Noise & Vibration Management and Monitoring Plan

Yaoure Gold Project, Côte d'Ivoire




Submitted to

Perseus Yaoure SARL

Submitted By

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REPORT ISSUE FORM

Client Name	**Perseus Yaoure SARL (Amara Mining SARL)**		
Project Name	**Yaoure Gold Project Environmental and Social Impact Assessment**		
Report Title	**Noise & Vibration Management and Monitoring Plan**		
Document Status	**Updated**	Issue No.	**2**
Issue Date	**February 2018**		
Document Reference	**7879140169**	**Report Number**	
Author	**Ian Hepplewhite**		**Signature & Date**
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Project Manager Approval	**Chantelle De La Haye**		27 September 2018

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TERMINOLOGY

Noise

The ratio between the quietest audible sound and the loudest tolerable sound is a million to one in terms of the change in sound pressure. Due to this wide range, a scale based on logarithms is used in noise level measurement. The scale used is the decibel (dB) scale which extends from 0 to 140 decibels (dB) corresponding to the intensity of the sound pressure level.

The ear has the ability to recognise a particular sound depending on the pitch or frequencies found at the source. Microphones cannot differentiate noise in the same way as the ear and to counter this weakness the noise-measuring instrument applies a correction to correspond more closely to the frequency response of the ear. The correction factor is called 'A Weighting' and the resulting measurements are written as dB(A). 'A Weighting' refers to the noise level that represents the human ear's response to sound. The dB(A) unit is internationally accepted and has been found to correspond well with people's subjective reaction to noise. Typical dB(A) noise levels for familiar noises are given in Table 0-1, below.

Table 0-1 Typical Noise Levels

Sound Pressure Level, L_p (dB re 20µPa)		Example	
1.0	0	2.0	Threshold of hearing for normal young people
3.0	20	4.0	Recording studio, ambient level
5.0	40	6.0	Quiet residential neighbourhood, ambient level
7.0	60	8.0	Department store, restaurant , speech levels
9.0	80	10.0	Next to busy highway, shouting
11.0	100	12.0	Textile mill; press room with presses running; punch press and wood planers, at operator's position
13.0	120	14.0	Ship's engine room; rock concert; in front and close to speakers
15.0	140	16.0	Moon launch at 100m; artillery fire, gunner's position

Source: Engineering Noise Control – Theory and Practice, Third Edition, Bies and Hanson, 2003

The noise levels given in Table 0-1 are sound pressure levels (L_p) and describe the noise level at a point in space. Sound power levels (L_w) are used to describe the noise output of a noise source. Noise levels vary over time depending on noise generating activities. The definitions in Table 0-2, are commonly used within noise assessments:

Table 0-2 Typical Noise Terminology

Term/abbreviation	Description
Sound pressure level (L_p)	Describes the noise level at a point in space
Sound power level (L_w)	Used to describe the total noise energy output of a noise source
$L_{Aeq, T}$	Is the equivalent continuous sound level and is the sound level of a steady sound having the same energy as a fluctuating sound over the same period (T). It is possible to consider this level as the ambient noise encompassing all noise at a given time. L_{Aeq} is considered the best general purpose index for environmental noise.
$L_{Aeq, 1hr}$	A measure 'daytime' noise which may apply over any assessment base i.e. a specific date, week or year. $L_{Aeq, 1hr}$ is referenced by the IFC EHS Noise Guidelines and is defined between 07:00-22:00. $L_{Aeq, 1hr}$ is also a measure 'night' noise which may apply over any assessment base i.e. a specific date, week or year. $L_{Aeq, 9hr}$ is referenced by the IFC EHS Noise Guidelines and is defined between 22:00-07:00.
$L_{A90, T}$	Represents the noise level exceeded for 90 % of the measurement period (T) and is used to indicate quieter times during the measurement period. It is usually referred to as the background noise level.
$L_{A10, T}$	Refers to the level exceeded for 10% of the measurement period (T). $L_{A10,T}$ is widely used as a descriptor of traffic noise.
$L_{Amax, T}$	Is maximum recorded noise level during the measurement period (T).
Fast Time Weighting	A sound pressure level measurement using a 125msec moving average time weighting period is said to have been determined using 'fast weighting'
Specific noise source	The noise source under investigation (usually for assessing the like hood of complaints)
Reference time interval, T_r	The specified interval over which an equivalent continuous 'A weighted' sound pressure level is determined.
Specific noise level, $L_{Aeq,T}$	The equivalent continuous 'A weighted' sound pressure level at the assessment position produced by the specific noise source over a given reference time interval (T).
Measurement time interval, eg T_m	The total time over which measurements are taken, eg T minutes.
Rating level, $L_{Ar,Tr}$	The specific noise level plus any adjustment for the characteristic features of the noise.
Ambient noise	Totally encompassing sound in a given situation at a given time usually composed of sound from many sources near and far.
Residual noise	The ambient noise remaining at a given position in a given situation when the specific noise source is suppressed to a degree such that it does not contribute to the ambient noise.
Residual noise level, $L_{Aeq,T}$	The equivalent continuous 'A weighted' sound pressure level of the residual noise.
BNL	The basic noise level at a reference distance of 10m away from the nearside carriageway edge is obtained from the traffic flow, the speed of the traffic, the composition of the traffic, the gradient of the road and the road surface.

Free field	An environment in which there are no reflective surface within the frequency region of interest.
Façade	Addition of 3dB (A) façade correction where measurement is conducted 1m away from exiting façades.

Ground Vibration

Vibration can be generated within the ground by a dynamic source of sufficient energy, eg a blast. It will be composed of various wave types of differing characteristics and significance collectively known as seismic waves. These seismic waves will spread radially from the vibration source decaying rapidly as distance increases.

There are four interrelated parameters that may be used in order to define ground vibration magnitude at any location. These are:

- ***Displacement****:* the distance that a particle moves before returning to its original position, measured in millimetres (mm);
- ***Velocity****:* the rate at which particle displacement changes, measured in millimetres per second (mms^{-1});
- ***Acceleration****:* the rate at which the particle velocity changes, measured in metres per second squared (ms^{-2}) or in terms of the acceleration due to the earth's gravity (g);
- ***Frequency****:* the number of oscillations per second that a particle undergoes measured in Hertz (Hz).

It is the maximum value of particle velocity in a vibration event, termed the ***"peak particle velocity (PPV)"***, that is of most significance and this will usually be measured in three independent, mutually perpendicular directions at any one location in order to ensure that the true peak value is captured. These directions are **longitudinal** (or **radial**), **vertical** and **transverse**.

The **PPV** of any one plane measurement is the accepted standard worldwide and as recommended by the British Standards Institution and the International Standards Institute, amongst others. It is also the basis for all the recognised investigations into satisfactory vibration levels with respect to damage of structures and human perception.

Airborne Vibration

Whenever an explosive is detonated, transient airborne pressure waves are generated. As these waves pass a given position, the pressure of the air rises very rapidly to a value above the atmospheric or ambient pressure. It then falls more slowly to a value below atmospheric pressure before returning to the ambient value after a series of oscillations. The maximum pressure above atmospheric is known as the ***"peak air overpressure"***.

These pressure waves comprise energy over a wide frequency range. Energy above 20 Hz is perceptible to the human ear as sound, whilst that below 20 Hz is inaudible, although it can be sensed in the form of concussion. The sound and concussion together is known as ***"air overpressure"*** which is measured in terms of decibels (dB) or pounds per square inch (psi) over the required frequency range.

The decibel scale expresses the logarithm of the ratio of a level (greater or less) relative to a given base value. In acoustics, this reference value is taken as 20 x 10^{-6} Pascals, which is accepted as the threshold of human hearing.

Air overpressure (AOP) is therefore defined as:

$$\text{AOP, dB} = 20 \text{ Log } \frac{\text{Measured pressure}}{\text{Reference pressure}}$$

Since both high and low frequencies are of importance - no frequency weighting network is applied, unlike in the case of noise measurement when an A - weighted filter is employed.

In a blast, airborne pressure waves are produced from five main sources:

- Rock displacement from the face;
- Ground induced airborne vibration;
- Release of gases through natural fissures;
- Release of gases through stemming;
- Insufficiently confined explosive charges.

Meteorological factors over which an operator has no control can influence the intensity of air overpressure levels at any given location. Thus, wind speed and direction, temperature and humidity at various altitudes can have an effect upon the propagation of air overpressure.

Other Terminology

The following terminology is also relevant to the blasting and vibration assessment:

- **Burden** is the distance, measured at right angles between a row of holes and the free face or adjoining rows of holes and
- **Spacing** is the distance between the centres of holes drilled in a row.

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17.0 INTRODUCTION

17.1 Purpose of this Report

This document has been produced for the purpose of supporting Perseus Yaoure SARL's(Perseus) proposal to develop the Yaoure Gold Project (the Project) in Cote d'Ivoire and constitutes a Noise and Vibration Management and Monitoring Plan (NVMMP) which makes up an Appendix of the Environmental/Social Impact Assessment (ESIA) for the site and is part of Perseus's Environmental/Social Management System. The NVMMP has been developed following a full assessment of noise and blasting vibration effects presented within the Noise and Vibration section of the ESIA Report submitted for the development of the Project.

The NVMMP details the noise and blasting vibration mitigation measures which have been included as part of the scheme and methods of ensuring their effective implementation. The particulars of the locations, frequency and methodology of routine noise and blast vibration monitoring to be undertaken throughout the life of the project, along with the relevant noise and blasting vibration emission limits, are presented. Actions to be undertaken in the event of an exceedance of the relevant noise limits or on receipt of any complaints are also specified.

18.0 NOISE & VIBRATION CONTROL MEASURES

18.1 Phases of Development

For the purposes of this NVMMP, the phases to which this Plan refers shall include the following activities:

- Construction Phase;
- Operational Phase; and
- Closure Phase.

18.2 Summary of Measures Included in the Scheme

Wherever possible, the main mitigation measures that will be implemented as part of the scheme are summarised below:

18.2.1 Plant Complement

- The plant complement will consist of modern machinery fitted with efficient silencers designed to minimise noise levels that are generated during operations;
- Plant will not be operated with covers open or removed, to ensure effective acoustic insulation is provided at all times;
- The plant will also be properly maintained in accordance with the manufacturers' instructions to ensure that the occurrence of malfunctions that can give rise to elevated noise levels is reduced, and any malfunctions that do occur are swiftly repaired;
- 'Smart', warbling or broadband reversing alarms will also be fitted to any mobile plant to reduce the intrusive nature of such sources, (particularly during the construction and closure phase(s) of the project);
- Avoid unnecessary revving of any engines, particularly during the construction and closure phase(s), and any equipment should be switched off when not in use;
- Keep any internal roads (particularly during the construction and closure phase(s)) well maintained and clean, avoiding steep gradients wherever possible;
- All plant to be operated, wherever possible, to meet the requirements of the IFC EHS Environmental Noise Guidelines. In addition, workers on the site will have to comply with the required IFC EHS personal noise dose levels, ensuring that an element of noise mitigation will have to be "designed in" initially;
- Minimise the drop heights of materials wherever practicable particularly during any waste/ore excavation and loading of material into dumptrucks and from wheeled loading shovels in the stockpiling area;
- The effectiveness of acoustic insulation and silencers fitted to plant will be qualitatively assessed and recorded. Any items of plant with defective insulation or silencers will be identified for immediate investigation and remediation;

- Pumps and other processing plant used on site will be powered by electricity wherever practicable, and all pumps, and generators will be placed at locations to minimise noise emissions to sensitive receptors. The Emergency Generators providing temporary power for the site are located in the Processing Plant area at a considerable distance from the nearest noise sensitive properties.

18.2.2 Bunds and Mounds

- Adoption of a sequential approach to construction of Waste Rock Dumps (WRDs), involving the construction of an outer face, behind which further tipping/loading would take place. This is particularly important for the construction of WRDs at night for local community receptors;

- In addition, it is recommended that if night-time tipping activities are required then regular noise monitoring is undertaken to determine compliance with the respective CIAPOL criteria (Anti-Pollution Centre of Cote d'Ivoire – CIAPOL).

18.2.3 Working Hours

Construction and Closure Phases

- Working hours for the construction, decommissioning and closure phases will generally be 24 hours per day, 7 days a week with the agreement of the appropriate Overseeing Body;

- Where possible, noisier construction activities will be limited to day shift, without the agreement of the appropriate Overseeing Body; and

- There will be adequate planning in place to ensure that lengthy construction operations, eg significant concrete pours, can be completed within the agreed working hours.

Operational Phase

- Working hours for the operational phase will generally be 24 hours per day, 7 days a week with the agreement of the appropriate Overseeing Body; and

- Blasting will be restricted to the hours of daylight only, for Health & Safety purposes.

18.2.4 Site Layout

- Consideration has been given to the mitigation of potential noise effects in the proposed site layout and phasing during the main phases of site construction and operation, for example the main processing plant area has been located to, wherever possible, maximise the stand-off distance to receptors and the attenuation provided by any intervening topography;
- All construction/operational activities close to the site boundary will be undertaken as quickly and efficiently as possible;
- Ensuring that the direction of working for extraction is such that plant operates behind a working face as much as possible to enhance the available barrier attenuation to sensitive receptors;
- If deemed necessary, the use of temporary noise barriers around particularly noisy plant and equipment (with any cooling requirements given careful consideration);
- Any internal roads will be regularly graded/swept to remove loose material and a site speed limit imposed; and
- All reasonable steps will be taken to limit the amount of construction delivery vehicles queuing or waiting to deliver to the site.

18.2.5 Site Management

- Regular monitoring of noise and blasting vibration levels at selected sensitive receptors, with additional monitoring undertaken during particular activities considered likely to generate elevated noise or vibration levels; and
- Appointment of a site contact to whom complaints/queries about operational activities can be directed. Any complaints to be investigated and action taken where appropriate.

18.2.6 Blasting Operations

A reduction in the potential operational blasting vibration impact may be achieved by the following good practice measures (eg taken from the Operator's Good Practice Guide outlined in the UK's Department of Environment Transport and Regions (DETR) report The Environmental Effects of Production Blasting from Surface Mineral Workings):

- Make accurate surveys and records of blast holes (and as per Appendix B of the IFC World Bank Industry Specific Guidance – Mining), if necessary the blast design should be revised in the light of the survey data;

- Ensure correct blast design including correct relationship between burden, spacing and hole diameter;
- Ensure accurate drilling, keeping subdrill to the minimum required (and as per the IFC World Bank Industry Specific Guidance – Mining).
- Maximise use of free faces including by careful planning of delay sequences;
- Optimise maximum instantaneous charge weight by:
    - Reducing number of holes;
    - Reducing instantaneous charge by decking charges;
    - Reducing bench height or hole depth;
    - Reducing borehole diameter.
- Optimise blast ratio in any changes to design;
- Where practicable ensuring direction of detonation away from sensitive areas;
- Wherever possible use of unconfined charges will be avoided particularly where fissures or broken ground or weaken of rock from previous blasting is known to be present;
- Wherever possible the use of surface lines of detonating cord will be avoided. All surface detonators and explosives will be adequately covered with suitable material;
- Stemming material will be of sufficient quality and quantity to confine adequately all explosives upon detonation. A coarse stemming material such as angular chippings will be produced on site. Drill fines will not be used;
- Bottom initiation will be considered in preference to top initiation (and as per the IFC World Bank Industry Specific Guidance – Mining);
- Misfire procedures will have due regard to under-burdened charges;
- If air overpressure is found to be a potential problem consideration will be given to reducing blast panel area.
- Blasting will be undertaken at regular times; and

- Ground and airborne vibration levels will be monitored regularly so that information may be employed into any necessary modifications of future blast designs.

In addition, as per the IFC World Bank Industry Specific Guidance – Mining document, the following management practices will be implemented at Yaoure where possible:

- Mechanical ripping should be used, wherever possible, to avoid or minimize the use of explosives;
- Use of specific blasting plans, correct charging procedures and blasting ratios, delayed/micro delayed or electronic detonators, and specific in-situ blasting tests (the use of downhole initiation with short-delay detonators improves fragmentation and reduces ground vibrations);
- Development of blast design, including a blasting-surfaces survey, to avoid over confined charges, and a drill-hole survey to check for deviation and consequent blasting recalculations;
- Implementation of ground vibration and overpressure control with appropriate drilling grids;
- Adequately designing the foundations of primary crushers and other significant sources of vibrations.
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19.0 NOISE MONITORING

19.1 Noise Limits

19.1.1 Construction, Decommissioning and Closure Phases

As far as Amec Foster Wheeler is aware there is no specific construction noise guidance within Ivorian Law. However, in the UK, BS5228-1:2009+A1:2014 *'Code of practice for noise and vibration control on construction and open sites'*, is used as the basis for construction noise assessments. *'Method 1 – The ABC method'* of Annex E (informative) of this British Standard presents an example of the determination of significance due to construction noise by considering the change in ambient noise levels up to a stated threshold level. The appropriate threshold levels to be used are based upon the existing measured ambient noise levels (rounded to the nearest 5dB) and the period during which construction is to take place (as shown in

Table **19-1** below). Based on the baseline monitoring undertaken in February 2015 the construction noise levels appropriate to the Yaoure Gold Project may be those within Category A in Table 19-1 below.

Table 19-1 Example Threshold of Significant Effect at Dwellings from Annex E of BS5228:2009+A1:2014

20.0 Assessment category and threshold value period	**21.0 Threshold Value, dB $L_{Aeq, T}$**		
	Category A A)	**Category B B)**	**Category C C)**
Night-time (2300-0700)	45	50	55
Evenings and weekends D)	55	60	65
Daytime (0700-1900) and Saturdays (0700-1300)	65	70	75

A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values

B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.

C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.

D) 1900-2300hrs weekdays, 1300-2300 Saturday and 0700-2300 Sundays.

Note 1. A potential significant effect is indicated if the $L_{Aeq, T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level

Note 2. If the ambient noise level exceeds the category C threshold values given in the table (ie the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq, T}$ noise level for the period increases by more than 3dB due to site noise

Note 3. Applied to residential receptors only

The noise assessment has assumed that construction of the development will be undertaken 24 hour per day, 7 days per week.

21.1.1 Operational Phase

Noise standards are set out in CIAPOL Decree No. 01164 of 4th November 2008. The area around the Yaoure Project can be described as encompassing either "residential or rural areas with low road traffic, traffic on waterways or air traffic" (e.g., Allahou Port – the fishing hamlet); "urban residential areas" (e.g., Akakro, Kouakougnanou and Kossou) and "urban residential areas, with some workshops or business use, or with certain degree of road/waterway/air traffic, and in the rural communities" (eg Allahou-Bazi and Angovia). Therefore the guidance in Table 19-2 below would apply, namely:

Table 19-2 Noise criteria from CIAPOL Decree No. 01164 (2008)

Zones	Time		
	Day (0700-1800hrs)	Intermediate period (1800 – 2200 hrs)	Night (2200 – 0700 hrs)
Hospital areas, recreational areas, areas of natural protection	40	35	30
Residential or rural areas with low road traffic, traffic on waterways or air traffic	45	40	35
Urban residential areas	50	45	40
Urban residential areas, with some workshops or business use, or with certain degree of road/waterway/air traffic, and in the rural communities	60	55	45
Areas with predominantly of commercial/industrial activities	70	65	50
Area with predominantly industrial use	75	70	60

In addition, the guidance contained within the Environmental Health and Safety (EHS) Guidelines published by the IFC (April 2007), which are technical reference documents with general and industry specific examples of international good practice, are also pertinent to this study. Reference to these guidelines forms part of the IFC's environmental and social review procedure and is compulsory for IFC clients. The EHS Guidelines are therefore considered to provide a useful resource which details the performance levels and environmental management measures which are considered achievable by existing technology and at reasonable costs.

The general EHS guidelines set out Noise Level Guidelines as detailed in

Table 19-3 below, which are based on the WHO Guidelines for Community Noise. In general, noise levels should not exceed these values, or result in a maximum increase in background levels of 3dB at the nearest receptor location. The guidelines also allow for an alternative approach, stating that where appropriate baseline data exists, describing the existing noise levels in the area, noise level limits can be represented by the baseline background or ambient noise levels.

The EHS guidelines also present examples of noise reduction options that should be considered where noise levels exceed these guideline values, along with recommendations for noise monitoring to be carried out either to establish existing ambient noise levels or to verify operational noise levels.

Table 19-3 IFC Noise Level Guidelines (dB)

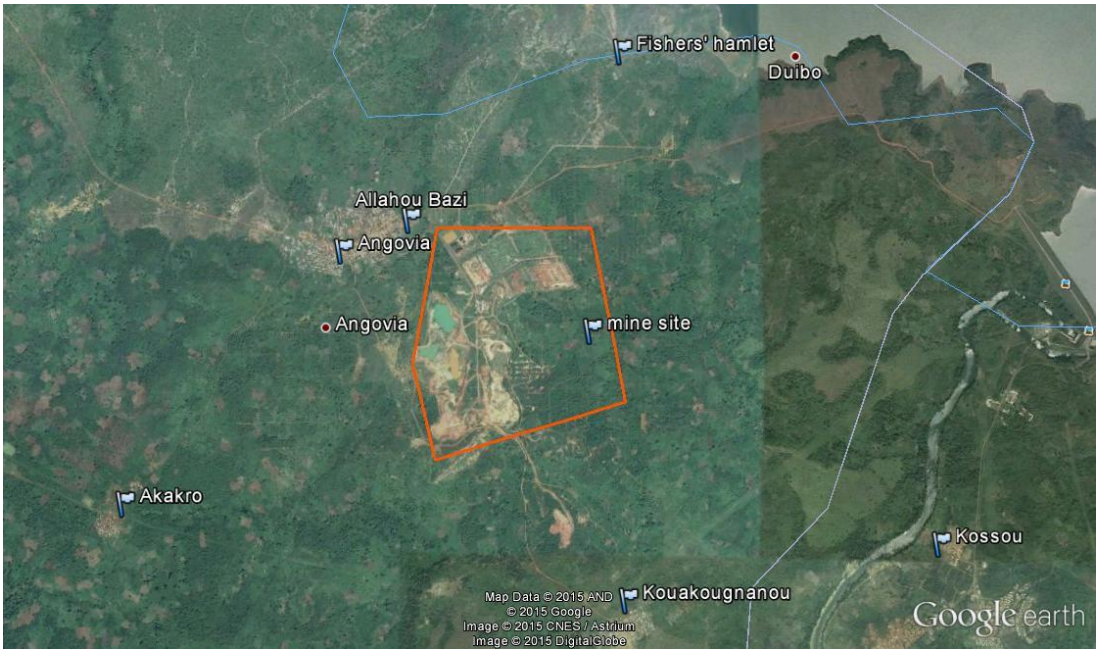
Receptor	Daytime 07:00-22:00 hrs ($L_{Aeq\ 1hr}$)	Night-time 22:00-07:00 hrs ($L_{Aeq\ 1hr}$)
Residential; institutional; educational.	55	45
Industrial; commercial	70	70

21.2 Noise Monitoring Locations

A number of legitimate settlements have been identified in the area surrounding the Yaoure Gold Project site and the following have been chosen as receptors:

- **Southern fringe of Allahou-Bazi** – Easting 220356, Northing 778347;
- **Southern fringe of Angovia** – Easting 219749, Northing 777964;
- **North eastern fringe of Akakro** – Easting 217897, Northing 775974;
- **Westeren fringe of Allahou Port (Fishing Hamlet)** - Easting 222395, Northing 779838;
- **Northern fringe of Kouakougnanou** - Easting 222612, Northing 774799; and
- **Northern fringe of Kossou** - Easting 225517, Northing 775434.

Figure 19-1 Yaoure Gold Mining Project – Noise Sensitive Receptor Locations



Noise monitoring will be undertaken at the above locations. Table 19-4 below summarises the receptors and the corresponding construction and operational noise limits applicable to each.

Table 19-4 Noise Limits for Yaoure Gold Mining Project dB $L_{Aeq, 1hr}$

Receptor	Construction, Decommissioning and Closure Noise Limits (BS5228-1:2009+A1:2014)			Operational Noise Limits (CIAPOL Decree No. 01164)		
	Daytime (0700-1900) and Saturdays (0700-1300)	Evenings and weekends (19:00 – 23:00)	Night-time (2300-0700)	Daytime (07:00-18:00)	Evenings and weekends (18:00 – 22:00)	Night-time (22:00-07:00)
Allahou-Bazi	65	55	45	60	55	45
Angovia	65	55	45	60	55	45
Akakro	65	55	45	50	45	40
Allahou Port (Fishing Hamlet)	65	55	45	45	40	35
Kouakougnanou	65	55	45	50	45	40
Kossou	65	55	45	50	45	40

Monitoring will be undertaken at locations representative of the noise levels near the façade of the identified property exposed to the highest development related noise.

21.3 Noise Measurement Instrumentation

Ambient noise levels will be measured using an integrating-averaging sound level meter (SLM) or equivalent system conforming to Class 1 as defined by BS EN 61672:Part1:2013 *'Electroacoustics, Sound Level Meters, Specifications'* or the latest update (which contains cross references to various International Electrotechnical Commission (IEC) publications).

The SLM will be field calibrated before and at the end of each survey by applying an acoustic calibrator or pistonphone conforming to the latest versions of BS EN 60942:2003 *'Electroacoustics - Sound Calibrators'* (which also contains cross references to various IEC publications) to the microphone to check the sensitivity of the measuring equipment. Any drift in calibration levels will be noted.

The equipment used for the noise monitoring will also have undergone more extensive independent laboratory tests of the performance of the system within any 2 year period.

Measurements of meteorological parameters (including wind speed and direction) will be made by an on-site meteorological station.

21.4 Noise Survey Specification

Noise monitoring during site operations will be the responsibility of Perseus staff or their appointed representatives. Noise measurements will only be undertaken by suitably experienced personnel. .

Noise measurements will be undertaken during the normal working day/evening /night-time period. Periods will be chosen to avoid meal breaks and times when plant and equipment on site is not operating.

The microphone height will be between 1.2 m and 1.5 m above ground level. To minimise the influence of reflections the microphone position will be at least 3.5 m from any reflecting surface other than the ground. In the event of measurements having to be made within 3.5 m of reflecting facades, a correction of 3 dB will be made to all results to convert them to free-field levels.

To minimise the influence on the noise readings from extraneous sources of physical interference, the following will be adopted:

- Providing a suitable foam windshield is fitted to the microphone, measurements would only be undertaken when wind speeds were below 5 ms^{-1};
- No measurements will be undertaken during periods of heavy precipitation; and
- No measurements will be undertaken immediately adjacent to sources of electrical interference such as overhead power cables or radio transmitters.

At each location, noise will be measured in sample periods of not less than 15 minutes during the following periods.

21.4.1 Construction and Closure Phases

For these phases the following definitions will apply:

- Daytime (07:00-19:00 hours weekdays and 07:00 – 13:00 hours Saturdays);
- Evening & weekends (19:00-23:00 hours weekdays, 1300-2300 hours Saturday and 0700-2300 hours Sundays); and
- Night-time (23:00 – 07:00 hours).

21.4.2 Operational Phase

For this phase the following definitions will apply:

- Daytime (07:00-18:00 hours);
- Evening (intermediate period) (18:00 – 22:00 hours); and
- Night-time (22:00-07:00 hours).

Sufficient periods will be accumulated to determine the site attributable $L_{Aeq,\ 1h}$ at each location during the day, evening or night, whichever is applicable. Whilst the main noise parameter will be the equivalent continuous sound level, or $L_{Aeq\ T}$, other additional noise parameters will also be simultaneously measured in order to more accurately define the noise climate. These will include $L_{A90,\ T}$, $L_{A10,\ T}$ and L_{Amax}.

Wherever possible, noise measurements will be made during calm conditions (average wind speeds of less than 5 ms^{-1}) or at locations with a positive wind component from the site operations. However, due to the vagaries of the Ivorian climate the latter may not always be possible.

Notwithstanding the above, as part of the monitoring schedule a note of the prevailing weather conditions during the monitoring period will be made. This will include details such as wind speed, wind direction, estimate of cloud cover, presence of precipitation or fog and details of any other factors such as conditions likely to lead to a temperature inversion. These observations will be corroborated by data from any on-site meteorological station.

A note of the type of instrumentation used for the surveys will be made including serial number and any calibration details. Observations will be made regarding the audibility of the site and what items of plant were operating during the period of the surveys. A detailed log of any extraneous events affecting noise levels will be made. Any use of the pause feature to limit the influence of extraneous noise events on the measurement will be recorded.

21.4.3 Frequency of Measurement

Noise monitoring will be undertaken as a minimum for the following:

- For normal construction and closure operations - once a week for daytime, evening and night-time operations;
- For normal operational operations - once a week for daytime, evening and night-time operations;
- During construction of the outer edges of the Waste Rock Dump/s (WRDs) at closest approach to receptors, and particularly to the southern fringes of Allahou-Bazi and Angovia; south western fringes of Allahou Port (Fishing Hamlet) and the northern fringes of Kouakougnanou;
- If a routine survey indicates non-compliance, an additional survey will be undertaken after appropriate investigation/ mitigation to confirm compliance;
- In response to a complaint, if the complaint has not been fully resolved by the initial visit by Perseus staff.

The frequency and/or duration of noise measurement may be amended once sufficient data has been gathered to indicate that operations comply with the relevant noise criteria. This will be agreed in writing with the appropriate Ivorian Authority, eg CIAPOL.

21.5 Noise Limit Exceedance Reaction Process

In the event that any noise limit at the selected locations is breached, a number of actions will be required to be undertaken in order to identify the cause of the exceedance (including the possibility that it may not be due to site attributable noise), and control noise emissions from that source if appropriate.

The proposed noise limits for noise from normal site operations are either close to or, in a lot of cases, less than existing ambient noise levels in the area. It is therefore likely that the routine monitoring will show that ambient noise levels (i.e. encompassing noise from all sources) at the monitoring locations may exceed the noise limits on some occasions, although this may not necessarily be due to any breach of the relevant noise limit by site operations.

21.6 Complaint Handling Process

All noise related complaints will be directed to a designated person at the Yaoure Gold Project. When making a complaint, the complainant will be asked to provide the following details:

- Complainant's name and address and where the noise is causing concern;
- Description of the noise e.g. impulsive, tonal, broadband, continuous, intermittent;
- Identification of possible source of noise e.g. dumptrucks on Waste Rock Dump (WRD) exposed edges, generators in Processing Plant area, etc;
- Time of day the noise occurs and duration of occurrence.

A visit to the complaint's home will be made either within 48 hrs of the complaint being received by Perseus staff or at another time agreed with the complainant. This initial visit will be undertaken with the aim of enabling Perseus's responsible person to hear the noise source causing concern, and to provide the opportunity to discuss the complaint.

If the complaint cannot be successfully resolved during this visit, an additional monitoring visit will be carried out at the earliest practicable opportunity. If the monitoring reveals an exceedance of the relevant noise limit, the noisy activity may be suspended, dependent upon the activity, until such time as investigations have been completed. The complainant should be kept fully informed of the results of the monitoring visit and any subsequent assessment and mitigation.

22.0 BLAST VIBRATION MONITORING

22.1 Vibration Limits

22.1.1 Construction and Closure Phases

There is no blasting during these phases and therefore no limits are required.

22.1.2 Operational Phase

As far as Amec Foster Wheeler is aware, there is no specific Cote d'Ivoire blasting vibration criteria available to use for the purposes of this NVMMP.

The International Finance Corporation of the World Bank Group have published Environmental Health and Safety (EHS) Guidelines (April 2007) which do not stipulate any environmental vibration criteria The industry specific EHS guidelines for mining recommend that vibration management strategies should be employed to ensure that the vibration generated from blasting operations is minimised at all times.

With respect to blasting, and as described in the Vibration Impact Assessment of the ESIA, it is considered that exceedance of a PPV of 6 mms^{-1} for 95% of all blasts in any six month period (with a maximum level of 12 mms^{-1}) at any of the residential properties located in the vicinity of Yaoure Gold Mine Project will normally be considered to represent potential significant vibration effects. As for the potential effects on major services (e.g., power lines, roads, water/gas mains), which are less sensitive to vibration, significant effects would only occur if a level of 50 mms^{-1} at a 99.9% confidence were to be exceeded.

22.2 Vibration Monitoring Locations

The same number of legitimate settlements identified in the noise section above, will be used for the blasting vibration monitoring (see Section 21.2). Table 22-1 below summarises the receptors and the corresponding blasting vibration limits applicable to each.

Table 22-1 Blast Vibration Limits for Yaoure Gold Mining Project - Peak Particle Velocity (PPV in mms-1)

Receptor	Operational Blasting Vibration Limits PPV	
	Residential Receptors (mms^{-1} at 95% confidence level)	Infrastructure Receptors (mms^{-1} at 99.9% confidence level)
Residential Receptors		
In the vicinity of Allahou-Bazi	6	N/A
In the vicinity of Angovia	6	N/A
In the vicinity of Akakro	6	N/A
In the vicinity of Allahou Port (fishing hamlet)	6	N/A
In the vicinity of Kouakougnanou	6	N/A
In the vicinity of Kossou	6	N/A
Infrastructure Receptors		
New Road (Option D)	N/A	50
Existing road (to North) into Processing Plant Area	N/A	50
Existing road (to east) into Processing Plant Area	N/A	50

Monitoring will be undertaken at the closest representative locations for each receptor group.

22.3 Vibration Measurement Instrumentation

Ground vibration levels will be measured using industry standard seismographs conforming to the requirements of the International Society of Explosives Engineers (ISEE) *'Performance Specification for Blasting Seismographs'* as a minimum. The equipment used for the vibration monitoring will also have undergone calibration tests of the performance of the system within a period of 12 months prior to use.

Measurements of meteorological parameters (including wind speed and direction) at the time of the monitoring surveys will be made by the on-site meteorological station.

22.4 Vibration Survey Specification

Vibration measurements will only be undertaken by suitably experienced personnel. Vibration measurements will be undertaken for EVERY production blast undertaken on the Yaoure Project. Vibration measurements will be undertaken outside the nearest residential property to the blast panel identified in Table 22-1 above. The accelerometer (geophone) block[1] will be located on a hard, stable surface. Where hard surfaces are not available the accelerometer (geophone) block will be either buried or the spikes (if available) may be used. The information within Section A of the International Society of Explosives Engineers (ISEE) document entitled *'Field Practice Guidelines for Blasting Seismographs 2009 Edition'* also gives useful guidance on the placement of accelerometer blocks.

Vibration measurements will be made, in the three mutually perpendicular axes, for each blast event. The seismograph trigger level will be set to a low enough threshold to enable data to be collected. This is typically 0.5 mms^{-1}, but could be lower depending upon the environs of the monitoring location. The following vibration parameters will be recorded as a minimum:

- Longitudinal, Vertical, & Transverse Peak Particle Velocity (PPV) in mms^{-1};
- Frequency (Hz) of occurrence of these individual PPVs;
- Resultant Peak Particle Velocity (PPV) in mms^{-1};
- Air Overpressure in dB.

Additional parameters such as acceleration (in ms^{-1}) and displacement (in mm) may also be automatically measured and recorded by the seismograph. To minimise the influence on the readings from extraneous sources of physical interference, no measurements will be undertaken immediately adjacent to sources of electrical interference such as overhead power cables or radio transmitters.

As part of the monitoring schedule a note of the prevailing weather conditions during the measurement period will be made that may influence the propagation of say air overpressure, for example any visible signs of temperature inversion. A note of the type of instrumentation used for the surveys will be made including serial number and any calibration details. Observations will be made regarding the perceptibility of the blast.

[1] Weighted block containing three accelerometers (geophones) (device for measuring vibration magnitudes) orientated in the three orthogonal planes, longitudinal, transverse and vertical. Block may be equipped with ground spikes for ease of mounting in the field.

22.5 Frequency of Measurement

Prior to production blasting commencing on site, a test blast will be fired which will be monitored with at least 6-8 No. seismographs, set at varying distances from the blast panel with the aim of collecting enough data to generate a specific regression line for Yaoure Project. This regression line will then be used for the design of future blasts.

22.6 Vibration Limit Exceedance Reaction Process

The day to day control of operations on site, and therefore vibration magnitudes, will be the responsibility of a single individual with suitable qualifications, experience, training and ability. This individual will have the appropriate authority to control blasting operations and, if necessary, to affect immediate remedial measures at any time to ameliorate potential vibration nuisance.

Procedures may be specified if recorded values exceed an agreed level. Typically these procedures will involve notification of the appropriate Ivorian Authority, of the event together with an assessment of its implication with respect to future blasting activity and the site's vibration limit.

If non-compliance with the guideline limits is identified as a consequence of the vibration monitoring programme, or through any other reason, the reasons for such non-compliance will be immediately investigated by the mineral operator under procedures detailed in the environmental management system for the site. Such an investigation may involve:

- Identification and cessation of activity(ies) causing breach;
- Investigate remediation methods, for example:
    - Maximise use of free faces by means including appropriate delay sequences;
    - Use of the optimum maximum instantaneous charge weight by:
        - Reducing number of holes;
        - Reducing instantaneous charge by decking charges;
        - Reducing bench height or hole depth;
        - Reducing borehole diameter.
    - Optimisation of the blast ratio in any changes to design;

Any deviation from agreed working practices will be identified and the situation remedied, as far as is reasonably practical.

22.7 Complaint Handling Process

A complaint response system will be maintained on site. Such a system will enable any complaints, including those regarding vibration, to be reported and appropriate action to be taken on site. The scheme of recording information about each blast, similar to that outlined in previous sections regarding noise, allows for easy investigation of any complaint.

23.0 REPORTING, RECORDING, COMMINCATION & REPORTING

23.1 Recording and Reporting

On completion of each noise and blast vibration survey, the monitoring database will be updated by Perseus (or their appointed representative) which will be available upon request. A summary report will be prepared and submitted to the appropriate Ivorian Authorities as required by law.

Results from noise and vibration monitoring will be kept at the site office and made available for inspection by the appropriate Ivorian Authority, at all reasonable times with copies being supplied to the Authority upon request. These reports will be kept by the operating company for the life of the project and will contain as a minimum the following information:

- The results of all noise and blast vibration measurements;
- Details of the instrumentation used including calibration details;
- Details of any corrections made to the noise measurements;
- The type and frequency of any events excluded from the measurements;
- Details of the site activities occurring during the noise surveys;
- Details of extraneous noise events affecting the results;
- Details of the meteorological conditions prevailing during the surveys;
- A statement as to the audibility of the site at each noise monitoring location, where measured noise levels are considered to be dominated by sources other than the site this would be clearly stated;
- Blast details (number holes, diameter of holes, MICs, burden & spacings, etc.);

- Results of monitoring including, PPVs and associated frequencies, resultant PPV and AOP.
- A comparison of the measured noise and vibration levels against the agreed guideline limits;
- Methodology and results of any calculations or modelling of site attributable noise;
- Details of any additional mitigation measures employed in response to a noise or vibration limit exceedance, and a measure of their effectiveness; and
- Details of any noise or vibration related complaints received and actions undertaken in response.

23.2 Communication

Staff will be kept informed of the environmental policy and environmental issues relevant to the Yaoure Project scheme through a range of means, including a combination of meetings and different media such as posters, notice-boards, team briefs etc. With respect to noise and blasting vibration, these communications will focus on the good practice measures detailed in Section 18.0.

With respect to communications with external bodies, as stated above, a noise and blast vibration monitoring summary report will be prepared and submitted to the appropriate Ivorian Authority as required by law. However, recognising that noise and blasting vibration are likely to be issues in which the local community will take an active interest, the summary report will also be made widely available via the local Liaison Committee.

It is recognised that the periods of temporary operations (which attract a higher noise limit than that for normal operations) are likely to be of most concern to local residents. Perseus Yaoure SARL propose to inform local residents, via the site liaison committee and the appropriate Ivorian Authority, of the timing and likely duration of planned temporary operations at least 48 hours in advance. If the required notice period is unable to be given, due to an operational need to respond to unforeseen circumstances, Perseus will inform the appropriate Ivorian Authority as soon as reasonably practicable.

23.3 Auditing

Perseus's SHEC Manager will undertake a site inspection once a fortnight during the works to ensure that the works are being undertaken in accordance with the NVMMP. The inspections will include a review of the most recent noise and blast vibration monitoring reports. The SHEC Manager will also undertake an annual audit of the NVMMP which will be more detailed than the site inspections and will include reviews of documentation. This audit will include an inspection of all noise monitoring reports and summary reports prepared during the audit period. Key issues arising from site inspections and audits will be raised at any Health, Safety and Environment meetings.

24.0 PROGRAMME

24.1 Implementation

This noise and vibration management and monitoring plan will be implemented within one month from the commencement of construction works covered by the appropriate authorisations. The first noise and test blast monitoring exercise will be undertaken as soon as suitable environmental conditions prevail for environmental noise/vibration monitoring.

24.2 Review and Updates

The NVMMP will be reviewed on a bi- annual basis by Perseus's SHEC Manager. In particular, previous monitoring results will be used to review the proposed frequency and duration of monitoring. Compliance with noise limits may enable the proposed monitoring frequency and/or duration to be reduced, whereas frequent exceedances may indicate the need for additional monitoring and corrective action. Any reductions in monitoring frequency/duration will not be implemented until agreed with the appropriate Ivorian Authority.