Conceptual Waste Management Plan

Yaoure Gold Project,

Perseus Yaoure SARL, Côte d'Ivoire

Submitted to

Perseus Yaoure SARL

Submitted by

Amec Foster Wheeler Earth & Environmental (UK) Ltd. (Original)
2D Consulting Afrique, Cote d'Ivoire (Update)

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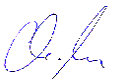
Author	**Christian Kunze**	 Signature & Date	
Reviewer	**Miguel Diaz** **Chantelle De La Haye**	 February 2018	
Submitted by	**Amec Foster Wheeler Earth & Environmental UK Ltd (Original)** **2D Consulting Afrique (Update)**		

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1.0 INTRODUCTION

1.1 Project Background

Perseus Yaoure SARL (Perseus) is developing a gold mining Project (the Yaoure Gold Project, or Project) in the Bouaflé Prefecture of the Marahoué Region in Côte d'Ivoire.

Perseus are required to carry out an Environmental and Social Impact Assessment (ESIA) as part of the Pre-Feasibility Study (PFS), which covers all phases of the Project life cycle, including the closure and rehabilitation phase.

One of the ESIA deliverables is a Conceptual Waste Management Plan that reflects the current knowledge of extractive wastes generated during the mining Project and the measures to minimise or mitigate the environmental impacts of extractive waste deposition. As Project design and waste characterisation progress, the Waste Management Plan will be updated and completed. It will be reviewed and revised as necessary during the Definite Feasibility Study (DFS) and again during the operation phase.

1.2 Objectives of the Waste Management Plan

The objectives[1] of a Waste Management Plan are:

- To prevent or reduce waste production and its harmfulness, in particular by considering:
    - Waste management in the design phase and in the choice of the method used for mineral extraction and treatment;
    - The changes that the extractive waste may undergo in relation to an increase in surface area and exposure to conditions above ground;
    - Putting topsoil back in place after the closure of the waste facility or, if this is not practically feasible, using soil forming material to create a vegetated cover;
- To ensure short and long-term safe disposal of the extractive waste, in particular by considering, during the design phase, management during the operation and closure of a waste facility and by choosing a design which:
    - Requires minimal and, if possible, ultimately no monitoring, control and management of the closed waste facility;

[1] Adapted from Art. 5 of the European Extractive Waste Directive 2006/21/EC

- Prevents, or at least minimises any long-term negative effects, for example attributable to migration of airborne or aquatic pollutants from the waste facility; and
- Ensures the long-term geotechnical stability of any earth or rock structures (tailings containment,, waste rock dumps) rising above the pre-existing ground surface.

Based on the above, this Waste Management Plan for the Yaoure Project shall:

- Outline the management of the wastes to minimise negative environmental impacts;
- Assist Perseus management to ensure the protection of the environment, public health and safety during and after closure of the mine and associated facilities;
- Reduce or eliminate long-term environmental impacts resulting from the waste storage facilities; and
- Serve as a resource to Perseus in Project-specific budget and schedule planning activities, such as the costing of waste management measures and establishing financial provisions for closure and rehabilitation of waste management facilities.

This Conceptual Waste Management Plan is based on information regarding the mine plan and waste characterization test results available at the time of writing.

1.3 Relation of the Waste Management Plan to other Management Plans

The Waste Management Plan is part of the Environmental and Social Management System (ESMS), a suite of interrelated management documents developed as part of the ESIA for the Yaoure Project that include, but are not limited to, the following:

- Water Management Plan;
- Stakeholder Engagement Plan;
- Conceptual Closure and Rehabilitation Management Plan; and
- Emergency Preparedness and Response Plan.

These plans are living documents subject to regular revisions and updates, relevant content from which will be integrated into the Waste Management Plan in the next revision.

1.4 General Waste Management Hierarchy and Objectives

According to IFC Performance Standard 3 (Resource Efficiency and Pollution Prevention), the following hierarchy of waste management options shall be adopted:

1. Avoidance;
2. Recovery; and
3. Disposal.

Negative environmental and social impacts from waste management shall be avoided in the first place, where possible. If they cannot be prevented, they shall be minimised as far as reasonably achievable, and residual impacts shall be compensated/offset.

The following general extractive waste management objectives are considered international best practice:

- Physical stability of waste facilities, especially slopes, earth structures and other containment structures;
- Prevention or minimisation of the runoff of ARD and contaminated seepage from waste dumps and TSF;
- Prevention or minimisation of the mobilisation and dispersal of contamination to the environment;
- Collection and management/treatment of water that cannot be discharged into the environment;
- Erosion protection of the waste dump surfaces and tailings facilities;
- Prevention of dust from waste facilities; and
- Aesthetics: minimization of visual impacts of rock stockpile slopes, TSF containment and other waste management facilities to improve aesthetic appearance.

This Waste Management Plan describes the approach taken by Perseus to satisfy these objectives.

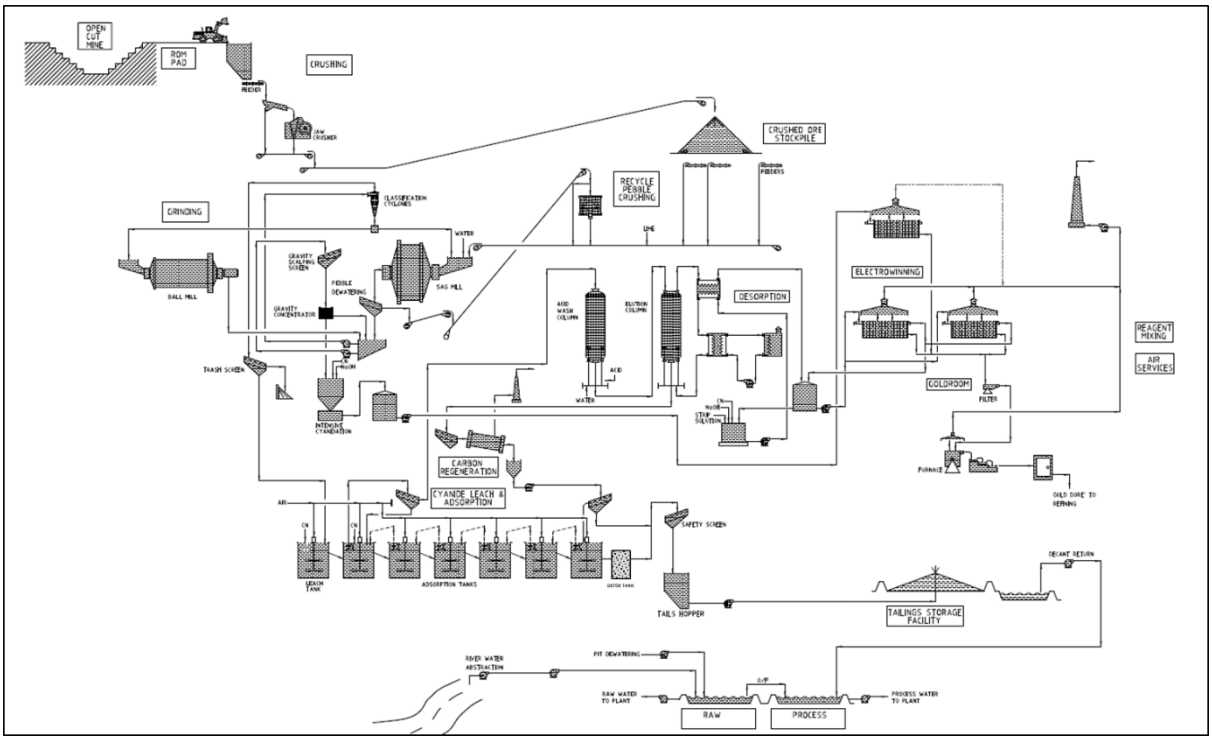
It should be noted that a site selection process for the TSF and the waste rock dumps has taken place, which aimed at a minimal impact on environmental and social receptors. This site selection process is described in the “Alternatives” section of the ESIA Report.

2.0 DESCRIPTION OF THE OPERATIONS GENERATING EXTRACTIVE WASTE

The mine will be operated as open pit (drill & blast, load & haul), generating waste rock and tailings in the tonnages shown in Table 2-1.

The gold extraction process is a standard process used in gold mines worldwide. Oxide and sulphide ore will be crushed and milled and then leached in the process plant using a standard cyanide leaching process, carbon in leach (CIL), followed by an elution/regeneration stage, electrowinning and smelting. The final product is doré. A simplified process flow sheet is shown in Figure 2-1.

Figure 2-1 Simplified flow sheet of the Yaoure Gold Project



The tailings will be stored in a TSF that is located south-east of the pit, as shown in Appendix 1.

With respect to residual cyanide in the tailings, international guidance such as the Cyanide Code (ICMI) will be considered and Perseus will endeavour to comply with the Code. Cyanide detoxification will be considered as part of the final, detailed process design following potential additional metallurgical testwork.

The Cyanide Code issued by ICMI recommends a maximum tailings concentration of 50 mg/l Weakly Acid Dissociable (WAD) cyanide unless systems are installed to prevent wildlife accessing the supernatant water. According to Standard of Practice 4.4 of the Cyanide Code, this recommended limit is based on evidence that solutions with 50 mg/l or less WAD cyanide are typically non-lethal to wildlife.

Table 2-1 Amounts of extractive waste generated, and footprints of waste facilities

	Footprint (ha)	Amount (Mt)
TSF	125 + 72 = 197	30
WRD	147	137

3.0 EXTRACTIVE WASTE CHARACTERISATION

The regional geology of the Project area is comprised of a series of Archaean, Birimian, greenstone belts separated by older migmatites and granites. Mineralization at Yaoure is associated with quartz veining. The Yaoure unit forms a syncline of tholeiitic basic metavolcanics and sediments overlain by more acidic volcanic rocks. The tholeiitic rocks are thought to have been formed following hydrothermal alteration and are composed of chert, disseminations and veinlets of pyrite, pyrrhotite, chlorite, epidote, tourmaline and carbonates.

A geochemical characterization programme[2] was undertaken covering all lithologies, all areas of the deposit, potential construction materials and six representative tailings samples representing different processing phases of the project from a geochemical perspective. Testwork comprised a standard sequence of Acid Base Accounting (ABA), Net Acid Generation (NAG), major oxides and trace elements using X-Ray Fluorescence (XRF), mineralogical characterization using X-Ray Diffraction (XRD) with Rietveld quantification and short term leaching using the Synthetic Precipitation Leaching Procedure (SPLP).

[2] Amec Foster Wheeler, Yaouré Geochemical Characterisation – Waste Rock, Construction Materials and Tailings. Report Number A151-15-R2286I, April 2015

The results from the Total Sulphur measurement indicated that the Yaoure waste rock has a low level of total Sulphur and hence sulphides. The vast majority of samples were found to be acid consuming or non-acid forming. Only one sample of transitional material was classed as low capacity PAF. As such, the risk of significant acid generation from the waste rock and construction materials is low

Selected samples were further characterized by mineralogical techniques and it was found that the level of element enrichment in the waste rock is low and there is a low perceived risk of metal leaching from the waste rock, subject to further testing. Therefore the drainage from the waste rock is unlikely to have a significant impact and any dust generated from the waste rock will have a close composition to the Earth's average crust composition.

The waste rock was found to be suitable to be used as a construction material from a geochemical perspective.

A similar test work programme was applied to the tailings samples. The tailings samples analysed as part of the DFS were classified as non-acid forming or acid consuming The mineralogical results presented would suggest that the level of element enrichment in the tailings is low but the supernatant (water) was found to be of a poor quality with elevated metals and cyanide. The tailings facility will hence need to be designed to limit seepage, and a low permeability liner and underdrainage system are required.

4.0 POTENTIAL ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

4.1 Overview of potential impacts and mitigation measures

The environmental and social impacts of extractive waste management activities are analysed in detail in the ESIA Report for the Yaoure Project, and shall not be repeated here.

Table 4-1 provides a summary of the potential impacts and the mitigation measures Perseus is committed to.

Table 4-1 Potential impacts related to extractive wastes, and mitigation measures

Area of concern	Potential impacts (pre-mitigation)	Mitigation measures
Groundwater contamination	Seepage from TSF and WRD may infiltrate into groundwater, polluting water resources used by communities for drinking, irrigation and livestock watering However, currently the occurrence of acid generating material is very unlikely	Continue waste characterisation test work The ground below theTSF will be compacted to reduce hydraulic conductivity In case potentially acid generating material (PAG) is identified: segregate PAG/non-acid generating and manage separately, and/or encapsulate PAG using non-acid generating material
Surface water	Erosion of wastes and increased load of suspended matter (turbidity) in surface water (Bandama River and tributaries)	Erosion protection measures: Keep clean and polluted streams separate (diversion ditches and channels) Drainage/runoff collection ditches around waste rock dumps Settling ponds to decrease silt load from waste management facilities
	Discharge of increased loads of metals and cyanide into surface water may lead to negative impacts on surface water quality and consequently impacts on biodiversity (mainly aquatic) and humans/livestock	Keep clean and polluted streams separate (diversion ditches and channels) Zero discharge water management and further optimisation of water management Provide for water treatment depending on water quality and potential risk Cover PAG material (not encapsulated by non-acid generating waste) with adequate cover to control water and oxygen flow and hence ARD generation
Air quality	Release of dust during dry periods, leading to nuisance, health effects and potentially negative impact on plants	Keep tailings beaches saturated Keep dust-prone waste surfaces wet (sprinkling) during dry season
	Release of gaseous cyanide (HCN) from TSF and toxic effects on humans and wildlife	Control pH in the discharged tailings (must be alkaline)
Noise	Noise generated by waste management operations (mainly hauling and dumping waste rock) may be a nuisance to people living nearby, e.g., Angovia	Best practice noise reduction measures (see Noise & Vibration Management Plan for details)

Biodiversity, wildlife	Animals (e.g., birds, amphibians) may drink from or bathe in tailings pond (elevated CN concentrations)	The most relevant parameter of tailings supernatant water quality is cyanide. The process will be controlled so that cyanide concentrations stay as low as possible, such as those levels recommended by the ICMI Cyanide Code or other suitable guidance, or systems to prevent access of wildlife to the supernatant water or scare wildlife away from the tailings basin
	Disturbance of habitats (especially Natural Habitats) by construction and operation of waste facilities	Offsetting of habitats where necessary and possible. However, follow concurrent rehabilitation approach during operations phase and integrate waste management facilities into overall concept of closure and habitat restoration.
Emergencies	Dam or waste rock slope failure may lead to injury, loss of property/livestock and ecological damage TSF dam breach may lead to sudden release of tailings and water and major consequences in downstream settlements and habitats	Regular inspections and geotechnical review of waste facilities Emergency Preparedness and Response Plan
Visual appearance, landscape, aesthetics	Visual disturbance by waste facilities, especially in close proximity to human settlements	Progressive rehabilitation to minimise visual disturbance during operation Reshape, grade, re-profile during closure to blend in with surrounding landscape Revegetate covered surfaces with locally adapted species

4.2 Runoff and seepage water collection

There will be an ongoing program of material characterization to determine whether it will be PAG, uncertain, or non-acid generating and management will mitigate any risks accordingly.

Around the WRD, a 10 m strip (use as road where required) with run-off collection sumps/sediment traps will be built.

4.3 Waste characterisation

Results of the waste characterisation program have shown that the occurrence of PAG material is low. During the operation phase, Perseus will continue to test waste rock and tailings in order to confirm that no PAG material is generated. . Should PAG material in substantial quantities arise, Perseus will apply a waste segregation strategy which is based on the PAG/NAG classification method to be developed as part of the waste characterisation program.

Waste streams will be regularly sampled and analysed for the determinant parameters (likely Total Sulphur), and classified into one of the categories, NAG or PAG. The principle of waste segregation and encapsulation is schematically shown in Figure 4-1.

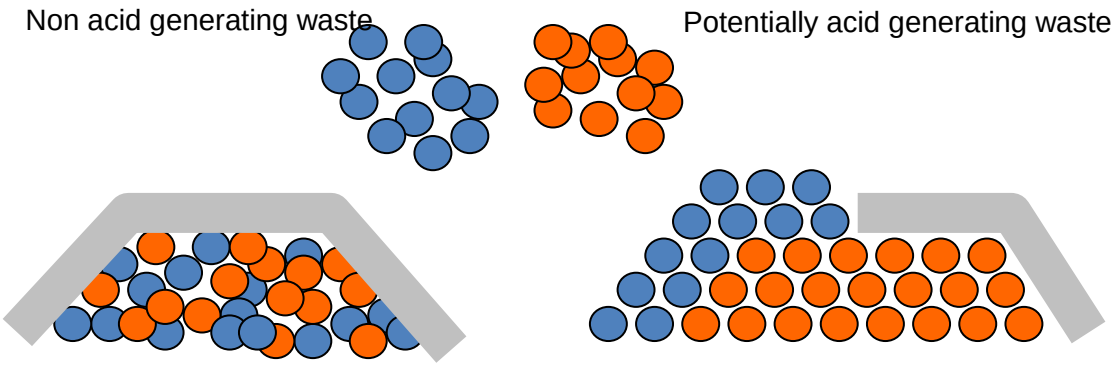


Figure 4-1 Principle of PAG/NAG waste segregation and encapsulation

In order to minimise the generation of ARD due to sulphide (pyrite) oxidation, the ingress of oxygen and water into the PAG (potentially acid generating) waste portion must be limited. If PAG and NAG (not acid generating, i.e., inert) wastes are dumped together, a relatively expensive cover controlling infiltration and oxygen diffusion must be placed on the entire waste dump. By contrast, if PAG and NAG wastes are kept separate, the area of PAG waste is smaller than in the case of undifferentiated disposal, and the NAG waste can be used to cover/encapsulate the PAG portion.

Experience from other mine sites clearly indicates that trial plots can assist in the design and optimisation of encapsulation and cover strategies, especially with respect to the long-term stability of cover performance.

4.4 Environmental Monitoring

The waste management facilities will be integrated into the environmental monitoring program for the operation and closure phases. The monitoring program will address the following:

- Water quality in the supernatant pond of the TSF;
- Seepage water quality (if collected);
- Ground and surface water up and downstream of the waste facilities;
- Dust concentration around the waste facilities; and
- Cyanide (HCN) concentration around the TSF.

Details of the monitoring program, i.e., location of monitoring points and suite of parameters to be monitored/analysed, will be determined when the construction details of the waste facilities are known.

Environmental monitoring data and regularly updated results of waste characterisation programs will be used to develop an understanding of whether the waste materials will generate acid and/or metalliferous leachate/seepage. If this is the case, it will be determined how long the water will have to be monitored and possibly collected, managed and possibly treated in the post-closure phase.

4.5 Geotechnical Inspections and Reviews

The Best Practice Reference Document (BREF) for the Management of Tailings and Waste Rock (MTWR 2009) provides guidance for inspections and stability assessments of the TSF and waste rock dumps:

Table 4-2 Proposed assessment regime of TSF and waste rock dumps, operation period

Assessment type	Frequency		Personnel
	Tailings	Waste rock dumps	
Visual inspection	Daily	Daily	Operator
Geotechnical review	Yearly	Yearly	Qualified engineer
Independent geotechnical audit	Yearly	Every 2 years	Independent expert
Stability assessment, SEED (Safety Evaluation of Existing Dams)	15 – 20 years	-	Team of independent experts

Inspections will also include erosion of embankment and waste slopes, particularly after heavy rainfall. Ditches, culverts, water diversion channels and similar structures will be regularly inspected and cleaned/repaired where necessary.

In the post-closure phase, geotechnical inspections and audits are less frequent, and may be phased out with time to an extent that inspections, audits/reviews are no longer necessary if restoration is properly completed.

5.0 NON-EXTRACTIVE WASTE

Non-extractive wastes, i.e., wastes not directly resulting from mining or processing, include the following:

- Packaging waste;
- Aluminium cans;
- Paper, cardboard;
- Scrap metal;
- Wooden packaging waste, crates, pallets;
- Glass;
- Plastics;
- Aerosol containers;
- Empty drums, containers;
- Used oils and oil filters;
- Oily rags;
- Used tyres;
- Wet acid batteries (car batteries) and other batteries;
- Used vehicles;
- Waste electrical and electronic equipment (WEEE);
- Fluorescent tubes;
- Medical waste;
- Wood (crates, boxes);
- Food waste;
- Contaminated soil; and

- Sewage and sewage treatment sludge (see Section **Error! Reference source not found.**).

As a general policy, all reasonable efforts will be made to minimise or eliminate the waste streams, and/or to re-use and recycle waste material, wherever feasible.

Medical waste will be incinerated on site in a special incineration facility.

Other waste streams will be further segregated, as necessary, to ensure that incompatible materials are not stored together. Waste storage carts, bins, or barrels will be arranged in such a way as to provide adequate access for container transfer and emergency response. Waste intended for off-site disposal will be collected at a specific transfer station.

Perseus will work with suppliers to take back any wastes whose origin can be identified, and with local waste management organisations to work out suitable waste management strategies for other wastes.

Should hazardous wastes arise that cannot be returned to suppliers, appropriate waste management solutions will be determined by Perseus in conjunction with the relevant authorities, which may include a dedicated waste management facility on site. This is in line with international best practice, e.g., IFC EHS Guidelines for Mining, (2007), which recommends management of hazardous wastes "in hazardous waste management facilities specifically designed and operated for this purpose". Such landfill would be closed at the end of the mine life.

6.0 CLOSURE, REHABILITATION AND AFTER-CARE OF THE WASTE MANAGEMENT FACILITIES

Closure and rehabilitation of the extractive waste facilities are considered in more detail in the Closure and Rehabilitation Plan[3].

7.0 REVIEW AND UPDATE OF THE WASTE MANAGEMENT PLAN

In the pre-construction phase, the results of the completed waste characterisation programme will be used to revisit the design criteria related to seepage collection and management, and to adapt the design according to the actual environmental risk.

During the operations phase, the Waste Management Plan shall be regularly updated, taking into account the following aspects, as applicable:

[3] Amec Foster Wheeler: Conceptual Closure Plan for the Yaoure Project of Perseus Yaoure SARL, Côte d'Ivoire, Report Number A151-15-R, April 2015

- More and detailed information on waste characteristics are available, mainly from ARD testwork on tailings and waste rock during the mine life;
- New regulatory requirements and changed legislative framework;
- Changed technological processes and resulting change of waste properties;
- New or changed waste disposal and closure/remediation technologies;
- Results of progressive rehabilitation and test plot trials; and
- Incidents and spill events, tailings pipeline rupture events etc.

International best practice suggests a review of the waste management plan at least every five years and/or amendments in the event of substantial changes to the operation of the waste facility or to the waste deposited.

Any amendments shall be notified to the competent authority.

Responsibility for the update lies with the General Manager of Perseus Yaoure SARL.