box No.: 3 of 3		
Depth (m): 11.19-12.0		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P17	Date Logged: 12/11/2015	Project No.: 15-549
Box No.: 1 of 3		
Depth (m): 0.0-5.19		
Box No.: 2 of 3		
Depth (m): 5.19-10.24		
Box No.: 3 of 3		
Depth (m): 10.24-12.0		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P18	Date Logged: 13/11/2015	Project No.: 15-549
Box No.: 1 of 2		
Depth (m): 0.0-4.5		
Box No.: 2 of 2		
Depth (m): 4.5-9.0		

PHOTOGRAPHIC LOG

Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P19	Date Logged: 15/11/2015	Project No.: 15-549

Box No.: 1 of 4

Depth (m): 0.0-4.7

Box No.: 2 of 4

Depth (m): 4.7-9.2

Box No.: 3 of 4

Depth (m): 9.2-13.5

Box No.: 4 of 4

Depth (m): 13.5-14.63

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P22	Date Logged: 14/11/2015	Project No.: 15-549
Box No.: 1 of 2		
Depth (m): 0.0-6.34		
Box No.: 2 of 2		
Depth (m): 6.34-10.58		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P23a	Date Logged: 15/11/2015	Project No.: 15-549
Box No.: 1 of 1		
Depth (m): 0.0-4.5		

PHOTOGRAPHIC LOG		
Client Name: Geomechanics	Site Location: Aggeneys	Project Name: Gamsberg Mine
Borehole No.: P24	Date Logged: 15/11/2015	Project No.: 15-549
Box No.: 1 of 2		
Depth (m): 0.0-6.24		
Box No.: 2 of 2		
Depth (m): 6.24-9.88		

GAMSBERG PLANT
APPENDIX B
Test Pit Profiles

GCS Geotechnical Engineering

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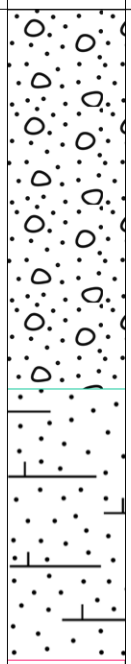
Project:	Gamsberg Mine	Hole No.:	PLT1
Client:	Geomechanics	Start date:	13/11/2015
Location:	Aggeneys	End date:	16/11/2015
Project No.:	15-549	Coordiantes:	-3326.598
Geologist:	SK		-3234307.475
Plant:	CAT 320B		(Hand held GPS)

Depth (m)	Lithology	Depth (m)	Material Description	Samples
0		0	Dry reddish brown blotched white and dark grey, medium dense (pp=45mm), layered, sandy silty fine to coarse **GRAVEL** with cobbles and boulders. Fault Breccia NOTE 1) Boulders, cobbles and gravels comprise angular top sub-rounded quartz and metamorphosed rock	1 Indicator at 0.0-0.7m; 1 MOD/CBR at 0.0-0.7m
0.2				
0.4				
0.6				
		0.7		
0.8			Light grey blotched dark grey, highly weathered, fine to very coarse grained, fractured, **very soft rock**. Calcrete NOTE 1) Quartz gravels and cobbles observed within cemented matrix	
1				
1.2		1.2		
1.4				
1.6				
1.8				
2				
2.2				
2.4				
2.6				

PP - Sidewall Geological Pick Penetration

Notes:

Final depth:	Refusal at 1.2 m on soft rock calcrete
Groundwater:	No Groundwater Seepage
Sidewall stability:	Sidewall collapse from 0.0-0.68m
Samples:	1 Indicator at 0.0-0.68m; 1 MOD/CBR at 0.0-0.68m

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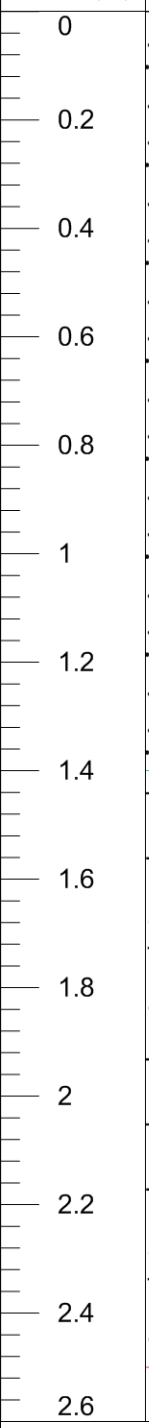
Project:	Gamsberg Mine	Hole No.:	PLT3
Client:	Geomechanics	Start date:	13/11/2015
Location:	Aggeneys	End date:	16/11/2015
Project No.:	15-549	Coordiantes:	-3805.632
Geologist:	SK		-3233432.548
Plant:	CAT 320B		(Hand held GPS)



Depth (m)	Material Description	Samples
0 – 0.4	Dry, reddish brown, loose (pp=50mm), layered, silty sandy **GRAVEL**. Fault Breccia NOTE 1) Gravel comprise sub-angular to sub-rounded, fine to coarse grained quartz	1 Indicator at 0.0-0.4m; 2 MOD/CBR at 0.0-0.4m
0.4 – 1.4	Dry, cream to light grey, dense to very dense (pp=5mm), intact, **GRAVEL**. Calcrete NOTE 1) Gravel comprise angular fine to coarse grained calcrete accretions	1 Indicator at 0.4-1.4m; 2 MOD/CBR at 0.4-1.4m
1.4 – 2.5	Creamish light grey, completely weathered, fractured, fine to medium grained, **very soft rock**. Calcrete	

PP - Sidewall Geological Pick Penetration

Notes:

Final depth:	Refusal at 2.5 m on very soft rock calcrete
Groundwater:	No Groundwater Seepage
Sidewall stability:	No Sidewall Collapse
Samples:	2 Indicators at 0.0-0.4m and 0.4-1.4m; 2 MOD/CBR at 0.0-0.4 and 0.4-1.4m

GCS Geotechnical Engineering

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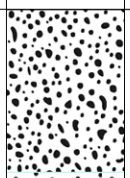
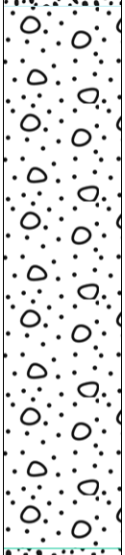
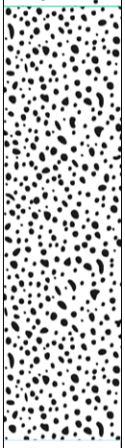
Project:	Gamsberg Mine	Hole No.:	PLT19
Client:	Geomechanics	Start date:	13/11/2015
Location:	Aggeneys	End date:	16/11/2015
Project No.:	15-549	Coordiantes:	-4299.81
Geologist:	SK		-3233595.879
Plant:	CAT 320B		(Hand held GPS)

Depth (m)	Lithology	Depth (m)	Material Description	Samples
0 – 0.2		0 – 0.3	Dry, reddish brown, loose to medium dense(pp=40mm), layered, silty gravelly fine to medium **SAND**. Fault Breccia NOTE 1) Gravel comprise sub-angular to sub-rounded fine to medium quartz	1 Indicator at 0.0-0.35m; 2 MOD/CBR at 0.0-0.35m
0.2 – 1.3		0.3 – 1.3	Dry, light grey, very dense (pp=0mm), intact, moderately cemented, **GRAVEL**. Calcrete NOTE 1) Gravel comprise fine to coarse angular calcrete accretions	1 Indicator at 0.35-1.3m; 2 MOD/CBR at 0.35-1.3m
1.3 – 2.1		1.3 – 2.1	Dry, reddish brown, very dense (pp=0mm), intact, moderately cemented, silty fine to medium **SAND** with abundant gravels. Fault Breccia NOTE 1) Gravels comprise fine to coarse grained sub-angular to sub-rounded quartz	1 Indicator at 1.3-2.1m; 2 MOD/CBR at 1.3-2.1m
2.1 – 2.6		2.1		

PP - Sidewall Geological Pick Penetration

Notes:

Final depth:	Refusal at 2.1 m on very dense calcretized fault breccia
Groundwater:	No Groundwater Seepage
Sidewall stability:	No Sidewall Collapse
Samples:	3 Indicators at 0.0-0.35m and 0.35-1.3 m and 1.3-2.1m; 3 MOD/CBR at 0.0-0.35m and 0.35-1.3 m and 1.3-2.1m

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Project:	Gamsberg Mine	Hole No.:	PLT23-24
Client:	Geomechanics	Start date:	13/11/2015
Location:	Aggeneys	End date:	16/11/2015
Project No.:	15-549	Coordiantes:	-5303.121
Geologist:	SK		-3230520.623
Plant:	Bell TLB		(Hand held GPS)

Depth (m)	Lithology	Depth (m)	Material Description	Samples
0		0	Dry, reddish brown, medium dense (pp=50mm), intact, silty fine **SAND** with occasional gravels. Colluvium NOTE 1) Gravels comprise sub-angular to sub-rounded fine to coarse grained quartz and calcrete accretions	1 Indicator at 0.0-0.2m; 2 MOD/CBR at 0.0-0.2m
0.2		0.2	Dry, light grey, dense to very dense (pp=0mm) nodular, silty **GRAVEL** with occasional cobbles. Nodular Calcrete NOTE 1) Gravel and cobbles comprise rounded fine to coarse grained calcrete accretions	1 Indicator at 0.2-0.5m; 2 MOD/CBR at 0.2-0.5m
0.4				
0.6		0.5	Light grey speckled dark grey, completely weathered, fractured, friable, foliated, fine to medium grained, **very soft rock**. Calcretized Biotite-rich Schist	
0.8		0.9		
1				
1.2				
1.4				
1.6				
1.8				
2				
2.2				
2.4				
2.6				

PP - Sidewall Geological Pick Penetration

Notes:

Final depth:	Refusal at 0.9 m on very soft rock calcretized biotite-rich schist
Groundwater:	No Groundwater Seepage
Sidewall stability:	No Sidewall Collapse
Samples:	2 Indicators at 0.0-0.2 m and 0.2-0.5 m; 2 MOD/CBR at 0.0-0.2 m and 0.2-0.5 m

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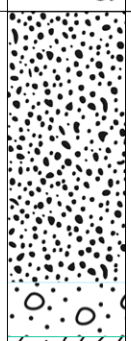
Project:	Gamsberg Mine	Hole No.:	PLT25
Client:	Geomechanics	Start date:	13/11/2015
Location:	Aggeneys	End date:	16/11/2015
Project No.:	15-549	Coordiantes:	-5160.36
Geologist:	SK		-3230055.589
Plant:	Bell TLB		(Hand held GPS)

Depth (m)	Lithology	Depth (m)	Material Description	Samples
0		0	Dry , reddish brown, very dense (pp=0mm), intact and well cemented, clayey fine to medium **SAND** with abundant gravel. Duricrete NOTE 1) Gravel comprise sub-angular fine to coarse grained quartz	1 Indicator at 0.0-0.5m; 2 MOD/CBR at 0.0-0.5m
0.2				
0.4				
		0.5	Dry, light grey, very dense (pp=0mm), nodular, **GRAVEL** with abundant cobbles. Calcrete NOTE 1) Gravels and cobbles comprise rounded fine to coarse calcrete accretions	
0.6		0.6		
0.8				
1			Light grey speckled dark grey, completely weathered, fractured, foliated, friable, **very soft rock**. Schist	1 Indicator at 0.6-1.3m; 2 MOD/CBR at 0.6-1.3m
1.2				
		1.3		
1.4				
1.6				
1.8				
2				
2.2				
2.4				
2.6				

PP - Sidewall Geological Pick Penetration

Notes:

Final depth:	Refusal at 1.3 m on very soft rock schist
Groundwater:	No Groundwater Seepage
Sidewall stability:	No Sidewall Collapse
Samples:	2 Indicators at 0.0-0.5 m and 0.6-1.3 m; 2 MOD/CBR at 0.0-0.5 m and 0.6-1.3 m

GAMSBERG PLANT
APPENDIX C1
Laboratory Test Results-Soil

Geopractica
SOILS & MATERIALS TESTING
P.O.BOX 227, MARAISBURG, 1700
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e mail: lab@geopractica.co.za

FOUNDATION INDICATOR

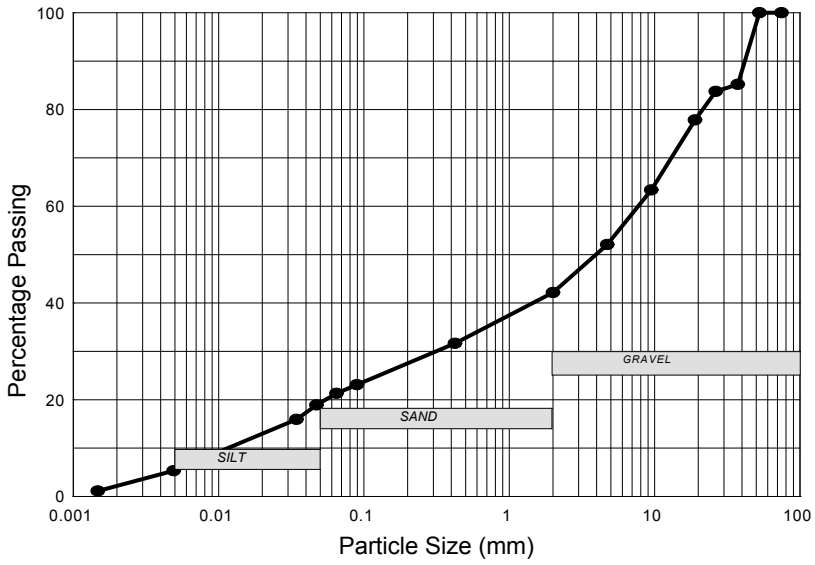
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 1 @ 0,0 - 0,68m	
Date	07 DECEMBER 2015	Test No	2273
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	85.23
26.50	83.74
19.00	77.90
9.50	63.38
4.75	52.09
2.00	42.18
0.425	31.66

GRADING ANALYSIS



HYDROMETER ANALYSIS

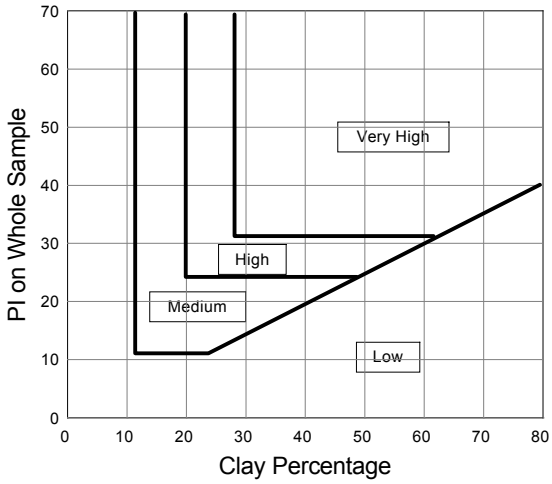
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0901	23.12
0.0651	21.34
0.0473	18.97
0.0346	16.01
0.0049	5.34
0.0015	1.19

ATTERBERG LIMITS & OTHER VALUES

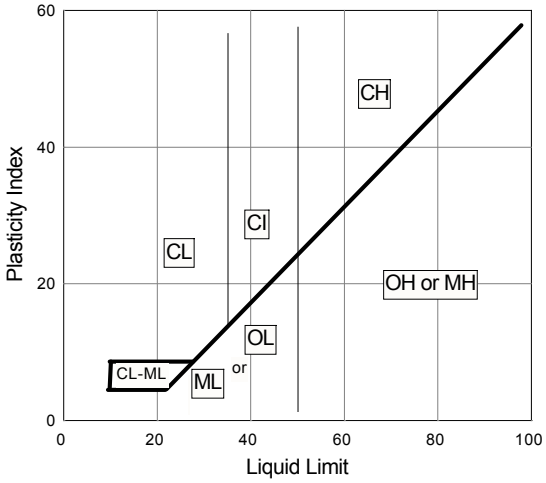
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	2.03
Moisture Content	2.44
PI on Whole Sample	Non Plastic
PRA Classification	A.1.b
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



Revision No 3 (06/04/2001)

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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE PLT 1 @ 0,0 - 0,68m		
Date	07 DECEMBER 2015	Test No	2254
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

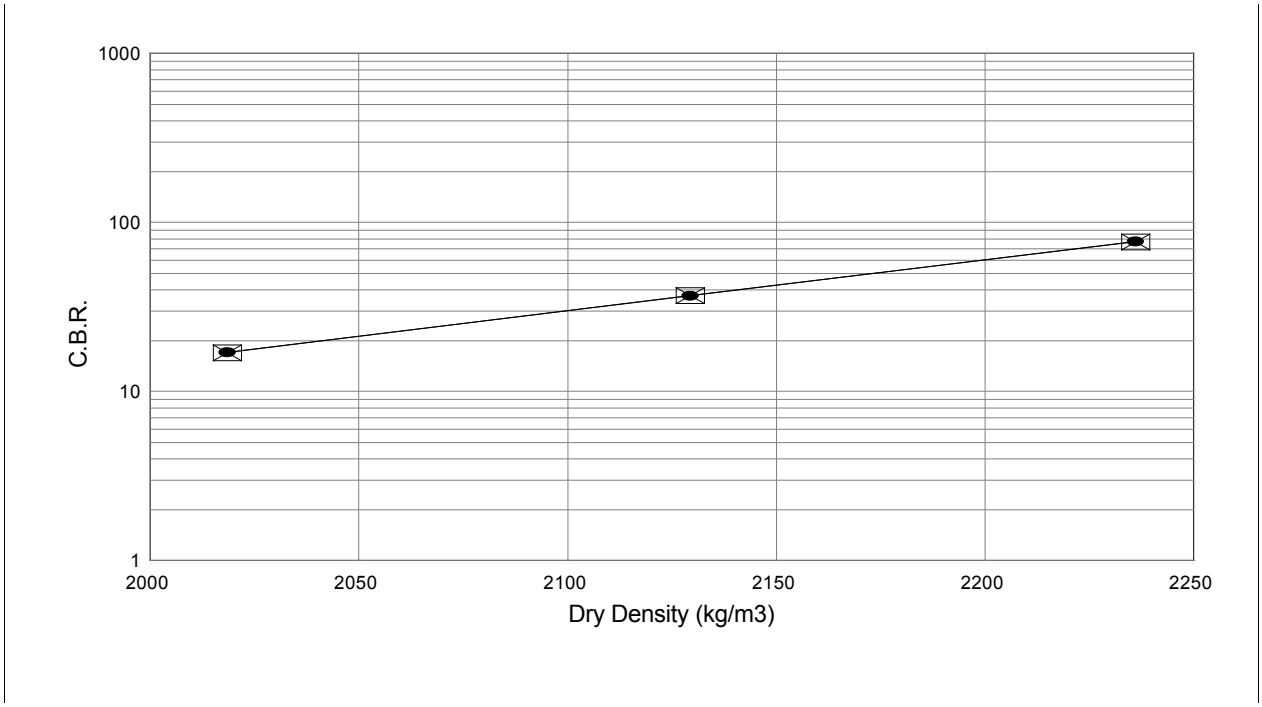
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	2238	Optimum Moisture Content (%)	6.9

Percentage Mod AASHTO	99.9	95.2	90.2
CBR @ 2.54mm	77	37	17
CBR @ 5.08mm	80	39	18
CBR@ 7.62mm	82	39	19
Average Moisture Content (%)		7.3	
Percentage Swell	0.05	0.14	0.22

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	17	26	36	57	78



Programed Data
Revision No 4 (1/5/2010)

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FOUNDATION INDICATOR

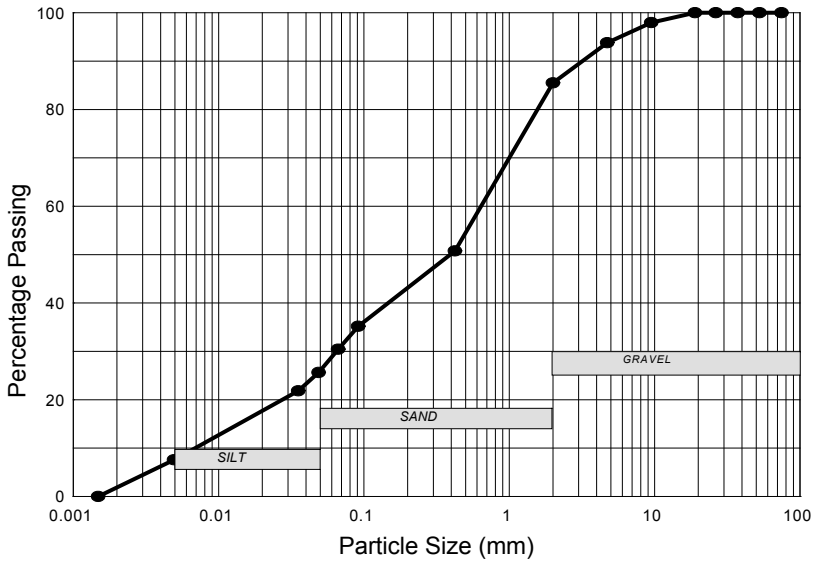
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 3 @ 0,0 - 0,4m	
Date	07 DECEMBER 2015	Test No	2255
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	97.98
4.75	93.85
2.00	85.51
0.425	50.81

GRADING ANALYSIS



HYDROMETER ANALYSIS

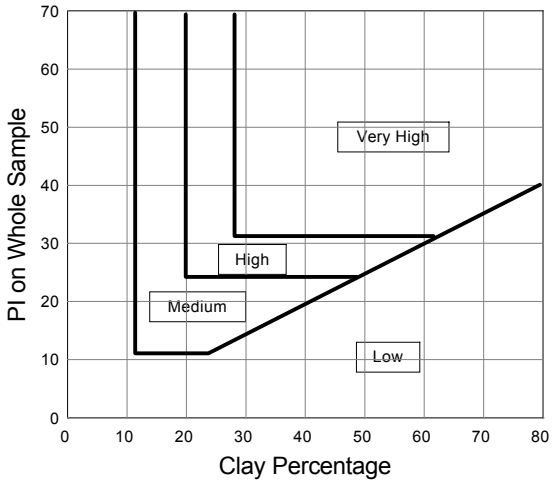
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0914	35.21
0.0669	30.45
0.0489	25.69
0.0354	21.89
0.0050	7.61
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

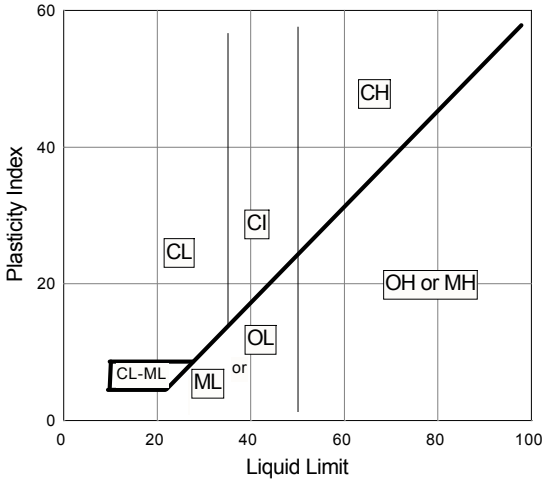
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.28
Moisture Content	1.64
PI on Whole Sample	Non Plastic
PRA Classification	A.2.4
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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FOUNDATION INDICATOR

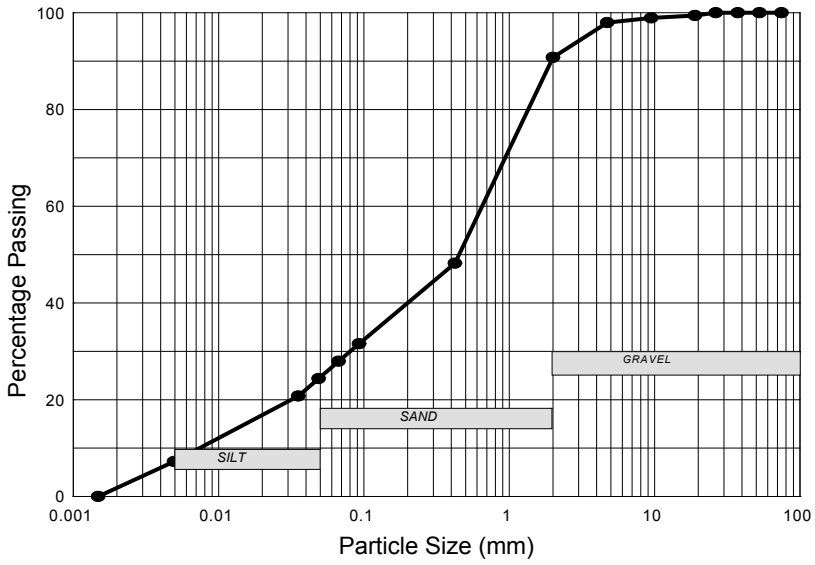
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 19 @ 0,0 - 0,35m	
Date	07 DECEMBER 2015	Test No	2256
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	99.45
9.50	98.95
4.75	97.98
2.00	90.77
0.425	48.24

GRADING ANALYSIS



HYDROMETER ANALYSIS

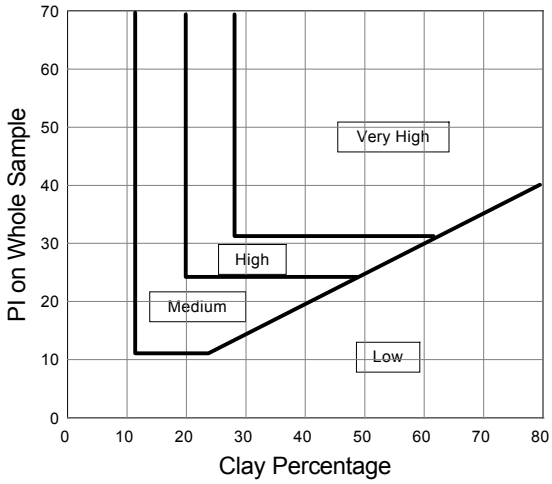
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0927	31.62
0.0674	28.01
0.0489	24.39
0.0354	20.78
0.0050	7.23
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

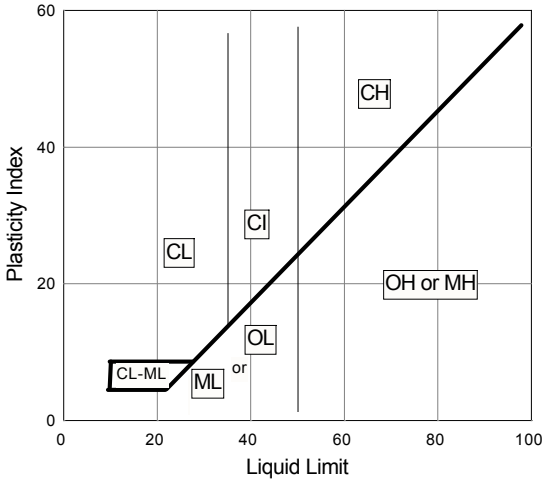
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.29
Moisture Content	1.12
PI on Whole Sample	Non Plastic
PRA Classification	A.2.4
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	PLT 19 @ 0,0 - 0,35m	
Date	07 DECEMBER 2015	Test No	2257
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

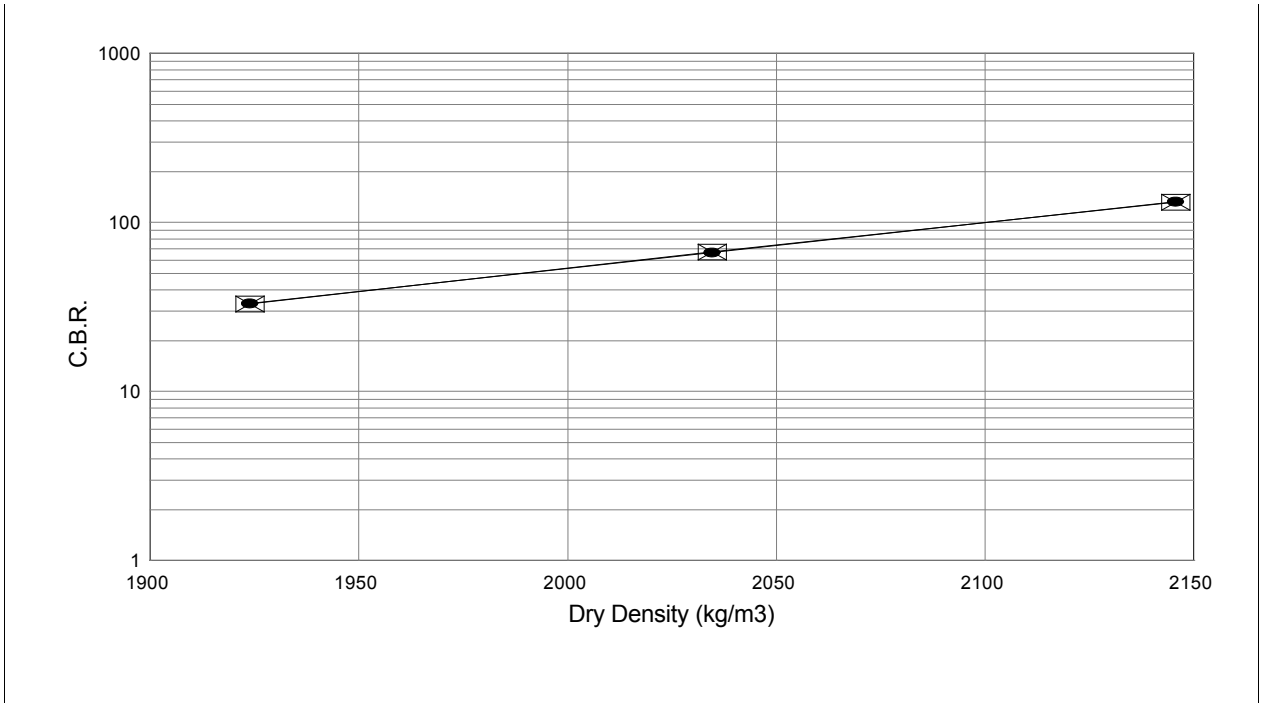
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	2141	Optimum Moisture Content (%)	7.0

Percentage Mod AASHTO	100.2	95.0	89.9
CBR @ 2.54mm	132	67	33
CBR @ 5.08mm	146	71	36
CBR@ 7.62mm	150	75	36
Average Moisture Content (%)	7.3		
Percentage Swell	0.72	0.84	0.94

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	34	50	66	98	129



Programed Data
Revision No 4 (1/5/2010)

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SOIL pH and CONDUCTIVITY TEST RESULT

Client	GCS		
Location	Gamsberg Mine		
Date	10 December 2015	Test No	2258, 2260, 2265, 2268, 2271
Job No	15307	Checked By	SG

Sample Description	pH	Electrical Conductivity EC (µS/cm)	Total Dissolved Salts TDS (ppm)	Resistivity R (Ohm/cm)
PLT 19 @ 0.0 - 0.35	8.2	198	99	5051
PLT 19 @ 0.35 - 1.3	8.3	208	116	4808
PLT 3 @ 0.40 - 1.40	7.9	188	77	5319
PLT23-24@ 0.0 - 0.2	8.0	246	124	4065
PLT 25 @ 0.0 - 0.50	7.9	190	90	5263

pH	Degree of Acidity
<4	Extremely Acidic
4.0 - 5.4	Strongly Acidic
5.5 - 6.4	Moderately Acidic
6.5 - 7.0	Slightly Acidic
7.1 - 7.4	Slightly Alkaline
7.5 - 8.4	Moderately Alkaline
>8.4	Strongly Alkaline

Resistivity (Ohm/cm)	Degree of Corrosivity
0 - 2 000	Extremely Corrosive
2 000 - 4 000	Very Corrosive
4 000 - 5 000	Corrosive
5 000 - 10 000	Mildly Corrosive
>10 000	Not Generally Corrosive

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FOUNDATION INDICATOR

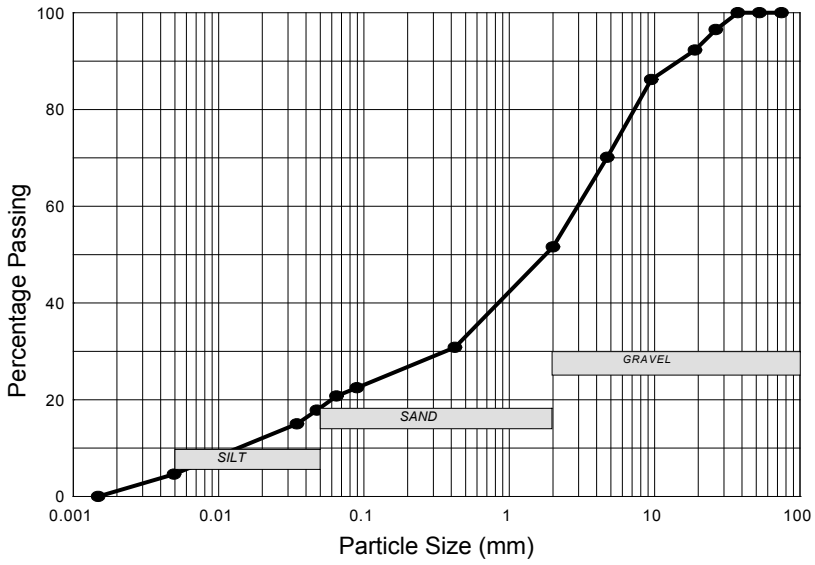
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 19 @ 0,35 - 1,3m	
Date	07 DECEMBER 2015	Test No	2259
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	96.55
19.00	92.29
9.50	86.25
4.75	70.17
2.00	51.60
0.425	30.85

GRADING ANALYSIS



HYDROMETER ANALYSIS

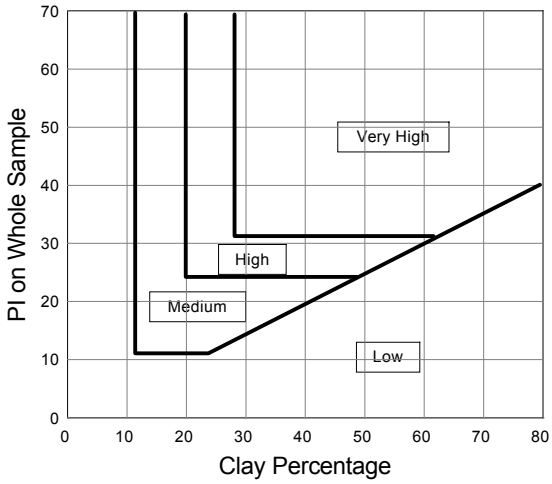
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0901	22.53
0.0651	20.80
0.0476	17.91
0.0348	15.02
0.0050	4.62
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

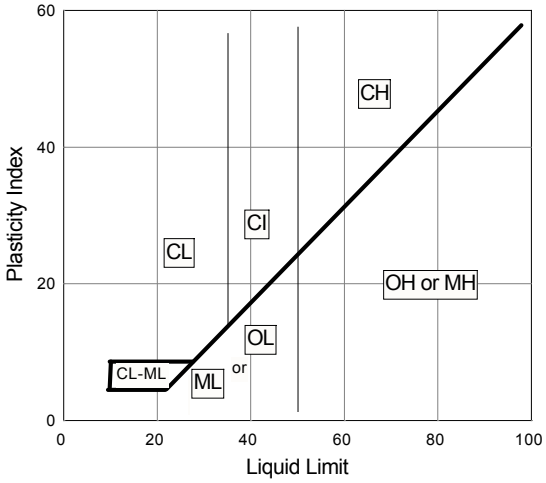
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.95
Moisture Content	2.16
PI on Whole Sample	Non Plastic
PRA Classification	A.1.b
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	PLT 19 @ 0,35 - 1,3m	
Date	07 DECEMBER 2015	Test No	2260
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

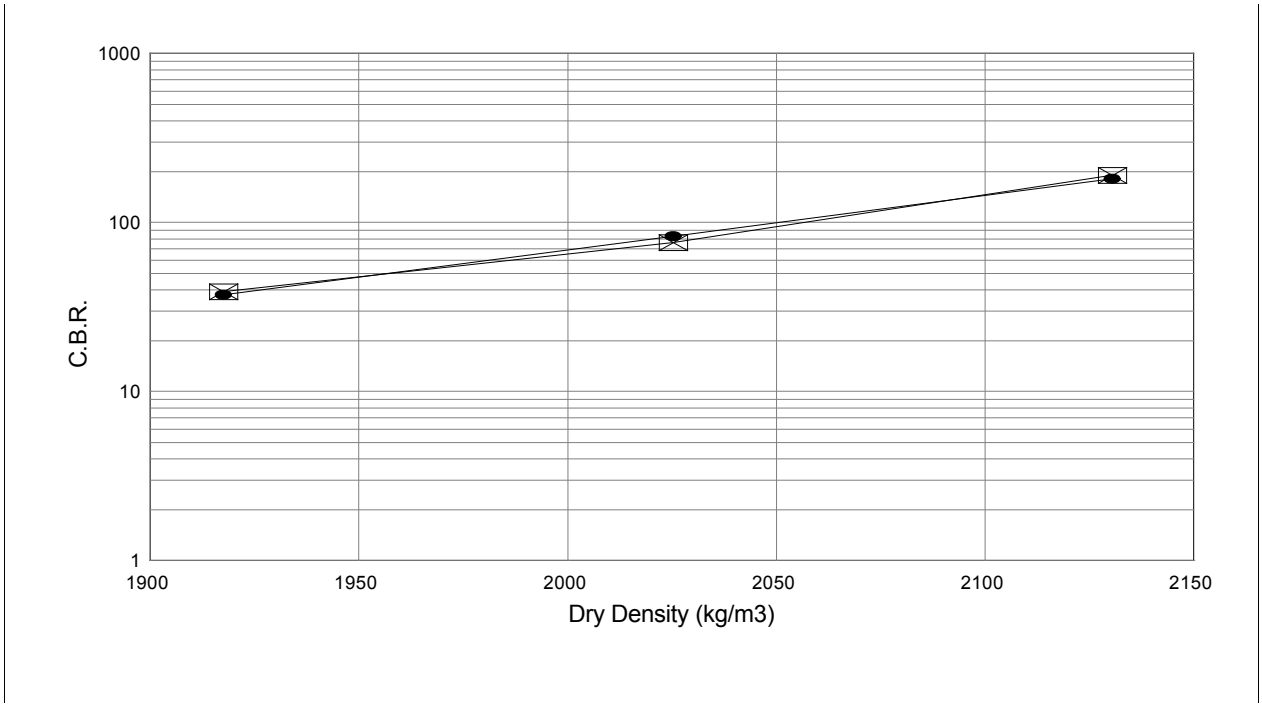
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	2127	Optimum Moisture Content (%)	7.4

Percentage Mod AASHTO	100.2	95.2	90.2
CBR @ 2.54mm	190	76	39
CBR @ 5.08mm	202	79	41
CBR@ 7.62mm	209	82	43
Average Moisture Content (%)		7.3	
Percentage Swell	0.18	0.22	0.35

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	36	58	80	129	177



Programed Data
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FOUNDATION INDICATOR

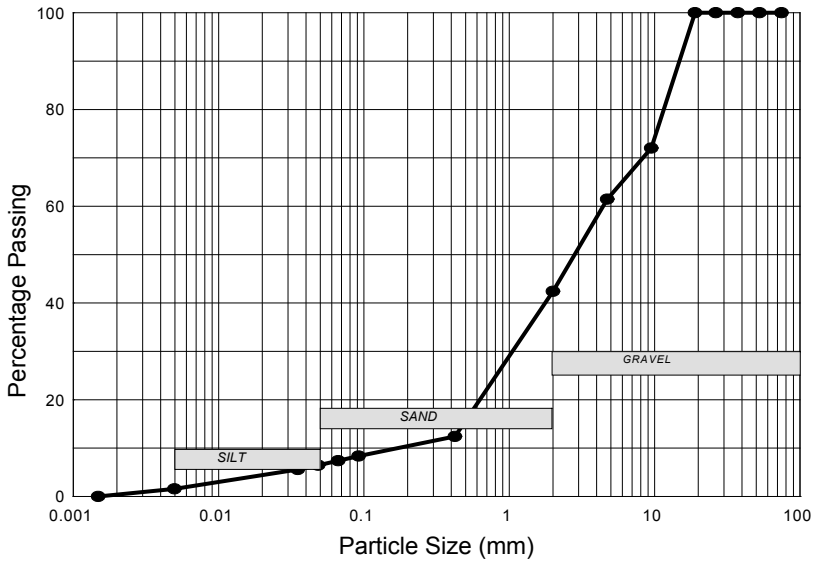
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 19 @ 1,3 - 2,1m	
Date	07 DECEMBER 2015	Test No	2261
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	72.09
4.75	61.48
2.00	42.46
0.425	12.43

GRADING ANALYSIS



HYDROMETER ANALYSIS

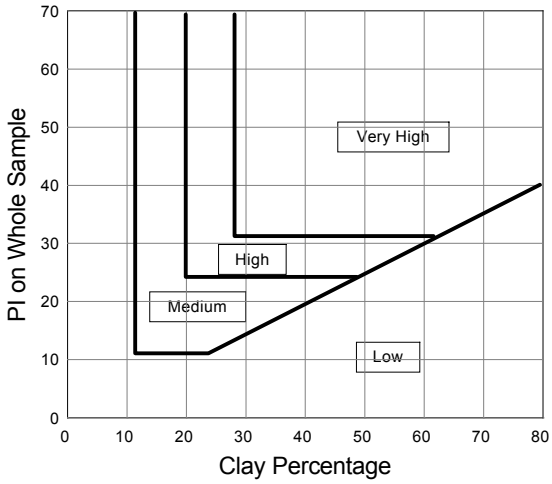
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0921	8.38
0.0669	7.45
0.0486	6.52
0.0352	5.59
0.0050	1.63
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

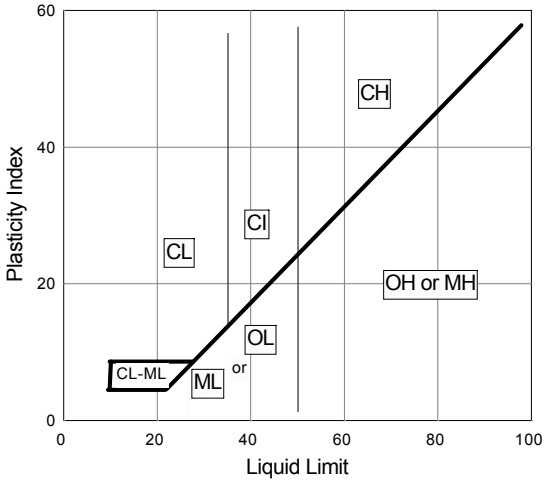
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	2.37
Moisture Content	2.37
PI on Whole Sample	Non Plastic
PRA Classification	A.1.a
Unified Classification	SW - SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



Revision No 3 (06/04/2001)

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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE PLT 19 @ 1,3 - 2,1m		
Date	07 DECEMBER 2015	Test No	2263
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

Direct Results from Test Procedure

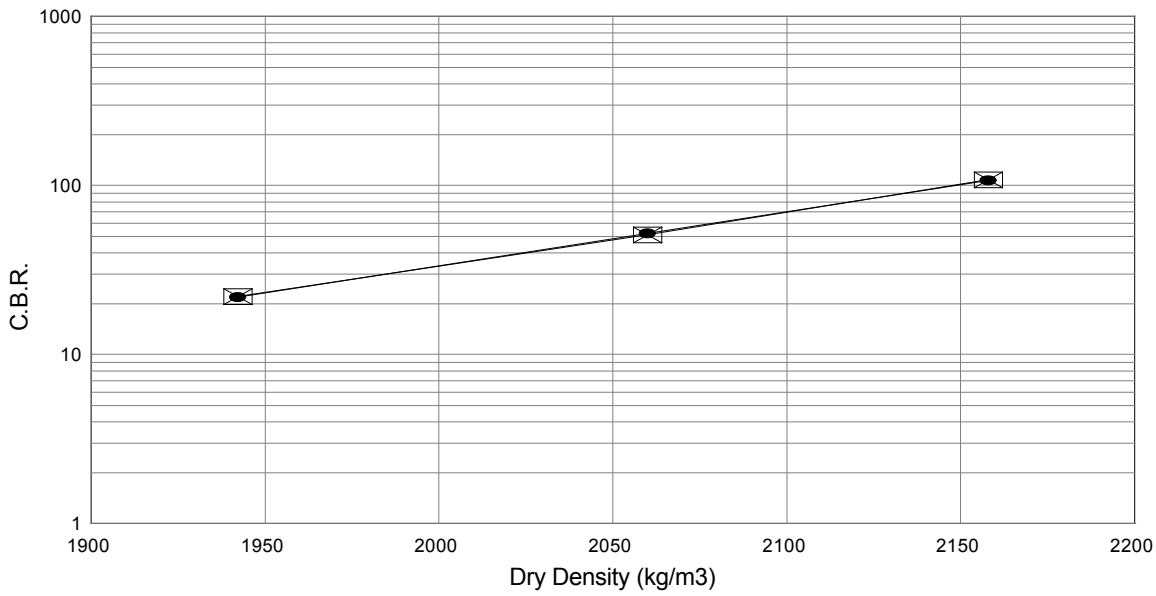
Maximum Dry Density (kg/m3)	2161

Optimum Moisture Content (%)	7.0

Percentage Mod AASHTO	99.9	95.3	89.9
CBR @ 2.54mm	108	51	22
CBR @ 5.08mm	111	54	24
CBR@ 7.62mm	118	56	26
Average Moisture Content (%)		7.3	
Percentage Swell	0.24	0.31	0.42

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	22	36	49	79	109



Programed Data
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FOUNDATION INDICATOR

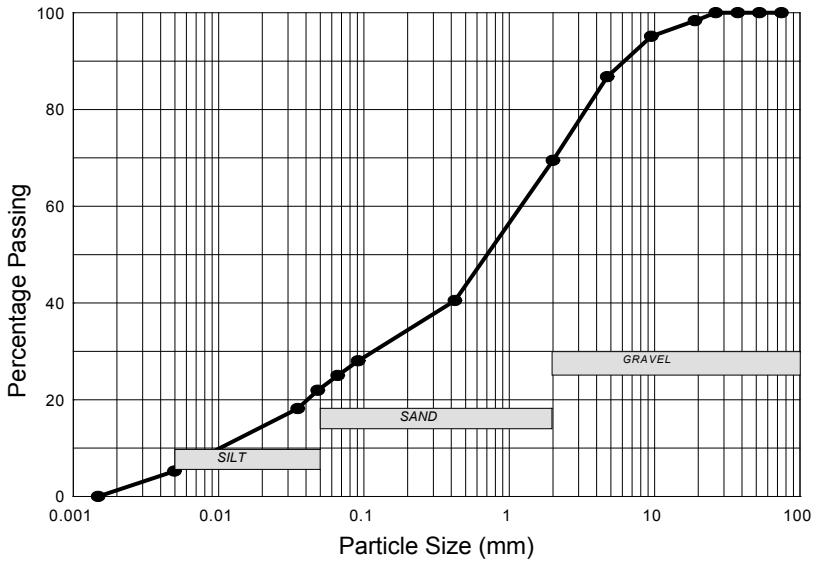
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 3 @ 0,4 - 1,4m	
Date	07 DECEMBER 2015	Test No	2264
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	98.36
9.50	95.14
4.75	86.80
2.00	69.50
0.425	40.53

GRADING ANALYSIS



HYDROMETER ANALYSIS

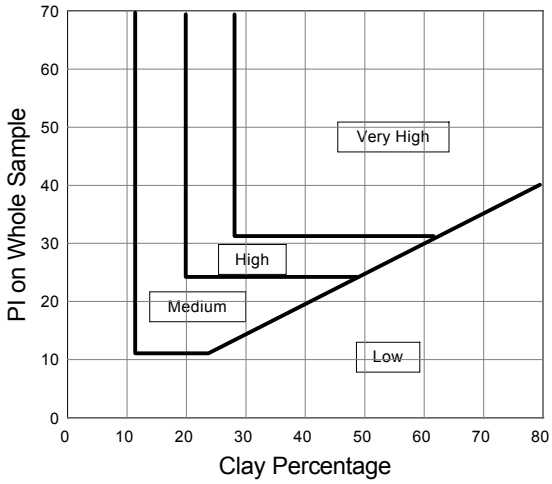
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0914	28.09
0.0665	25.05
0.0482	22.01
0.0352	18.22
0.0050	5.31
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

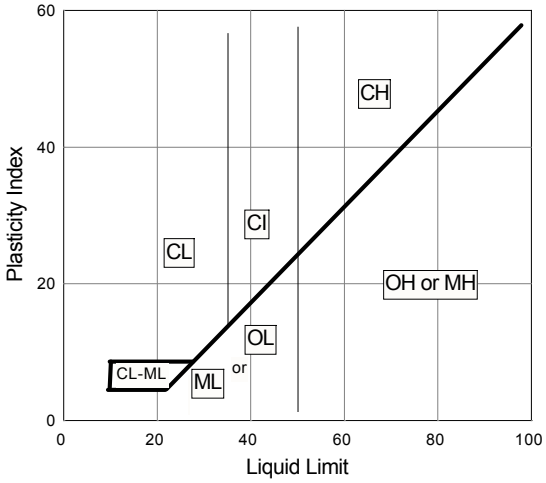
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.62
Moisture Content	4.81
PI on Whole Sample	Non Plastic
PRA Classification	A.2.4
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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FOUNDATION INDICATOR

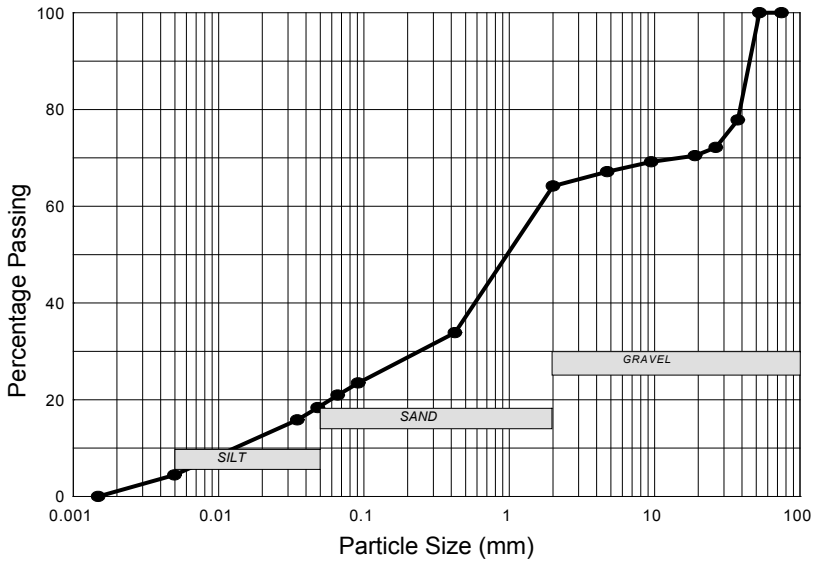
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 23 - 24 @ 0,0 - 0,2m	
Date	07 DECEMBER 2015	Test No	2267
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	77.89
26.50	72.16
19.00	70.47
9.50	69.23
4.75	67.16
2.00	64.18
0.425	33.90

GRADING ANALYSIS



HYDROMETER ANALYSIS

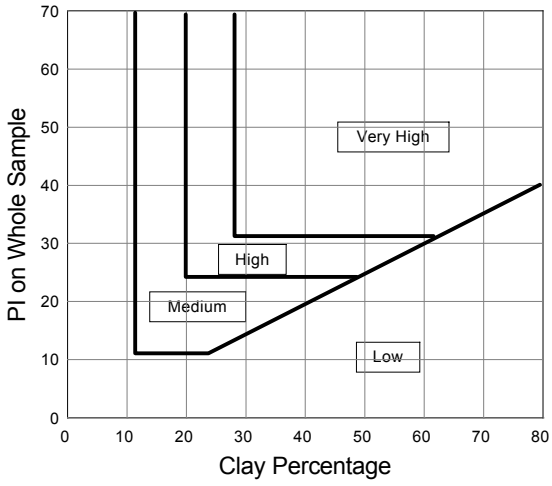
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0914	23.49
0.0665	20.95
0.0482	18.41
0.0350	15.87
0.0050	4.44
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

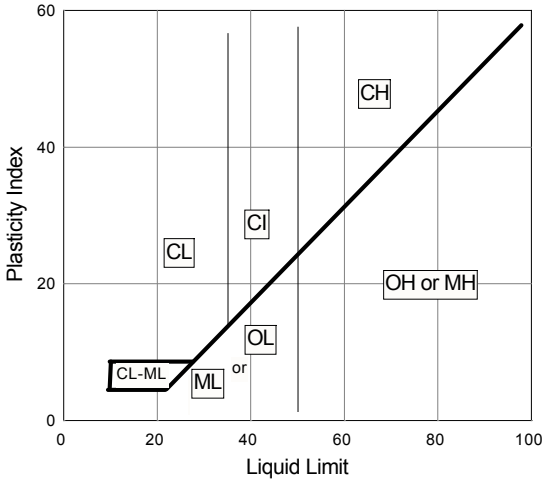
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.78
Moisture Content	2.06
PI on Whole Sample	Non Plastic
PRA Classification	A.1.b
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE PLT 23 -24 @ 0,0 - 0,2m		
Date	07 DECEMBER 2015	Test No	2268
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

Direct Results from Test Procedure

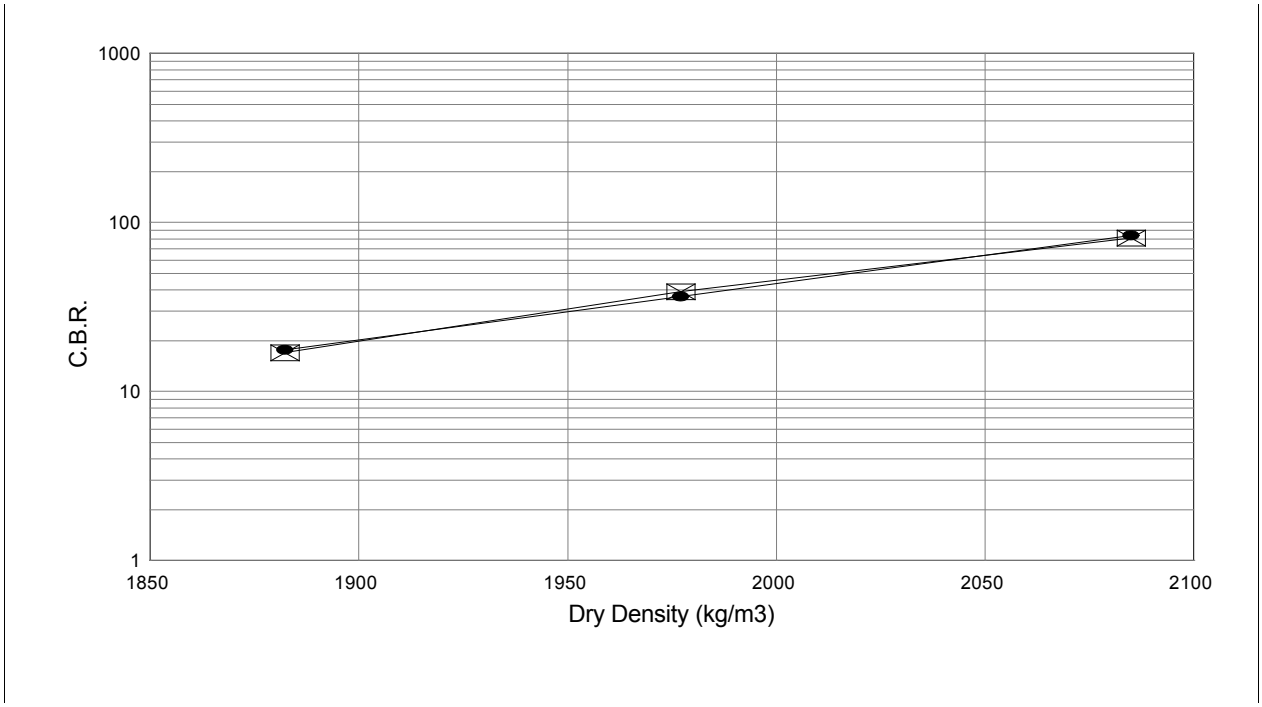
Maximum Dry Density (kg/m3)	2084

Optimum Moisture Content (%)	7.0

Percentage Mod AASHTO	100.0	94.9	90.3
CBR @ 2.54mm	81	39	17
CBR @ 5.08mm	84	41	19
CBR@ 7.62mm	85	41	19
Average Moisture Content (%)		7.3	
Percentage Swell	0.06	0.08	0.11

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	17	27	37	60	83



Programed Data
Revision No 4 (1/5/2010)

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FOUNDATION INDICATOR

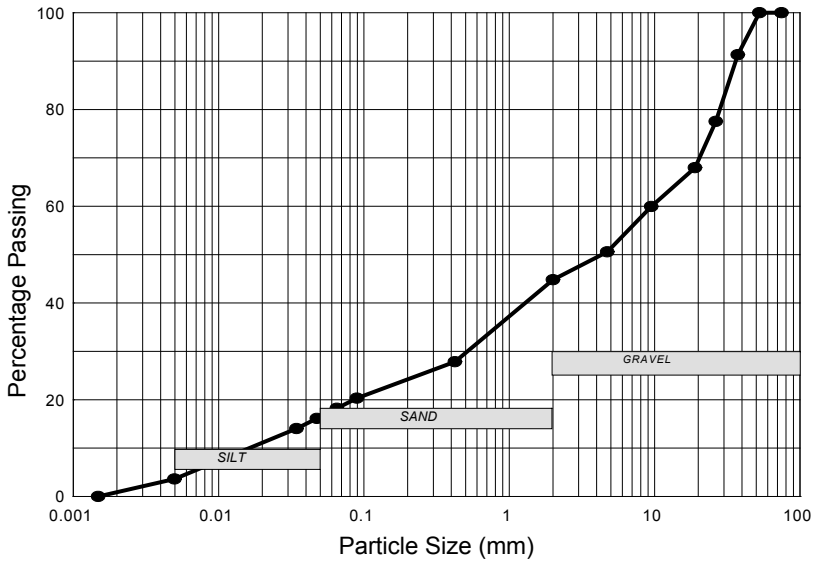
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 23 - 24 @ 0,2 - 0,5m	
Date	07 DECEMBER 2015	Test No	2269
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	91.37
26.50	77.57
19.00	68.03
9.50	59.99
4.75	50.60
2.00	44.82
0.425	27.90

GRADING ANALYSIS



HYDROMETER ANALYSIS

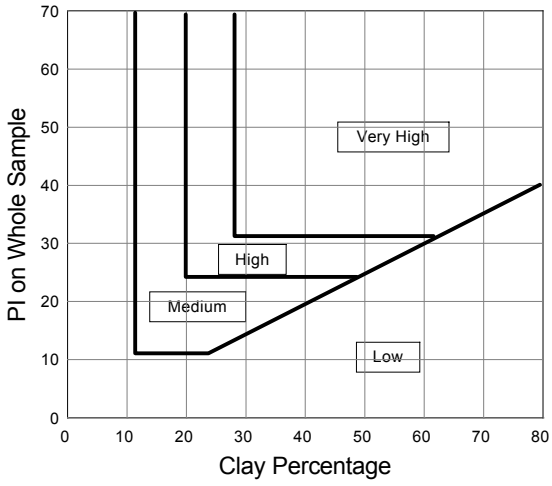
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0901	20.38
0.0656	18.29
0.0476	16.20
0.0346	14.11
0.0050	3.66
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

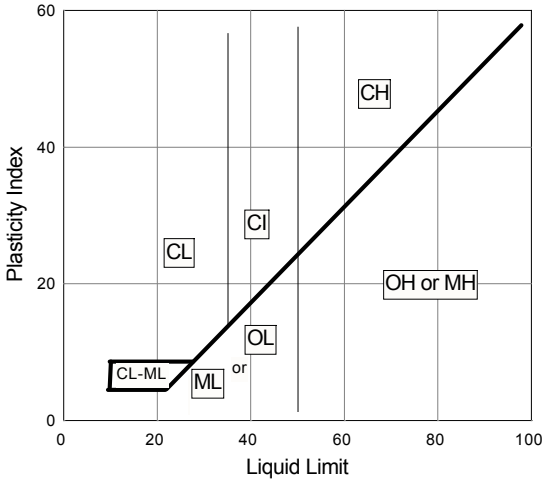
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	2.07
Moisture Content	3.66
PI on Whole Sample	Non Plastic
PRA Classification	A.1.b
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	PLT 23 - 24 @ 0,2 - 0,5m	
Date	07 DECEMBER 2015	Test No	2269b
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

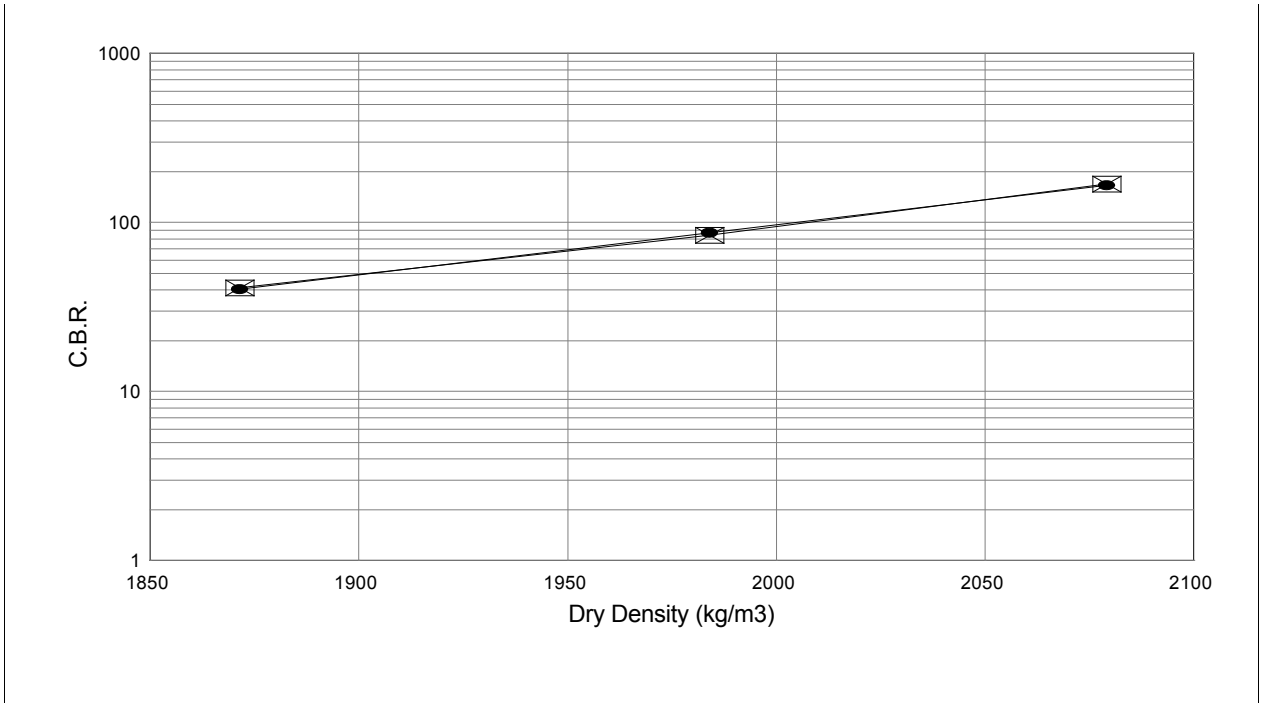
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	2082	Optimum Moisture Content (%)	9.6

Percentage Mod AASHTO	99.9	95.3	89.9
CBR @ 2.54mm	169	84	41
CBR @ 5.08mm	173	86	44
CBR@ 7.62mm	173	88	44
Average Moisture Content (%)		9.6	
Percentage Swell	0.02	0.03	0.05

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	41	63	83	127	169



Programed Data
Revision No 4 (1/5/2010)

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FOUNDATION INDICATOR

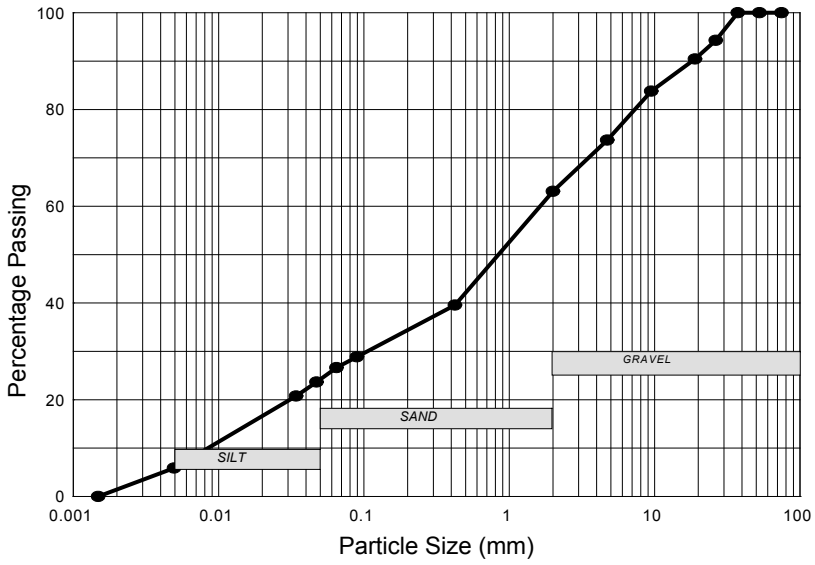
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 25 @ 0,0 - 0,5m	
Date	07 DECEMBER 2015	Test No	2270
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	94.35
19.00	90.44
9.50	83.81
4.75	73.72
2.00	63.14
0.425	39.60

GRADING ANALYSIS



HYDROMETER ANALYSIS

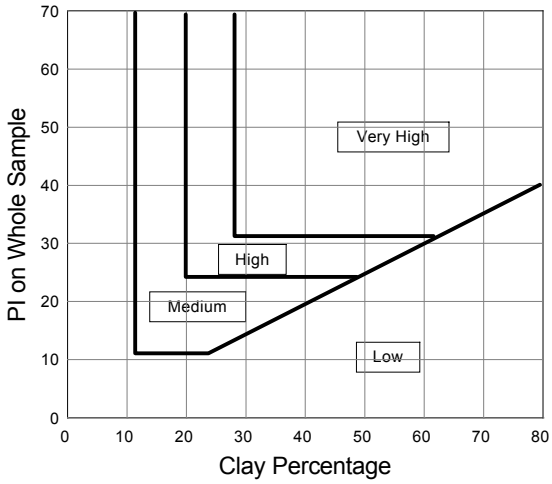
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0901	28.92
0.0651	26.70
0.0473	23.73
0.0343	20.76
0.0050	5.93
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

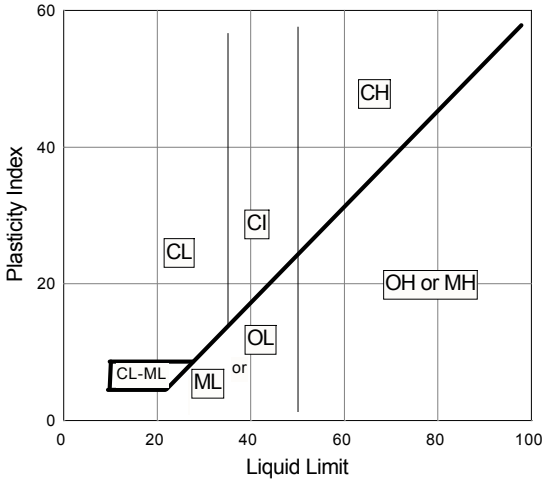
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	1.68
Moisture Content	4.02
PI on Whole Sample	Non Plastic
PRA Classification	A.2.4
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	PLT 25 @ 0,0 - 0,5m	
Date	07 DECEMBER 2015	Test No	2271
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

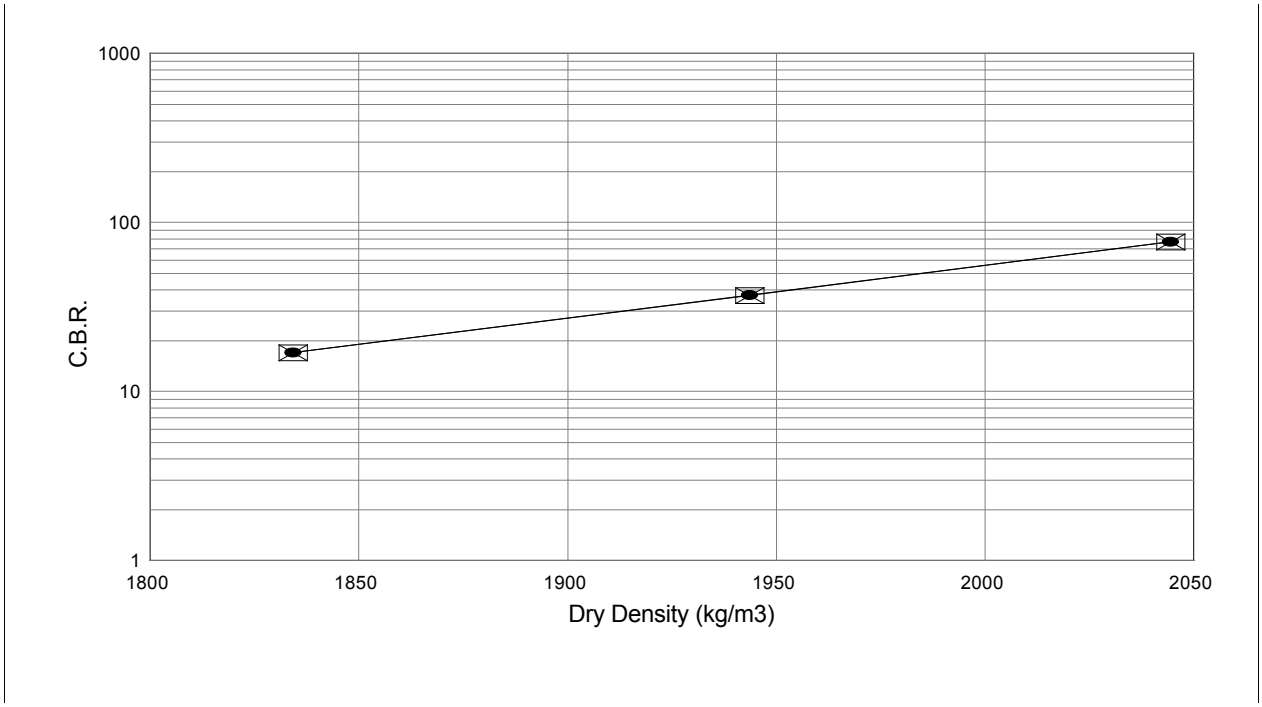
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	2041	Optimum Moisture Content (%)	9.7

Percentage Mod AASHTO	100.2	95.2	89.9
CBR @ 2.54mm	77	37	17
CBR @ 5.08mm	79	38	17
CBR@ 7.62mm	82	38	19
Average Moisture Content (%)		10.1	
Percentage Swell	0.00	0.01	0.02

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	17	27	36	56	75



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FOUNDATION INDICATOR

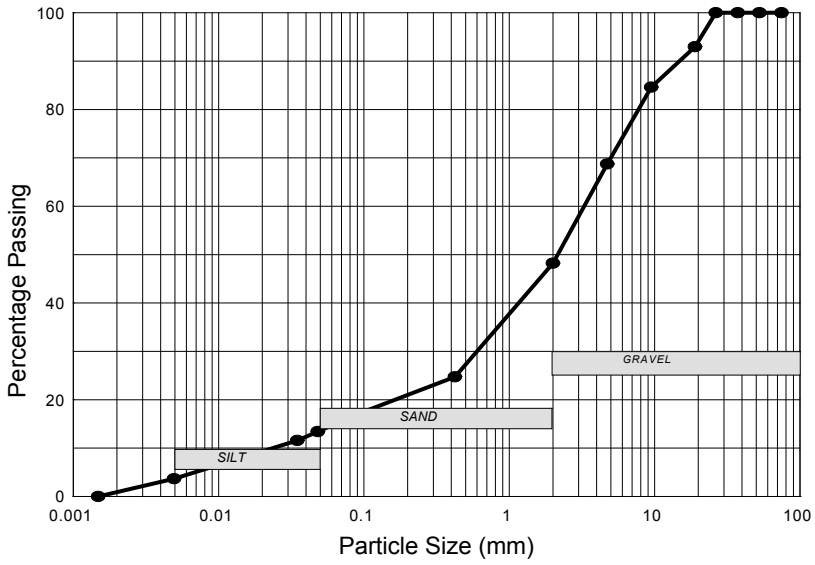
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P LT 25 @ 0,6 - 1,3m	
Date	07 DECEMBER 2015	Test No	2272
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	93.00
9.50	84.65
4.75	68.76
2.00	48.28
0.425	24.75

GRADING ANALYSIS



HYDROMETER ANALYSIS

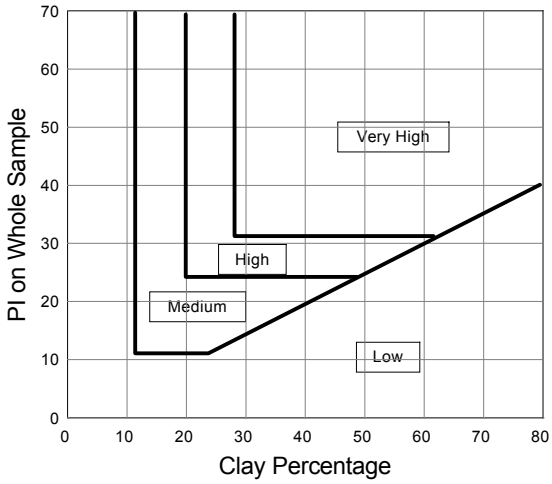
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0914	17.15
0.0665	15.30
0.0482	13.44
0.0350	11.59
0.0050	3.71
0.0015	0.00

ATTERBERG LIMITS & OTHER VALUES

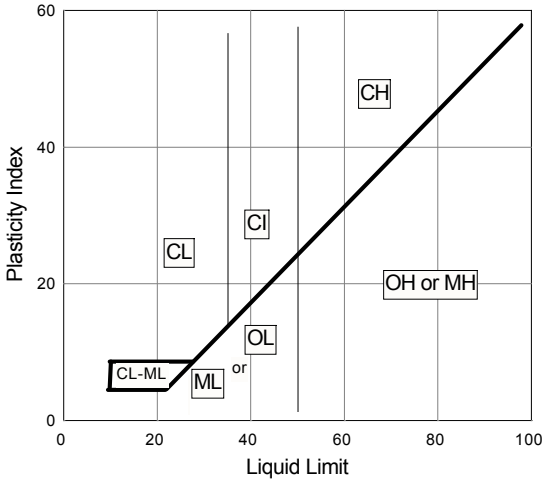
Liquid Limit	Non Plastic
Plastic Limit	Non Plastic
Plastic Index	Non Plastic
Linear Shrinkage	0
Grading Modulus	2.10
Moisture Content	1.55
PI on Whole Sample	Non Plastic
PRA Classification	A.1.b
Unified Classification	SM

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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C.B.R. DETERMINATION

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	PLT 25 @ 0,6 - 1,3m	
Date	07 DECEMBER 2015	Test No	2273
Job No	15307	Checked By	EB
Calibration Date	21 April 2010	Calibration Certificate	2077

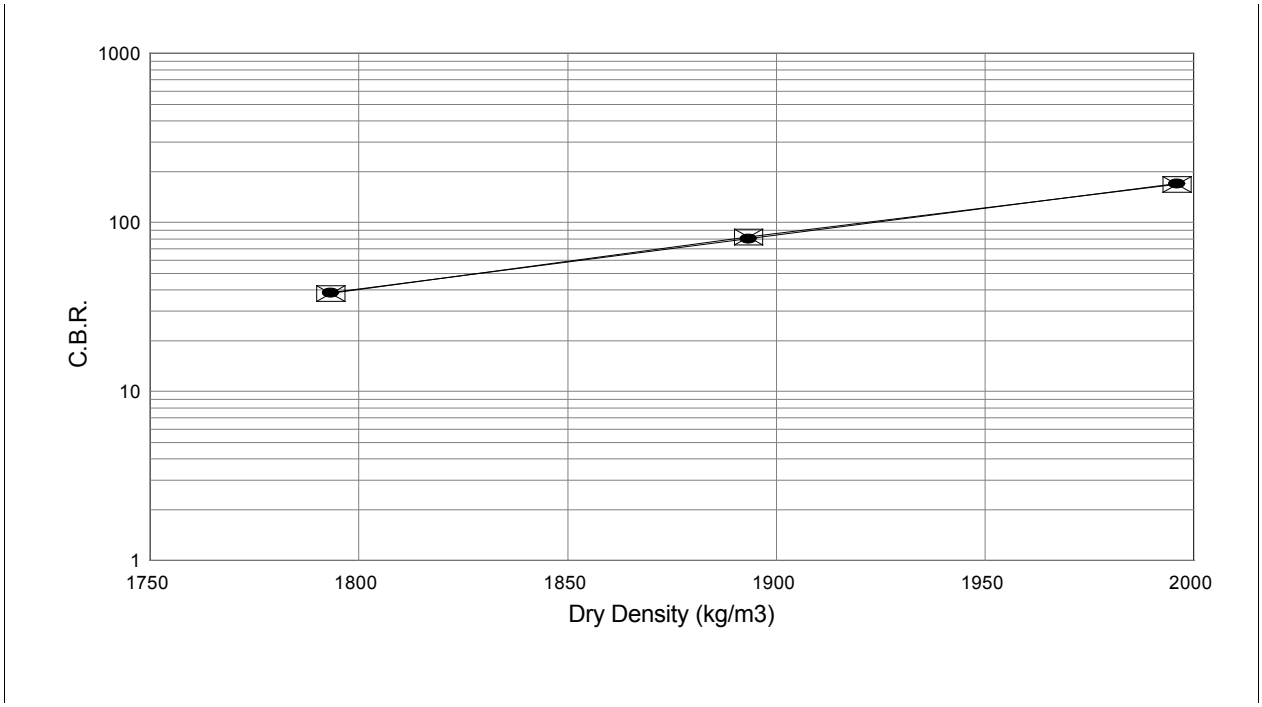
Direct Results from Test Procedure

Maximum Dry Density (kg/m3)	1996	Optimum Moisture Content (%)	7.9

Percentage Mod AASHTO	100.0	94.9	89.9
CBR @ 2.54mm	168	82	38
CBR @ 5.08mm	170	82	41
CBR@ 7.62mm	173	84	44
Average Moisture Content (%)		8.2	
Percentage Swell	0.02	0.04	0.06

Interpolated Results

Percentage Mod AASHTO	90	93	95	98	100
CBR	39	61	82	127	170



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FOUNDATION INDICATOR

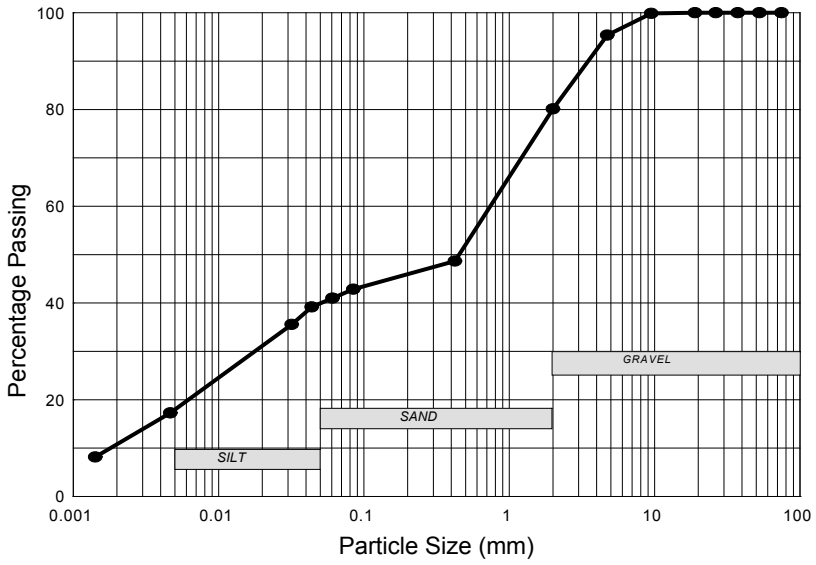
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 07 @ 1,5 - 1,64m	
Date	07 DECEMBER 2015	Test No	2274
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	99.89
4.75	95.42
2.00	80.15
0.425	48.72

GRADING ANALYSIS



HYDROMETER ANALYSIS

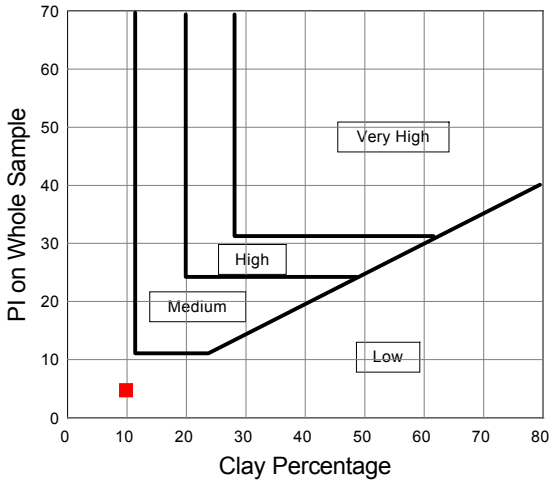
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0847	42.88
0.0609	41.05
0.0437	39.23
0.0319	35.58
0.0047	17.33
0.0014	8.21

ATTERBERG LIMITS & OTHER VALUES

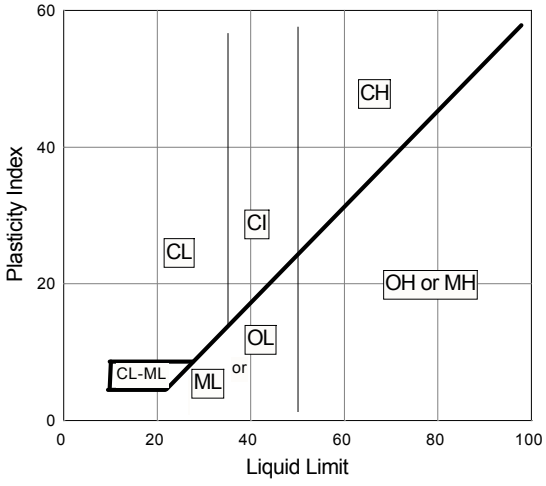
Liquid Limit	37
Plastic Limit	27
Plastic Index	10
Linear Shrinkage	5
Grading Modulus	1.28
Moisture Content	13.28
PI on Whole Sample	5
PRA Classification	A.4
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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COLLAPSE POTENTIAL at 200 kPa

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE P 07 @ 1,5 - 1,64m		
Date	07 DECEMBER 2015	Test No	2275
Job No	15288	Checked By	EB

Sample Height (mm)	20	Sample Diameter (mm)	64	Sample Specific Gravity	2.64

Sample Preparation	NMC

Effective Stress (kPa)	Time (mins)	Consolidation Reading	Voids Ratio	Strain (%)
10	90	779	0.932	0.00
10	480	781	0.930	0.10
33	1920	792	0.920	0.65
65	2040	802	0.910	1.15
127	2160	820	0.893	2.05
200	2400	829	0.884	2.50
200	3840	857	0.857	3.90
498	4050	905	0.811	6.30
993	4290	948	0.769	8.45
1868	5730	990	0.729	10.55
743	5850	988	0.730	10.45
118	5970	976	0.742	9.85
10	6090	956	0.761	8.85

Moisture Content Calculations

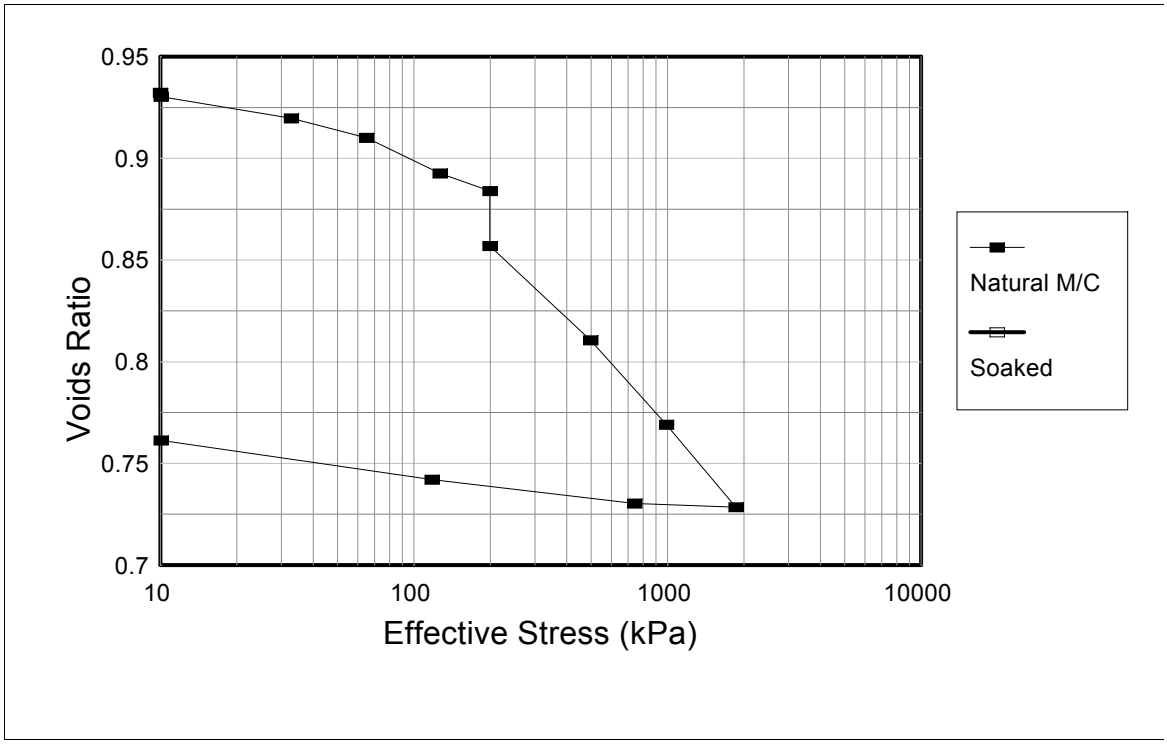
Mass wet sample plus ring before test (gms)	312.10
Mass wet sample plus ring after test (gms)	316.80
Mass dry sample plus ring (gms)	302.40
Mass ring (gms)	214.50
Moisture content before test (%)	**11.04**
Moisture content after test (%)	**16.38**

Other Data

Initial Dry Density (kg/m3)	**1366**
Initial Void Ratio	**0.93**

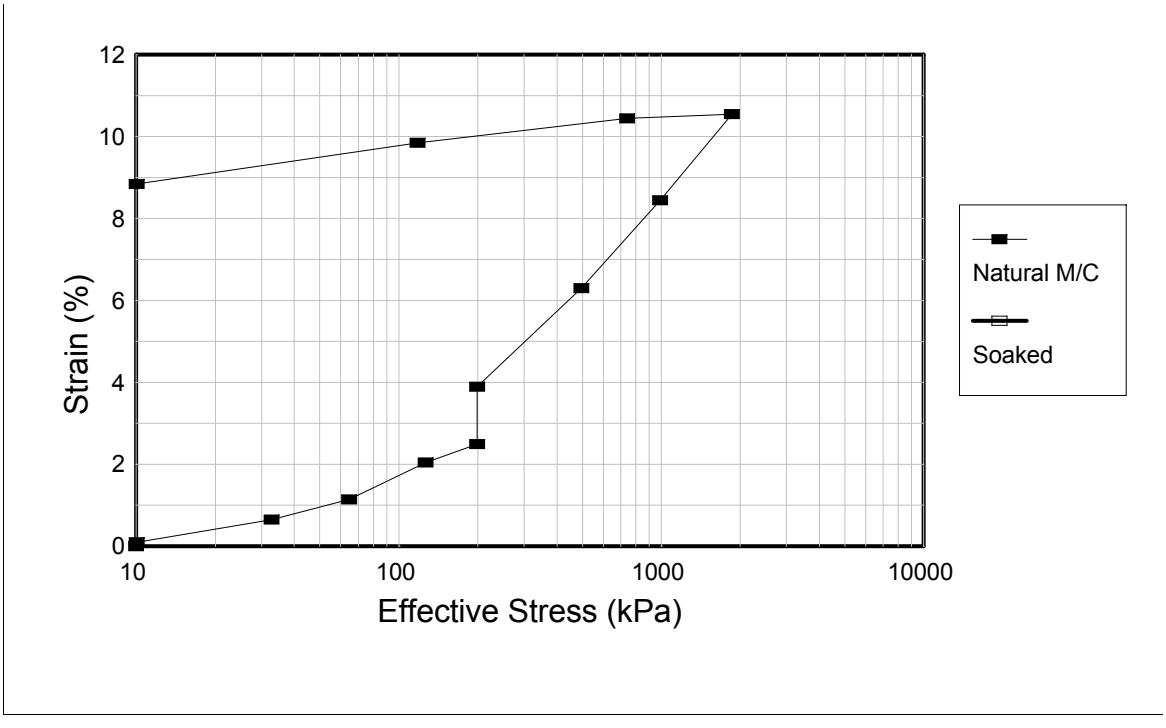
VOIDS RATIO v EFFECTIVE STRESS

Test No: 2275



STRAIN v EFFECTIVE STRESS

Test No: 2275



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FOUNDATION INDICATOR

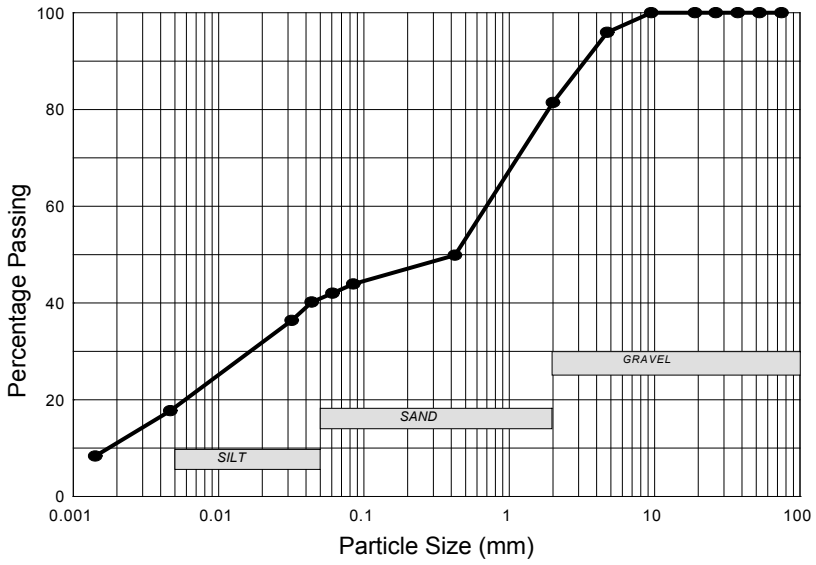
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 08 @ 1,5 - 1,6m	
Date	07 DECEMBER 2015	Test No	2276
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	100.00
4.75	95.96
2.00	81.46
0.425	49.91

GRADING ANALYSIS



HYDROMETER ANALYSIS

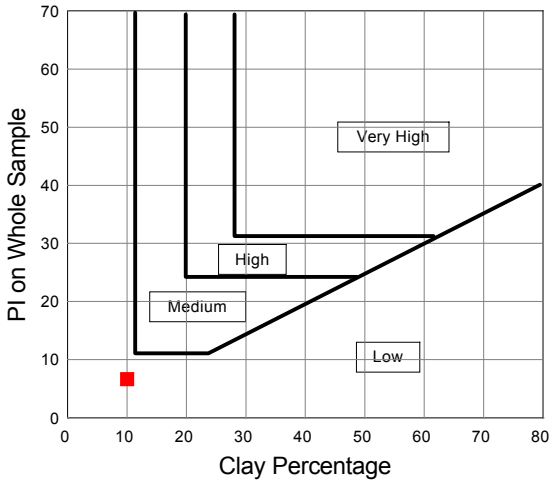
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0847	43.93
0.0609	42.06
0.0437	40.19
0.0319	36.45
0.0047	17.76
0.0014	8.41

ATTERBERG LIMITS & OTHER VALUES

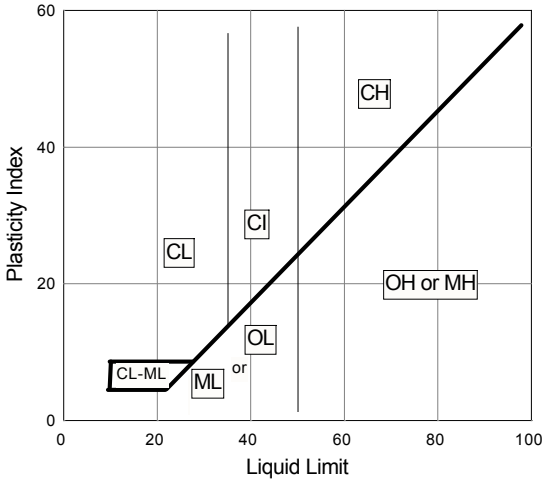
Liquid Limit	39
Plastic Limit	26
Plastic Index	13
Linear Shrinkage	7
Grading Modulus	1.25
Moisture Content	12.76
PI on Whole Sample	7
PRA Classification	A.6
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



Revision No 3 (06/04/2001)

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SHEAR BOX

Client	GCS Consultants		
Location	Gamsberg (P08 1.5 - 1.6m)		
Date	7th December 2015	Test No	2277sb
Job No	15307	Checked By	cd

Sample Preparation	Undisturbed - Quick, undrained at NMC
Notes	Rate of strain 1.017 %/min

INITIAL M/C (%)	12.9
FINAL M/C (%)	13.1

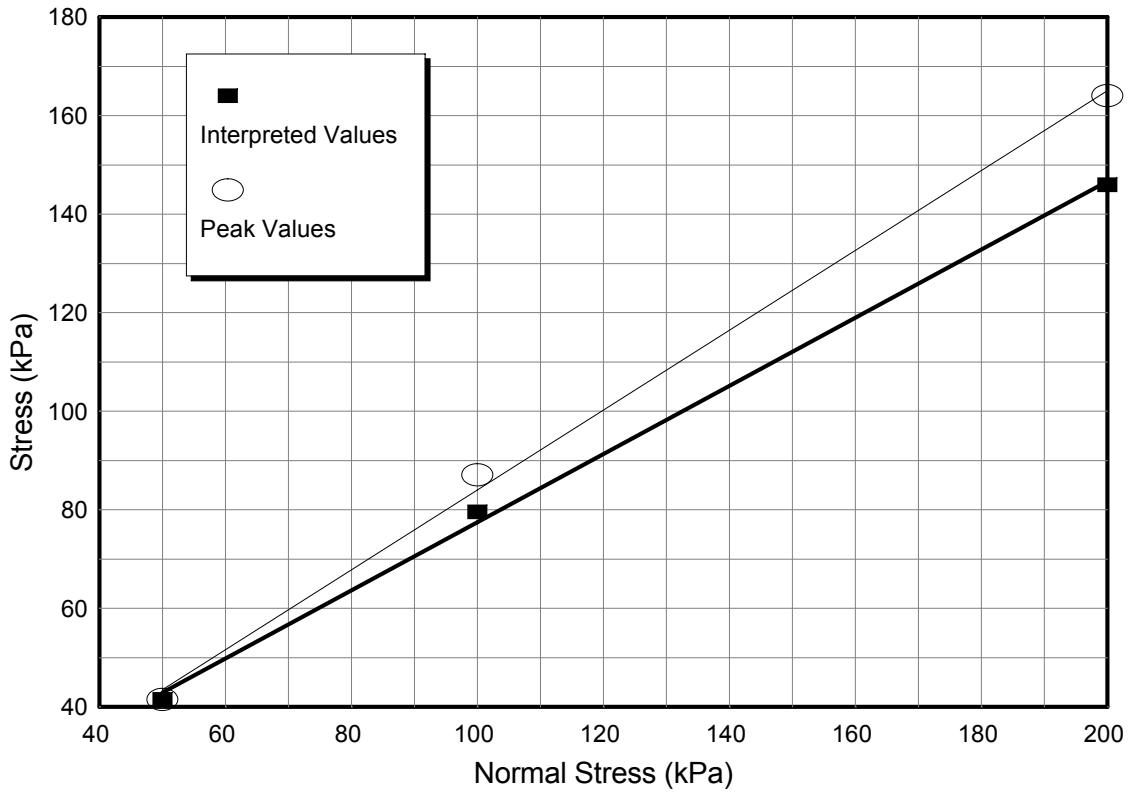
SHEAR PARAMETERS

a) Based on absolute "Peak Shear Stress" as obtained from laboraotory test

COHESION (kPa)	3
PHI (deg)	39

b) Based on "Interpretation" of peak stress based on shape of the stress / strain graph given on page 2 of this report

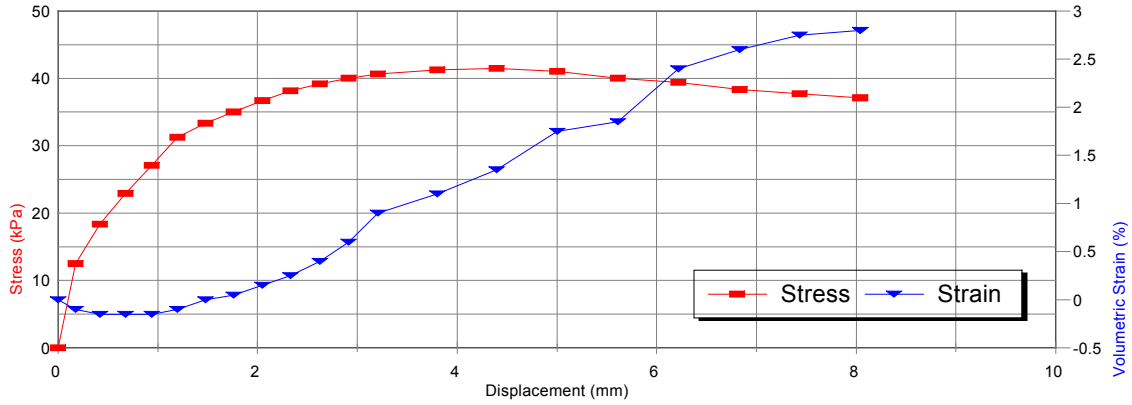
COHESION (kPa)	8
PHI (deg)	35



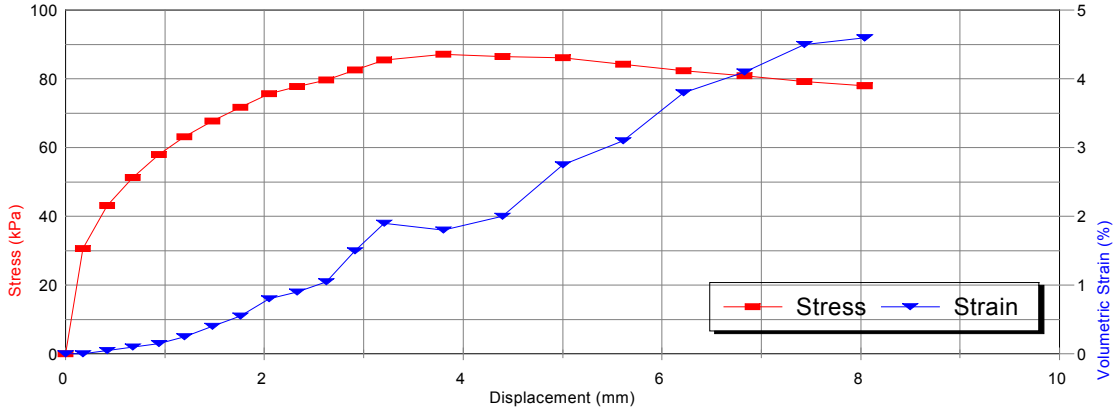
Programe Data
Revision No 1 (17/08/2001)

Test No	2277sb

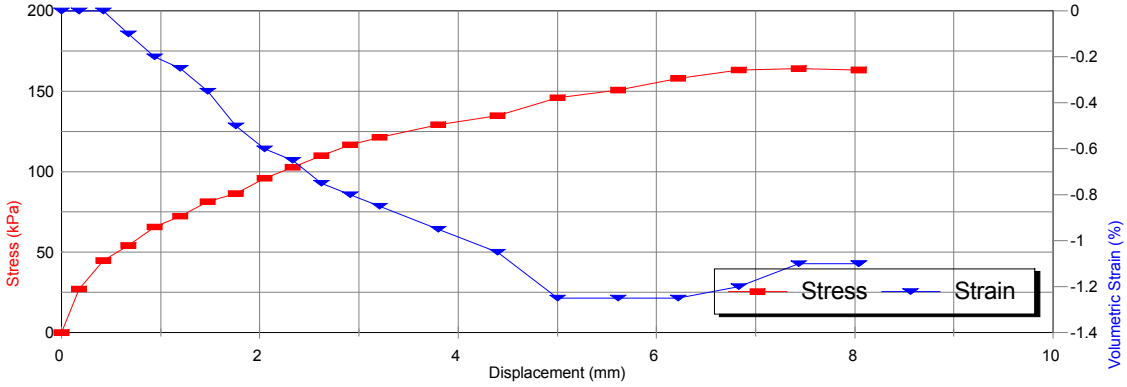
Cycle Number	1
Normal Stress (kPa)	50



Cycle Number	2
Normal Stress (kPa)	100



Cycle Number	3
Normal Stress (kPa)	200



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FOUNDATION INDICATOR

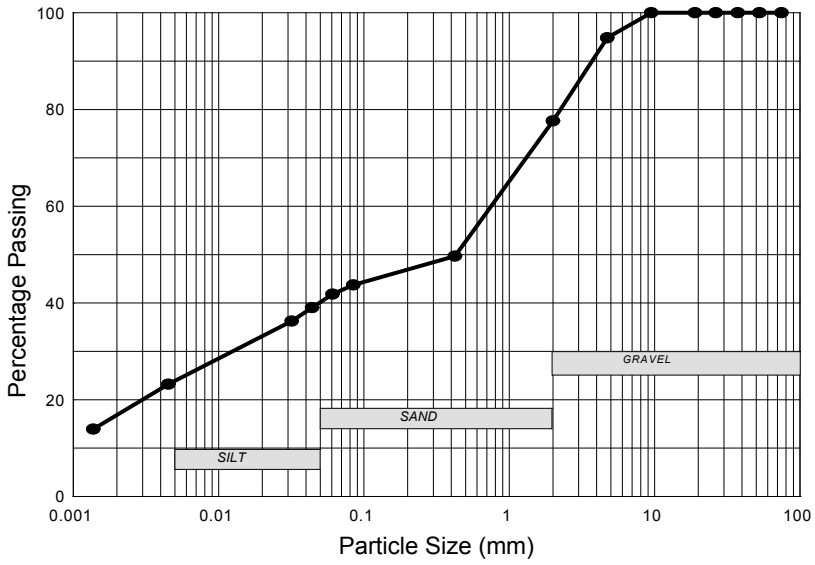
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 09 @ 1,5 - 1,8m	
Date	07 DECEMBER 2015	Test No	2278
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	100.00
4.75	94.85
2.00	77.70
0.425	49.71

GRADING ANALYSIS



HYDROMETER ANALYSIS

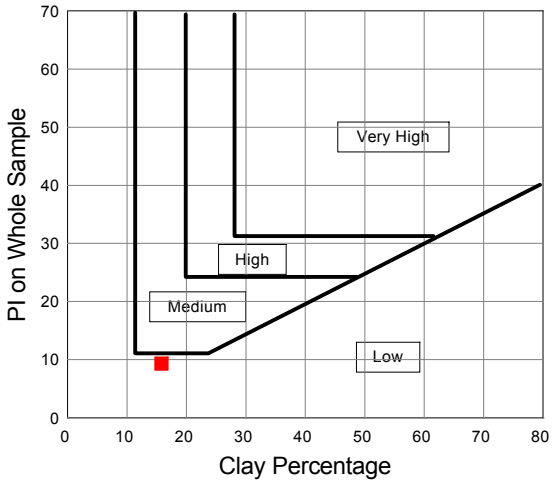
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0847	43.76
0.0609	41.89
0.0441	39.10
0.0319	36.31
0.0045	23.27
0.0014	13.96

ATTERBERG LIMITS & OTHER VALUES

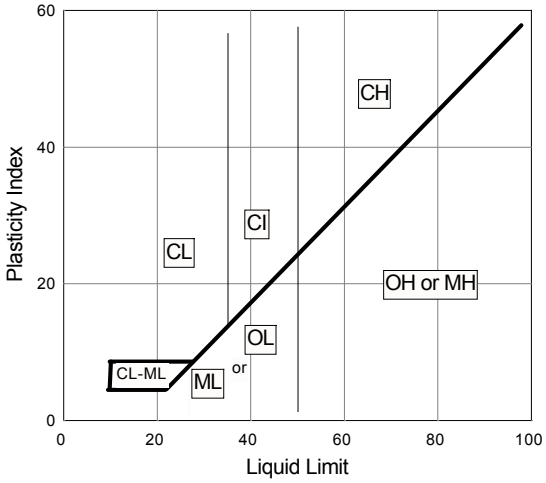
Liquid Limit	49
Plastic Limit	30
Plastic Index	19
Linear Shrinkage	9
Grading Modulus	1.29
Moisture Content	14.19
PI on Whole Sample	9
PRA Classification	A.7.5
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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SHEAR BOX

Client	GCS Consultants		
Location	Gamsberg (P09 1.5 - 1.9m)		
Date	7th December 2015	Test No	2279sb
Job No	15307	Checked By	cd

Sample Preparation	Undisturbed - Quick, undrained at NMC
Notes	Rate of strain 1.017 %/min

INITIAL M/C (%)	16.3
FINAL M/C (%)	16.5

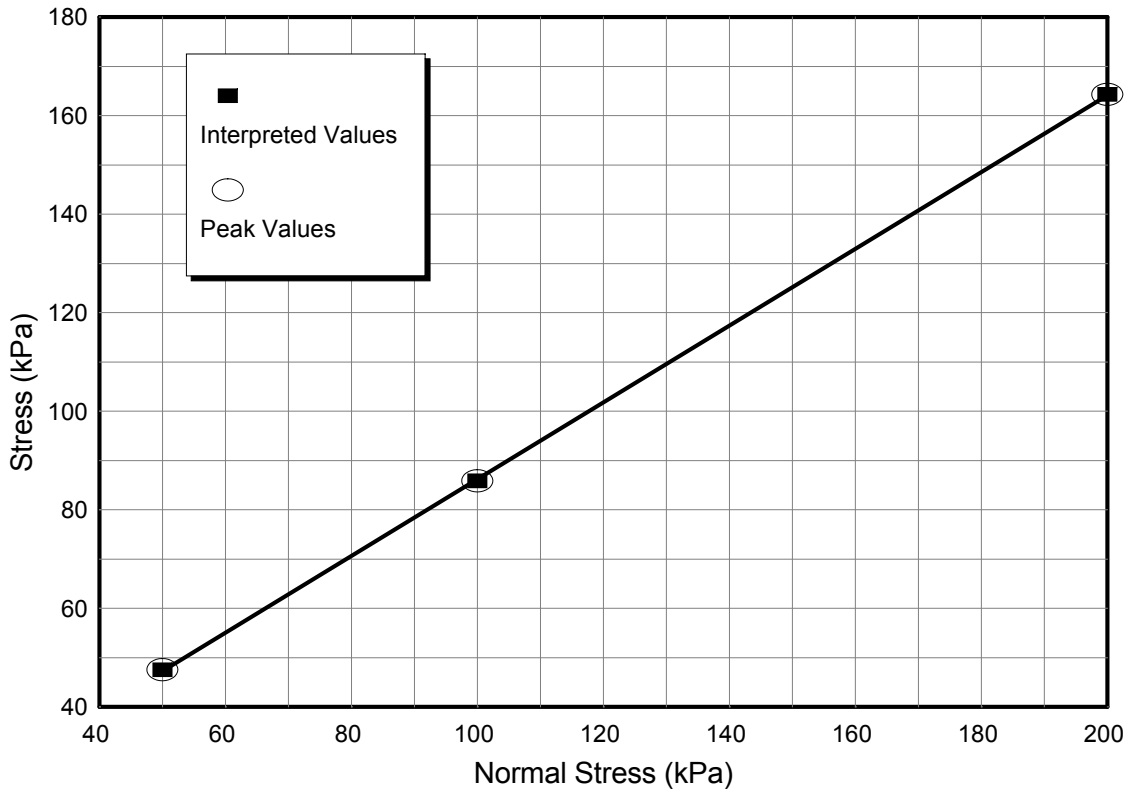
SHEAR PARAMETERS

a) Based on absolute "Peak Shear Stress" as obtained from laboraotory test

COHESION (kPa)	8
PHI (deg)	38

b) Based on "Interpretation" of peak stress based on shape of the stress / strain graph given on page 2 of this report

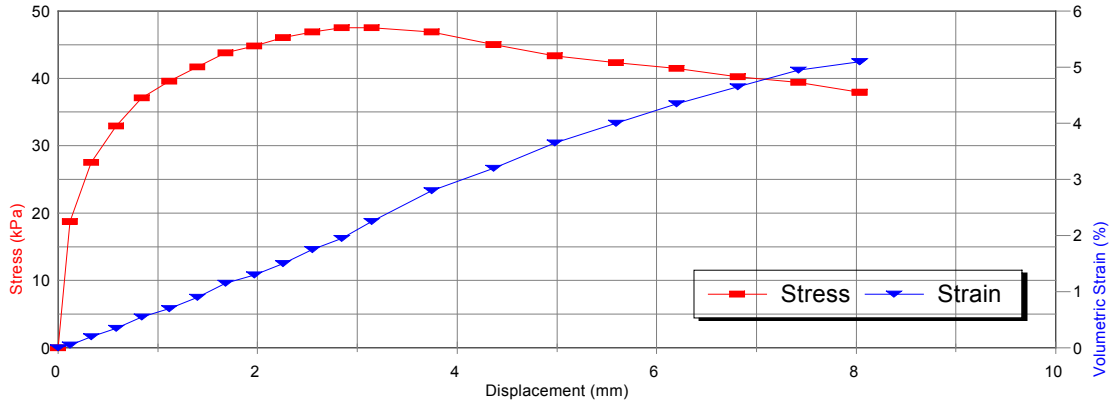
COHESION (kPa)	8
PHI (deg)	38



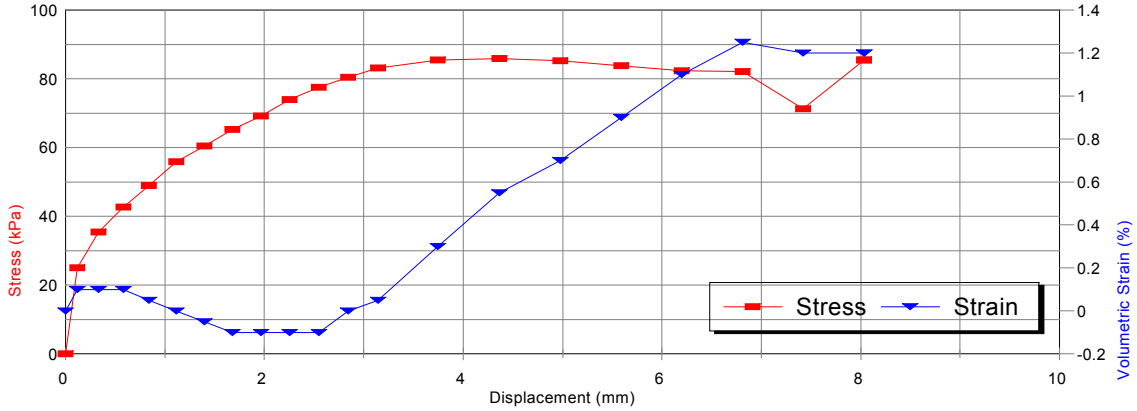
Programe Data
Revision No 1 (17/08/2001)

Test No	2279sb

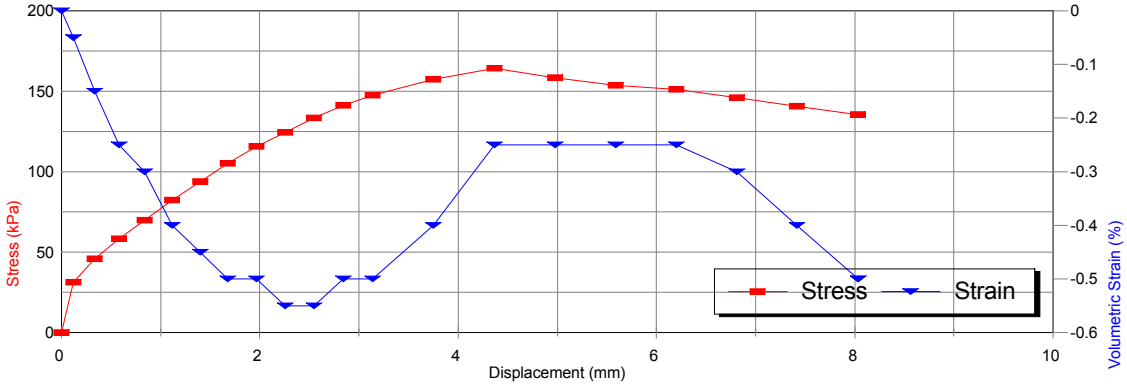
Cycle Number	1
Normal Stress (kPa)	50



Cycle Number	2
Normal Stress (kPa)	100



Cycle Number	3
Normal Stress (kPa)	200



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FOUNDATION INDICATOR

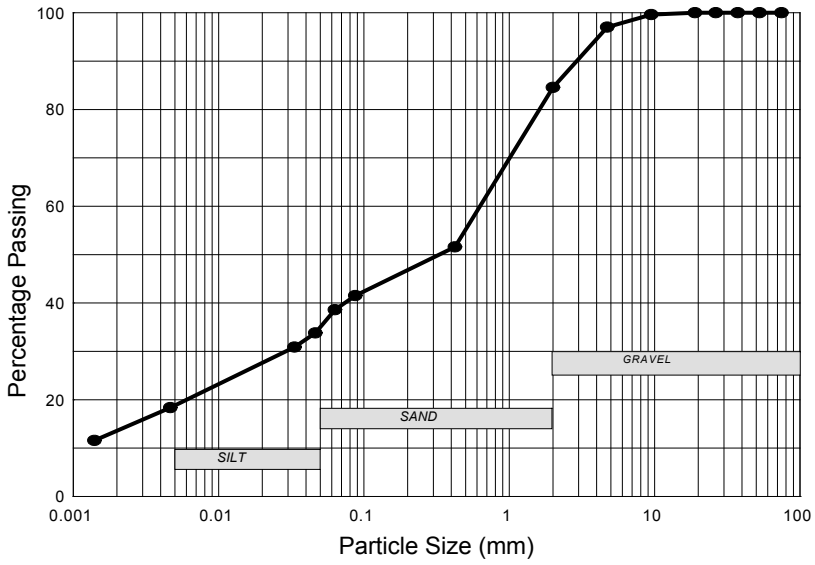
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 11 @ 1,5 - 1,9m	
Date	07 DECEMBER 2015	Test No	2280
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	99.67
4.75	97.03
2.00	84.58
0.425	51.62

GRADING ANALYSIS



HYDROMETER ANALYSIS

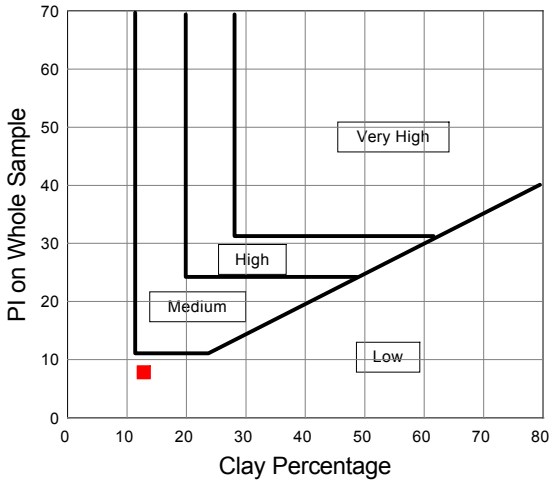
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0874	41.57
0.0633	38.67
0.0464	33.83
0.0335	30.93
0.0047	18.37
0.0014	11.60

ATTERBERG LIMITS & OTHER VALUES

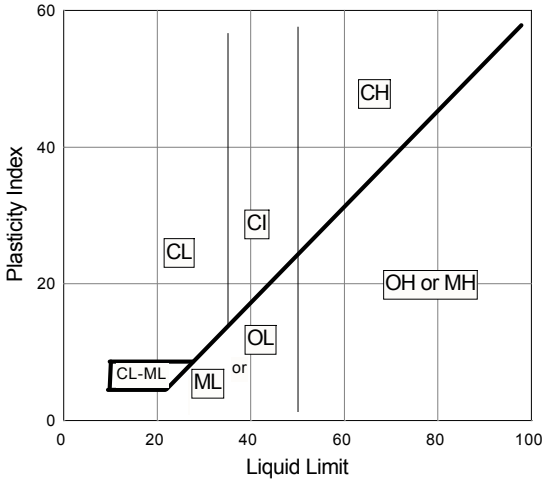
Liquid Limit	41
Plastic Limit	26
Plastic Index	15
Linear Shrinkage	7
Grading Modulus	1.22
Moisture Content	15.19
PI on Whole Sample	8
PRA Classification	A.7.6
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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COLLAPSE POTENTIAL at 200 kPa

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE P 11 @ 1,5 - 1,9m		
Date	07 DECEMBER 2015	Test No	2281
Job No	15288	Checked By	EB

Sample Height (mm)	20	Sample Diameter (mm)	64	Sample Specific Gravity	2.586

Sample Preparation	NMC

Effective Stress (kPa)	Time (mins)	Consolidation Reading	Voids Ratio	Strain (%)
10	90	678	0.774	0.00
10	480	679	0.773	0.05
33	1920	688	0.765	0.50
65	2040	698	0.756	1.00
127	2160	715	0.741	1.85
200	2400	725	0.732	2.35
200	3840	740	0.719	3.10
498	4050	774	0.689	4.80
993	4290	831	0.638	7.65
1868	5730	888	0.588	10.50
743	5850	871	0.603	9.65
118	5970	849	0.622	8.55
10	6090	830	0.639	7.60

Moisture Content Calculations

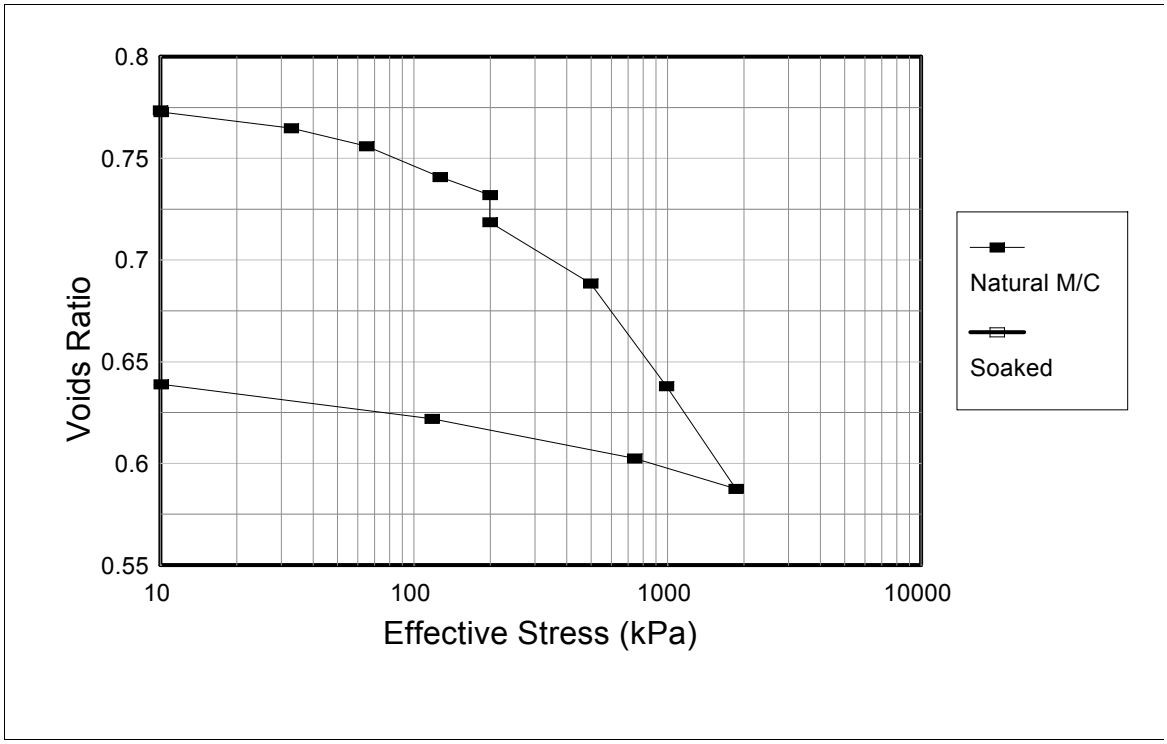
Mass wet sample plus ring before test (gms)	321.90
Mass wet sample plus ring after test (gms)	322.90
Mass dry sample plus ring (gms)	308.70
Mass ring (gms)	214.90
Moisture content before test (%)	**14.07**
Moisture content after test (%)	**15.14**

Other Data

Initial Dry Density (kg/m3)	**1458**
Initial Void Ratio	**0.77**

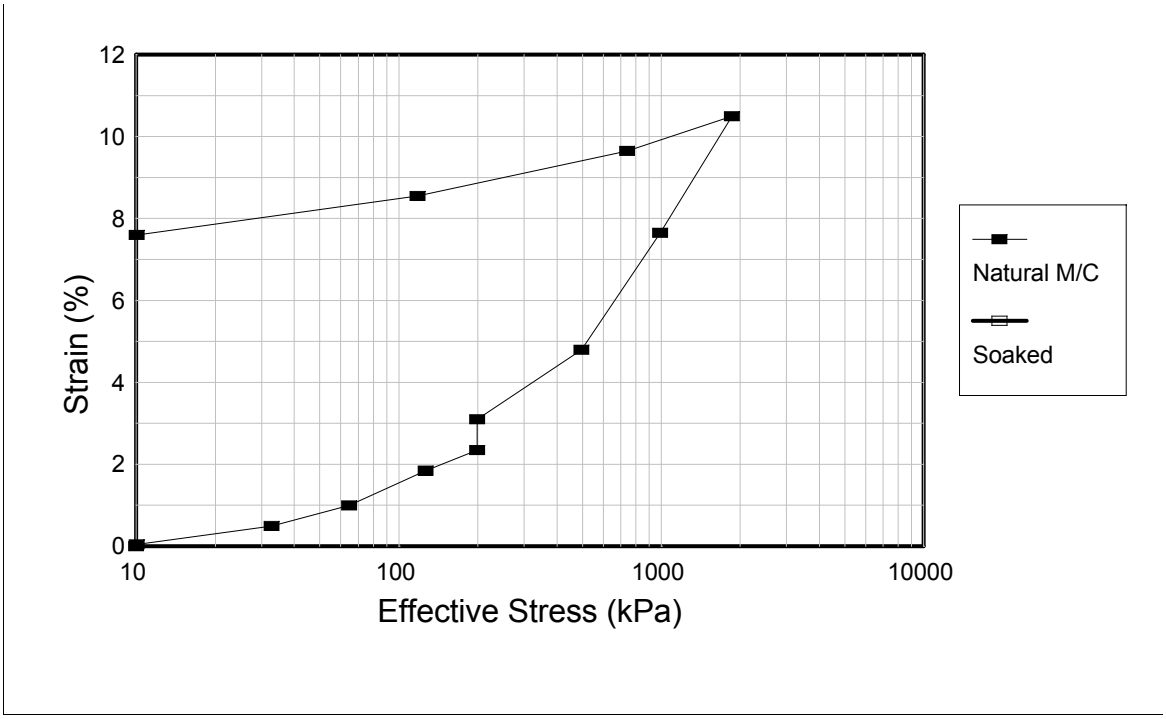
VOIDS RATIO v EFFECTIVE STRESS

Test No: 2281



STRAIN v EFFECTIVE STRESS

Test No: 2281



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FOUNDATION INDICATOR

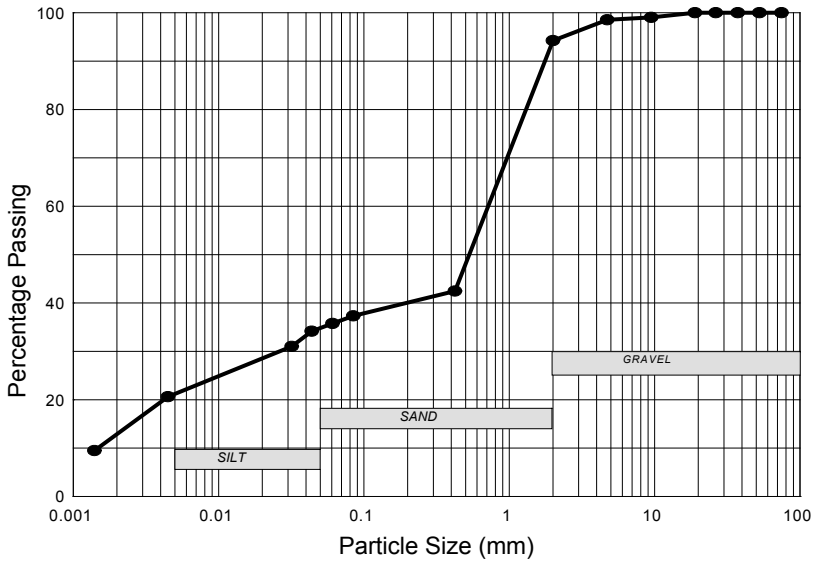
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 13 @ 1,5 - 2,05m	
Date	07 DECEMBER 2015	Test No	2282
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	99.07
4.75	98.55
2.00	94.26
0.425	42.48

GRADING ANALYSIS



HYDROMETER ANALYSIS

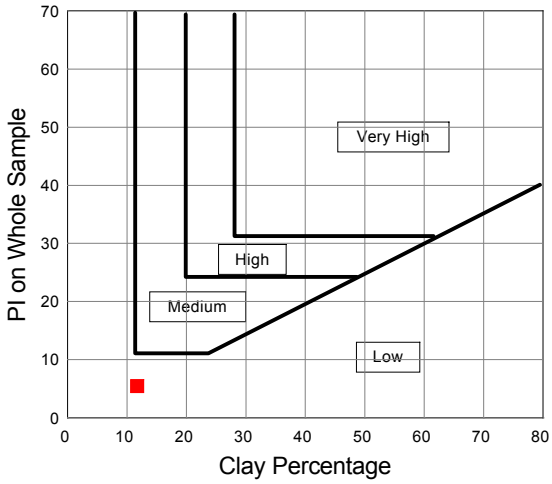
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0847	37.39
0.0609	35.80
0.0437	34.21
0.0319	31.03
0.0045	20.68
0.0014	9.55

ATTERBERG LIMITS & OTHER VALUES

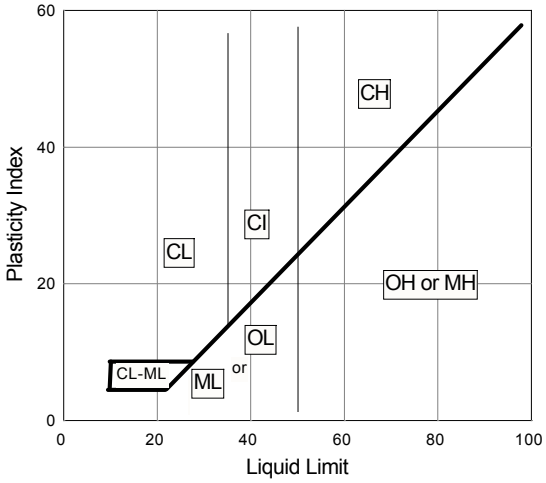
Liquid Limit	38
Plastic Limit	25
Plastic Index	13
Linear Shrinkage	7
Grading Modulus	1.26
Moisture Content	24.95
PI on Whole Sample	6
PRA Classification	A.6
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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COLLAPSE POTENTIAL at 200 kPa

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE P 13 @ 1,5 - 2,05m		
Date	07 DECEMBER 2015	Test No	2283
Job No	15288	Checked By	EB

Sample Height (mm)	20	Sample Diameter (mm)	64	Sample Specific Gravity	2.607

Sample Preparation	NMC

Effective Stress (kPa)	Time (mins)	Consolidation Reading	Voids Ratio	Strain (%)
10	90	1256	0.910	0.00
10	480	1257	0.909	0.05
33	1920	1269	0.898	0.65
65	2040	1293	0.875	1.85
127	2160	1355	0.816	4.95
200	2400	1384	0.788	6.40
200	3840	1388	0.784	6.60
498	4050	1429	0.745	8.65
993	4290	1465	0.711	10.45
1868	5730	1502	0.675	12.30
743	5850	1491	0.686	11.75
118	5970	1478	0.698	11.10
10	6090	1467	0.709	10.55

Moisture Content Calculations

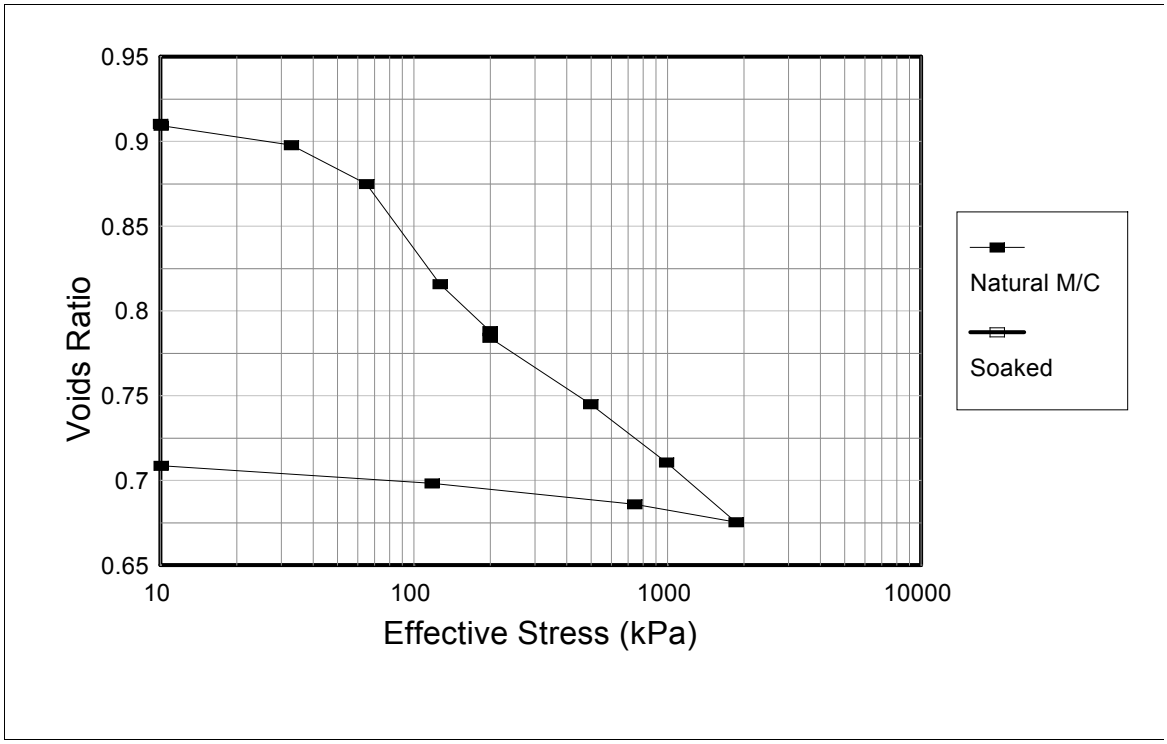
Mass wet sample plus ring before test (gms)	321.40
Mass wet sample plus ring after test (gms)	316.40
Mass dry sample plus ring (gms)	300.80
Mass ring (gms)	213.00
Moisture content before test (%)	**23.46**
Moisture content after test (%)	**17.77**

Other Data

Initial Dry Density (kg/m3)	**1365**
Initial Void Ratio	**0.91**

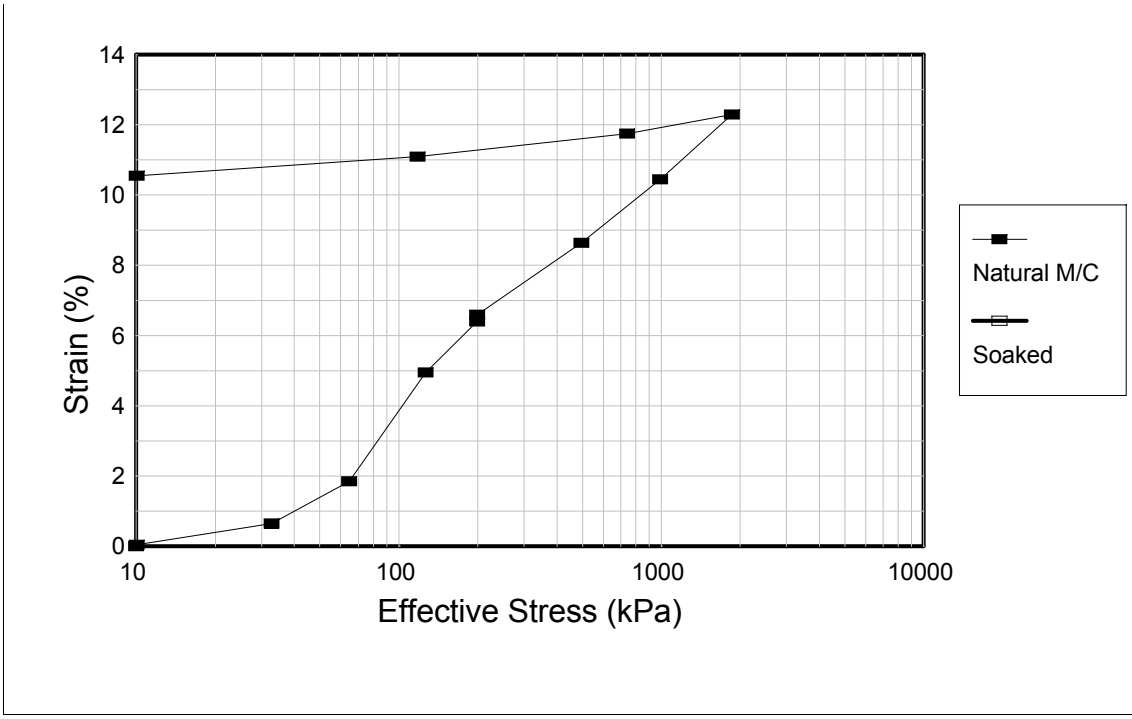
VOIDS RATIO v EFFECTIVE STRESS

Test No: 2283



STRAIN v EFFECTIVE STRESS

Test No: 2283



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SOILS & MATERIALS TESTING
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TEL: (011) 674 1325
FAX: (011) 674 4513
e mail: lab@geopractica.co.za

FOUNDATION INDICATOR

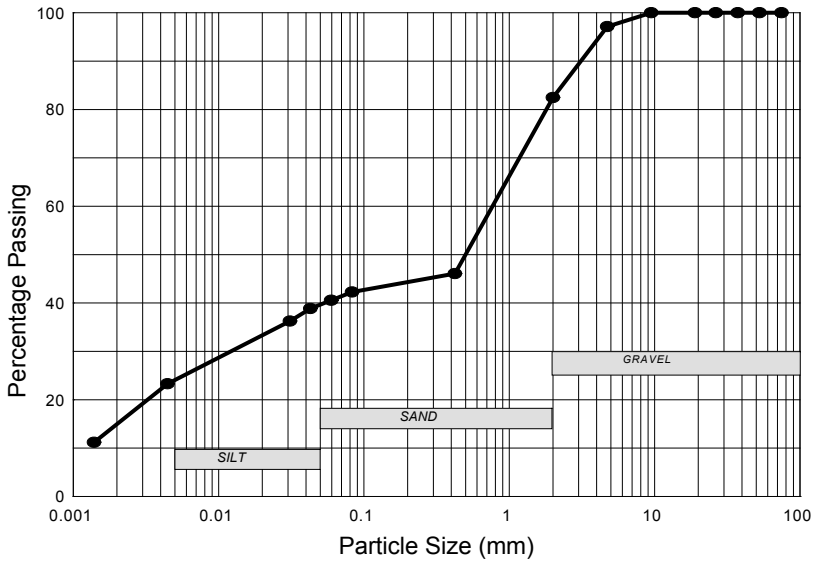
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 16 @ 1,5 - 1,75m	
Date	07 DECEMBER 2015	Test No	2284
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	100.00
4.75	97.16
2.00	82.50
0.425	46.13

GRADING ANALYSIS



HYDROMETER ANALYSIS

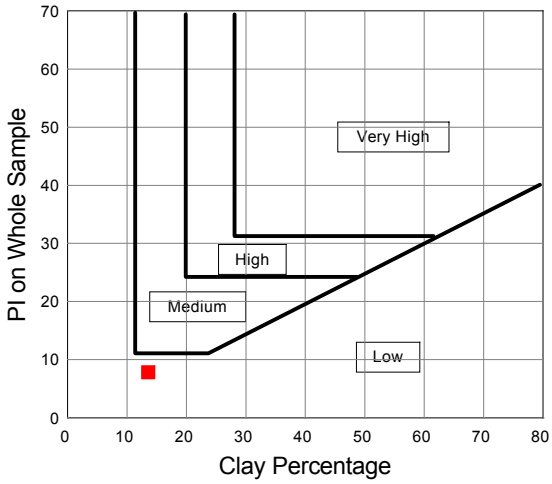
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0832	42.33
0.0599	40.60
0.0430	38.87
0.0312	36.28
0.0045	23.32
0.0014	11.23

ATTERBERG LIMITS & OTHER VALUES

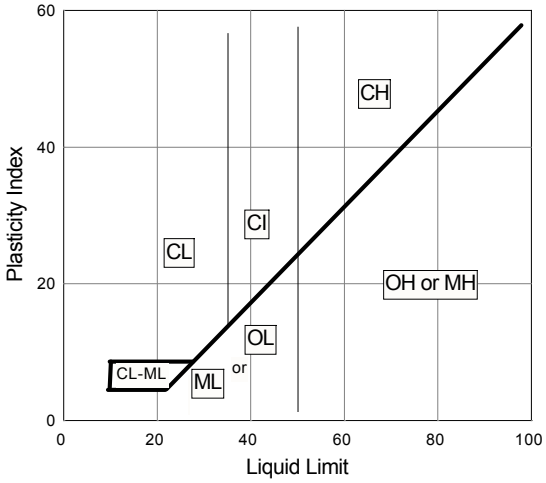
Liquid Limit	50
Plastic Limit	33
Plastic Index	17
Linear Shrinkage	9
Grading Modulus	1.29
Moisture Content	19.26
PI on Whole Sample	8
PRA Classification	A.7.5
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



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COLLAPSE POTENTIAL at 200 kPa

Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE P 16 @ 1,5 - 1,75m		
Date	07 DECEMBER 2015	Test No	2285
Job No	15288	Checked By	EB

Sample Height (mm)	20	Sample Diameter (mm)	64	Sample Specific Gravity	2.67

Sample Preparation	NMC

Effective Stress (kPa)	Time (mins)	Consolidation Reading	Voids Ratio	Strain (%)
10	90	335	0.748	0.00
10	480	336	0.747	0.05
33	1920	344	0.740	0.45
65	2040	357	0.728	1.10
127	2160	374	0.714	1.95
200	2400	386	0.703	2.55
200	3840	393	0.697	2.90
498	4050	438	0.658	5.15
993	4290	480	0.621	7.25
1868	5730	525	0.582	9.50
743	5850	519	0.587	9.20
118	5970	503	0.601	8.40
10	6090	484	0.617	7.45

Moisture Content Calculations

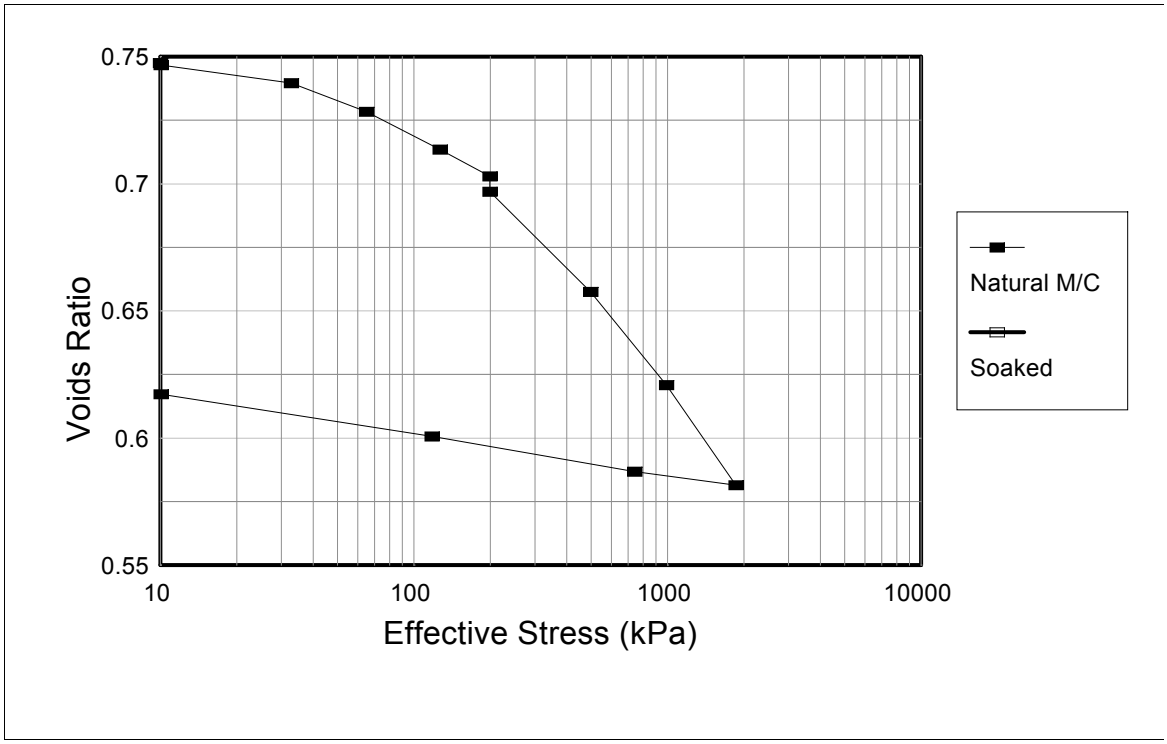
Mass wet sample plus ring before test (gms)	330.20
Mass wet sample plus ring after test (gms)	327.60
Mass dry sample plus ring (gms)	312.90
Mass ring (gms)	214.60
Moisture content before test (%)	**17.60**
Moisture content after test (%)	**14.95**

Other Data

Initial Dry Density (kg/m3)	**1528**
Initial Void Ratio	**0.75**

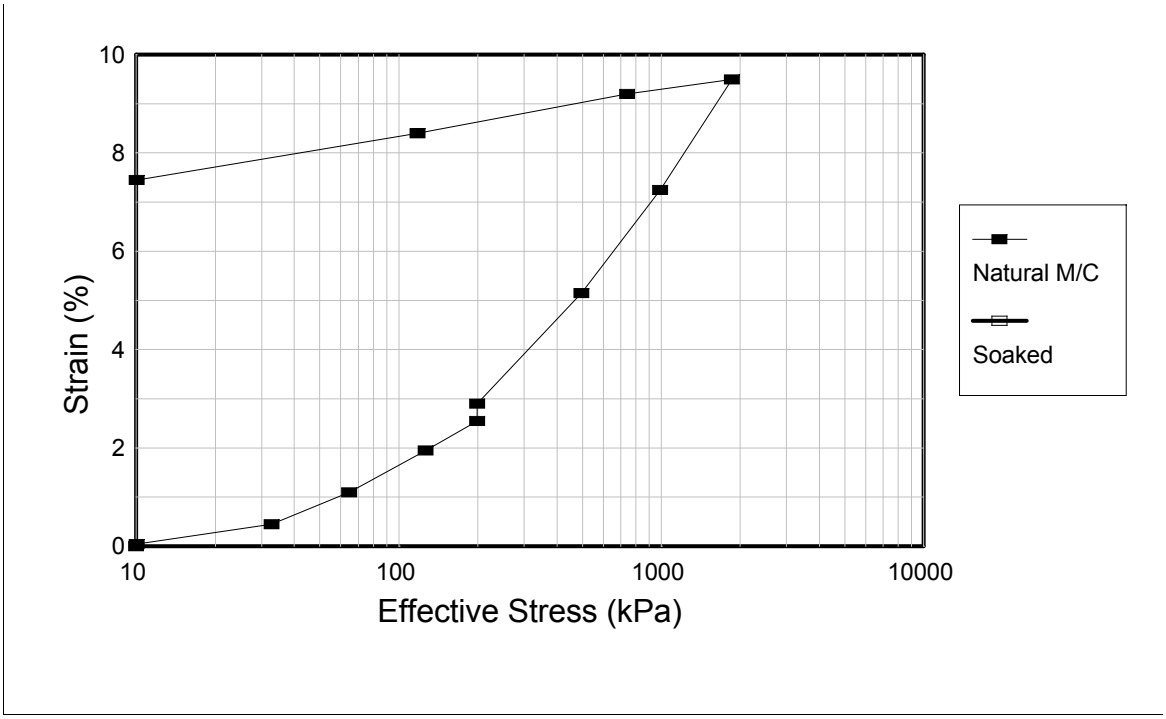
VOIDS RATIO v EFFECTIVE STRESS

Test No: 2285



STRAIN v EFFECTIVE STRESS

Test No: 2285



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FOUNDATION INDICATOR

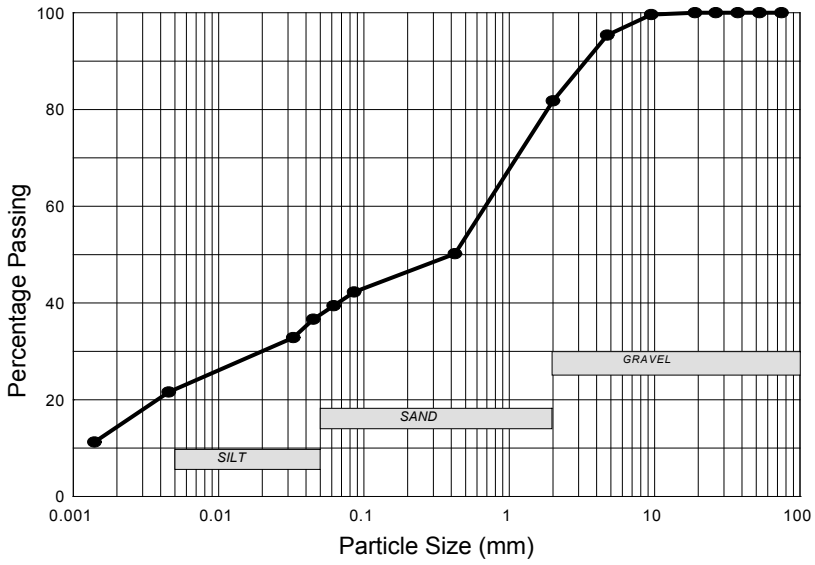
Client	GCS GEOTECHNICAL ENGINEERING		
Location	GAMSBERG MINE	P 18 @ 1,5 - 1,63m	
Date	07 DECEMBER 2015	Test No	2286
Job No	15307	Checked By	EB

SIEVE ANALYSIS

Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
75.00	100.00
53.00	100.00
37.50	100.00
26.50	100.00
19.00	100.00
9.50	99.67
4.75	95.39
2.00	81.81
0.425	50.19

GRADING ANALYSIS



HYDROMETER ANALYSIS

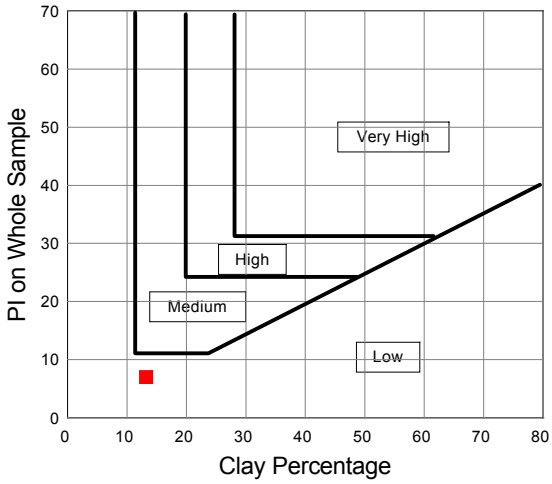
Values are expressed as a percentage of total sample

Sieve Size (mm)	Total Passing (%)
0.0861	42.30
0.0623	39.48
0.0451	36.66
0.0328	32.90
0.0046	21.62
0.0014	11.28

ATTERBERG LIMITS & OTHER VALUES

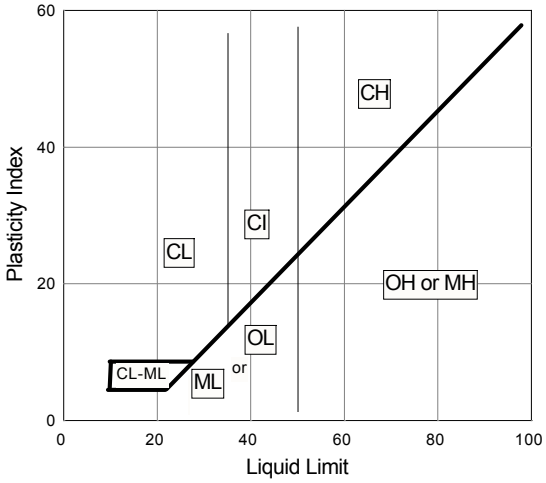
Liquid Limit	38
Plastic Limit	24
Plastic Index	14
Linear Shrinkage	7
Grading Modulus	1.26
Moisture Content	26.25
PI on Whole Sample	7
PRA Classification	A.6
Unified Classification	SC

ACTIVITY CHART



PLASTICITY CHART

for Fine Grained Soils



Revision No 3 (06/04/2001)

Geopractica
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SHEAR BOX

Client	GCS Consultants		
Location	Gamsberg (BHP18 1.5 - 1.63m)		
Date	7th December 2015	Test No	2287sb
Job No	15307	Checked By	cd

Sample Preparation	Undisturbed - Quick, undrained at NMC
Notes	Rate of strain 1.017 %/min

INITIAL M/C (%)	26.8
FINAL M/C (%)	22.4

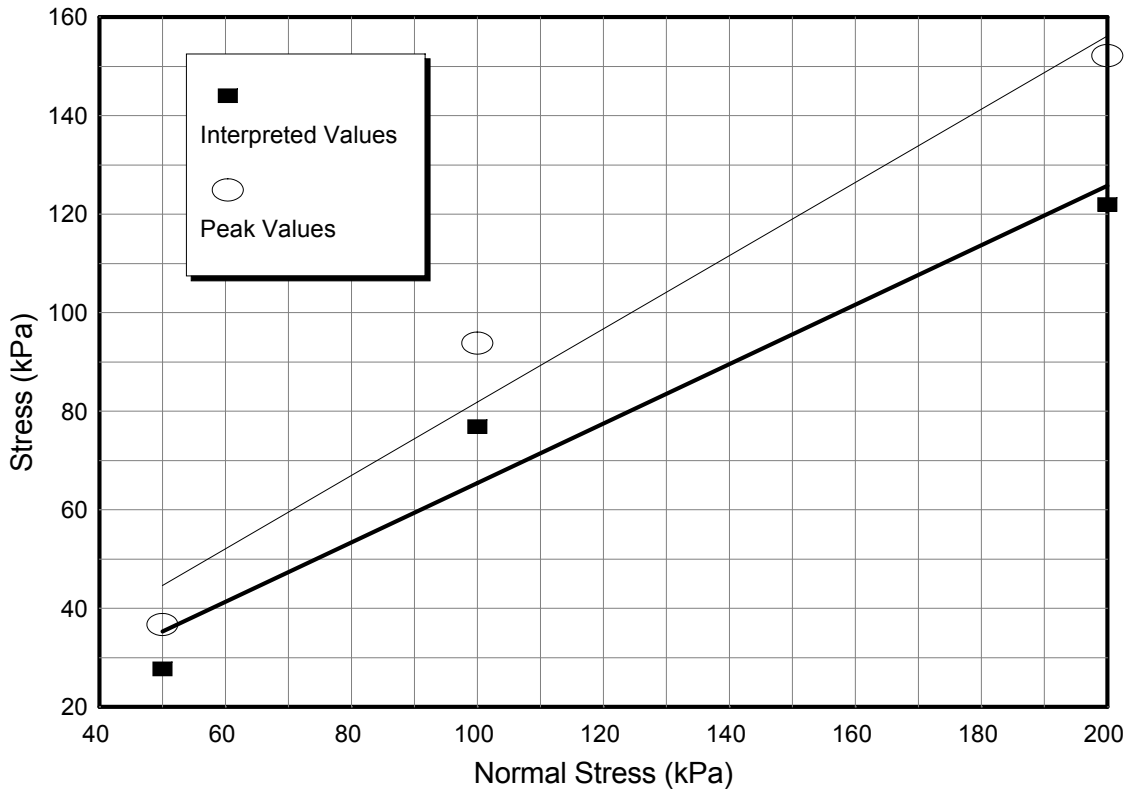
SHEAR PARAMETERS

a) Based on absolute "Peak Shear Stress" as obtained from laboraotory test

COHESION (kPa)	8
PHI (deg)	37

b) Based on "Interpretation" of peak stress based on shape of the stress / strain graph given on page 2 of this report

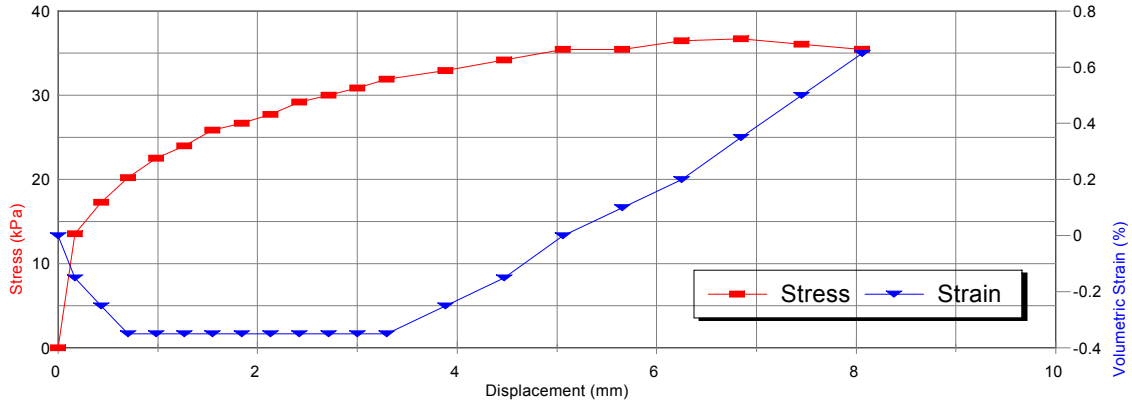
COHESION (kPa)	5
PHI (deg)	31



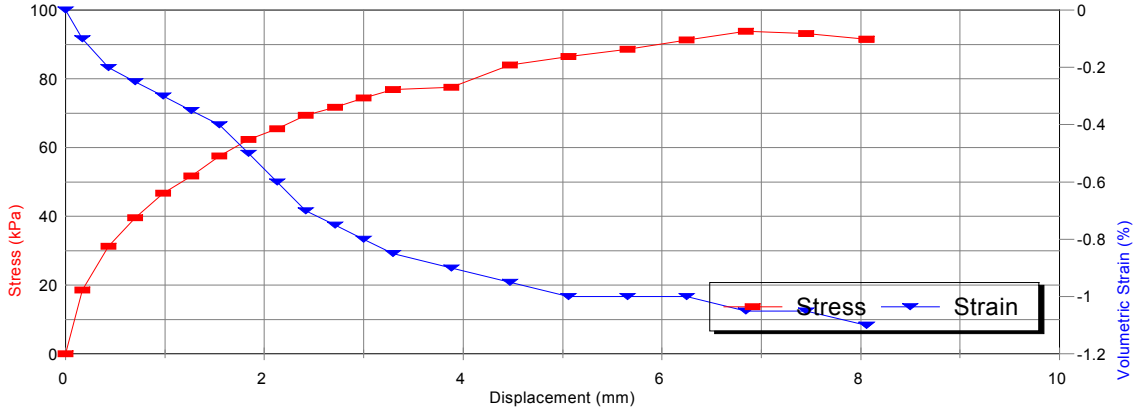
Programe Data
Revision No 1 (17/08/2001)

Test No	2287sb

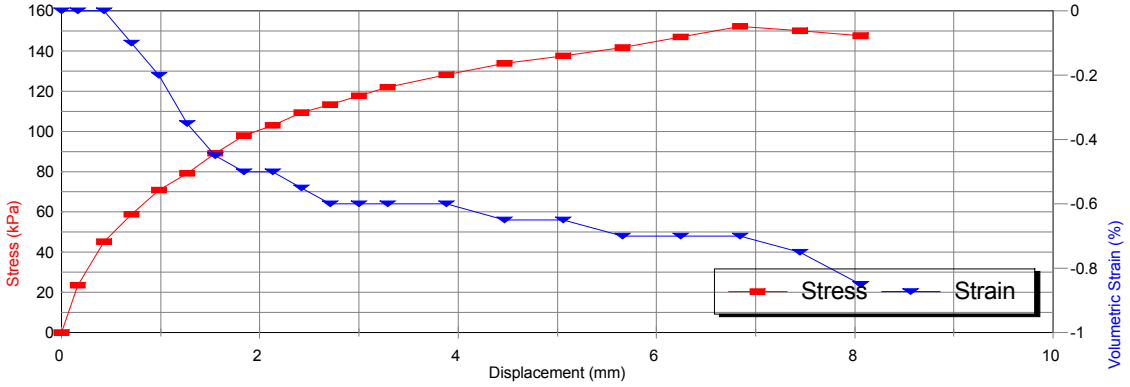
Cycle Number	1
Normal Stress (kPa)	50



Cycle Number	2
Normal Stress (kPa)	100



Cycle Number	3
Normal Stress (kPa)	200



GAMSBERG PLANT
APPENDIX C2
Laboratory Test Results-Rock

ROCKLAB REPORT **CONFIDENTIAL**
2015-GCS-GEOTECHNICAL-05

Issued by:

ROCKLAB
(ROCK MECHANICS & EXCAVATION LABORATORIES)
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LA MONTAGNE 0184
PRETORIA
SOUTH AFRICA
TEL: +27 12 813 4910
E-MAIL: CHENJ@ROCKLAB.CO.ZA

RESULTS OF ROCK PROPERTIES TESTS

Sampling site: Gamsberg Mine

BY

DR J. F. CHEN

Submitted to:

GCS GEOTECHJHICAL ENGINEERING

9 DECEMBER 2015

C O N T E N T S

TABLE 1 RESULTS OF UNIAXIAL COMPRESSIVE STRENGTH TESTS

ROCKLAB
DIVISION OF SOILLAB (PTY) LTD
Tel: 0027 12 813 4910
E-mail: Chenj@rocklab.co.za

Client: GCS Geotechnical Engineering

Sampling Site: Gamsberg Mine

09-12-2015

SPECIMEN PARTICULARS				SPECIMEN DIMENSIONS					SPECIMEN TEST RESULTS			
Rocklab Specimen No. 6449-	BH No	Depth From.. To.. m	Description	Diameter mm	Height mm	Ratio of Height to Diameter	Mass g	Density g/cm³	Failure Load kN	Strength (UCS) MPa	Failure Code	Note
UCS-01	P12	12.08-12.30	SR to MHR breciated shist	51.94	53.9	1.0	290.64	2.54	69.50	32.8	3B	
UCS-02	P10	6.15-6.26	VSR calcretised alluvium	53.39	105.7	2.0	439.54	1.86	1.31	0.6	XA	
UCS-03	P8	3.83-4.04	calcretised alluvial boulder	52.50	70.5	1.3	314.44	2.06	4.21	1.9	XA	
UCS-04	P04	4.24-4.38	VSR calcretised alluvium	52.35	53.9	1.0	203.00	1.75	5.63	2.6	XA	
UCS-05	P04	7.10-7.33	VSR to SR calcretised alluvium	51.87	97.3	1.9	415.61	2.02	5.07	2.4	XA	
UCS-06	P15	9.13-9.31	VSR calcretised alluvium	53.18	75.2	1.4	329.70	1.97	7.63	3.4	XA	
UCS-07	P18	5.14-5.27	VSR to SR calcretised alluvium	52.49	108.6	2.1	538.68	2.29	15.28	7.1	XA	
UCS-08	P09	9.80-9.96	calcretised alluvium VSR	52.90	123.0	2.3	511.81	1.89	10.63	4.8	XA	
UCS-09	P12	9.86-10.0	VSR to SR calcretised alluvium	51.95	98.2	1.9	390.02	1.87	8.22	3.9	XA	
UCS-10	P15	11.02-11.21	SR schist	52.18	128.7	2.5	655.57	2.38	8.77	4.1	2B	

Note: All tests were conducted according to the ISRM's (International Society for Rock Mechanics) specification.

APPENDIX 1

CLASSIFICATION OF ROCK SPECIMEN FAILURE MODE INFLUENCED / NOT INFLUENCED BY DISCONTINUITIES DURING COMPRESSION TESTING

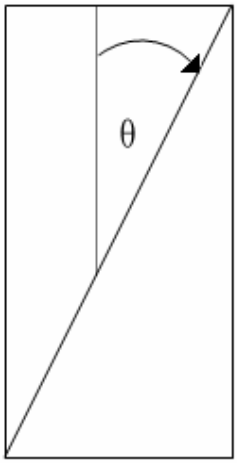
FAILURE NOT INFLUENCED BY DISCONTINUITIES (INTACT)

TYPE CODE	DESCRIPTION OF SUB CODES	
	A	B
X	SLIDING SHEAR FAILURE	COMPLETE CONE DEVELOPMENT
Y	SPLITTING	BREAKING INTO A LOT OF PIECES

FAILURE INFLUENCED BY DISCONTINUITIES

TYPE CODE	DESCRIPTION OF SUB CODES	
	A	B
	PARTIAL FAILURE ON DISCONTINUITY	FAILURE COMPLETELY ON DISCONTINUITY
1	AT 0-10° TO AXIS	AT 0-10° TO AXIS
2	AT 11-20° TO AXIS	AT 11-20° TO AXIS
3	AT 21-30° TO AXIS	AT 21-30° TO AXIS
4	AT 31-40° TO AXIS	AT 31-40° TO AXIS
5	AT 41-50° TO AXIS	AT 41-50° TO AXIS
6	AT 51-70° TO AXIS	AT 51-70° TO AXIS
7	AT 71-90° TO AXIS	AT 71-90° TO AXIS
0	Multiple Discontinuities	Multiple Discontinuities

Example: Failure Type3B: Failure completely on a discontinuity with an orientation of between 21° and 30° to the specimen axis.



GAMSBERG PLANT
APPENDIX D
ERT Results

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Geophysical Characterisation for Black Mountain Aggeneys Plant in Gamsberg, Upington

Report

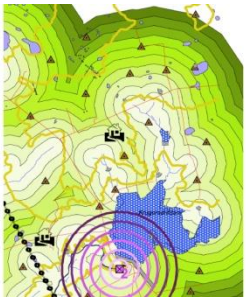
Version - **Final**

12 January 2016

Geomech Africa

GCS Project Number**: 15-549**

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Geophysical Characterisation for Black Mountain Aggeneys Plant in Gamsberg, Upington

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Geomech Africa
15-549

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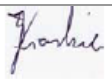
	Name	**Signature**	**Date**
Author	Teboho Shakes Shakhane		January 2016
Document Reviewer	Kobus Troskie		
Director	Nino Welland		

LEGAL NOTICE

EXECUTIVE SUMMARY

GCS Water & Environment (Pty) Ltd (GCS) was commissioned by Geomech Africa to conduct a geophysical characterisation for the proposed Black Mountain Aggeneys Plant. The study was aimed at characterising the shallow subsurface material properties using an electrical resistivity survey. The results of the survey will eventually be used to refine the geotechnical characterisation results.

The electrical resistivity survey, using a multi-electrode resistivity surveying technique known as Electrical Resistivity Tomography (ERT), was used to collect the subsurface apparent resistivity distribution data. The said data was collected along four (4) survey traverses: Traverse 1, 2, 3 and 4, all of which were 200 m long. Upon completion of the fieldwork, the measured apparent resistivity data was appropriately edited, processed and ultimately inverted to produce 2D apparent resistivity distribution profiles.

All the profiles for the inverted resistivity data, from all the survey traverses, indicated two principal resistivity characteristics. These include an area with relatively high resistivity values (≥179 Ωm) indicative of a substratum/bedrock. Overtop the substratum was a zone with relatively suppressed resistivity values (≤83 Ωm) indicative of a loose (unconsolidated) formation. The interpretation gave an indication of the general interface between the bedrock and unconsolidated zones ranging between z≈5 mbgl and z≈9 mbgl.

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1. INTRODUCTION

GCS Water & Environment (Pty) Ltd (GCS) was commissioned by Geomech Africa to conduct a geophysical characterisation for the proposed Black Mountain Aggeneys Plant. The study was aimed at characterising the shallow subsurface material properties using an electrical resistivity survey. The results of the survey will eventually be used to refine the geotechnical characterisation results.

2. SCOPE OF WORK

The scope of this work included the following:

- Geophysical survey,
- Data analysis and Interpretation; and,
- Reporting.

3. METHODOLOGY

The principal methodology followed in this work entailed the following:

- geological description of site;
- electrical Resistivity Tomography (ERT) survey;
- data analysis and interpretation; and,
- compilation of the report (this document).

3.1. Geological description

The geological extract from a 1:250 00 geological map over which the survey was undertaken is presented in Figure 1[1]. The map indicates that the site, over which the survey was undertaken, is located within quaternary sediments. These sediments comprise of sand, scree, rubble and sandy soils (Q-s2).

Surrounding areas are characterised by lithologies ranging from coarse-grained leucognesiss to layered sequence of bedded quartzite and politic schist.

[1] *The 1:250 000 geological map presented in this section is the intellectual property of the Council for Geoscience, South Africa and is used by permission. Copyright and all rights are reserved by the Lesotho government.*

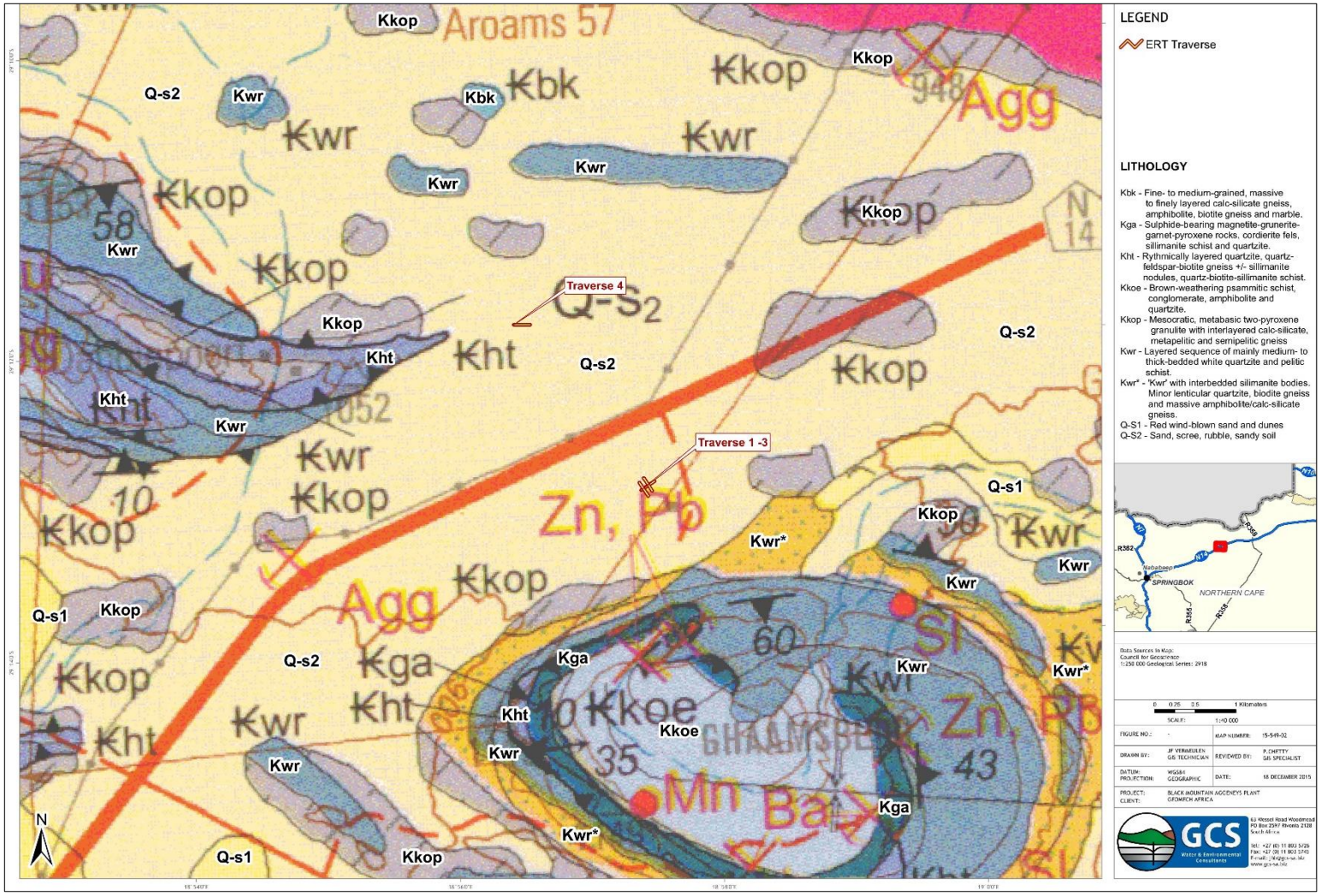


Figure 1: ERT traverses superimposed on to the geological extract from a 1:250 00 geological map

3.2. ER survey

3.2.1. Basic Principles Statement of ERT

The ERT system uses a series of electrodes along a straight line attached to a multi-core cable (e.g., 100 m long cable). A DC or slowly varying AC current is artificially injected into the Earth through a series of grounded current electrodes and the resulting potential measurements are made at a number of grounded potential electrode pairs. This information (injected current and the measured potential) is then used to calculate subsurface apparent resistivities.

The distances between the electrodes (two out current electrodes and two inner potential electrodes) are varied based on various four-electrode array configurations e.g., Wenner, Schlumberger, Dipole-dipole, etcetera. These array configurations all can be used to characterise subsurface material properties. However, the standard Wenner (Wenner α) and the hybrid Wenner-Schlumberger arrays are the most popular arrays and can be used interchangeably depending on the geological conditions (as per the geological description) and other related technical conditions (as per the site conditions).

Wenner-Schlumberger array has a slightly better horizontal coverage compared to the Wenner array; however, its signal strength is lower in areas where electrode grounding is partial and electromagnetic background noise is eminent. Therefore, the Wenner-Schlumberger array is usually deployed in suitable areas where electrode grounding is substantial and electromagnetic background noise is less. Due to a small geometric factor, a high signal-to-noise ratio and a smaller first fitting variance, Wenner leads to a strong signal and less noisy data even in areas with electromagnetic background noise. The geological map indicated that the site over which the survey was undertaken is located within quaternary sediments comprising of sand, scree, rubble and sandy soils. On site observations noted that these sediments were very dry and loose. As such, the standard Wenner protocol was preferred for this particular work.

In the Wenner array, the vertical resolution of the subsurface resistivities is achieved by increasing the common distance between the electrodes while maintaining the location of the centre point of the array. The horizontal resolution is achieved by moving the electrodes laterally across the surface while maintaining a constant electrode separation. The ultimate result is a 2D collection of raw subsurface resistivity measurements at different depths along a given survey line. The inversion (e.g., using the RES2Dinv inversion algorithm by Geotomo) of this 2D survey data results in a resistivity model graphically depicting the subsurface distribution of apparent resistivities depending on the geometry of the subsurface materials (e.g., rocks, clays, weathered zones etcetera) along the surveyed line.

3.2.2. Survey geometry

The survey geometry employed during the ERT survey is shown in Figure 2. The apparent resistivity data were recorded along four (4) survey traverses (Traverse 1, 2, 3 and 4) using the Terrameter SAS-1000 geoelectrical unit by ABEM. The survey was undertaken with four 100 m multicore cables with a spacing of 2.5 m between the take-outs probing maximum depth of 35 metres below ground level (mbgl). All of the survey traverses were 200 m long and oriented as shown in Figure 2. Traverse 1 and 4 were surveyed starting from the west to the east while Traverse 2 and 3 were surveyed from the north to south. The starting and ending coordinates for the surveyed traverse are presented in Table 1.

Table 1: Starting and ending coordinates for the four surveyed traverses

Traverses	Coordinates***			
	Start		End	
	Latitude	Longitude	Latitude	Longitude
1	-29.2166	18.95788	-29.2157	18.95958
2	-29.2153	18.95823	-29.2167	18.95926
3	-29.2158	18.95769	-29.2173	18.95876
4	-29.1978	18.94253	-29.1979	18.9446

***WGS98*

3.3. Data Analysis and Interpretation

Upon completion of the fieldwork, the 2D measured apparent resistivity data was appropriately edited, processed and ultimately inverted using the RES2Dinv inversion algorithm by Geotomo. Prior to the inversion of the data, the following processing and editing steps were undertaken on the raw data:

- noisy data were checked on each profile (*e.g.,* -ve values);,
- bad data points were checked (*e.g.,* large single data point anomalies);,
- a trial for the inversion data was made and an initial model performed to check the RMS error between the observed and calculated apparent resistivity (bad data points with large RMS errors would be cut-off from the original data using the RMS error statistics bar chart in RES2D program); and,
- final inversion model with least RMS (a rule of thumb is that the percent RMS be ≥100% on the RMS error statistics bar chart).

The resultant 2D data were then interpreted based on the scientifically proven link between apparent resistivity characteristics and subsurface material properties as per the requirements of the survey.

Figure 2: A Google satellite extract showing the positions and orientations of the survey traverses

4. SURVEY RESULTS

In this section, the results of the geoelectrical surveys are presented as two-dimensional (2D) resistivity models of the subsurface. In the models, the horizontal (*x*-) axis represents the position along the survey line, while the vertical (*z*-) axis represents the depth below surface, both given in metres (m). Because the survey traverses are all situated on the same geological properties, as revealed by the geological map, the same colour scale is used on all the survey profiles in order to be able to draw comparisons between the inverse resistivity profiles.

The inversion profiles of the subsurface apparent resistivity data collected along survey Traverse 1, 2 and 3 are presented in Figure 3. Profile 1 of the inverted resistivity data from Traverse 1 indicates two principal resistivity characteristics. This includes an area with relatively high resistivity values (≥179 Ωm) indicative of a substratum/bedrock. Overtop the substratum is a zone with an offset in terms of resistivity values from ≥179 Ωm to ≤83 Ωm indicative of a loose (unconsolidated) formation. Similar subsurface resistivity characteristics are also observable on the inverted resistivity data in Profile 2 and 3 (for Traverse 1 and 3 respectively). The interpretation given to the three resistivity profiles give an indication of the general interface between the bedrock and unconsolidated zones which is, on average, $z \approx 9$ mbgl.

The inversion profile (Profile 4) of resistivity data obtained from Traverse 4 shows similar results as those obtained from Traverse 1, 2 and 3. The only difference is that the substratum is relatively shallower; $z \approx 5$ mbgl on average. It must be noted that, the unconsolidated formation interpreted from all the profiles appears to show heterogeneous resistivity distribution. This indicates differences in terms of the degree of consolidation. Areas with resistivity distribution between 1.79 Ωm and 38.6 Ωm could be interpreted as the relatively less loose material while the one ranging between 38.6 Ωm and 83 Ωm could possibly be relatively more unconsolidated. In Profile 4, the unconsolidated zone appears to deepen at an area around $x \approx 45$ m and at $x \approx 160$ m to the end of the model.

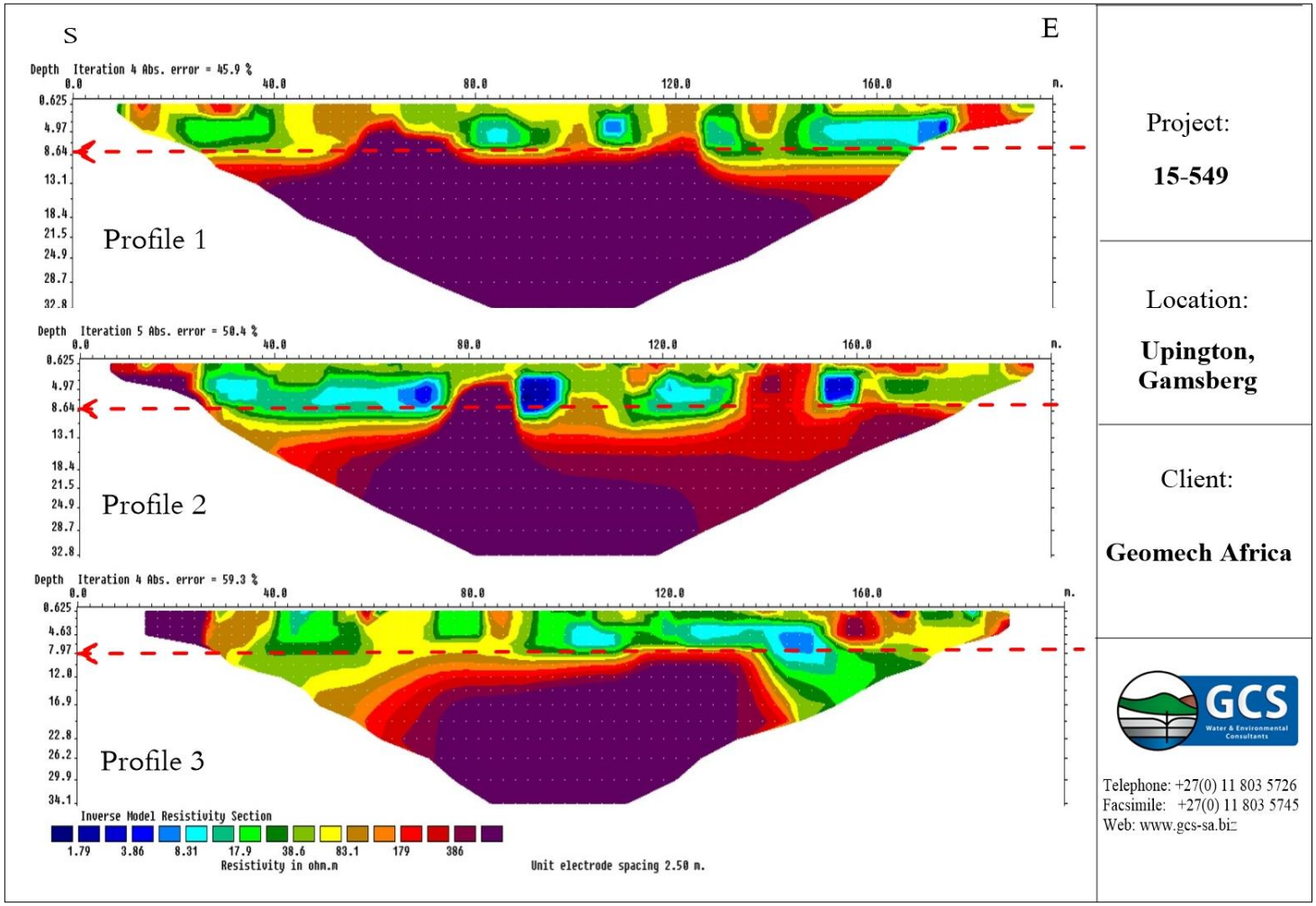


Figure 3: Inverted profiles for the subsurface apparent resistivity data obtained from the three (Traverse 1, Profile 2 and Traverse 3) survey traverses (red dotted line indicates average interface between bedrock and unconsolidated zone)

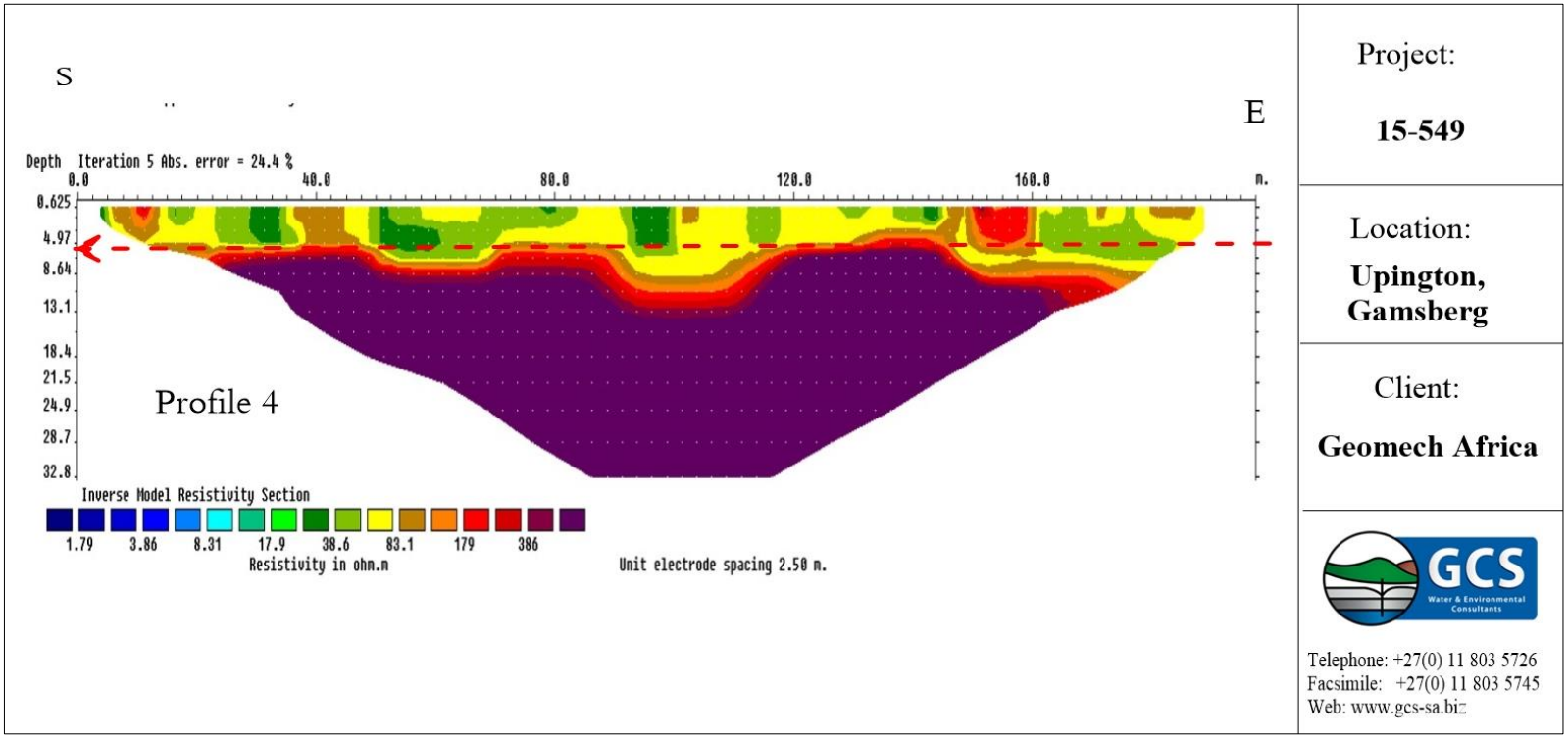


Figure 4: Inverted profile for the subsurface apparent resistivity data obtained from Traverse 4

CONCLUSION

From the results of the ERT investigations, considerable resistivity contrasts have been consistently observed. These contrasts have been distinguished between unconsolidated materials overlying a bedrock at depth. The interpretation gave an indication of the general interface between the bedrock and unconsolidated zones ranging between $z \approx 5$ mbgl and $z \approx 9$ mbgl. The coordinates in Table 2 represent areas that need to be treated with caution because the unconsolidated zone appeared to deepen considerably.

It must be noted that, geophysical surveying techniques most commonly do not measure subsurface geoelectrical properties in absolute terms but differences in relative terms. As such, values provided are not absolute values of the subsurface.

Table 2: Areas with the possibly deeper unconsolidated material

Distance on the Traverse (m)	Coordinates**	
	Latitude	Longitude
45	-29.216096°	18.957915°
160	-29.216998°	18.958564°

***WGS98*

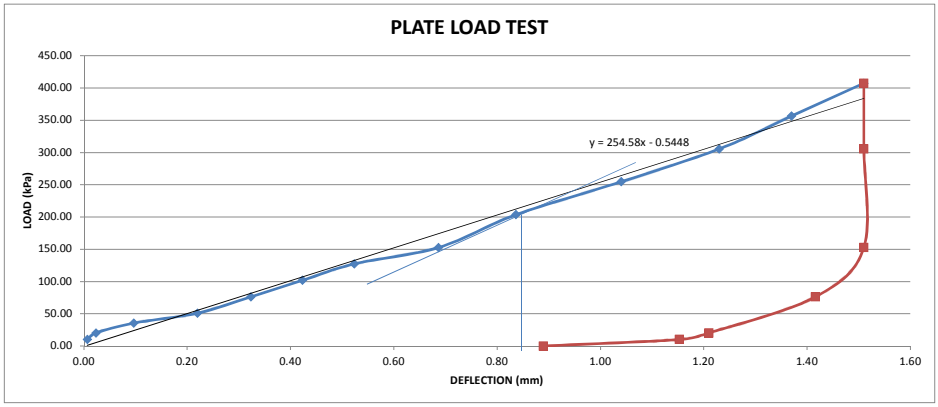
GAMSBERG
APPENDIX E
Plate Load Test Results

Client:	Verdanta Resources	Date:	13/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P1	Operator:	DM
Site	Plant Area		
Depth (m)	0.46		

Calibration: 1MPa = 6.79 kPa (CALCULATED FROM GAUGE)

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.4	2.55	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0	0	0	0.00
LOAD	1.4	10.19	2	0.02	0	0	0.01
	2.8	20.37	4	0.07	0	0	0.02
	4.9	35.65	7	0.19	0.04	0.06	0.10
	7.0	50.93	10	0.4	0.11	0.15	0.22
	10.5	76.39	15	0.5	0.15	0.32	0.32
	14.0	101.86	20	0.7	0.19	0.38	0.42
	17.6	127.32	25	0.9	0.26	0.41	0.52
	21.1	152.79	30	1.06	0.36	0.64	0.69
	28.1	203.72	40	1.36	0.37	0.78	0.84
	35.1	254.65	50	1.63	0.44	1.05	1.04
	42.1	305.58	60	1.87	0.5	1.32	1.23
	49.2	356.51	70	2.03	0.58	1.5	1.37
	56.2	407.44	80	2.2	0.63	1.7	1.51
UNLOADING	42.1	305.58	60	2.2	0.63	1.7	1.51
	21.1	152.79	30	2.2	0.63	1.7	1.51
	10.5	76.39	15	2.2	0.52	1.53	1.42
	2.8	20.37	4	2.07	0.34	1.22	1.21
	1.4	10.19	2	2.03	0.28	1.15	1.15
	0.0	0.00	0	1.82	0.04	0.81	0.89

All loads and unloads timed at 5min intervals



Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{0.825} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 86.6 MPa

Modulus Of Subgrade Reaction K

Calculated at 1.0mm deflection

$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{33.7}{1.0}$$

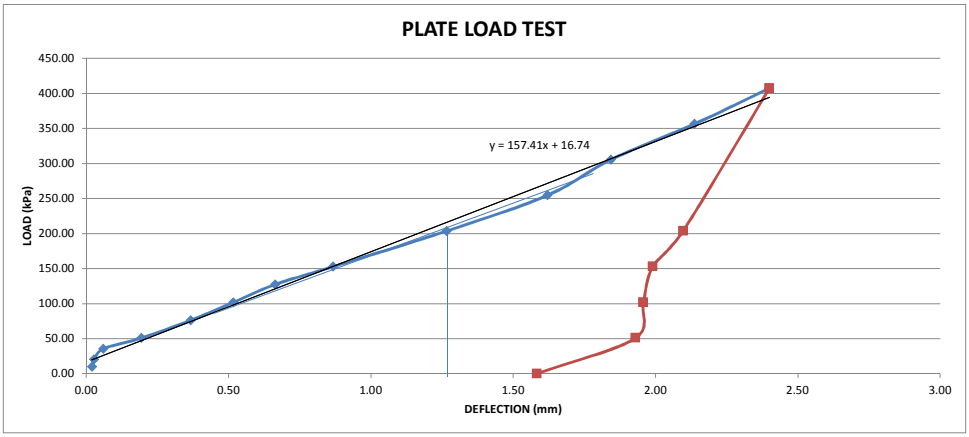
$K =$ 33.7 MPa/mm

Client:	Verdanta Resources	Date:	13/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P3	Operator:	DM
Site	Plant Area		
Depth (m)	1.35		

Calibration: 1MPa = 6.79 kPa (CALCULATED FROM GAUGE)

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0.01	0.01	0.01	0.01
LOAD	1.4	10.19	2	0.02	0.02	0.02	0.02
	2.8	20.37	4	0.03	0.02	0.03	0.03
	4.9	35.65	7	0.06	0.04	0.08	0.06
	7.0	50.93	10	0.19	0.28	0.11	0.19
	10.5	76.39	15	0.36	0.54	0.2	0.37
	14.0	101.86	20	0.58	0.72	0.25	0.52
	17.6	127.32	25	0.82	0.86	0.31	0.66
	21.1	152.79	30	1.07	1.02	0.51	0.87
	28.1	203.72	40	1.61	1.32	0.87	1.27
	35.1	254.65	50	2.07	1.61	1.18	1.62
	42.1	305.58	60	2.42	1.86	1.25	1.84
	49.2	356.51	70	2.73	2.12	1.56	2.14
	56.2	407.44	80	3.04	2.34	1.82	2.40
UNLOADING	28.1	203.72	40	2.54	2.34	1.41	2.10
	21.1	152.79	30	2.48	2.29	1.2	1.99
	14.0	101.86	20	2.45	2.26	1.16	1.96
	7.0	50.93	10	2.44	2.24	1.11	1.93
	0.0	0.00	0	2.15	1.78	0.82	1.58

All loads and unloads timed at 5min intervals



Elastic Modulus/Young Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{1.237} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 57.8 Mpa

Modulus of subgrade reaction K

Calculated at 1.0mm deflection

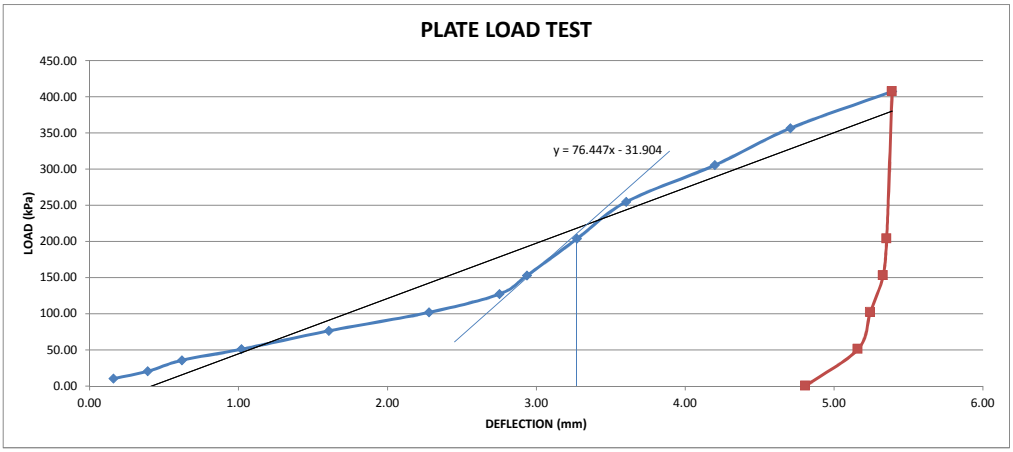
$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{25.3}{1.0}$$

K= *25.3* Mpa

Client:	Verdanta Resources	Date:	18/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P19	Operator:	DM
Site	Tailings Site		
Depth (m)	0.60		

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0.14	0.05
HALF BEDDING	0.7	5.09	1	0	0	0.24	0.08
	1.4	10.19	2	0.06	0	0.42	0.16
	2.8	20.37	4	0.1	0.03	1.04	0.39
	4.9	35.65	7	0.14	0.06	1.66	0.62
	7.0	50.93	10	0.28	0.42	2.36	1.02
	10.5	76.39	15	1.27	1.1	2.45	1.61
	14.0	101.86	20	2.17	1.55	3.12	2.28
LOAD	17.6	127.32	25	2.99	2.15	3.12	2.75
	21.1	152.79	30	2.99	2.35	3.47	2.94
	28.1	203.72	40	3.33	2.97	3.52	3.27
	35.1	254.65	50	3.69	3.54	3.58	3.60
	42.1	305.58	60	4.15	3.96	4.49	4.20
	49.2	356.51	70	4.35	4.38	5.39	4.71
	56.2	407.44	80	5.34	4.69	6.14	5.39
	28.1	203.72	40	5.33	4.65	6.08	5.35
	21.1	152.79	30	5.33	4.62	6.04	5.33
UNLOADING	14.0	101.86	20	5.33	4.56	5.84	5.24
	7.0	50.93	10	5.32	4.48	5.68	5.16
	0.0	0.00	0	5.05	3.86	5.51	4.81

All loads and unloads timed at 5min intervals



Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{3.248} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 22.0 Mpa

Modulus Of Subgrade Reaction K

Calculated at 1.0mm deflection

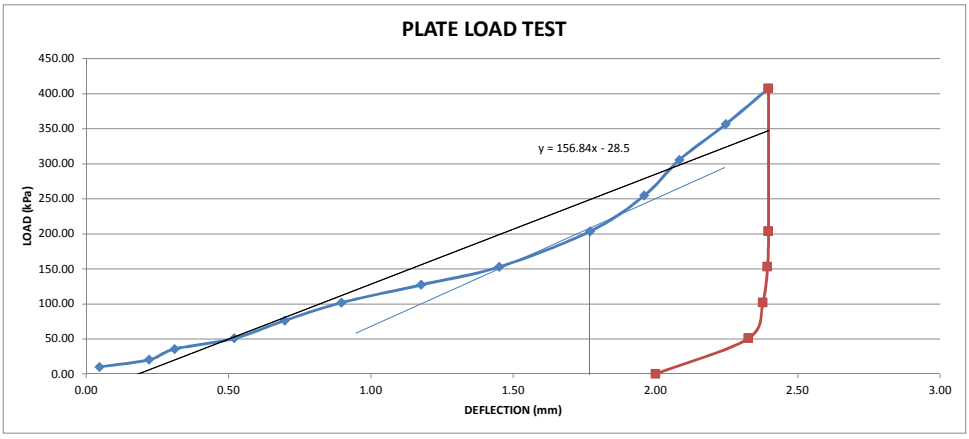
$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{33.7}{1.0}$$

K= *44.82* MPa/mm

Client:	Verdanta Resources	Date:	13/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P19	Operator:	DM
Site	Plant Area		
Depth (m)	1.70		

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0.04	0.02	0.01	0.02
LOAD	1.4	10.19	2	0.1	0.02	0.02	0.05
	2.8	20.37	4	0.6	0.02	0.04	0.22
	4.9	35.65	7	0.81	0.05	0.07	0.31
	7.0	50.93	10	1.04	0.28	0.24	0.52
	10.5	76.39	15	1.28	0.39	0.42	0.70
	14.0	101.86	20	1.52	0.48	0.69	0.90
	17.6	127.32	25	1.86	0.72	0.95	1.18
	21.1	152.79	30	2.23	0.99	1.13	1.45
	28.1	203.72	40	2.68	1.19	1.44	1.77
	35.1	254.65	50	2.91	1.4	1.57	1.96
	42.1	305.58	60	3.17	1.47	1.61	2.08
	49.2	356.51	70	3.38	1.57	1.79	2.25
	56.2	407.44	80	3.58	1.71	1.9	2.40
UNLOADING	28.1	203.72	40	3.58	1.71	1.9	2.40
	21.1	152.79	30	3.57	1.71	1.9	2.39
	14.0	101.86	20	3.52	1.71	1.9	2.38
	7.0	50.93	10	3.5	1.66	1.82	2.33
	0.0	0.00	0	3.22	1.34	1.44	2.00

All loads and unloads timed at 5min intervals



Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{1.746} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 40.9 Mpa

Modulus Of Subgrade Reaction K

Calculated at 1.0mm deflection

$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{16.58}{1.0}$$

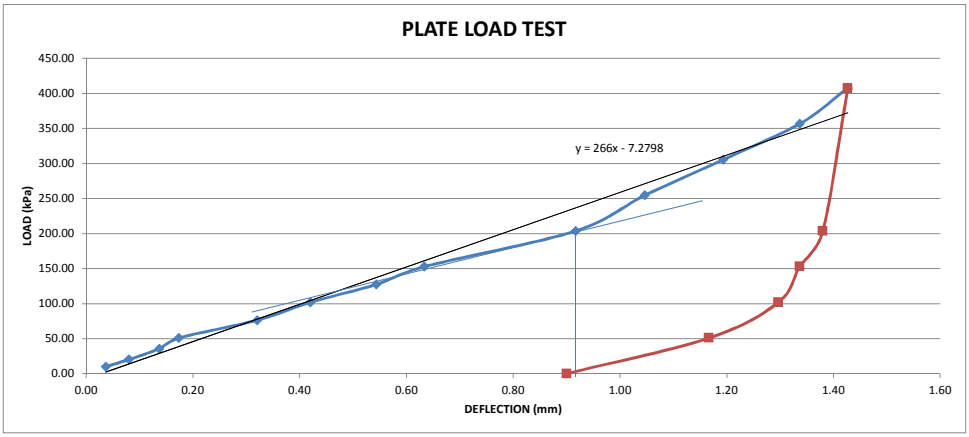
K= *16.58* MPa/mm

Client:	Verdanta Resources	Date:	18/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P23-24	Operator:	DM
Site	Tailings Site		
Depth (m)	0.35		

Calibration: 1MPa = 6.79 kPa (CALCULATED FROM GAUGE)

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0.03	0.03	0.03	0.03
	1.4	10.19	2	0.04	0.04	0.03	0.04
	2.8	20.37	4	0.1	0.1	0.04	0.08
	4.9	35.65	7	0.17	0.17	0.07	0.14
	7.0	50.93	10	0.2	0.2	0.12	0.17
	10.5	76.39	15	0.35	0.35	0.26	0.32
	14.0	101.86	20	0.46	0.46	0.34	0.42
LOAD	17.6	127.32	25	0.58	0.58	0.47	0.54
	21.1	152.79	30	0.65	0.65	0.6	0.63
	28.1	203.72	40	0.97	0.97	0.81	0.92
	35.1	254.65	50	1.1	1.1	0.94	1.05
	42.1	305.58	60	1.25	1.25	1.08	1.19
	49.2	356.51	70	1.36	1.36	1.29	1.34
	56.2	407.44	80	1.45	1.45	1.38	1.43
	28.1	203.72	40	1.45	1.33	1.36	1.38
	21.1	152.79	30	1.42	1.3	1.29	1.34
UNLOADING	14.0	101.86	20	1.38	1.27	1.24	1.30
	7.0	50.93	10	1.16	1.14	1.2	1.17
	0.0	0.00	0	0.83	0.89	0.98	0.90

All loads and unloads timed at 5min intervals



Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{0.895} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 79.8 Mpa

Modulus Of Subgrade Reaction K

Calculated at 1.0mm deflection

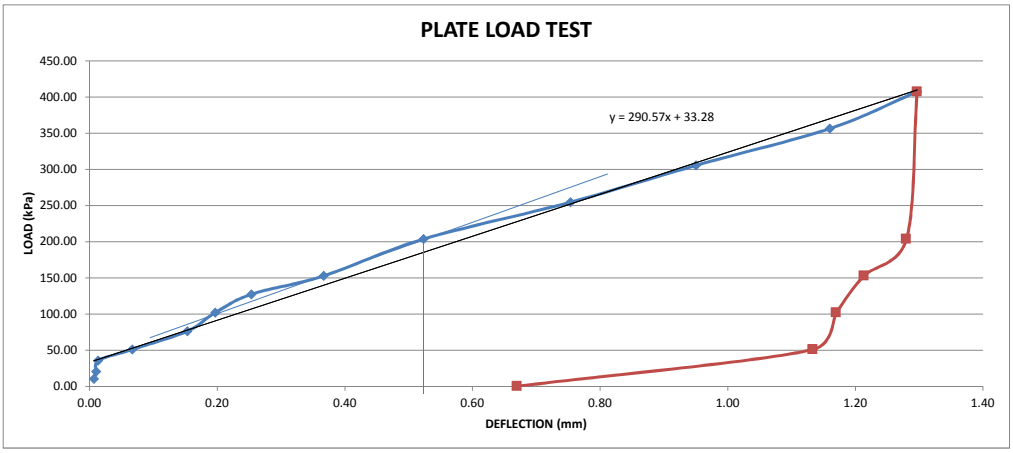
$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{33.7}{1.0}$$

K= *34.21* MPa/mm

Client:	Verdanta Resources	Date:	13/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P25	Operator:	DM
Site	Tailings Site		
Depth (m)	0.70		

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0.01	0	0.01	0.01
LOAD	1.4	10.19	2	0.01	0	0.01	0.01
	2.8	20.37	4	0.01	0	0.02	0.01
	4.9	35.65	7	0.01	0	0.03	0.01
	7.0	50.93	10	0.01	0	0.19	0.07
	10.5	76.39	15	0.01	0	0.45	0.15
	14.0	101.86	20	0.01	0	0.58	0.20
	17.6	127.32	25	0.01	0	0.75	0.25
	21.1	152.79	30	0.15	0	0.95	0.37
	28.1	203.72	40	0.4	0	1.17	0.52
	35.1	254.65	50	0.59	0.32	1.35	0.75
	42.1	305.58	60	0.84	0.42	1.59	0.95
	49.2	356.51	70	1.1	0.52	1.86	1.16
	56.2	407.44	80	1.3	0.56	2.03	1.30
UNLOADING	28.1	203.72	40	1.3	0.56	1.98	1.28
	21.1	152.79	30	1.2	0.56	1.88	1.21
	14.0	101.86	20	1.15	0.56	1.8	1.17
	7.0	50.93	10	1.1	0.56	1.74	1.13
	0.0	0.00	0	0.35	0.51	1.15	0.67

All loads and unloads timed at 5min intervals



Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{0.511} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 139.6 Mpa

Modulus Of Subgrade Reaction K

Calculated at 1.0mm deflection

$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{47.7}{1.0}$$

K= *47.70* MPa/mm

Client:	Verdanta Resources	Date:	13/11/2015
Project:	Gamsberg Mine	Reference No:	15-549
Test No.	P25	Operator:	DM
Site	Tailings Site		
Depth (m)	1.70		

	Applied Load (MPa)	Applied Load (kPa)	kN	Gauge 1 (mm)	Gauge 2 (mm)	Gauge 3 (mm)	Average (mm)
BEDDING	0.1	1.00	0.5	0	0	0	0.00
HALF BEDDING	0.7	5.09	1	0.08	0.08	0.08	0.08
LOAD	1.4	10.19	2	0.1	0.1	0.1	0.10
	2.8	20.37	4	0.16	0.16	0.16	0.16
	4.9	35.65	7	0.29	0.29	0.29	0.29
	7.0	50.93	10	0.58	0.58	0.58	0.58
	10.5	76.39	15	0.81	0.81	0.81	0.81
	14.0	101.86	20	1.07	1.07	1.07	1.07
	17.6	127.32	25	1.2	1.2	1.2	1.20
	21.1	152.79	30	1.26	1.26	1.26	1.26
	28.1	203.72	40	1.7	1.7	1.7	1.70
	35.1	254.65	50	1.99	1.99	1.99	1.99
	42.1	305.58	60	2.22	2.22	2.22	2.22
	49.2	356.51	70	2.3	2.3	2.3	2.30
	56.2	407.44	80	2.37	2.37	2.37	2.37
UNLOADING	28.1	203.72	40	2.37	2.42	2.16	2.32
	21.1	152.79	30	2.28	2.35	2.1	2.24
	14.0	101.86	20	2.21	2.3	1.98	2.16
	7.0	50.93	10	2.08	2.24	1.87	2.06
	0.0	0.00	0	1.52	1.8	1.61	1.64

All loads and unloads timed at 5min intervals

Elastic Modulus/Youngs Modulus

Stress Range 0 - 200 kPa

$$E = \frac{\pi}{4} \cdot \frac{P}{\rho} \cdot D\,(1 - \gamma^2) \qquad E = \frac{\pi}{4} \cdot \frac{200}{1.667} \cdot 0.5\,(1 - 0.3^2)$$

$E =$ 42.9 Mpa

Modulus Of Subgrade Reaction K

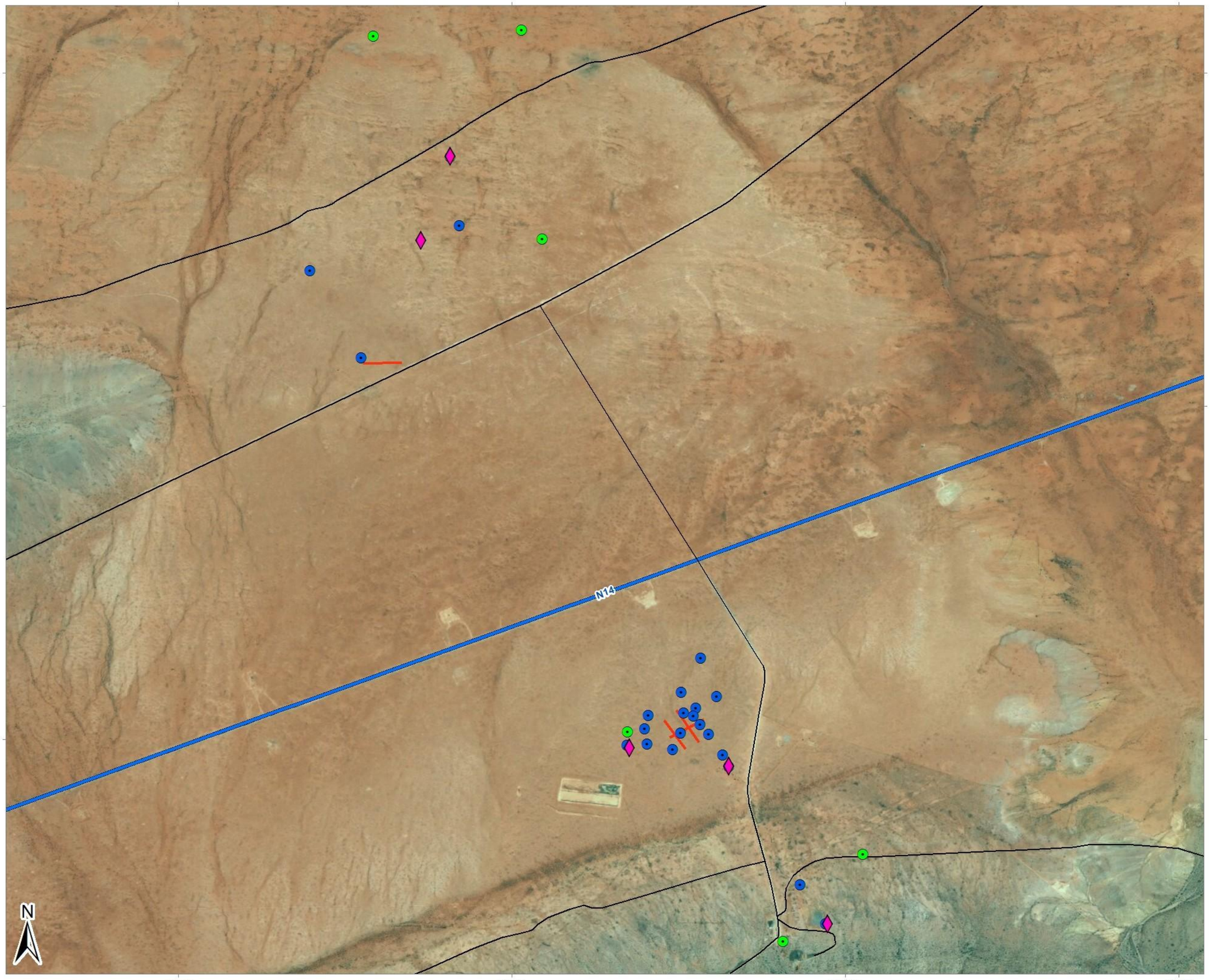
Calculated at 1.0mm deflection

$$K = \frac{Load\ (MPa)}{Deflection\ (mm)} \qquad K = \frac{33.7}{1.0}$$

K= *13.1* MPa/mm

GAMSBERG PLANT
SITE PLANS

FIGURE 1: SITE PLAN SHOWING TEST POSITIONS



LEGEND

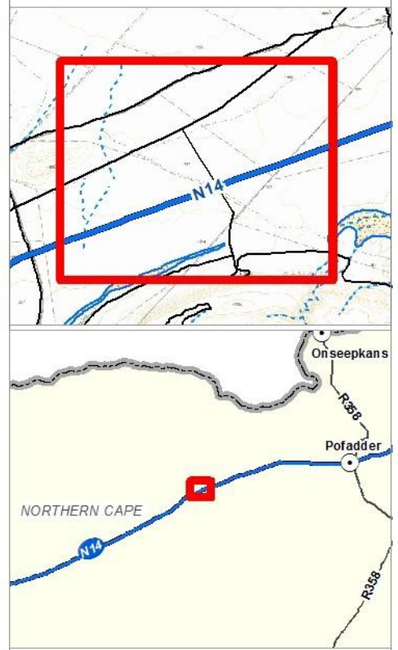
- Test Pits & Plate Load Tets

Borehole

- Borehole Drilled
- Borehole Removed from Programme

Road Network

- National Route
- Main Road
- Secondary Road
- Street
- Electrical Resistivity Line



Data Sources:

NGI Topographical Data Series & Aerial Photography
Google Earth
ArcGIS Online
Extent Data From Client

0 250 500 1 000 Meters

SCALE: 1:20 000

FIGURE NO.:	-	MAP NUMBER:	15-549-03
DRAWN BY:	G.JONES GIS TECHNOLOGIST	REVIEWED BY:	S.KELLY ENG. GEOLOGIST
DATUM: PROJECTION:	WGS84 GEOGRAPHIC	DATE:	JANUARY 2016
PROJECT:	GAMSBERG MINE GEOTECH		
CLIENT:	GEOMECH AFRICA (PTY) LTD		

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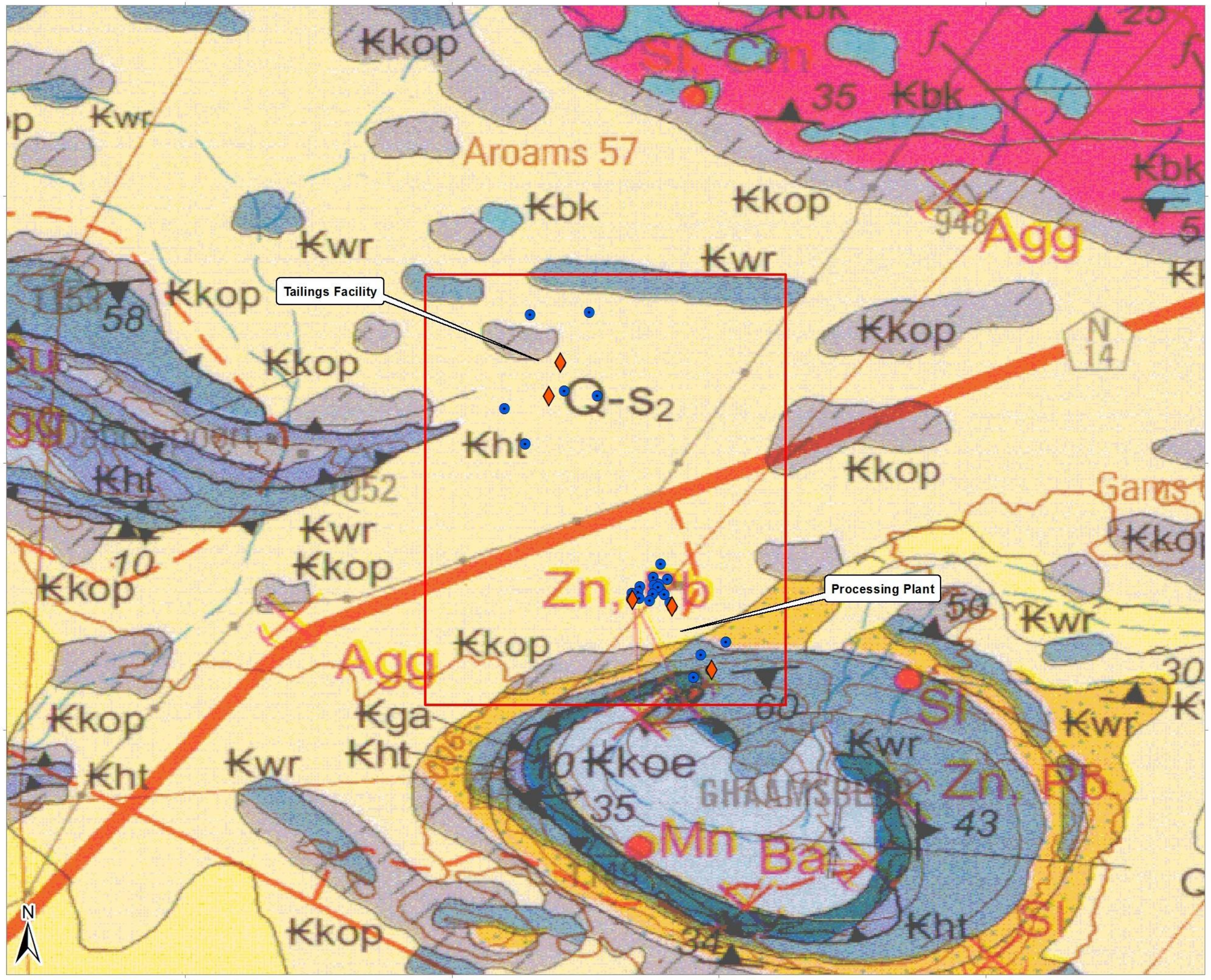
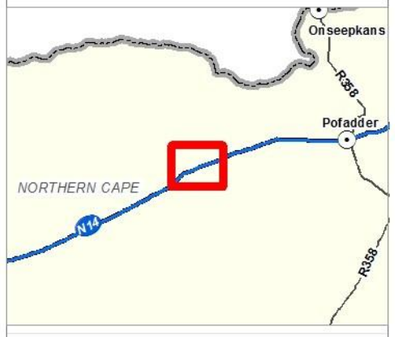
FIGURE 2: GEOLOGY MAP



LEGEND

- Test Pits & Plate Load Test
- Original Borehole Positions
- Extent Location
- Q-s — Sand, scree, rubble, sandy soil
- Kwr — Layered sequence of maily medium to thick bedded, white quartzite and pelitic schist with interbed-ded sillimanite bodies. Minor lenticular quartzite, biotite gneiss and massive amphibolite/calc-silicate gneiss
- Kht — Rhythmically layered quartzite, quartz-feldspar-biotite gneiss +/- sillimanite nodules, quartz-biotite-sillimanite schist



Data Sources:

NGI Topographical Data Series & Aerial Photography
Google Earth
ArcGIS Online
Extent Data From Client

0 625 1 250 2 500 Meters

SCALE:	1:50 000		
FIGURE NO.:	-	MAP NUMBER:	15-549-02
DRAWN BY:	G.JONES GIS TECHNOLOGIST	REVIEWED BY:	S.KELLY ENG. GEOLOGIST
DATUM: PROJECTION:	WGS84 GEOGRAPHIC	DATE:	JANUARY 2016
PROJECT:	GAMSBERG MINE GEOTECH		
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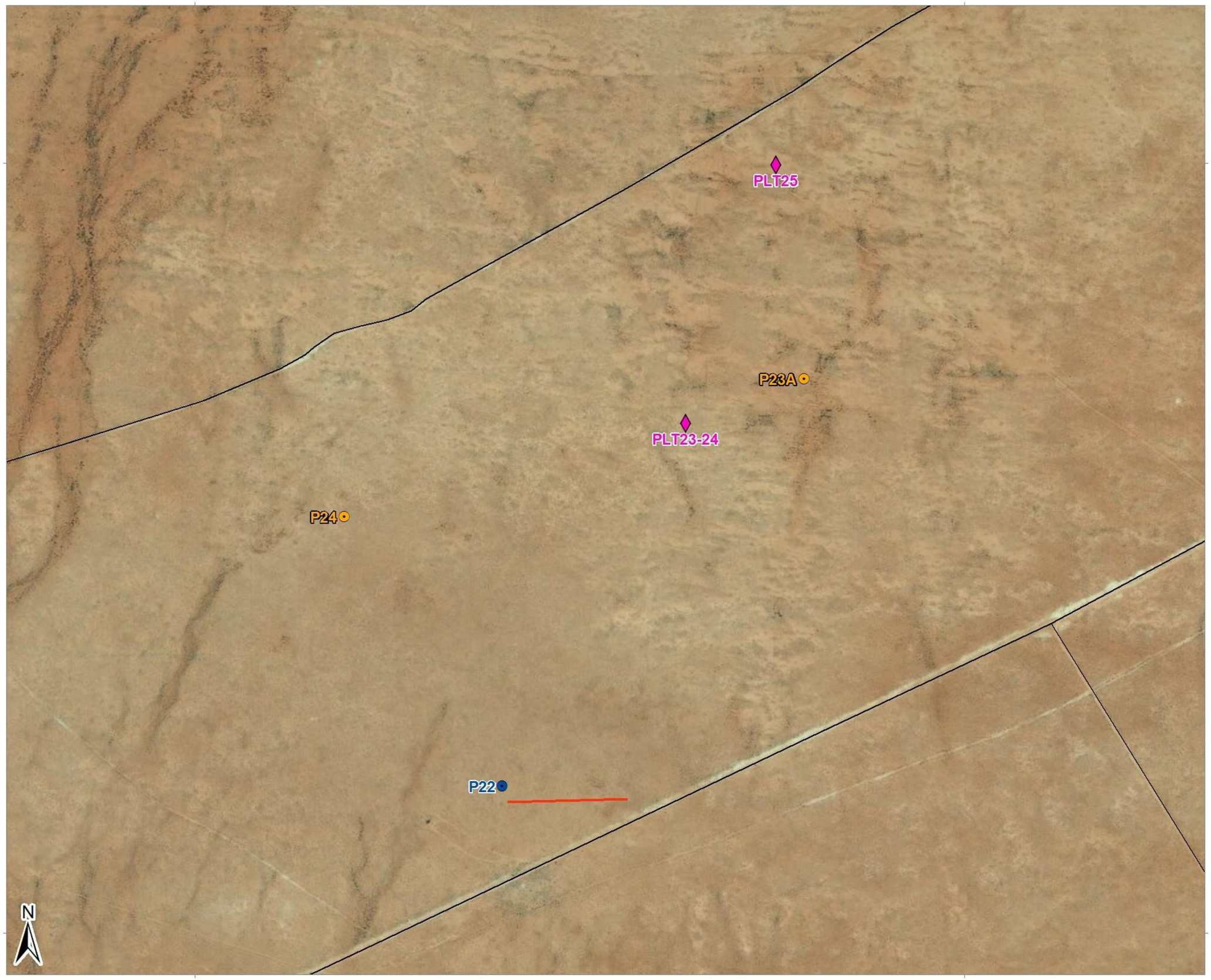
FIGURE 3A: SITE PLAN SHOWING GEOTECHNICAL CONSTRAINTS OF TAILINGS SITE



LEGEND

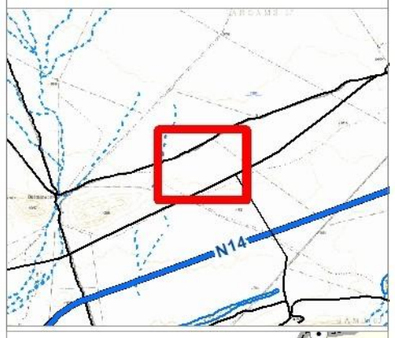
- Test Pits & Plate Load Tets

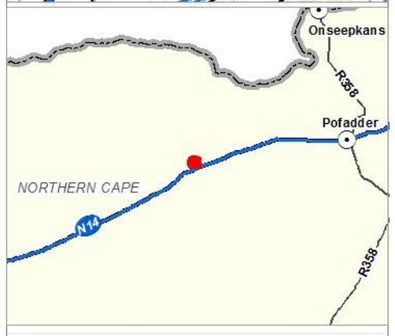
Borehole

- Difficult Excavation at 1.5m
- Borehole

Road Network

- National Route
- Main Road
- Secondary Road
- Street
- Electrical Resistivity Line





Data Sources:

NGI Topographical Data Series & Aerial Photography
Google Earth
ArcGIS Online
Extent Data From Client

0 85 170 340 Meters

SCALE: 1:6 500

FIGURE NO.:	-	MAP NUMBER:	15-549-04
DRAWN BY:	G.JONES GIS TECHNOLOGIST	REVIEWED BY:	S.KELLY ENG. GEOLOGIST
DATUM: PROJECTION:	WGS84 GEOGRAPHIC	DATE:	JANUARY 2016
PROJECT:	GAMSBERG MINE GEOTECH		
CLIENT:	GEOMECH AFRICA (PTY) LTD		

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FIGURE 3B: SITE PLAN SHOWING GEOTECHNICAL CONSTRAINTS OF PLANT SITE

29°12'45"S

P13
P12
P11
P9
P17
P10
P8
P7
P16
P15
P6
P19
P18
PLT19
P14
P4
P3
PLT3
P5
P1
PLT1
N

29°13'30"S

18°57'45"E

LEGEND

Test Pits & Plate Load Tets

Borehole

Difficult Excavation at 1.5m

Low Bearing Capacity

Borehole

Road Network

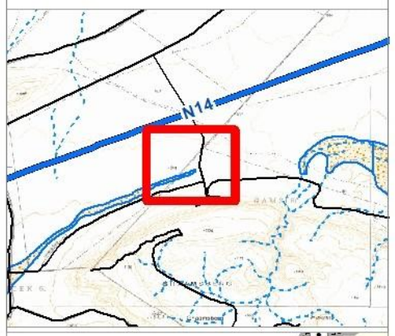
National Route

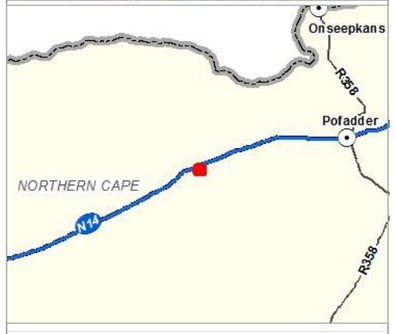
Main Road

Secondary Road

Street

Electrical Resistivity Line





Data Sources:

NGI Topographical Data Series & Aerial Photography
Google Earth
ArcGIS Online
Extent Data From Client

0 85 170 340 Meters

SCALE: 1:6 500

FIGURE NO.:	-	MAP NUMBER:	15-549-05
DRAWN BY:	G.JONES GIS TECHNOLOGIST	REVIEWED BY:	S.KELLY ENG. GEOLOGIST
DATUM: PROJECTION:	WGS84 GEOGRAPHIC	DATE:	JANUARY 2016
PROJECT:	GAMSBERG MINE GEOTECH		
CLIENT:	GEOMECH AFRICA (PTY) LTD		

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