Before the Waikato Regional
and Hauraki District Councils

Under	the Resource Management Act 1991 (**RMA**)
In the matter of	An application for resource consents to extend the Waihi Gold Mine via underground and open pit mining methods known as Project Martha
By	**OceanaGold (New Zealand) Limited** Applicant

Statement of evidence of John Heilig for Oceana Gold (New Zealand) Limited

28th October 2018

Counsel:
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Qualifications and experience

1 My name is John Heilig.

2 I hold the qualifications of Bachelor of Engineering (BE) with Honours and a Doctor of Philosophy (PhD), both from the University of Queensland in Australia with the latter awarded in 1988.

3 I have worked in the mining industry for more than 30 years and have extensive Australian, New Zealand and other international experience in the measurement, assessment and impact of the effects from blasting in mining, quarrying and civil construction projects. I have been associated extensively with design, vibration analysis and prediction at more than 800 sites throughout the world. I have also consulted to government agencies on acceptable vibration criteria. I have provided, and am continuing to provide, advice and design input into the existing mining undertaken by OceanaGold (New Zealand) Limited (**OGNZL**) at Waihi. I have been involved in the review and analyses of blasting activities at Waihi since 1990.

4 In preparing this evidence I have reviewed:

(a) The reports and statements of evidence of other experts giving evidence relevant to my area of expertise, including:

(i) The planned mining schedule described in the evidence of Mr O'Leary, including both the development and stoping designs for the Martha Underground Mine (including the Rex vein).

(ii) The planned blasting locations for the Phase 4 Cutback works along the northern limits of the existing Martha Pit.

(iii) The evidence of Ms Harwood in relation to blasting-related air emissions.

(b) The parts of the section 42A report relevant to my area of expertise.

(c) Submissions relevant to my area of expertise.

5 I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014. This evidence has been prepared in accordance with it and I agree to comply with it. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

6 I have been asked by **OGNZL** to prepare evidence in relation to the vibration impacts of Project Martha. This includes:

(a) A description of the potential environmental effects from blasting;

(b) An assessment of the type and scale of blasting associated with Project Martha and its predicted effects, including both underground and open pit operations;

(c) An analysis of existing blasting operations at the mine and of the conditions that currently apply to manage effects; and

(d) Recommended mitigation measures and proposed conditions to manage the effects of blasting from Project Martha.

7 I confirm that my evidence relates to the proposal known as Project Martha as described in Chapter 3 of the Assessment of Environmental Effects dated 25 May 2018 (**AEE**).

8 I confirm that I am the author of a report dated April 2018 entitled Vibration Assessment Project Martha attached as Appendix G to the AEE. I also confirm that I am responsible for the preparation of an additional technical note which was forwarded to OGNZL with responses to questions asked by the Hauraki District Council (**HDC**) under section 92 of the Resource Management Act 1991 (**RMA**). The document addressed Questions 4.1 to 4.5 of the HDC further information request.

9 In preparing this statement, I have assumed that all information and documents provided to me by OGNZL, or because of a specific request, were complete, accurate and up to date. Where an assumption has been made, I have not made any independent investigations with respect to that assumption. I am not aware why any of the assumptions would be incorrect.

Executive Summary

10 The assessment for Project Martha is the sixth detailed blast vibration modelling exercise undertaken since 2002 (Favona, Trio, Correnso, SUPA (Slevin Underground Project Area) and MDDP (Martha Drill Drive. Project) all preceded Project Martha) by Heilig & Partners. The Martha and Extended Martha projects were completed prior to 2002. The modelling results for the previous projects were reviewed and the predicted vibration effects were found to closely match the measured levels. Where there were noticeable differences between the values, the comparison showed

that the modelling was conservative with the predictions greater than the actual effects. The vibration modelling process undertaken for Project Martha, and the reliability of the results it produces, remain unchanged from those of the previous projects.

11 The recommendations and conclusions for Project Martha are based upon approximately 30 years of operational experience of the effects and responses to blast vibration – being the start of modern mining in the Martha Pit.

12 The proposed conditions for Project Martha are generally based around the permitted standards in the Operative Hauraki District Plan, together with some refinements to the consent conditions for the Martha Pit, Favona, Trio, Correnso, SUPA and MDDP. In this respect, the proposed vibration conditions are well aligned with the outcomes sought in the Hauraki District Plan with respect to the appropriate protection of amenity. Some revisions are, however, recommended to best reflect the dual requirements of permitting a mining operation that implements best engineering practices and protects the amenity of persons within the environment, as well as a set of criteria that can be appropriately administered by the Hauraki District Council.

13 My analyses have shown that compliance with the proposed 5mm/s vibration criterion at each of the adjacent sensitive receivers will require strict control over explosive weights and result in explosive weights varying from less than 2 kilograms through to potentially 30 kilograms for those areas further away from the residents or in the deeper areas of the Martha Pit or the Martha Underground Mine. OGNZL has previously demonstrated through the mining of Martha, Favona, Trio, Correnso and SUPA, its capability to incorporate similar explosive weights into its mine schedule. It is fully expected that blasting for the Project Martha can be similarly accommodated.

The Effects from Blasting

14 The environmental impacts of blasting occur as one or more of three main effects – vibration, overpressure (air borne vibration), and flyrock. The potential impacts depend upon the nature of the operation (open pit or underground) as well as the scale of blasting, the nature of the material being blasted and through which the energy released from blasting travels and the proximity of the activities to sensitive receivers.

15 Both vibration and air overpressure occur to varying extents from all open pit blasting. Through appropriate blasting practices and a blast design philosophy that varies the scale of blasting according to the distance to the

nearest sensitive receiver, the levels of ground vibration and overpressure can be controlled to acceptable values. Overpressure from underground blasting is typically not an issue.

16 Flyrock can be considered to refer to the movement of rock beyond a small working area around the blast pattern, commonly of the order of 20 to 50 metres depending upon the size of the mining operation. Large mining operations with large blasthole diameters and long blasthole lengths displace the blasted rock over much larger areas than small bench, selective gold mining operations. The Martha Pit would be regarded as a smaller operation in this regard. Like ground vibration and air overpressure, flyrock can also be controlled, as demonstrated by the isolated instances of flyrock that have occurred from the many thousands of blasts that have occurred in the Martha Pit.

17 Levels of both vibration and overpressure can be assessed and the levels compared against international standards, guidelines or other peer reviewed values to confirm their acceptability with respect to personal amenity or structural damage. There are however no quantitative standards for flyrock and an acceptance of the potential consequences generally compares to the proximity of sensitive infrastructure and personnel with the scale of blasting.

Ground Vibration

18 The primary factors known to influence the level of ground vibration from blasting include:

(a) The weight of explosive per delay;

(b) The distance between the blastholes and the point of measurement;

(c) The local geological conditions and the influence of geology and topography on vibration attenuation.

19 Each of the above factors have been considered in the blasting assessment.

20 High levels of ground vibrations have the potential to impact on both human comfort and structural integrity. The criteria in Section 8.3.2.3 of the Hauraki District Plan and the Australian Standard AS2187.2, present levels of vibration that best aim to ensure that vibration levels are maintained at or below levels of human tolerance. Whilst compliance with such limits does not necessarily ensure residents surrounding the operation will not

perceive the vibration from blasting, it ensures that a high percentage of the population will be tolerant of the blasting.

21 For the purposes of assessing the impact on amenity, the vibration from both the Phase 4 Cutback blasting, the underground development and production blasting at the Martha Underground Mine (including Rex) should be treated equally. The different blasting activities typically generate perceptible levels of vibration, but 30 years of blasting and feedback from the community at Waihi has not indicated that a distinction between the types of blasting is discernible by the residents

22 Defining a vibration level based on perception and amenity remains the most appropriate basis for a performance standard. People are sensitive to vibration, although may be unable to distinguish between different levels or intensity of vibration. The protection of amenity values as the basis for determining an appropriate vibration limit is also recognised in many of the commonly referred to international standards (Australian, British, German and so on), as well as the limits given in the Hauraki District Plan.

23 Vibration levels based on human comfort are also significantly more stringent than those aligned with the protection of the built environment from structural or cosmetic damage. Therefore, setting vibration limits for human comfort will in turn ensure no structural or cosmetic damage to buildings.

24 In addition to blasting potentially impacting upon amenity and properties, and although Waihi is not unique in this regard, it is appropriate to also consider whether blasting could impact upon the stability of old mine workings.

25 A collapse of old mine workings in 1999 and again in December 2001 led to surface subsidence in the area south and east of the Martha Pit. A review of the potential effects and any contributing source from the Martha blasting was undertaken and a report prepared in January 2002. The report was reviewed by the Institute of Geological and Nuclear Sciences who concluded the findings of the document were accurate and agreed that the impact of blasting on the underground workings was not a contributing factor in the collapse events.

Airblast Overpressure

26 Ground vibration and how it is perceived is reasonably well understood by many residents around Waihi. In addition to the blast producing vibration pulses through the ground, blasting also induces similar pulses through the air, referred to as airblast overpressure.

27 Airblast is affected by the blast design and the proximity of the explosive charges to the surface. If this distance is insufficient to contain the explosive gases, the venting of these explosive gases into the atmosphere can produce elevated levels of overpressure. Unlike vibration however, the geology has a negligible impact on the level of overpressure.

28 Also, unlike vibration which can be perceived at very low levels, any direct perception of overpressure is unlikely unless the level of overpressure exceeds 145 to 150dBL. The perceived effect on people at these elevated levels is commonly felt as a pulse impacting on the chest or face. These levels rarely occur from blasting unless the receiver is very close to a blast, typically within tens of metres.

29 The impact of the airblast overpressure would be limited by aspects of design, including the confined blasting, absence of a free face, small explosive weights, and a mine design that for most of the project efficiently shields properties by blasting below the crest of the pit perimeter.

30 The most commonly observed effect of elevated overpressure levels is the associated rattling that it may cause to some parts of a dwelling, such as ill-fitting windows, loose timber panelling and so on. In this manner, the effect is often confused with that of elevated vibration.

31 At low levels of overpressure, like those generated by well controlled blasting, the impact is not detrimental to persons, is incapable of damaging any property, and is unlikely to cause rattling and other side effects mistaken for increased vibration levels.

Flyrock

32 Whilst best practices would always endeavour to control the extent of any flyrock from blasting, it is generally of minor consequence for any underground blasting perhaps with the general exception of blasting that occurs near to underground services, such as electricity, water and air services, damage to which affects only OGNZL. The potential impacts of flyrock in the Project Martha assessment are therefore limited to the Phase 4 Cutback.

33 There are two potential sources of flyrock from blasthole patterns. They are the vertical face and the horizontal surface.

34 Given that most of the blasting for the Phase 4 Cutback will remain confined with no free face (and in those instances where a free face does exist it will be orientated towards the centre of the pit) the possibility of flyrock is restricted to that originating from the horizontal surface around

the collar region. Whilst flyrock remains a very critical component of any blast design process, the nature of the blasting in the Martha Pit eliminates many of the contributing factors to accidents that have been observed at other sites where flyrock has been reported. Some limited secondary blasting to break down the size of larger boulders may be undertaken to enable trucking of the rockfall debris. While secondary blasting can generate fly rock, the debris is located near the centre and base of the pit, several hundreds of metres distant from the pit crest. The practice of popping boulders has occurred at Martha in the past. Care is taken to minimise the explosive quantities required to break the rock and no fly rock issues associated with this practice have been reported to date.

35 OGNZL has continued to demonstrate very good control of flyrock throughout its mining of the Martha Pit, with only one incident occurring during the previous 30 years of mining. The incident occurred in July 2007 and was assessed by OGNZL, HDC and their respective advisors. A set of guidelines was produced and formally adopted in the Vibration Management Plan, effectively making the guidelines part of the consent conditions. The guidelines have continued to be adhered to in the design of blasting activities in potentially sensitive areas. The recommendations have been shown to be effective without further incident over the more than 470,000 blastholes that have since been initiated in the Martha open pit.

36 As with all blasting activities undertaken in locations where flyrock could potentially occur and affect the safety for persons around the blast area, careful attention to the design and loading practices remains critical. OGNZL has demonstrated that it can successfully undertake blasting in critical areas through the recent, partial completion of a new ramp in the north-west corner of the pit and by successfully completing the interim remedial works along the north wall without incident. Blasting on both projects was at a comparable elevation and proximity to public and private property as will occur with Project Martha during the initial blasting near the pit rim.

37 Given that careful attention to the loading practices is critical and practices such as ineffective stemming could result in flyrock, I have recommended to OGNZL that all persons associated with the blasting on the northern wall area should undergo specific training about the correct loading practices and design procedures that should be used to limit the potential for flyrock.

38 Based upon the estimated zone of the rock that could require blasting, the conservative flyrock modelling, the blast training package, the cautionary approach of occasional, temporary traffic management along Bulltown and Cambridge Roads for around five minutes when blasting is within 50m of

the roads, temporary closure of some parts of the pit rim walkway at the time of blasting, and the large knowledge base of blasting along the north wall with small explosive weights, I expect that OGNZL can safely undertake blasting in the prescribed areas. The primary flyrock controls will be consistent with the standard risk control measures. The option of using blast mats will remain one of the possible mitigation actions that OGNZL could utilise in the event that risk assessment for the blast confirms that additional measures could be required.

Types of Blasting

39 The type of blasting differs according to whether it occurs for the open pit or underground operations. Blast patterns for the open pit operation tend to be simpler, involving drilling of blastholes on a regular pattern to a consistent depth, loading a known quantity of explosive into the base of the blasthole, adding stemming material to the blasthole above the explosive column and initiating the blast with a series with small time intervals (milliseconds) between successively detonated blastholes.

40 Blasting in underground operations is more complex and broadly either classed as development or production. Development blasting is small scale, in terms of the blasthole diameter, blasthole length, generally the explosive weight and overall yield of broken rock, but typically has a longer duration than production blasts. Production blasting is typically larger scale, although less than the amount of rock broken by an open pit blast. The blasting is significantly more detailed in design than open pit blasting.

Vibration Assessment

41 Since 2003, the vibration monitoring system for each of the mining projects at Waihi has been automated and allows for the near instantaneous reporting of vibration results. The vibration results are communicated from the monitoring sites via a modem to a dedicated computer at the OGNZL office in Moresby Ave where they are automatically processed, and the preliminary results forwarded through to the HDC and other key personnel, generally within 5 minutes of a blast.

42 The basis of assessing the expected effects from the blasting for each of the areas within Project Martha is the data collected since 2003. Depending upon the location of the blast area, the nearest historical data from other projects has been regressed to determine an area specific vibration/distance/explosive weight relationship, that is, a specific relationship for the Phase 4 Cutback, Rex and the remainder of Martha Underground Mine. These data replace that measured from the trial

blasting information that had previously been undertaken to support consent applications for each new project.

43 The analyses show considerable variability in vibration levels. There are occasions where a similar combination of distance and explosive weight, yields vibration values less than 0.75mm/s and yet on other occasions more than 10mm/s. The variability is however typical of that produced from very large data sets that incorporate multiple projects completed over an extended period.

44 A comparison of the predicted vibration levels and the measured levels of vibration during the mining process show good agreement, typically within 15%. For the Trio project, within 3%. The data contributing to the increased variability is typically associated with unfavourable rock mass conditions. Improved practices, better accuracy in terms of the delivery of explosive quantities, and an improved understanding by the underground workers of the critical nature of blasting compliance have all contributed to reducing both the level and variability of vibration from the Correnso operation when compared to the initial stages of mining the Favona orebody.

45 Because of these improvements, the predicted levels of vibration from Correnso Underground Mine have been shown to be around 10% less than the expected levels, part of which would be associated with improved quality assurance practices as well as limited variation in ground conditions.

46 It is expected that the accuracy of the predictions for Project Martha will be like these recently completed projects, that is, within 5 to 15%.

47 The impacts of blasting in each of the different orebodies have been assessed. This includes determining the maximum extents of the vibration by showing a series of vibration contours of varying levels between 2 and 5mm/s in 1mm/s increments. The analyses also include a series of vibration envelopes at representative properties closest to the various project elements that illustrate the range of vibration levels and how these vary according to the mining blocks over the life of the project. The envelopes have been developed annually for representative properties over the entire life of the Project Martha. The envelopes provide a better representation of the predicted vibration effects experienced at each of the selected properties (as opposed to the contours that show just the maximum vibration level predicted at any time without consideration of the number of times events of that magnitude might occur).

48 Phase 4 of the Martha open pit is set to commence in 2022. The blasting is scheduled for 8 years with completion of the lower limits of the pit in

2029. Blasting commences on the upper pit rim of the north wall crest of the pit. Explosive weights will be low, varying from less than 2.5 kilograms through to approximately 15 kilograms. These lower explosive quantities are typical of those used for the 80 blasts associated with the north wall interim remediation blasting.

49 My assessment for the Phase 4 Cutback concludes that the planned scale of mining can comply with the proposed conditions with respect to vibration limits and therefore ensure the reasonable protection of amenity.

50 The Martha Underground Mine, including Rex, is planned to include development blasting for establishing the accesses together with the larger scale production blasting.

51 The development blasting has been assessed and extends over the full life of the mine, commencing in 2020 and finishing in 2030. Development blasting occurs in all years, with the exception of 2027 and 2028 where activities are restricted to production blasting only. In all of the Martha Underground, development blasting can proceed unrestricted with advance lengths of 3.6 metres. Development blasting for the Correnso operation typically uses explosive quantities of 5 kilograms and permits advances of around 3 metres. Similar quantities of explosive and lengths of advance are anticipated for the planned Martha Underground mine.

52 When compared to previous blasting at Favona, Trio and Correnso, the explosive quantities are like the modelled weights for the Martha Underground. The blast designs required to achieve the necessary production rates will therefore be similar also. Given the method of mining and permissible range of explosive weights, the modelling confirms the Martha Underground can be effectively blasted and remain compliant with conditions that ensure the protection of amenity.

53 Development blasting for Rex is scheduled to commence in 2020 and continue for three years until completion in 2022. Some of the initial stages of development are nearer to the surface and require low explosive weights of less than 2 kilograms to achieve compliance. Where the permissible explosive weight for sections of development is reduced, the lengths of advance achieved in these areas will be correspondingly reduced to between 1.5 and 3 metres. Similar decreases in advance as part of the Favona mining have been required to mitigate poor ground conditions so mining with these parameters is consistent with previous methods. Development blasting at depth can be designed with the maximum explosive weight and greater lengths.

54 Stope production blasting is scheduled to commence in 2020 following the development blasting. The location of Rex and the proximity to residential receivers limits the explosive weights to between 5 and 10 kilograms in the first year of production. As mining advances from the northern to southern limits of the orebody, and from the low to the upper levels, the explosive quantities reduce to less than 2.5 kilograms. These sections are likely to require cut and fill type methods of mining. Mr O'Leary discusses the mining methods likely to be used in the upper levels of Rex in his evidence.

Anomalous Zones

55 Based on decades of vibration measurements from Waihi mining activity, an approach jointly proposed by OGNZL HDC and their respective advisors has been developed to identify and treat anomalous vibration zones. The path of investigation for these potentially anomalous areas is being detailed and will be incorporated into the Vibration Management Plan. The approach considers an anomalous area as one where measured vibration values are repeatedly more than 2.2 times the expected maximum level. The recommended approach is based upon statistical methods and provides a procedure which can be easily applied.

56 A review of the blasting results at Waihi over the last 15 years has confirmed only one anomalous zone. Because no cause for this anomaly has been firmly established, the possibility of other anomalous locations cannot be dismissed. However, it should be noted that Project Martha comprises blasting primarily in and under the Martha Pit where blasting has occurred for 30 years without identifying an anomaly. Other anomalous locations would be identified through the deployment of the roving monitors and the statistical treatment of the data, the triggers for both of which will be detailed in the Vibration Management Plan.

57 Confirmed anomalous zones will be treated by implementing a tailored solution which could differ for the different properties around the area. As discussed in Bernie O'Leary's evidence, a range of options is available, namely: the installation of a new compliance monitor at that location, engaging with the landowner to negotiate affected party approval or purchasing of the property.

Vibration Monitoring

58 The monitoring equipment and deployment for demonstrating vibration compliance will remain unchanged from current practices which have been shown to be appropriate.

59 The monitoring sites have been proposed. Where possible, and they are considered to provide a representative location, it is beneficial to maintain the existing monitoring sites. This allows a continuity of monitoring results to better determine any anomalous vibration zones.

60 The blasting results from all the monitoring locations will be displayed on OGNZL's web page. It is proposed to use an aerial photograph showing each of the monitoring locations with a pop-up menu showing the blast events and recorded vibration levels like those which have been implemented for Correnso.

Submissions

61 I have read the submissions to the project. Submissions both supporting and opposing the application have been received. A number of these submissions contain comments that are relevant to my area of expertise. These amounted to twenty-three opposing submissions to either or both the Hauraki District Council and the Waikato Regional Council. A submission from one commercial business in opposition to the project was also received.

62 These submissions raise isolated concerns with all matters having been addressed in either my technical report or in other sections of my evidence. The submissions therefore do not affect my recommendations, or those opinions expressed in the documents. The issues raised in these submissions do not require a reworked comprehensive response, however given the few concerns, it may be beneficial to the hearing committee to understand my views on these common areas of concern.

63 The matters raised in the submissions that I have reviewed include:

(a) Concern regarding damage to residential properties that would occur from the vibration produced by the blasting activities, how damage would be identified/confirmed and how any damage would be rectified;

(b) Concern regarding the vibration limit and its ability to ensure that personal amenity is maintained;

(c) Whether vibration could impact on the continued operation of sensitive equipment;

(d) The possibility that the blasting effects could impact on the soils around Waihi, possibly creating subsidence;

(e) Concerns regarding the transparent and appropriate monitoring and reporting of impacts.

64 An appropriate set of conditions coupled with a workable Vibration Management Plan (VMP) are key to the project. When both are effectively developed and administered, the vibration related impacts associated with the project can be addressed to a standard that ensure the amenity for the adjacent residents and the integrity of any assets are appropriately protected.

65 The 5mm/s vibration limit addresses the two key matters of ensuring the vibration produced by the project will prevent structural damage to the adjacent properties and ensure the amenity of residents around Waihi is not unduly affected. The 5mm/s value is based upon Australian Standards and supported by other International Standards and can be further justified by comparison with other peer reviewed international papers.

66 It is not uncommon for residents adjacent to blasting projects to be concerned that vibrations could damage their property. The likelihood of damage to properties arising from the vibration generated by the blasting is however extremely low. For any of the other projects I have been involved with, or know about, I am unaware of damage to properties as a result of blasting activities producing a level less 5mm/s. Other naturally occurring environmental effects induce stresses that far exceed those produced by vibration. As an example, a humidity change of around 20% induces a level of stress equivalent to that generated by a vibration pulse with an amplitude of around 60mm/s. Routine daily weather phenomena produce far greater stresses than the equivalent stress level induced by a level of vibration compliant with the 5mm/s limit.

67 Whilst there will likely be noticeable cracks to some Waihi properties over the mining period, these changes will however be no different or occur at any increased rate when compared to properties that lie well beyond the mining area. The vibration limit is very heavily biased towards human comfort and therefore effectively prevents any opportunity for structural or superficial damage to infrastructure around or above the mining activities.

68 Three submissions (#80, #189 and #208) raise the matter of condition surveys and how any defects will be subsequently addressed. Should a resident believe that their property has been damaged by the mining process, the approach is to review the property condition, assess the relevant vibration data, identify the potential sources of damage and in the event the damage is determined to be associated with the project, prepare a plan for repair. This provides a baseline should damage to the property

from the blasting activities occur. The OGNZL Property Policy details these measures and is available to persons to view on the OGNZL web page.

69 Whilst the vibration from the blasting may on occasions be perceptible to residents around Waihi, the permissible limits restrict the vibration to below levels that could induce damage to residential or commercial premises.

70 The 5mm/s vibration limit is consistent with the existing conditions for Martha and Correnso, and less stringent than the 6mm/s that applied to the Favona and Trio mines. I am unaware of any confirmed instances of blast vibration-related property damage occurring in Waihi, and as I address in more detail later in my evidence, there have been 182 independent surveys of Waihi dwellings since 1991, none of which has identified vibration-related damage.

71 Other large-scale projects completed in Australia and New Zealand, such as Waterview, the North South Bypass, the Airport Link, Inner Northern Busways and Legacy Way in Brisbane, and the NorthConnex, WestConnex and WestConnex Stage 2 in Sydney and the WestGate, Melbourne Metro Tunnel in Melbourne have all applied limits for blasting exceeding 5mm/s.

72 Two submissions (#208 and #209) have suggested that the permissible vibration limit should be reduced to 2.5mm/s with the percentage compliance increased to 98%. Both suggestions are inconsistent with the recommendations of all International Standards applicable to blasting. To my knowledge, there are no peer reviewed documents or standards suggesting the applicable vibration limit for blasting should reduce to below 5mm/s. The same documents indicate a percent compliance of 90%, 95%, 4 from 5 successive blasts or 9 from 10 successive blasts. A level above 95% has never been proposed.

73 Limiting the vibration to 2.5mm/s at 98% compliance would equate to an average vibration level of less than 1mm/s which would ultimately render the blasting ineffective and overall the mining unproductive.

74 A business entity (#198) has raised concerns about the possibility that blast induced vibrations could impact upon the continued operation of the sensitive equipment. I understand the enterprise is located in the first story of a centrally-located commercial premises (Westpac Bank) that has been assumed to be available for residential use in my modelling, i.e. a location where vibration needs to meet the 5mm/s standard. At the time of writing, a meeting is being arranged to allow me to talk to the submitter direct. In the interim, without knowledge of the equipment and the permissible operational criteria, it is difficult to confirm whether any impacts would be

likely. Based upon successfully completed blasting activities at other projects where blasting has been undertaken within tens of metres of sensitive electronic equipment, the likelihood of damage or impact on the equipment is extremely low. The electronics manufacturing facility within the same building as the OceanaGold offices would have over time been closer to the blasting activities and is expected to house equipment far more sensitive equipment with respect to vibration impacts. Notwithstanding these comments, it is however my recommendation that the sensitivity of the submitter's equipment is further investigated and if necessary, OceanaGold undertake remedial measures to ensure its continued operation. I expect to be able to provide more information regarding the outcome of my meeting with the submitter at the hearing.

75 A submission (#201) has identified that technology and mining are progressive and recommendations need to reflect these changes. OceanaGold has incorporated a flexible approach by adhering to a set of enforced conditions, such as the vibration limit, durations coupled with Vibration Management Plan that specifies how these impacts will be managed and controlled. The Vibration Management Plan allows for continual improvements, additional monitoring locations, data presentation to be regularly revised according to OceanaGold, Council's and Waihi resident's requirements. Changes to the Vibration Management Plan necessarily require Council approval.

76 A submission (#208) raises concerns about the possibility that the blasting could impact on the soils around Waihi, possibly creating subsidence. It is known that vibrations can affect soils, although any densification depends upon the soil type and the level of vibration. Only certain ground conditions are however susceptible to vibratory densification and the vibrations must be high. The British Standard BS7385-2 reports on laboratory tests that identified for soils that would be far more susceptible to impact from vibration than those at Waihi, the soil became vulnerable to impact only at vibration levels above 10mm/s, and even then, the effect is dependent up the duration of the vibration. The 5mm/s limit and the short duration of a blast event restricts vibration impacts to below a value capable of affecting the soil stability.

77 Two submissions (#1 and #208) have questioned the independence and method of monitoring and reporting. To assess compliance with the vibration limits, vibration levels will be monitored in accordance with the Vibration Management Plan and the relevant applicable standard (AS2187.2) and compared against the limit and percentile values given in the Conditions. The representative monitoring properties will be chosen based upon:

(a) The proximity to the blast area, ensuring that the monitoring sites are located as close as practically possible to the sensitive receivers;

(b) Monitoring locations that offer a secure area that minimise the possibility of interference from the public or other sources of vibration;

(c) Monitoring locations that provide a representative indication of the vibration level.

78 Monitoring locations will be continually revised as the source of the vibration changes according to the mining schedule. The monitoring and reporting structure will remain as per the current system for both Martha and Correnso and be proactive. The measured levels would continue to be presented publicly on the OGNZL web site within several minutes of the blast event. The system will continue to be independently administered and provide simultaneous results to all persons, including the public web site, OGNZL and HDC.

79 In summary, I consider that all the issues raised by the submitters have been appropriately addressed in my technical report and further clarified in my evidence.

Review of S42 Report and Proposed Consent Conditions

80 The S42 Report prepared by Blastechnology raises several matters in response to the technical report prepared by Heilig & Partners and the subsequent response by OGNZL to the section 92 request for further information. These include:

(a) Potential flyrock from the Martha Pit blasting

(b) Vibration averaging

(c) Vibration monitoring,

(d) Duration of MP4 Blasts, and

(e) Property damage

Flyrock

81 I agree that blasting that is undertaken near to occupied premises or public spaces should follow best practices to ensure the possibility of flyrock is minimised. This necessarily ensures best practices with respect to blast design, as well as very careful attention to loading methods and stemming procedures. Previous practices for blasting along the northern wall have demonstrated the procedures are aligned with best practices regarding controlling any incidences of flyrock.

82 I agree with Blastechnology that various blast parameters and rock mass factors, in addition to those possibly introduced by human error, can increase the extent of any flyrock. The important parameters include stemming length, explosive density, rock mass density and drag co-efficient. It is also agreed that it is reasonable to apply a factor of safety to the calculated projectile distance when establishing a clearance zone around the blast area when using the nominal design values for each of the flyrock model inputs as the point estimate the model generates does not account for parameter variability and can therefore understate the fly rock distance. It is however important to acknowledge that unlike most flyrock assessments, the probabilistic modelling approach adopted in my report incorporates variations in these parameters, that is it considers a 400 mm tolerance in the stemming length, includes a 5% variability in the explosive density, incorporates a 25% variability in the rock mass density, contains a 100% variability in the drag co-efficient with a full 360 degree projection and 90 degree vertical ejection angle. The results shown in my report therefore already account for variability in the model input parameters and produce a more conservative flyrock distance that does not require the addition of a somewhat arbitrary factor of safety.

83 Given the different distances that may be calculated depending upon the flyrock model and the input parameters, rather than use a factor of safety approach to establish if any additional precautionary measures are required, it is recommended that the Vibration Management Plan set out appropriate methods and procedures for managing the potential for flyrock when blasting along the North Wall. I note that this is already provided for in the wording of the consent conditions and is incorporated in the existing Vibration Management Plan.

84 I have agreed on many occasions with the recommendations of Blastechnology that blasting can safely occur close to existing properties with appropriate controls in place.

Vibration Averaging

85 The S42 Blastechnology report has recommended that the processes followed at Correnso requiring separated vibration statistics for development and production blasting be imposed for Project Martha. Both blast types require compliance with 5mm/s for 95 percent of blasts.

86 My technical report recommended that the conditions should not differentiate between development and production blasts for the purposes of establishing compliance. All blasts for the project are designed to comply with 5mm/s. Combining, or separating, the measured levels of vibration from open pit, underground production, or development activities will not affect how they are designed or assessed, and on this basis, the differentiation is considered to have no benefit in terms of amenity. Each blast is designed to comply with 5mm/s with a 95% degree of certainty, irrespective of its type, location or current compliance statistics.

87 In addition to the development and production blast classification, the average vibration condition details a unique set of criteria that, aside from Waihi, are not imposed on blasting activities anywhere in the world. The intent of the condition is to limit repeated blasting within a small area. Within a 6-month period, the condition requires that the average level of vibration from development and production blasting is limited to 2mm/s and 3mm/s respectively. The Rex orebody is limited in its geographical spread, effectively prohibiting the opportunity to blast within different areas to affect the average level of vibration. Based upon a constrained mine schedule with few options for adjusting the blasting location because of the small lateral spread of the orebody, compliance with the average development or production criteria will significantly impact on the mining of Rex. Adjustments to the mine plan that affect the location of the blasts or increasing the three-year period of mining for Rex may be necessary to achieve compliance. This could result in more frequent or blasting over a longer period as a measure to ensure compliance, but not necessarily improve amenity. This appears contrary to the objective of the condition and therefore of questionable value.

88 OGNZL employ a rigorous method of designing and reviewing blast patterns to ensure that the blast activities comply with a 5mm/s vibration limit. On no occasions, are blasts designed to produce more than 5mm/s with a degree of certainty less than 95% confidence, that is, irrespective of OGNZL's present blasting performance or the type of blast, all blasts are similarly designed. Whilst some blasts may be cautiously adjusted downward in their explosive weight because of a previous unexplainably

elevated level of vibration, no blasts are ever overdesigned on the basis that “the company is comfortably compliant with 5mm/s”.

89 My view remains that imposing the averaging requirements is unnecessary for Project Martha. I note however that OGNZL has accepted the consent conditions that impose averaging for reasons of consistency.

90 In terms of monitoring and recording vibration events, it is significantly easier and more robust to set up a single monitoring network and to record each vibration event and its related blast design in a single database.

91 There are currently no conditions on the existing consents that require the vibration effects from individual mines (e.g. Correnso and SUPA) to be monitored and recorded separately. To a resident perceiving a vibration effect, the source of that event is immaterial. To the extent that blasting could occur in several locations simultaneously (e.g. in Rex and elsewhere in the Martha Underground Mine), monitoring the combined vibration as a single event accounts for any cumulative effect. Monitoring and reporting of vibration levels for the Rex and Martha Underground operations will allow calculation of the number of blast events that comply with 5mm/s, as well as the average values, for the development and production blasts. The monitoring and reporting of the vibration level from the Martha pit blast will allow calculation of the percentage of blast events complying with 5mm/s.

Vibration Monitoring

92 The proposed vibration monitoring locations have been identified and presented in my technical report.

93 The report has identified other representative properties around the proposed Project Martha areas and calculated the expected levels of vibration based upon the scale of blasting. Based on the modelled results, it is agreed that it may be appropriate to place an additional monitor along Kenny Street although at least one of the existing monitoring locations of Main South, Main Central or the Scout Hall would be closer to blasting activities than any new monitor along Kenny Street. The additional monitor could possibly better serve to improve predicted levels of vibration rather than assess compliance.

94 In addition to the existing network of Correnso vibration monitors that have been deployed to assess vibration levels from the underground blasting, three additional sites have been installed as per the drawing presented in the S42 Blastechnology report. The additional locations include the Waihi CBD (marked as the preferred location on the Blastechnology report), the Pensioner Flats and the Central School. The CBD monitor location was not

included in my original drawings as the site was not active at the time of the report preparation. All monitors have been operational for the previous 6 months. These data are not included the algorithm for predicting levels of vibration at other locations nor are they assessed with respect to compliance. Over the last 6-month period, only the Pensioner Flats monitor has triggered, and this has occurred less than 5 times and only when the threshold was reduced. The peak level of vibration is 0.5 mm/s.

95 I note that the staff report questions whether commercial properties should be added for compliance purposes rather than restricting the compliance location to properties used for residential purposes (refer to page 21 of the HDC S42a report). The Australian Standard and other international standards recommend limits for commercial properties above the 5mm/s limit for residential properties, e.g. AS2187.2 recommends 25mm/s. This limit might be appropriately applied to the commercial properties along Seddon Street. However, as the Hauraki District Plan provides for residential use in the first storey of commercial properties, my modelling assumes the 5mm/s residential limit applies to any two-storey buildings in Seddon Street. The relevant properties closest to the project are at 14 Hazsard Street (the northwest corner of Hazsard and Seddon), 74 Seddon Street (the Westpac Bank on the southeast corner of Hazsard and Seddon), 100 Seddon St, and 112 Seddon St (the Sterling Hotel on the southwest corner of Seddon and Mueller). I consider the proposed Pensioner Flats and CBD monitoring locations sufficient to determine compliance with 5mm/s at these sites. Meeting the 5mm/s limit at these buildings and at nearby residential properties means that all other commercial buildings in the town centre will receive vibration magnitudes of considerably less than 25mm/s without the need for a specified vibration limit or compliance monitoring obligation.

96 The S42 Blastechnology report has raised concerns about the assessment of anomalous vibration readings and how these are addressed. It is accepted that the recent review was lengthy, partly attributable to attempting to define a set of workable procedures that define an anomalous area, and secondly how the area would be treated. Given that this is the first anomaly that has been identified in 30 years of mining at Waihi, the various phases of identifying, confirming and classifying the anomalous area, plus establishing guidelines as to how any future anomalies should be identified and treated is a complex task. A document has now been prepared to address anomalous vibration zones, including their identification and recompense to affected persons. This document has been jointly prepared by HDC, OGNZL and their respective advisors. I understand that OGNZL is preparing an additional procedure for dealing

with anomalous areas for consideration by HDC that, once finalised, will be included in an amended Vibration Management Plan.

Duration of MP4 Blasts

97 Under the consent conditions for the Correnso Underground Mine, blast events are limited to no more than 18 seconds. The underground operation's blasting regime has always complied with the duration limit, and I note that OGNZL has accepted the same set of duration limits for Project Martha.

98 There is currently no limit on the duration of the blast events in the Martha Pit. To remain compliant with proposed vibration criterion, some blasting at the lower charge weights around 1.5 kilograms will be required. To maintain production at these very low charge weights necessitates firing large panels containing many holes. Experience has shown that large panels cannot be fired continuously as the magnitude of vibration builds with time (i.e. there is an additive vibration effect that increases as more holes are fired). The cumulative vibration effect is managed by separating the panels into several smaller portions and introducing a 1-2 second delay between each sub-panel to allow vibration from the preceding sub-panel to dissipate prior to blasting starting in the subsequent panel. Compliance with the vibration magnitude limit requires extended blast event durations and therefore no duration limit for the open pit is proposed.

Property Damage

99 OceanaGold has implemented a "Property Policy" that includes a broad "we break, we pay" policy as well as a component for assessing reported instances of damage. This includes the options of a third-party investigation.

100 Since 1991, an independent Building Research Association of New Zealand (BRANZ) has undertaken 182 surveys of properties around the Waihi area assessing the possibility of damage from mining activities, including both underground and open pit activities. Some of these studies have also been completed for reference properties to document changes in their condition at a location remote from the mining activities where they would be considered to have no impact. The assessments have included both residential and commercial properties. Although multiple defects have been observed, the group has concluded the observed defects are consistent with those generated by variations in climatic conditions, natural wear and tear of the property and/or sub-standard building procedures. These BRANZ conclusions are consistent with my findings. The locations

where these surveys have been completed are shown in the following image.

101 The locations of these properties range from above the mining activities to more than 1 kilometre from the closest vibration monitoring location. There is no indication that residents some distance from the vibration monitoring stations are excluded from the option of an independent survey assessment. Similarly, the options are not limited to residential properties.

Recommended Blasting Conditions

102 A set of blast related conditions is proposed for Project Martha in Appendix O of the S42 report. The proposed conditions are generally based around the Hauraki District Plan standards, the conditions of the existing land use consents held by OGNZL, including those conditions applied to Correnso but include a small number of changes to better reflect the dual requirements of permitting a mining operation that adheres to best engineering practices as well as an operation that protects the amenity of persons within the environment. I note that OGNZL has accepted most of the conditions in the staff report. I comment on the recommended changes sought by OGNZL below.

103 OGNZL seeks that blasts for maintenance/safety purposes are excluded from condition 31 and condition 32a. A proposed “out of hours” (including Sundays and public holidays) blasting limit of 95% compliance with 1mm/s is recommended for the underground operations to permit small scale works to remedy issues within the mine that impact upon safety and the

mining schedule, such as blasting of oversize rock, blasting of blockages within draw-points and so on. The scale of these blasts will be small, likely to be no more than a few holes, and in most cases decoupled from the host rock, and therefore generating very low levels of vibration.

104 The scale of development blasting that is considered feasible for Rex will vary from less than 2 kilograms through to potentially more than 7 kilograms. Production stoping is modelled to vary between less than 2.5 kilograms through to more than 10 kilograms in the deeper sections of Rex. The modelling indicates that compliance with 5mm/s in some areas will require low explosive weights irrespective of whether the blasting is development, cut and fill or conventional small-scale production.

105 The Correnso conditions have differentiated development and production blasts based on explosive weight with those less than 7 kilograms classed as development and the designs using more than 7 kilograms as production blasts. The approach has been appropriate for Correnso. It is however recommended a clearer definition of the two blast types be applied for the Martha Project, particularly given that there will be occasions where development blasts could involve more than 7 kilograms and production blasts less than 7 kilograms. A clearer definition is proposed that directly relates to the intent of the blast, that is:

106 Development Blast – Any blast that is used in the creation or enlargement of a tunnel for the purposes of mine construction or access;

107 Production Blast – Any blast that is not a development blast (excluding any blast for maintenance/safety purposes).

108 I note that Bernie O'Leary's evidence provides OGNZL's justification for the proposed changes to these definitions. I agree with the proposed changes to the definitions.

109 I note that condition 34 b. adjusts the timing of the meal break to match the new time for the meal break underground.

110 Changes are proposed to condition 47 regarding those matters that are to be included in the Vibration Management Plan. As previously stated I believe that condition 47 a.(vi) remains appropriate as it stands, i.e. without any reference to a factor of safety. Condition 47 a (vii) is proposed to be amended to allow appropriate procedures to be developed in the unlikely event that an anomalous vibration zone is identified by the roving monitor.

111 Condition 53 a. is proposed to provide for the report of all blasts for maintenance/safety purposes.

112 The changes proposed to Condition 55 a and b and condition 56 are essentially tidy ups as described in Richard Turner's evidence.

113 I understand that the morning and evening underground blast events at the 7am and 7pm shift changes are not practically feasible for the open pits as they lie outside the proposed allowable blasting times for the pit. Similarly, any morning and afternoon blast events in the open pit would occur at times that cannot be matched in the underground.

114 On this basis, firings in the open pit would therefore occur at different times to those in the underground.

115 No change to the existing Consent Condition is proposed for the operations in the Martha Pit.

Conclusion

116 The assessment for Project Martha is the sixth such detailed modelling exercise undertaken since 2002 (Favona, Trio, Correnso, SUPA (Slevin Underground Project Area) and MDDP (Martha Drill Drive Project) all preceded Project Martha) by Heilig & Partners. The Martha and Extended Martha projects were also completed prior to 2002. The modelling results for each of the previous projects were subjected to a detailed review and were found to appropriately predict the vibration effects with enough detail and accuracy to allow grant of consents for those projects. The Project Martha vibration modelling process and the reliability of the results it produces remain unchanged from those of the previous projects.

117 The recommendations and conclusions for Project Martha are based upon around 30 years of operational experience of the effects and responses to blast vibration since the start of modern mining in the Martha open pit.

118 The proposed conditions for Project Martha are generally based around the permitted standards in the Operative Hauraki District Plan, together with the Martha, Favona, Trio, Correnso, SUPA and MDDP consent conditions. In this respect, the proposed vibration conditions will be well aligned with the HDC plan objectives of maintaining amenity and providing consistency. Some minor revisions to the conditions applicable to recent projects are recommended.

119 The expected scale of blasting, and the associated effects, for each of the Project Martha sites have been based upon an analysis of the recorded vibration levels monitored over the previous 15-year period. These data have been analysed to establish relationships between vibration level, distance and explosive quantity for each of the projects.

120 The analyses have shown that compliance with the proposed 5mm/s vibration criterion at each of the adjacent sensitive receivers will require strict control over explosive weights and result in explosive weights varying from less than 2 kilograms through to potentially 30 kilograms for those areas further away from the residents or in the deeper areas of the MP4 pit or the underground mine. OGNZL has previously demonstrated through the mining of Martha, Favona, Trio, Correnso and SUPA, its capability to incorporate similar explosive weights into its mine schedule. It is fully expected that blasting for the Project Martha can be similarly accommodated.

John Heilig
28th October, 2018

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