Pit Slope Management Plan

WAI-350-PLN-001

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2	6/5/2019	All		Major review for Project Martha

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OCEANAGOLD WAIHI

PIT SLOPE MANAGEMENT PLAN - MARTHA

MAY 2019

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27 June 2019

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for Hauraki District Council

Leigh Robcke 25/6/2019

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1 INTRODUCTION

1.1 Site Overview

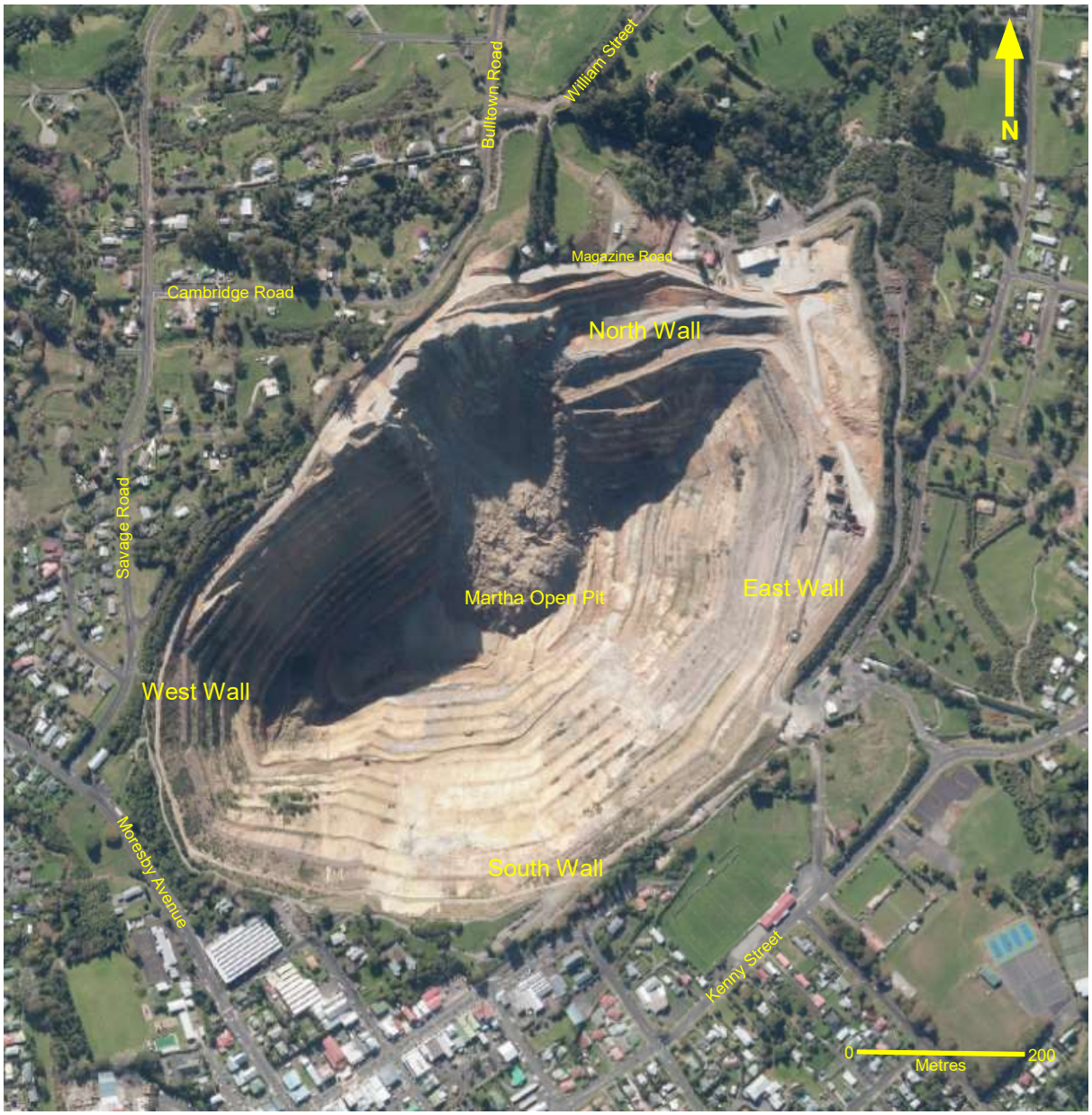


Figure 1 – Plan View of Martha Open Pit and Surrounding Roads

1.2 Purpose and Scope

The purpose of the Pit Slope Management Plan is to outline the monitoring and management of pit slope stability, groundwater, pit rim ground movement for the existing Martha open pit including the planned Phase 4 pit (MP4). The plan also details the procedures for the backfilling of historical stopes located within 30m of the toe of the Phase 4 cutback. Preparation of the Plan is a requirement of Condition 70 of the Land Use Consent for the Phase 4 pit, the scope and content of the Plan is also outlined in Consent Condition 70 (see Section 1.2 below).

This Plan supersedes and incorporates pit slope management plans prepared for the four consented mine plans for the Martha Open Pit since open pit mining commenced in 1988, namely the Licensed Pit, Extended Pit, South Stability Cutback (SSC), and the East Layback (Pit 66D).

The key processes for monitoring and management of pit wall slope performance and the surrounds of the open pit are:

a) Collection of geotechnical data including slope stability monitoring, geotechnical mapping, groundwater monitoring, locating of historical voids, mapping of any wall failures;

b) Ongoing analysis; and modelling and re-design if necessary;

c) Monitoring of progress of the excavation and interactions with MUG and historical voids;

d) Maintaining relevant standard operating procedures (SOP's) covering probing, monitoring, geotechnical surveys;

e) Ensuring that response and remedial measures are in place and are reviewed regularly to ensure they remain appropriate.

1.3 Consent Requirements

The Company is required to undertake pit slope and geotechnical management by the relevant conditions of Land Use Consent (LUC) No. 97/98 – 105 granted by Hauraki District Council (HDC) for the Extended Pit and its modifications, and LUC202.2018.00000857.001 granted in 2019 by HDC for Project Martha. The relevant clauses are listed below:

Land Use Consent No 97/98 - 105

Clause 3.19(I)

"To carry out its primary function, the Panel shall report in writing to the Hauraki District Council on all matters which are submitted to it for review, other than draft proposals submitted to it by the consent holder and which are superseded, and at least at the following times:

- *Prior to commencing the extension related mining activities associated with the open pit*
- *At all critical stages during development of the open pit (e.g. slope formation near the Cornish Pumphouse, major remedial works [e.g. coal seam at 1800 east], initial work on forming the pit perimeter)*
- *On completion of open pit mining*
- *On completion of lake filling*
- *On rehabilitation of Areas A and B*

and at least on the following matters:

- *The Pit Slope Management Manual and any subsequent updates as are appropriate*
- *Progress against the Annual Work Program*
- *Site development including hydrogeological issues and geotechnical issues*
- *performance against the requirements of the Pit Slope Management Manual*
- *pit slope stability monitoring, and rehabilitation and closure plans".*

Clause 3.19(j)

"The consent holder shall develop a Pit Slope Management Manual. This manual shall be peer reviewed by the Peer Review Panel and submitted to Council for approval prior to exercise of this consent. The Pit Slope Management Manual shall address at least the following issues:

- *procedures for the investigation, monitoring, excavation and backfilling of old mine stopes where required*
- *specifications for construction and placement of stope pillars where required*
- *development of a monitoring regime focused on monitoring groundwater and pit slope behaviour*
- *procedures for the investigation and remedial measures of old coal seams, and monitoring of the same*
- *location and installation of horizontal drains for the purposes of addressing groundwater and surface water effects*
- *monitoring of Pumphouse stability*
- *instability contingency response".*

Clause 3.19(j)

"The consent holder shall consult with land owners and/or occupiers within the buffer zone associated with the extended open pit (as defined on Plan 9). In each case the consent holder shall:

- *identify the facilities potentially at risk*
- *develop a contingency response appropriate to these facilities in the event of instability".*

LUC 202.2018.00000857.001 – Project Martha (2019)

Condition 70

"The consent holder shall prepare a Pit Slope Management Plan. This plan shall be peer reviewed by the Peer Review Panel (required in accordance with Condition 13 of Schedule One) and submitted to Council for certification 30 working days prior to the exercise of this consent. If certification is not provided within 30 working days of Council's receipt of the Pit Slope Management Plan activities authorised by this consent may commence. The Pit Slope Management Plan shall address at least the following issues:

a. Procedures for the investigation, monitoring, excavation and backfilling of old mine stopes where practical and safe to undertake within 30 m below the toe of the Phase 4 Cutback;

b. Development of a monitoring regime focused on monitoring groundwater and pit slope behaviour, including pit wall movement due to underground mining;

c. Location and installation of horizontal drains for the purposes of addressing groundwater and surface water effects;

d. The identification of areas around the Martha Pit that may be subject to ground deformation and associated structures / facilities that may be at risk; and

e. Development of a contingency response appropriate to these facilities / structures in the event of instability - including restoring these facilities to their former condition, the provision for interim structures / facilities or alternative structures / facilities in the event they are affected by the mining activities authorised by this consent.

These table below details where this management plan satisfies the above Project Martha consent conditions.

Condition	Document reference	
70a	Section:	7, 9.8, 10.2
70b	Section:	7, 9.8, 10.1, 10.4
70c	Section:	9.8, 10.4
70d	Section:	3.1, 7, 8.7, 9.8
70e	Section:	7, 8.7

This management plan addresses the requirements of the EMMA Land Use Consent and Project Martha Consent Conditions related to the Pit Slope Management Manual (EMMA) and Pit Slope Management Plan (Project Martha).

2 BACKGROUND

Mining operations within the Martha open pit commenced in 1988. There have now been four pits excavated at Waihi: the Licensed Pit, Extended Pit (1999), South Stability Cutback (SSC) (2005), which was originally aimed at pit closure; and the East Layback (Pit 66D)(2007).

Both the SSC and East Layback pits were designed to achieve more stable conditions by moving the new pit walls and important historical infrastructure as far as practical outside the rock mass zone affected by the historical underground workings. This process has generally been successful as demonstrated by the performance and success of the SSC, the East Layback and the moving of the Pumphouse.

All failures to date in the Martha Pit, both large and small, have occurred in sections of the rock mass substantially affected by the historical underground workings. In April 2015, a section of the main ramp along the north wall of the Martha pit failed resulting in the cessation of mining. Twelve months later in April 2016, a much larger failure occurred resulting in approximately 1 million tonnes of material failing from the north wall. The open pit has been on a care and maintenance regime since. In 2017, approximately 500,000 tonnes of material was unloaded from the crest of the north wall. Analysis of the north wall failure has shown it was also linked to the historical underground mining.

In 2018, OceanaGold applied for resource consents for Project Martha. These consents were granted in February 2019. Project Martha comprises:

- The Martha Phase 4 pit (MP4); and
- The Martha underground mine (MUG).

MP4 and MUG will operate largely in parallel, with material mined from MP4 used as backfill for the underground mines. The current Martha pit extends to about 270 m below surface and the old underground workings extend to about 620 m below surface.

The MP4 pit will be a continuation of the stabilisation process undertaken in 2017, because the cutback removes the north wall failure, and moves the north wall further outside the rock mass zone affected by the historical underground mining.

3 PHASE 4 MINE PLAN

The MP4 cut back will be mined in a single top down sequence. The pit is shown in Figure 2. A realignment of Cambridge and Bulltown Roads will be required prior to excavating the outer limits of Phase 4 north wall. A noise bund and noise fence will also be constructed between the realigned roads and the new crest of the north wall.

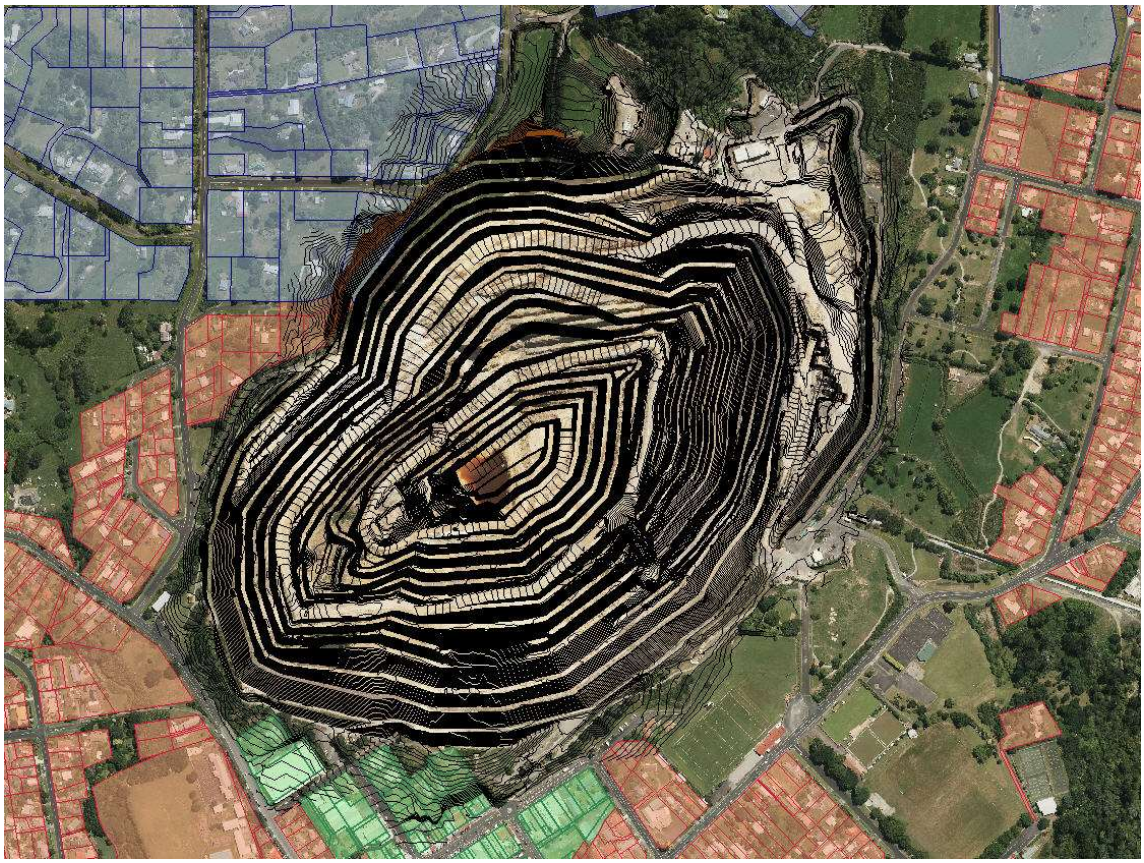


Figure 2 – Plan of Martha Phase 4 Pit within the Project Area

MP4 will be mined in a single top down sequence. The planned cutback will be mined in a series of sections, Figures 3 to 5. In order to achieve the target depth and due to the limited size of the cutback, temporary ramps will be necessary. OceanaGold have divided the cutback into three stages:

- Interim Pit 1, the upper part of the cutback down to 1120 mRL, which will be mined with small equipment and access via the east wall and Magazine Road, Figure 3;

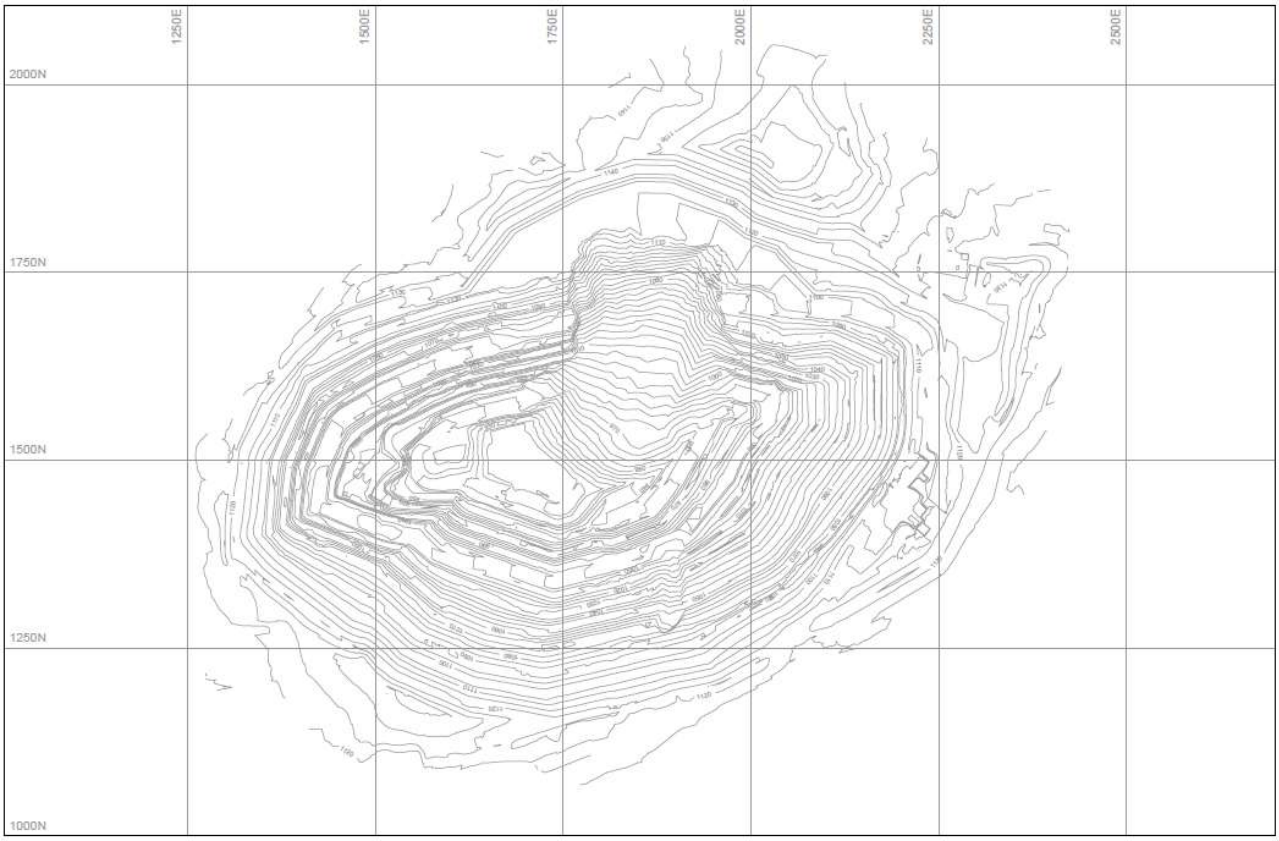


Figure 3 – Phase 4 Interim Pit 1 Upper

- Interim Pit 2, the central portion including the establishment of the northern haul road to 1070 mRL and connection to the lower southern haul road with temporary ramps, Figure 4; and

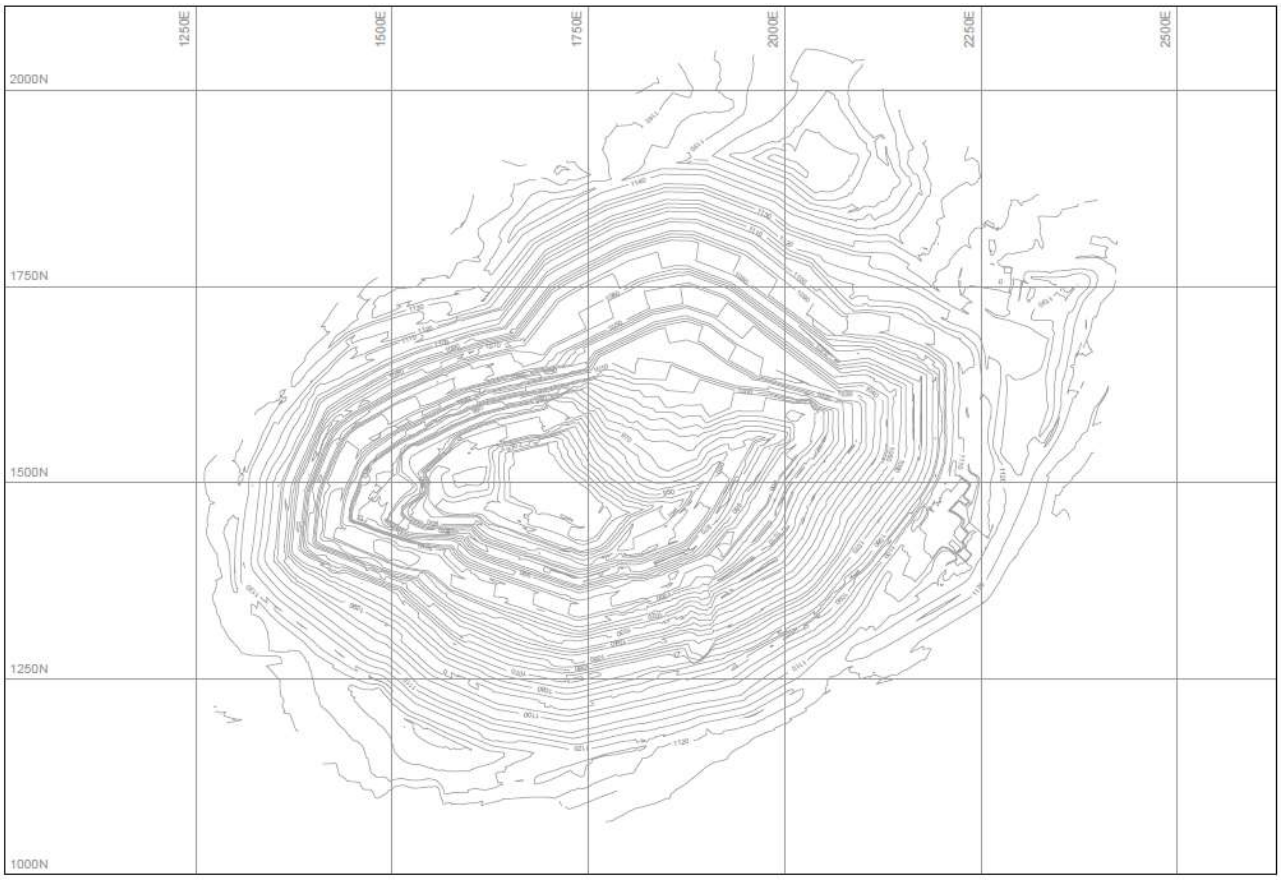


Figure 4 – Phase 4 Interim Pit 2

- Phase 4 final, the completion of the cutback to a depth of 275 m, 875 mRL, Figure 5.

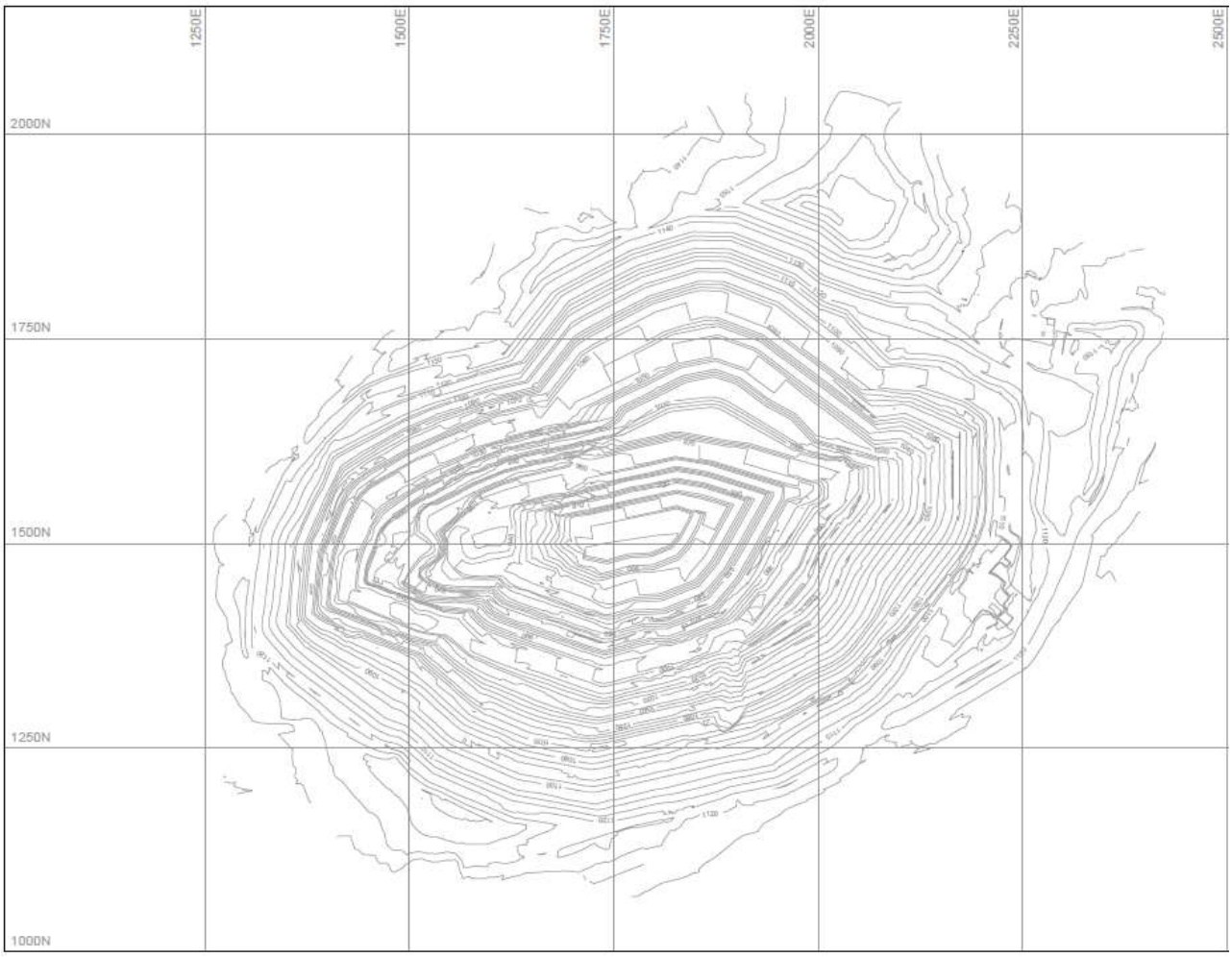


Figure 5 – Phase 4 Final Pit

The planned pit will take around eight years to mine. Ore and waste will be mined by conventional drill and blast methods. The controlled blasting practices used over the last two decades will be continued. Horizontal drain holes will be installed - rotary drilled to a depth of ~100m in a similar configuration as that installed in the Eastern Layback. Holes drilled prior to the North Wall failure that made water will provide the target zones, the wet areas in the northeast, and especially in the Younger Andesite (Blue Shear).

3.1 MP4 Pit Slope Design

The overall slope design for MP4 north wall cutback is:

a) Upper slope 30° for 160 m; and
b) Lower slope 50° for 85 m.

MP4 uses the same general bench (5m wide) and batter (30-50°) configuration as that used successfully for the East Layback and before that for the Extended Pit north walls.

The geotechnical conditions at Waihi are significantly impacted by the presence of historical mine workings. Caving initiated during historical mining has resulted in zones of poor-quality rock mass within and outside of the pit slope limits. There has been ongoing large-scale block movement (termed the disturbed zone) over the last one hundred years and this large-scale block movement will continue into the caved zones in the future beyond the life of the open pit.

The modelled pit slopes have factors of safety in terms of static slope stability greater than unity (FOS>1.0) based on considered conservative parameters which indicates the pit walls as designed can be expected to remain stable given the current rock mass conditions and static conditions. However, the ongoing large-scale block movement of the disturbed and caved zones will mean that the walls will be undergoing movement during mining greater than that which would be expected simply from excavation of the pit. This may result in local instability of slopes, if rock mass conditions deteriorate or are poorer in certain zones than modelled. Block movements can be rotational (tilting), downward or lateral. Movements are not expected to be continuous but of a stick-slip nature.

The historical workings have been reasonably well documented in terms of spatial location and types of stoping as well as descriptions of caved zones. However, it is acknowledged that this data is incomplete. The extents of the underground workings have been used to determine caved zones and disturbed zones. These have been termed mining blocks. Several mining blocks have been identified bounded by historical stoping on the Martha, Welcome, Empire, Edward, Letter and Albert veins. Nearly all these m ining b locks show some ability to translate or rotate. Caved zones have been identified on the hanging wall of the Martha and Edward lodes at 70-80 degrees to vertical and the disturbed zones are interpreted sliding on pre-existing shears at 60-70 degrees towards the caved zones.

Understanding the mechanics of pit wall deformation requires an understanding of the underground caving around the historical workings and consequent block movements.

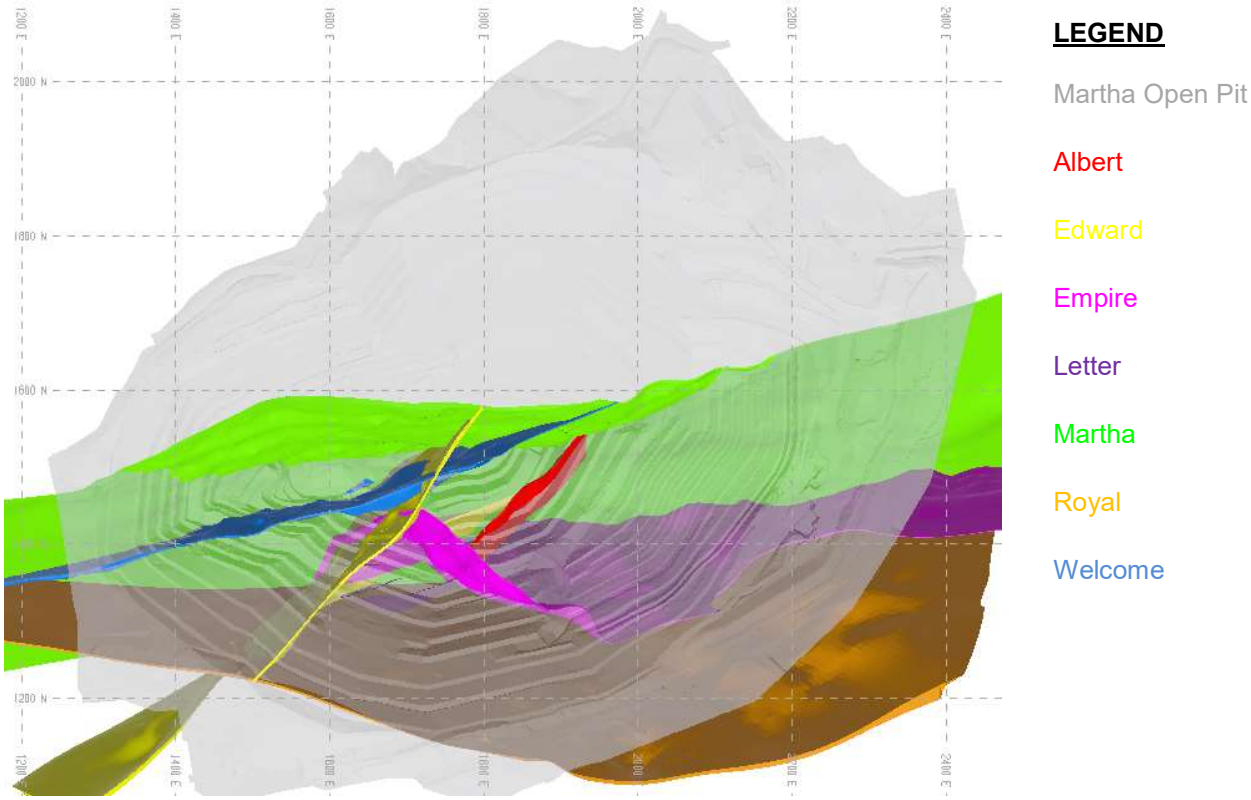


Figure 6 – Veins of the Martha Open Pit

South Wall Cutback

In 2005, Newmont (previous owner) requested Pells Sullivan Meynink (PSM) to undertake studies related to closure planning to satisfy the Mining License conditions. At that time, the east wall and south east wall had been declared high hazard zones and geotechnical advice received by Newmont

had indicated that these slopes could not be considered stable in the long term and recommended stabilization.

This advice was provided to Newmont in the draft report PSM125.R34. Based on the draft report PSM125.R34 Newmont implemented remedial stabilization works.

In assessing the justification for remedial stabilization work, Newmont noted that PSM125.R34, Section 10.1, conclusion No 11, Items f) and e) are significant conclusions in assessing the justification. That is:

- Over time, rock strength can be expected to decrease because of wall movement, and if fully softened strengths are realized, then the Factor of Safety (FoS) for the southeast wall will be less than 1.0 after pit flooding occurs. The conclusion is therefore that the Extended pit will have unstable walls over the long term, which can be expected to fail. These FoS are also less than the consented pit design minimum criterion.

- The PSM report indicates that even without softened strengths, the south east and south wall of the consented pit does not meet the seismic loading conditions set out in the original consented pit design criteria. The indicated FoS are less than 1.0 for the south and south-east wall for the 450-year return period earthquake, and FoS < 1.3 for the 20-year return period earthquake which is less than the consented pit design minimum criteria.

Based on these two very significant conclusions from the consultant, Newmont concluded that its south and southeast walls required significant stabilization works to enable a long-term low maintenance closure plan to be implemented.

The remedial works, termed Pit 64A were designed by Newmont based on the design slope angles provided by PSM. The remedial works, the southern layback was completed in December 2010 and achieved the objective of stabilizing the south wall.

<u>East Wall Cutback</u>

In 2009, Newmont requested PSM to undertake studies related to providing a final cut to improve the stability of the east wall to satisfy the mining licence conditions. This advice was provided to Newmont in the PSM125.R39 report and peer reviewed by the Geotechnical Peer Reviewer. This report addressed the East Layback, termed Pit 66D.

The design of the East Layback was optimized over several stages and as a result the design was modified to:

- Better match the slopes to the geology
- Reduce the risk of similar failures to those that have resulted in step-ins in the past
- Achieve a better final slope in terms of condition and performance
- Address the risk issues of concern to Newmont and the independent reviewers.

The East Layback was a cutback of the failed slope of the Extended pit. Following failure of the East wall of the Extended pit, an interim slope was chosen at that time because of the large unknowns about the effects of the historic underground mining and the Milking Cow cave zone. The intention was to monitor the performance of this interim slope over time. This interim wall, after a long period of movement, failed following a subsidence event.

The East Layback design was formulated to maintain the integrity of the slope during mining and by forming a pit slope in a new position, aimed at alleviating some of the historical underground mining influences to improve the long-term slope stability.

A favourable feature of the East Layback was that it effectively places most of the historical underground cracking and collapses, associated with and around the Milking Cow, inside the pit crest and below the proposed lake level.

The geotechnical strategy adopted for the Pit 66D design was developed to alleviate, where practicable, the combined adverse impacts of the historic underground mining and the variable geotechnical conditions in the Ignimbrite Zone and Younger Andesite. The new design included remedial elements for long term pit closure and the formation of the pit lake and was closer to a closure design than a conventional cutback. The Eastern Layback commenced in May 2010 and successfully stabilized the Eastern wall.

North Wall Interim Remediation Cutback

In 2014, it became evident that an area of the north wall was moving beyond expected mining rebound movement rates. In addition, significant cracking was detected near the crest of the north wall. Newmont engaged PSM to conduct a site visit to investigate the movement and as a result PSM produced reports PSM125-235R and PSM 125-237R in February 2015 and April 2015 respectively.

An acceleration of the movements in one part of the movement zone commenced in February 2015, which was accompanied by the slowing or halting of movements in other parts of the wall around this area of acceleration. In combination these two aspects meant the area with the accelerated movements had become partially decoupled, by geological structure, from the remainder of the movement area.

The pit was closed in April 2015 following a series of small failures that undercut the haul road and led to cessation of mining. From 2015 to 2016 movements became more concentrated in the western side of the area of movement. On 26th April 2016, a major portion of the north wall failed. OceanaGold requested PSM to determine cause of the movement and provide recommendations for remediation. This was advised to OceanaGold in report PSM125-252R.

> *"It is considered that there is no benefit in progressing immediately towards a final remediation of the north wall failure area. Some areas have stabilized but others are showing ongoing movement and continued fretting and or failure to the northwest and east is expected. Some interim remediation of these areas with partial cutbacks that would lie within a final envelope of remediation is recommended."*

In 2017, the north wall was stabilized as per recommendations with an interim remediation cut. Monitoring throughout the North Wall Interim Remediation Cutback indicated movement on the north wall slowing or halting as the wall was continuing being unloaded. No significant movement has occurred since. As of September 2017, the Martha Open Pit has been in 'care and maintenance'.

3.2 Interactions With MUG

The elements of the planned MUG mining relevant to MP4 are:

- Separate to the planned mining, selected existing unfilled historical stopes will be stabilised by filling with either rockfill or a cemented fill. Many of these stopes are located in the upper levels of the historic workings immediately below the MP4 Pit;
- In addition, a proportion of the planned mining of MUG will entail re-mining of historical stopes (remnant mining). The important factors about this mining are:
  - Many of these historical stopes are located immediately below the MP4 Pit; and
  - Cemented aggregate fill (CAF) will be used extensively in the backfilling of historical voids encountered in MUG.

PSM report that backfilling the historical workings is expected to improve the overall rock mass conditions in the zone underlying the MP4 Pit. This is understood to mean that the addition of backfill will minimise further deterioration of rock mass conditions in the zone underlying the pit floor It is expected that this will have two positive impacts on MP4 pit, firstly by improving pit stability conditions both in the short term and long term, and secondly by reducing any impacts of the MUG mining in general. This is also expected to reduce the longer-term potential for ongoing creep of the rock mass.

Numerical modelling by PSM of the open pit / Martha underground interaction shows that overall mining of the Martha underground is predicted to result in relatively small displacements and strains, provided stopes are backfilled. The Martha underground plans to extract around 4Mt of ore mainly from virgin stopes and remnant wall rock using the modified Avoca mining method from around 1050mRL to 500mRL. The predicted total displacements in the MP4 walls are around 0.2 m and occur in the east wall, with the maximum occurring in the disturbed zone of the east wall. There are also predictable localised displacements in the historical unfilled stopes at the toe of the north wall.

Maximum shear strains occur on the south wall and are predicted to be about 1% in the deformed zone of the south wall. There are localised strains greater than 1% predicted in the historical unfilled stopes at the bottom part of the pit. The vertical extent of the strains in the south east wall as a result of the Martha underground are from the pit base at 870mRL to around 1050mRL.

Displacements and shear strains are predicted to occur in different locations due to the geology and proximity of proposed and historic stopes, see figures 7 and 8 below.

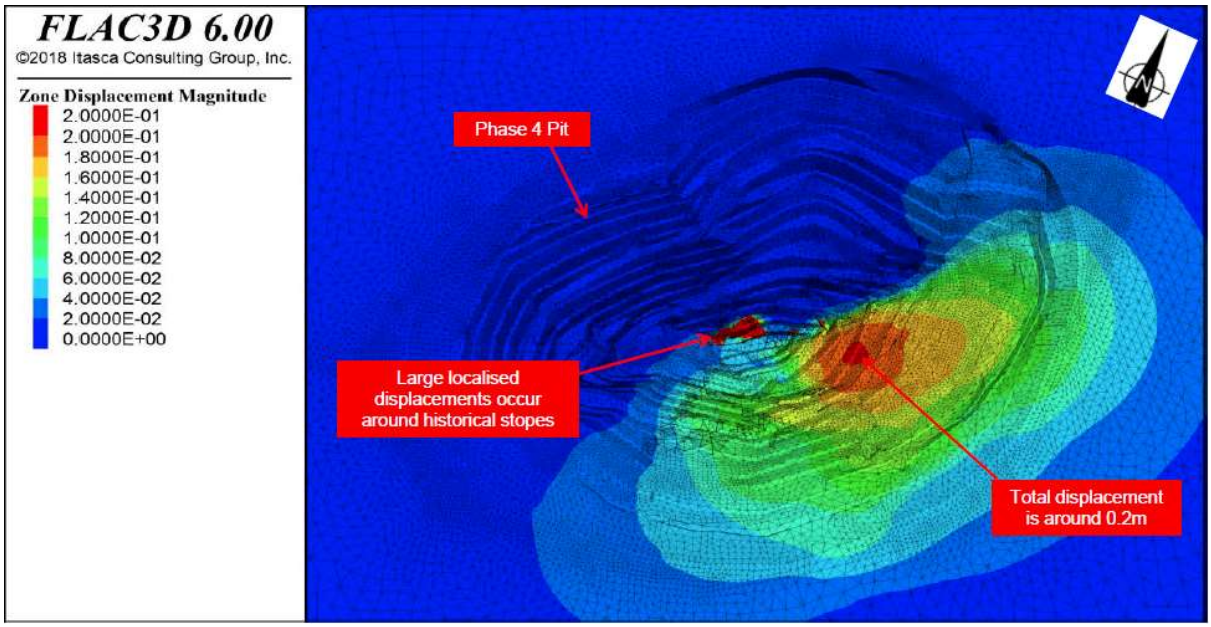


Figure 7 – Predicted Total Displacement After Year 9

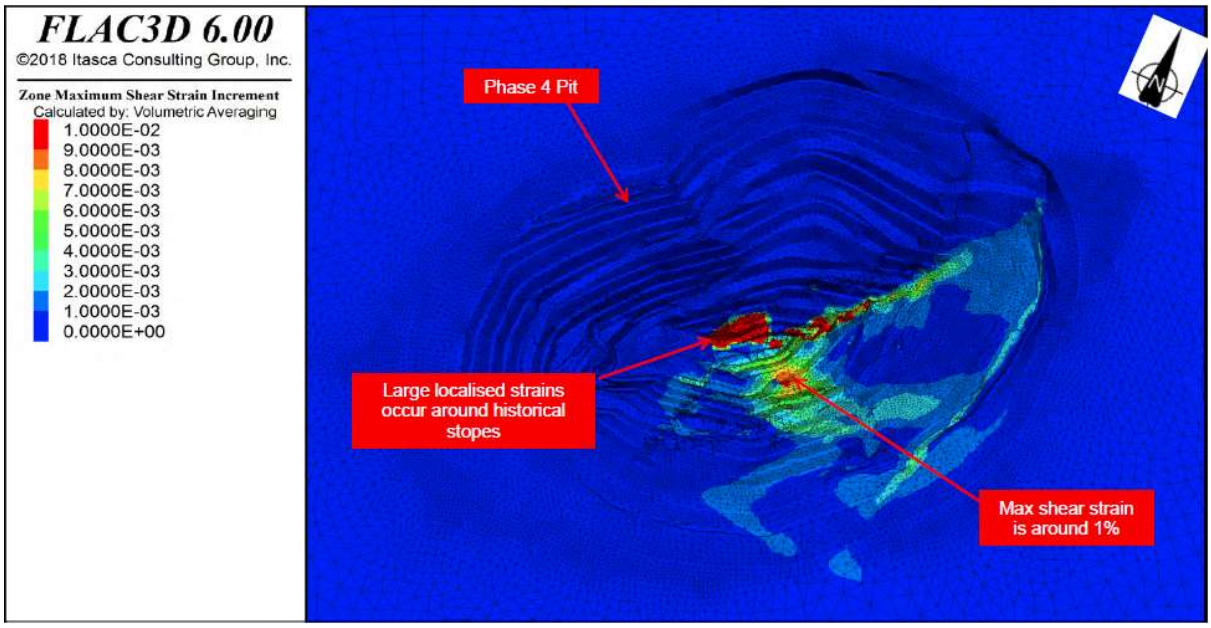


Figure 8 – Predicted Max Shear Strain After Year 9

Overall, PSM found no global slope instability in MP4 based on the displacement and strain results discussed above. However, there is potential for localised (bench scale) instabilities at the pit surface in some areas above the historical stoping.

The Rex Underground is a small, short life, narrow vein mine that is isolated from the historic and planned new underground mining. The mine is south of the MP4 Pit and underlies the rugby field and part of the township. The geometry of the planned mine and its geometric relationship to MP4 Pit is captured in the following points:

- The mine is around 250 m in strike length;
- The top of the mine is 80 m below ground surface;
- It extends from 1030 to 850 mRL;
- The lower RL is the level of the base of the MP4 Pit;
- In plan the top of the mine is located 180 m south of the MP4 Pit crest;
- However, measured horizontally to the pit wall, the distances are much greater. The closest distances from the top and bottom of the underground mine to the MP4 Pit wall are 270 and 390 m respectively.

Access will be via the Martha Drill Drive Project (MDDP) area. Mining will utilise the Modified Avoca stoping method with stopes backfilled with waste rock and occasionally Cemented Aggregate Fill (CAF).

Based on these factors it was assessed by PSM in their report for Project Martha (PSM125.282R) that the proposed Rex Underground will have no impact on the MP4 Pit.

4 ROLES AND RESPONSIBILITES

4.1 Roles and Responsibilities

4.1.1 OceanaGold

General Manager

The General Manager is responsible for ensuring that this plan is implemented and kept current. The General Manager is responsible for authorizing changes to the Emergency Response procedures and the trigger levels.

All releases to the media or district council associated with geotechnical issues must be through the General Manager or his nominee.

Open Pit Manager

The Open Pit Manager is responsible for the safety of the Open Pit Mining Operations. The Open Pit Manager is responsible for implementation of the requirements of this management plan.

The Open Pit Manager or his nominee must also manage the operation and supervise the health and safety aspects of the operation.

Geotechnical Engineer

The Geotechnical Engineer is responsible for:

- ensuring all monitoring data is obtained in a timely and accurate manner;
- interpreting the monitoring data and providing timely reports to mine management;
- requesting advice on monitoring data from the consultant; and
- providing recommendations on mining geotechnical aspects to the Open Pit Manager.

4.1.2 Mining Contractor

The contractor's Project Manager is responsible for ensuring that the pit wall slopes and safety berms are excavated in line with the pit design; pit walls are not impacted by blast damage; and that drain holes are installed to design. The Project Manager must also immediately report any ground movements, cracking, appearance of voids or historical stopes, and any wall failures that is observed by the contractor's workforce to the Geotechnical Engineer or Open Pit Manager.

4.1.3 Geotechnical Consultant

The internal review and audit functions are filled by geotechnical consultants, Pells Sullivan Meynink (PSM), who make regular scheduled visits to Waihi.

Each visit by the Consultant will entail the following activities:

- Review of mine development data;
- Assessment of geotechnical conditions and data;
- Assessment of slope dewatering;
- Review of any slope failures; and
- A wrap up meeting to summarize the situation and a follow up report.

The consultant will provide technical support to the Mining Geotechnical Department as required generally in terms of:

- identifying instrumentation changes or new additions;
- numerical modelling; and
- review.

The contact is:

Mr. Tim Sullivan

Pells Sullivan Meynink Pty Ltd

G3, 56 Delhi Road

North Ryde NSW 2113

Australia

Telephone: 61-2 9812 5000

Facsimile: 61-2 9812 5001

4.1.4 Other Contractors

Geotechnics Ltd., Tauranga are contracted to carry out measurements using inclinometers on 1 borehole cased with grooved tube. The contact is:

Ryan Milligan [Rmilligan@geotechnics.co.nz]

Geotechnics

56 Tenth Avenue, Tauranga, NZ

Ph: 07-571-0280,

Cell 021-571-733

Fax: 07-571-0281

Email: Rmilligan@geotechnics.co.nz

Global Survey Ltd is contracted to maintain the GEOMOS pit wall prism monitoring system. The contact is:

Mr. Mark Green/Mr. Bryan Claridge

Global Survey Ltd

19F Triton Drive Albany

AUCKLAND

Ph. + 64 9 915 6670

Fax + 64 9 915 6671

Mob. +64 27 221 0507

www.globalsurvey.co.nz

Earthmoving equipment may be required for remedial works. P&G Contracting Ltd have small scale equipment in Waihi which can be used for remedial works. C&R Developments Ltd based in Hamilton have large scale equipment which can be used for remedial works if required. The contractors' representatives are:

- P&G Contracting Ltd. - Mike (Poss) Hurley - 027 448 8904

- C&R Developments Ltd – Nick Ross 027 487 8070

4.1.5 Peer Review

The Martha pit operates under land use consents granted by the Hauraki District Council (HDC). The consent conditions require that OGNLZ engages a peer review panel[1]. In respect of the Martha Pit, the peer reviewers are required to have demonstrated expertise in:

- Geotechnical engineering, with recognised experience in open pit construction and rock mechanics;
- Hydrogeology, with recognised open pit mining experience; and
- Rehabilitation and closure.

The primary function of the peer review panel is to ensure that the conditions relating to the design, construction, operation and rehabilitation of the Martha Pit are met. The conditions require that peer review needs to have a particular focus on pit slope stability issues.

Of direct relevance to the Pit Slope Management Plan, the above peer reviewers are to report in writing to the HDC (and Waikato Regional Council) on "*all matters which are submitted to* [them] *for review……"*

- *The Pit Slope Management Manual and any subsequent updates as are appropriate;*
- *Progress against the Annual Work Program;*
- *Site development including hydrogeological issues and geotechnical issues;*
- *Performance against the requirements of the Pit Slope Management Manual;*
- *Pit slope stability monitoring…."*

The conditions require that the peer reviewers prepare their reports "*at least at the following times*".

- *Prior to the commencement of any mining activities authorised by this consent;*
- *At all critical project stages;*
- *On completion of mining;*
- *On completion of lake filling;*
- *On completion of closure;*

In practice, the peer reviewers report every year based on the monitoring data provided to them by OGNZL.

The Peer Reviewers are:

Geotechnical Matters - Professor Phil Dight

Australian Centre for Geomechanics - University of Western Australia

35 Stirling Highway (M600), Crawley, Western Australia

Australia

Ph: +61 8 6488 3300

Cell: +61 4 1995 6672

[1] Condition 3.19 of land use consent no. 97/98 – 105 for the Extended Martha Mine Project and, for Project Martha, condition 70 of land use consent LUC 202.2018.00000857.001 and conditions 5-13 of Schedule One to that land use consent.

Email phil.dight@uwa.edu.au

Hydrogeology – Mr Chris Kidd

18 Glengariff Avenue

Killarney Heights

NSW 2087

Australia

Ph: +61 4 6781 0169

Email chris.h.kidd@gmail.com

Rehabilitation – Dr Craig Ross

Manaaki Whenua – Landcare Research

Private Bag 11052

Manawatu Mail Centre

Palmerston North 2087

New Zealand

Ph: +64 6 353 4807

Email Rossc@landcareresearch.co.nz

4.2 Coverage

The pit will operate from Monday to Friday 7am to 7pm. Some production activities may be carried out on Saturday 7am to 12 noon. Normal pit monitoring operations will occur only within these times. Outside of these times the Geotechnical Engineer and Open Pit Mine Manager will:

- cover geotechnical issues.
- receive EDM triggers.
- implement the geotechnical hazard identification and response:

	Key Person	Position	Cell Phone
1	Kevin Storer	Open Pit Manager	027 488 5261
2	Liam Ireland	Geotechnical Engineer	027 868 0104

5 KNOWLEDGE MANAGEMENT

5.1.1 Location of Geotechnical Monitoring Databases

The geotechnical monitoring database covers the Automated prism monitoring, this is held in a patented GeoMoS SQL database situated on the Geotechnical Monitoring Computer. This computer is not connected to the OceanaGold corporate network. Files are held in:

C:\Leica Geosystems\GeoMoS\Databases\MSSQLSERVER

Data is backed up on the Geotechnical Monitoring Computer external backup. This database contains the survey station ID and the prism monitoring results since 14th April 2005 for the north, south, west and east walls. Competent persons for amending the database are Engineers L. Ireland and T Maton. Technical support is available through Bryan Claridge of Global Surveys, Auckland. Telephone 09 915 6672, Cell 0272210507.

This database contains the survey station ID and the prism monitoring results since 1997. The database has export functions for vectors as well as report files f o r cumulative movements.

All data is backed up off site or held in the fire proof room at Moresby Avenue. Back up of the server located in the Mill is daily using a two-week rolling tape system. Daily backups exist for two weeks; weekly backups exist for three months and monthly are retained in the Moresby Avenue fireproof room. Contact is IT department:

Mark Lilly Ph 021 0256 6913 or 07-863-9815

5.1.2 Location of Geotechnical Inspection Logs

During mining activity, the pit will be inspected daily by the pit supervisor and weekly by the Geotechnical Engineer. Any signs of ground movement noticed by the pit supervisor or reported by others shall be immediately notified to the Geotechnical Engineer who will then undertake a detailed inspection and evaluation. The pro-forma sheet for the inspections is completed in hard copy and stored in the Moresby Avenue, Waihi fireproof room. The location of the Geotechnical Inspection Logs is:

G:\Mining\Geotechnical\\Martha\Geotechnical\Martha\Pit inspections

The Laser located in the Conveyor tunnel is inspected by the Crusher Operator / assistant during each operating day and an entry made into the record sheet. The records will be collected by the surveyor and stored in the Fireproof Room, Moresby Avenue.

The Geotechnical Diary is held by the Geotechnical Engineer. The Geotechnical Engineer will record daily the items of geotechnical significance related to Martha Pit.

5.1.3 Location of Weekly Geotechnical Wall Status Report

Weekly Geotechnical Wall Status Report will be updated weekly by the Geotechnical Engineer and presented at the Tuesday's Production Meeting. The reports are located:

G: \Mining\Martha\Geotechnical\Martha\Geotechnical\Weekly Hazard Reports

5.1.4 Location of Geological Database

Geological Plans showing pit wall structure, veins, stope intersections, faults etc. are held in the geologist's plan cabinet at the Moresby Avenue office, Waihi. Drilling logs and drill core

photographs are held in the filing cabinet in the fireproof room at Moresby Avenue. Historical plans associated with the Martha underground workings are also held in the fireproof room.

Digital based records are stored within MineSight at

X:\Waihi\Resource_estimation\Martha_current.tri

The data is predominantly stored in two formats, attributed 2D (XY) and 3D (XYZ) string or point data and as 3D wireframe models of geological surfaces, historical underground workings and drill data. Hard copy plans/sections of the digital data can be produced at any scale.

5.1.5 Location of Geotechnical Reports

Geotechnical reports on the Martha Pit comprise largely reports received from Pells Sullivan Meynink. Hardcopies of these are held in the fireproof room at Moresby Avenue, Waihi. Pells Sullivan Meynink hold both hard and soft copies at their office in Sydney.

5.1.6 Geotechnical Data Held by Other Parties

All data collected from the OceanaGold inclinometers is held by Geotechnics, Tauranga. Contact is Ryan Milligan.

Data from extensometer measurements to end June 2003 is held by Pells Sullivan Meynink at their Sydney office. Contact: Alex Duran. All PSM reports and letters to Newmont Waihi and OceanaGold are held on file in the Sydney office. Contact: Tim Sullivan.

5.2 Communication & Training

As part of their job description, the Open Pit Manager, General Manager, Open Pit Supervisor, Contractors Project Manager and Geotechnical Engineer are required to be familiar with the Open Pit Management Plan. Soft copies of the Management Plan will be issued to these personnel and be available on the Waihi intranet.

Geotechnical updates will be presented at intervals as a topic at the monthly safety / toolbox meetings of the open pit workforce. Attendees at the meeting will include the equipment operators and the supervisory staff. It is expected the presentation will include:

- ◊ Summary of monitoring results to date;
- ◊ Summary of rockfalls and other geotechnical events;
- ◊ Geotechnical hazard identification:
- ◊ Current geotechnical hazards.

6 GEOTECHNICAL MODEL

6.1 Geotechnical Model

A comprehensive compilation of all the available information on historical underground mining was carried out in 2002-2003. This new information on the historical workings was analyzed and integrated with the exposures in the pit, the information from some of the previous investigation drilling, the geological mapping in the pit, the pit wall performance in various sectors and the pit wall movements. This assessment was presented in 2003 in PSM Report 125.R28, updated in 2004 in PSM Report 125.R31 and evaluated further with reference to the Pumphouse in 2005, PSM Report 125.R33.

These compilations have all shown that the collapses and events over the last 10 years at Waihi, although single events, comprise part of the long-term ongoing sequence of underground instability related movements. These movements started early last century as an extensive, large scale block subsidence of the hanging walls of some workings.

Looking widely at the whole of the area of underground mining as one system it is evident that there are several separate but linked subsidence, movement and collapse mechanisms operating at scales ranging from the local to the global scale. These mechanisms started during underground mining and have probably continued ever since.

In summary, the model for the historical underground mine as currently understood comprises:

- Open stopes at depth, shrinkage stopes, essentially open voids. The current condition and amount of residual opening of these stopes is unknown.
- Local collapses above individual stopes along all the Lodes.
- Very large blocks that have moved and slid mainly in the hanging walls of the Lodes. The movements are of significant magnitude, recorded as 0.6m to about 3.5m on the historical sections. Some of these movement blocks are recorded on the old mining sections. However as evidenced by the failure of the east wall other “geological faults” formed by these mechanisms have not been recorded. It is also uncertain how these initial movements have behaved over the decades since first recorded.
- There is a very large area centered on the Martha Lode and extending south to the Empire and Royal Lodes, that is undergoing global creep and small- scale step type movements. These movements are only small, measured in 10’s of mm but are occurring over very large areas. The boundaries and partial controls on this outer zone are to date, mainly the old stopes, e.g. the Empire and Royal Lode, which are acting like geological faults.
- A “caved zone” of rock mass mainly around the old “Milking Cow”. This is concentrated in the hanging wall but also occurs to a lesser extent in the footwall of Martha Lode. The full extent and degree of dislocation/disruption of the rock mass in this zone is not well known. This commenced as unplanned caving and then was continued by the miners as a planned caving operation.
- Local chimney cave developments that have developed to various elevations, for example the cavity in Royal Workings Borehole RDH06. Many these chimneys have now been mapped in the pit. Similar chimneys are believed to be the root feeder systems for the 1999 and 2001 Collapses.
- The major Lodes; Martha, Welcome, Edward, Empire, Royal, Albert; which have all been mined extensively over many years. These Lodes exist now either as stopes filled with soil and waste (cut and fill) or open stopes. In either event these Lodes now form major planes of weakness in the rock mass. These Lodes can intersect to form large blocks in the rock mass defining zones and partly controlling directions and larger scale creep movements.
- Remnant pillars between stopes that are in an unknown condition and which appear to have been robbed at various times during the underground mining.

The classic model for deformations around a planned underground caving operation entails three concentric zones:

- Caved Zone - The central zone comprising a broken rock mass, with sizes ranging from very large blocks to silt size.
- Disturbed Zone – A zone around the central zone comprising a disturbed rock mass with large block sliding on shears, opening of joints, infill and minor local caved zones.
- Deformed Zone – An outer zone surrounding the inner two zones with displacement on shears/faults and any other underground workings, with movements and or subsidence over large areas.

In simple terms the overall underground system at Waihi can be conceptualized in terms of this classic model, with the exceptions that because of geometry and layout of the underground workings the zones are skewed towards the south, southeast and east. Disturbed and deformed zones are poorly developed on the north wall. There is no evidence of any of these Zones in the west of the pit. Further to the east where the more recent unmineralized geological unit, the Ignimbrite Zone, overlies the Andesite the manifestation of these Zones at the surface tends to be masked or modified.

The main movement/deformation mechanisms assessed to be operating now at Waihi due to the underground effects described above include:

- Large-scale subsidence over caved zones,
- Creep of large areas,
- Block subsidence or settlement;
- Local chimney development and
- Sinkhole collapse formation.

It would be evident that these effects occur in the whole area covered by the Edward Lode in the west, close to the footwall of the Martha Lode in the north, the approximate projection of the Royal Lode in the south and is somewhat open in the east-southeast direction.

6.2 East Wall

The east wall stability has been assessed in PSM125.R39 and the following is an extract from the summary of this report:

The geotechnical strategy adopted for the Pit 66D design has been developed to alleviate, where practicable, the combined adverse impacts of the historical underground mining and the variable geotechnical conditions in the Ignimbrite Zone and Younger Andesite. This new design, which includes remedial elements for long term pit closure and the formation of the pit lake, is closer to a closure design than a conventional cutback.

The proposal for the East Layback design is to honour the intent of the Licence Conditions, but at the same time recognize the practical reality of the situation created by the underground workings, utilize the IGNS Hazard Zoning and incorporate the effects of pit flooding.

The first eastern pit wall, the Licenced Pit, was formed on the western side of the Milking Cow and showed movement for about 4 ½ years but no failure.

The east wall of the Extended Pit failed in 2002 after experiencing ongoing movement and cracking over several years. Analysis of the failure showed the cracking was related to the juxtaposition of the shrinkage stopes and caving at depth, beneath shallow cut and fill stoping on the Martha Lode. The

cut and fill (which was clay fill) in effect formed a “geological fault” zone in the upper 150m to 200m along the Martha Lode.

The current interim east wall has also shown ongoing movement for a period more than 4 years. An initial subsidence event occurred in August 2009 and this event appeared to be bounded by the same subsidence fault as the 2002 failure. Further significant failure occurred in October 2009. Both the 2002 and 2009 failures have been in the Ignimbrite Zone largely above the Younger Andesite.

Comparison of the historical underground information with the geology, the failure and cracking data and the monitoring shows both the 2002 and 2009 failures were on slopes located within historical cave and subsidence affected zones. The 2009 failure is also bounded in the east by a subsidence fault, which became evident as the failure developed.

Based on the available records there is now a well-defined eastern limit to the main cave affected subsidence effects on the east wall, which from the available information and correlated with historical records, appears to be around the crest of the current pit, Pit 64. The Milking Cow structure has resulted in all the instability and movement problems suffered by the second and third pit walls.

The analysis and design of the East Layback are presented in the light of the historical experience gained from 20 years of open cut mining at Waihi. The East Layback will be the fourth pit wall excavated in the materials present in the eastern end of the Martha pit. The East Layback (the fourth pit wall) is on the eastern margin of the Milking Cow and the upper half of the slope lies outside the Milking Cow Zone. The overall conclusions from the assessment of the East Layback are that conditions overall and the long-term stability will be considerably improved compared to the current pit.

Stability analyses of the East Layback show high Factors of Safety in accord with historical designs at Waihi. Filling the pit with water post mining will further increase the Factors of Safety and improve stability. The Factors of Safety for the current east wall are substantially lower and for two of the design cases, fully softened strengths and serviceability limit state earthquake loading, are below 1.0, meaning the slope is unstable, as has proven to be the case. The East Layback meets all the slope design criteria adopted and accepted for the Southern Stability Cutback (SSC).

Probabilistic analysis shows the East Layback has a low Probability of Failure, and this is well below generally accepted criteria.

Stress displacement modelling has also been carried out as a check on the Limit Equilibrium analysis. This modelling shows largely elastic displacements and there are no indications of overall slope failure.

The SSC, which was completed in December 2010, was formulated to cutback the south wall to a flatter angle and move it further away from some of the very adverse historical underground effects. The SSC has now been completed and the monitoring results now show there is minimal movement occurring. Hence this slope has achieved its design purpose.

The East Layback is in large part an extension of the SSC and together they form an overall arcuate shaped cutback of most of the south and east walls. This produces an overall pit shape that is more favourable from a stability perspective. Given the stability analysis results, the design modifications to improve stability and performance, and the planned remediation during mining, the East layback is designed to provide a long term safe and stable slope for the east wall of the pit.

The geotechnical strategy for the East Layback comprises:

- Steeper slopes in the higher strength layers and flatter slopes in the lower strength materials.

- The new slope will incorporate the crusher at the top, at or just below lake level, 1103.5 mRL, and this means the new east wall is partially unloaded at the top compared to the current wall.
- Over-excavation and buttressing of some of the weaker layers during mining with stronger rock, to control progressive deterioration, including erosion, local failure and sloughing.
- Additional support, including shotcrete, mesh and bolting, will be used as dictated by the conditions encountered during excavation.
- Routine installation of horizontal drains in all layers from the Welded Ignimbrite down.
- The overall effects of these measures on the stability and performance of the East Layback are:
- Moving the slope as far to the east as practicable,
    - Hence the slope, at least in the lower strength materials, will for the large part lieoutside the old “Milking Cow” subsidence zone,
    - Erosion and time dependent deterioration of weaker units will be controlled,
    - The new slope is lower at the top, because the crusher slot is incorporated, which will increase stability; and
    - The East Layback will tie into the existing South Stability Cutback and remove the current external “noses” which protrude into the pit and have the potential to be less stable.

6.3 Phase 4

A stability analyses was undertaken by PSM for Phase 4 Pit and reported on in PSM125-282R. The following is an extract discussing the material strengths and design criteria based on those strengths.

In the Martha pit there is a mixture of soil, soil/rock and rock materials, some of which occur in multiple layers. In soil/rock mixtures design is usually based on evaluation of the potential for local and overall slumping type failure. In hard rock conventional practice relies on consideration of rock structure and potential for rock structure controlled failure. However particular slopes, for example the southeast wall, have an upper Ignimbrite Zone layer underlain by Andesite. The reality is some parts of the slope have a FOS and some parts have a certain Probability of Failure (Pf) or Reliability. This is a function of the nature of the site materials.

In the Andesite, the inter-ramp and overall angles have been assessed using the geological structure data. It should be noted that for all the pit walls excavated at Waihi over the last 20 years in the Andesite rock, there has only been one significant failure related to structure, the North Wall Failure, for which the situation is complicated by the historical underground mining effects.

The stability criteria for the Martha Pit were developed as part of the studies for the SSC. Those criteria were reviewed and accepted by the HDC and their independent reviewers. The criteria were developed initially for the Extended Pit and have then been expanded to allow for the impacts of the historical underground mining and the possibility of some ongoing creep.

In conventional engineering terms if a slope is moving it is often termed marginally stable and the FOS is thought to be close to 1.0. However, in the Martha Pit one of the main causes for movement is the subsidence of the underground workings. A long-term difficulty in the Martha Pit situation had been differentiating between creep movements due to subsidence and movements related to creep of the pit walls and or pre-slope failure movements. These two movement causes could also form a continuum, with one ultimately leading the other.

Significant movement of rock materials causes a loss of strength. The slopes in the Licensed Pit were initially analysed using strength parameters derived from methodologies in common engineering

usage. These strengths have continued to be revised downwards mainly based on back analysis of various pits, assuming the observed movements indicate marginal stability and a FOS close to 1.0. This is a conservative assumption, but it means in some instances the final design strengths are probably understated. These uncertainties about the strengths means the resultant FOS are also probably understated. These factors need to be considered when evaluating the shear strengths used in stability analyses and the design FOS.

The Phase 4 Pit entails a cutback of the eastern end of the north wall of the existing pit. In essence, this represents a change to around one quarter of the existing pit and is essentially a cutback to remove the North Wall Failure. The existing pit is a combination of the Extended, South Stability Cutback and East Layback pits.

The MP4 pit is much flatter overall than the north wall of the East Layback and this is necessitated by the operational need to incorporate additional haul roads and wide benches.

Both the SSC and East Layback pits were designed to achieve more stable conditions by moving the new pit walls and important historical infrastructure as far as practical outside the rock mass zone affected by the historical underground workings. This process has generally been successful as demonstrated by the performance and success of the SSC, the East Layback and the moving of the Pumphouse.

Hence the MP4 pit is a continuation of that stabilization process. MP4 is a remedial cutback of a failure undertaken in order to re-establish the mine, which is a normal part of conventional mining activities and there is nothing unique or special in the planned cutback.

The MP4 pit is in large part an existing structure that has already been constructed and its performance has been monitored over time. The existing pit stability condition is the starting point for MP4. Monitoring has now been in place for up to two decades and does not show large scale pit wall instability movements. Consequently, in engineering terms there has been a mine scale validation of the ultimate material properties used for the design of the pit walls.

The model showing the distribution of the zones affected by the historical underground mining has been updated using the new drilling undertaken by OceanaGold since 2005. This cave model has proven to be quite robust over time with only relatively small changes. The model shows a large area in the south and the lower east of the pit that progresses outwards from caved to disturbed to deformed materials. This area is approximately bounded by the Martha Lode in the north, the Edward Lode in the west and extends south to the surface projection of the Royal Lode. In the east the effects are masked in part by the thickening unit of younger volcanics.

The monitoring data reflects this cave model with:

1. No movement in the north and west
2. Small creep movements in the upper south, which is the hanging wall of the Royal Lode.
3. In the east wall low rates of creep movement are occurring in parts. However, this area has a very complex pattern of historical underground mining both outcropping on the slope and underlying it. It appears that subsidence of the Milking Cow is continuing. There are also some local movement of the filled Martha Stopes.
4. These overall patterns of movement were expected and were known to probably be the result when both the South Stability Cutback and the East Layback were designed.

An investigation has been carried out to evaluate the potential for other structural planes to that which contributed to the North Wall Failure. This study has not identified any related structures.

The stability has been checked and overall the FOS are high for the MP4 pit. The lower slope is potentially affected by underground slopes and disturbed rock mass. Backfilling of any Martha stope voids within the upper 30m below the MP4 pit during mining will be undertaken where it is safe and practical to do so.

The lower east wall appears to have marginal stability mainly in and around the Milking Cow. This was known and was part of the original understating for the East Layback Pit. This is the region currently affected by the creep movements. However, the strength parameters are known to be conservative based on the actual put exposures. Hence depending on the assumed strength parameters higher FOS in keeping with generally accepted standards apply.

6.4 Summary of Changes to Geological Model

Since the 2002-2003 studies, the significant events have comprised:

- Cracking and movement on the 1070 m RL and 1090 m RL berms below the Pumphouse.
- September 2004 - Renewed tilt movements of the Pumphouse itself.
- 2003-2005 - Spreading of the Seddon St. cracks across to Haszard St. and continued movement on the western set of cracks in Seddon St.
- September 2005 - Cracks observed immediately below the Pumphouse above the 1125 m RL berm.
- 2003-2005 - Continued movement of all prisms in the south, southeast and east.
- 2015 – Failure of the north wall

There have also been several significant changes to the geological model including:

- More complex local bed geometry in the upper Ignimbrite Zone on the east wall.
- A much thicker Younger Andesite Unit (Blue Shear) in the toe of the east wall.
- A newly discovered cave/subsidence zone on the eastern side of the Albert Stope, that is in part responsible for the thicker Younger Andesite Unit, but also underlies the toe of the east-southeast pit wall.
- Abundant seepage and probable high groundwater levels in the Younger Andesite Unit.
- The geotechnical characteristics of the Younger Andesite have not improved with depth, and if anything, this is a weaker rock unit than anticipated.
- General deterioration in the Andesite rock mass within the cave/subsidence affected zone at depth in and around the old “Milking Cow”.

Further deterioration of the ‘Milking Cow’ due to MUG is expected. This will require the geological model and its impact on Martha Phase 4 to be updated as an ongoing process.

7 GEOTECHNICAL MANAGEMENT SYSTEM

A Geotechnical Management System has been in place for some time for the Martha open pit. It is a process used by the Geotechnical Engineer to monitor, investigate and analyze the performance of the pit slopes and surrounding areas during operation of the pit.

Figure 9 below shows the monitoring systems that are currently installed and operating within the Martha Pit. Survey prisms (blue dots) are measured by theodolites (blue triangles) located on the south and north west pit walls. The theodolites measure every prism on a 4-hour cycle.

There is a ground scanning radar (orange square) located on the south east wall that continuously monitors the north wall failure and surrounding areas (orange zone). One scan takes approximately seven minutes.

Two inclinometers (green diamonds) are situated behind the north wall failure and are measured by Geotechnics once a month.

In the north east of the Martha Pit, there are several piezometers (pink dots) which have data loggers installed. The data is uploaded once a month by the environmental department. All data from the monitoring systems are saved to respective data bases and reported to council annually at the peer review meeting.

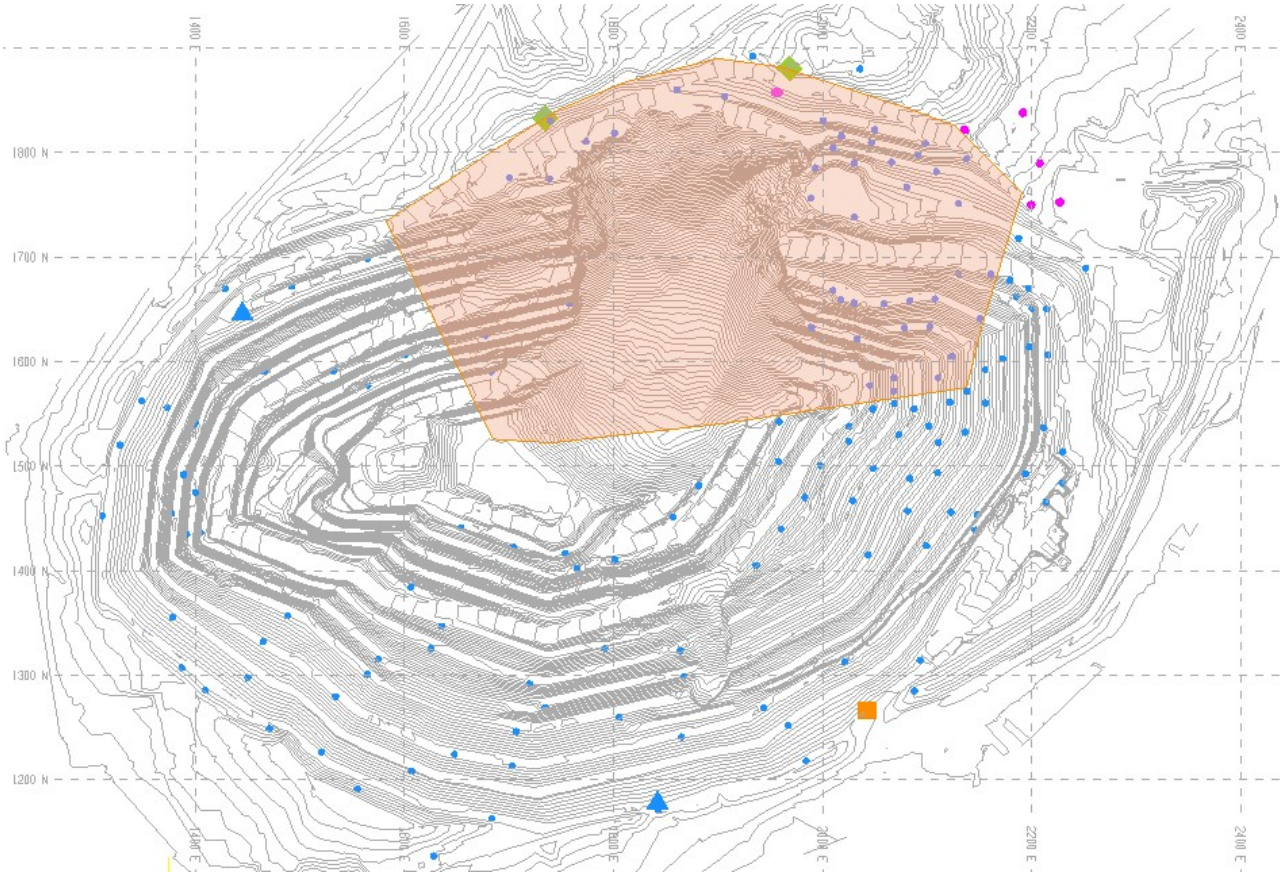
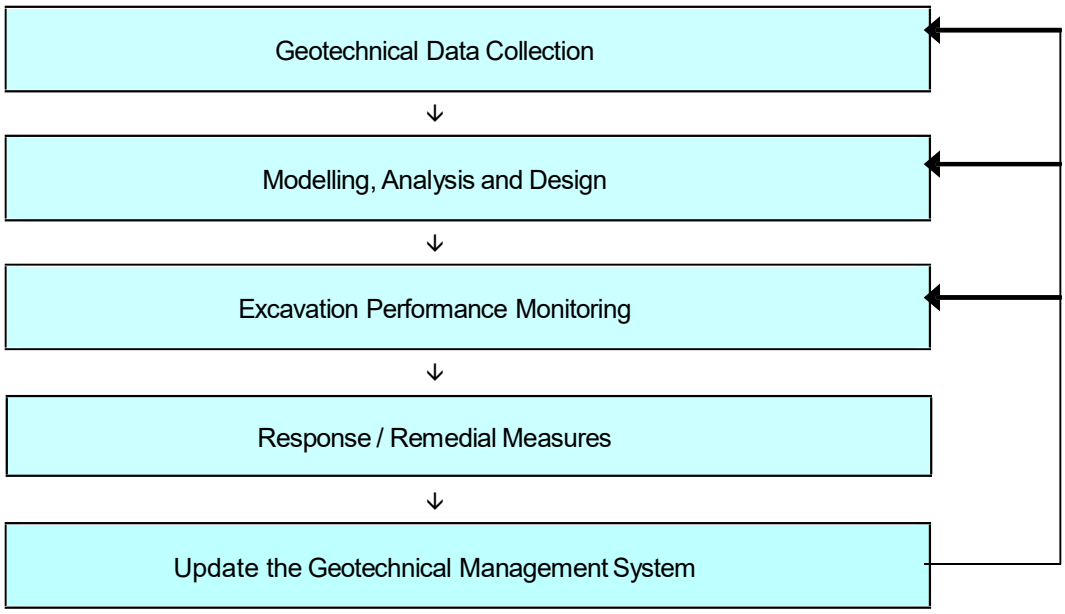


Figure 9 – Current operating geotechnical monitoring systems in the Martha Pit

As operations progress, the impact of mining activities on slope performance can change day to day – for this reason the Geotechnical Management System is dynamic (meaning that it is updated continually). It comprises the following activities:



and it applies to the following areas:

- Martha open pit excavation and pit walls,
- Surface facilities area comprising the Jaw and Stamler crushers and belts CV1, CV13, C V 16 and CV15 in the crusher slot and CV2 to the Barry Road extents,
- Open pit stockpile area and magazine facilities,
- Historical pump house and adjacent historical structures,
- Grey Street and Barry Road subsidence area,
- Eastern stream area,
- Areas around the pit that may be subject to ground deformation resulting from mining in the pit.

Monitoring includes instruments in the immediate vicinity of the open pit, the surface facilities area, the Cornish pump house and Grey Street.

There are currently no areas near the open pit where structures are affected by mining induced instability. Figure 10 below indicates hazard zones - identified in a 2009 study by PSM - where potential subsidence was more likely to occur due to historical workings. In the unlikely event where the structural integrity of a building is comprised and the safety of public or personnel is at risk of harm, the Emergency Management Plan will be activated.

Where the structural integrity of a building is compromised, and the safety of others is not threatened, an independent civil structural engineer will be engaged to assess damages and provide recommendations for repair/restoration - and if possible - relocation. If applicable, Heritage New Zealand will also be engaged if the affected structure has historical significance. The provision of interim/alternative structures-facilities will be only implemented at the advice of expert assessments provided to OGNZL by a structural engineer, which shall be made available to the HDC.

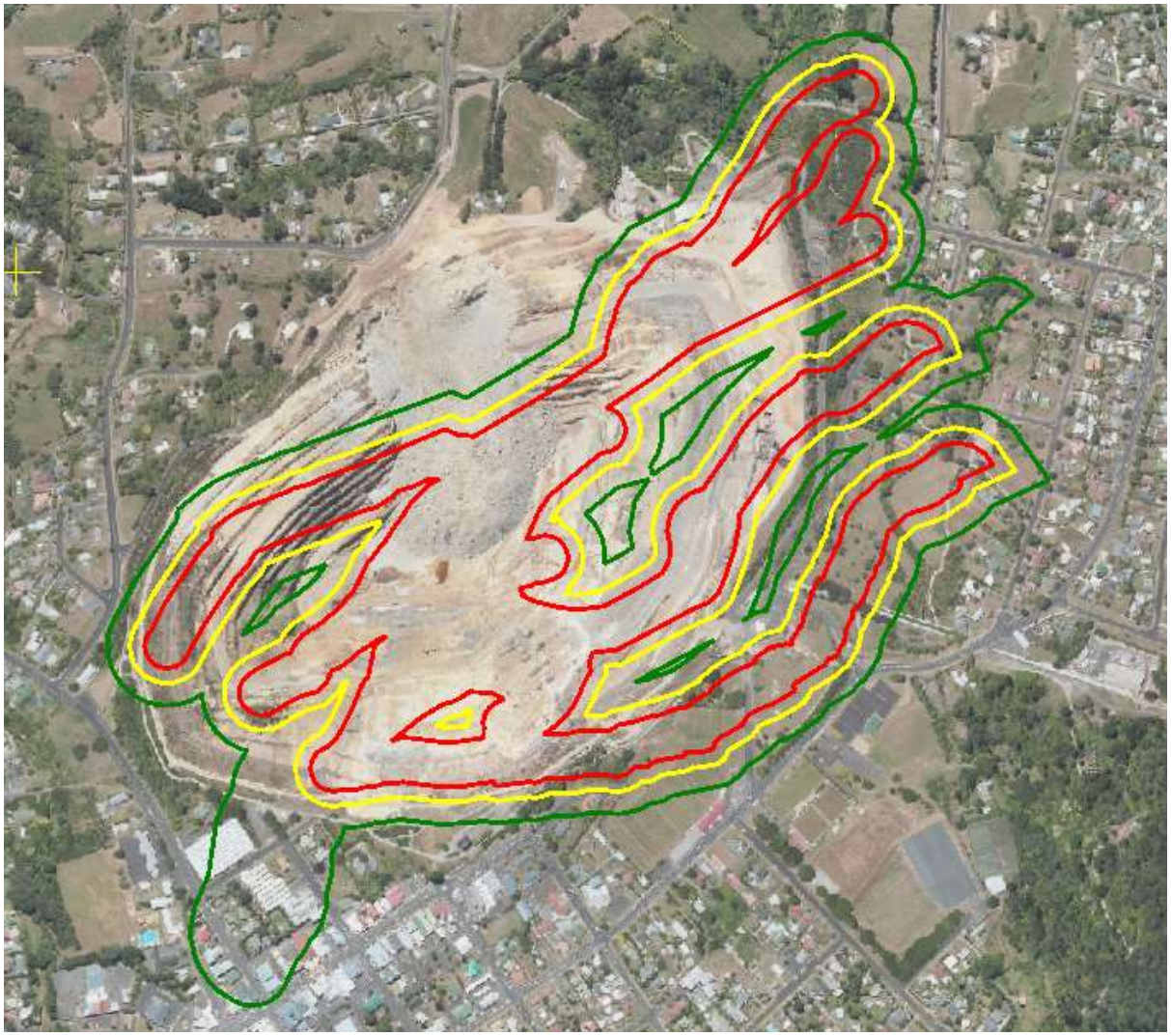


Figure 10 – Subsidence Hazard Zones from High (red) to Low (green)

8 GEOTECHNICAL HAZARD IDENTIFICATION & RESPONSE

8.1 Purpose

Significant geotechnical hazards in the Open Pit can be grouped into three main areas, slope failures, collapse through subsidence and earthquake events; which can also occur as a combination. Intermediate geotechnical hazards may comprise rockfalls, subsidence or cracking of haul roads or cracking of pit walls. These hazards are managed by:

- Ensuring that the Crushing and Conveying area, SFA (Surface Facilities Area) and Pit are evacuated in a timely, controlled and efficient manner should potentially hazardous movements or measurements be recorded on any of the various geotechnical monitoring instruments in and the around the pit.
- Ensuring that all management requiring immediate notification are informed of the type of event that has occurred and the actions taken to mitigate the possible results that might ensue from the occurrence.

8.2 Geotechnical Hazard Identification Process

There is a four-level system for managing geotechnical hazards: green, yellow, red and the Emergency Management Plan (EMP).

Under normal conditions (Condition GREEN) the inspection process will include:

- The Geotechnical Engineer will review inclinometer measurements when data are received from Geotechnics Ltd.
- The pit wall prisms are monitored automatically by robotic theodolites sited on both the south wall (P5), north west wall (P4) controlled by the GEOMOSS Leica system. Measurements are undertaken twice daily at 0400 hrs. and 2300 hrs. Email alerts are sent to mine operations personnel if measurements exceed set thresholds (nominally 60mm of vector movement).
- Radar monitoring is to be conducted using a GroundProbe SSRXT Radar to provide real-time wall displacement monitoring. Radar setup is to be carried out by the Geotechnical Engineer, with support from Survey, in accordance with the SSR-Viewer help Reference Guide. Scan regions will be set to encompass all high walls above and below the active mining bench, with exclusion zones surrounding active mining regions. All scan regions shall have both a **Critical Alarm**, and a **Geotechnical Alarm** set.
- The **Geotechnical Alarm** threshold shall be set at a cumulative rate of 6mm/h on a 5m x 5m minimum point grid initially. The Geotechnical Alarm shall be sent to the Geotechnical Engineer and the Open Pit Manager.
- The **Critical Alarm** threshold shall be set at a cumulative rate of 12mm/h on a 5m x 5m minimum point grid initially. The Critical Alarm shall be sent to the Geotechnical Engineer, Open Pit Supervisor's, Open Pit Manager. The Underground Geotechnical Engineer and Underground Technical Services Superintendent shall be notified.
- During crushing operations, crushing staff will inspect the tunnel laser daily. The Crusher operator will also check the laser offset from target and report any change / deviation from target to the mine survey.
- The Open Pit Supervisor or Geotechnical Engineer will inspect accessible parts of the pit, surface facilities area and crusher area on a weekly basis looking for cracks, subsidence features, blast damage or other signs of instability.

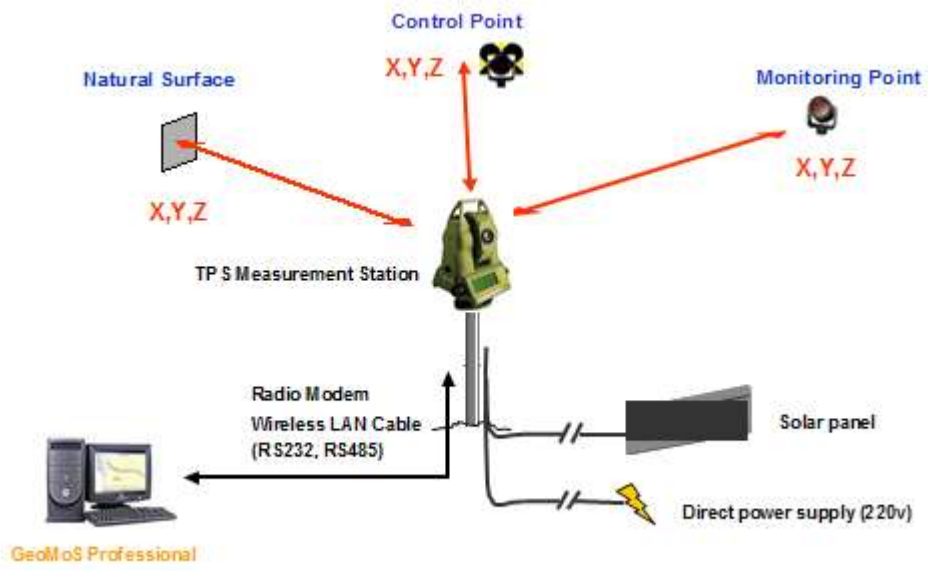
Geotechnical Monitoring

Item	FREQUENCY	COMMENTS
Borehole Inclinometers	Monthly	Geotechnics Tauranga undertake field measurements monthly, process data in Tauranga and email to the Geotechnical Engineer who will inspect charts produced for cumulative movement and time displacement movement.
Pit Wall Prisms	Twice Daily	Automated robotic theodolites are programmed to survey all current prisms on a twice daily basis using Leica TM30 and TM50. The results are to be placed into the GEOMOSS monitoring database. The Geotechnical Engineer will check the movement vectors on a working day basis and examine those areas / prisms which show movement more than 1mm/day.
Radar Geotechnical Monitoring	Real-time	The SSRXT, Movement & Surveying Radar is a slope monitoring radar used to monitor the **real-time** stability of areas of concern. The Geotechnical Engineer sets up and performs MSR monitoring, reporting any alarm level is triggered.
CV2 Laser	Daily	During operation, the Crusher operator will check the laser offset from target daily and report any change / deviation from target to the mine survey.
Pit Inspections	Daily	During mining operations, the Geotechnical Engineer or Pit Supervisor will carry out a scheduled inspection of the accessible benches, the 1120RL light vehicle track and working areas on a weekly basis. Any new cracking or other structural features will be noted on the walkover sheet and bought to the attention of the Open Pit Manager and / or Mine Geologist. Following a report on fall of ground / slope failure or high rainfall event a geotechnical pit inspection will be carried out.

8.3 Wall Stability – GEOMOS Systems

The principal tool for monitoring the performance (and stability) of the pit walls is the GEOMOS Leica monitoring system. OGNZL Waihi employs two separate and independent systems, one set up on the north west wall (P4) and one set up on the south wall (P5). This system features:

- Dedicated robotic theodolite on station
- Measures free station (instruments position) before each measurement cycle
- Monitoring points (prisms) - installed at various intervals (generally ~100m apart) on benches around the entirety of the pit. As operations advance, new monitoring points are installed.
- Programmed to operate at set time intervals
- Automatic computation of deformation results including limit checks of calculated results
- User defined settings for measurements, computations, limit checks, etc.
- Various message types (limit check exceeded, power supply, communication problems, burglary, sensor problems) sent to email.



The GEOMOS software allows direct output of prism vectors which can be viewed immediately to identify “hot spots” and then discrete prisms can be viewed for x, y, z components.

8.4 Wall Stability – Radar Geotechnical Monitoring System

Radar monitoring is conducted using a GroundProbe SSRXT Radar to provide real- time wall displacement monitoring. Radar setup is to be carried out by the Geotechnical Engineer, with support from Survey, in accordance with the SSR-Viewer help Reference Guide. Scan regions will be set to encompass all high walls above and below the active mining bench, with exclusion zones surrounding active mining regions. All scan regions shall have both a **Critical Alarm**, and a **Geotechnical Alarm** set.

- The Geotechnical Alarm threshold shall be set at a cumulative rate of 6mm/h on a 5m x 5m minimum point grid initially. The Geotechnical Alarm shall be sent to the Geotechnical Engineer and the Open Pit Supervisor.
- The Critical Alarm threshold shall be set at a cumulative rate of 12mm/h on a 5m x 5m minimum point grid initially. The Critical Alarm shall be sent to the Geotechnical Engineer, Open Pit Supervisor, Open Pit Manager. The Underground Geotechnical Engineer and Underground Technical Services Superintendent shall be notified.
- Radar maintenance shall be carried out monthly by a GroundProbe Australia service person.
- Technical support for radar communications is available from OGNZL IT department.

8.5 Trigger Levels

8.5.1 Condition Yellow

Borehole Inclinometers

- Greater than 100mm cumulative movement over length of inclinometer or greater than 80mm movement in a single interval.

Surface Prisms

- Within the Crusher slot, a sudden fall of more than 25 mm in two or more adjacent prisms

- Within the Open Pit, the "trigger point" for concern with the monitoring data is if the movement rate is double the survey accuracy from the last reading. In this case the prism should be re-surveyed as soon as possible. If the reading is proven to be correct, then an additional reading should be taken the following day.
- Total movement of 36mm will trigger this alert level.

Radar Monitoring

- This condition threshold shall be a verified cumulative rate exceedance of 6mm/h on a 5m x 5m minimum point grid.

Other

- Any unusual variation from the long-term trend in a monitoring point's movement.
- Walkover identifies extensive new cracking of surface / pit slopes.
- Vertical subsidence on a crack greater than 150mm
- Rockfalls of greater than 1000t.
- Sudden loss of surface water
- Sudden appearance of new cracks in SFA or sudden opening of existing cracks by more than 50mm.
- Probe holes in the open pit intersect cavity more than 15m deep in more than 20 holes.
- Appearance of new cracks in infrastructure or ground, or sudden opening of existing cracks, or appearance of sinkholes in areas outside the Pit rim that may be deformed by mining.

8.5.2 Condition Red

Borehole Inclinometers

- Greater than 500mm cumulative movement over length of inclinometer or greater than 300mm movement in a single interval.

Surface Prisms

- Within the Open Pit, the "trigger point" for the prisms would be if the movement rates double over two consecutive readings.
- Within the Crusher slot –
- 1. A sudden fall of more than 100 mm in two or more adjacent prisms.
  2. Development of any accelerated pattern of vertical movement in two or more prisms

Radar Monitoring

- This condition threshold shall be a verified cumulative rate exceedance of 12mm/h on a 5m x 5m minimum point grid initially.

Other

- Walkover identifies multiple large-scale new cracking of surface / slopes
- xx Appearance of new cracks in infrastructure or ground, or sudden opening of existing cracks, or appearance of sinkholes in areas outside the Pit rim that may be deformed by mining.

8.6 Response on Trigger Levels being Reached

On one or more of the trigger conditions being exceeded the Open Pit Manager will be informed at once by the reviewer (generally the Geotechnical Engineer) of the data. In the absence of the Open Pit Manager the reviewer of the data will inform the General Manager of the exceedance. Flowcharts showing the response are included below.

8.6.1 Condition Green

This is the normal operating condition.

8.6.2 Condition Yellow

For Condition Yellow Trigger Levels, the Open Pit Manager or his delegate will upon receipt of the information and in consultation with the Geotechnical Engineer:

1. Inspect the data and the areas affected,
2. Notify the Geotechnical Consultant,
3. Increase the level of monitoring (for inclinometers to twice weekly and affected prisms to hourly).
4. Convene a formal meeting attended by the Open Pit Manager, General Manager, Open Pit Supervisor and Mine Geologist to discuss data from the affected area and assess risk.
5. If risk is considered moderate / high, inform General Manager and request Geotechnical Consultant review data against geotechnical model predictions and provide recommendation. In the event of new cracking or subsidence detected outside the pit rim HDC will also be advised.
6. If excavation is being undertaken near the area where the trigger level has been exceeded, then the area shall be considered unstable and the procedure in Section 8.7 will be initiated.

8.6.3 Condition Red

Immediate Action

For Condition Red Trigger Levels, the Geotechnical Engineer will immediately notify the Open Pit Manager. The Open Pit Manager will inform the General Manager and Open Pit Supervisor of:

1. The nature of the exceedance,
2. The threat (or otherwise) likely to be caused by the exceedance,
3. The action(s) taken to make safe both personnel and the operations

The Open Pit Manager or his delegate will upon receipt of the information and in consultation with the Geotechnical Engineer decide as to whether to invoke the Emergency Management Plan - Mine based on any safety threat which may be present and to evacuate the Open Pit Area in accordance with the Emergency Management Plan (WAI-250-PLN-001).

The Open Pit Manager and Geotechnical Engineer will inspect the data and the areas affected.

Follow-on Action

The geotechnical monitoring data (prisms, inclinometers and radar monitoring) will be emailed and analysed by the Geotechnical Consultant. In terms of the Open Pit prism data:

- In this case, the area of the moving prism(s) or the radar monitoring data should be inspected. If the cause of the movement cannot be determined, then mining activity in the area should be

reduced to day shift only or suspended and another set of readings should be made the following day.

- Continued acceleration of the movement should require closure of the pit floor below the moving area until the situation has been fully investigated.
- If an increase in movement greater than four times the survey error is recorded for any reading when there have been no previous accelerations noted on a prism, or exceedance of radar monitoring critical threshold limits, the operations staff should be informed immediately, and the area below cleared until the point has been resurveyed and inspected. If the reading is confirmed, then the area should remain cleared until the situation has been investigated.

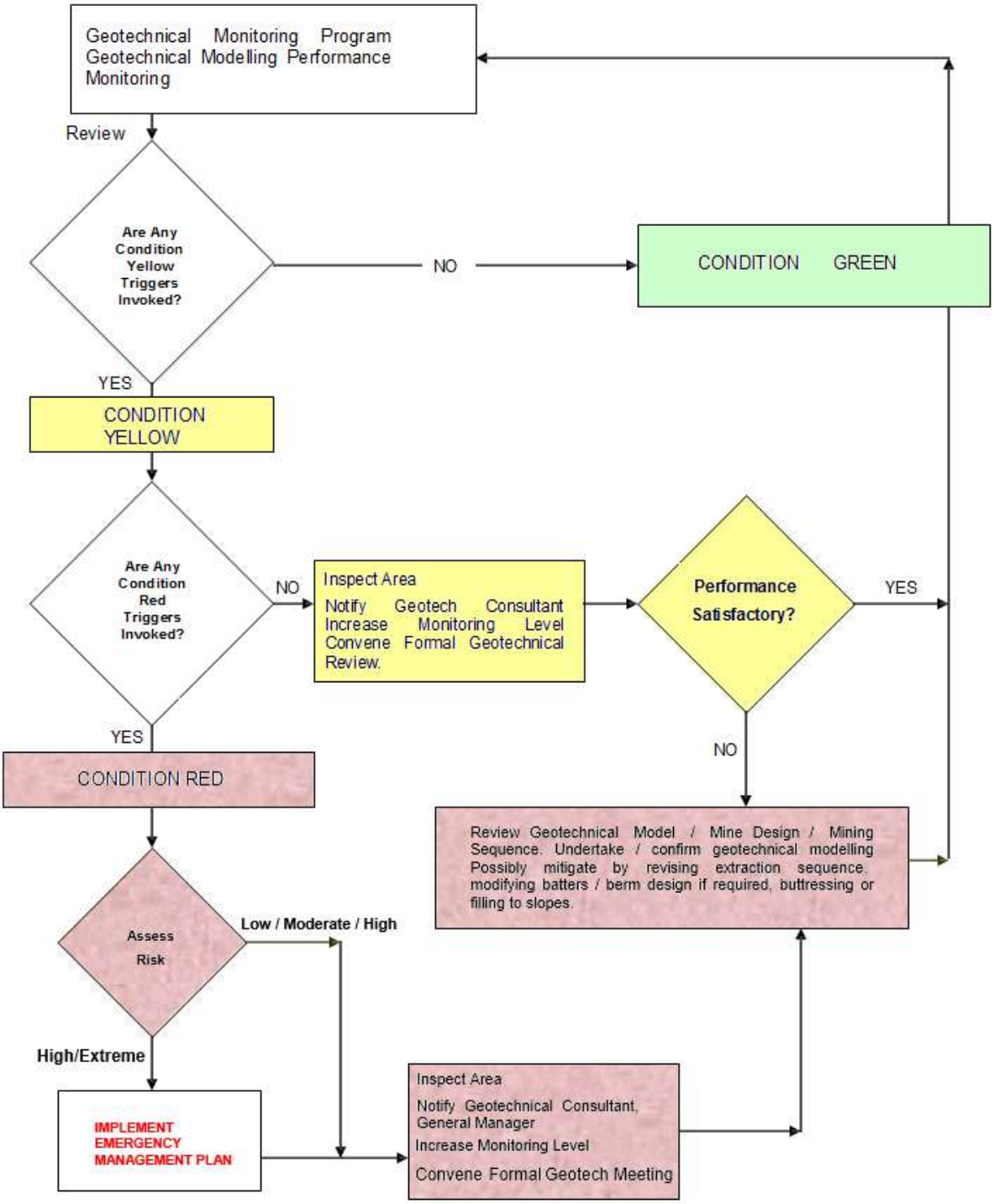
A formal meeting will be convened attended by the Open Pit Manager, General Manager, Open Pit Supervisor, Geotechnical Engineer, Mine Geologist and Geotechnical Consultant (by phone) to discuss data from the affected area and assess both short term and long-term risk. If there is predicted or imminent high risk identified, the OGC Emergency Management Plan will be triggered and the process managed by the Incident Management Team (IMT) using the Coordinated Incident Management Structure (CIMS). The IMT will manage any emergency triggered at OGC inclusive of those related to geotechnical matters (and including issues identified outside the pit rim).

The Geotechnical Consultant will review data against geotechnical model predictions and provide recommendation which may include but not restricted to:

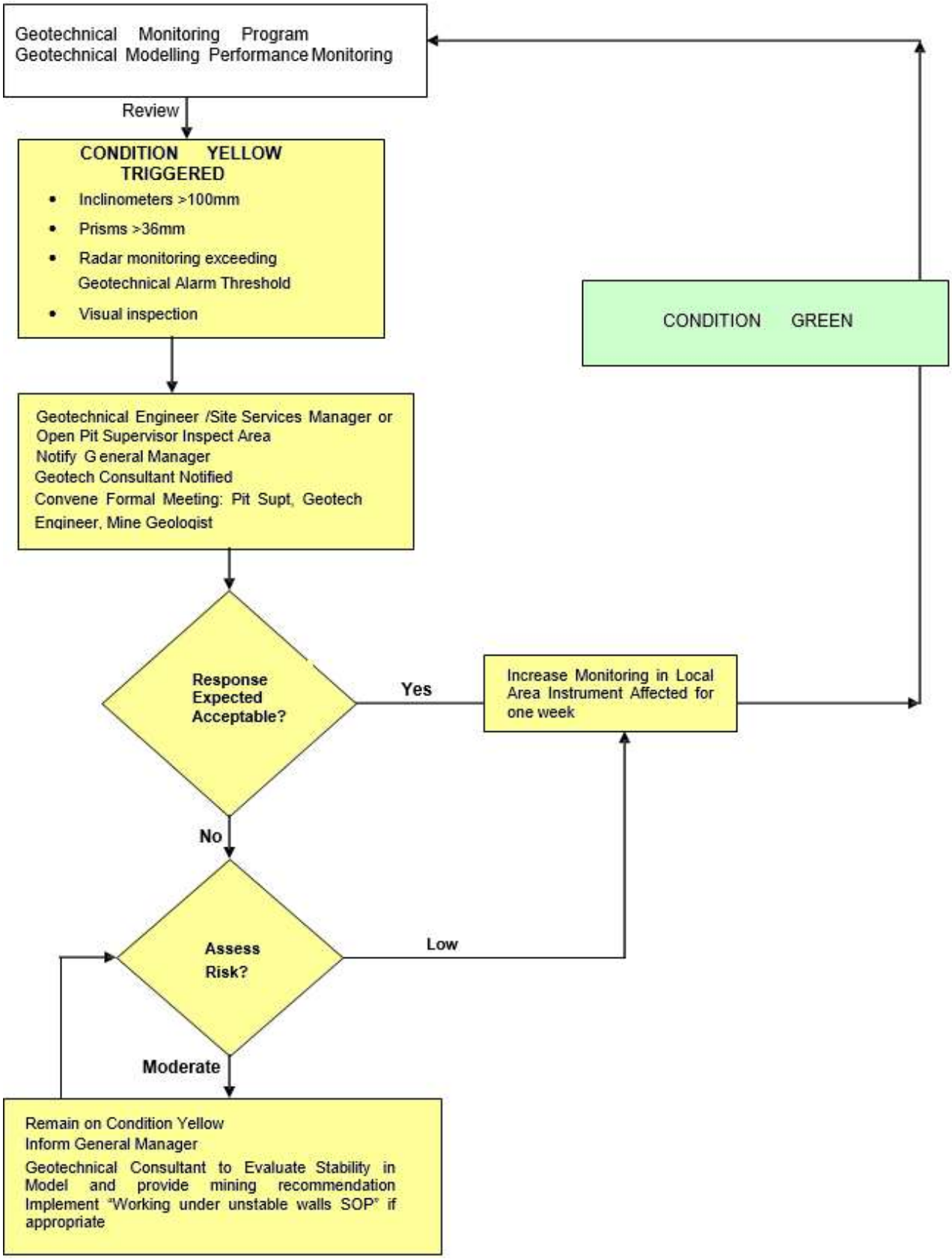
- Mining Sequence and Access
- Buttressing
- Drainage
- Additional support to stope backfill
- Modifying batters / berms
- Additional instrumentation

8.7 Flowcharts

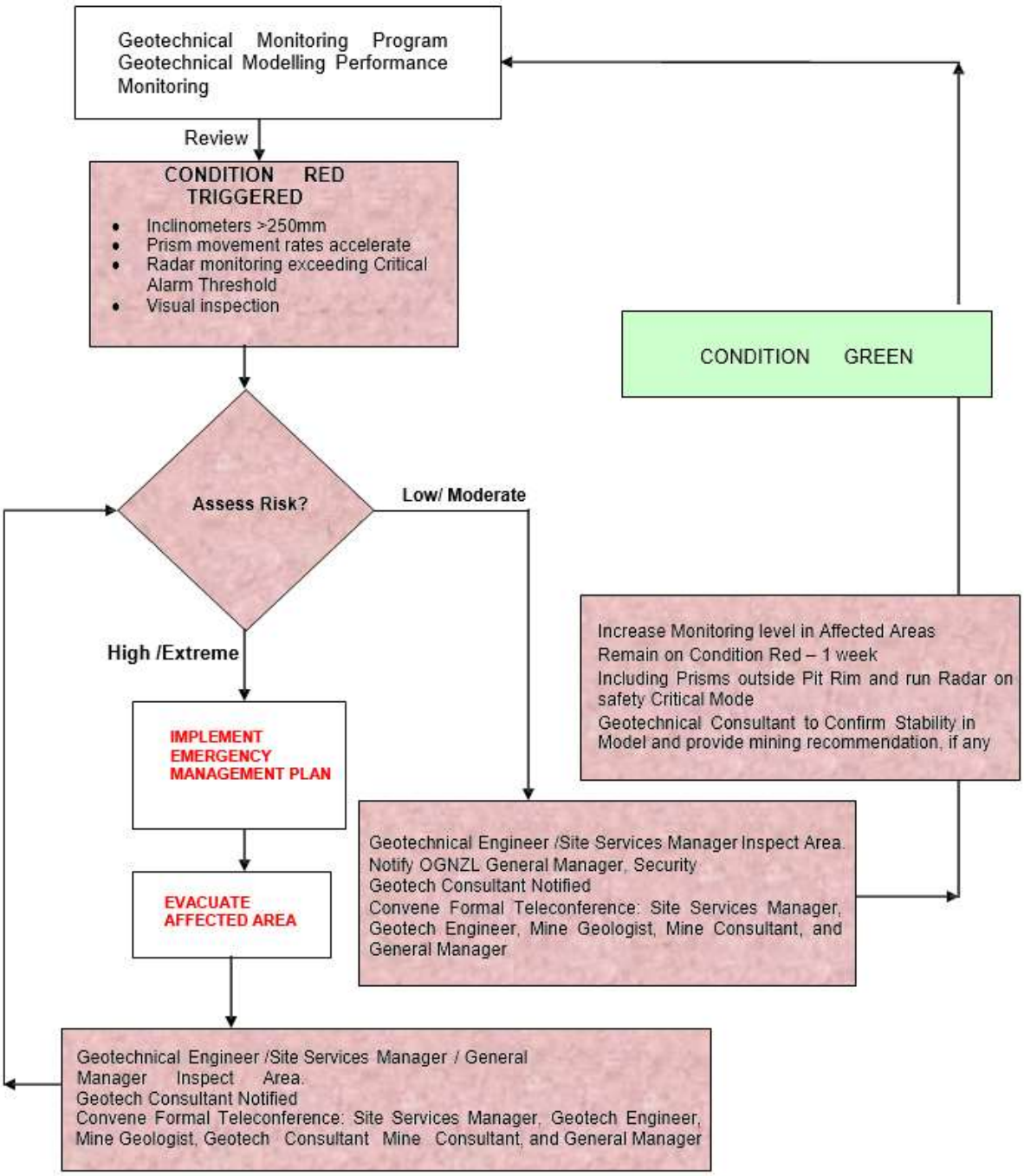
Flowchart - Geotechnical Hazard Monitoring & Response



Flowchart – Condition Yellow Response


Geotechnical Monitoring Program
Geotechnical Modelling Performance Monitoring
Review
CONDITION YELLOW TRIGGERED
Inclinometers >100mm
Prisms >36mm
Radar monitoring exceeding Geotechnical Alarm Threshold
Visual inspection
CONDITION GREEN
Geotechnical Engineer /Site Services Manager or Open Pit Supervisor Inspect Area
Notify General Manager
Geotech Consultant Notified
Convene Formal Meeting: Pit Supt, Geotech Engineer, Mine Geologist
Response Expected Acceptable?
Yes
Increase Monitoring in Local Area Instrument Affected for one week
No
Assess Risk?
Low
Moderate
Remain on Condition Yellow
Inform General Manager
Geotechnical Consultant to Evaluate Stability in Model and provide mining recommendation
Implement "Working under unstable walls SOP" if appropriate

Flowchart – Condition Red Response



8.8 Assessment of Geotechnical Hazards

The following guidelines should be used for assessing the extent of the geotechnical hazard risk posed by the trigger levels described in the flowcharts. Consideration needs to be given to Consequence (normally the magnitude of any potential failure or the impact on major infrastructure) and the likelihood of the event occurring

Geotechnical Hazard Consequence Categories

Consequence Parameters	1	2	3	4	5
Management	An event, the impact of which can be absorbed through normal activity.	An event, the consequences of which can be absorbed but management effort is required to minimise the impact.	A significant event which, can be managed under normal circumstances.	A critical event which, with proper management, can be endured	Disaster, Potential to lead to collapse of business
Economic Cost	<$1M	$1M-$2M	$2M-$5M	$5M-$10M	+$10M
Effect	Damage to equipment	Temporary loss of access to ore. Damage to equipment	Loss of access to ore, Major Wall failure	Loss of major haul road or SFA	Large scale wall failure, Loss of major haul road or SFA
Safety			Lost Time Injury	Fatality	Fatality

Geotechnical Hazard Likelihood Categories

Likelihood	Indicative Occurrences
Almost Certain	Within 12 months
Likely	Once every 2 years
Possible	Once every 5 years
Unlikely	Once every 10 years
Rare	Once every 20 years

Geotechnical Hazard Risk Categories

Risk	1	2	3	4	5
Almost Certain	High	High	Extreme	Extreme	Extreme
Likely	Moderate	High	High	Extreme	Extreme
Possible	Low	Moderate	High	Extreme	Extreme
Unlikely	Low	Low	Moderate	High	Extreme
Rare	Low	Low	Low	Moderate	High

8.9 Frequency of Monitoring

The following frequency of monitoring is planned for the various instrumentation based on conditions imposed by the trigger levels.

Instrument	Condition Green	Condition Yellow	Condition Red
Inclinometers (1)	Monthly	Fortnightly	Twice Weekly
Laser in CV2	Daily	Daily	Twice Daily
Wall Prisms	Twice Daily / Weekly	Twice Daily / Weekly	Daily
Affected Prisms	Daily	Daily	Hourly
Radar Monitor	Real-time	Real-time	Real-time
Crack Monitor	Weekly	Weekly	Daily
Pit Walkover	Weekly	Twice Weekly	Daily
Ground Water Level	Weekly	Weekly	Weekly

8.10 Notification / Contact Phone Numbers

Open Pit Supervisor

- Liam Ireland - 027 868 0104 or 863 9907
- Robert Dix - 027 655 6669

If no contact:

Open Pit Manager

- Kevin Storer - 027 488 5261 or 863 9772

If no contact:

General Manager

- Bernie O'Leary - 0274 221 771 or 863 9829

Other Contact

- Baxter Road Security - 07 863 3300

9 CHANGE MANAGEMENT, DATA MANAGEMENT AND REPORTING

9.1 Pit Design

9.1.1 Pit Design Plan

This will be updated when a new design is issued and the changes will be described in the Record of Changes to Current Pit.

9.1.2 Record of Changes to Current Pit

The following changes have been made to the pit design over time.

Date	Pit Name	Description / Comments	Approved
Dec-18	Phase 4	North wall layback as authorised by Land Use consent 202.2018.00000857.001to establish the Martha Underground Mine and to enable the Martha Pit North Wall Cutback and Reopening of the Martha Pit	TM
Jun-12	Pit 66D1.7	Steepened the 1060-1050mRL batter resulting in a revised south wall of the ELB	JR/EC
Jun-12	Pit 66D 1.6	Laid back the north eastern corner of the ELB to remediate a failure in the area	JR/EC
May-12	Pit 66D 1.5	Dropped half of the 1070mRL berm north wall to the 1065mRL because of a blast failure below the haul road.	JR/EC
May-12	Pit 66D 1.4	Added a large buttress to remediate a failure on the north eastern corner. 1070mRL berm was removed to accommodate the foot print of the buttress	JR/EC
Mar-12	Pit 66D 1.3	Removed berm to accommodate switchback on the 1067.5mRL north wall	JR/EC
Jun-11	Pit 66D	Small section of batter below crusher on 1103 flattened to accommodate for weak soil strength	TM
Sep-10	Pit 64A rev02	Design Note on Pit64A rev02 Temporary Ramps	TM
Mar-09	Pit 64A rev02	Design Note 19th March 2009, lowering southern ramp, removing part of eastern buttress steepening ace slope angles on south and south west walls below 1010mRL Flattening south west face slopes above 1010mRL.	GG
Jun-08	Pit 64 rev01	Revised slopes in south-west sector between 1070mRL and 1030mRL to incorporate buttress and flatter slopes through softer material.	GG
Aug-06	Pit 63A rev06	Revised haul road design below 930 RL to recover remnant ore and drop cut to base of pit to 890RL	GG
Jul-06	Pit 63A rev05	Revised haul road design below 930 RL to recover remnant ore and drop cut to base of pit to 892RL	GG
May / June 2006	Pit 64	Cutback to southern wall to provide for an increase in wall stability under strain softening and seismic conditions. Required the relocation of historical Pumphouse.	GG / JA
Jul-05	Pit 63A rev05	Revised western wall 950 Bench and below on the western wall due to ore distribution.	GG
Apr-05	Pit 63A rev01	Revised Pit design to accommodate flatter slopes to lower eastern wall, provision of a stability buttress to eastern wall, flattening and buttressing of the haul road around the Edward Stope and steepening of the haul road below 990 RL. Changed target depth from 880mRL to 900mRL.	GG
May-04	Pit62 V	Revised 985 bench western end due to ore distribution. added 1000mRL berm to east wall and amended change to 987 haul road below berm	KPR
Jul-03	Pit62_U	Revised design northern corner of east wall above 1090mRL to permit existing ramp arrangement to be retained.	KPR
Jun-03	Pit62_5T	East wall redesigned to avoid noses on intersections with existing walls. Revision requested by PSM	KPR
Jun-03	Pit62_5T	1050 Berm West wall reduced to 7m, to allow flattening of batters at lower levels and provide more adequate turn-around at 1020RL	KPR

9.1.3 EOM Survey Pick Up

Updated monthly by Surveyor.

As mining progresses, the surveyor will 'pick up' excavated areas using various survey techniques and provide the collected information to the open pit engineer. The digital string files are used to create an 'as built' pit using modelling software which can then be used to check against the original pit design.

9.1.4 Stope / Levels / Shafts Intersections with Current Pit

Updated monthly by Geotechnical Engineer.

The Open Pit Design is held in directory G:\Mining\medswork and can be viewed using Medsystem software (MineSight). The underground model including stoping by type (shrinkage, cut and fill, other), levels and shafts is held in directory G:\Mining\Geology\minesight_project_msresources\stopes and can be viewed using Medsystem. Updates from pit mapping will be included in the underground workings model.

9.1.5 Ground Support Installed

Updated by Geotechnical Engineer whenever ground support is installed.

9.2 Monitoring Records

9.2.1 Current Active Prism Location Plan

Updated by Geotechnical Engineer when new prisms are installed, or existing prisms become defunct.

9.2.2 Plot of Prism Vectors

Updated weekly by Geotechnical Engineer.

9.2.3 Review Radar Monitoring Images

Reviewed daily by Geotechnical Engineer.

9.2.4 Inclinometer and Piezometer Location Plan

Updated by Geotechnical Engineer only if a new instrument is installed.

9.2.5 Crusher Slot Monitoring

Updated after each daily measurement by crusher and conveying personal and checked monthly by the Geotechnical Engineer.

9.2.6 Plot of Cracks and Sinkholes

Updated only if new cracks or sinkhole is identified by Geotechnical Engineer.

9.2.7 Ground Water Levels, Mine Pumping Volumes & Drain holes

Updated monthly by Geotechnical Engineer.

9.3 Pit Slope Failure Reports

Updated only if new slope failure occurs. Recorded by Geologist or Geotechnical Engineer. Failure analysis to be completed by Geotechnical Engineer (with assistance from consultant if required) and added to the Pit Slope Failure register: G:\Mining\Geotechnical\Martha\Geotechnical\Martha\Pit Wall Failure Reports.

9.4 Pit Inspections Register

Will be updated weekly by Geotechnical Engineer.

9.5 Seddon Street Monitoring

Inclinometer will be measured monthly by Geotechnics and sent to Geotechnical Engineer for analysis.

9.6 Geotechnical Correspondence In/Out

Updated by Geotechnical Engineer.

9.7 Risk Assessments – Current

https://oceanagold.sharepoint.com/waihi/health/Pages/default.aspx

All activities undertaken on site require some form of risk assessment to ensure adequate controls are put in place for personnel safety. Activities that prove to be high or extreme risk will be added to the OceanaGold Risk register. Activities identified to be lower in risk will require either a field level risk assessment to be undertaken and/or a job hazard analysis (JHA).

9.8 Phase 4 Monitoring Plan

Prior to open pit operations recommencing the Bulltown and Cambridge road will require realignment and the noise bund relocated to establish the pit rim. The design has not been finalized at this point in time.

Pit Slope Behaviour

The Pit Slope monitoring systems operating for the existing Pit and described in the EMMA Pit Slope Monitoring Manual will be extended to cover the Phase 4 Pit.

Prism monitoring will be established at the pit rim and on a grid of 100m horizontal and nominal 20m vertical distance depending on the berm interval. The base station will be surveyed in to provide for precise measurements. Prism coverage on the other walls is satisfactory but may be upgraded prior to the start of mining to ensure coverage of nominal 100m horizontal, 20metres vertical. A dedicated total station monitoring the south, east and west walls located at the northern pit crest.

Groundwater

As the Phase 4 pit is developed horizontal dewatering bores will be installed to a similar configuration as that installed in the Eastern layback. Holes will be rotary drilled and approximately 100m deep. Holes drilled prior to the north wall failure that made water will provide the target zones. Horizontal Drain holes installed in the Phase 4 Pit will be collar, azimuth and dip surveyed and flow rates recorded and monitored periodically.

The piezometers installed on the northern wall and eastern wall and described in PSM125-252R will continue to be monitored as MP4 is mined. This will be tied into the piezometers to be installed above the Rex lode and other existing piezometers. The ground water model will be assessed by GWS as part of the annual dewatering and settlement review. Any anomalous readings in piezometers will be

followed up by repeat measurements the next working day and if confirmed reported to GWS for assessment.

Prior to commencing mining below the 1104mRL, a risk review will be undertaken that includes OceanaGold's geotechnical consultant(s) to identify structures including roads and public utilities and to develop a contingency plan / response in the event that pit wall instability is identified as causing or potentially causing damage.

Old Mine Stopes and Voids

Procedures for the investigation, monitoring, excavation and backfilling of old mine stopes where practical and safe to undertake that may be intersected below the toe of the Phase 4 Cutback include but are not be limited to:

Records and models

- Maintaining and updating of the historical workings digital terrain model including Martha underground stoping and backfilling records to identify remaining voids close to the design pit base as the pit approaches the design base.
- Application of probe drilling and/or use of cavity scanner to identify extents of voids.
- Recording results to a database.
- Referencing the underground mine Void Management Plan - (WAI-350-PRO-021).

Geotechnical, monitoring and design

- Geotechnical assessment as to whether addition of a sand and / or cementing product would improve stability on a case by case basis.
- Monitoring of the backfilled areas with dedicated prisms.
- Modification of the pit base / design should localised instability be identified or adverse intersections with the historical stopes.
- Development of SOP's for placing the waste rock as mining progresses bench by bench.

Installation of support

- Selection of suitable waste rock from within the open pit for backfilling historical voids
- Installation of ground support including shotcrete where appropriate.
- Placement of waste rock fill in the base of the pit after completion of mining. This is to be sourced from material hauled from stockpile close to RoM or recovered from the western pit stockpile or from the underground mine.
- Firing of bridges or remnant pillars in pit floor to facilitate back filling.

Current SOP's relevant to these tasks are referenced in Section 10 of this document.

10 STANDARD OPERATING PROCEDURES

10.1 Existing Monitoring Methods

The following procedures for monitoring are in place:

- Waihi Walkover Inspection - (WAI-350-PRO-028)
- Waihi Monitoring Pit Wall Prisms – (WAI-350-PRO-029)
- Radar Geotechnical Monitoring- (WAI-350-PRO-011)
- Waihi Monitoring Inclinometers - (WAI-350-PRO-031)
- Waihi Laser Monitor in Conveyor Tunnel - (WAI-350-PRO-032)
- Waihi Guidelines for Installing New Monitors - (WAI-350-PRO-003)

10.2 Operating in Areas Containing Underground Workings

When mining or operating in areas containing old workings or modern underground workings, the 'Stability Assessment Process' – (WAI-415-GUI-003) shall be followed to determine critical areas which could become unstable during future excavations – in particular, 30m below the toe of the phase 4 cutback. Voids or stopes that have potential to cause stability issues shall be managed using methods highlighted in the Void Management Plan–(WAI-400-PLN-011).

When backfilling a void is required, an assessment of the ground conditions around the void shall be undertaken by the Geotechnical Engineer. The selection of the type and method of backfill used will take account of the ground conditions, the proximity of the void to the pit wall, proximity of any other voids, accessibility of the void to be backfilled and the level of backfill strength required. Options include ROM waste rock; CRF (Cemented Rock Fill – ROM waste rock mixed with cement); or CAF (Cemented Aggregate Fill – finer material such as gravel mixed with cement) –

Additional inclinometers and prisms can be installed to improve monitoring in 'at risk' areas. The slope stability radar can be relocated to optimize coverage to areas which have potential to become unstable.

The relevant procedures are:

- Operating in Areas Containing Old Mine Workings -(WAI-350-PRO-021).
- Delineating Probe Zones - (WAI-851-PRO-015)
- Void Management Plan – (WAI-400-PLN-011)
- Waihi Safe Working with Subsidence of Old Workings- (WAI-350-PRO-023)

10.3 Geotechnical Mapping

The mapping procedure used is Waihi Geotechnical Mapping - (WAI-350-PRO-001).

10.4 Hydro-Geology

There is an array of monitors in place to measure the groundwater and the potential impact it has on highwall stability. Vibrating wire and stand pipe piezometers in various locations around the pit perimeter are measured frequently to produce an understanding of groundwater levels and flows. Groundwater monitoring facilities are shown on Figure 9 in section 7 of this report. Monitoring is conducted according to procedures in the Dewatering and Settlement Monitoring Plan.

As the Phase 4 pit is developed, horizontal dewatering boreholes will be installed in a similar configuration as that installed in the Eastern Layback to depressurize the slope. The preliminary plan will have three rows separated by 80m elevations with four bores on each row. Holes will be rotary drilled approximately 100m apart to a depth of 100m. In the event groundwater is the cause of further

pit slope instability, additional horizontal dewatering drains can be used to improve regional stability. Furthermore, additional piezometers, inclinometers, prisms and radar scanning can be installed to analyze the effect dewatering holes are having on slope stability.

Relevant procedures are:

- Waihi Piezometer Monitoring – (WAI-200-PRO-021)
- Waihi Horizontal Drains - (WAI-350-PRO-002)
- Waihi Pit Pumping Monitoring - (WAI-350-PRO-004)

10.5 Pit Wall Procedures

The relevant procedures are:

- Waihi Support to Pit Slope Walls - (WAI-350-PRO-005)
- Waihi Working Under Highwalls Unstable Walls or Potentially Unstable Walls - (WAI-350-PRO-010)

10.6 Geotechnical Diary

A geotechnical diary or log for the Martha open pit operations will be in the form of an A5 Collins diary located in the Geotechnical Engineer's office and tabled at the morning production meeting.

The intention of the diary is to record recent observations of a geotechnical nature, which may include:

- noting any fresh cracking to the pit walls;
- changes to existing cracking in the pit walls;
- rockfalls (major or minor);
- movement on abandoned underground workings;
- loosening / opening of geological structures such as joints;
- unusual softening of areas of haul roads;
- other signs of instability;
- changes in drainage patterns from rock faces or weep holes.

The entry should record:

- the location (either the bench level or pit area) where the feature has been observed;
- name / initials of person entering observation;
- and the type / extent of feature observed
- actions initiated, for example closure of area, survey.

10.7 Other Procedures

- Waihi Completing Pit Slope Failure Report - (WAI-350-PRO-006)
- Waihi Monthly Geotechnical Reporting - (WAI-350-PRO-007)
- Waihi Travel Beneath the East Wall Cutback and Lower North Wall - (WAI-350-PRO 009)

11 REVIEWS

This management plan shall be reviewed annually whilst MP4 is in operation and following any significant event that impacts upon the management of pit slopes. Examples include a significant wall failure or significant ground movement. The review shall be undertaken by the Geotechnical Engineer in consultation with the geotechnical consultant.

12 REFERENCES

1. Appendix P Pit Stability Assessment from the Martha Underground Mine_PSM
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