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Our Ref: PSM125.L88
Date: 1 March 2006

Mr. Adriaan van Kersen
Newmont Waihi Gold
43 Moresby Avenue
WAIHI NEW ZEALAND

Dear Adriaan,

RE: PUMPHOUSE RELOCATION: GEOTECHNICAL RISK ASSESSMENT OF SITE 4A

1. INTRODUCTION

This letter follows on from requests from Messrs. A. van Kersen and P. Bawden, Newmont Waihi Gold (NWG) to provide advice on re-location of the Pumphouse.

It is generally recognised that the Pumphouse in its current location is at risk from a number of factors. This is reinforced by the recent movements of the structure itself and by the cracking on the slope below it.

It is understood a Working Party has been formed to address longer term pit closure issues including risks associated with further collapse of old underground workings. The Working Party includes local regulatory authorities, IGNS and various technical advisers. The objective of the Working Party is to re-assess the previous risk assessment studies by IGNS of caving and collapse due to underground workings around the Martha mine and to extend those studies to incorporate all areas including the open pit.

NWG have concerns about the overall timing of results from such a study and the potential impacts on the ongoing viability of implementing remedial work on the Pumphouse if there are significant delays. Current estimates indicate results may not be available till mid to late 2006. This timing may cause difficulties for NWG, who have therefore requested early advice on re-locating the Pumphouse.

2. OBJECTIVES AND SCOPE OF WORK

The particular requests from NWG comprised:

1. Risk assessment for siting the Pumphouse at location Site 4A, Figure 1.

2. Assessment of the likely style of and any ground movements that could be expected at Site 4A.

3. If differential settlement does occur, assessment of whether any such movements could be managed without compromising the integrity of the Pumphouse.

4. Advice on whether any ground settlement will be episodic or progressive, the maximum tilt that may occur and the directions of any such tilt(s).

This assessment is based on the following information:

- Monitoring of cracks in Seddon Street by Hauraki District Council (HDC).

- Monitoring data for the southeast quadrant of the pit and surrounding areas by NWG.

- Mapping of cracks in Seddon Street and Hazard Street by NWG.

- A Geotechnical Investigation by Engineering Geology Ltd. of the alternate siting options and of the relocation path.

- Mine geological and geotechnical information provided by NWG.

- General experience of the author, with observation and monitoring at Waihi over the past 10 years.

This assessment has of necessity been limited by available time and is not supported by comprehensive calculation and computer modelling.

However, the assessment is based on more than 10 years of experience with Waihi and very detailed ongoing assessment of geotechnical conditions as the pits have been developed. This experience has also allowed a comprehensive evaluation of caving and subsidence movements and detailed evaluations of the impacts of historic underground mining activities.

3. BACKGROUND TO SITING AND RE-LOCATION

The Pumphouse is approximately 9m x 15m in plan. It is understood a structural engineering study has been carried out on the Pumphouse structure itself and appropriate bracing and support will be used to ensure the integrity of the structure.

Three possible sites were investigated by Engineering Geology Ltd; 4, 11 and 4A. Site 4A is shown on Figure 1. The re-location will entail shifting the Pumphouse to the new site located south west of the open pit and this is understood to be a constraint resulting

from two factors, firstly the allowable gradients and secondly moving the Pumphouse away from the underground workings. Geotechnical risk associated with the actual moving of the Pumphouse, including the planned pathway, is not included in the PSM scope of work.

4. CURRENT RISK ZONING

Site 4A lies outside of and approximately 10m from the edge of the Low Risk Subsidence Zone defined by using the IGNS methodology for the previous subsidence collapse risk zoning. The site is also 60m from the edge of the High Risk Zone. This Risk Zoning is for the Royal Lode Workings, the nearest relevant Lode, Figure 2.

The IGNS report concluded in regard to the Low Risk Zone that:

> *"…. It is considered unlikely that a sinkhole or collapse crater will form. Rather there could be relatively minor subsidence and ground cracking …. that may cause distortion to a building, such as jamming windows and doors, but is unlikely to be life threatening."*

and

> *"Low probability – the probability of a sinkhole reaching the surface in this zone is less than 0.1%, but there may be relatively minor surface settlement and ground cracking that is not life threatening".*

Site 4A is outside the Low Risk Subsidence Zone.

5. CRACK ZONES

In 1999 a subsidence collapse occurred in the park adjacent to the open pit. At the same time a line of cracking developed in Seddon Street about 120m east of Site 4A. The street and surrounding area were subsequently refurbished but movements on the cracks have continued. Initially in 1999 the cracks showed horizontal separation only, but over time there has also been some vertical downward movement on the northern, pit side of the cracks. Over time other cracks have developed further west in Seddon Street and then more recently in Hazard Street. There are now three distinct cracked zones south west of the open pit, Figure 2.

These zones have all shown different styles of movement and these differences are considered to be a reflection of the subsurface geometry of lodes and stopes, which appear to be the local deformation controls.

The following factors should be noted in regard to these zones:

1. The cracks are not continuous between the three zones.

2. The cracks in each zone have occurred at widely different times, separated by years.

3. The sequence style of cracking and movement in each zone has been different:

   - Zone 1
     - Initial "semi-circular" crack shape, which became linear over time.
     - Horizontal separation and vertical dislocation, pit side of the crack down.
     - Approximately linear cracks.
   - Zone 2
     - Initial "semi circular" cracks with horizontal separation only.
     - Later development of internal cracks, i.e. closer to the pit and these later cracks show transverse movement, north side of the cracks to the west compared to the south side.
   - Zone 3
     - Horizontal separation followed subsequently by some vertical displacement, pit side of the crack up compared to the south side.

4. These zones have similar plan dimensions to the other cracked and deformed areas, Figure 5.

Monitoring of the original cracks in Zone 1 has been undertaken by HDC since April 2004 and this data shows, Figures 3 and 4:

- Total movement to date on cracks over a period of about six years is of the order of 20mm, as recorded visually by HDC.
- The movements are episodic.
- The maximum movement rates are very slow, <0.02mm/day or about 7mm per annum.

6. RELATIONSHIPS BETWEEN CRACK ZONES AND HISTORIC MINING

Detailed review of all the geotechnical aspects of the Martha Mine was undertaken in 2003. That review included an evaluation of the historic underground mining records compiled by NWG. That study concluded in regard to the underground model that:

> *"These components of the model form 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."*

Figure 5 shows a compilation of historic subsidence and more recent cracking superimposed over the old underground workings.

The movements in Zones 1, 2 and 3 are controlled in large part and influenced in the first instance by the very large zone of subsidence and caving centred on the Martha,

Edwards, Welcome and Empire Lodes and their intersections. However the secondary influence, which operates more locally, is the individual Lode geometry and associated stopes.

Hence while there is global movement towards the north northeast, this will be manifested more locally as different responses which are affected by local lode and stope geometry and historic mining.

Attachment A presents a series of north south sections showing the lodes, stopes and current ground surface including the open pit. These sections are through each of the three zones:

- Zone 3 - 1400 to 1500m E,
- Zone 2 - 1600 to 1700m E and
- Zone 1 - 1700 to 1850m E.

The sections show the current cracking in relation to the local zones. A series of interpreted sections showing large scale block movements are presented in Figures 6 to 8.

Based on this broad understanding, the interpretation of the deformations in each of the three zones is:

- Zone 1
  - Local "sliding" subsidence on the surface projection of the Royal Lode, which is itself very planar and continuous in the areas of cracking, Figure 6.
  - The cracks are the southern limit of a movement zone extending from the Martha Lode in the north and which comprises in order from north to south the following; a broad subsidence and collapse, local sinkhole formation over the Royal Lode and sliding subsidence along the Royal Lode respectively.
- Zone 2
  - The explanation for Zone 2 is not as straight forward as Zone 1 because it is not as readily explained by local the geometry of the Royal Lode.
  - The cracking is best understood in terms of the movements further north on the pit slope where a prominent reverse scarp formed some years ago. Based on this and the lode geometry the Zone 2 cracks are interpreted to be caused by subsidence of a very large graben controlled by the Edward, Royal and Empire/Welcome Lodes, Figure 7.
  - The reason for the initial "semi circular" crack form is less apparent although experience has shown this is probably a surface manifestation of the initial strains reflected through the 12 to 14m of soil like materials at the surface. This also happened initially in Zone 1.

- The more recent transverse movements across the crack appear to be a manifestation of the fact that the wedge of rock between the cracks and the stopes thins to the west, allowing the block to pivot.

- Zone 3 - This crack, which started as horizontal separation and then manifested a vertical movement, northern side of the crack upwards, is interpreted as large scale "toppling" block rotation towards the north east, Figure 8. However, interpretation of Zone 3 movement is slightly more complex because the sections are oriented north south and the movement vectors are north northeast. Hence for Zone 3 it is difficult to directly relate the cracks shown on the section with the overall mining because the real control on the cracking is the underground mining in the centre of the pit which is further east. In Zone 3 the local stopes on Sections 1400 to 1500mE should be compared with the Martha Workings on Sections 1700 to 1800mE.

Although it appears on first assessment that the cracks form one large continuous area in the southwest of the open pit, the reality is there are three separate zones of cracking and deformation which are all somewhat different. Site 4A is located within Zone 2.

7. ZONE 2

Only Zone 2 is relevant to the Pumphouse re-location to Site 4A. The geological and geotechnical factors relevant to an interpretation of the causes of the cracks and movements to date in Zone 2 and used for prediction of likely future performance are:

1. There are no stopes or underground workings directly underlying the cracks.

2. The Geotechnical Investigations show the subsurface profile at Site 4A comprises:

Borehole 6	0 – 3m	- More Recent Volcanic Ash,
	3m to 14m	- Extremely Weathered Andesite and
	>14m	- Extremely low to high strength rock, Andesite.
Borehole 7	0 to 1.6m	- More Recent Volcanic Ash,
	1.6m to 12.5m	- Extremely Weathered Andesite and
	>12.5m	- Extremely low to high strength rock, Andesite.

3. The upper materials are not readily erodible and this is confirmed by the long term performance of the pit slopes in this area. Hence the risk of longer term erosion and migration of fines into the cracks leading to sinkhole development at the surface is assessed as very Low.

4. Monitoring of the pit walls and the area to the south on the northern side of the cracks shows the whole southwest area is undergoing long term creep movement towards the north northeast. This movement is controlled in large part by subsidence movements of the hanging wall of the old Martha Lode workings.

5. The cracks are aligned approximately normal to the vectors of movement for this area.

Based on these factors the cracking and movements in Zone 2 are interpreted to be caused by large scale creep movements of the block of rock defined by the old underground Workings of the Martha, Royal and Edward Lodes. Experience has shown these movements are unlikely to be entirely linear over time and should vary spatially around the area, simply because the block of rock is so large. It is estimated that the block of rock defined by Zones 1 to 3 is approximately 20M cubic metres. Like most rock mass blocks of this scale it will not be homogeneous. Similarly the old underground workings, which in essence are controlling the creep movements are themselves also not homogeneous.

8. CONCLUSIONS

There is now a wide body of experience with underground related subsidence, collapse and deformation movements at Waihi. The direct experience relates to the period of open cut mining, approximately 17 years, but this has recently been supplemented by the detailed historical review in 2003. This experience shows the principal potential deformation mechanisms at Site 4A are:

a) Sinkhole collapse – similar to the 1999 and 2001 events.

b) Cracking and movement along the edge of an historic cave zone located above old workings.

c) Cracking and differential movement along subsurface geological features reflected at the ground surface.

d) Widespread “global” subsidence, comprising both horizontal and vertical movements and or tilt.

a) Sinkhole Collapse

Site 4A is outside the IGNS subsidence collapse hazard zones. The site is not underlain by a thick layer of recent soil strength material, and is not directly underlain by old underground workings.

The risk of sinkhole collapse at Site 4A is assessed as negligible.

b) Cave zone – related cracking and movement

Site 4A is remote from any known cave zones and is not directly underlain by underground workings.

The risk of these movements at Site 4A is assessed as negligible.

c) Cracking and differential movement along geological features

Site 4A does not directly overlie old underground workings or the line of the ore lodes. No other known geological features (faults, dykes, etc.) pass through the site. In addition, exposures in the adjacent pit wall and as generally confirmed by boreholes 6 and 7, indicating Site 4A is underlain by a large block of better quality and less weathered/altered rock.

Based on this assessment the risk of these deformations impacting on Site 4A is assessed as low.

d) Global subsidence movements

The monitoring by NWG and the cracking shows that Site 4A will be affected by global subsidence; comprising horizontal and vertical movements and probably tilt.

The monitoring of the pit slopes and surrounding areas together with the measurement of the cracks in Seddon St. shows that two potential tilt directions are applicable to Site 4A; north easterly towards the main underground workings and southwest-northwest parallel to the Seddon St. cracks.

Assuming a 100 year design life, which is the norm in civil engineering, the Pumphouse at Site 4A is expected to be subject to:

1. Continued episodic subsidence movements.

2. Continued episodic horizontal movements.

3. Continued differential movements leading to tilt of the structure in at least a north easterly direction but also possibly in two other directions, southeast and northwest.

The final “risk” to the Pumphouse in its new location, Site 4A, is a combination of two factors:

- Firstly the likelihood (chance of occurrence) of the different deformation mechanisms (movements); and

- Secondly the likelihood that implementing cost effective engineering foundation solutions to accommodate such movements will not be feasible.

Based on experience it is assessed that it will be possible to design an adequate foundation system that will be able to withstand deformation within operational tolerances and incorporate remedial measures to provide ongoing rectification of any such deformations. Hence this second component of risk at Site 4A is assessed as very low.

Obviously accurately predicting movements is fraught with difficulty, particularly over the very long term. However, a large period of monitoring (about 15 years) is now available. This monitoring has been used to estimate long term movement rates. Rates of

differential settlement have been estimated from differential movement between adjacent surface points located outside the open pit, but within the general area of Zones 1 to 3. Given the uncertainties it is appropriate to be conservative and this will ensure the foundation solutions are able to adequately cope with movements in excess of the predictions. Hence the predicted movements have been increased by 100%. The predictions are:

- Vertical settlement - Global movement of the whole foundation area;
  - 10mm per annum.
- Horizontal movement - Global movement of the whole foundation area;
  - 5mm per annum.
- Differential settlement - Measured southwest to northeast 0.4mm/metre/year.
- Capacity to re-level - On the following axes (mine grid); 120° to 300° and 030° to 210°.

We trust this is in accord with your expectations and would be pleased to discuss any element.

For and on behalf of
PELLS SULLIVAN MEYNINK PTY LTD

DRAFT

T.D. SULLIVAN

Cc: Peter Bawden

Encl:

Figure 1	Location Plan Site 4A
Figure 2	Cracks & Movement Zones
Figure 3	Seddon Street Cracks – (Zone 1) Horizontal Movements
Figure 4	Seddon Street Cracks – (Zone 1) Vertical Movements
Figure 5	Historic Subsidence Plan & New Zones
Figure 6	Zone 1
Figure 7	Zone 2
Figure 8	Zone 3
Attachment A	Sections showing relationships between underground workings and cracks