# PEER REVIEW OF
# 'WILDLIFE CYANIDE RISKS AND COMPLIANCE WITH THE INTERNATIONAL CYANIDE MANAGEMENT CODE: NEWMONT WAIHI GOLD MINE'

by

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## EXECUTIVE SUMMARY

Newmont Waihi Gold (NWG) has requested that Dr. Owen Nichols, Associate Professor Barry Noller and Dr. Alan Julian peer review the company's wildlife and cyanide monitoring and management programs described in the report 'Wildlife Cyanide Risks and Compliance with the International Cyanide Management Code: Newmont Waihi Gold Mine' and associated appendices. The report, prepared by Donato Environmental Services, was designed to identify any protective mechanisms that may prevent wildlife deaths occurring should released cyanide levels at the mine's tailings storage facility exceed 50mg/L WAD CN. The work and associated reporting are being carried out as part of NWG's application for certification under the International Cyanide Management Code (ICMC), Standard of Practice 4.4.

Overall, the review team found the design of the monitoring programs described to be sound, the data analyses accurate and the conclusions drawn likely to be correct. The report includes recommendations which take into account the need to identify risks to wildlife, to have protective mechanisms in place and to provide evidence of management procedures to satisfy the Code requirement that wildlife be protected.

Wildlife mortalities are low and, whilst cyanide toxicosis cannot be dismissed as a possible cause in all cases, no deaths were clearly attributable to this.

We support the conclusion that two hypotheses describe the protective mechanisms that operate on TSF 1A, resulting in very low (possibly no) cyanide related wildlife mortalities:

- **Hypothesis 1: Rapid degradation of cyanides occurs *in-situ* within TSF 1A due to low copper (and WAD metallo-cyanides) concentrations rendering the supernatant (open water) and most TSF habitats benign to wildlife**.
- **Hypothesis 6: Toxic habitats within TSF 1A are very small in area (<0.1% of the TSF), unattractive to wildlife and only rarely used by wildlife.**

The data demonstrate that Hypothesis 1 is verified, and acts as the primary protective mechanism for wildlife. Hypothesis 6 also contributes significantly to the lack of cyanide-related mortalities. However, as a small area remains in TSF 1A where the risk to wildlife is higher, this hypothesis only describes a partial protective mechanism.

We also suggest that the following hypothesis should be considered a partial protective mechanism:

- **Hypothesis 3: Lack of aquatic food resources within TSF 1A supernatant pond reduces (or eliminates) wildlife interaction with the supernatant**

It is clear that the lack of food resources in the supernatant (and tailings stream) reduces or eliminates feeding for many water bird species, and consequently reduces bird numbers. However, some species attempt to feed and for these, some risk remains. The Hypothesis therefore can only be considered a partial protective mechanism; nevertheless it does make an important contribution to reducing the overall chances of mortalities.

It is our view that, subject to the company maintaining current operating practices and procedures, the study fulfils the requirements for Certification under the ICMC Standard of Practice Section 4.4 by demonstrating few if any cyanide-related mortalities and explaining the reasons for this in terms of operating protective and partial protective mechanisms.

However, a small residual risk remains in the area around the spigot, the tailings stream and the delta. For this reason, and to increase the company's understanding of variations in wildlife utilisation and operating parameters, it is recommended that monitoring of wildlife and spigot WAD CN and Cu be carried out daily (with the need for further monitoring reviewed after 12 months). If any bird mortalities occur and are shown to be (or likely to be) due to CN toxicosis, NWG should immediately investigate the causes, report the incident to ICMI, investigate the feasibility of the aeration, exclusion or other suitable options described, and implement an effective solution if possible.

Other recommendations are also given to address any identified deficiencies or suggest improvements to the proposed monitoring and management systems.

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# 1 INTRODUCTION

In May 2008 Newmont Waihi Gold Mine (NWG) approached Environmental Management and Research Consultant's Dr. Owen Nichols requesting that he lead a peer review team whose role was to review the company's wildlife and cyanide monitoring and management programs designed to identify any protective mechanisms that may prevent wildlife deaths occurring should released cyanide levels at the mine's tailings storage facility (TSF) exceed 50mg/L WAD CN. The work and associated reporting are being carried out as part of NWG's application for certification under the International Cyanide Management Code (ICMC), Standard of Practice 4.4. Members of the peer review team were:

- Dr. Owen Nichols – Consulting Wildlife Ecologist with considerable experience in monitoring and managing mine-related impacts on wildlife (Lead Reviewer);
- Associate Professor Barry Noller – Environmental Chemist and Toxicologist with wide experience in assessing and managing toxic substances; and
- Dr. Alan Julian – Veterinary Pathologist with local experience in determining the causes of wildlife mortality.

Short biographic notes are given in Appendix 1.

Team members were initially given copies of the following two reports:

1. Donato Environmental Services (2008) International Cyanide Management Code Compliance Position Statement: Newmont Waihi Gold Mine; and
2. Fransen, P., Thompson, Gary Choat (2008) Birdlife at a Cyanide Bearing Tailings Storage Facility, Waihi Gold Mine, New Zealand

A meeting was then held on 20 May 2008 between the peer review team, staff of Newmont Waihi Gold, and the consultant conducting the monitoring, David Donato of Donato Environmental Services (DES). Review team members were briefed on work carried out to date, and work planned to complete the project. Members had the opportunity to ask questions regarding detail and comment on the monitoring program.

Monitoring then continued, data were analysed and the final draft report was prepared. Peer review team members received a copy of 'Wildlife Cyanide Risks and Compliance with the International Cyanide Management Code: Newmont Waihi Gold Mine' and associated appendices on 16$^{th}$ September 2008.

Individual peer review reports were prepared according to a scope of work given by NWG, and these were then incorporated into a combined peer review report. The scope of work provides terms of reference as described by the International Cyanide Management Code and associated Auditor Guidance. Reviewers were required to ensure that the combined report addresses the following key components for review:

1. Ensure that the science is sound and the conclusions are well-founded by checking the assumptions, calculations, extrapolations, alternate interpretations, methodology, and conclusions of the research.

2. Suggest ways to clarify assumptions, findings and conclusions, filter out potential biases, identify oversights, omissions and inconsistencies, and encourage authors to more fully acknowledge limitations and uncertainties.
3. That there is historical data to support recommendations by the operation attempting to demonstrate that an alternative to limiting the WAD cyanide concentration to 50 mg/L is acceptable.

Further guidance for the reviewers, as required by the ICMC and summarised by NWG, is given in Appendix 2.

This report describes the peer review team's findings according to the terms of reference described above. This report is divided into the following sections:

- Wildlife Surveys;
- Exposure to CN;
- Hypotheses and Protective Mechanisms;
- Limitations;
- Proposed Recommendations by DES; and
- Conclusions and Recommendations

Appendix 3 of this report lists a number of spelling and grammatical corrections and suggestions which should be addressed.

# 2 WILDLIFE SURVEYS

## 2.1 Bird Surveys

Ongoing bird monitoring has been carried out at NWG since early 2005. Earlier studies are summarised in DES Report Appendices 2 and 3, and provide useful data on species visitation of the two water bodies as well as an apparent lack of bird deaths due to cyanide. Initial work by DES in January 2008 determined that as well as daily monitoring by NWG staff, more detailed studies were required, including intensive studies by external experts to obtain data on bird utilisation of key TSF habitats in relation to cyanide concentrations and potential impacts. This information is needed to fulfil the Code requirement that in the presence of discharges >50mg/L WAD CN, the presence and details of any protective mechanisms need to be demonstrated and understood.

Overall, the monitoring approach subsequently adopted is similar to techniques used at other sites and projects such as the ACMER Cyanide-Wildlife project (eight TSFs, Donato et al. 2004), Anglo Gold Ashanti's Sunrise Dam mine (which has received ICMC certification) and more recently in a Minerals and Energy Research Institute of Western Australia study on three hypersaline TSFs in Western Australia's goldfields. It is therefore considered that the bird survey method used at Waihi meets the requirements for certification in terms of its design. It has provided valuable data which, on the whole, has enabled NWG to determine whether any impacts have occurred, and the likelihood of future impacts given the resulting good understanding of bird utilisation of key TSF habitats in relation to CN concentrations (this is discussed in more detail in Section 3). However a number of limitations in relation to the adopted survey methodologies and possible future issues need to be recognised and taken into account in interpreting current data, and developing recommendations for future monitoring and management.

- Seasonal aspects of bird utilisation need to be taken into account. This has already been done to some extent with results clearly showing that larger numbers of birds utilise the water bodies after the hunting season commences on the first weekend in May, and the increase is predominantly in ducks, i.e. target species that would be expected to seek refuge. However, data do not yet include daily monitoring over a full 12 month period including all seasons, and in conjunction with daily spigot discharge chemistry monitoring; neither does it yet fully assess variability between seasons (although at Waihi this would be expected to be less than in many Australian sites, for example). The possibility remains that other potentially 'at risk' species, or greater numbers of species currently interacting with tailings, could visit the site during other seasons, so it is important to not just rely on data obtained to date when interpreting findings, even if this does include times when many birds are there. NWG needs to determine whether there are any seasonal migratory patterns or movements that might result in large numbers of birds passing through (albeit briefly) and being potentially exposed to high risk events. On the basis of the current findings, the likelihood of any 'surprises' is considered low, however it is recommended that while habitats exist where WAD CN levels exceed 50mg/L, daily monitoring should continue – indeed, this is a requirement of the Code. In exceptional circumstances, monitoring of birds may be required twice daily, e.g. if weather patterns or other factors result in particularly high bird numbers, or higher numbers of a threatened species are recorded, or mortalities possibly related to cyanide are noticed in TSF 1A.

- Given the plan that future monitoring be conducted by in-house staff, it is recommended that taking a digital camera with a reasonably good zoom lens be considered, as these can prove particularly useful documenting visitation events and identifying bird species.

- Two rare or threatened species, viz. the NZ Dabchick and NZ Dotterel have been recorded on site, with data in Appendix 4 indicating that two NZ Dabchicks were recorded in TSF 1A (however, information from NWG's P. Fransen indicates that locality records for these two were misinterpreted, and none have been recorded in TSF 1A to date). Numbers of this species are very low and findings demonstrating an absence of food suitable for Dabchicks (i.e. aquatic invertebrates in the supernatant) indicate that the risk of mortalities, even if they were to utilise TSF 1A, is also very low. However, although mudflats may not be their preferred habitat, Dotterels do occasionally inhabit areas not unlike those near the spigot discharge where higher cyanide concentrations occur; it has been recorded on the embankment wall of TSF 1A (not a 'preferred habitat') and on bare ground in TSF 2. Also, Appendix 7 indicates that several other rare or threatened bird species probably occur in the area and could possibly interact with the tailings. Therefore, it is very important that

  - Monitoring continue to detect the presence of the above two threatened species or any others, and if present, characterise utilisation patterns, understand risk and detect any impacts; and
  - Staff be trained to recognise any rare or threatened species, including their appearance, behaviour and likely habitats utilised.

- As well as the current training of staff to recognise rare or threatened species, it is important that ongoing and refresher training in bird recognition and monitoring techniques, and response procedures if any rare species or mortalities are observed, be conducted, especially if staff turnover occurs.

- Monitoring surveys of TSF 1A and 2 have been very comprehensive and give a good indication of which birds utilise the two water bodies, and details of their utilisation patterns. It is important that monitoring of both water bodies continues, as any species present in TSF 2 could potentially also utilise TSF 1A and theoretically be at risk; also, results from TSF 2, where CN concentrations are benign to wildlife, provides useful data on background mortalities. However, as indicated in DES Report Table 6 (Appendix 4), some of the numbers include several counts in a single day; it is also possible that during counting, birds could be scared from one water body to the other and give a misleading picture of the extent of utilisation. This is not likely to have affected the overall interpretation and conclusions of the existing report. Nevertheless, those conducting monitoring should be aware of the possibility and attempt to avoid scaring birds from one water body to the other, and take it into account when it is noticed.

## 2.2 Surveys of Other Wildlife Potentially At Risk

Monitoring shows that birds constitute the great majority of fauna interactions with the two TSFs. One introduced frog species has been recorded. The only terrestrial mammal species present are feral and not of significance from a conservation perspective. Overall, it is valid to conclude that the risk TSF 1A poses to non-avian vertebrates is minimal, however the following aspects should be noted:

- The possibility of Hochstetter's Frog *Leiopelma hochstetteri* occurring in the Waihi gold mine region is noted in Appendix 7. Although not the rarest of New Zealand's frogs, this species' IUCN Status is Vulnerable and, together with the other NZ frogs, it is of considerable scientific interest from an evolutionary perspective. Appendix 7 notes that the species' habitat includes sites close to waters edge. Whilst the risk of impacts due to cyanide is likely to be low, nevertheless given the species' scientific interest and its distribution, status and habits, and the lack of specific information on its distribution in the area, it is recommended that a local survey of the species' presence be conducted.

- Surveys of insectivorous bats were not successful due to software problems with January ANABAT data and adverse weather conditions during other surveys. Therefore, the extent to which bats utilise TSF 1A and 2 for foraging or drinking is not known. The report mentions that two bat species may be present. The Long-tailed Bat (North Island) *Chalinolobus tuberculata* is classified as 3 Nationally Vulnerable in NZ, with an IUCN status of Vulnerable. The Short-tailed Bat *Mystacina robusta* is also listed as threatened although its status from the report is unclear, and the species forages on the forest floor rather than seeks food on the wing (P. Fransen pers. comm.). The low concentration of WAD CN in the supernatant and the very low likelihood that bats would interact with areas near the spigot where higher WAD CN concentrations are present probably result in a very low risk to bats. Nevertheless, given the lack of data on bat species and the possible presence of these and other species, the study's recommendation that monitoring be conducted on a seasonal basis using ANABAT (or similar) detectors established on TSF 1A and TSF 2 for five consecutive nights is appropriate, although winter may not be required as activity is likely to be low. If bats are shown to be present, further work will be required to determine their activity patterns, habitat utilisation, and any risk of cyanide mortalities.
- As well as the species discussed above, the only other threatened species whose range and habits suggest they are known to, or likely to interact with tailings habitats on TSF 1A are the NZ Dabchick and the NZ Dotterel. Data indicate that the risk to these species is low, however ongoing monitoring is recommended and it is important that those conducting the monitoring are aware of both species appearance and habits.

## 2.3 Surveys of Aquatic and Terrestrial Invertebrates

### 2.3.1 Aquatic Invertebrates

Surveys of aquatic invertebrates have been carried out using recognised procedures that would detect macroinvertebrates if present in sufficient numbers to constitute a food source for waterbirds. Relevant habitats have been surveyed where present, e.g. open water and reed beds. As with studies elsewhere (e.g. the recent MERIWA study of three gold mines in Western Australia's goldfields), these have shown that aquatic macroinvertebrates are not present in active tailings dams, but are present in natural fresh water bodies – or, in the case of Waihi, former TSF 2. This finding provides valuable evidence of a partial protective mechanism (i.e. lack of food), and is discussed in more detail in Section 3.

### 2.3.2 Terrestrial Invertebrates

Surveys of terrestrial invertebrates were also conducted using accepted invertebrate survey methods, in this case malaise traps and pan traps. However in this case, the surveys did not show a large difference between the macroinvertebrate populations of TSF 1A and 2, which is to be expected as these species are not interacting directly with the tailings. Implications for wildlife, particularly birds, are therefore different for species that feed on aquatic vs. terrestrial species.

## 3 EXPOSURE TO CYANIDE

The report provides detailed information on bird utilisation of the various habitats in the two TSF's. As noted above, bird survey methods are sound and the data provide the opportunity for linking habitat utilisation patterns with measured cyanide levels.

Understanding links between bird utilisation patterns and cyanide concentrations are the key to understanding potential exposure and therefore risk.

Detailed cyanide sampling has only been carried out over a limited time period and not the full range of seasons, and there is limited replication of some sampling e.g. across the supernatant over time and seasons. Nevertheless, the report demonstrates that for TSF 1A, the wildlife habitat occupying the largest area and utilised by the greatest numbers of birds, viz. the supernatant, contains WAD CN levels below 10mg/L. Figure 4b in Appendix 5 shows no WAD CN values greater than this figure, and Figure 8 shows that sampling was conducted across TSF 1A. The concentrations recorded are not toxic to wildlife according to the accepted literature (as quoted in DES Report Appendix 1).

Records of bird mortalities show that overall, relatively few bird deaths occurred, with some of these on TSF 2, which is no longer used and presumably reflects background natural mortalities. The use of balloons demonstrates that if frequent deaths were occurring on TSF 1A, these would be detected. Records of numbers of actual deaths vary in the report and appendices, partly because different sections describe different time periods. It is suggested that all wildlife deaths recorded, together with associated information on locations and causes, be tabulated in the one section and the different study periods noted.

Autopsies show a number of possible causes of death, with none clearly attributable to cyanide toxicosis, however there is a report that one mallard duck had cyanide detected in the liver and in some cases, cyanosis could not be excluded as a possible cause. Nevertheless, records of mortalities noted above, and the lack of observable toxicosis symptoms, suggest very few cyanide-related mortalities.

The report concludes, on the basis of chemistry monitoring data and the literature, that the low WAD CN is due to low copper (and other WAD metallo-cyanide) concentrations, and notes that provided these remain low, WAD CN concentrations in the supernatant will remain below levels that pose a risk to wildlife. This conclusion appears to be correct. However, it should be noted that in the DES report Appendix 5 Pages 5.11 and 5.12, a number of tables are incorrectly referred to (or the wrong table number quoted); once this is understood the conclusions are clear. The statistical significance of the correlation coefficients in Figures 10 and 11 should be checked. Rough 'back of the envelope' calculations seem to indicate that the correlations may be statistically significant; if correct, this would considerably strengthen the argument that a link exists between Cu and WAD CN concentrations.

The survey of aquatic invertebrates shows that none are present in the supernatant of TSF 1A. Likewise, there appear to be no aquatic plants (although this was only determined visually). These factors are likely to result in lower utilisation by some wildlife species, for example the threatened NZ Dabchick, whose food includes aquatic invertebrates, was recorded regularly on TSF 2 but, to date, not on TSF 1A (P. Fransen, pers. comm.). Likewise, numbers of Grey Ducks and Paradise Shelducks were also much lower in TSF 1A. Black Swans feed on aquatic plants and their numbers were lower in TSF 1A. The interpretation of these observations is that the general lack of a food resource results in low utilisation of TSF 1A. However it is noted that although utilisation was low, it is not zero, as for three species occasional foraging – presumably seeking food – was observed. It is not known whether this activity did, or might, result in CN ingestion, however it is concluded that a small residual risk may exist, therefore the lack of macroinvertebrates in supernatant and tailings can only be considered a partial protective mechanism. Nevertheless, it does reduce the overall risk for a number of species.

Other species that feed on either aerial invertebrates or invertebrates that die and land on the water or tailings surface, such as swallows, were observed foraging in both TSF 1A and 2 and probably utilise both water bodies to a similar extent. For these species, some ingestion of solution may occur however the amount is likely to be lower than for aquatic feeding species, and given the WAD CN concentrations recorded, the risk is likely to be low.

Risk for some species is likely to be much higher in an area around the discharge spigot that contains a small discharge pool, tailings stream and associated delta where the concentration is high enough to cause mortalities if sufficient volume of solution or tailings is ingested. Habitats such as the tailings stream could occasionally be utilised by some waterbird species – in fact it was used by two mallard ducks on one occasion for a brief period but both showed no ill effects. The size of the area is quoted as being less than 0.1% of the overall TSF 1A area (an approximate value in square metres should be stated). It is concluded that the risk of wildlife interaction is therefore low. Given the utilisation patterns and low mortalities this appears to be the case.

Where possible, it is preferable to make quantitative statements relating to detail rather than broad qualitative statements. In this instance, it should be possible to calculate the risk of bird mortalities for this area relative to that for other areas of TSF 1A and 2, using data obtained to date and ongoing monitoring data. For example, for the area around the spigot discharge, the relative risk will be a function of the number of times samples exceed 50 mg/L (e.g. 60/100) x the proportion of TSF 1A the area occupies (0.1% or 0.1/100) = 0.0006. This can be compared against the natural death rate for birds to work out the overall increase in risk. However, a number of factors would need to be considered including the proportion of the spigot and surrounding area where concentrations exceed 50 mg/L, and variations between bird species in the extent and purpose for which they utilise the different habitats of TSF 1A. Calculating natural death rates would also not be straightforward as the data for most species indicate that no mortalities occurred on either TSF, while mortality rate calculations for gulls could be confounded by the fact that individual birds are not identified (e.g. banded), and therefore live birds may be counted more than once. Nevertheless, some calculations may be possible using current data and results obtained from ongoing monitoring. It is therefore recommended that an attempt be made to quantify the risk of the area around the spigot in comparison with the remainder of TSF 1A.

Whatever the actual risk value might be, it is not strictly correct to state that TSF 1A is benign to wildlife, as mentioned in the Executive Summary and elsewhere. Some areas, such as the supernatant, may be benign to wildlife under the species use patterns observed, however some other areas, albeit small, are clearly not benign. Page 15 Paragraph 2 notes that 'On 3 of 11 recorded occasions beach habitats in the vicinity of a discharging spigot have exceeded 50 mg/L'. This relatively high number supports the need for frequent monitoring and, together with the estimated area of 0.1%, can be used to calculate risk as discussed above.

Some level of risk therefore remains, and it should be noted that detailed bird monitoring (including habitat utilisation) to date in conjunction with daily spigot sampling has not covered a full 12 months i.e. the full suite of seasons, and has also not fully assessed possible variation between years. It is important that, as noted in the report Recommendations No. 2, that wildlife monitoring continues daily as long as WAD CN levels exceed 50 mg/L. Several recommendations for reducing the risk posed by habitats around the spigot discharge are given later in this review.

Data reported in the study indicate that some wildlife have been observed drinking from TSF 1A supernatant. This therefore represents a potential exposure pathway, however the extent of any intake is not known, although it likely to be low given the low concentrations recorded in the supernatant.

The extent of exposure of bats to cyanide cannot be concluded with certainty at this stage, due to the lack of information on their utilisation of the site. It is possible that one or more bat species may ingest supernatant whilst drinking, or supernatant or tailings whilst feeding. Given the low WAD CN concentration in the supernatant and most of the tailings, the extent of exposure of bats is likely to be low (when compared, for example, with that of aquatic biota).

## 4 HYPOTHESES AND PROTECTIVE MECHANISMS

The original nine hypotheses (DES Report Appendix 2) were condensed to six that were then evaluated using the data obtained during the present study, interpretation of the analyses, and Hill's criteria. The validity of the study's conclusions for each of the hypotheses is discussed below.

**Hypothesis 1: Rapid degradation of cyanides occurs *in-situ* within TSF 1A due to low copper (and WAD metallo-cyanides) concentrations rendering the supernatant (open water) and most TSF habitats benign to wildlife**.

Monitoring data shows that rapid degradation of cyanides does occur within TSF 1A on exposure of tailings solution to air. This results in cyanide concentrations in the supernatant and most TSF habitats that would not cause wildlife mortalities, given the use patterns observed. The lack of mortalities clearly attributable to cyanide over the seven months of intensive monitoring, and the previous three years of wildlife monitoring, confirm this. The mechanism for the cyanide degradation (low concentration of copper and other WAD metallo-cyanides) is explained – although as noted in Section 3 above, some corrections and statistical correlation analyses are required in the DES Report Appendix 5, Pages 5.11 and 5.12.

A small area around the spigot, estimated at <0.1% of the total, remains where concentrations would be toxic if ingested by wildlife. This is discussed later.

The report is correct in stating that this hypothesis is supported and is a primary protective mechanism, provided the current chemistry parameters are maintained.

**Hypothesis 2: Routine mill processes result in recurring dilution of the tailings waste stream to non-toxic levels**.

Whatever dilution occurs within the tailings waste stream, even if this does lower the WAD CN levels released from the spigot, it is clear that concentrations at release and in the resulting pool, stream and delta exceed the values required for code compliance; therefore, as concluded in the DES report, this cannot be considered to be a protective mechanism.

**Hypothesis 3: Lack of aquatic food resources within TSF 1A supernatant pond reduces (or eliminates) wildlife interaction with the supernatant**.

In Section 3 above, it is noted that a lack of aquatic invertebrates and plants in TSF 1A reduces feeding behaviour for some species, and therefore would reduce the risk of CN ingestion. This would also apply to the tailings stream. However, some 'exploratory' feeding behaviour occurs from time to time for some species. The DES report is correct in concluding that the lack of aquatic food resources is not a full protective mechanism, however it clearly does reduce wildlife interaction with cyanide in supernatant and tailings, and therefore should be considered a partial protective mechanism.

**Hypothesis 4: Wildlife does not drink TSF supernatant due to alternative drinking sources**.

Data reported in the study indicate that the conclusions in this regard are correct; although other water sources are available and the mesic climate means that the frequency of drinking is likely to be less than in hot and arid areas, nevertheless wildlife have been observed drinking from TSF 1A supernatant. Therefore, this may represent some degree of risk for some species and therefore, as concluded in the DES report, cannot be considered a protective mechanism.

**Hypothesis 5: At-risk wildlife species are not present within TSF 1A**.

As noted in Section 3 above, monitoring data at NWG show that a range of 'at risk' species, as determined by their observed behaviour and studies conducted elsewhere, are present in TSF 1A. The absence of 'at risk' species is therefore clearly not a protective mechanism – the DES report's conclusions in this regard are correct.

**Hypothesis 6: Toxic habitats within TSF 1A are very small in area (<0.1% of the TSF), unattractive to wildlife and only rarely used by wildlife.**

Cyanide monitoring data in Appendix 5 of the study clearly shows that spigot pools, tailings streams and, on occasions, the resulting delta contain WAD CN levels regarded as toxic to wildlife. However, data also show that wildlife utilisation of the spigot pools and tailings stream is very low, with only two recorded instances of species utilising the streams and no deaths. This is expected as experience elsewhere indicates that wildlife generally find such habitats unattractive on tailings storage facilities, although the reason(s) for this (high turbidity affecting feeding ability or palatability? lack of vegetation?) are not yet clear. In the deltas where WAD CN levels are lower but occasionally approach 50 mg/L, wildlife utilisation is greater. Given the relatively low combined area occupied by the spigot pool, stream and delta, as well as the lack of (or in the worst case, low numbers of) mortalities attributable to cyanide, it is valid to conclude that, in effect, this represents a partial protective mechanism, as concluded by the study.

In combination with Hypotheses 1 and 3, the study therefore fulfils the requirements for Certification under the Code, noting that Guidance for Auditors for Standard of Practice 4.4 states that: '(the) Operation could demonstrate that a higher concentration of WAD cyanide in open water does not cause wildlife mortality due to site-specific reasons. For example, if there are no birds that drink from the beach of an impoundment in the area of an operation, then the 50 mg/l limit would not apply at the discharge point'. It is reasonable to assume that this (i.e. no birds drinking or feeding) would apply to the situation at the spigot pool and tailings stream on most occasions, although not necessarily at the delta.

Overall, members of the peer review team are confident that the protective and partial protective mechanisms currently in place, together with the recommendations suggested, will work and therefore be protective of wildlife and satisfy the Code requirements for certification under Standard of Practice Section 4.4. It is acknowledged that some residual risk remains and there is always a small possibility that birds of a particular species could land next to a tailings stream and attempt to drink or feed. In the very unlikely event that one or more bird mortalities occur and are shown to be (or likely to be) due to CN toxicosis, NWG should immediately investigate the causes, report the incident to ICMI, investigate the feasibility of the aeration, exclusion or other options described below, and implement an effective solution if possible. These options include:

1. Designing some simple aeration or cascading system that would result in more rapid degradation of cyanide. This would greatly reduce WAD CN concentrations and either eliminate or significantly reduce the area of tailings stream and delta where concentrations exceed the recommended 50 mg/L limit;
2. Given that the area of higher risk habitat is relatively small, it should be possible to design a wildlife exclusion system such as a bird netting cage that floats on supernatant or sits on the tailings. Using the measurements quoted, for a particular spigot outlet this would only need to cover an area of 20m x 20m or thereabouts and should be relatively straightforward to construct; and/or
3. Other option(s) agreeable to ICMI.

If aeration of the discharge stream proved successful, other options may not be necessary, subject to confirming reduction of WAD cyanide concentration at the spigot.

One or other of these options, if required, would virtually eliminate the risk of mortalities given any likely scenario, and would therefore eliminate any remaining concerns regarding the following statement in the Auditor's Guidance: 'In many cases, operations have maintained open ponds with toxic concentrations of cyanide for years with few wildlife mortalities. However, such "good luck" is not sufficient for Code compliance, and operations are required to take positive measures to prevent wildlife mortality.' Implementing one or other of these options, if and when required, would represent such positive measures.

## 5 LIMITATIONS

*Sampling*:

A relatively large number of samples have been collected to date and these give a good general idea of where WAD CN concentrations may exceed 50 mg/L. However the data do show quite large variation in spigot WAD CN concentrations and it is important that the extent of this variation is well understood. It is also possible that future ore characteristics or operating procedures could alter the extent or frequency of spikes. Therefore, as noted in Section 7 of this review, it is recommended that daily monitoring of spigot samples for WAD CN and Cu continues in order to gain a more complete understanding of this variation, and to improve the reliability of estimating the risk of occurrence of 50 mg/L WAD cyanide exceedences. In some cases where plant operations or ore feed change, large changes in WAD CN or Cu outputs could occur – where there is a risk of this happening, monitoring of spigot output and wildlife may be required twice daily while the risk remains. This approach will ensure that, should any wildlife deaths occur, WAD CN and copper samples will be available on the actual day of the event, and will show whether any spikes occurred. Table 5, which shows bird mortalities but not WAD CN concentrations on the same day, illustrates the fact that interpretation of the cause of mortalities without such data can be difficult. The results and need for monitoring at the same or a reduced frequency could be reviewed after twelve months.

*Nocturnal wildlife interaction*:
The study recognises that although the risk to bats is likely to be low, the extent and characteristics of any interactions with tailings facilities has not been determined. It is therefore suggested that ANABAT detectors or similar be used to document bat presence on TSF 1A and 2 on a seasonal basis. This would address the limitation. Birds would also utilise the site at night, however avifaunal surveys at this time are difficult and it is considered sufficient that early morning inspection for affected or dead birds be carried out, given the small area considered 'at risk' to wildlife. However, limitations such as this support the recommendation above that if cyanide related mortalities occur, options such as aeration of the tailings discharge, exclusion of the area near spigots using netting or other options agreeable to ICMI, should be considered and implemented if possible.

*Wildlife dosage*:
The study report is correct in noting that calculation of actual dosages for particular species is very difficult, even given relatively detailed feeding observation data and accurate information on supernatant or tailings CN concentrations. However, this is the same situation as encountered at other sites, and does not affect the overall conclusions of the study which are based on sound chemistry, behavioural and mortality data.

*Control of copper and CN*:
The links between Cu (or other WAD metallo-cyanide) concentrations and cyanide degradation are well understood. However, WAD CN concentrations did not reach a concentration where wildlife mortalities were unequivocally demonstrated. Therefore, the DES report states that recommended maximum discharge spigot and supernatant concentrations of Cu and WAD CN under the systems operating at Waihi cannot be based on specific demonstrated toxicity thresholds. In fact, it may be possible to use the 50 mg/L WAD cyanide level – which has been confirmed in numerous studies - for this purpose by calculating the maximum copper concentration for Cu cyanide complex up to 50 mg/L WAD cyanide, e.g. from Appendix 6 supernatant is 3.7% $Cu(CN)_2^-$ and 96.0% $Cu(CN)_3^-$ which allows calculation of Cu in 50 mg/L WAD.

Calculations by A/Prof. B. Noller show the concentration of copper that is equivalent to the distribution of copper cyanide species based on molar proportions in the sample if completely complexed to 50 mg/L CN. Using the sample data in Appendix 6 this gives:

- Decant 1A 23/11/08 41.5 mg/L Cu
- Decant 1A 10/5/08 45.8 mg/L Cu
- Supernatant 9/6/08 40.9 mg/L

In summary, although the copper cyanide species can vary in proportion in the sample, the Cu concentration equivalent to 50 mg/L CN is approximately 50 mg/L Cu; hence the correlation between WAD CN and Cu concentrations (as noted in Figures 10 and 11 of Appendix 5).

The DES report proposes that recommended maximum discharge spigot and supernatant concentrations of Cu and WAD CN be based on current operating parameters, at least until further information is available. This is an appropriate solution to the problem, provided ongoing wildlife and chemistry monitoring are conducted to confirm the recommended operating parameters are appropriate.

*Accuracy of chemistry monitoring data*:
The accuracy of chemistry monitoring data is discussed in the DES report's Appendix 6. It should be noted that the validity of key conclusions from the report, i.e. that supernatant WAD CN concentrations are very low and those in the spigot stream and tailings pool are well over 50 mg/L, would not be affected by anything other than very large sampling or analytical inaccuracies.

*Risk to ducks and gulls*:
The study correctly concludes that there is a theoretical residual risk, albeit small, to both gulls and ducks. The risk also exists for other species including stilts, swallows, and several threatened species, however it is likely to be low for the reasons indicated.

The study does acknowledge that although the autopsies in most cases suggest other causes of death apart from cyanide toxicosis, the possibility of this cannot be discounted, at least in some cases. The success of autopsies in establishing a likely cause of death depends on both the time since death, and the techniques used. In future it is important that if any dead birds are observed, they are autopsied as soon as possible, following a predetermined protocol that maximises the chances of detecting any cyanide related mortalities (or, conversely, eliminates cyanosis as a cause of death).

*Threatened species*:
Threatened species are discussed in Section 2.2 of this review; some limitations exist with regards to the information available for them, or conclusions drawn. Hochstetter's Frog may be present in the general area and a survey of its presence and abundance near TSF 1A is recommended. Several bat species may be present and recommended surveys for these are discussed earlier. Two threatened bird species have been recorded at the site. The NZ Dabchick has been sighted on TSF 2 and although it is unlikely to feed in the supernatant of TSF 1A due to the absence of aquatic invertebrates, nevertheless it could attempt to feed so ingestion of some solution is possible. While WAD CN concentrations remain low, the risk to this species is likely to be low, even if it does utilise TSF 1A in small numbers. The NZ Dotterel was observed on several occasions on an embankment. DES report Appendix 4 states that the species preferred habitat includes 'beaches where freshwater streams enter the sea but also uses firm intertidal mudflats' and concludes that the risk to the species is low because none of the toxic areas within TSF 1A are prime habitat for the species. This may not be totally correct; dotterels commonly forage on bare mudflats not unlike those found near the tailings streams and deltas, and where CN concentrations are high. Also, whilst wildlife may 'prefer' certain habitats when available, they often readily use other habitats when their preferred habitat is not available. The risk to this species, although relatively low due to the low numbers present and the very small area of TSF 1A possessing toxic CN levels, may nevertheless be

higher than predicted in the report. It is very important that NWG staff conducting wildlife monitoring are aware of the fact that these two bird species may be present, and are able to recognise them.

## 6 PROPOSED RECOMMENDATIONS BY DES

On the basis of the project findings, the report makes a number of recommendations which generally appear to be sound.

Recommended operating parameters are based on the conclusion that there are currently no (or at most, very few) cyanide-related mortalities, therefore it is concluded that until further data are available, limits for key operating parameters should be based on actual monitoring data obtained during the project, with some additional safety margin included. This assumes that data for the parameters is normally distributed – which should be verified using the Kolmogorov-Smirnov Goodness of Fit Test (or similar). Limits are suggested for the following parameters: Maximum WAD CN, 80 percentile WAD CN, copper, all mg/L and all at spigot and supernatant, while significant increases of pH above the current range must be avoided (although this must be balanced by having a sufficiently high pH to give safe operating cyanide concentrations for workers (see Leading Practice Handbook on 'Cyanide management' 2008). It is then recommended that monitoring of process and tailings solutions, as well as wildlife continue as required under the Code (while WAD CN exceeds 50 mg/L) to encompass a range of seasons, annual variation in weather and bird utilisation, ore feed scenarios and variation in operating procedures.

Overall, this approach appears sound and is considered likely to maintain the protective mechanisms described. There would appear to be little alternative given that specific toxic thresholds are not known for any of the species present (as there have been no clearly attributable cyanide mortalities) and in any case, these would vary between species and probably other conditions such as weather and, of course, chemistry of the tailings solution. Recognising that some uncertainties remain, the DES study recommends that monitoring of WAD CN and Cu in spigot discharges continues, together with daily monitoring of wildlife utilisation by trained in-house staff. If any wildlife deaths are noted, surveys by in-house staff should commence immediately and intensive wildlife monitoring, including detailed assessment of habitat utilisation, should be conducted as soon as possible using external experts, to determine the details and extent of mortalities and address the causes.

These recommendations appear to be appropriate whilst discharges >50 mg/L continue. However sampling CN and Cu twice weekly during the season of high bird visitation and weekly during the low visitation season is not considered sufficient given that further seasonal variation in bird utilisation patterns may exist but have not yet been monitored, and it is important that any variation including that due to effects of changes in operating parameters or ore composition be documented and fully understood. Should any bird mortalities occur, as noted earlier, it is very important that a spigot discharge sample be available for the actual day so that this can be linked to the autopsy report and the species behavioural patterns, and illustrate whether there was a spike in WAD CN at the time.

Chemistry and bird monitoring data should be subjected to detailed statistical review after 12 months. Any aspects not currently fully understood and noted in this review should be investigated. At that time it might be possible to reduce the frequency of spigot sampling and/or vary operating parameters, however as required under the Code, daily wildlife monitoring will need to continue as long as discharge concentrations exceed 50mg/L.

If WAD CN concentrations in spigot discharges drop below 50 mg/L the frequency of wildlife and WAD CN monitoring may be able to be reduced, as noted in the DES report. However, if regular spikes in WAD CN are observed then monitoring frequency should only be reduced if studies demonstrate that the spikes in concentration do not pose a risk to wildlife.

All of the other recommendations provided in the DES report are appropriate given the findings of the study, and knowledge available through the literature and other comparable studies. However, as noted earlier, some additional recommendations are appropriate, and these are given in the following section.

## 7 CONCLUSIONS AND RECOMMENDATIONS

Overall, the study appears to be based on sound monitoring procedures (although recognising the limitations noted); analytical methods are appropriate and no errors in calculations were noted; and the interpretations with regards to what protective or partial protective mechanisms are operating appear to be correct (although Hypothesis 3, concerning food availability, should also be considered a partial protective mechanism). On this basis, provided the recommendations in the DES report and those noted below are implemented, the NWG tailings facility should fulfil the requirements for the ICMC Standard of Practice 4.4.

It is recognised that some residual risk remains, with the spigot pool, tailings stream and delta possessing WAD CN concentrations considered a threat to wildlife. Utilisation of these habitats appears to be very low, so the risk is likely to be correspondingly low, however the possibility of ducks, dotterels, stilts or other waterbirds landing on the area and attempting to feed cannot be discounted. It is therefore recommended that options to reduce this risk be considered, as described below.

As noted in this review, it is recommended that, as well as the recommendations provided in the DES report:

- A survey to detect the possible presence of Hochstetter's Frog should be conducted in the vicinity of the TSFs (at the appropriate time of year for this species);
- In-house wildlife monitoring staff must be trained to recognise the appearance and habits of the NZ Dabchick and NZ Dotterel and any other threatened

species potentially present, and instructed to carefully check the identity of any possible sightings, and record details, numbers, habitat, and behaviour;

- As well as training staff to recognise rare or threatened species, it is important that ongoing and refresher training in bird recognition and monitoring techniques, and response procedures if any rare species or mortalities are observed, be conducted, especially if staff turnover occurs;
- The use of digital cameras with a good zoom lens should be considered to document wildlife utilisation of tailings habitat and help identify species;
- Bat surveys should be conducted as proposed;
- If any dead birds are observed, they must be autopsied as soon as possible, following a predetermined protocol that maximises the chances of detecting any cyanide related mortalities (or, conversely, eliminates cyanosis as a cause of death).
- Monitoring of spigot discharge for WAD CN and Cu should be conducted daily;
- Prior to adopting operating parameters, and when reviewing them, data should be checked statistically for goodness of fit to confirm they are normally distributed;
- In some cases where plant operations or ore feed change, large changes in WAD CN or Cu outputs could occur – where there is a risk of this happening, monitoring of spigot output and wildlife may be required twice daily while the risk remains;
- Likewise, in exceptional circumstances, monitoring of birds may be required twice daily, e.g. if weather patterns or other factors result in particularly high bird numbers, or higher numbers of a threatened species are recorded, or mortalities possibly related to cyanide are noticed in TSF 1A;
- As described in Section 4 Hypothesis 6, if cyanide-related mortalities occur, NWG should immediately investigate the causes, report the incident to ICMI, investigate the feasibility of the options described below, and implement an effective solution if possible. These options include:
    - Designing and constructing a simple aeration or cascading system that would result in more rapid degradation of cyanide. This would greatly reduce WAD CN concentrations and either eliminate or significantly reduce the area of tailings stream and delta where concentrations exceed the recommended 50 mg/L limit;
    - If aeration as described above proves impractical or only partially successful, given that the area of higher risk habitat is relatively small, it should be possible to design a wildlife exclusion system such as a bird netting cage that floats on supernatant or sits on the tailings. Given the measurements quoted for a particular spigot outlet, this would only need to cover an area of 20m x 20m or thereabouts;
    - Other option(s) agreeable to ICMI.

## ACKNOWLEDGEMENTS

We would like to acknowledge the help of Newmont Waihi Gold (Pieter Fransen) and Donato Environmental Services (David Donato) staff who provided the information used in this review, and willingly answered any questions of detail.

## REFERENCES

Donato D, Noller B, Moore M, Possingham H, Ricci P, Bell C, and Nichols O.G. (2004) Cyanide use, wildlife protection and the International Cyanide Management Code: an industry brokered approach. Minerals Council of Australia Inaugural Global Sustainable Development Conference, Melbourne. Minerals Council of Australia.

## APPENDIX 1: Brief Biographies Of Reviewers

### Dr. Owen Nichols:

Dr. Owen Nichols has more than 28 years experience in the environmental management of mining industry projects throughout Australia, South-east Asia and China. He worked for Alcoa's Environmental Department for 11 years and since then has consulted for most major mining companies. He has also studied environmental management and rehabilitation at mines in the UK, USA, Ireland, New Caledonia, Canada and Mongolia. Dr. Nichols specialises in designing and assessing mine rehabilitation programs, evaluating and managing impacts on biodiversity and the natural environment, pre-mining surveys, designing and analysing environmental monitoring programs, mine closure planning, compliance auditing, general project management and the co-ordination of study teams and research programs. Many of his projects have necessitated effective interaction with Government and other key stakeholders. He has published more than 50 papers and 100 consulting reports, and worked in numerous environments including eucalypt forests, woodlands, heathlands, arid regions, rain forests and wetlands. Whilst he was Environmental Research Manager at Alcoa, the company was added to the United Nations Environment Program Global 500 list for the excellence of its rehabilitation, the only mining company in the world to receive this honour. In April 2002, Dr. Nichols was appointed to the position of Research Program Manager by the Australian Centre for Mining Environmental Research, where his role included developing and managing research projects on a range of mining environmental issues, and conducting training programs for industry and Government personnel.

Projects directly relevant to the management of wildlife utilisation of tailings dams include:

- Assessment and management of bird impacts on caustic residue storage areas at Alcoa;
- Co-ordination of the ACMER project on managing risks posed by cyanide TSF's to wildlife;
- Extensive research on wildlife utilisation of wetlands, including artificial created wetlands;
- Technical (peer) review of projects investigating the protective mechanisms operating at cyanide TSF's in Western Australia's goldfields;
- Numerous consulting projects on wildlife survey techniques;
- Several related publications, including Principal Author of the Leading Practice Handbook on Biodiversity Management, and ICMM's Good Practice Guidance for Mining and Biodiversity.

### Associate Professor Barry Noller:

Associate Professor Noller has a PhD (1978) in Environmental Chemistry from the University of Tasmania. He worked as a Research Fellow at the Australian National University (1978-1980), Senior Research Scientist at the Alligator Rivers Region Research Institute, Jabiru, Northern Territory (1980-1990) and then as Principal

Environmental Chemist for the Department of Mines and Energy, Darwin Northern Territory (1990-1998). During this period Professor Noller was involved with the environmental management and regulation of all gold mines in the Northern Territory and was technical manager of the Northern Territory study on Bird Usage Patterns on Mining Tailings and their Management to Reduce Mortalities completed in 1998. He was also a co-author and reviewer of the Best Practice Environmental Management in Mining Handbook on Cyanide Management. From 1998-2006 Professor Noller has been Deputy Director of the National Research Centre for Environmental Toxicology (ENTOX) – The University of Queensland, Coopers Plains, Qld. ENTOX has a strong involvement with the utilisation of the risk assessment process to deal with toxicological hazards, including in environmental systems. Since November 2006 Professor Noller has been appointed as Honorary Consultant at the Centre of Mined Land Rehabilitation (CMLR) a centre of the University of Queensland based at St Lucia. The CMLR is part of the Sustainable Minerals Institute.

Professor Noller has been working and publishing in the field of environmental chemistry and industrial toxicology for the past 32 years and has presented >200 conference papers and published >130 papers. His professional activities undertaken at 4 different centres have covered processes and fates of trace substances in the environment, particularly in tropical environmental systems with special reference to risk management associated with their application and studies of the bioavailability of toxic elements in mine wastes, including waters. He has undertaken a number of consulting activities in Queensland, Tasmania, New South Wales and the Northern Territory and was appointed in 2007 as Lead Author of the Australian Government Sustainable Leading Practice Development Program for the Mining Industry Handbook on Cyanide Management.

**Dr. Alan Julian:**

Alan graduated from Massey in 1973 and then worked for a short time in clinical practice in Wanganui before joining the Wallaceville Animal Health Reference Laboratory as a Veterinary Investigation Officer. He trained as a pathologist with Dr. Peter O'Hara and then in later years worked with Dr. Bill Hartley so had the benefit of learning from two very experienced and well recognized pathologists.

During this period Alan had one year working at the Regional Animal Health Laboratory in Lethbridge, Alberta, Canada on a job exchange. Alan then spent four months at the University of Guelph preparing for the American College of Veterinary Pathology examination. One of Alan's first responsibilities at Wallaceville was screening of the exotic sheep in quarantine on Mana Island for Scrapie and other exotic diseases. From this arose an interest in neuropathology that has continued till today.

Alan moved north to join the Ruakura Animal Health Laboratory in 1986. Once at Ruakura and the lab started to become commercialized, work with the equine industry was started. The knowledge and cases received over the initial years were used when Alan was a Moderator for a conference on the diseases of horses for the other pathologists in New Zealand.

Since 1986 Alan has seen several changes in the organizations but his work as a pathologist has continued. In recent years Alan has a specialist role in screening all cases from meatworks where Cysticercosis or hydatids is suspected. Alan is also one of the pathologists contracted to the Animal Health Board to examine tissues for tuberculosis.

He has published over twenty  peer reviewed and seventeen non-peer reviewed papers on a range of topics related to natural and experimentally induced diseases of both domestic species,  local NZ wildlife and some zoo animals including papers on:

- Leptospirosis in the Opossum *Trichosurus vulpecula*;
- Tuberculosis in the Opossum *Trichosurus vulpecula*;
- Mite infestation of New Zealand short-tailed bats;
- Adenoviral hepatitis in a female bearded dragon; and
- Feather disease in Eastern Rosellas.

He was also invited to present a present a paper titled "Veterinary Toxicology in New Zealand" in Oct 2006 at an International Veterinary Toxicology Symposium. Annual Conference of the American Association of Veterinary Laboratory Diagnosticians. Minneapolis. USA.

**APPENDIX 2: Guidance for Reviewers (from the ICMC, as summarised by Newmont Waihi Gold)**

The peer reviewers are encouraged to be familiar with the following International Cyanide Management Institute's (ICMI) documents:

- Gold Mining Operations Verification Protocol for the International Cyanide Management Code
- Implementation Guidance for the International Cyanide Management Code
- The International Cyanide Management Code,
- Auditor Guidance for Use of the Gold Mining Operations Verification Protocol.

ICMI defines Peer Review process as: 'A peer review is an in-depth critique of assumptions, calculations, extrapolations, alternate interpretations, methodology, and conclusions drawn in an original work. It is a documental, critical review, typically performed by a panel of at least three independent persons having technical expertise in the subject matter to be reviewed (or a subset of the subject matter to be reviewed) to a degree at least equivalent to that needed for the original work.

Reviewers cannot be involved as a participant, supervisor, technical reviewer, or advisor in the work being reviewed, and must be free of conflict of interest as defined in ICMI's Auditor Criteria Document'.

The pertinent Standard of Practice is 4.4: "Implement measures to protect birds, other wildlife and livestock from adverse effects of cyanide process solutions" [1].

"One of the few numerical guidelines included in the Verification Protocol is a 50 mg/l WAD cyanide limit for exposure of birds, other wildlife and livestock included in the Implementation Guidance. This recommended limit is based on anecdotal evidence that solutions with 50 mg/l WAD cyanide are typically non-lethal to wildlife. Operations that restrict access of birds and other wildlife to open waters above this level are typically in full compliance with this Standard of Practice" [2] p.35.
"The Code does not specify that this limit applies at the discharge to a tailings impoundment. However, certain types of birds commonly drink tailings water as it flows across the beach of an impoundment. Therefore, in areas where such birds are found, the quality of tailings water is subject to the 50 mg/l limit before it enters the supernatant pond" [2] p.35.

"It may also be possible for operations to use alternative methods to meet this Standard of Practice. Operation could demonstrate that a higher concentration of WAD cyanide in open water does not cause wildlife mortality due to site-specific reasons (emphasis added). For example, if there are no birds that drink from the beach of an impoundment in the area of an operation, then the 50 mg/l limit would not apply at the discharge point" [2] p.36.

Similarly, if the operation could demonstrate that a 50 mg/l concentration of WAD cyanide is not lethal to the specific types of birds and other wildlife that live and pass through the area, then some higher but still protective level would be appropriate. However, making these demonstrations to the auditor's satisfaction will not, and should not, be easy. Anecdotal evidence such as "we've never seen any bird mortality" is not sufficient, although any assertion that the 50 mg/l limit is unnecessary must be supported with comprehensive, daily inspection records demonstrating that there are no mortalities [2] p36.

"The operation must also present the scientific rationale for the lack of mortality at a cyanide concentration that would otherwise be toxic. This could be a study by an appropriately qualified person concluding, for example, that no wading or shore birds are known to be in the area, or that the local population of birds and wildlife are resistant to this cyanide concentration. Such a study must be peer-reviewed and sufficiently rigorous that a causal relationship is established. Like any competent scientific study, the results must be independently reproducible and predictive. Even though the initial Verification Audit looks at current compliance at the time of the audit, an operation attempting to demonstrate that an alternative to limiting the WAD cyanide concentration to 50 mg/l is acceptable must have historical data to support such a claim." [2] p36.

Furthermore "Such a study must be peer-reviewed and sufficiently rigorous that a causal relationship is established. Like any competent scientific study, the results must be independently reproducible and predictive" [2] p37.

"For purposes of compliance with this Standard of Practice, peer review is an independent, documented evaluation of scientific research for competence and validity. The review checks the assumptions, calculations, extrapolations, alternate interpretations, methodology, and conclusions of the research to ensure that the science is sound and the conclusions are well-founded. When necessary, the peer review process suggests ways to clarify assumptions, findings and conclusions, filters out potential biases, identifies oversights, omissions and inconsistencies, and encourages authors to more fully acknowledge limitations and uncertainties" [2] p37.

"Even though the initial Verification Audit looks at current compliance at the time of the audit, an operation attempting to demonstrate that an alternative to limiting the WAD cyanide concentration to 50 mg/l is acceptable must have historical data to support such a claim" [2] p37.

***References:***

1. International Cyanide Management Institute, *The International Cyanide Management Code, September 2006*. 2006, International Cyanide Management Institute. p. www.cyanidecode.org.

2. International Cyanide Management Institute, *Auditor Guidance for Use of the Gold Mining Operations Verification Protocol, September*. 2007, International Cyanide Management Institute.

## APPENDIX 3: List of Spelling and Grammatical Corrections and Suggestions

Executive Summary Piv Para3. The reference to Physical Chemistry needs include the details of what was measured. The use of the term in this case over-generalises what is meant.

Executive Summary Piv Para5: The details 'four wildlife carcasses have been detected within TSF 1A and a further six carcasses have been detected within TSF 2' should include the % mortalities in brackets if the data are available. This can be expressed as % on the day (e.g. for species A, 1 bird was recorded dead, 49 healthy = 2% mortality) or over a longer period (e.g. in Q1 200X for species A there were 3 deaths out of a total of 120 sightings, approx. 2.4% – however, this is likely to be an underestimate as there would be a high chance that some live birds would be counted on more than one day.

Executive Summary Pv Para2: see comment below for P6 Para6 re testing for normality.

Executive Summary Pv: The sentence 'The site water balance over the next three years shows metallo-cyanides varying cyclically and remaining up 50 g/m3' needs to be explained more clearly.

Executive Summary Pv. The following sentence is not clear and should be explained, rephrased or put into context 'the site water balance over the next three years shows metallo-cyanides varying cyclically and remaining up 50g/$m^3$'

P2 Para3: First sentence 'Cyanide related deaths have been recorded infrequently at NWG…' needs rewording as it is not clear, and needs to be more precise and/or refer to specific figures. Appendix 3 states only one mallard duck had cyanide detected in the liver and in others mortality due to cyanosis was inconclusive. Deaths clearly attributable to cyanide are low, as are total deaths; clarify whether this is referring to one or both.

P2 Para8: The detail 'bioavailable cyanide (the hazard)' described in Management Option 2 could be made more specific by referring specifically to the metallo-cyanide, especially copper component, of WAD cyanide.

P5 Point 3: The detail 'minimal transitional metallo-cyanide complex formation' should refer specifically to minimal metallo-cyanide complex formation as copper cyanide complex does not readily break down; i.e. is not transitional.

P5 Point 4: The detail 'degradation of cyanide' should refer to free cyanide.

P5 Point 11: Here 'chemistry' refers to chemical equilibrium process or reaction.

P6 Para3: The dot point 'WAD or free cyanide concentrations' should be WAD including free cyanide concentrations.

P6 Para 6: The sentence ‘The cyanide discharge and soluble copper concentrations are, as expected, normally distributed with approximately 70% of the observations falling within the interval of the standard deviation around the mean’ needs to be confirmed by showing the result of the Komolgorov-Smirnov test or other applicable statistical test to show that this is a correct statement.

P7 Table 1 and subsequent tables: These tables e.g. ‘Table 1. Chemistry parameters measured by site monitoring.’ need to include n = number of samples and are better displayed with standard error (SE=SD/√n) so that different means values can be compared directly. Note Figures 2 and 3 have the value of n but n should accompany the data in the table. Tables 3 and 4 correctly use standard error (SE).

P11: In the discussion on seasonality of wildlife utilisation it should be mentioned that the duck hunting season begins on the first weekend in May.

P11 second last para last sentence: ‘January results were effectively replicated’ would be a better way of stating it, assuming that’s what you mean.

P14 Para4: Re drinking of tailing solutions, it is stated that ‘There are ample green vegetative food resources in the vicinity and hydration needs of waterbirds are probably met through food resources’. Avian physiology and water balance studies suggest this may be correct, however a reference should be quoted here to support this hypothesis. Appendix 1 does refer to birds in arid conditions obtaining water via metabolic processes, however this would not be the situation at NWG.

P15 Para 2: ‘in the vicinity of a discharging spigot’ is mentioned twice. It would be useful to mention what this means – 1m, 5m, 20m? This is discussed later but it would help the reader if a figure was mentioned here. Check spelling of discharge

P15 Para 4: As previous comment – later <0.1% is mentioned (P21 Hypothesis 6); could also mention it here with an explanation of how it was calculated

P15 Para 4: The risk assessment matrix is in Appendix C of Appendix 4

P15 Para 5: The sentence ‘If any historical wildlife deaths were due to cyanosis recorded at TSF 1A…’ should presumably read ‘If any historical wildlife deaths recorded and TSF 1A were due to cyanosis…“. Also, clarify whether this might mean there were deaths recorded that were not investigated or are not included in this report?

P15 Para 5: should be ‘systemic amyloidosis’ not systematic

P16 Para 5: Use similar habitats, not equivalent.

P16 Table 5: It is not clear whether in all cases samples were taken close to where the carcasses were found? This should be clarified. If CN was the cause it is reasonable to assume that they received a toxic dose close to where they died.

P18 Point 1: This should read '..due to low WAD metallo-cyanides including copper..'

P20 Hypothesis 3: Mallard spelling. Also, it could be argued that food availability is a partial protective mechanism for *some* species.

P21: It would help if the report explained somewhere why tailings streams and spigot pools are considered to be unattractive to wildlife, e.g. no food, colour, what? The literature or experience elsewhere should give some indication.

P22 Wildlife Dosage paragraph: effects, not affects.

P22 Last Paragraph –next page: The sentence 'A toxicity threshold was not reached therefore a trigger value for copper concentrations cannot be determined.' can be estimated by assuming that a maximum amount of copper can complex with cyanide to give 50 mg/l WAD cyanide as 50 mg/L of free cyanide or weakly complexed forms (which will be equally as toxic to birds). The next sentence is correct.

P24 Para3: It is reasonable to assume that the toxicity threshold is 50 mg/L based on the re-occurrence of this value in studies worldwide; where 50 mg/L (or a value thereabouts) is exceeded, and wildlife interactions include ingestion of sufficient tailings solution, mortalities are observed.

P24 Para 5: 'Discharging at or near….' may need to express more caution here given the associated risks to wildlife and Code non-compliance.

P25 Para5: Daily monitoring is warranted in order to improve the reliability of estimating the risk of occurrence of 50 mg/L WAD cyanide exceedences. Following a year the situation can be reviewed.

P27 Table 8: Caution may be needed re. the recommendation that monitoring frequency can be reduced if discharge is <50 mg/L WAD CN; even if CN monitoring shows levels <50 mg/L does that mean that there could be spikes >50, if so what are the implications re risk to wildlife?

P27 Training: Environmental staff should be able to recognise threatened species

**APPENDIX 1 of DES Report**:

The reviewers did not have access to all the references quoted and therefore have not been able to check whether they have been quoted accurately in text.

P1.3: The title of the article quoted differs from that listed in references 7 and 8. Also, it is stated that the 'Full article is attached as Appendix A"; this does not appear to be with the documents we received.

P1.8 L4: rapid (not raid)

P1.8: Re the bird in Arizona that was recorded 20km from the nearest known source of CN; more explanation is warranted here as the implications are that possibly birds could fly off and die elsewhere, when it is generally accepted that this is not the case. Could there have been other (e.g. natural) sources of cyanide? Does the report have any more relevant information? See also Page 1.11 Para 4.

P1.8 second last para: noted that access to pools near spigot is often not possible; so it may be advisable to use the precautionary principle and assume spigot discharge concentration is the value they are exposed to until it reaches the supernatant.

P1.12 Para 3: Whether or not birds can distinguish between tailings dams and similar water bodies formed from precipitation probably depends on a number of aspects such as solution colour, presence of food, salinity, presence of other birds etc. Visually there may be little difference between TSF 1A and TSF 2, for example, however some species are soon able to 'work out' the difference and make much greater use of TSF 2.

P1.14 Resemblance to Natural Habitats – in relation to the previous point, the discussion on 'checking for presence of food' is a good summary of how birds probably interact with TSF 1A in relation to searching for food.

P1.18: Foraging techniques section also provides a very good analysis of the need for some species to forage feed and possibly ingest some CN

P1.22 Para 1: Fix last sentence

P1.22 Para 2: The sentence on bacteriophages also does not make sense.

P1.22 Para 2: The sentence 'A variety of variables need to be present for the growth and inoculation of *C botulinum*' needs to be clarified; inoculation does not seem an appropriate term.

P1.24: Re. Aspergillus - this fungus affects lungs and airsacs mainly and rarely the trachea so reference 171 needs to be checked to see if they state trachea specifically.

Reference section: some of the references are 'et al' – they should written in full.

Overall comment: the review is generally fairly good, it could be more NZ specific but does cover key aspects relevant to risk anywhere, inc. NZ. It shows bats could be a problem, and explains feeding strategies well. Clarification is needed re. whether birds can fly off and die elsewhere. Also, is there enough information to show from other studies that birds simply do not make much use of tailings = sterile water bodies?

## APPENDIX 2 of DES Report

Pii: Re the sentence 'However, cyanide-related deaths have been recorded infrequently at NWG, with historical cyanide toxicosis incidents characterised by relatively low numbers of wildlife deaths'; note that Appendix 3 states only one mallard duck had cyanide detected in the liver and in others mortality due to cyanosis was inconclusive. The statement needs to be more precise or refer to some set of figures.

## APPENDIX 3 of DES Report

P4 Para6: The autopsies from NWG have dates and numbers in brackets – it is assumed these refer to the numbers of deaths in each year, but should be clarified. These numbers seem higher than those quoted elsewhere, partly because they cover a longer period; consistency throughout the document and appendices should be checked. Note also systemic amyloidosis not 'amygloidosis'.

## APPENDIX 4 of DES Report

P4.4: Bat detection; should be four hours beginning at sunset rather than sunrise.

P4.16: Refers to Appendix 4A This is not numbered in this document. There is a necropsy report on a hawk where the diagnosis was not made. No report on the second seagull is attached.

APPENDIX C is labeled but there does not appear to be an APPENDIX B, no reference to APPENDIX B was noted.

## APPENDIX 5 of DES Report

P5:1 Para2: The description of procedure needs to emphasise that treatment for sulfides and oxidants was undertaken as separate steps apart from the addition of 0.1% NaOH preservative or that there was no treatment for sulfides and oxidants (because spot tests may have shown no effects were detected).

P5:2 Para 3: The high measured WAD cyanide concentrations at the spigot support the need to continue daily monitoring.

P5:3 Para1: The statement 'A histogram of spigot discharge WAD cyanide values shows that they are normally distributed (Figure 2) with half the values between 60 and 100 mg/L' needs to be verified statistically by testing the data for normal distribution using the Komolgorov-Smirnov Goodness of Fit Test or similar.

P5:5 Table 3: Clarify what the range means in this Table, presumably it is the difference between the lowest and highest concentrations recorded?

P5:11 Table 4: Solid should be 'slurry'.

P5:12 Figures 10 and 11: These figures are incorrectly cited in text. Also, there needs to be a re-assessment of the interpretation of the two graphs by determining the value of P for the particular n= 80 or 60 and n= number of samples to give the number of degrees of freedom. It will then be possible to determine the significance of the value of r (or $r^2$).

The statement in the last paragraph 'There is a very weak relationship between spigot WAD cyanide and copper concentrations ($r^2$=0.12 (Figure 10))' may not be correct as there appears to be a significant correlation between the two variables.

**APPENDIX 6 MEMORANDUM 176 – CYANIDE REVIEW WAIHI GOLD MINE**

Comments on Page 6:

2. Regarding author MA's Comment: 'Suggest Waihi obtains clarification on what suite of metals would satisfy this auditor': The purpose of undertaking ICP-MS scan of trace elements of tailings streams on some regular frequency, e.g. yearly is to identify if any unexpected elements are now present. This step ensures that such additions from changing ore patterns can be detected.

3. Regarding author MA's Comment: 'it is not clear what the reviewer is referring to here and the specific objectives of the analysis. Three solution Cu-CN species are present in equilibrium; IC/HPLC analysis does not resolve them. Cyanide species calculations would appear more appropriate, subject to sampling/assaying QC/QA': Cyanide species estimations are based on calculations. Some practitioners may have difficulty understanding the concepts of thermodynamically-based equilibrium calculations. The measurement of the Cu-CN species by IC/HPCL analysis is able to confirm the existence by an alternative technique that can show the calculated concentrations as real and confirms the correlation between copper and WAD Cyanide concentration.

Comments on Page 9: 'An understanding of cyanide-soluble copper in feed ore types, as well as of mine plan is of critical importance in cyanide TSF management". This needs to be checked.

Comments on Page 10: The plot 'Effect of Cu on WADCN at Spigot - Need comments on the displayed plot' needs to show the values : r, n and the level of P in line with earlier plots given in Appendix 5.

Comments on Page 14: The technique of 'Cyanide species deportment calculations' needs a summary outline and references to the show source of the program.

**‘WILDLIFE CYANIDE RISKS AND COMPLIANCE WITH THE INTERNATIONAL CYANIDE MANAGEMENT CODE: NEWMONT WAIHI GOLD MINE’**
**- a review of the Addendum by Dr. Owen Nichols, Environmental Management and Research Consultants (Lead Reviewer of the main report)**

The Addendum to the report entitled ‘Wildlife cyanide risks and compliance with the International Cyanide Management Code: Newmont Waihi Gold mine’ was prepared to clarify issues raised in the initial review and subsequent Cyanide Code audit process. Specifically, these issues related to the comment noted by the Peer Review Team that ‘a small residual risk remains in the area around the spigot, the tailings stream and the delta’ and subsequent comments made by Norm Greenwald that clarification was needed with regards to the situation regarding protective mechanisms, noting that the study needed to ‘establish a causal relationship between the identified critical parameters and the protection of wildlife, and recommend whatever measures are necessary to maintain the system so that it continues to protect wildlife’. His report also noted that the situation ‘…demands a rationale to explain why no mortality has been observed.’ The Peer Reviewer’s report noted that ‘It would help if the report explained somewhere why tailings streams and spigot pools are considered to be unattractive to wildlife, e.g. no food, colour, what? The literature or experience elsewhere should give some indication’.

The Addendum prepared by Donato Environmental Services (DES) was designed to address these issues. This review summarises my views on whether the Addendum has fulfilled these objectives. It should be noted that my views in this review are intended to complement (but not replace) those stated in the original review prepared by the three Peer Reviewers. They should therefore be read and considered in conjunction with that document.

Specifically, the report focuses on the following characteristics of the potentially toxic flowing tailings streams:

- The high suspended solids content, which affects visibility and palatability;
- The turbulence of the flowing stream, which prevents macroinvertebrates settling on it; and
- The lack of any aquatic macroinvertebrates in the tailings stream.

By analysing these in relation to bird behaviour and morphology, it attempts to establish whether protective mechanisms exist, and if so, describe them in detail with reference to established scientific knowledge and observed monitoring data.

The resulting proposed protective mechanisms are as follows:

- The high content of suspended solids eliminates feeding attempts by sight hunting species. This is undoubtedly correct, it is inconceivable that sight hunting species would attempt to feed under such conditions;
- No terrestrial invertebrates are entrained on the surface due to the turbulence. Flying insects would not settle on such a moving surface so maintaining the

flowing stream would effectively provide a protective mechanism for bird species that usually feed in this manner;

- There is a lack of aquatic and terrestrial macroinvertebrates in the flowing tailings streams. The only recorded feeding attempts have been brief ‘speculative’ filter feeding. The report cites scientific literature which demonstrates that, even under normal conditions, avian filter feeder’s morphological adaptations allow them to ingest prey without ingesting the substrate or liquor. In the case of the Waihi tailings streams, there is no prey, so even the very rare attempts at feeding (which would soon be discontinued due to a lack of success) would not be expected to result in the ingestion of tailings liquor;
- It is correctly concluded that the suspended solids eliminate the tailings liquor as a drinking resource.

Together these explain the extremely low bird utilisation of the habitat, with only two Mallards recorded on the tailings streams out of 20,500 visitation records to TSF 1A. The proportionally lower visitation rate of this habitat (by an order of magnitude) indicates that water birds are preferentially avoiding it, and the protective mechanisms described above for particular bird groups explain why. This establishes a causal relationship between site characteristics and observed wildlife utilisation. Other characteristics of the tailings stream habitat, such as a lack of suitable perching structures, would further decrease the area’s suitability for particular bird species.

It is correctly concluded that the only cases of wildlife interaction with the flowing tailings streams consists of very few attempts at filter feeding, with no observed ill-effects due to the protective mechanisms described. The mode of filter feeding utilised, together with the species’ morphological adaptations and the lack of food resources (which means they very quickly give up trying), render the flowing tailings streams within TSF1A effectively non-toxic.

The protective mechanisms are summarised into four hypotheses, and the report concludes that, on the basis of scientific knowledge and monitoring data, all are supported as protective mechanisms. This conclusion appears to be correct.

The approach used to determine operating parameters, and the resulting recommendations, is based on that used in the main report and appears to be sound.

On the basis of the information presented, I believe that the Addendum’s conclusions and recommendations are correct, and that it has demonstrated a causal relationship between critical parameters (e.g. solids content/turbidity/flow and waterbird utilisation – or, more specifically, the lack thereof). It clearly demonstrates a rationale why no mortalities have occurred. The Addendum therefore meets the requirements outlined in the introductory paragraph of this review.

Grammatical and other corrections are listed on the following page.

**Grammatical and other corrections:**

P6 Para 3: States that cyanide-related deaths have been infrequently recorded at Waihi. I was under the impression from the main report than there have been no definite 'cyanide-related' deaths, although the causes of a few were inconclusive?
P8 Para 1: '…compared to all other habitats..' may be better expressed as '…compared to other habitats in general…' as the same calculations have not been performed for each habitat.
P9 Para 4: Piscivorous means fish-eating not sight hunting
P9 Para6: The Latin name should be in italics
P10 Para1: likewise, use italics
P10 Para 1: 'ocular' should read 'optical'
P10 Para 4: 'This demonstrates that.' should read 'Collectively, these studies demonstrate that for a range of bird species, prey must be present for wildlife feeding activity to occur; also the amount of feeding attempts is determined by prey abundance'.
P11 Para 2: should this read 'Interaction with….is the only *possible* exposure?' (without the italics)
P11 Para 3: use morphological, not physiological.
Same paragraph: Suggest change to 'render the flowing tailings streams *effectively* non-toxic'. They are still toxic however the bird utilisation and morphological adaptations mean that birds do not ingest lethal amounts, if any.
P13 Hypothesis 4 in Findings para: 'and *in* numerous other smaller water bodies…'
The Hills criteria paragraph for this hypothesis needs to be expressed more clearly.