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**AFRICAN MINERALS LIMITED**

## Tonkolili Iron Ore Project

# Stage 1 Environmental, Social and Health Impact Assessment

305000-00006-0000-EN-REP-0020

18 Jun 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

## SYNOPSIS

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project has three phases of production as summarised below.

Phase 1 involves mining, beneficiation and export of a surface hematite deposit at a maximum rate of 8 Mtpa. Transport and export of the ore will use a combination of road, rail, stockpiling at the refurbished port facility at Pepel and transshipment to cargo vessels moored off-shore. Phase 1 is due to start production in early 2011 and early enabling works are either already underway or close to starting. The focus of this Environmental, Social and Health Impact Assessment (Stage 1 ESHIA) is the Phase 1 project.

Phase 2 involves the mining and processing of additional transition material at a rate of approximately 17Mtpa as well as continuation of the phase 1 mining to give a combined production rate of 25Mtpa. Phase 3 comprises mining a deeper, hard-rock magnetite deposit, processing the magnetite to a concentrate and export at a design rate of 45Mtpa. This will potentially rise to higher rates of production depending on the confirmation of subsequent geological resource models. Phase 2 and 3 infrastructure is configured substantially differently from Phase 1 and will transition from light-rail or road trucking progressively towards dedicated heavy-haul rail transport from the mine to a new deep water port facility to be located at Tagrin. Phase 2 and 3 are due to commence circa 2014 and are the subject of a forthcoming ‘Stage 2 ESHIA’ that will follow this document. The Stage 2 ESHIA therefore primarily evaluates the environmental and social issues that could potentially manifest during mining phases 2 and 3. The Stage 2 ESHIA will also provide an opportunity to update the impact assessment with additional findings from an ongoing programme of studies and monitoring.

This ESHIA has been prepared for submission for approval on the understanding that elements of the infrastructure design and ESHIA study are not yet fully developed. In recognition of this, the proponent (AML) has committed to undertake completion of the various ESHIA studies, which are either ongoing or soon to be undertaken and will be reported on in updates to the Environmental Management Plan (EMP) and as part of the Stage 2 ESHIA. Comprehensive environmental and social (E&S) management will continue, with the studies inputting to project design, construction and development. It is recommended that rigorous risk review is applied in the interim ahead of ESHIA Stage 2 submission in order to identify appropriate Environmental and Social (E&S) management measures, which will be delivered through the ongoing EMP that will extend into the operational phase.

This ESHIA includes a review of the legislation framework associated with environmental, social and health management and assessment. The ESHIA considers the Phase 1 project, the existing physical conditions i.e. the environmental and human baseline and the likely impacts that may arise, both positive and negative. Where there are impacts identified that could cause adverse effects, the ESHIA considers alternatives, mitigating measures and what the likely remaining or residual impact will be after such intervention. Finally, the ESHIA sets out requirements for ongoing management, assessment, monitoring and institutional relations.

A significant volume of physical and social data collection as well as assessment work has been compiled into this impact assessment to comply with regulatory requirements ensure an adequate understanding of the project is available for decision making. In some areas, it is recognised that further work is required, including further project definition in order to be able to define more specific impacts and mitigation measures and develop effective management strategies. However, the ESHIA is thought to be sufficiently complete for it to meet its intended decision-making purpose. Furthermore, an Environmental Management Plan (EMP) has been prepared which provides a framework for managing the delivery of mitigation measures, further monitoring and continual improvement in the project's environmental and social performance. The EMP is a live document that is part of a management system reporting on updated information as it becomes available, and allowing feed into ongoing design work.

Where construction management plans can be prepared based on the currently available information, these have been provided. In other instances, the management plans will need to be formulated pending further work. All that can be presented at this time is a thematic management plan that outlines the scope of the management intervention that will likely be necessary.

The EMP in this Stage 1 ESHIA includes a number of thematic plans, describing how mitigation will be delivered where required and these will be updated with new survey data as it becomes available and as infrastructure designs progress, enabling decision making to ensure minimisation of potential adverse effects.

This is particularly important for the terrestrial and marine eco-systems that could be affected by the project. To date it has been recognised that areas under the direct footprint of the project contain either recognised high conservation value species or habitat that is of major significance. An integrated approach involving additional assessment, avoidance wherever possible of critical areas, mitigation, development of compensatory programmes and community development programmes is required. Further study work is required and will be included in a Stage 2 ESHIA later in 2010 that will provide more specific design and definition to these programmes.

It is also important that management plans take into account consequential impacts that will arise, many of which will be unintended and difficult to control. This includes impacts associated with speculative influx of migrant workers and accelerated degradation of habitat in areas that was hitherto relatively inaccessible and sparsely populated. Management plans need to describe a clearer understanding of how compensation, alternative livelihood schemes, regulation and sustainable community development can be effectively implemented in order to reduce secondary impacts.

Recommendations are given for ongoing monitoring, auditing and performance evaluation of the environmental and social elements of the project so that continued improvement, adherence to agreed standards and effective liaison with SLEPA is maintained.

Monitoring will involve internal and external inspections as well as auditing of performance and compliance with contract documents. Where a degree of capacity building is required to ensure that inspection visits and audits by the competent authority (SLEPA) can be achieved then it is understood and has been recorded (Appendix 1) that AML will make provision for this. In addition, inspection visits and audits by independent consultants, appointed by AML, will produce monitoring reports that SLEPA can access and comment on. Currently this has been done by the ESHIA consultants in

The monitoring strategy proposed for the project can be termed "Adaptive Environmental Monitoring" with the responsible party required to adapt methods and activities to the ongoing design and implementation activities and prevailing environmental conditions in a continuous process.

## Disclaimer

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*This Assessment has been developed on available data that is acknowledged to be based on sampling and survey that is still ongoing. Where data gaps are present in the ESHIA, WorleyParsons has tried to clearly identify the current status of knowledge. In some instances, a programme of ongoing study works is recommended.*

*Furthermore, this ESHIA has been produced in a relatively rapid timeframe in order that an assessment can be made available to authorities prior to planned works which are scheduled to occur in the near future. As a consequence, the ESHIA has not been subject to the level of quality assurance that WorleyParsons would typically apply*

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**PROJECT - STAGE 1 ENVIRONMENTAL, SOCIAL AND HEALTH IMPACT ASSESSMENT**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| 0 | Issued for Use | P. Burris | p.p. R.Fitzsimmons | R.Fitzsimmons | 18-Jun-10 | A. Huckbody | 18Jun-10 |

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# EXECUTIVE SUMMARY

The project has been evaluated using a rigorous impact assessment methodology comprising the following:

- A review of compliance with the Sierra Leone legislation framework;
- A description of the project and review of alternatives;
- Determination of the project physical and social baseline conditions at a regional and site-specific level;
- Derivation of a standardised methodology based on evaluating valued receptors and impact index derived from assessing extent, duration and magnitude;
- Assessment of the likely impacts that may arise, both positive and negative. Where impacts are identified that could cause adverse effects, the ESHIA considers alternatives, mitigating measures and what the likely remaining or residual impact will be after such intervention;
- The environment and social impact assessment has been applied systematically to four areas of the project: the mine, the transport corridor, the port and the off-shore and coastal zone.

The following principal issues have been determined:

### *Air & Noise*

Air quality impacts comprising both dust and exhaust emissions arising from land clearance, mining, stock-piles, vehicles and machinery have been identified as primary emission sources. The implementation of standard mitigation measures involving adequate containment of loads during haulage, dust suppression by water spraying, extractive covers at key point sources and machinery selection should result in no major impacts.

The proximity of the proposed transport route in relation to villages and residential areas remains a key issue. Whilst a principle of avoidance of resettlement wherever possible has been upheld, the combination of public safety and dust and noise nuisance issues means that in some instances, even though mitigation measures may be partially effective, it has been considered more appropriate and responsible to pursue a resettlement solution. The maintenance of a buffer zone should be sufficient for most residential areas, but in exceptional cases where a suitable buffer cannot be maintained and resettlement is not feasible, additional mitigation measures (e.g. noise barriers or noise isolation) at sensitive receptors will minimize the impacts. A buffer zone of 500m has generally been accepted for the project, if communities lie within this zone then a review of either resettlement or mitigation is required.

Noise sources vary, but blasting, crushing and transport noise, including aircraft, are considered to be potentially the most significant. Assuming that occupational noise limits are maintained within facilities then it is predicted that appropriate environmental noise standards will be met at a distance of 500m from the facilities.

### *Ecology & Biodiversity*

Ecological impacts across the project have been evaluated and found to be significant primarily due to the high level of biodiversity and conservation value of certain plant species. This is the case at a variety of discreet habitat settings including forest and grass-lands located at the mine-site, along riverine forests, inland valley swamp locations and in mangrove forest in the coastal areas.

Principal direct impacts will arise from the clearance of land within the footprint of the project and its associated infrastructure. Vegetation that is not cleared or buried may be indirectly impacted by alteration, spread of invasive species and pressure from the influx of people that will increase the pressure on resources.

At Pepel Port, the potential release of acidity and metals from disturbed acid sulphate soils (if present) could cause localised impacts to vegetation.

At the mine and along the transport corridor, disturbance of fauna, particularly large mammals such as chimpanzees may further reduce natural colonisation by indigenous plant species where fauna play a role in seed dispersal.

The impacts of habitat loss and fragmentation will affect terrestrial and aquatic ecosystems. Avoidance of areas of ecological value is the primary tool that is applied to minimise impacts. However, the impact of land clearance and burial in the primary mining and rock dump areas can neither be avoided, nor mitigated because of the immovable location of the ore bodies and practicalities governing design of the mine and waste rock areas. The project proponent (AML) should therefore undertake a commitment to seed collection, replanting, habitat renewal and protection at alternative selected conservation site(s). This offset or equivalence approach will not alter the primary ecological loss and cannot realistically overcome the direct impact resulting from clearance of forest and vegetation. However, in combination with avoidance of sensitive areas outside of the mine footprint wherever possible, an off-set conservation programme can contribute to lowering the overall residual impact to a moderate level.

### *Hydrology and Hydrogeology*

The project will result in an increase in suspended sediments in rivers, alteration of river channels and changes in catchment behaviour. Without mitigation this could lead to flooding as well as a variety of water quality impacts. Changes of chemistry could occur with the water considered to have low chemical buffering capacity. At the mine and transport corridor the potable and construction water demand may lead to over-abstraction of local surface and groundwater sources leading to impacts on downstream flows affecting both communities and dependent eco-systems.

At Pepel Port, groundwater is considered both a sensitive and vulnerable resource. Construction and operational groundwater abstraction could lead to lowering of water levels in local wells and saline intrusion, while brownfield regeneration and the industrial port operations could lead to contamination of a system that is important for sustaining potable water supplies as well as providing baseflow discharging into the inter-tidal zone.

Residual, post mitigation impacts from the project will include some permanent loss of flow from springs and streams as well as alteration of stream and river channels and local water levels. However, more significant changes in local hydrology and hydrogeology are expected in Phase 3 which will require a significantly higher water demand.

### *Soils & Land Use*

Soil impacts will arise during construction and operational phases as a consequence of land clearance or sterilisation / burial, increased erosion or inundation due to the modification of drainage patterns, compaction from vibration and loading under temporary stockpiles/structures. Chemical contamination could occur from release of hydrocarbons and other chemicals including diesel and lubricant oils and explosives residues. Some soil resource can be rehabilitated if progressive reclamation techniques are applied. These impacts may constrain or modify existing land-uses in the mine area. The residual (post-mitigation) impacts of land clearance and sterilisation / burial on soil resources and land-use are likely to remain significant and extremely long-term or permanent in the mine area. Other residual impacts should be minor if appropriate preventative and mitigation measures are put in place.

### *Socio-Economic*

Socio-economic effects are strongly dependent on project phase. During construction some villages may require resettlement. Villages on the periphery of the project area will suffer loss of land resulting in potential temporary disruption of land used for shelter, access to agriculture and natural resources. However a compensation principle is being applied throughout the project to ensure affected people are not disadvantaged or made worse off by the project. Some employment opportunities will be created with associated economic benefits to the wider community.

During operations, however, there is again a mix of both economic benefit and social disturbance. Benefits (lasting about 8 years) will mainly be in the form of wages, disbursement for the procurement of supplies, social investments and payment of revenue to the government. Potential negative impacts will mainly be due to disturbance to land owners and influx of workers and job seekers bringing pressure on social infrastructure and natural resources and possible increases in social ills.

Mitigation measures are dependent on establishing transparent and effective social management processes including harm minimisation, compensation and long-term community development mechanisms. The following mitigation measures are expected to reduce the intensity of the residual impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.

- Implementation of a grievance mechanism.
- Preparation of a Community Development Action Plan.

In some instances these community mitigation measures require co-opting the support of local government and Non-governmental Organisations (NGOs).

***Human Health***

The major impacts identified in the preliminary health impact assessment were primarily associated with community resettlement; impacts associated with worker in-migration (disease, food security, substance abuse, home violence); increased burden of disease such as cholera and malaria due to project activities and water storage facilities (drinking water tanks, waste and raw water storage ponds); and degradation of surface and groundwater (sedimentation/erosion, contamination, changes in drainage patterns). Moderate impacts were associated with increased road traffic, project noise and reduction of locally produced food.

Mitigation measures have been proposed for those impacts with major or moderate significance which, if implemented, are predicated to result in moderate, minor, or insignificant residual impacts. Since human health is dependant on many factors such as good air, soil, water and food quality, and stable socio-economic status, the assessment of potential impact on human health associated with the Phase 1 project has been integrated with results of many of the other ESHIA disciplines (e.g., air, noise, hydrology, hydrogeology, flora, fauna, soil, water quality, and social-economic assessment). Implementation of mitigation measures recommended by these disciplines would therefore reduce the potential for adverse human health impacts (HIA) and will be considered in the final HIA.

Positive impacts identified include access to improved healthcare facilities (for general public), health benefits through local employment, improved access to the region and positive aspects of resettlement.

***Offshore & Coastal Impact Assessment***

The baseline preliminary survey indicates that the coastal and marine habitat around Pepel Port is healthy and contains a high level of biodiversity. There are a number of potential impacts that could arise from reduction and clearance of habitat areas. However, the majority of the port infrastructure is already in place, and most of what is required will be refurbished rather than constructed from new. As a result there should be no significant increase in the existing port footprint, and therefore no significant area of coastal habitat cleared. The currently proposed development footprint for Pepel Port will result in reasonably minor losses of mangroves.

There is currently no evidence of any existing impact on the surrounding mangroves due to the presence of residual hematite ore from the previous operations at Pepel, although there are elevated levels of heavy metals in the near-shore soil samples.

The construction will increase ambient noise and light levels, and potentially result in disturbance of sensitive coastal fauna such as birds. Due to the high density of wetland birds present in the project location, and its position inside a designated Ramsar site, increased light is a potentially significant impact, especially if construction work takes place during bird migratory or breeding seasons. Therefore a number of mitigation measures are proposed to minimise impact or better still avoid sensitive habitat areas (eg high avifauna population, important nesting and feeding sites, and migratory and nesting seasons).

A more detailed assessment of wastewater discharges is required to develop the necessary approach to wastewater treatment and management. As a minimum, mitigation measures that are included should include installation of temporary treatment plant to treat construction camp discharges, ensuring treated water discharge is located away from sensitive locations and in areas of strong tidal currents to increase dilution and removal; and compliance with World Bank discharge limits as specified in the Stage 2 Environmental Basis of Design document. Improved environmental performance has already been incorporated into the project design at Pepel to ensure there is drainage away from the coast and incorporation of settling sumps for stormwater runoff.

During construction and refurbishment there is a risk of increased run-off due to earthworks, and a risk of oil and chemical contamination from disturbance of existing contaminated land, and new incidents of fuel, lubricant and coating spills used in construction machinery, and from potential oil spills.

This will require management through run-off collection and treatment systems, waste management planning, spill response plans (contingency planning and emergency response measures should be in place). Industry best practice regarding refuelling activities, oil handling activities and machinery maintenance is required considering the site's sensitivity.

The refurbishment or replacement of mooring dolphins, to enable the mooring of transshipment vessels will primarily impact the sub-tidal habitat through smothering, pile driving, and placement of rock material. No mitigation measures are required other than further characterisation of the selected mooring site.

The construction and refurbishment of marine structures could result in elevated turbidity within the immediate vicinity of the port. However, given the natural conditions of the estuary particularly during wet season conditions it is considered that the habitat is likely to be resilient to increased turbidity levels over the relatively short duration of the construction programme at Pepel Port.

Construction/refurbishment activity also has the potential to disturb marine sediment. Further characterisation of nearshore and intertidal marine sediments is recommended prior to construction.

Underwater construction activities, in particular pile driving, can generate high levels of underwater noise. Marine mammal and the impact of underwater noise and ship collisions remain as a moderate impact due to lack of information at this stage but surveys are underway.

The majority of marine traffic in the estuary is focussed around Freetown. Trans-shipment operations are currently expected to involve Handymax trans-shipment vessels, which will transfer ore to a loading on anchorage point outside the mouth of the estuary. The impact of the trans-shipment operations on shipping in the estuary is not expected to be significant.

The location of the trans-shipment anchorage is not currently confirmed however, two potential anchorage locations proposed by CSL are circa 32.0 nautical miles and circa 44.0 nautical miles offshore. If an anchorage is selected that could introduce invasive species from in-bound shipping releasing ballast water at the destination location then the AML will need to ensure the 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments is strictly followed.

Routine discharges from vessels may have effects on water quality similar to the effects created by discharges from the port, such as changes in water pH, colour, temperature, smell, dissolved oxygen, nutrient levels and bacterial contamination. Mitigation of these effects will need to be achieved through ensuring the prevention of pollution from shipping (under the MARPOL treaty) which will require regulation of the shipping contractors by the Port Authority.

Loading of the transshipment vessels at Pepel and offloading at the anchorage during transshipment will lead to some inevitable overboard spillage of iron ore. Although it is assumed that the system will be designed to be highly efficient, even minor spillage will create a cumulative impact over the life of the project. The potential behaviour of the iron ore in the water should be evaluated by a laboratory assessment of the proposed iron ore product and its constituents.

Capital dredging will be required to open the navigation channel to access Pepel port with subsequent ongoing maintenance dredging required to keep the channel open. Dredging is designated as a moderate impact in this report on the basis of what is currently known about dredge location and ecology of the spoil disposal locations. More detailed assessment will be undertaken when details of a work programme and contractor have been clarified. A dredging plan is included in the EMP and will be modified on the basis of the outcome of a more detailed dredging impact assessment once the requisite data is available.

***Distributed Impacts***

Provision of bulk materials such as earth and fill for ground conditioning will be controlled through activity-specific management plans and protocols and contractors will be accountable for adherence to the plans and protocols.

The project's dependency on existing infrastructure will be limited. There will be initial reliance on imported goods and contractor services for food, accommodation and camps with opportunities for goods and services to create livelihood benefits for project communities. Adherence to prior and clear project announcements is expected.

An impact is likely to arise from interim storage of wastes in particular pest, odour and litter control. The AML will need ensure that its contractor's implement a hierarchy of waste elimination at source, recycling, reuse, recovery, and as a last resort – disposal. In addition provision for destroying or treating hazardous waste is required to render it non-hazardous if possible, with provision for safe storage where-ever and for as long as treatment/destruction is not an option..

***Commitments, Management and Performance***

This ESHIA has been prepared for submission for approval on the understanding that elements of the infrastructure design and ESHIA study are not yet fully developed. In recognition of this, AML has committed to undertake completion of the various ESHIA studies, which are either ongoing or soon to be undertaken and will be reported on in updates to the Environmental Management Plan (EMP) and as part of the Stage 2 ESHIA. Comprehensive environmental and social (E&S) management will continue, with the studies inputting to project design, construction and development. It is recommended that rigorous risk review is applied in the interim ahead of final ESHIA Stage 2 submission in order to identify appropriate Environmental and Social (E&S) management measures, which will be delivered through the ongoing EMP that will extend into the operational phase.

A significant volume of assessment work has been achieved and the impact assessment has been completed to a sufficient level for regulatory decision making. It is recognised that further work is required, including further project definition in order to be able to identify more specific impacts and mitigation measures and develop effective management strategies.

Where generic construction management plans could be generated based on the currently available information then these are have been provided. In other instances, the management plans will need to be formulated pending further project description and or study work and all that is presented now is an outline of the management plan purpose.

This is particularly important for the terrestrial and marine eco-systems that could be affected by the project. To date it has been recognised that areas under the direct footprint of the project contain either recognised high conservation value species or habitat that is of major significance. An integrated approach involving additional assessment, avoidance wherever possible of critical areas, mitigation, development of compensatory programmes and community development programmes is required. Further study work is required and will be included in a Stage 2 ESHIA later in 2010 that will provide more specific design and definition to these programmes.

It is also important that management plans take into account consequential impacts that will be created many of which will be unintended and difficult to control. This includes the impact associated with speculative influx of migrant workers and accelerated degradation of habitat in areas that was hitherto relatively inaccessible and sparsely populated. Management plans need to develop a clearer understanding of how compensation, alternative livelihood schemes, regulation and sustainable community development can be effectively implemented to reduce secondary impacts.

Recommendations are given for ongoing monitoring, auditing and performance evaluation of the environmental and social elements of the project so that continued improvement, adherence to agreed standards and effective liaison with SLEPA is maintained.

Monitoring will involve both internal and external inspections and auditing of performance and compliance to contract documents. Where a degree of capacity building is required to ensure that inspection visits and audits by the competent authority (SLEPA) can be achieved then it is understood and has been recorded (Appendix 1) that AML will provide provision for this. In addition inspection visits and audits by independent consultants, appointed by AML, will produce monitoring reports that SLEPA can access and comment on. Currently this has been done by the ESHIA consultants and their baseline data collection, however independent monitoring by CEMMATS is due to commence imminently, with reporting to SLEPA.

The monitoring strategy proposed for the project can be termed "Adaptive Environmental Monitoring". It is adaptive in the sense that the responsible party must adapt its methods and activities to the ongoing design and implementation and prevailing environmental conditions in a continuous process.

# 1 INTRODUCTION

## 1.1 Background

African Minerals Limited (AML) has identified an extensive magnetic anomaly in the Sula Mountain range in Sierra Leone and has confirmed the presence of a world-class iron ore deposit. The Tonkolili Project comprises the construction of a mine, ore processing and pit-to-port infrastructure to transport materials and product in the form of iron-ore concentrate.

The Project has three phases of production. Phase 1 involves mining, beneficiation and export of a surface hematite deposit at a maximum rate of 8 Mtpa. Transport and export will occur using a combination of road, rail and stockpiling at the refurbished port facility at Pepel and transshipment to waiting off-shore cargo ships. Phase 1 is due to start production in early 2011 and early enabling works are either already underway or close to starting. This Environmental, Social and Health Impact Assessment (ESHIA) focuses on the Phase 1 project.

Phase 2 involves the mining and processing of transition material at a rate of approximately 17 – 25Mtpa. Phase 3 comprises mining a deeper, hard-rock magnetite deposit, processing the magnetite to a concentrate and export at a design rate of 45Mtpa. This will potentially rise to higher rates of production depending on the confirmation of subsequent geological resource models. Phase 2 and 3 infrastructure is configured substantially differently from Phase 1 and will transition from light-rail or road trucking progressively towards dedicated heavy-haul rail transport from the mine to a new deep water port facility to be located at Tagrin. Phase 2 and 3 are due to commence 2014 and will be the subject of a 'Stage 2 ESHIA' in 2010 that will evaluate the Phase 2 and 3 specific impacts and also report on additional study work for the Stage 1 ESHIA project that has been developed during the intervening period.

This ESHIA includes a review of the legislation framework associated with environmental, social and health management and assessment. The ESHIA considers the Phase 1 project, the existing physical conditions; that is, the environmental and human baseline and the likely impacts that may arise, both positive and negative. Where there are impacts identified that could cause adverse effects, the ESHIA considers alternatives, mitigating measures and what the likely remaining or residual impact will be after such intervention. Finally, the ESHIA sets out requirements for ongoing management, assessment, monitoring and institutional relations.

**Box 1: Project Phases**

**Phase 1**

Steady state production: 8mtpa

Infrastructure: Road haul base case but currently undertaking engineering studies to explore feasibility of an extended rail route

Product: Direct Shipping Ore (DSO) He (Duricrust)

FOOS: Q1 2011 if road haul, but moves to Q3 2011 if extended rail option

Full capacity: Q4 2011

**Phase 2**

Steady state production: 25mtpa

Infrastructure: Extended rail route with spur to Tagrin and one terminal at Tagrin. Will also need processing plant at Tonkolili

Product: DSO He Duricrust and non DSO He Transition (a combination of the two)

FOOS: Q4 2013

Full capacity: Q1 2014

**Phase 3**

Steady state production: 45mtpa

Infrastructure: New heavy haul rail and new bulk port at Tagrin

Product: Magnetite

FOOS: Beyond 2014

Full capacity: 12 month ramp up

## 1.2 Purpose

The ESHIA report for Phase 1 of the Tonkolili Iron Ore Project has been prepared on behalf of AML to present to the Sierra Leone Environment Protection Agency (SLEPA) for the following purpose:

- To provide an understanding of the potential environmental, social and health impacts associated with the Phase 1 project activities;
- To outline the environmental, social and health commitments required for the project and the associated management and mitigation plans identified to address these issues;
- To provide a data baseline for comparison of change.

The report provides an assessment that starts with identification of relevant legislation and institutional bodies and a summary of the project including the primary project components as well as the supporting infrastructure and widely distributed effects that could reasonably be assumed to occur.

Much of the report is concerned with obtaining a representative characterisation of the existing baseline conditions at the project area. This section has been reported as a high level summary and makes reference to a number of supporting studies that have been completed and included as Appendices. Following the baseline description the ESHIA presents an overview of the potential impacts and associated mitigation measures. The impact assessment has used a standardised, semi-quantitative methodology based on identifying and ranking *valued receptors*. The basis for this methodology is explained.

Within the impact assessment section, there is also analysis of what is the remaining level of impact after mitigation measures have been implemented. The ESHIA then discusses the need for ongoing further study programmes where clearly needed as well as future management practices that AML will have to undertake following the completion of the assessment process.

Some of these management practices are strategic in the sense that they are either not entirely understood at the moment or may be conditional upon factors that are outside of the control of AML. So that there is an appropriate level of accountability over future performance and commitments, the ESHIA describes requirements for future performance monitoring and auditing as part of the proponent's Environmental & Social Management System.

The report builds on a series of deliverables that have already been prepared as part of an official regulatory process in liaison with SLEPA shown in Table 1-1 below. Copies of the transcripts for these official documents are provided in Appendix 1:

**Table 1-1 Prior ESHIA Deliverables**

| **Element** | **Date** |
|---|---|
| ESHIA Pre-Screening Announcement Form | 13th November 2009 |
| ESHIA Screening Form | 15th March 2010 |
| ESHIA Scoping Procedures Report | 22nd March 2010 |
| Haul Road Scoping Report | 15th April 2010 |
| Haul Road Environmental Management Plan | 29th April 2010 |
| Community Development Action Plan (CDAP) for the Haul Road | 29th April 2010 |
| Public Consultation and Stakeholder Forum, convened with SLEPA in Freetown | 17th May 2010 |
| AML Letter of intent to provide SLEPA access and support to Multipartite Monitoring | 30th March 2010 |

## 1.3 The Project Proponents

African Minerals Limited (AML) is a mineral exploration company registered in Sierra Leone with a contactable office in Freetown, contact details of the project proponent have been given in the project ESHIA screening form and remain current and valid.

AML developed from a former Sierra Leone mining company (SLDC) and maintains a portfolio of mining projects in Sierra Leone and elsewhere in Africa. AML is currently employing more than 800 Sierra Leoneans, the majority of which are associated with the exploration activities and pre-production works that are ongoing at Tonkolili.

AML has commissioned WorleyParsons to produce a Feasibility Study for the Tonkolili project and is in the process of preparing to apply for a mine operating licence.

The team of environmental consultants that have worked on developing this Stage 1 ESHIA include Worley Parsons as the nominated environmental consultant, SRK, CEMMATS, Wildlife Conservation Society (WCS), the UK Meteorology Office and Kew Gardens as well as a large number of individual specialists and experts that have contributed to sections of the report.

The main project entities in relation to the environment and social activities of the project at this stage in its development are listed below with a brief outline of their relationship to the project. Information that is derived from these sources is noted by a code.

| **Code** | **Project Entity** |
|---|---|
| AML | African Minerals Limited -project proponent. |
| WP | WorleyParsons - project engineer and ESHIA consultant |
| Ausenco | Process plant design engineer |
| GoSL | Government of Sierra Leone |
| SLEPA | Sierra Leone EPA |
| SRK | SRK Consulting (UK) Ltd - project sub-consultants |

## 1.4 Distribution and Intended Audience

The Stage 1 ESHIA report for Tonkolili Iron Ore Project is intended to inform SLEPA, district councils, chiefdoms, community members, government and non-government organisations and other stakeholders about the potential environmental and social impacts associated with Phase 1 of the Tonkolili project. The ESHIA is a legislative requirement in Sierra Leone and this Stage 1 ESHIA report is submitted on behalf of the project proponent.

## 1.5 Glossary

### Definitions

*Phase 1 of the Project* – is Phase 1 of the Tonkolili Iron Ore Project and represents the mining of hematite ore found as a shallow capping deposit overlying the main Tonkolili deposits. This is planned for the initial stages of the project and entails exporting the product via Pepel Port.

*Phase 2 of the Project* – is Phase 2 of the Tonkolili Iron Ore Project and consist of mining and processing of transitional material.

*Phase 3 of the Project* – is Phase 3 of the Tonkolili Iron Ore Project and consist of the open pit mining operation and transportation of concentrate by rail to a newly developed port at Tagrin Point from which it is exported to global markets.

### Abbreviations

| | |
|---|---|
| ANFO | Ammonium nitrate-fuel oil |
| ARI | Average Recurrence Interval |
| BOD | Basis of Design |
| EHS | World Bank Environmental, Health, and Safety Guidelines (2007) |
| EPA | Sierra Leone Environment Protection Agency |
| EQS | Environmental Quality Standards |
| EnvID | Environmental Identification ( a screening process to identify key issues) |
| GOSL | Government of Sierra Leone |
| GVWC | Guma Valley Water Company |
| DFS | Definitive Feasibility Study |
| DfID | UK Department for International Development |
| EHS | Environmental, Health and Safety |
| EITI | Extractive Industries Transparency Initiative |
| ESHIA | Environmental, Social and Health Impact Assessment |
| HIA | Health Impact Assessment |
| ICMM | International Council on Mining and Metals |
| IFC | International Finance Corporation |
| ILO | International Labour Organisation |
| IMO | International Maritime Organisation |

| | |
|---|---|
| IUCN | International Union for Conservation of Nature |
| MAFF | Ministry of Agriculture and Forestry and Food Security |
| MEP | Ministry of Energy and Power |
| MFMR | Ministry of Fisheries and Marine Resources |
| MLHCPE | Ministry of Lands, Housing, Country Planning and the Environment |
| MMR | Ministry of Mineral Resources |
| MoE | Ministry of the Environment |
| MoH | Ministry of Health |
| MTA | Ministry of Transport and Aviation |
| MTAP | Mine Technical Assistance Project |
| MTC | Ministry of Tourism and Culture |
| MWI | Ministry of Works and Infrastructure |
| NWRB | National Water Review Board |
| OP | Operational Policy |
| PM | Particulate Matter |
| SALWACO | Sierra Leone Water Company |
| STAT | Statutory Requirements |
| TQ | Technical Query |
| UNCTAD | United Nations Conference of Trade and Development |
| UNEP | United Nations Environment Program |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| US EPA | United States Environmental Protection Agency |
| WBG | World Bank Guidelines |
| WHO | World Health Organisation |

## 1.6 Referenced Documents

This document has been developed from a variety of sources including some which are used repeatedly for reference through the body of this Stage 1 ESHIA report. Listed below are the references to these sources.

**Document Title**
Ndomahina E.T. 2008. Republic of Sierra Leone Mineral Sector Technical Assistance Project Environmental and Social Impact Assessment (ESIA) Study.
SRK Consulting. June 2009, Tonkolili Iron Ore Project: Environmental and Social Initiation Study.

Nippon Koei UK, BMT Cordah and Environmental Foundation for Africa. January 2005. Bumbuna Hydroelectric Project Environmental Impact Assessment.

Ayibotele N. B. March 2005, National Policy Guideline and Action Plan on Water Supply and Sanitation: Water Supply and Sanitation for Sierra Leone.

NBSAP. 2002. Convention on Biological Diversity, National Biodiversity Strategy and Action Plan (NBSAP).

WorleyParsons. February 2010. Environmental Impact Assessment Screening Form.

The Mines and Minerals Act 2009. Government of Sierra Leone.

The Environmental Protection Act 2008. Government of Sierra Leone.

# 2 ESHIA PROCESS

## 2.1 Relationship between Phase 1, Phase 2 and Phase 3 of the Tonkolili Iron Ore Project

Although many aspects of Phase 1, Phase 2 and Phase 3 of the Tonkolili project are separate, the relationship between these phases is on the whole transitional and may involve at different times some or all of phases running concurrently.

Phase 1 mining operations will result in a product comprising Direct Shipped Ore (DSO) lump and fines which will be mined from a surface (duri-crust) deposit. This phase represents an early, smaller-scale operation that is reliant on a combination of brownfield refurbishment and mining of the relatively easily accessible surface hematite deposits at Tonkolili. Because of these factors, the construction stage of Phase 1 is expected to commence in 2010 and be completed within approximately 6 months enabling a relatively rapid commencement of mining and export.

Phase 2 mining operations will be a combination of continuing the hematite duri-crust mining plus extraction of hematite from a deeper saprolite layer. This will require some grinding and separation probably creating a tailings waste stream. The development scenario is based on providing mine and process plant facilities supported by a narrow gauge rail network to transfer the product to out-loading facilities at Pepel and Tagrin Point. It is expected that Phase 2 will deliver 17 Mpta over and above the 8 Mtpa expected from Phase 1.

Phase 3 represents a significantly larger project reliant on mining a deeper magnetite deposit and more mineral processing, haulage and out-loading infrastructure development. Export of magnetite concentrate is planned to commence after 2014. Phase 3 necessitates a longer construction time than for Phase 1 and 2 and consequently there are elements of the early ‘enabling’ works of Phase 3 that are planned to commence at an earlier date. Therefore Phase 3 construction could occur whilst the earlier phase are in construction and operation.

The Phase 1 project may create significant positive legacy factors in the form of the refurbished former ‘Delco’ rail line and Pepel Port area when Phase 1 transitions into Phase 2. It is understood that this has been considered in the projects lease arrangements with Government of Sierra Leone (GoSL) and that the legacy potential for these assets may enable other mining operations to develop in Sierra Leone. AML has also agreed to manage the port and railway, making those facilities available to other users, including other mining companies and general freight and passenger transport companies, at commercial rates.

It is intended that this infrastructure will in due course provide a facility servicing the West African sub-region, enabling both Sierra Leone and neighbouring countries to export their goods to international markets. The rail and port infrastructure will provide access for people in the region to a reliable and efficient mode of transport; it will encourage the development of other businesses in the area whilst promoting decentralisation from a densely populated Freetown. AML therefore anticipates that the project will bring positive benefits to the local and national economies as well as improving the standard of living for the people of Sierra Leone.

An ESHIA that considers Phase 2 and 3 of the project will be prepared and submitted separately in 2010.

## 2.2 ESHIA Steps

### 2.2.1 Screening

The purpose of screening is to determine whether an EIA (or ESHIA) study is required. Therefore the screening process involves a preliminary determination of the expected impact of a project on the environment and of its relative significance.

Screening processes for the Tonkolili project have included development of an Environmental Aspects Register and submission of a Screening Form with outline project information to SLEPA.

***Environmental Aspects Register***

As part of the screening process an Environmental Aspects Register was developed to gain a preliminary understanding of the project activities and possible consequences in relation to environmental and social aspects. The risk pathways were analysed to identify potential biophysical, social and health impacts. This preliminary screening of environmental and social risks provided a basis for further investigation ensuring that all the major risk pathways had been considered (See Appendix 2 for the Environmental Aspects Register.)

***Submission of Screening Form***

The Screening Form for the project was submitted to the EPA in March 2010. The Screening Form submission triggered screening of the project by SLEPA, albeit it had already been recognised at the pre-Screening stage in November 2009 that the project was Category A. Screening also triggered the Scoping process to obtain agreement on the terms of reference for the ESHIA study.

### 2.2.2 Scoping

On the basis that the project constitutes a Category A project, the next step in the ESHIA process was agreement on the project approach, appropriate project boundary limits; the information necessary for decision-making; and the significant effects and factors to be studied in detail. The scoping stage clarifies the requirements of GoSL through agreed Terms of Reference for the preparation of an ESHIA.

Accordingly a Scoping Procedure document was submitted to SLEPA in March 2010 that contained information on the approach to the ESHIA, including scopes of work for the various specialist studies, examples of rapid assessment surveys and information on the location and preliminary design of key project facilities.

A Regulatory 'Road Map' was also produced to establish a programme of ESHIA deliverables in line with implementation of the early components of the project.

See Appendix 1 for the Regulatory Road Map and Scoping Documents for the Tonkolili project.

Further Scoping was completed in May 2010 when there was formal presentation with stakeholders to describe the scope of works and methodology for the future ESHIA reports. The presentation also included comments and feedback from interested stakeholders. A transcript of the presentation and issues raised is included in Appendix 1.

A separate Scoping report was produced in April 2010 for the haul road component of the Phase 1 project as requested by the SLEPA. This report outlined specific environmental and social issues related to the haul road and was produced at an early stage to reflect the early construction timeline for this component of the project.

### 2.2.3 Impact Assessment

The following components have been included in this impact assessment.

***Project Description & Baseline***

A full project description is required to gain an understanding of the project elements and activities. The project description presented in this ESHIA is complete to the best of our ability with the known information about the project.

The baseline description provides an assessment of the existing environment including social, health as well as physical aspects within the project area and in the surrounding region.

***Impact Assessment***

This assessment includes the projects likely effects on the existing environment including social, health as well as physical aspects. Specific review have been completed to assess potential impacts to air quality, noise, ecology and biodiversity, hydrology and hydrogeology, soils and land use, geology and geomorphology, socio-economic effects, cultural heritage and human health. Impacts are assessed by magnitude, extent and duration and their relationship to sensitive or 'valued receptors'.

***Review of Mitigation Measures***

Mitigation measures aim to prevent adverse impacts from happening and to control the impacts that do occur within an acceptable level. Opportunities for impact mitigation will occur throughout the project cycle. The objectives of mitigation are to enhance the environmental and social benefits of the project; avoid, minimise or remedy adverse impacts; and ensure that any residual adverse impacts are kept within acceptable levels. The mitigation measures are discussed in the impacts section so that the clearest analysis of what are considered to be remaining or residual impacts can be obtained.

***Management Strategies***

Management plans and strategies will translate recommended mitigation and monitoring measures into specific actions that will be carried out by AML. Management plans will then form the basis for impact management during project construction and operation.

***Commitments Register***

The Commitments Register presents the issues that require further management after completion of the assessment. These issues may be residual impacts identified in the ESHIA impact assessment process. The register includes a description of the issue, action required to address the issue, person responsible and date that action is required by.

***Auditing, Monitoring & Continual Performance Improvement***

The auditing and monitoring step provides information that will assist in impact management and to improve understanding of cause-effect relationships and mitigation methods. Auditing is necessary to certify that practice is in accordance with established procedures and to identify how processes or systems can be improved. Continual improvement is central to auditing, monitoring and performance assessment.

## 2.3 Terms of Reference for ESHIA

### 2.3.1 Terms of Reference

One of the principle functions of the scoping stage is to guide the development of appropriate terms of reference for the ESHIA. This has been developed using a combination of consultation and procedural techniques.

The stakeholder engagement process is broadly outlined in Section 2.4 below. Consultation undertaken during project Scoping has enabled the development of ESHIA Terms of Reference by engagement with stakeholders and determination of their different interests. This has taken place at many different levels in the project as follows:

- ‘Phase 2b‘ survey work has involved community consultation to help define and target specialist scientific survey work (for example botanical studies near the mine site). Local names, use of natural resources, distribution and trends in abundance or decline have been developed from this level of focus-group consultation;
- Discussions at a community level through the Early Works Consultation Committee (EWCC) forum about community level concerns and expectations. This has been recorded and used to define specific issues such as proximity of project facilities. District level consultation with affected communities near the mine site has been taking place since September 2009, with monthly EWCC forums running from February 2010 across the entire project area;
- Consultation with high level stakeholders (Ministers and GoSL Department Heads) through 2009 and into 2010 has helped align the study work according to local legislation and cultural norms. This level of consultation has also helped clarify the expectations associated with the level and protocol for community consultations. Ministerial consultations have helped focus studies towards areas of concern, for example ministerial consultations have indicated specific conservation requirements, data gaps and areas of legislation reform

SLEPA procedural guidelines associated with conducting an ESHIA for mining and on-site mineral processing have also been used in preparing the ESHIA Terms of Reference. The following sections have been developed (procedural guidelines are presented in Appendix 1):

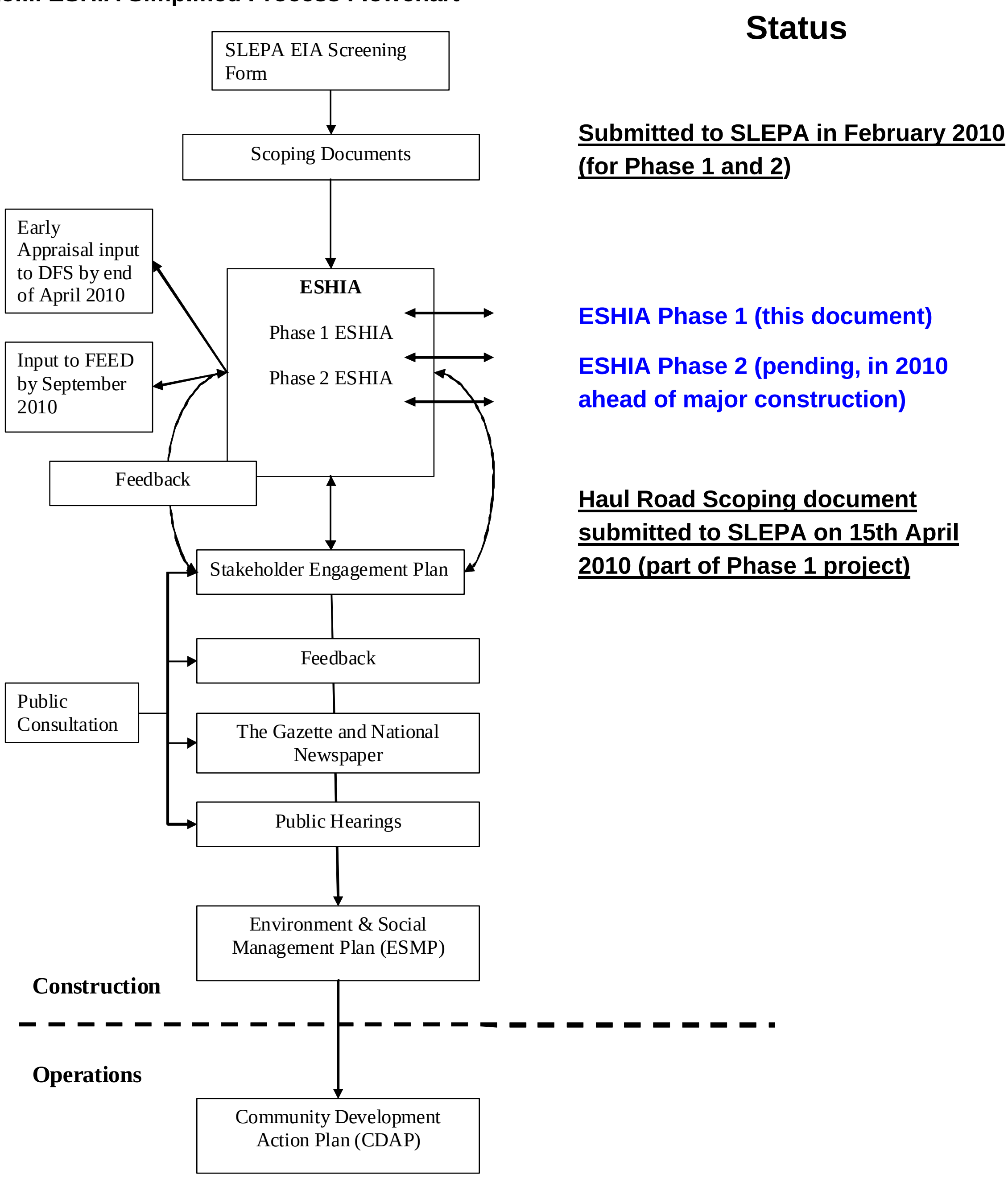
**Table 2-1 Procedural Fulfilment of the ESHIA**

| SLEPA Procedural Requirement | ESHIA Section | ESHIA Report Content |
|---|---|---|
| Purpose and Physical Characteristics of the Project | Section 3 | PROJECT DESCRIPTION |
| Land-use Requirement of the Proposed Project | Section 3 | PROJECT DESCRIPTION |
| Operational Features of the Proposed Project | Section 3 | PROJECT DESCRIPTION |
| Alternative Sites and Processes Considered | Section 3.4 | Project Options & Alternatives |
| Physical Features of the Proposed Site | Section 6 | PROJECT AREA BASELINE |
| Legislative and Policy Framework | Section 4 | Legislative and Policy Framework (See Section 3: 'PROJECT DESCRIPTION');; |
| Impact on Human beings and the Human-made Environment (Construction and Operations); | Section 7 | POTENTIAL IMPACTS & MITIGATION |
| Impact on Land, Water Resources, Air Quality and Climate, Flora and Fauna | Section 7 | POTENTIAL IMPACTS & MITIGATION |
| Other Indirect and Secondary Impacts | Section 7.6 | Distributed Impacts from Project |
| Information Gaps and Uncertainties | Section 9 | ONGOING WORKS |
| Significance of Impacts | Section 7.1 and Section 8 | Impact Identification & Evaluation and RESIDUAL IMPACTS |
| Mitigating Measures | Section 7 | POTENTIAL IMPACTS & MITIGATION |

Terms of Reference for the different phases of the Tonkolili project have been established together. Screening information, stakeholder presentations and scoping materials have carefully differentiated the two project phases while also clearly describing their inter-dependencies.

During Scoping an ESHIA flow chart was developed that provides a plan of how the ESHIA process could be best managed. The flow-chart is presented in Figure 2-1. It was recognized that a series of separate ESHIA covering the different phases would be necessary.

**Figure 2-1 Tonkolili ESHIA Simplified Process Flowchart**



This rationale has been followed with the submission and development of the following ESHIA components:

- A series of reports that in combination represent the ESHIA for the Phase 1 Haul Road;
- Stage 1 ESHIA (this document);
- Stage 2 ESHIA (pending);
- Specialist ESHIAs required for specific technical elements of the project (eg Dredging Impact Assessment, Visual Impact Assessment, also pending);
- Development of Risk Assessments to evaluate non-routine events such as spillages, integrity failures, traffic and accidents;
- Strategic Environmental Assessment – to evaluate potential change at national and institutional level arising from this project (pending).

The integrity and coherence of the ESHIA program particularly with respect to determination of overall cumulative effects whilst individual ESHIA components are being developed is achieved through the following ongoing activities:

- liaison with SLEPA throughout;
- over-arching environmental and social management (auditable); and
- monitoring by independent organization with reporting to SLEPA and stakeholders.

This ESHIA has been prepared for submission for approval on the understanding that elements of the infrastructure design and ESHIA study are not yet fully developed. In recognition of this, the proponent (AML) has committed to undertake completion of the various ESHIA studies, which are either ongoing or soon to be undertaken and will be reported on in updates to the Environmental Management Plan (EMP) and as part of the Stage 2 ESHIA. Comprehensive environmental and social (E&S) management will continue, with the studies inputting to project design, construction and development. It is recommended that rigorous risk review is applied in the interim ahead of final ESHIA Stage 2 submission in order to identify appropriate Environmental and Social (E&S) management measures, which will be delivered through the ongoing EMP that will extend into the operational phase.

### 2.3.2 Scope

The Scope of the Stage 1 ESHIA has included the following elements:

1. Development of project information from AML and their contractors;
2. Undertaking environmental identification (EnvID) review and developments of an environmental and social aspects register;
3. Site-specific studies that have been undertaken over the last 12 months using an ESHIA team from WorleyParsons, international experts and local specialists and organizations;

4. The scope of the survey work undertaken comprises terrestrial ecology (fauna, flora, avi-fauna and aquatic); marine ecology and sampling of water and sediment, air and noise studies, surface and groundwater sampling, weather measurements, flow measurements and well inventories, soil logging and physicochemical sampling, socio-economic baseline studies incorporating specialist focus group including women's groups and youth organizations and an initial health appraisal across a small randomized population sample along with a district level health review;
5. Repeat study work in order to evaluate seasonality;
6. The scope of the assessment work undertaken comprises biological species sample collection and categorization, water, soil, sediment and tissue laboratory assessment and evaluation against guideline values, numerical modelling and screening to determine air quality, climate, marine and groundwater behaviour, processing of socio-economic questionnaires and review of pollution sources and control measures and waste management capacity;
7. The impact assessment has used standardized impact magnitude and valued receptors techniques. Extent, duration and likelihood values have been standardized against WorleyParsons risk management terms;
8. Identification of further work programs have been evaluated, critiqued and scoped based on gap analysis by relevant specialists in the respective fields;
9. Identification of mitigation techniques, future management practices and ongoing monitoring and performance auditing has been developed in conjunction with AML's environmental management office and represents a commitment from the proponent linked as a conditionality to the ESHIA licensing process.

### 2.3.3 Exclusions

The Stage 1 ESHIA work has utilised over 12 months worth of survey and study work as described in the scope above. Notwithstanding the large body of work already collected there are recognized to be a limited number of areas that are still not well understood. Coverage of these areas in the ESHIA has been achieved by taking a strategic view on likely impact and behaviour extrapolated from what is currently known. The following exclusions apply to this work:

- SLEPA has not provided direct comment with respect to the Terms of Reference or scope of this Phase 1 study. Guidance on the coverage and content of this report has been taken from comments returned by SLEPA relating to the ESHIA interim reports prepared for the Haul Road;
- There is no single feasibility study report that covers the entire Phase 1 project. Details on project description, layout and alternatives has been derived from information obtained either directly from AML or their nominated contractors;

- Limited to no information other than site selection has been available for the air-strip proposed near the mine-site; a full assessment of this facility has therefore, been excluded from the Stage 1 ESHIA;
- Limited information other than basic site selection has been available for the dredge spoil disposal sites; a full assessment of this facility has therefore, been excluded from the Stage 1 ESHIA;
- Limited to no information has been available for the proposed power supply or supplies for Phase 1; a full assessment of this facility has therefore, been excluded from the Stage 1 ESHIA;
- This report has not addressed all aspects of the IFC performance standards and hence by extension, the Equator Principles. However it is considered that a sufficient level of assessment and ongoing environmental management is underway / pending to demonstrate acceptable non-financial risk management and avoidance;
- It has not been possible in the available time to obtain seasonal data for all of the representative periods (wet, dry and transitional periods).

## 2.4 The Stakeholder Engagement Process

Consultation and disclosure about this project to the public, affected people and a wide range of other stakeholders has been achieved through a stakeholder engagement process. This is still underway and it can be said there will be maintenance of a forum through community committees and official liaison throughout the life of project. Implementation of the stakeholder engagement process based on detailed analysis and a structured approach to public consultation and disclosure in all project phases is provided in more detail in Chapter 10.

In summary, this process is structured as follows:

- Stakeholder analysis will be presented, outlining the different stakeholders involved in the Project and their potential to influence project outcomes;
- National norms followed in Sierra Leone and international requirements including the Equator Principles (EP) and the Voluntary Principles on Security and Human Rights (VPSHR) for stakeholder engagement;
- Different types of stakeholder engagement activities will be explained and the activities undertaken to date will be listed and reported on;
- Analysis of comments from stakeholders will be presented at the outset and then updated at various defined stages throughout the Project lifecycle;
- A plan for stakeholder engagement in subsequent phases of the Project is proposed including the human, logistical and financial resources required for the plan.

## 2.5 The Structure of this Report

The structure of this report is summarised below:

- Chapter 1 is the introduction to the ESHIA report;
- Chatpter 2 describes the ESHIA process, the relationship between the project phases, terms of reference, stakeholder engagement and IFC policies;
- Chapter 3 is the description of the project which consists of the following project elements: mine; transport corridor; port and offshore. The section also describes the supporting infrastructure required by the project;
- Chapter 4 presents the institutional bodies and national legislation that applies to this project;
- Chapter 5 describes the existing environmental and social conditions in the overall regional area, including the following issues climate, air & hydrology; soils land use & ecosystems; marine and population and demographics;
- Chapter 6 describes the existing environmental and social conditions in the project area. The mine, transport corridor and port project elements are assessed against the following categories: air quality; noise; archaeology; ecology & biodiversity; hydrology & hydrogeology; soil & landuse; geology & geomorphology; socio-economic and human health. The offshore & coastal environment has also been considered;
- Chapter 7 outlines the potential impacts for each of project elements and provides an evaluation and assesssment of the signifcance of the impacts. Mitigation measures have been identified to address these significant impacts;
- Chapter 8 presents the ongoing assessment works that will be undertaken as part of the ESHIA programme;
- Chapter 9 outlines the environmental and social management plans required to address issues identified in the ESHIA studies;
- Chapter 10 contains the Public Consultation and Disclosure Plan & Resettlement Policy Framework;
- Chapter 11 presents auditing, monitoring and continual performance improvement;
- Chapter 12 is the Commitments Register which outlines the future commitments required for the long term management of the project;
- Chapter 13 Conclusions and Recommendations;
- Chapter 14 References.

# 3 PROJECT DESCRIPTION

## 3.1 Project Overview

'Base-case' engineering options for the project have been used in this report. However, it is also recognised that further alternatives and options are being considered leading to optimisation during successive stages of the project. More detail on engineering design and material quantities is given in the referenced reports. The description below represents the know project description as of May 2010 and has been selected on the basis of relevance to the determination of likely environmental and social footprint of the project that were identified during the development of the Environmental Aspects Register (See Appendix 2).

The review of engineering, baseline conditions and preliminary impacts has been structured into four elements comprising the Mining Area, Transport Corridor, Port Facilities and Offshore.

## 3.2 Proposed Development

The locations of the principal elements of Phase 1 of the Tonkolili project are described below and in Table 3-1:

- Mining Area - hematite deposits from Phase 1 are located along the crown of the Simbili formation. Supporting mine infrastructure, accommodation facilities and mining plant will be located in the Mawuru and Tonkolili valleys southwest of Simbili. See Figure 3-3
- Transport Corridor – a haul road is under construction from the mine site to a rail interchange at Lunsar (approximately 120 km). Ore is then transported by narrow-gauge rail to Pepel along the original Delco rail line which is to be refurbished;
- Port Facilities – ore will be exported from Pepel port using a combination of new and refurbished facilities for rail dumper, ore handling and stockpiling and the existing wharf interface including refurbishment of the existing jetties;
- Offshore – the base-case option assumes off shore anchorage loading of ocean going bulk carriers (Panamax or Cape size) from transshipment vessels loaded at the primary Pepel jetty.

**Figure 3-1 Phase 1 Mine to Port Transport Route**

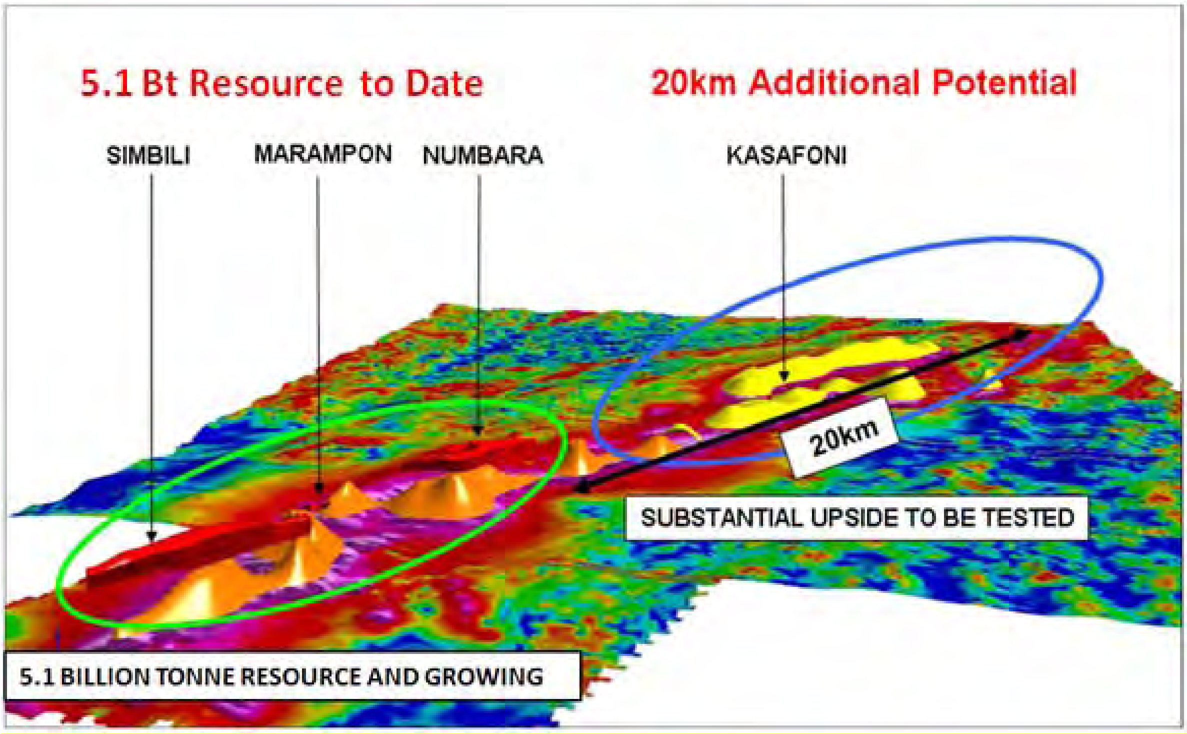

**Table 3-1 Summary of the different locations of Phase 1**

| Project Element | Phase 1 Location |
|---|---|
| Mine Area | A 1-2 km$^2$ mining area that spans the crest of Simbili and with additional areas for accommodation and beneficiation infrastructure. |
| Transport Corridor | New haul road and refurbished Delco rail line |
| Port Area | Pepel Port, occupying the southern part of Pepel Island |
| Offshore | Panamax shipping from transshipment anchorage offshore of Freetown |

### 3.2.1 Element 1 - Mining Area

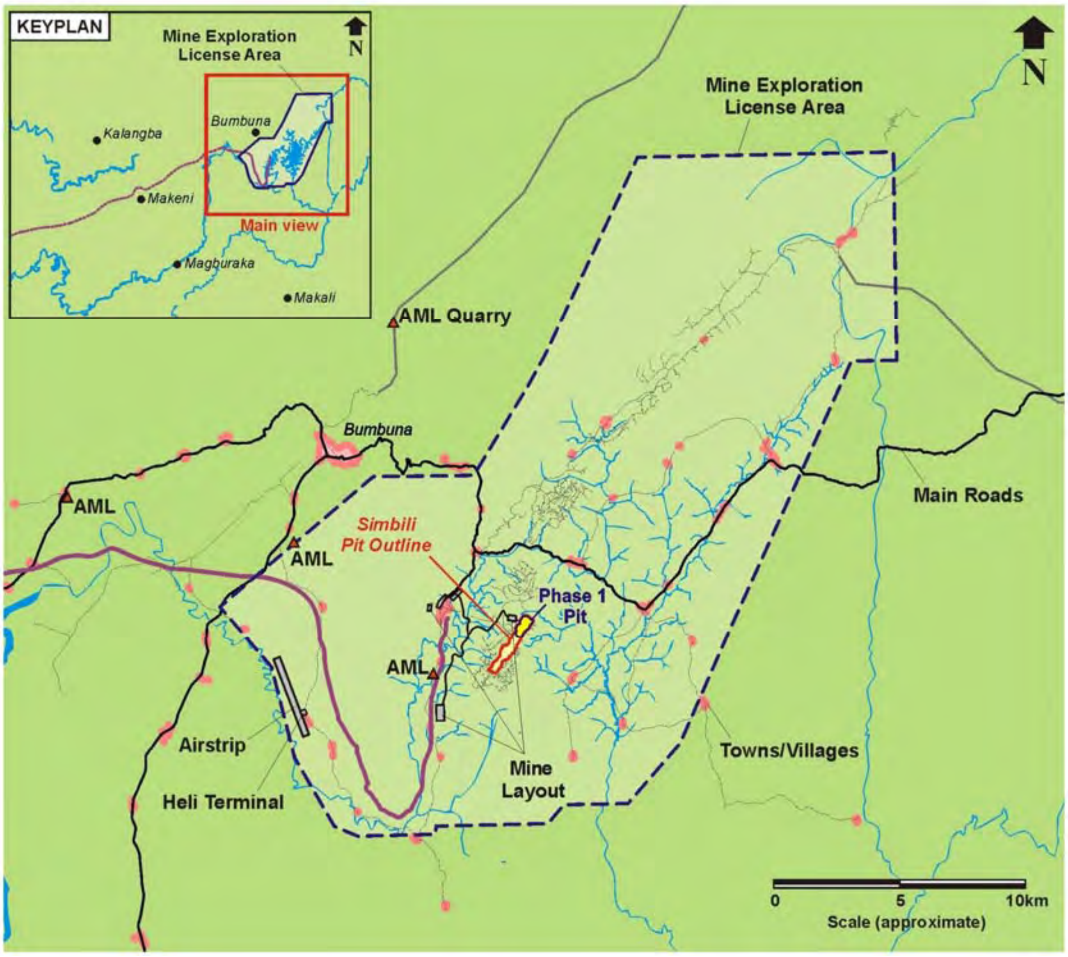
The magnetite and hematite deposits that forms the basis for the full-development Tonkolili project occurs in a north-east to south-west trending hilly outcrop. Drilling work has confirmed the magnetite ore body reaches commercial grades of iron enrichment beneath three hills named Simbili, Marampon and Numbara illustrated in Figure 3-2 below. Hematite occurs as a duri-crust deposit on these deposits extending to approximately 50m depth with a further 50m depth of transitional zone. Phase 2 mining will target this transitional material. Magnetite is encountered at approximately 100m depth below surface. Phase 3 mining will target magnetite beneath Simbili, Marampon and Numbara and the expected pit depths extend to approximately 700m depth (SRK, May 2010).

**Figure 3-2 Tonkolili Mineral Deposits**




Phase 1 of the Tonkolili project targets the overlying hematite/goethite deposit in the Simbili region, and is intended to produce 8,000,000 tonnes (8Mtpa) of saleable product per year. Exploration has indicated an ore reserve in the order of 800 Mt. The iron content of the hematite/goethite ore can be increased to exportable grades through beneficiation. This requires relatively lower levels of processing and investment in order to commercialise this phase of the project than needed for Phase 2 and 3. Crushing and sorting techniques will be required during Phase 1 near the point of extraction with limited to no chemical or processing involved. The hematite deposit extends to approximately 50m depth in some areas, although it is characterised as having a highly variable distribution and concentration across the deposits. Between the base of the hematite deposit (-50m) and the top of the underlying Tonkolili deposit (-100m) there is a 'transition zone' of heterogeneous mineral composition. This transition zone will be mined as part of the Phase 2 works.

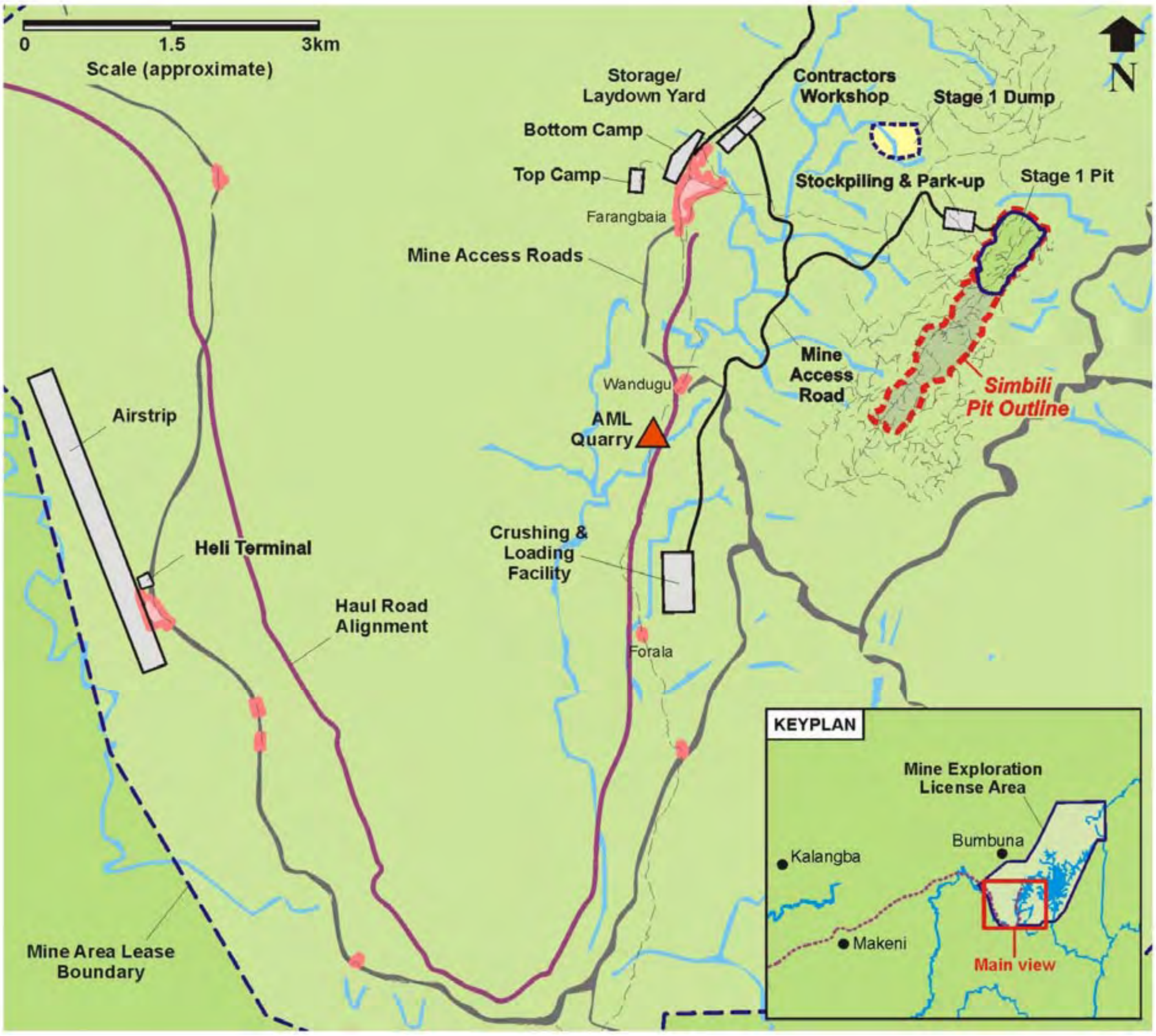
**Figure 3-3 Phase 1 Mine Location**




Shipping of the hematite product is planned to commence in January 2011. In order to produce the required 8 Mtpa, some 10.4 million tonnes of run-of-mine will have to be beneficiated, and a total of 34 million tonnes of material (ore and waste) will need to be mined. The strip ratio is expected to vary between 0.5 to 1.5 during Phase 1 mining.

Mining will be undertaken with a conventional truck and shovel operation. Ore will be hauled to a crushing and screening plant, to be located southwest of Simbili. Waste will be initially used for construction of access and haul roads, and for various other infrastructure projects in preparation for the commencement of Phase 3 construction. Excess waste will be dumped in areas to the west and northwest of Simbili, outside the final magnetite pit limits so as to avoid rehandling.

**Figure 3-4 Phase 1 Mine Detail**




Phase 1 mining equipment will consist of 3 hydraulic shovels (operating weight 380t each) and 21 haul trucks (payload capacity 130-140t each). Ancillary equipment will include 2 water carts (130t capacity), three tracked dozers (Caterpillar D10 or equivalent), and 2 graders (Caterpillar 16M or equivalent).

Mining will be conducted on a 24 hour basis, with three crews working two 12 hour shifts.

The designed pits are 50m deep and 1.3 km2. The approximate location of the mining areas on Simbili is shown in Figure 3-4 and it is likely that the northern zone will be mined first.

*Mine Layout*

The proposed Pit with the Stockpiling and Park-up area is located approximately 2.5 km east-southeast from the main village of the area, Farangbaia, and 3.3 and 3.7 km east-southeast from the

AML bottom and top camps, respectively. The stockpiling and parking area is approximately 3 km southwest of Kemadugu, 2.7 km southeast of Kegbema, 2.5 km northeast of Wandugu, 5 km northeast of Furia, and 5.3 km from other small villages in the greater area.

An airstrip will be oriented approximately north-south in the Tonkolili River valley west of the Farangbaia forest reserve.

The main access road extends south from the contractor's workshop area to the mine haul road and is located approximately 800 m east of the centre of the main village, Farangbaia, 850 m east of the bottom camp and 1.3 km from the top camp.

The mine haul road is approximately 400 m east of the centre of Wandugu and Furia.

The Contractors Workshop is approximately 600 m northeast of the centre of Farangbaia, and approximately 1.2 km northeast from the centre of the bottom camp to the centre of the top camp.

The Crushing and Loading Facility is approximately 600 m northeast from the centre of Furia and approximately 2 km south from the centre of Wandugu.

Material from Phase 1 will be hauled down a series of ramps to the north and through a cutting on the western side of the ridge. Ore will continue to be transported down to the crushing pad, located to the south of the Tonkolili River, near the village of Wandugu. Waste from this phase will be taken to a waste dump located to the northwest of the cutting (Figure 3-4) although some of the more competent waste will be used for additional road and pad construction, in preparation for the commencement of the second phase and the subsequent magnetite operation.

*Dewatering*

Major dewatering should not be required, given the elevation and drainage of the Phase 1 pits, however, localised dewatering may be necessary from time to time. It should be noted that the deposit lies in a tropical region, which is subject to a large amount of rainfall during the months of May to October. The mean annual rainfall for the region is 2,542mm.

*Accommodation*

Camp facilities will be constructed for the development. Capacity of camps is estimated to be 600.

*Blasting*

Blasting activities will begin within 3-4 weeks of the project start up and will be conducted for most of the life of the project as the excavation first progresses along the ridge to the northwest in Phase 1, then advances to the south in Phase 3. Blasting will occur 2 times each week during the day only, and will generally be confined to within the top 20 meters of excavation. Each blast will affect an area of 4,000 $m^2$. Given the nature of the rock, powder factors are likely to be low; therefore vibration from blasting activities should also be low. Some oversize blasting may be required in lower levels of the excavation. Blasting is likely to utilize Ammonium nitrate-fuel oil (ANFO) as a bulk explosive and non-electric (nonel) surface and down-hole delays. Each hole will be stemmed prior to blasting.

*Site Restoration*

The entire Simbili hematite mining operation is contained within the larger magnetite pit shell and therefore, rehabilitation of the pit is not deemed necessary on the assumption that Phase 3 will continue on from Phase 1 and 2. The haul road to the ore pad will be utilised during Phase 3 as an access road. The waste dump for Phase 1 will be enlarged as part of the Phase 3 magnetite waste disposal facility.

### 3.2.2 Element 2 -Transport Corridor

Beneficiated hematite ore will be transported using a combination of road-trains on along a specially constructed haul road followed by haulage using a light-gauge rail track. The 122 km long haul road built from the mine site to a railhead about 8 km North-West of Lunsar where it ties in with the existing railway which is to be refurbished.

More detailed description of the haul road design, cross-sections, waypoints, river crossings, villages, forests and other areas of environmental and social concern have been provided in a stand-alone Haul Road Scoping report submitted to SLEPA in April 2010 (WorleyParsons Report ref. EN-REP-0014). Relevant excerpts are provided in Appendix 1. Only a brief summary is included below.

**Figure 3-5: Map 1 of Haul Road Alignment**

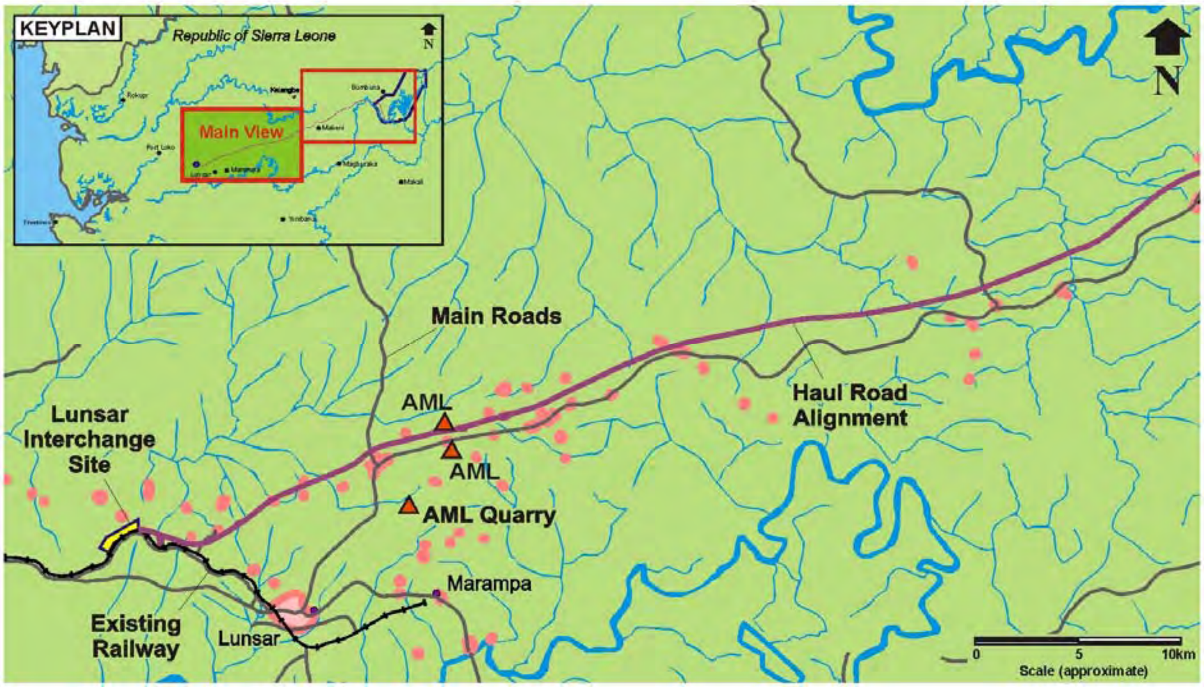
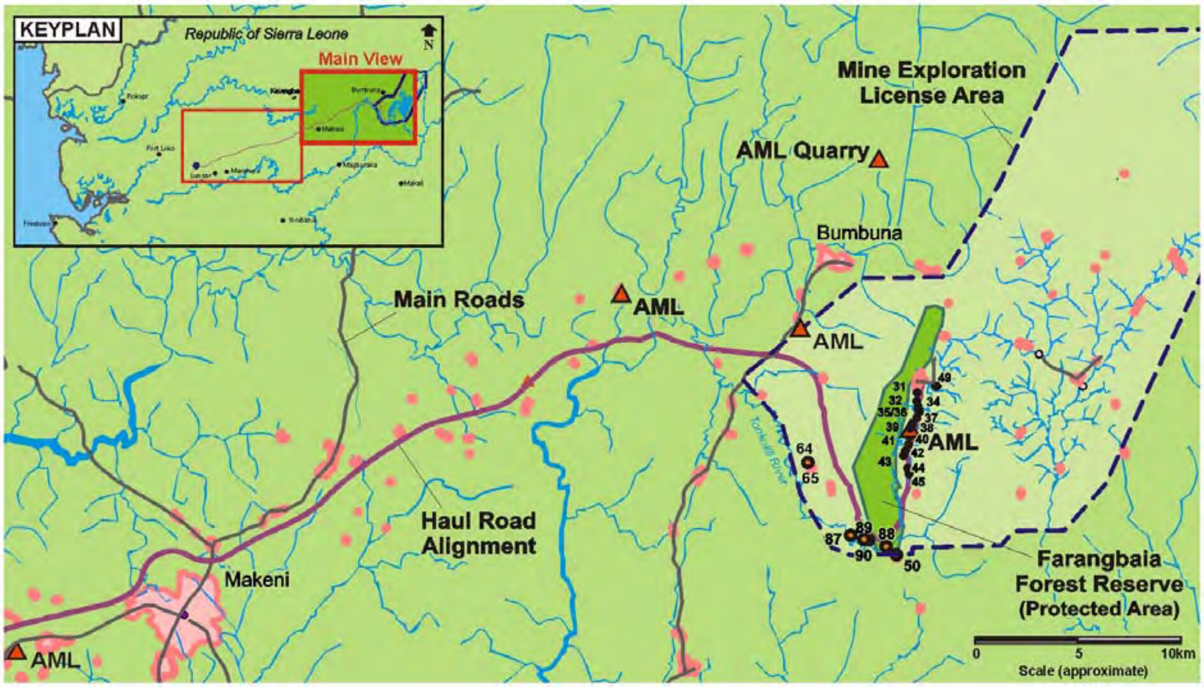


**Figure 3-6: Map 2 of Haul Road Alignment**




Between Lunsar to the Rokel River crossing the topography is slightly sloping, gently undulating and varying in elevation between about 100 and 110 masl. Here the haul road will be situated generally on low embankments or shallow cuts. From the Rokel River to the mine site (chainage Km 110 to Km 122), the topography becomes much steeper and there are steep valley slopes and rivers and the underlying material is hard rock. Here, significant cut and fill volumes should be expected with most of the cut in hard rock, probably requiring the use of explosives (subject to approvals granted from the Government of Sierra Leone).

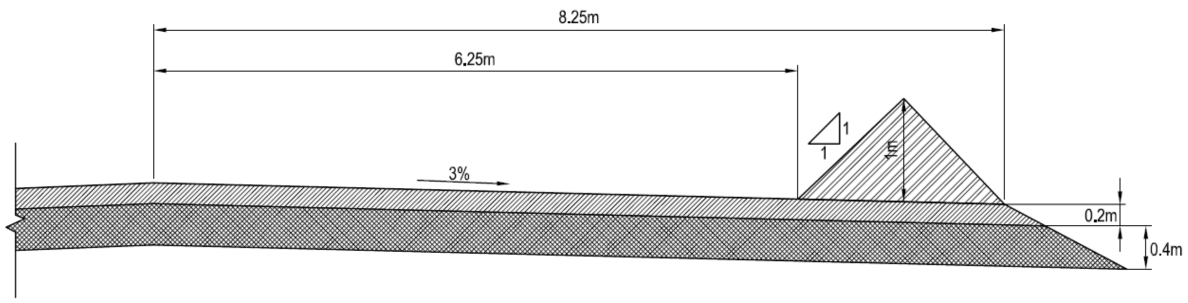
The first part of the schedule of works for the haul road has been initiated comprising initial reconnaissance survey and in some areas development of a scout road. The development of further work associated with clearance, road widening, profiling and sealing (drainage etc) are subject to confirmation from SLEPA in response to prior submissions (Haul Road Scoping, EMP and other reports that have been generated in April 2010).

During the initial site clearance and creation of the scout road, vegetation has been cleared using bulldozers. Further clearance will be required for the entire length and width of the route using a heavy flail attachment on 360 excavators or similar approved fittings for a tractor. Local labour will use machete / sickle to cut back.

The following environmental management measures are being undertaken. All decomposable vegetation waste will be re-introduced into neighbouring vegetated areas. Trees will be logged in a controlled manner and under direct supervision of trained competent personnel. Logging gangs will be operating well ahead of road construction activities. Suitable timber will be sent to saw mill for replacement sleepers. Waste timber will be stockpiled for disposal or re-introduced into bush. All tree roots will be removed in entirety by mechanical means / chains and shackles. Virgin bush will be cleared with the use of CAT D6 / D8 machinery along proposed centreline of roadway. All construction waste is anticipated to be non-hazardous. All waste to be recycled and re-used wherever possible, and surplus to be used as haul road earth berms. Organic top soils will be stored in managed stockpiles and reused for profiling of berms and other waste material that can be revegetated and for rehabilitation of other areas impacted by the project.

When completed the road will comprise a compacted but unsealed surface edged with 1m high earth berms. The road will have two lanes, with a nominal width of 12.5 m (16.5 m with berms). Drainage from the road will be controlled by a cross-sectional road profile that drains to the edges with gaps in the berm edging at intervals to release flows.

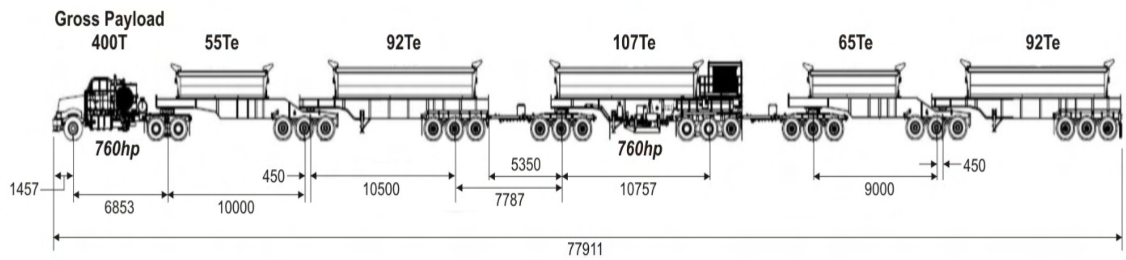
**Figure 3-7: Typical cross-section of the Haul Road**




At about Km 94 the haul road will cross the River Rokel - the major river in the area (approximate span 90m). There will be other smaller river crossings at km 50 (River Tabai – approximate span 40m) and at around Km 110 where the haul road will cross the Tonkolili River at several locations (approximate spans 20m).

The ore will be hauled using road train type vehicles. The road-trains will consist of a tractor unit and five motorised trailers with a gross payload of 400 tonnes.

**Figure 3-8: Road-train**




| | | | | | | | | | | Totals |
|---|---|---|---|---|---|---|---|---|---|---|
| TARE | 7.8 | 22.7 | 22.2 | 17.0 | 16.2 | 26.1 | 16.7 | 22.2 | 17.0 | **168.0** |
| PAYLOAD | 1.1 | 27.6 | 50.9 | 58.4 | 59.4 | 47.6 | 41.9 | 52.7 | 58.4 | **398.0** |
| GROSS | 8.9 | 50.3 | 73.1 | 75.4 | 75.7 | 73.7 | 58.6 | 74.9 | 75.4 | **566.0** |
| ALLOWED | 12.0 | 50.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | **587.0** |

Speed limit on the road will be set at 60 km per hour. Minimum travel time for road-trains will be approximately 2 hours. 22 vehicles will be travelling between the mine and Lunsar Interchange. Transshipping will operate 24 hours a day.

### *Route Selection*

The following design principles have been utilized for the haul road:

- All villages to be provided a clearance of at least 500m where practicable;
- Severed access tracks between villages to be maintained with 2.4m diameter corrugated steel pipe culverts to act as an underpass beneath the haul road. Actual requirements and locations to be site determined;
- A clearance of at least 500m is to be provided to areas of sacred bush where practicable. Site-specific requirements and locations are subject to local variability;
- 100m minimum clearance from any overhead power lines will be observed. All temporary access beneath lines to be fitted with ticker tape marker poles as notification measure. Clearance levels to be sited and clearly marked on both sides;
- 500m minimum clearance to any Telecom communication towers. All temporary access beneath lines to be fitted with ticker tape marker poles as notification measure. Clearance levels to be sited and clearly marked on both sides;
- At road intersections a modular steel bridge to carry the existing road over the haul road will be installed. Where the existing roads are minor, a manual form of traffic control will be required (manned boom).

### *Construction Materials*

Crushed rock and nodular ferricrete gravel will be used as construction material for the haul road. The material will be excavated from the quarries nearest to the construction areas. Several potential quarry sites have been identified as being economically and technically suitable. Crushed rock potential quarries are located at the following locations:

- Makele Quarry at Makeni is an existing quarry but will require complete renovation with new equipment;
- Potential quarry site located 1km north of km 48 on the existing road requiring investigation and development. The rock has been identified as amphibolite from 2 small surface exposures. The overburden may be ferruginous and suitable for sub-base or selected fill layers;
- Kerfay quarry near Lunsar appears to have had minor use in the past but will need development. The rock is granite which is exposed at the surface.

There are numerous granite exposures ranging up to significant sized granite domes. It is possible that these will provide rock suitable for use in the base course. Investigation and development will be required.

Borrow pits for nodular ferricrete gravel were recorded at various locations adjacent to the existing road and adjacent to the road running north from Farandugu. Visual observations indicated that the material has high nodular gravel content and should have a CBR (California Bearing Ration) well in excess of 30 and possibly up to 80. Observations in cuttings indicated extensive availability of ferricrete. It is expected that up to 40 percent of the material excavated from cuttings of more than 3m depth may be suitable for sub-base and wearing course construction. The haul road is to be constructed with four layers comprising Sub Grade, Sub Base a Base layer and the Surface.

***Equipment***

The equipment used for the haul road construction include - excavators, graders, pumps and concrete batching as well as small plant. Equipment is listed in full in the Haul Road Scoping report (WorleyParsons, April 2010).

***Accommodation***

Three camps will be constructed in order to accommodate workers:

- Rogbere Camp;
- Makeni Camp; and
- Camp close to Tonkolili.

Construction of the camps is required as an early Phase 1 activity and the project programme requires completion June 2010. Design, dimensions of the camps, energy sources, water and waste management and power demand will be controlled through specific environmental management plans.

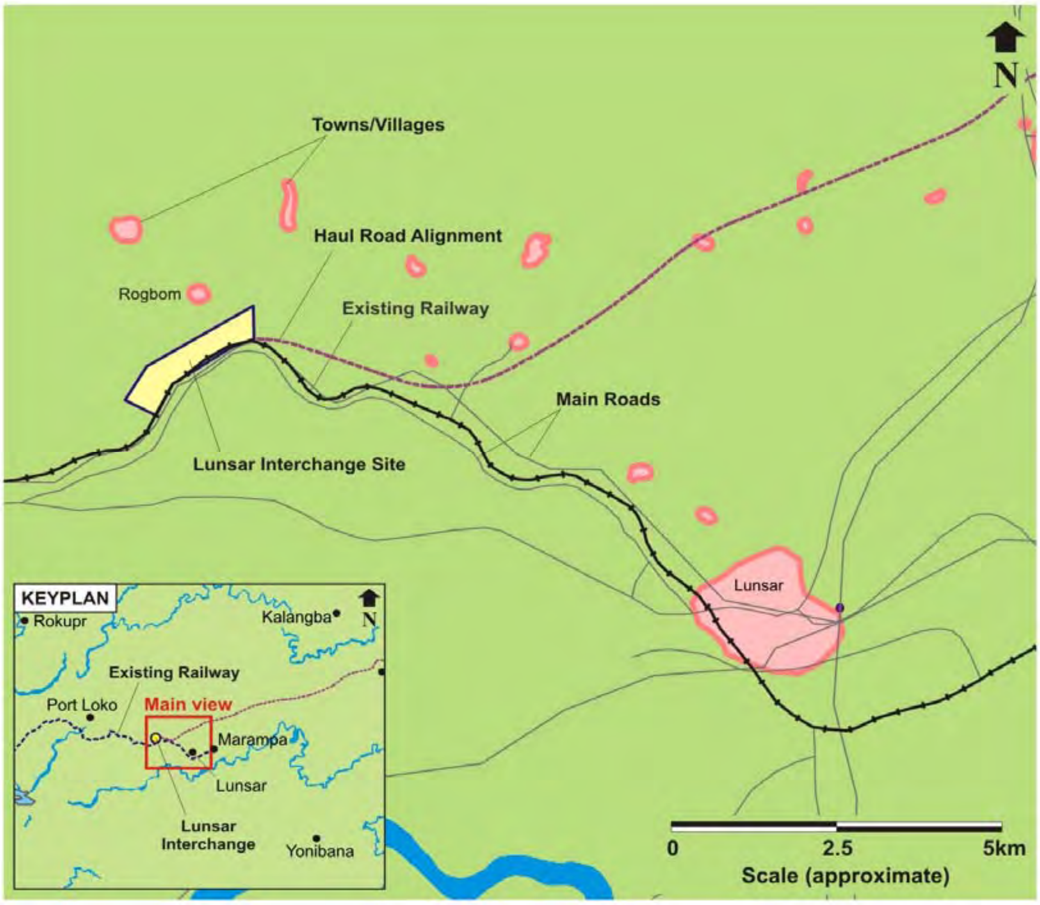
It is assumed that water requirements will be one bore hole per camp. Water treatment plants will be constructed at each camp. 30,000 L a day of water will be treated, while 50,000 L will be stored at each camp. At the moment it is assumed that black water treatment plants will be placed at each camp. Solids will be removed periodically by honey sucker.

***Lunsar Interchange***

The road-trains will offload hematite ore at Lunsar Yard. The loading yard at Lunsar will consist of 3 stacking lines for stock-piling iron ore. The capacity of the combined stockpile will be around 4 million tones. The construction of the Yard will include building of four staging lines at Lunsar yard each approximately 1km in length to serve as the load out yard, installation of six 1:9 40kg turnouts, the supply and installation of one 40kg stopblock. The works will also include the construction of one office building. Fuel will be provided at the fuel yard, which will be 100 m in length. Fuel storage for road trains and the facilities will be required. The interchange will operate on a 24 hours per day basis. Six trains will carry ore to the Pepel Yard each day. Each train will consist of 50 wagons. Total payload per train will be 2500 tonnes max.

Rail transport from Lunsar will be along a narrow-gauge railway line which had previously been between Marampa and Pepel for iron ore transport operations (Delco 1933 to 1975). The 'Delco' line is to undergo refurbishment along with the port and wharfing facilities at the terminus on Pepel Island, which AML are operating under a 99 year lease agreement with the Government of Sierra Leone (GoSL). The lease arrangement licenses AML to reconstruct, manage and operate Pepel Port and the Pepel – Marampa Railway.

**Figure 3-9 Lunsar Interchange**

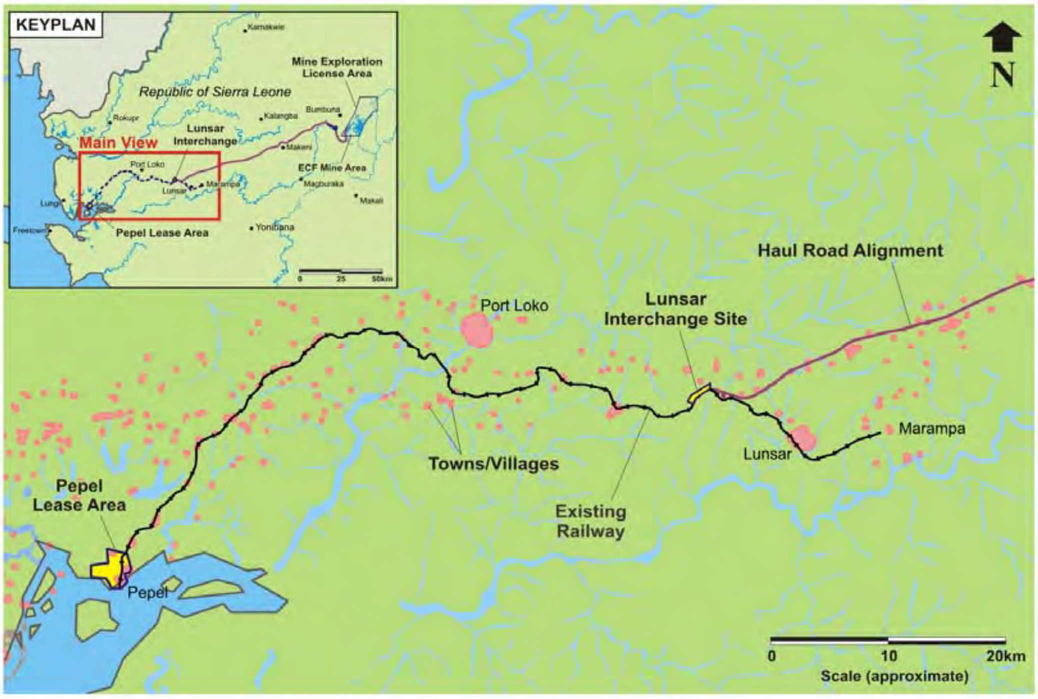


***Phase 1 Rail Refurbishment***

Construction activities will require a number of works to be undertaken along the existing narrow gauge (1065mm) single track rail line alignment.

The scope of work includes the repair and construction of approximately a 72km main line, two 1km loops and a new rail loading yard at Lunsar as well as remedial work on the existing rail infrastructure at Pepel yard.

**Figure 3-10 Rail Map**




Line clearance works will be performed by local workers using hand held machetes The track will be constructed by initially lifting the existing rails and sleepers wherever they remain in position then relaying 40kg/m rails comprising reconditioned and new sections to be laid on reconditioned steel sleepers spaced at 650mm centers laid on 1200m³ ballast profile. One loop lines will be constructed at approximately 20km and a former loop at 42km reinstated and a new loading yard constructed at Lunsar.

***Construction methodology:***

1. Site Preparation

The works to be performed by the contractor involves the following:

- *Camp Site Establishment*

- *Site Vegetation Clearing* - grass, shrubs, bush, trees and other vegetation along rail formation and adjacent to drainage channels will be removed by local workers with a use of hand held machetes. Strip top soil to nominal depth of 200mm will be removed and stockpiled as directed by the engineer.
- *Earthworks and Civil* - the scope of works will include treatment of the existing ballast formation throughout its length, construction of a gravel road with level crossing supply and installation of new storm water culverts including inlet and outlet structures. The works will also include excavation and construction of new table drains, shaping of earthworks to facilitate drainage. Blinding and reinforcing will be installed if required. The materials camp will be fenced.

2. Platelaying Works

The methodology for platelaying works will comprise:

- *Existing track upliftment and stockpiling for later reuse* - existing thermite welds will be removed by means of disc cutter or similar throughout 53km of existing track infrastructure. Approximately 53km of existing permanent way material will be lifted and stockpiled alongside the formation for later reuse. 11 turnouts will be lifted and moved to stockpile in the Pepel yard. Works will be performed by a combination of local labour and front end loaders;
- *Track reinstatement* - the works include the supply (where necessary) and construction of approximately 72km of “new” single line track from Pepel to Lunsar. A new 1km loop will be constructed at approximate chainage 20 km from the Pepel yard. An existing 1km loop will be restated at Port Loko approximately 41km from the Pepel yard. 1:9 40kg turnouts will be installed in Pepel yard and the two loops. The works will be performed by a combination of local labour and front end loaders;
- *Track welding* will be carried out by on track welding machine;
- *Alignment & tamping* - 79km of track and 21 turnouts will be tamped with a heavy duty on track mechanical and mechanical switch tamper. Replacement of sleepers on bridges and in Pepel yard will be performed by local labour;
- *Supply and installation* of Proposed various track signs will be installed along the rail alignment;
- *Abandoned railway material* will be sorted and stockpiled on the site.

3. Schedule

The duration of these construction works has been estimated as 229 days to complete the planned activities.

4. Operation of railway

The following table provides a brief overview of the rail specifications and activities.

**Table 3-2 Overview of Rail Specifications & Activities**

| Criteria | Value |
|---|---|
| Axle load | 17 t |
| Rail length | 72km |
| Operation time | 24h/day |
| Rail Wagon payload | 40-47 tons (max 50t) |
| No of wagons per train | 50 |
| Total payload per train | 2500 tons |
| Number of trains per year | 2190 |
| Number of trains per day | 6 |
| Total train offloading time at dump station | 2 min/wagon = 1.5h/train |

5. Equipment

Equipment to be used during construction works includes a diesel locomotive and track mounted plant including an axle horse and mechanical tamper. There will also be a significant amount of plant that will access the rail track from the adjacent road including flat bed truck, dozer and smaller plant such as welding gear. Estimates of fuel use and construction duration are given below. Overall approximately 1 million L of fuel are expected to be used during the rail refurbishment.

**Table 3-3 Diesel Usage Over Construction**

| Description of Plant / Equipment | Duration working days | Total Hrs construction | Fuel Efficiency ($L.hr^{-1}$) |
|---|---|---|---|
| Loco | 137 | 2 192 | 30 |
| FEL CAT IT 14 | 2 104 | 18 937 | 14 |
| Double axle horse (Local) | 1 155 | 10 399 | 133 |
| 1 ton LDV | 2 100 | 18 900 | 38 |
| 8 ton flat bed Tata/4x4 | 1 050 | 9 450 | 50 |
| Dozer D6 | 21 | 189 | 20 |
| On Track Mechanical Tamper | 220 | 1 981 | 20 |
| Butt Welder | 219 | 1 975 | 50 |
| Generators | 1 200 | 19 200 | 8 |
| Sundry fuel | 210 | | 300 |

6. Employees

The workforce is estimated to comprise 19 expats supported by 165 locals involved in construction activities. The local workforce comprises 25 skilled or semi-skilled and 140 unskilled. All staff will be moving along the works area as the works progress.

7. Camp locations.

The rail camp will be located in Pepel yard, while one mobile on track (on the railway line) camp will move as the work progresses. At this stage all sources of energy will be self generating i.e. generators varying in size from 6Kva - 25Kva however AML is responsible for the free issue of electricity at various locations along the route.

8. Anticipated waste types and quantities from construction

At this stage the waste related to the construction will be limited to the following:

- Packaging from material – 20 to 50kg size bags and cardboard (total estimated tonnage will be 5 tonnes over the contract period of 10 months);
- Paper and cardboard form locals (total estimated tonnage will be 2 tonnes a month over a period of 10 months).

All waste will be stockpiled in the suitable area indentified by the client, where waste can be treated.

### 3.2.3 Element 3 - Port Facilities

Hematite ore will be taken to Pepel Port where the material handling system will be capable of either directly loading ore from the train or stockpiling and then reclaiming depending on the timing of ship movements. Ore will be exported via transshipment vessels (TV) to an offshore anchorage. The iron ore will be transferred to ocean going bulk carriers (OGV) for export.

Ultimately, the total iron ore exported will be 8 million tonnes per annum (8 Mtpa). During the first year of operation the amount of iron ore exported will ramp up as follows.

**Table 3-4 – Export volumes during first year of operation**

| Month | Export volume (tonnes per month) |
|---|---|
| **Dec-10** | 100,000 |
| **Jan-11** | 100,000 |
| **Feb-11** | 150,000 |
| **Mar-11** | 250,000 |
| **Apr-11** | 400,000 |
| **May-11** | 400,000 |

| | |
|---|---|
| **Jun-11** | 500,000 |
| **Jul-11** | 666,000 |
| **Aug-11** | 667,000 |

Pepel Port is located in the Sierra Leone Estuary about 20km from the sea and 12km upriver from Freetown. It has not operated since 1985 but infrastructure is still present in the area including housing and office facilities, a power plant, fuel tanks, conveyer belts and a jetty / ship loader. The area of the Pepel Port is approximately 1725 ha.

To enable operations, the Port will need to be renovated. The objective of the Pepel Port project is to refurbish and upgrade the existing facilities to enable a maximum loading capacity of 4000 tonnes per hour (tph). A schematic of the existing facilities is provided in Figure 3-11. The operations will be similar to those of the existing port and therefore there is no need to expand the port footprint and no additional land clearance is required.

The planned refurbishment and upgrade of Pepel will include the following:

- Power Generation System;
- Dual Train Dumping Station;
- Stacker Feed System;
- Reclaim Feed System;
- Shiploader;
- Offshore Transshipment Anchorage

**Figure 3-11 Schematic of Existing Pepel Port Layout**


The iron ore will be transferred by rail to Pepel Port and offloaded at a double dump loadout station. Total train offloading time at the dump station will be approximately 1.5 hours. The iron ore will be transported to a double boom stacker by conveyors. The capacity of each onshore conveyor will be 2000 tph. The stacker will form 2 stockpiles with capacity of 200000 tonnes each. Four front end loaders will excavate the ore from the stockpiles and offload it in collecting hoppers. The ore will then be transported to the jetty by the transfer conveyor. The capacity of the transfer conveyor will be 4000 tonnes per hour.

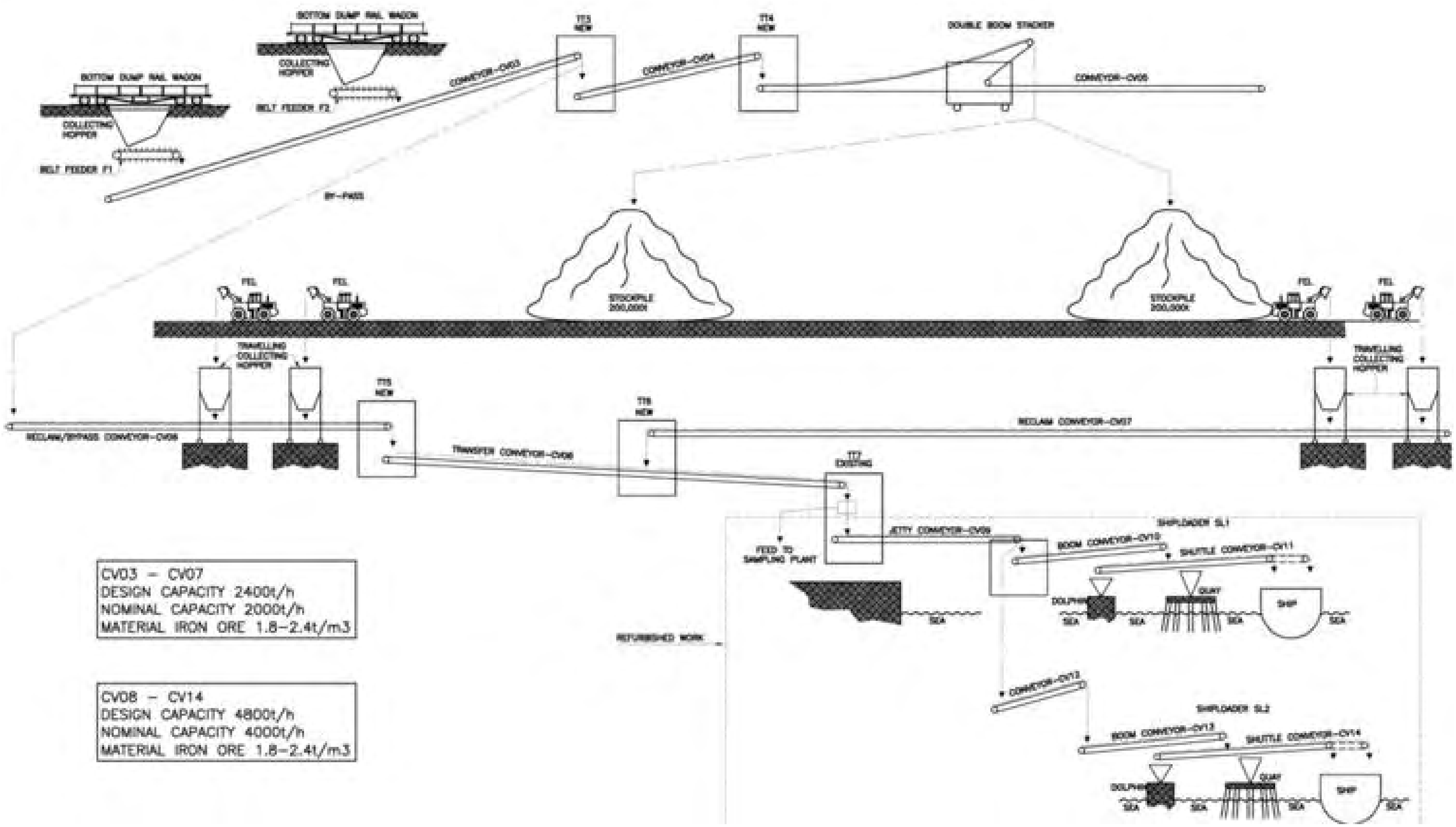
A schematic diagram of the process flow is presented below (Figure 3-12)

Power requirements for the port are yet to be determined. At present, it is assumed that a new power generation facility will be established, which utilises diesel generators. It is assumed that it will be a package plant with no seawater cooling requirement. Diesel will be transported to Pepel by road and stored within the existing storage facilities following their renovation.

The existing liquid waste management facilities, including wastewater and run-off will be improved and treatment provided to meet legislative requirements. An assessment of drainage facilities and wastewater treatment and disposal options is ongoing and will be documented within the Waste Management Plan.

Port operations will be 24 hour.

### Figure 3-12 Schematic diagram of material handling at Pepel



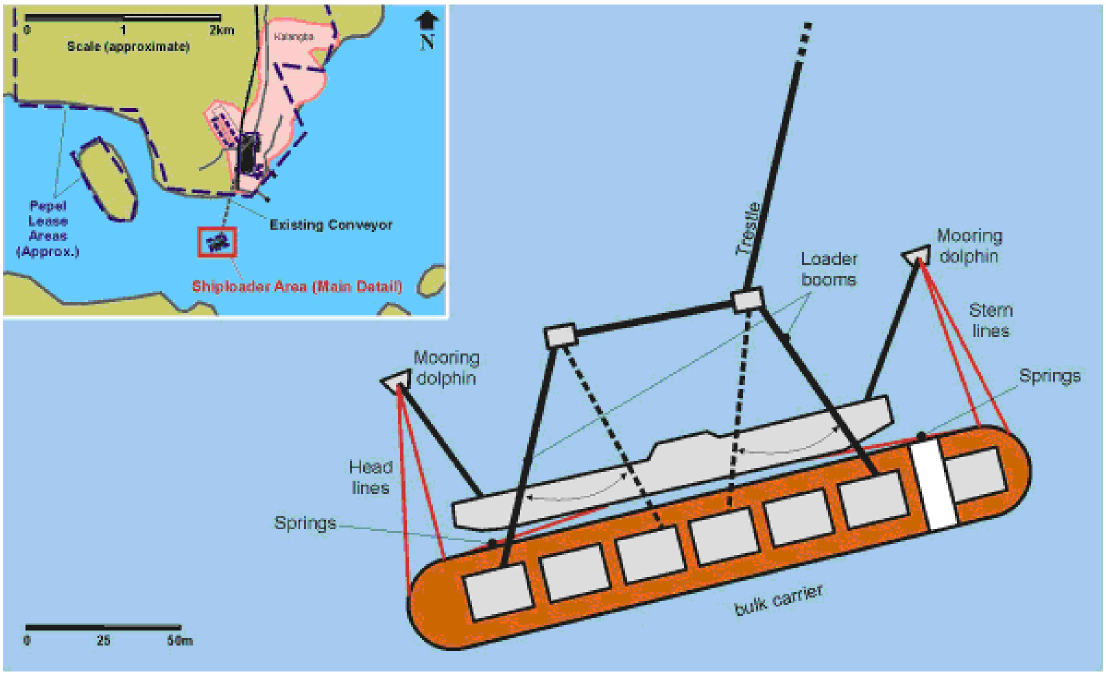
### 3.2.4 Element 4 – Offshore (Marine engineering)

The existing terminal comprises a 140m long jetty with two quadrant ship loaders with a maximum outreach of 25.5m. The mooring layout comprises the berthing face of the jetty head and two mooring dolphins set back from the berthing line.

All marine structures will need to be refurbished, including the shiploader booms, stackers/reclaimers, stockyard conveyor and berths. The two mooring dolphins are beyond refurbishment and will be replaced. Two additional dolphins may be required to safely moor the TVs.

The detailed design of the mooring and shiploading facility is yet to be finalised a potential layout is shown in Figure 3-13.

**Figure 3-13 Example Ship-Loader Layouts for Pepel Port**



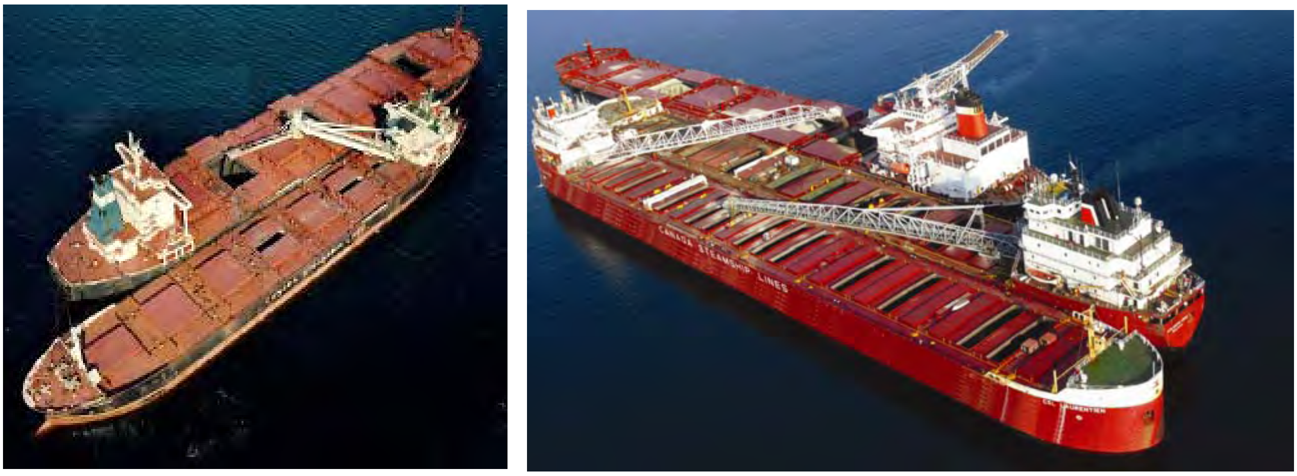

Transshipment is proposed as Pepel Port is unsuitable for cape-sized vessels due to its location within the estuary and the depth of the access channel. Transshipment results in a significant reduction in capital and maintenance dredging requirements.

The OGV will be anchored offshore and the ore will be transported from Pepel to the anchorage by the TV. Self unloading Handymax vessels with a cargo lift of approximately 30000 tonnes – similar in size to the vessels previously use by the port – are proposed to be used as TVs. Two TVs will be required and each will be doing approximately one round trip per day between Pepel and the transshipment anchorage once the objective export volume of 8 Mtpa is reached. The OGV is expected to be a Cape-size vessel with a cargo capacity of approximately 170000 tonnes. Panamax vessels with a lower capacity may be used.

The transshipment anchorage location has not been finalized and is currently being assessed but it will be located outside the estuary some distance offshore where there is sufficient water depth for the OGV.

TVs will transport the iron ore to the anchored OGV. The TV will transfer the ore directly into the OGV, using its conveyor and crane system. The rate of transfer is approximately 2000 tph. Examples of transshipment operations and storage vessels are shown in Figure 3-14.

**Figure 3-14 Example transshipment operations**



The proposed dredging project involves dredging a shipping channel from the disused port facility at Pepel Island to allow navigation from the entrance of Sierra Leone River (Figure 3-15).

**Figure 3-15 Navigation Channel to Pepel Island**


***Dredge Channel***

Preliminary design of the berthing/manoeuvring area and navigation channel from Pepel Island to the mouth of the Bunce River comprises the following key elements:

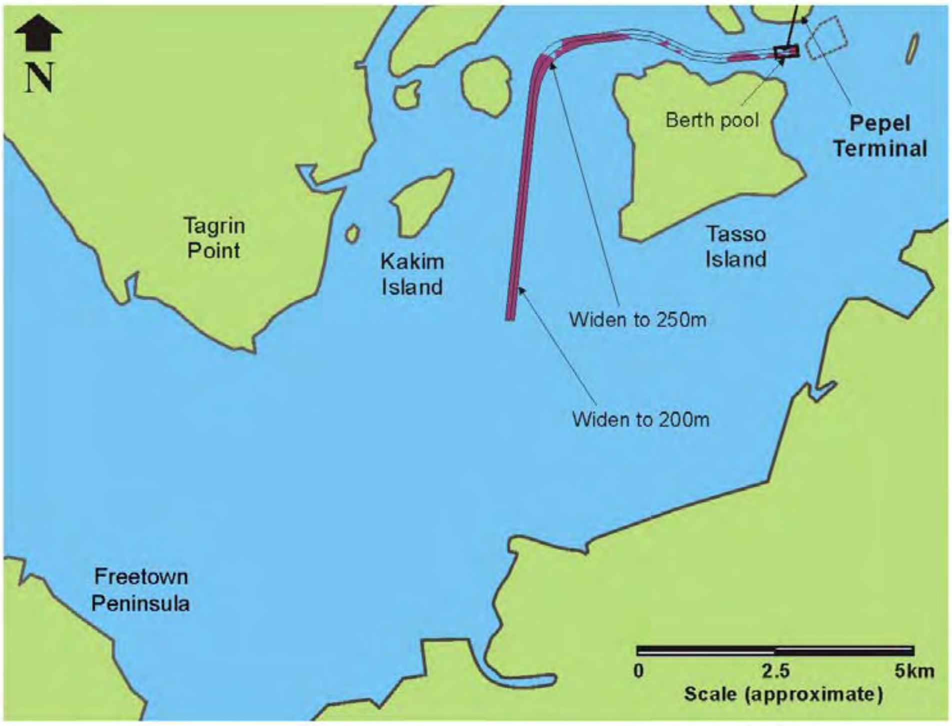
- Turning basin depth: -7.0 m chart datum (CD)
- Channel depth: -10.5 m CD
- Channel width (straights): 120 m
- Channel width (bends): 250 m adjacent to Tasso Island; and
- Channel side slopes: 1V:5H (vertical and horizontal)

The dredging works will reinstate the channel used by Pepel port when it was previously in operation.

The initial water depths for the scope of work are derived from the UK Hydrographic Office Admiralty charts and are a minimum of -7 m CD in the main navigational channel. The estimated dredging areas are shown in Figure 3-16. This will be dredging of material that has infilled in the Pepel channel since Pepel port was last used and maintenance dredging took place.

The estimated volume of dredge material is approximately 1.5 million $m^3$. However, further bathymetry surveys are underway to confirm the dredging requirements.

**Figure 3-16 Proposed dredging areas - manoeuvring area and Navigation Channel**




Additional maintenance dredging will be required on a yearly basis to maintain the navigation channel. The frequency and volume of maintenance dredging required is currently being assessed. However, high deposition is expected in some areas during the rainy season such as in Kakim channel and historical information suggests that volumes of between 0.5 - 1.0 million $m^3$ may need to be dredged each year to restore depths.

***Dredging Methodology***

As infill of a previous channel is being dredged, the material is expected to be relatively soft. Therefore a Trailing Suction Hopper Dredger (TSHD) will be used for the dredging works.

Suction dredging such as TSHD is commonly used for dredging silty, sandy or gravely soils or soft clayey soils. Sediment grabs indicate that much of the Pepel channel has medium coarse grain sediments, probably due to the strong tidal currents along the channel. There are some areas where finer sediments have been deposited. This is described in more detail in the baseline section 6.5.1.

A hopper will be used to collect the dredged material in its cargo hold to transport to the dredge spoil disposal site.

The dredging cycle starts with the dredger sailing with an empty hopper to the proposed dredging area using its highly accurate navigation systems.

The TSHD shall deepen the channel by removing consecutive layers of the seabed material. In addition to the given dimensions, an average of 2 m overwidth at each side and an over-depth between 0 m and 0.5 m is dredged as a result of positioning tolerances.

The characteristics of a typical TSHD are presented in Table 3-5.

**Table 3-5 Example TSDH vessel characteristics**

| | **Approx. Specification** |
|---|---|
| Hopper capacity | 11 000 m³ |
| Deadweight | 18 000 ton |
| Length | 140 m |
| Breadth | 25 m |
| Draught loaded | 9 m |
| Suction pipe diameter | 1 m |
| Pump power (trailing) | 3 500 kW |
| Pump power (discharging) | 8 000 kW |
| Propulsion power | 2 x 6 000 kW |
| Speed | 15 kn |

***TSHD Working Principles***

The TSHD it is a sea-going, self-propelled dredging vessel, which includes a hopper to store the dredge material. It is commonly used.

The dredging systems of a TSHD consist of one or two suction tubes, each driven by a powerful centrifugal pump, called the sand pump. During the dredging, and in a process, which is quite similar to the domestic vacuum cleaner, the lower ends of the suction tubes are trailing along on the seabed, while the sand pumps provide the suction power to lift the materials from the seabed into the hopper. The suction pipe has a special draghead, which is designed to maximize the dredging efficiency during the loading phase (Figure 3-17).

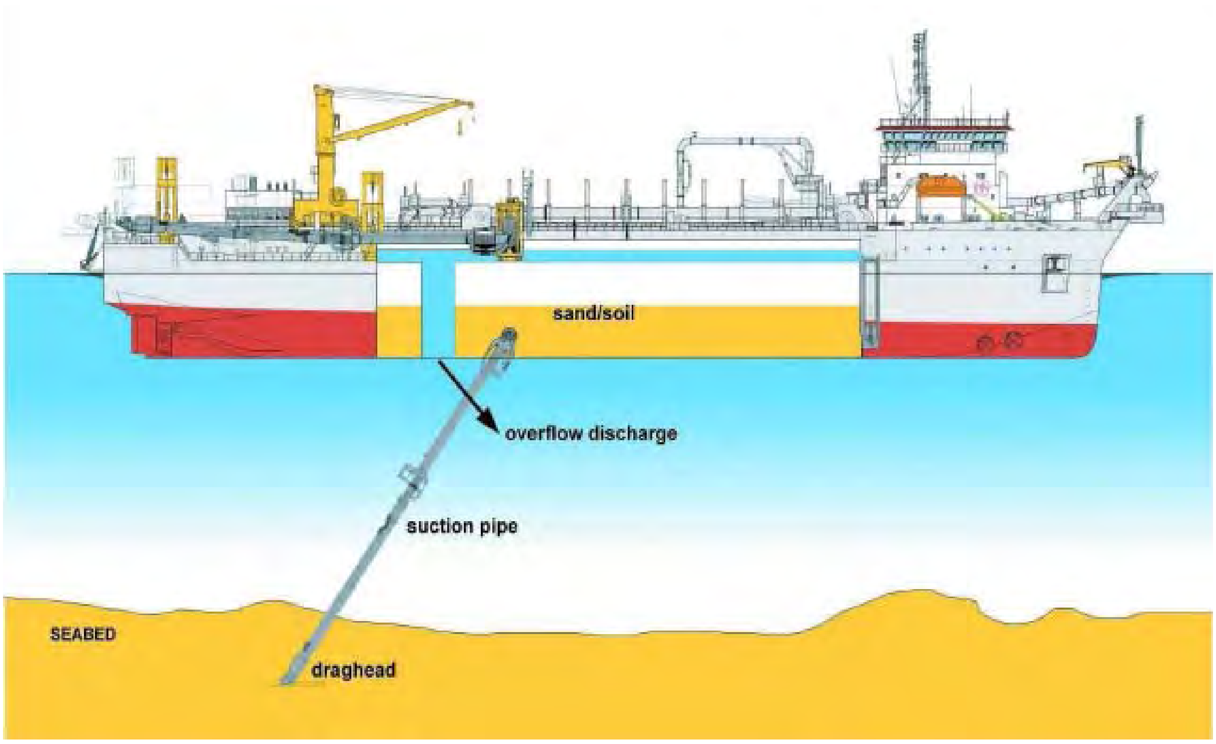
**Figure 3-17 Typical draghead (left) and suction pipe (right) from TSHD**

The sediment is loosened and removed from the seabed by a combination of suction provided by the sand pump, the forward motion of the vessel and the cutting and jetting characteristics of the draghead. The materials dredged from the seabed, will be pumped into the hopper as a sediment/water mixture. Care will be taken to minimise the water content in the mixture.

In the hopper the sand material settles due to gravity and the water flows back to the sea through the overflows situated in the hopper.

Figure 3-18 shows the general layout of TSHD operations.

**Figure 3-18 General layout of TSHD working at dredging site**




The dredge material is stored in the hopper for transport to the offshore disposal area (Figure 3-19).

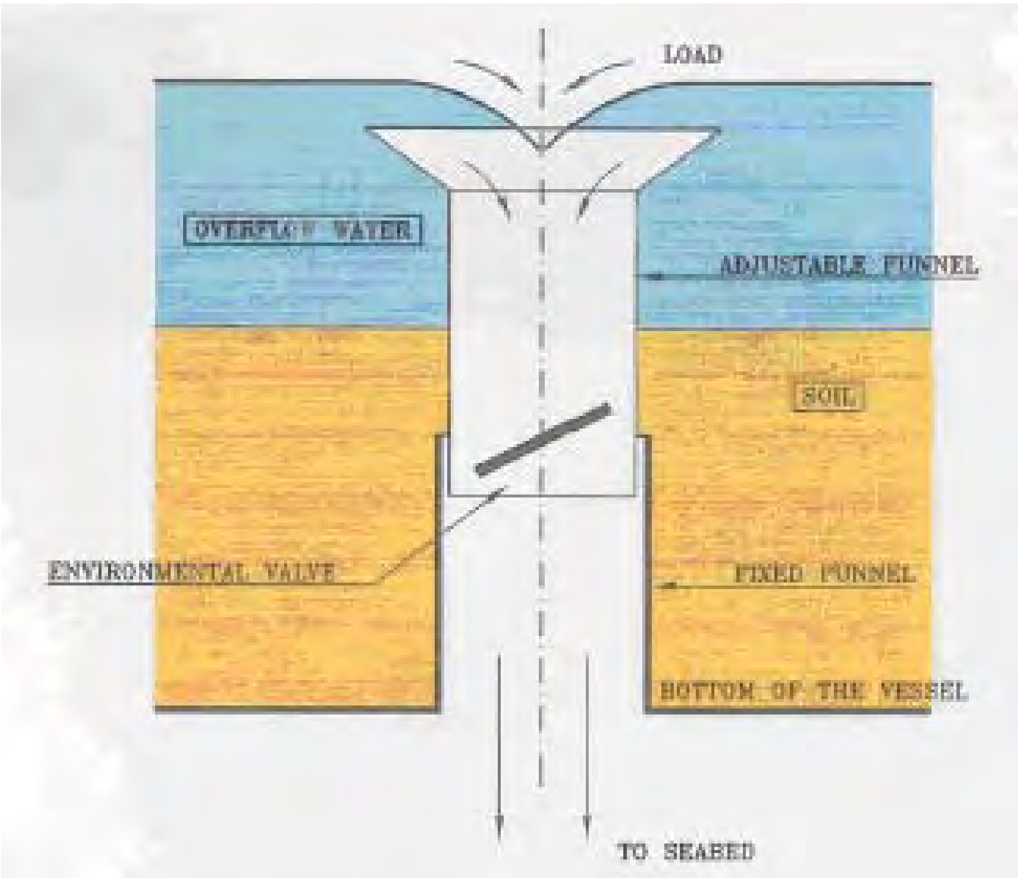
**Figure 3-19 Hopper wells**

In order to increase the volume of dredge material that can be stored and minimise the number of trips to the disposal site excess water overflows from the hopper. There is a risk of increased turbidity due to the hoper overflow.

To minimize the potential fine plume, an overflow funnel is constructed inside the hopper. It consists of a height adjustable funnel mounted on top of a vertical cylinder which ends under the keel of the dredge. The excess water is discharged under the dredger (see Figure 3-20), at the highest level possible, thus minimising the concentration of suspended solids in the overflow water.

There is also an anti-turbidity valve or “green valve”, which is a hydraulically controlled valve mounted inside the overflow funnel(s). This valve drastically reduces the turbidity generated by the overflow water (or dredge plume) drained through the overflow funnels. It reduces the overflow funnel, which ensures that the water level inside the overflow funnel will be maintained and the mixture will “fall” from a lesser height. As a result less air gets mixed into the overflow and the dredge plume will not have a tendency to rise up, next to or behind the vessel. Without the use of this green valve the finer particles in the overflow mixture are churned up by the vessel’s propellers and hence create those infamous turbid clouds behind the trailer dredger.

**Figure 3-20 Typical overflow funnel with anti-turbidity valve**

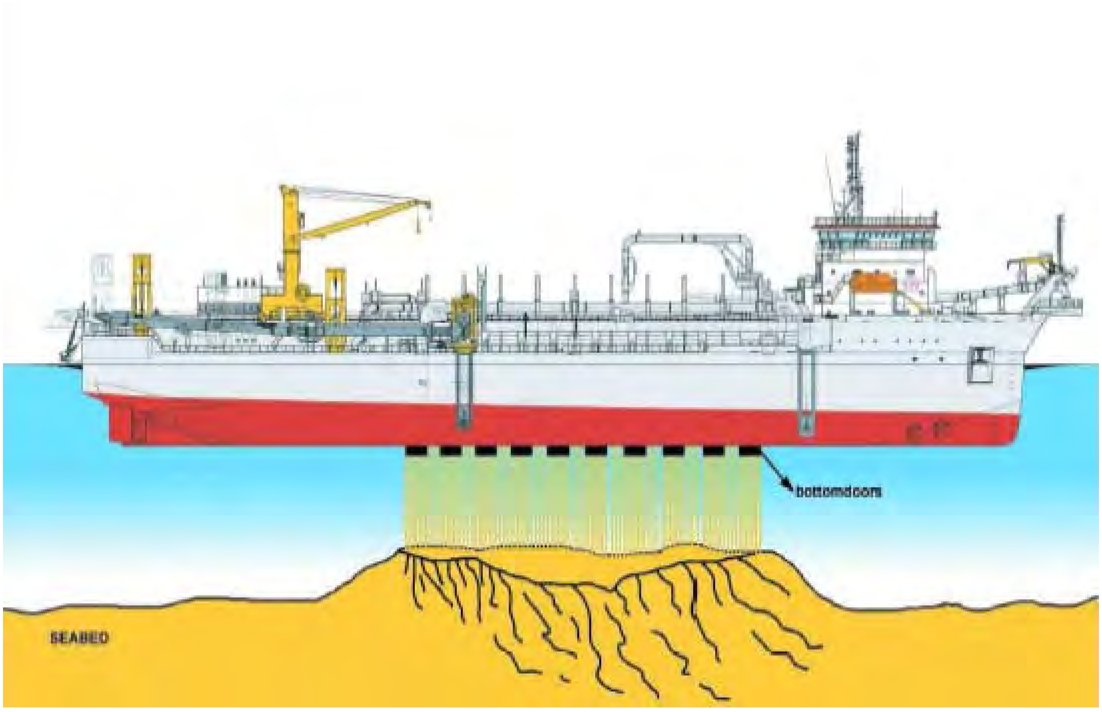


### *Dredge Disposal*

As soon as the hopper is fully loaded, the suction tubes will be hoisted back onboard and the dredger will head to the dredge disposal site.

Bottom dumping is the fastest way to unload the hopper by discharging the load through the opened bottom doors of the hopper (Figure 3-21). Water jets inside the hopper will ensure the hopper is completely empty and free of any dredged soil prior to closing the bottom doors. Due to the draft of the vessel the material will fall approximately ten metres through the water column to the seabed. As part of the EMP an assessment is required to ensure that the material remains within the disposal site.

**Figure 3-21 Bottom dumping procedures, at disposal sites**

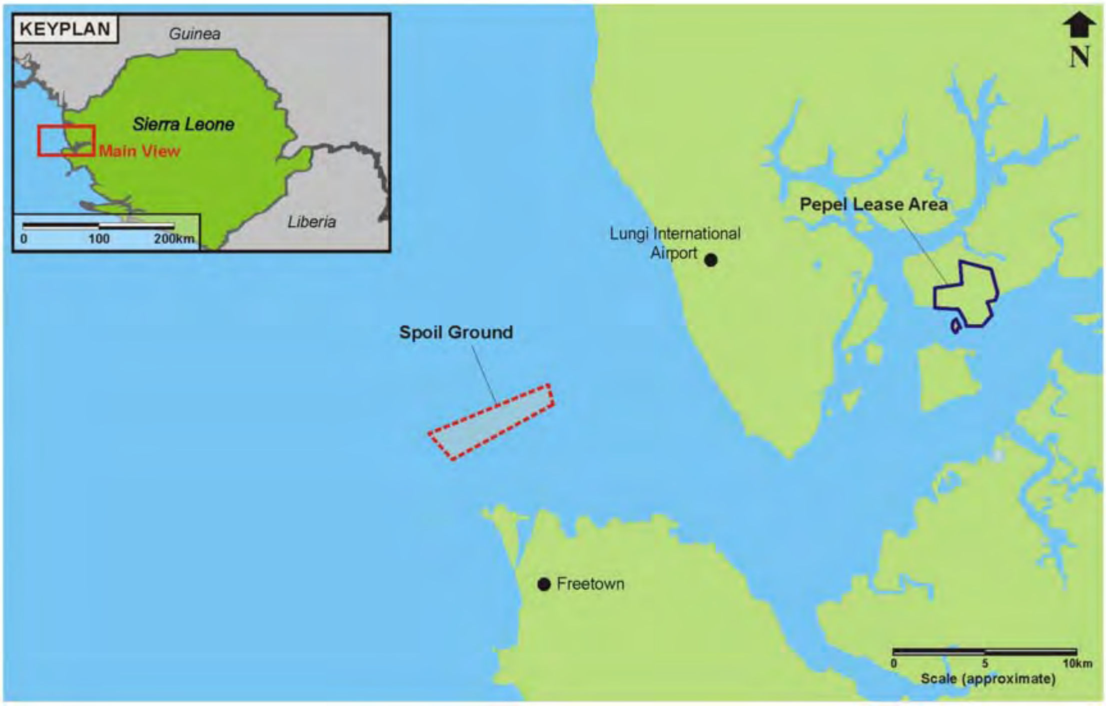



The TSHD can also discharge at sea via its own suction tube, to discharge it at a greater depth. The depth is restricted to the length of the suction tube but will be sufficient for the proposed disposal ground.

All dredged materials will be transported to the agreed dumpsite approximately 5 km north of Cape Sierra Leone, which is shown in

Figure 3-22.

**Figure 3-22 Proposed spoil ground**




***Duration***

Dredging will take place 24 hours/day for 7 days/ week. Therefore it will take up to 7.5 weeks to remove the estimated 1.5 M $m^3$ of sediment.

The yearly maintenance dredging will take up to 2.5 weeks, assuming a dredge volume of 500,000 $m^3$ of sediment and a dredging capacity of 200,000 $m^3$/wk.

Timescales for capital dredging will be confirmed once the bathymetry survey is complete and the final dredge volume is calculated. Maintenance dredging requirements will be dependant on infilling and estimates will be refined following modelling of sediment transport in the estuary.

## 3.3 Supporting Infrastructure

### 3.3.1 Power supply

Power requirements for Phase 1 are localized, the overall power requirements are approximately 4.5 Mw for the project (AML Stakeholder Presentation, May 2010).

*Hematite Mine*

Power supply to the mine activities will be provided by diesel powered generators with a localised distribution system within the mine area.

Power demand will be required for the contractors' workshop, workers' camps and crushing and loading facilities, among others.

*Haul Road*

Power supply to the haul road will be only needed during the construction phase at 3 construction camp locations (Rogbere, Makeni and Tonkolili).

Energy sources and power demand are yet to be finalised; however, it is anticipated that the demand for general camp activities will be covered by Diesel Generators at each camp.

*Lunsar Interchange*

Power will be required for both, the construction and the operation phases of the Interchange Yard. During construction, power demand will be satisfied through the use of Diesel Generators that will supply the construction camp and any other machinery in requirement of power. During the operation phase, the power demands for the office building will be also provided through the use of a Diesel Generator.

The power demand is still to be finalised for both construction and operation phases.

*Rail Refurbishment*

Power will be needed during construction / refurbishment at both the rail camp to be located in Pepel yard and one mobile on track (on the railway line) camp that will move as the work progresses. At this stage all sources of energy will be self generating i.e. generators varying in size from 6Kva - 25Kva. AML has taken responsibility for the free issue of electricity at selected locations along the route.

The Pepel Yard Generators will work on diesel and its estimated fuel demand is 8 $L.hr^{-1}$, making it a total of 168 960 L of fuel on the basis of 1 200 days for the construction.

*Pepel Port*

Power supply to the port area during construction will be provided by packet generation sets with a localised distribution system within the port area. The initial port power requirements, yet to be estimated, will be provided by 6.6 kV power generators fed by a diesel fuel source.

*Pepel Operational Phase Power Requirements:*

The stacker power requirements and the power requirements for the reclaimers, which will operate on diesel, are being determined and there is a base-case assumption that refurbishment of the existing power house at Pepel in conjunction with generator sets will be the selected model. Diesel was previously brought into Pepel Port and stored using a dedicated fuel jetty connected to a 6Ml fuel farm. Confirmation of renewal of this process is still underway. An alternative is that diesel will be supplied to Pepel from Tagrin Port when Phase 3 operations commence.

### 3.3.2 Water supply

Potable and construction water supply will be required at numerous locations across the project area. Although preference has been given to utilise groundwater resources for potable use, it is likely that due to the accelerated nature of Phase 1 a significant component of potable water will be trucked in from Freetown, as is the current practice at the mine exploration camp. Construction water will be sourced from nearby groundwater resources through a drilled groundwater borehole or a network of several boreholes.

*Hematite Mine*

It is likely that the Phase 1 mine water will be supplied from existing springs / streams that are currently in use for exploration activities. Currently, potable water demand is estimated as an average of 20 L per person per day. Construction water demand is yet to be determined.

*Haul Road*

Haul road construction camps will require a temporary water supply in form of groundwater wells to be drilled at each location. The latest assumption is that there will be three camp locations along the haul road alignment, water demand for each of them is yet to be determined.

It is assumed that water requirements will be one bore hole for camp. Water treatment plants will be constructed at each camp. 30,000 L/day of water will be treated, while 50,000 L will be stored at each camp.

*Lunsar Interchange*

At the interchange there will be an office and 2 portable toilets, the location of which is also unknown. All these facilities will require water, which is likely to come from groundwater wells drilled in the area. Water requirement specifications for construction and operation are still pending.

*Rail Refurbishment*

Water supply during the rail refurbishment will be required, as a minimum, at the rail camp in Pepel yard, and on the mobile (on the railway line) camp. It is anticipated that each location will have a different water requirement, largely depending on the number of personnel working at each and on the construction water requirements, yet to be determined.

It is anticipated that drinking water (bottled) will be supplied by AML from Freetown and that construction water requirements will be sourced from drilling wells at each of the camps.

*Pepel Port*

During Phase 1 of work, a water supply will be required at Pepel Island. No significant fresh surface water bodies exist on or near Pepel Island and groundwater is the primary available resource. Average water demand for the initial construction and operation of the proposed port and related facilities has been estimated to be about 250 $m^3$/d (2.9 l/s), but could reach a maximum of 300 $m^3$/d (3.5 l/s).

It was proposed by Scott Wilson that nine production wells are located east and west of Mayela village. On the basis of a yield of 0.5 l/s per well, seven wells will be required to meet the demand of

3.5 l/s, and two additional wells for stand by purposes. Spacing between wells is approximately 250 m to prevent excessive interference. It is recommended that well depths should be no more than 25 meters in depth.

At the present moment it is known that GCS Ltd is carrying out drilling works in the South-East of Pepel Yard under the instructions from AML. There are two wells drilled, which will be pumping approximately 2 l/s from each well. The wells extend to 32 and 42 mbgl respectively instead of proposed 20-25 m.

### 3.3.3 Fuel Supply

*Hematite Mine*

Fuel will be required for energy generation and for the use of the mine machinery as well as for transport purposes.

Fuel required by the mine activities will be supplied by tankers from Freetown. Currently, there is a fuel yard in the town of Bumbuna.

Fuel storage for the mine activities and camp demands will be managed according to a specific environmental management plan in conjunction with the fuel operations plan that is still in development.

*Haul Road*

Fuel supply to the haul road will be needed during the construction phase at all 3 construction camp locations (Rogbere, Makeni and Tonkolili).

Fuel sources, storage facilities and demand are yet to be finalised.

*Lunsar Interchange*

Fuel will be required for both, the construction and the operation phases of the Interchange Yard. During construction, fuel will be probably trucked-in from Freetown. Fuel demand during construction is yet to be determined.

During operation, fuel will be provided at the fuel yard, which will be 100 m in length. The location and the quantity of fuel being stored are yet to be determined. Fuel will serve the operation of the trains on a 24 hours per day basis (6 trains/day to the Pepel Yard).

*Rail Refurbishment*

Equipment (machinery and generators) to be used during construction works will be working on fuel and the estimated fuel consumption for the duration of the works is 1 045 909. On the assumption that 1 200 days will be needed for the construction phase, the daily fuel consumption is estimated as 87.1 L/day.

The trains to be used during operation will be General electric 2300HP, there will be 3 trains with 50 wagons (6 trains/day).

*Pepel Port*

Fuel supply for power generation and machinery to the port area during construction and operation is likely to be brought into Pepel by tanker via the existing jetty as per the previous (Delco) operations which included a 6Ml fuel farm situated at Pepel. It is assumed that a similar fuel storage system will be established to run the on-site generators, construction and operation machinery and re-fueling vessels.

Fuel tanks will be built at Pepel Port to supply the needs of the port activities.

### 3.3.4 Bulk material management

*Hematite Mine*

Borrow material will be sourced from a new quarry to be located south of the village of Wandugu, on the haul road alignment. Material, quantities and daily demands are yet to be determined.

Building materials and quantities are also to be determined, although it is expected that, as a minimum, cement, steel and camp materials will be needed. Material will be stockpiled at the plant facility.

*Haul Road*

See section 3.2.2 for details.

Camp construction materials will be also needed for the three camps along the haul road.

*Lunsar Interchange*

Building materials expected to be needed for construction include cement, steel and camp materials. Final material and quantities are to be determined.

*Rail Refurbishment*

Ballast quarries will be needed although material requirements and quarry locations are yet to be determined.

Camp materials will be needed for the camps at Pepel Yard and for the mobile camp.

A description of material to be used during rail refurbishment is given in the table below together with an estimate of the quantities needed and the source.

**Table 3-6 Construction Material for Rail Refurbishment**

| MATERIAL / DESCRIPTION | UNIT | QUANTITY | SOURCE |
|---|---|---|---|
| Derail Devices | ea | 2 | South Africa |
| Stop Signs | ea | 18 | Sierra Leone |
| Advance Warning Signs | ea | 18 | Sierra Leone |

| | | | |
|---|---|---|---|
| Track Whistle Boards | ea | 96 | Sierra Leone |
| Siding Number Boards | ea | 2 | Sierra Leone |
| Transport Miscellaneous Items | ea | 137 | Unknown |
| Rails in 12 or 18 Meter Length | km rail | 63.28 | United Kingdom |
| Type Heavy Duty Steel Sleepers | no | 76050 | South Africa |
| Type Wooden Crossing Timbers Varying in Length from 2.1meter to 4.2 Meter | no | 1974 | Sierra Leone |
| Timber Sleepers for Bridges | no | 367 | Sierra Leone |
| Fastenings Type Pandrol to Suit Existing Steel Sleepers Typically Type 1802 | per ea | 106785 | South Africa |
| Bridge Sleeper Fastenings | per sleeper | 367 | South Africa |
| Turnout Sleeper Fastenings | per turnout | 21 | South Africa |
| Turnout Sests 1:9 40 Kg/M | set | 21 | South Africa |
| Stop Block | no | 1 | South Africa |
| Lubricators | no | 20 | South Africa |

*Pepel Port*

Large amounts of construction materials will be needed in the refurbishment of Pepel Port. This will include cement, steel, glass, brick, timber, etc.

The source of the material and the quantities are yet to be determined.

### 3.3.5 Demand on existing facilities/ resources

Construction and refurbishment along the Delco Rail Line and at the Pepel Port Lease will require the support of local goods and services as well as, to a limited extent co-sharing of infrastructure such as access roads. The interaction with existing facilities and resources will be most apparent along the 72 km of existing rail line and the upgrade of some of the existing facilities at Pepel, such as the Dual Train Dumping Station; the Stacker Feed System;, the Reclaim Feed System; the Shiploader Feed System and some existing buildings (offices and housing).

The Haul Road will be built in predominantly Greenfield areas with a self-sufficient contracted work force. Some interaction with existing footpaths / minor unpaved roads is expected and has been addressed in the Haul Road Environmental Management plan and Community Development Action Plan (WorleyParsons, April 2010)

The mine site and the Lunsar Interchange will be Greenfield projects that will utilise the existing mine exploration camp infrastructure and develop a specific community development plan at Lunsar.

### 3.3.6 Solid Waste Management

Solid Waste from both operational and construction activities will be dealt with in a structured and auditable manner from the commencement of the project through design, into construction and on to operation and monitoring and beyond. Waste minimisation will be emphasised from the outset of the project, in addition to ensuring that the waste produced is dealt with in accordance with the principles outlined within a defined Waste Hierarchy (reduction, reuse, recovery and recycling, see WorleyParsons Report Preliminary Concepts for Solid Waste Appendix 3). All applicable in-country legislation and best practice will be adhered to. Where disposal or treatment is required, this should be undertaken in accordance with the treatment recommendations included in the section below.

*Hematite Mine*

Solid waste will be generated at the worker camps will be dealt in accordance with the waste hierarchy, with a significant fraction of the waste sent to an incineration unit provided specifically for both workers and operational municipal waste generated at the mine. Currently sewage and solid waste including putrescible is being dumped at waste pits without pre-treatment. Pits are being managed only by intermittent cover using surface soils. Improvement and upgrading of waste management is a priority item currently being undertaken by AML.

*Haul Road*

It is anticipated that the haul road will generate negligible operational waste. The primary waste arising from the construction will be spoil potentially in the region of 800,000m$^3$ based on preliminary cut and fill calculations. This waste is considered to be inert and does not require an engineered facility for disposal; however areas should be outlined at outset for stockpiling and bunding. Where possible the road should be designed to achieve a cut and fill balance. As a minimum, land areas should be set aside for spoil disposal; there may be an opportunity to re-use spoil in some port reclamation works.

*Rail refurbishment*

It is not anticipated that the operation of the rail facility will generate significant waste issues; however, there is a potential for waste arising from existing material that cannot be reused (especially scrap metal). At this stage the waste related to the construction will be limited to the following:

- Packaging from material – 20 to 50kg size bags and cardboard (total estimated tonnage will be 5 tonnes over the contract period of 10 months);
- Paper and cardboard from locals (total estimated tonnage will be 2 tonnes a month over a period of 10 months).

All waste will be stockpiled in a suitable area to be identified by AML, where waste can be treated.

*Pepel Port*

*Construction*

At Pepel port, the project development will comprise a materials handling facility, and relevant supporting infrastructure such as power, water, access roads, accommodation facilities, workshops, warehouses, laboratories and administration buildings, train unloading facility, stockyard and wharf. This will comprise a combination of existing asset refurbishment and new development.

It is anticipated that the primary component of the wastes generated from Port construction will be metals that will have a residual scrap value either locally or could be readily exported in sufficient quantities. There is also likely to be significant quantities of hazardous waste in the form of oils and other industrial wastes which should be disposed of either to the main incineration unit proposed for the Port Construction Workers Camp, or to individual workshop oil burners.

*Operation*

Waste will be generated by the ongoing process activities at the port. Primary waste generated from these activities will include:

- Waste oils;
- Metals from refurbishment of plant;
- Packaging, plastics and pallets;
- Lead acid batteries; and
- Waste electrical and electronic equipment waste.

In addition the operational staff at the Port will generate a small volume of general office and municipal waste, which should be disposed of to the incineration unit proposed for the Port Construction Workers Camp.

All residual waste that cannot be recycled incinerated or the ash from the incineration unit should be sent to the landfill proposed to support the development of the Port Construction Works Camp.

For further information on Phase 1 waste management refer to Appendix 4 for Solid Wastes Management Practice Guidelines.

### 3.3.7 Waste Water Treatment

Suitable Black and Grey Water disposal options will be engineered throughout the project in order to attain compliance with the project basis of design (WorleyParsons, 2010). Waste water treatment plants will be placed at each camp. Solids will be removed periodically by honey sucker.

WorleyParsons has produced an environmental basis of design for the overall project (namely Phase 3) that will be referred to and used as a reference for good practice. A project specific waste water management strategy and plan for the project will be developed that will address approaches to sewage sludge disposal, implementation of secondary and tertiary level treatment and synergies where possible with the project solid waste management strategy.

## 3.4 Project Options & Alternatives

ESHIA requires an analysis of alternatives, which should provide a systematic comparison of feasible alternatives to the proposed project and evaluation of their potential social and environmental impacts. Alternatives to be considered should include, as appropriate, planning alternatives, site or route locations, location of facilities, infrastructure alternatives, technology, operations, land use alternatives, financial alternatives, and the 'without project' alternative.

Alternatives design, technology and site selection of the project elements has been considered already. A significant factor that has been taken into consideration has been the attempt to minimise adverse or negative social or environmental impacts. The project design presented above (the base case) mostly represents the best trade-off that can be achieved, with the available information between minimised impacts and good engineering performance.

Consideration of other alternatives is an inherent component of project design, which is ongoing at present. Consequently the ESHIA alternatives analysis process informs project design. This ESHIA summarises all alternatives considered, including the 'without project' option.

A summary of some of the high level strategic options and alternatives that have been considered to date or are under consideration in relation to minimising environmental and social impacts is presented below. More detailed alternatives analysis is provided for specific project elements and facilities in the relevant impact and mitigation sections that follow:

***Mining***

- The location of the ore bodies is fixed and there is limited available option to consider in terms of alternative location or mining methods or scheduling as the mine plan is based on a single optimised mining model;
- However, it is important to consider that the Phase 1, 2 and 3 mining projects are interactive in the sense that Phase 1 mining and the mining of transition material as part of Phase 2 has a significant effect on lowering the amount of Phase 3 overburden and hence waste rock generation;
- The overall 'without project' alternative would involve abandoning the mining project as well as the infrastructure aspects of the project that are conditional upon the mining operation proceeding. The project represents a nationally significant development opportunity with major social, environmental and governance impacts both positive and negative. This ESHIA presents an unbiased assessment of the project so that the GoSL with respect to its constitutional responsibilities can make an informed decision in its capacity of considering the national interests and sustainable development.

***Transport Corridor***

- The road and rail alignments located within the borders of the 6km wide leased transport corridor have undergone route selection taking into account environmental and social constraints. The route selected has avoided protected areas such as Farangbaia Forest Reserve, riverine forest areas and areas of conservation habitat on the basis of constraints analysis. During the route selection assessment, all villages have been provided with a clearance of at least 500m and a clearance of at least 500m from sacred bush areas has been provided;

- Assessment of extension of the Delco (light) rail system from Marampa (Lunsar) to the mine site as an alternative to the haul road / road train option. This is currently under review.

***Port Area***

- The Pepel Port project has wherever feasible looked at alternatives associated with brownfield regeneration rather than new build so as to minimise cost, material and resourcing requirements. This carried significant environmental and social benefit in terms of pragmatic use of resources and limiting impacts to areas that are already have a degree of conditioning associated with the previous operations;
- The project has considered design alternatives that wherever feasible put material handling plant; for example, conveyors and road loops underground through tunnels to limit co-sharing of space with public amenities. This has been driven by a combination of community and space management and public safety factors.

***Offshore***

- The alternative of zero dredging in the Sierra Leone estuary whilst still accommodating cape-size vessels has been considered by potentially using a much longer approach trestle spanning across the estuary. This alternative is still under study;
- Other alternatives currently under consideration include potential dredging. The inbound bulk carriers would enter from sea, transit to Freetown to pick up a pilot. Transit to and from Pepel would be timed to maximize water depth around high tide. Based on the available data there are shallow depths at various sections along the route. In addition to the potential dredging of the turning basin off the berth there will be a need for dredging at Tasso Island channel and Kakim channel. There may be a need to dredge high spots in the river section; however these areas may be passable at given heights and times of tide. The assumption is Panamax vessels (80,000 dwt) will be used and require an estimated 6.3 million $m^3$ of dredge material, based on initial assessments.

# 4 LEGAL, POLICY AND ADMINISTRATIVE FRAMEWORK

The GoSL's responsibility and role in protecting the nation's natural resources and ensuring that sustainable development (Article 21) is pursued has been enshrined in law under the National Environmental Policy (1994).

This policy places responsibility on the Government to secure for all Sierra Leoneans a quality of environment adequate for their health and well being and to conserve and use the environmental and natural resources for the benefit of present and future generations.

The policy also requires that Government manages development so as to restore, maintain and enhance the ecosystems and ecological processes essential for the functioning of the biosphere; to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems.

The policy outlines in general terms how these aims can be implemented using a combination of raising public awareness, encouraging community participation and strengthening environmental protection standards, monitoring and data use.

The policy states that ESHIA can only be effective when done prior to proposed activities which may significantly affect the environment or use of a natural resource and to provide relevant information, in a timely manner, to persons likely to be significantly affected by a planned activity and to grant them equal access and due process in administrative and judicial proceedings.

The policy promotes environmental management through the creation of administrative and infrastructural support with appropriate financial backing.

Finally there is reiteration of the need to develop good international relations by adherence to international treaties, care with regard to transboundary issues effective prevention or abatement of transboundary environmental protection.

## 4.1 Institutional Bodies

In 2008 the GoSL passed the Environment Protection Agency Act No. 11 of 2008 (EPA 2008) which established the Environmental Protection Agency (EPA) as the competent authority for reviewing and processing ESHIA. The EPA Board of Directors also comprises representatives from the following Ministries:

- Ministry of the Environment;
- Ministry of Local Government;
- Ministry of Mineral Resources;
- Ministry of Marine Resources;
- Ministry of Agriculture and Forestry;

- Ministry of Tourism;
- Ministry of Trade and Industry;
- Ministry of Transport;
- Ministry of Health; and
- Petroleum Unit.

The EPA has a wide range of environmental management functions including coordination of the activities of government agencies and other agencies on matters relating to environmental protection and management. The EPA is also responsible for ESHIA compliance and licensing (see Section 3.1.3 for further details).

At present the EPA is not fully fledged. Predecessors to the EPA include the Department of Environment (DOE), within the Ministry of Lands, Country Planning and the Environment (MLCPE), and the 2005 National Environmental and Forestry Commission (NACEF), which was later referred to as the Environment Commission (SRK Consulting, 2009).

## 4.2 Relevant Sierra Leone Legislation

All aspects of the Project shall be designed to meet the requirements of all current relevant Acts, Rules and Notifications, including but not limited to those listed below:

- Environmental Protection Act, 2008;
- Mines and Minerals Act 2009;
- National Lands Act, 2006;
- Forestry Act, 1988;
- Forestry Regulations, 1989;
- The Water (Control and Supply) Act (1963);
- Public Health Act, 1990;
- Labour Act, 1990;
- Wildlife Conservation Act, 1977.

See Appendix 5 for a list of legislation applicable to environmental and social impacts from Phase 1 of the Tonkolili project.

### 4.2.1 Legislation Relevant to Ecological Protection

***Forests***

No classified forest may be cut, burned, uprooted, damaged or destroyed, except with a written permission from the Chief Conservator of the forest (Part VI, Section 21 Subsection 2 Forestry Act, 1988). Failure to observe this is an offence punishable with a fine.

Classified forests, which may be either national or community forest have protection or production as their primary purpose, and are to be managed accordingly. There is a general prohibition against logging and other activities in classified forests, except by authorized exception from the Chief Conservator of the forest.

Granting of licences for this is conditional upon fee payments to a reforestation fund and also on agreement of appropriate provision for replanting and undertaking reforestation/rehabilitation of disturbed land.

***Vegetation Clearance***

Vegetation clearance is also controlled under Forestry Regulation, 1989 which states that removal of vegetation has to be carried out under licence and keep to a specific land area within a stated time.

***Riverine/Mangrove Vegetation***

No land between the high and low water marks, nor those above the high water mark on both sides of the bank of any waterway, covering a distance of one hundred feet (approximately 33 m), shall be cleared of any vegetation except permitted by a clearance licence (Part XI,Section 38).

***Sacred Bush***

Sacred forests/bushes are common throughout rural Sierra Leone and most villages have one or several forests within close proximity. The values of these forests to communities are many and varied, ranging from spiritual significance to meeting places to the practical source of trees and non-timber forest products. Increasingly, within the proposed transport corridor, sacred forests/bushes are some of the last areas of remaining natural habitat left, prominent within wider landscape of degraded vegetation and agriculture.

The Forestry Regulations of 1989 states under article XI, paragraph 40:

*“No tree or vegetation shall be removed from areas abandoned as sacred bush except under the authority al a clearance licence issued by the Chief Conservator of Forests.”*

## 4.3 ESHIA Legislative Requirements

On the basis of a formal application submitted to the Sierra Leone Environmental Protection Agency, the Tonkolili Iron Ore Project has been classified under Category A (EPA letter to AML dated 4.12.09). According to the Equator Principles a Category A project requires a full environmental impact assessment to assess the “potential significant adverse social or environmental impacts that are diverse, irreversible or unprecedented” (Equator Principles Website, March 2010).

It is understood that the government of Sierra Leone use this categorization system to regulate the ESHIA process and set the terms for an ESHIA licence. As part of the licensing the project’s ESHIA needs to follow agreed terms of reference which will be established in conjunction with the EPA.

The national legislation relevant to the preparation of the Tonkolili ESHIA and the Stage 1 ESHIA project includes the EPA Act 2008 and the Mines and Minerals Act 2009 (MMR 2009). The following sections outline the ESHIA requirements in each of these Acts.

#### ESHIA PROCEDURE OUTLINED IN THE ENVIRONMENTAL PROTECTION ACT 2008

The EPA 2008 briefly charts the procedure to obtain an ESHIA licence in Sections 23-29, with emphasis on the responsibilities of the EPA and the EPA Board, as stated below.

- An application must be made to the EPA for a licence, accompanied with a description of the proposed project;
- The EPA will decide (within 14 days) whether an ESHIA is required;
- If required, the applicant should then prepare an ESHIA;
- On receipt of the ESHIA, the EPA will circulate it to professional bodies or associations including Government Ministries and non-governmental organisations (NGOs) for review;
- Government Ministries and non-governmental organisations (NGOs) for review;
- The EPA will also open the ESHIA for public inspection and comment and will notify the public of this in two issues of the Gazette (consecutive issues) and two issues of a newspaper (with an interval of at least seven days between the first and second publications);
- The EPA will submit the comments on the ESHIA, together with the ESHIA, to the Board for consideration;
- If the Board approves the ESHIA, it will instruct the Executive Director of the EPA to issue an ESHIA licence;
- The EPA will issue a licence to undertake the activity/ project.

The ESHIA can only be approved by a multi-department Government Board. This Board then advises the Executive Director of the Environment Protection Agency (EPA) on its decision on whether to issue the licence or not (see Part IV of the Environment Protection Act, 2008 for further details).

In relation to social requirements, the EPA 2008 alludes to a requirement for social impact assessment in the Third Schedule of the Act. It states that the ESHIA should include “social, economic and cultural effect that the project is likely to have on people and society”.

### 4.4 ESHIA requirements in the Mines and Minerals Act 2009

The Mines and Minerals Act 2009 sets out procedures to obtain mining licences and was approved by the GoSL Cabinet in November 2009. Under this Act, a mining licence cannot be obtained until the ESHIA has been prepared, submitted, reviewed and approved first. An ESHIA licence is a form of permit which contains additional stipulations upon the holder such as abatement or remedial measures.

The Bill requires an applicant to have undertaken an ESHIA in consultation with the public and be able to "'verify possible impacts from the 'stakeholder's perspectives". The licence is required in order to commence mining operations of the nature intended by AML and will stipulate a number of cadastral and financial technicalities. The Bill requires an eligible 'person' (project proponent or company) has to present their licence application to the Ministry of Mineral Resources (MMR) accompanied by an environmental impact assessment (ESHIA) licence (refer to Section 106 (2) (s), GoSL 2009).

Section 133 states the applicant needs to develop an ESHIA that "shall contain the type of information and analysis reflecting best international mining practice" and outlines required headings from environmental baseline through to monitoring responsibilities and an environmental management programme.

It should also be noted that the Mines and Minerals Bill (2009) also requires the following:

- S.106-2 (i-(v)): proposals for the progressive reclamation and rehabilitation of land disturbed by mining and for the minimisation of the effects of mining on surface water and ground water and on adjoining or neighbouring lands;
- S.106-2 (i-(vi)): a statement on the effects of the mining operations on the environment and on the local population and proposals for mitigation, compensation and resettlement measures; and
- S.106-2 (i-(vii)): a statement on any particular risks (whether to health or otherwise) involved in mining the mineral;
- S. 59 (1g & 1h), 115 & 116: promotes preferential employment of citizens of Sierra Leon, as well as preferential procurement of goods and services from Sierra Leone;
- S. 23-18: deals with restrictions on exercise of mineral rights and compensation for disturbance of rights and for compulsory acquisition of land.

The MMR's expectations for these documents have not yet been confirmed. It also needs to be confirmed whether these documents could be prepared and officially validated or approved before the ESHIA licence is obtained.

### 4.5 Mine Technical Assistance Project (MTAP)

The 2009 Mining Technical Assistance Project (MTAP) for Sierra Leone is a capacity building initiative sponsored by the World Bank. The project is part of an integrated approach to extractive industries reforms that extends the goal of sound management and transparency along the full spectrum of the extractive industries management chain, from the awarding of licenses and contracts to the monitoring of operations, to the collection of taxes and sound, equitable distribution of revenues, and finally to the implementation of sustainable development projects (Ndomahina, 2008).

The objective of MTAP is to (i) increase efficiency and transparency of the mining sector management by the Government; and (ii) facilitate contribution of mining sector into local economic development. The project addresses specific mining impacts in relation to climate, geology, water resource, groundwater, noise odour and dust, traffic, and cultural and archaeological resources. Mitigation measures outlined include dust control measures, discharge controls on tailings and sedimentation ponds and silencers to reduce noise.

## 4.6 MTAP Resettlement Policy Framework

GoSL / World Bank Mining Sector Technical Assistance Project (MTAP) Resettlement Policy Framework (RPF) suggests the resettlement and compensation principles, organisational arrangements and criteria to be applied to meet the needs of persons affected by the project. In accordance with World Bank OP 4.12 (see Section 7.3.7) and the established Terms of Reference, the RPF covers the following sections:

- Introduction and Project Description;
- Principles and objectives governing resettlement and compensation preparation and Implementation;
- A description of the process for preparing and approving Resettlement and compensation Plans;
- Land acquisition and likely categories of impact;
- Eligibility criteria for defining various categories of project affected persons;
- A legal framework reviewing the relationship between the laws of Sierra Leone and regulations and Bank policy requirements and measures proposed to bridge any gaps between them;
- Methods of valuing affected assets;
- Organizational procedures for the delivery of entitlements, including, for projects involving private sector intermediaries, the responsibilities of the financial intermediary, the government, and the private developer;
- A description of the implementation process, linking resettlement and compensation implementation to civil works;
- A description of mechanisms for redressing grievances;
- A description of the arrangements for funding resettlement and compensation, including the preparation and review of costs estimates, the flow of funds, and contingency arrangements;
- A description of mechanisms for consultations with, and participation of, displaced persons in planning, implementation, and monitoring.

## 4.7 International Conventions to which Sierra Leone is signatory

In the last decade, Sierra Leone has become party to most international treaties relevant to the environment and social issues. Lists of the relevant treaties that have been signed by Sierra Leone are presented below (derived from SRK Consulting, 2009). Sierra Leone is receiving assistance from various United Nations agencies to meet the requirements of the treaties, including revision of national legislation.

***Environmental conventions***

- United Nations Framework Convention on Climate Change 1992;
- Kyoto Protocol to the United Nations Framework Convention on Climate Change 1997;
- Vienna Convention for the Protection of the Ozone Layer 1985;
- Montreal Protocol on Substances that Deplete the Ozone Layer 1993;
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal 1989;
- Bamako Convention on the Ban of the Import into Africa and the Control of Transboundary Movement and Management of Hazardous Wastes within Africa 1991;
- UN Convention to Combat Desertification 1994;
- Stockholm Convention on Persistent Organic Pollutants 2001;
- Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade 1998;
- African Convention on the Conservation of Nature and Natural Resources 2003;
- Convention on Biological Diversity 1992;
- Cartagena Protocol on Biosafety to the Convention on Biological Diversity 2000. Convention on International Trade in Endangered Species of Wild Fauna and Flora 1973;
- Convention on Wetlands of International Importance (Ramsar Convention) 1971;
- Memorandum of Understanding concerning Conservation Measures for Marine Turtles of the Atlantic Coast of Africa;
- Memorandum of Understanding concerning Conservation Measures for the West African Populations of the African Elephant;
- Convention on the Conservation of Migratory Species of Wild Animals, 1983 (Bonn Convention) (yet be signed); and
- The Convention covering the protection of the World Cultural and Natural Heritage Sites, UNESCO 1972.

***Marine conventions***

- The UN Convention on the Law of the Sea (UNCLOS 1982);
- The Convention of the International Maritime Organization (IMO), Geneva, 1948;
- International Convention for the Prevention of Pollution from Ships 1973 and 1978 Protocol (MARPOL);
- International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL, 1954);
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1973 (London Dumping Convention) (IMO);
- OSPAR Convention - Guidelines for the Management of Dredged Materials; and
- HELCOM Convention - Guidelines for the Disposal of Dredged Spoils.

See Appendix 5 for additional treaties on international labour standards (ILO Conventions) and human rights treaties.

Sierra Leone is a signatory to the Extractive Industries Transparency Initiative (EITI). This initiative supports improved governance in resource-rich countries through the verification and full publication of company payments and government revenues from extractive industries including oil, gas and mining. Countries rich in natural resources have tended to under-perform economically, have a higher incidence of conflict, and suffer from poor governance. Through the EITI, it is hoped that by encouraging greater transparency some of these negative impacts can be mitigated. Benefits to companies centre on mitigating political and reputational risks. Sierra Leone was accepted as an EITI candidate country on 22 February 2008. Sierra Leone has until 9 March 2010 to undertake validation however an extension has been requested (EITI website, Sierra Leone website, March 2010). In the new Minerals and Mines Act a section on reporting, disclosure and dissemination of information related to revenues and payments made by the mineral right holders and the Government provides the legal basis to make implementation of the EITI compulsory. It is stated as the obligation of the license holder and contravening this provision would be considered a prosecutable offence.

# 5 REGIONAL BASELINE

## 5.1 Climate, Air & Hydrology

### 5.1.1 Climate

Sierra Leone has a tropical monsoon climate, modified by local influences such as a decrease in temperature with altitude and variation in rainfall distribution induced by topography.

Characteristic of 'monsoon' climates are a wet season and a dry season each year - driven by the annual cycle in the latitude at which the sun's diurnal sky trajectory passes directly overhead. During the northern hemisphere winter, dry northeasterly winds, originating over the Sahara desert, blow across Sierra Leone. Conversely, in the northern hemisphere summer moist south-westerly winds from the Gulf of Guinea are drawn across Sierra Leone. Hurricanes are not known to occur in this region, any strong winds in the area would be related to squall lines.

Between March and November, a broad, east-west-aligned, rain-prone belt associated with the moist air from the Gulf of Guinea advances northwards across Sierra Leone and then retreats southwards again, drawn in the direction of the Inter-Tropical Convergence Zone (ITCZ). However, this simplistic explanation for Sierra Leone's wet season fails to explain all of its features. For instance, the axis of rain-prone belt is not co-incidental with the surface position of the ITCZ, but displaced some 300-400 km to the south. In some years there is a brief lull in the rains in the middle of the wet season while the entire rain-belt lies to the north, despite there being a plentiful supply of moist Gulf air. The assumed direct coupling between the ITCZ and the position of main seasonal rain belt has been questioned, and the factors involved are complex and still not fully understood. To the north of the main monsoon rain belt is a zone where thunderstorms and line squalls develop, and move from east to west with the tropospheric winds.

Hayward and Oguntoyinbo (1987) provide an overview of the climatology of the different weather elements experienced in West Africa which results from the mechanisms discussed above. Sunshine duration is greatest in the winter period, and much reduced in the rainy season as cloudy days predominate. There is a slight increase in sunshine from the south to the north in Sierra Leone. There is little seasonal variation in mean air temperatures, with slightly hotter conditions in April and May. Altitude influences temperature as well as other weather variables, with temperatures generally decreasing with altitude. Mean wind speeds are generally low, and high impact gusts are rare. The greatest wind speeds in the dry season occur when the 'Harmattan' wind blows from the east or north-east, while in the wet season higher wind speeds are associated with storms and squalls. The prevailing wind direction is from the south-west for most of the year, especially near to the coast and especially during the monsoon. Annual average rainfall is greatest along the coast, and decreases with distance inland. The Met Office makes a rough estimate of mean annual potential evaporation of 1000 mm for the Sierra Leone area, with a peak in March. This is likely to be higher for inland areas than on the coast.

For more information on climate and weather in the project area see Literature Review of Available Information and Data - Stage 1 -Prepared by the Met Office in Appendix 6 and Stage 2 – Climate Assessment and Data Analysis - Prepared by the Met Office in Appendix 7.

### 5.1.2 Hydrology

Sierra Leone possesses a tropical and humid climate, with clearly defined dry and rainy seasons. Annual rainfall averages about 2 526 mm.year$^{-1}$, ranging from 1 900 to more than 4 000 mm.year$^{-1}$, depending on proximity to the coast. Most of the rain falls between July and September.

The hydrology of Sierra Leone comprises a fairly dense network of rivers and streams, of which the larger ones generally flow throughout the year. Groundwater contributes baseflow to larger rivers during the dry season, while many of the smaller tributaries feeding these larger rivers cease to flow. About 80 percent of the rural population obtains its water from surface water sources.

The country can be divided into twelve river basins, of which five are shared with Guinea and two with Liberia. The most important ones, from west to east are: the Kolente (Great Scarcies), Kaba, Rokel (also known as the Seli), Pampana (Jong), Sewa, Loa, and Mona. The river catchments in Sierra Leone are relatively small, but because of heavy rainfall, produce large flows.

There are numerous valley swamps located in the headwaters of major rivers and their tributaries. These flat bottomed valleys are drained by slow flowing streams and are normally swamped for more than six months of the year. These areas are very important in rice and vegetable production. In 1999, Sierra Leone signed the Ramsar Convention on Wetlands with the only confirmed Ramsar site being the Sierra Leone Freetown Estuary area.

Sierra Leone has two major dams, both built for hydroelectricity (Guma and Bumbuna). There is considerable potential for the development of small-scale hydroelectric schemes that could also be designed to accommodate irrigated agriculture.

The internal renewable surface water resource is estimated at 150 km$^3$.year$^{-1}$; seasonal variations are very important, as only 11-17 percent of the annual discharge occurs between December and April (dry season). Internally produced groundwater is estimated to be 50 km$^3$.year$^{-1}$ of which 40 km$^3$.year$^{-1}$ are considered to be overlap between surface water and groundwater.

## 5.2 Geology, Hydrogeology, Soils, Land Use & Ecosystems

### 5.2.1 Regional Geology

Sierra Leone is predominantly underlain by rocks of Precambrian age (older than 500 million years), with a younger coastal strip approximately 50 km wide. This strip comprises of marine and estuarine sediments of Tertiary and Quaternary to Recent age.

The Tertiary deposits are from the Bullom Group and occupy the higher ground, while younger Quaternary and recent deposits occupy the low lying areas. The Bullom Group comprises interlayered silts, sands, clays and occasional lignites. Onshore, the thickness of the Bullom Group is variable but is known to be greater than 60 m, possibly reaching up to 120 m. The younger Quaternary deposits comprise alluvium deposits (generally highly organic soft sandy clay).

The Precambrian rocks can be divided into two major units, the granite-greenstone complex and the Kasila Group.

The granite-greenstone complex consists of a series of iron and magnesium rich rocks metamorphosed to amphibolite facies (the Kambui Group, previously known as the Sula Group) overlying the granitic basement. The grade of metamorphism in the basement generally increases towards the Kambui Group boundary giving rise to local occurrences of granulites, known as the Mano-Moa Formation (Birchall, *et al.*, 1979).

The Kasila Group comprises a series of high grade basic granulites and amphibolites that developed into a zone of shear deformation to form the southwest margin of the basement complex. During the development of the Kasila Group, part of it was thrusted eastwards onto the basement complex during an event known as the Rokelide Orogeny (*c.* 550Ma), giving rise to low grade schists, metasediments, banded iron formation (BIF) and lavas of the Marampa Group.

The Rokel River Trough developed very late in the Precambrian and a series of sandy and clayey sediments (quartzites, sandstones and marls) were deposited within this trough to form the Rokel River Group. Periodic volcanic activity during this time gave rise to basic and intermediate lavas and ashes (the Kasewe Hills Formation).

Two periods of igneous activity occurred during the break up of Gondwanaland in the early Mesozoic. The earliest of these, associated with the initial stages of rifting resulted in the intrusion of the Freetown Igneous Complex, a layered complex of gabbro, norite, troctolite and anorthosite located at the peninsular of Freetown. Numerous dolerite sills and mainly east-west trending dykes were also intruded during this time. The second period of activity was the intrusion of kimberlite dykes and pipes (*c.* 90Ma) mainly in the eastern section of the country distant from the project area (Birchall, *et al.*, 1979).

### 5.2.2 Hydrogeology

Limited investigation work have been undertaken to obtain information on the hydrogeology of Sierra Leone. With a population largely reliant on surface water, groundwater has overall received less attention.

According to a report published by the World Bank, the aquifers of the Bullom Series are considered the most productive aquifers in the country (World Bank/UNDP, 1991). This is supported by the high density occurrence of hand dug wells located within the elevated terraces of the coastal strip. Pump tests conducted on the aquifer of the upper Bullom Series (top 40 m) at Pepel Port, found that water from the aquifer could be pumped at a rate of 5 $L.s^{-1}$ from a single 150 mm diameter well. WorleyParsons have requested and are waiting for pump test data from GCS Ltd to assess aquifer properties.

Sierra Leone is largely underlain by igneous and metamorphic rocks, which typically have very low primary porosity (the porosity that results from the original formation of the rock). However, their secondary porosity (porosity resulting from processes post formation, e.g. faulting, dissolution) could be high, albeit, localised.

### 5.2.3 Soils

Sierra Leone has a total land area of approximately 7.2 million hectares, about 5.4 million of which is cultivable. Of this, about 4.3 million hectares are low fertile arable upland and 1.1 million hectares are of more fertile arable swamps. With nearly 80 percent of the labor force depending upon this land for their agricultural subsistence activities (largely slash-and-burn, with rice cultivation making up the bulk of the subsistence activity), the overall health of these lands will depend upon how well farmers are able to maintain the soil, water, and living resources (US AID, 20007). The combined effects of poor farming practices — shifting cultivation, recurrent bushfires and overgrazing, increasing population, ensuing shortening of fallow periods of land — have all been identified as contributing factors to soil erosion resulting in land degradation.

### 5.2.4 Land Use

Sierra Leone has a total land area of approximately 7.2 million hectares, about 5.4 million of which is cultivable. Of this, about 4.3 million hectares are low fertile arable upland and 1.1 million hectares are of more fertile arable swamps. With nearly 80 percent of the labor force depending upon this land for their agricultural subsistence activities (largely slash-and-burn, with rice cultivation making up the bulk of the subsistence activity), the overall health of these lands will depend upon how well farmers are able to maintain the soil, water, and living resources (US AID, 2007). The combined effects of poor farming practices — shifting cultivation, recurrent bushfires and overgrazing, increasing population, ensuing shortening of fallow periods of land — have all been identified as contributing factors to soil erosion resulting in land degradation.

Along the project areas, it is apparent that cultivation of land has been practiced for a number of generations, due to evidence of extensive land working and land scars (slow recovery of cultivated land). The local economy of the Districts affected by the project seems to be dominated by agriculture with a traditional focus on rice.

Agriculture is generally subsistence in nature, and, according to other literature on the project affected areas, poverty levels among the farmers are high, with 70 percent of the population falling below the UN defined poverty line (Coastal & Environmental Services, 2009).

A wide range of food crops are grown under the shifting cultivation system; sorghum, millet, maize, cassava, beniseed, groundnut and beans are the associated crops grown with rice. Farmers have very rudimentary equipment and practices.

During the dry season farming is restricted to valley flood plains (SRK 2009), while hillslopes are also used for cultivation in the rainy season. Cassava, plantain, sweet potato, cashew nut, ground nut and sweet corn are all commonly observed growing across the project area and fruits including pineapple, orange, papaya, banana and mango are also grown, mainly in the immediate vicinity of villages. Mango seems to be the most important fruit tree, since trees are found in large numbers around all villages along the project area. In the rainy season rice is a staple crop. Palm wine tapping is evident everywhere and fishing is also common in rivers and streams.

At present, forest resources are subjected to increasing deforestation due to the rapidly growing population and consequent demand for more agricultural land, urban requirement for timber and fuelwood, mining for minerals, and recurrent bush fires. With population pressure and commercialization today, the rate of exploitation has far outstripped the rate of regeneration by natural means. The result is deforestation and an acute threat to biodiversity, observed everywhere along the project areas.

According to a study completed in 2004, logging, firewood collection, and mining ranked as the top three perceptions of the actions most responsible for land degradation (US AID, 2007).

### 5.2.5 Ecology

Sierra Leone is divided into four major biogeographic regions: the coastal lowlands, the interior plains, the interior plateau and scattered mountains and hills. The coastal lowlands occupy the south-western third of the country and do not rise above 75 m above sea level (masl). They are interrupted by inselbergs and merge into the interior plains, which reach 200 masl in the east and cover 43 percent of the country's land surface. The interior plains end in an abrupt escarpment which runs from north-west to south-east and marks the start of the eastern interior plateau (at 300–600 masl), which covers 22 percent of the country. Two massifs top the plateau: the Sankan Biriwa–Tingi Hills (1,709 masl) and Mount Bintumani (1,945 masl). The latter is the highest peak in West Africa to the west of Mount Cameroon. Ten major rivers flow roughly parallel in a southwesterly direction across the country to estuaries and bays on the coast.

Two major biomes characterize the country's vegetation; the Sudan–Guinea Savanna and the Guinea–Congo Forests. The Sudan–Guinea Savanna biome occurs in the north and includes grassland, savanna woodland and Lophira-dominated tree-savanna. A large area of forest-savanna mosaic stretches over parts of the north and north-east and forms a zone of transition between the savanna and forest biomes. The Guinea–Congo Forests biome occupies much of the north-east and south-east. The vegetation typical of this zone is moist evergreen lowland forest with Afromontane elements at higher altitudes. Local climatic conditions and human activities have, however, particularly modified the climax forest vegetation in various parts of the country so that large areas are now covered by secondary regrowth.

<u>Ecoregions</u>

Three ecoregions, as described by the World Wildlife Fund, fall within the project area.

On the coast, where the Pepel Port is to be developed, the ***Guinean Mangroves***, an ecoregion that stretches from Senegal to Ivory Coast, occur. These mangroves are influenced by a large tidal range and high inputs of freshwater. The mangroves in this ecoregion contain stands that are more than 25 m in height and extend as far as 160 km inland. As the best developed mangroves in western Africa, this ecoregion provides important habitat for migratory birds and endangered species such as the West African manatee and the pygmy hippopotamus. The West African mangroves are relatively species poor containing five tree species, compared, for example, to the East African mangroves, which host up to nine mangrove tree species.

The ***Guinean forest-savanna mosaic*** extends through the central part of the project area, which mainly corresponds to the transport corridor to be used for haul road and railway development. This ecoregion of West Africa consists of a band of interlaced forest, savanna, and grassland running east to west and dividing the tropical moist forests near the coast from the West Sudanian savanna of the interior. Constantly occurring fires keep back the growth of trees in open country. A typical species of this ecoregion, *Lophira laceolata*, is a tree that is more resistant to fire. This species is widely distributed along the project area. The interlacing forest, savanna and grassland habitats are highly dynamic, and the proportion of forest versus other habitat components has varied greatly over time. Savannah vegetation covers 35 percent of Sierra Leone and includes forest savannah, mixed tree savannah and grassland savannah. This ecoregion is known to support large mammals such as elephant, leopards, hyenas, chimpanzees, baboons and monkeys, although their densities along the project area are likely to be very low to non-existent.

On the eastern part of the project, on the Sula Mountains, the ***Guinean Montane Forest*** ecoregion is present. This ecoregion consists of high altitude peaks and plateaus that spread across four countries in the Upper Guinean region of West Africa. The broad range of elevation, coupled with the underlying geology and anthropogenic activities, have given rise to different plant associations on several of the mountains. Although details of the number of endemic plants are not fully compiled, 35 plant species are known to be strictly endemic, with several mountains containing their own unique plant species. Floristic diversity results from a combination of geographic isolation, varied topography and soils, migration, speciation, climatic factors and anthropogenic activities. Studies of the Loma Mountains have produced considerable information about the flora, with records for 1,576 species distributed in 757 genera and 135 families. The fauna is also diverse with close to 15 strictly endemic vertebrate species, including species found on single mountains. A number of other rare forest mammals may also occur marginally in the mountains of this ecoregion, including Johnson's genet (*Genetta johnstoni*, DD) and a murid rat (*Praomys rostratus*). The western chimpanzee (*Pan troglodytes verus*, EN) also occurs in this ecoregion, with high densities reported from Mt Loma. The largest predator in the ecoregion is the leopard (*Panthera pardus*, EN). Avifaunal diversity is also high, and a number of rare species occur (Collar and Stuart 1988), including two near-endemic species, the Sierra Leone prinia (*Prinia leontica*, VU) and the iris glossy-starling (*Coccycolius iris*). The ecoregion is also of importance for endemic amphibians. More than 10 species are believed to be strictly endemic (WWF database), including Nimbaphrynoides occidentalis, an endemic toad occurring in savannas on Mount Nimba (Curry-Lindahl 1966 in WWF). In terms of reptiles, the area is of lower importance, with less than five species of near-endemic reptile being recorded. Several new species of insects in the family Coleoptera have been reported for both the Loma and the Nimba Mountains (Villiers 1965 in WWF). It is very likely that all the mountains of this ecoregion contain single-site endemic invertebrates, although the data are not compiled to prove this.Mining, slash-and-burn farming, and man-made fires are the major threats of this ecoregion. Grassland wildfires are largely human caused, but natural fires due to lightning strikes also occur (Morton 1986 in WWF).

*Current status*

Although once a predominant ecosystem in Sierra Leone, the forest now covers only 5 percent of the land area and consists of evergreen and semi deciduous vegetation. Sierra Leone is one of the most heavily deforested countries in the region (Barrie, 2002 in Walston, Hayes and Wolstencroft, 2010). A study of vegetation-cover showed about 5 percent of the country (c. 350,000 ha) to be covered by closed canopy evergreen forest, occurring mostly in the south-east, 3.6 percent (c. 250,000 ha) by secondary forest and about 52 percent (c. 3,700,000 ha) by forest regrowth and bush fallow. Distinctive fringing vegetation and gallery forests occur along the main riverbanks, while coastal mangroves cover some 286,600 ha (Davies and Palmer, 1989 in Walston, Hayes and Wolstencroft, 2010). It is worth noting that the whole of Sierra Leone below about 09o15' North was covered with largely closed canopy forest 20-40m tall with lianas and epiphytes, but little ground cover or grass (Grubb et al., 1998 in Walston, Hayes and Wolstencroft, 2010).

Moist closed evergreen lowland forests once covered the inland plains of Sierra Leone and across the mine site though it would have included areas of moist semi-deciduous forest as well, especially in the medium-altitude areas such as the Tama-Tonkolili Forest Reserve (Grubb et al., 1998 in Walston, Hayes and Wolstencroft, 2010). However, farmbush, grasslands and scrub now predominate in the region.

Lowland and submontane forest throughout West Africa has been impacted by development, resulting in large and potentially threatening declines in the range of many species unique to this region. The Tonkolili region is no exception, where forest, the natural climax vegetation of most of the region, is now largely restricted to narrow strips along river valleys and on the steepest slopes, and sacred groves and community forests (Darbyshire and van der Burgt, 2009).

## 5.3 Marine

### 5.3.1 Physical Environment

The Sierra Leone coastline is over 500 km long and includes a number of estuaries and islands including Banana, Turtle and Sherbro islands. Generally the nearshore profile is relatively steep. Where the Freetown estuary is located, however it is relatively shallow and rather irregular (Anthonie, 1991).

The Sierra Leone river estuary is a sheltered marine basin receiving waters from several tributaries, including the Rokel, Seli and Bunce rivers and the Kumrabe Creek (FAO, 1986 and Ramsar, 1999). The flow of freshwater from these rivers strongly influences the hydrographic conditions of the estuary as demonstrated by the range of salinity recorded. This reaches a maximum during the wet season when there is a measurable influence of freshwater extending to the continental shelf (FAO, 1986). The estuary is bounded to the north and south by a lowland coastal plain, indented by creeks. The Western Area Peninsular (WAP) (Freetown mountain) rises in the south. At its entrance into the Atlantic Ocean, the estuary widens to about 11 km and suddenly deepens at its southern shore to form a natural harbour, the third largest in the world (Ramsar, 1999).

During the dry season from November to April, currents inside Freetown Estuary are primarily governed by astronomical tides. Conversely, during the rainy season estuarine circulation is strongly controlled by the enhanced river run-off currents (Lorax, 2009). The regions tides are semi-diurnal and tidal range is variable depending on location in the estuary; the maximum tidal range at Freetown is 2.5m, whilst within the estuary the range is greater at 3 to 4.5m. The highest currents occur in the entrance to the estuary due to constriction of the flow around the sand banks to the north of the estuary entrance.

Coastal processes along the Sierra Leone coast are driven by wave energy and tidal currents. The regional wave climate consists of two long period swells (period = 7 – 16s) and locally generated wind waves (period < 5s) from the northwest. Wave energy is low to moderate with deep-water heights of less than 1.2 m occurring for 72 percent of the time. However, between June and October, moderate to high energy waves (1.5 – 4m) from the south are superimposed on the north-westerly waves (Anthonie, 1991).

### 5.3.2 Water and Sediment Quality

Other than at Pepel and Freetown, the lack of industry on the shores of the estuary should mean that the estuarine waters are free of industrial contamination. However, the deficiency of appropriate sanitary systems in the coastal and river communities may have led to bacterial contamination and high nutrient concentrations nearshore, although there is no evidence in the water quality data collected so far. Strong tides and high run-off volumes result in high turbidity levels in the water column throughout the estuary.

Basic water quality parameters have been measured over a period of approximately two months throughout the estuary and further offshore, including the Pepel Port site. Preliminary results, covering 21 sites and 29 profiles taken between 16 February and 12 March 2010, show that the water column appeared to be well mixed at most sites with little or no variation in temperature, salinity, pH or DO with depth. Turbidity generally increased with depth.

Similarly, little information is available regarding the estuary's sediment quality. Estuarine sediment is a series of sands, clays and gravels with occasional thin beds of argillaceous limestone, calcareous grit and additional seems of lignite (Tucker, 1973). As for water contamination of sediment is not expected and has not been indicated by preliminary sample results that have been collected so far around Tagrin and in the proposed dredge channel. The only exception to this is in the inter-tidal area at Pepel Port, where there is evidence of iron ore contamination of estuary / seabed sediments due to previous port operations.

### 5.3.3 Coastal and Marine Habitats

Along the northern shelf from Sherbro Island in Sierra Leone to the southern border of Guinea, the coastline is characterized by extensive mangrove forests, sandy beaches, mudflats and isolated areas of rocky outcrops (Fisheries and Aquaculture Department, 2010). These habitats serve as important shelter, feeding and nesting grounds for fish, birds and marine mammals. The northern stretch of coast, including the Sierra Leone estuary, is influenced by the Canary current, and is the most productive zone, with demersal, pelagic and shellfish resources (Fisheries and Aquaculture Department, 2010).

In addition to providing a highly valuable habitat for marine and terrestrial fauna, mangrove forest also plays a crucial role in coastal protection and reducing erosion from run-off and coastal processes. Locally, the mangroves have an important socio-economic role as a source of wood for firewood/charcoal and as a medium upon which shellfish anchor which provides an important food and nutrition source.

The mangroves of Sierra Leone occupy almost half of the country's coastline and cover a total area of approximately 100,000 ha (FAO, 2007). Mangrove is concentrated in four major areas, one of which is the Sierra Leone river estuary. As is the case throughout the world, the mangrove forests in Sierra Leone have been heavily exploited due to rapid population increase and high levels of poverty. It is estimated that nearly 40 percent of Sierra Leone's mangroves were cleared between 1980 and 2000. The high demand for the land and wood coupled with the lack of community participation in the management of mangrove resources has created a *de facto* open-access regime. This has resulted in mangrove cover that consists mainly of low re-growth with few larger trees, especially in the area around Freetown.

The Freetown shoreline consists of a rocky foreshore, from the upper inter-tidal zone to deeper subtidal areas offshore. There is an area of rocky habitat in the deeper waters between offshore Freetown and offshore Murraytown, close to the main shipping channel. This habitat supports a diverse community of soft corals, hydrozoans, acsidians and sponges. There are no true coral reefs along the coast mainly due to the intrusion of the cool waters of the Benguela and Canary currents and the high turbidity of the estuary waters (Ukwe et al. 2006). There are a number of ship wrecks along the western coastline of Sierra Leone, which act as artificial reef and provide important habitats for marine species such as soft corals and sponges. There is also reef habitat in shallow areas of exposed rock.

Seagrasses are important habitat areas that provide transition ecosytems and can be influential as marine spawning grounds. However, potential seagrass habitats in the estuary mouth were surveyed and none was found.

### 5.3.4 Marine fauna

With its high rainfall, Sierra Leone has an extensive system of rivers and swamps. A variety of mammals, birds and reptiles are found in the water, on rocks and sandy beaches or along the riparian zone. Rivers that periodically flood and dry have a variety of migratory bird species that nest on the exposed rocks, sandbanks and mudflats (USAID, 2007).

The Sierra Leone River Estuary is afforded some notoriety for its avifaunal abundance and is therefore designated as a Ramsar site, under the Convention on Wetlands of International Importance (the Ramsar convention), to which Sierra Leone is a signatory.

Turtles are believed to inhabit the coastal waters in and around the estuary mouth[1]. Five marine turtle species nest on beaches in Sierra Leone; green turtles, olive ridley, loggerhead, leatherback and hawksbill. The primary nesting beaches are around the Sherbro and Turtle islands (IUCN, 2010), which are a significant distance from the project site. Beaches to the north-west of Tagrin point provide potential turtle nesting sites. However, an initial survey suggests that human presence already deters the turtles from using these beaches. Therefore, it is believed that the turtles may use the estuary for foraging and the offshore area as a migration route.

Scientific reports concerning marine mammals' population dynamics are lacking for Sierra Leone; however, small cetaceans are sighted frequently in the waters at the mouth of the estuary near Freetown according to local specialists and observations from marine users[2]. Marine Mammals known to inhabit the coastal and estuarine waters of Sierra Leone include cetaceans (for example Humpback whale, common dolphins and Clymene dolphin) and the sirenean (African manatee). The threatened humpback dolphin may be present in the mouth of the estuary. However, as it inhabits the nearshore zone where there is much human activity, it may no longer be present in this area. The African manatee is believed to inhabit smaller waterways up river, avoiding brackish water and human presence.

Sierra Leone has abundant fish resources and as a result supports widespread fishing activity throughout its coastal and inland waters; contributing almost 10 percent of GDP (FAO 2008). This activity can be broadly classified into three sub-sectors:

- Highly mechanized and capitalized industrial fishery,
- Developing aquaculture and inland fisheries; and
- Low technology but widespread artisanal fishery, which makes up the majority of the fishing in and around the estuary.

Recent interviews with fishermen in March 2010 operating out of Tagrin confirm that Bonga (*Ethmalosa spp*) is the primary fish species for local fishermen within the waters around Tagrin and Pepel and are available for capture there throughout the year. In addition the 'Spanish' (*Sphyraena barracuda)* is a prized fish caught offshore in the dry season. The surveys also found that fish known locally as kutar, snapper, shinenose, bonita fish (March – May), shovelnose, longneck and grab were landed, with most of these other species taken west of Tagrin Point and outside of the estuary.

Sierra Leone has 23 bird species with global conservation status, including the White-necked Picathartes, Lesser Flamingo, Damara Tern, Lesser-crested Tern, Avocet, Water Dikkop, Greater Flamingo, Northern Shoveler Terek Sandpiper, Curvew sandpiper, Great snipe and Rose-ringed Parakeet. The Sierra Leone river estuary is regarded as one of the four most important sites for Palaearctic migrants birds in the country as the mud/sand foreshore, intertidal mud and muddy sand habitats provide the appropriate feeding grounds for most waders and other waterbirds; the estuary is not only a feeding area but also a roosting area for most waterbirds in the country. A short survey was

[1] Aruna, Edward. 2001. *Survey of the marine turtle species and an assessment of threats that affect their survival along the Goderich-Sussex coastline of Sierra Leone* (Dissertation submitted to the department of Biological Sciences for the award of B.Sc, Biological Sciences)
[2] A number were observed by ClassDiving and in sittings during the baseline survey in March 2010

undertaken as part of the preliminary baseline assessment and all eight of the winter wader species listed on the Ramsar designation being observed.

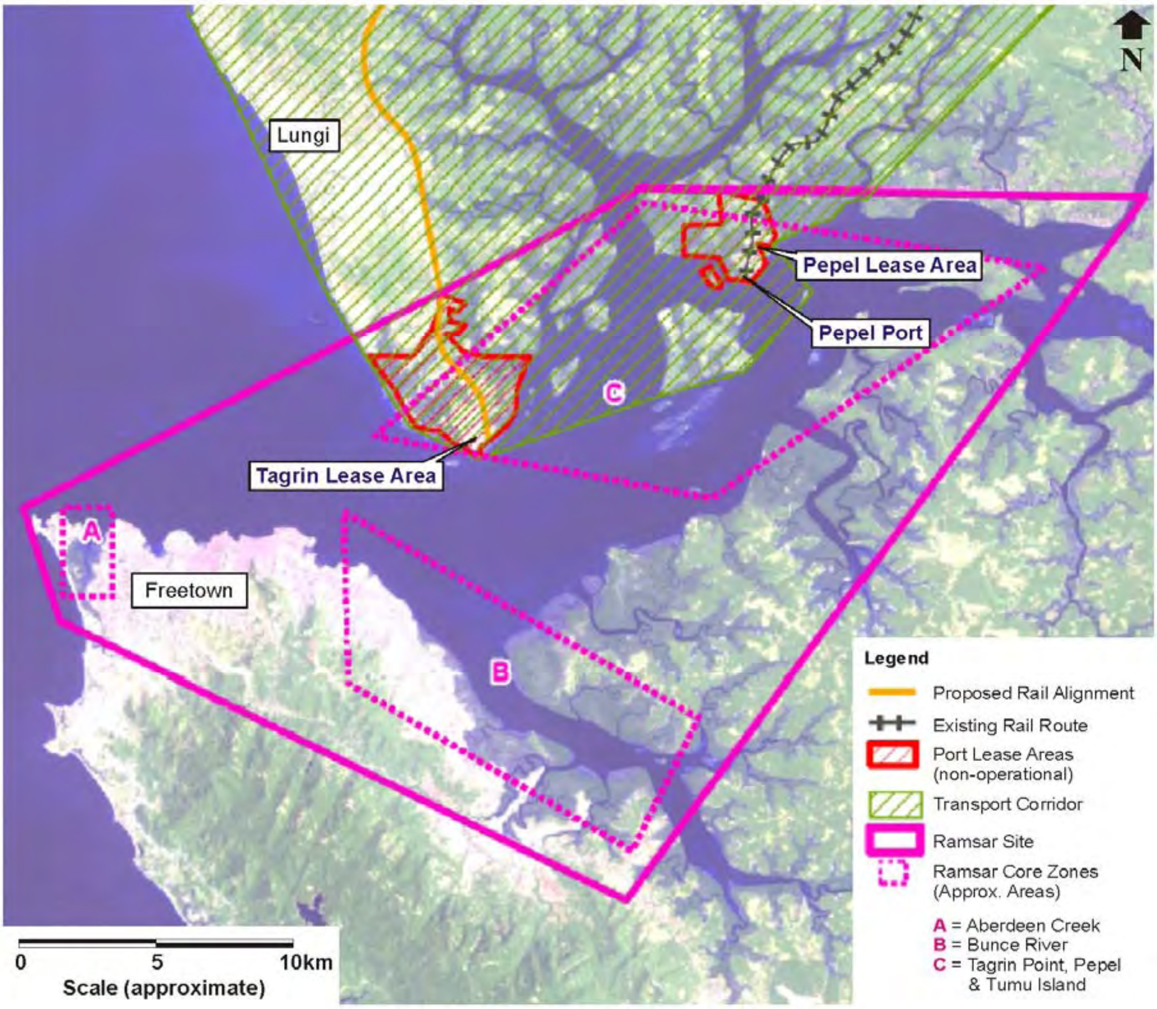
### 5.3.5 Protected Areas

The Sierra Leone river estuary was designated a Wetland of International Importance under the Ramsar convention in 1999. To improve the sustainable management of the Ramsar Site (including the livelihood promotion at the local community level), the Sierra Leone Ramsar Administrative Authority proposed the establishment of a Marine Protected Areas as a priority for implementation (Ramsar, 2008).

The link between functional mangrove ecosystems and associated marine/estuarine ecosystem health and fisheries production was a primary consideration in establishment of the Sierra Leone River Estuary Ramsar site.

Pepel Island falls within one of the core areas of the Sierra Leone River Estuary Ramsar site (see Figure 5-1).

**Figure 5-1 Location of Pepel Island and Tagrin ports within the Ramsar Site**




## 5.4 Population & Demographics

Sierra Leone is one of the world's poorest countries. Decades of economic decline and about ten years of civil war have had severe consequences on the economy. Poverty is widespread with more than 70 percent of the population living below the poverty line. The country ranks last in the Human Development Index. Despite some economic recovery after the end of armed conflict in 2002, the country is still considered a fragile state as it faces the challenges of poverty, corruption and economic mismanagement.

The Republic of Sierra Leone is composed of three provinces: the Northern Province, Southern province and the Eastern province and one other region called the Western Area.

Sierra Leone has a population of about 6 million comprising of over 20 ethnic groups. The Temne in the north and the Mende in the South are the largest with each group representing around 30 percent of the total population. Creole, descendants of freed Jamaican slaves who were settled in the

Freetown area in the late-18th century, represent around 10 percent of the population. Refugees from Liberia's civil war also reside in the country as well as small numbers of Europeans, Lebanese, Pakistanis and Indians. Muslim is the dominant religion in Sierra Leone followed by indigenous beliefs systems and Christianity.

The official language of Sierra Leone is English, however regular use is limited to the literate majority, and native languages of Mende (principal vernacular in the south) and Temne (principal vernacular in the north) are widely spoken. The Krio language (English-base Creole) and Bengali are also spoken. The literacy rate (defined as aged 15 and over who can read and write English, Mende, Temne, or Arabic) is 31.4 percent.

Annual population growth rate is 2.6 percent. The life expectancy is 37 years. The infant mortality rate is 170/1000 live births, and the under 5 mortality rate is 286/1000. In 2009 the male to female ratio was around 0.93. About 70 percent of the population is rural and the annual rate of urbanization is estimated to be around 2.9 percent between 2005 and 2010.

### 5.4.1 Health Status Summary

A desktop literature review was performed to provide a brief summary of the existing health status in Sierra Leone, with focus on the Northern Province and project-influenced districts where possible. The desktop study was carried out in the first quarter of 2010 and involves review of available literature using internet sources.

In 2007, Sierra Leone ranked as the least developed country in the world (WHO 2009), with an estimated 53 percent of people living below the international poverty line of US$1.25 per day in 2005 (UNICEF 2008). The country suffered great upheaval during the period of civil war (1991-2002) with injury, death and displacement amongst the population. There were also consequences for many areas of Sierra Leonean infrastructure, including the healthcare system. All levels of the system were affected with displacement of health care professionals and destruction of basic health infrastructure (WHO 2009).

**Health Policy and Initiatives**

Various health initiatives, both national, and internationally aided are in progress in Sierra Leone. Many of these are aimed at tackling the priority health issues. The Sierra Leone National Health Policy from the Ministry of Health and Sanitation (MoHS) (2002) cites the following as the current national priority health problems:

- Malaria;
- Sexually Transmitted Infections (including HIV/AIDS);
- Tuberculosis;
- Unsatisfactory reproductive health including maternal and neonatal mortality;
- Acute respiratory infections;
- Childhood immunisable diseases;

- Nutrition-related disease;
- Water, food and sanitation-borne disease;
- Disability; and
- Mental illness.

The WHO develops country cooperation strategies for a number of countries as a means of intensifying its interventions within those countries. The current WHO Country Cooperation Strategy for Sierra Leone 2008-2012 (WHO 2009) cites four strategic priorities:

- Reduction of the burden of communicable and non-communicable disease with particular focus on the prevention and control of malaria, reducing HIV/AIDS and tuberculosis and enhancing the national vaccination programmes to prevent and control vaccine-preventable diseases;
- Lowering rates of infant, child and maternal mortality and morbidity along with encouragement of responsible and healthy sexual and reproductive health behaviour;
- Improving access to and quality of health services; and
- National health development through cooperation and partnerships.

**Life Expectancy**

As a nation, the Sierra Leonean life expectancy at birth is currently estimated by WHO at 49.4 years (WHO 2009); however, in the past decade estimates have been as low as 37 years (WHO 2006). In 2004, the life expectancy in the Tonkolili district was estimated at 47.9 (47.3 for males and 48.6 for females), slightly below the national estimate and below the average for the Northern Province as a whole (49.8) (SSL 2004). Life expectancies in Port Loko and Bombali districts were slightly higher than Tonkolili at 49.0 (males 48.1; females 50.0) and 52.5 (males 51.6; females 53.5) respectively (SSL 2004). WHO report that the low Sierra Leonean life expectancies are due to the levels of communicable and non-communicable disease as well as child and maternal mortality rates (WHO 2009). They cite the underlying causes as widespread poverty, limited access to safe drinking water, poor sanitation, high levels of illiteracy (particularly amongst females), overcrowded living conditions, poor feeding and hygiene practices and inadequate access to good quality healthcare services (WHO 2009).

**Women, Children and Childbirth**

At 6.3 per woman, Sierra Leone has one of the highest fertility rates in the world (WHO 2009). However, maternal mortality rates also rank amongst the highest, with an estimated 2,100 maternal deaths per 100,000 live births (UNICEF 2008). Contraceptive prevalence is low (5 percent) and access to good quality care during and after childbirth is lacking, with only 43 percent of births attended by a skilled professional (UNICEF 2008). In surveys of attitudes toward domestic violence, it was reported that 85 percent of the population believe a husband to be justified in hitting his wife for reasons such as burning food, arguing back, or going out without telling him (UNICEF 2008). Female genital mutilation/cutting (FGM/C), a practice carried out for social reasons which affects the health and well-being of both women and their babies, is extremely common in Sierra Leone. An estimated

94 percent of women overall are affected, although rates in rural communities reach 97 percent (UNICEF 2008).

In general, child health in Sierra Leone is poor. At close to 30 percent, the under-five child mortality rate is the highest in the world with neonatal deaths representing 20 percent of the total under-five mortality (WHO 2009). In the Northern Province of Sierra Leone, in which the project is to take place, infant, child and under-five mortality rates are slightly below the national average (SSL 2004). Malaria, diarrhoea and pneumonia are the three principal causes of child death, with malnutrition as a common contributory factor. In 2007 it was estimated that 4,000 children (0-14 years) were living with HIV in Sierra Leone (UNICEF). Child labour is prevalent; data gathered between 1999 and 2007 estimates that it affects 48 percent of children aged 5 to 14 years (UNICEF 2008). The target for immunizations in Sierra Leone is 90 percent and some headway has been made in curbing diseases such as measles (WHO 2009).

**Malaria**

Malaria is widespread and transmitted year-round in Sierra Leone (WHO 2004). During the past decade, prevalence of malaria in the general population has at times been greater than 50 percent (WHO 2009). It is the number one cause of infant mortality and accounts for a large proportion of outpatient consultations (35 percent) (WHO 2004). In children under five years, malaria was responsible for between 50-60 percent of all admissions (WHO 2009). Malaria also accounts for 70 percent of the anaemia reported in pregnant women (WHO 2009). Governmental malaria control programmes and funding are in place, and a joint MoHS/WHO program for the control of malaria was initiated in 2004. The malaria programs aim to achieve better case management, vector control, prevention of malaria-in-pregnancy and health promotion but face challenges including changes in environmental conditions and sales of counterfeit malarial drugs (WHO 2009).

**HIV / AIDS**

HIV / AIDS is increasing in Sierra Leone, with higher rates in urban areas (2.1 percent) than rural areas (1.3 percent) (WHO 2009). HIV and AIDS impacts not only those infected, but can also have knock-on effects in a society. For example, in 2007, an estimated 16,000 children (0-17) had been orphaned as a result of AIDS, and school attendance amongst that group was almost 20 percent lower than the general population (UNICEF 2008). Data gathered between 2000 and 2007 suggests that the level of public understanding about the cause and prevention of AIDS is low; for example only 17 percent of young women (15-24 years old) had comprehensive knowledge of HIV (UNICEF 2008). Of note is the fact that the prevalence of HIV and AIDS amongst those with tertiary education is three times greater than those with no education (WHO 2009). In 2007, the Sierra Leone government introduced the *Prevention and Control of HIV and AIDS Act, 2007* covering areas including education and information, safe practices, testing and access to healthcare, transmission, monitoring and discrimination.

**Other Communicable Disease**

Other communicable disease of note in Sierra Leone currently include tuberculosis, leprosy, neglected tropical diseases (soil transmitted helminthes, onchocerciasis [river blindness] and lymphatic filariasis, dracunculiasis [guinea worm disease], yaws and schistosomiasis), lassa fever, yellow fever and diarrhoeal diseases (WHO 2009). Population movement counts amongst the risk factors for increased transmission for a good number of these diseases (WHO 2004).

The burden of tuberculosis in Sierra Leone is increasing. Between 2004 and 2007, the number of registered cases almost doubled, despite a poor case-detection rate of 50 percent (WHO 2009). Also of concern is the rise in multi-drug resistant tuberculosis (MDR-TB) and prevalence of TB/HIV co-infection. A tuberculosis control program is in place in Sierra Leone; however it faces challenges related to high default rates, low case-detection rates and the high percentage of patients without sputum results (WHO 2009).

Onchocerciasis or 'river blindness' is a vector-borne disease which has a high infection intensity and high resultant blindness rate in some parts of northern Sierra Leone. Risk factors for increased risk of exposure to the infectious agent (*Onchocerca volvulus*, a filarial worm) include subsistence farming fishing, bathing and mining (some areas) (WHO 2004).

Yaws disease was effectively eradicated prior to the war, but a recent re-emergence has created the need for public health intervention (WHO 2009). In the past, this disease has been a problem in remote communities of Bombali and Port Loko (WHO 2004), and there are currently plans for a yaws survey in the endemic Bombali region. The survey will be a joint initiative between the Sierra Leone Ministry of Health and Sanitation (MoHS) and WHO (WHO 2009). Portions of the proposed Phase 1 project are expected to operate in both the Bombali and Port Loko districts.

WHO rate the scale of infection with intestinal helminthiasis in Sierra Leone as 'enormous'. These worms cause reduction in vigour, illness, impaired intellectual development and reduced quality of life. Programs are underway in Sierra Leone to map and better understand the types of soil transmitted helminthes in the districts (WHO 2009).

Yellow fever has a WHO alert threshold of one case. In 2003 there were 4 confirmed cases in Tonkolili (WHO 2004).

Schistosomiasis is a public health concern and emerging disease in six districts within Sierra Leone, one of which is Tonkolili (WHO 2009).

**Non-Communicable Diseases**

There is a heavy burden of non-communicable disease including malnutrition, mental health issues and substance abuse, disability and injury in Sierra Leone.

Malnutrition is common, especially amongst women and children. It has many direct health effects and can also act as a contributory factor, increasing the severity of other diseases. In pregnant women, maternal malnutrition leads to low birth weight, a causative factor in neonatal death (UNICEF 2008). In Sierra Leone, approximately 25 percent of children are born with a low birth weight, and up to 30 percent of under fives suffer from moderate to severe underweight (UNICEF 2008).

Substance abuse is a significant problem in Sierra Leone, and the facilities to deal with mental health issues are lacking (WHO 2009). Surveys suggest that a large proportion of the population use alcohol, tobacco and drugs (e.g. cannabis, cocaine and heroine) (WHO 2009). A draft mental health policy has been drawn up; however, the availability of resources to implement it remains a challenge.

The major causes of disability in Sierra Leone are illness, congenital abnormalities, aging, accidents (including traffic), and war (SSL 2004). Following the civil war, a sizable number of people live with amputations (WHO 2009). In 2004, 2.2 percent of people in the Northern Province were classified as disabled and 6 percent of these had war-related disabilities (SSL 2004). The prevalence of war-related disability is lowest in the Northern Province of Sierra Leone.

**Environmental Health**

Environmental health and the provision of safe drinking water are important issues in Sierra Leone. At present, overall, approximately 46 percent of households drink water from unimproved sources, a number which rises to 68 percent in rural communities (UNICEF 2008, WHO 2009). Only 30.5 percent of households dispose of excreta by sanitary means and wastewater is rarely treated before release (WHO 2009). All of these factors increase the burden of water-borne and diarrheal disease and impact general health.

# 6 PROJECT AREA BASELINE

## 6.1 Baseline Study Techniques

Conducting baseline studies is an iterative process that builds on data already collected and leads to more targeted and specific information. The aim is to gain an understanding of the existing conditions in the project area to enables a good understanding of the sensitivity and function of the environment prior to the project commencing. For consistency across this project we have standardised the terminology for the baseline study phases as follows:

- Phase 1a: Desktop review and planning for the studies to collate relevant information, review legislation, identify specialists and prepare a base map for further work;
- Phase 1b: Undertake reconnaissance-level field studies to ground-truth the base map produced, identify habitats of potential conservation importance and to record significant ecological features in the study area. This phase is termed the Rapid Assessment Programme (RAP);
- Phase 2a: Scoping consultations with key stakeholders and the general public to understand key biodiversity issues related to local livelihoods and cultural significance;
- Phase 2b: Specialist investigations to collect detailed baseline data on species and habitats within the project area for all relevant seasons;
- Phase 3a: detailed targeted study (content driven), and
- Phase 3b: detailed in-fill study (coverage driven).

This terminology has been used in each of the following thematic disciplines: air and noise, hydrology, soil and landscape, ecology, social and community and marine for all the relevant project areas.

All the thematic disciplines, to varying levels of detail depending on sensitivity have been applied to produce a baseline for each of the project elements i.e. the mine area, the transport corridor, the port area and the marine and coastal zone.

## 6.2 Mining Area

### 6.2.1 Air Quality

A desktop study was conducted that included a review of the available information for the study area (Phase 1a) and a monitoring campaign was designed (Phase 1b) to assess the background air quality levels in the study area. The campaign was carried out in February 2010.

Ambient air measurements were conducted with passive sampling monitoring devices (diffusion tubes installed in the field for a period of 15 days), after which the devices were collected and sent to the laboratory for analysis. Diffusion tubes were obtained from Scientifics Laboratory in the UK. The contaminants monitored were nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$).

The sampling scenario covered 13 positions for the air quality measurements divided between the mine site, the port site and the transport corridor. The distribution of the sampling locations is shown in Figure 6-1.

**Figure 6-1 Air Quality Monitoring Campaign Measurement Locations**


Results obtained from the monitoring campaign were analyzed and compared with relevant guidelines.

Relevant international standards for environmental air quality include those published by the World Bank Group (WBG) in the WBG Environmental, Health, and Safety Guidelines (known as the “EHS Guidelines”), which are used by the WBG and the International Finance Corporation (IFC), as described in the Pollution Prevention and Abatement Handbook (PPAH) (World Bank Group, IFC, 2007). Ambient air measurements were conducted during a period of 15 days; therefore, results are not directly comparable with the periods given by legislation. When possible, the larger period (1 year) with a more restrictive limit has been considered.

Existing air quality at the proposed mining area is expected to be very good, because the area is a Greenfield site without existing industrial development or crowded populations. Dust is considered to be the primary air pollutant, generated from vehicle movements on unpaved roads and off-road.

The monitoring locations are listed in Table 6-1. The results obtained from the laboratory analysis for $NO_2$ and $SO_2$ (PA1-PA4 locations) are shown in Table 6-2.

**Table 6-1 Locations for Air Quality Monitoring Campaign in the Mining Area**

| Location | Coordinates | Remarks |
|---|---|---|
| PA1 | 29P 201325 991125 | In crops that have been burnt down in the hamlet of Little Furia. |
| PA2 | 29P 201944 993103 | In crops outside Wandugu village. |
| PA3 | 29P 207381 996691 | At a tree behind the health centre in Kemadugu. Traffic more frequent (approximately 5-10 cars / day). |
| PA4 | 29P 204163 997066 | On a drill pad (abandoned). Possibility of drilling activities close to the location. A small village (Kegbema) was observed at a short distance. |

**Table 6-2 Results of Baseline $NO_2$ and $SO_2$ Concentrations on Air in the Mining area**

| Loc. | Exposure time (hours) | $NO_2$ Analysis | | | $SO_2$ Analysis | | |
|---|---|---|---|---|---|---|---|
| | | µg/m³ | WHO limit (µg/m³) | Comments | µg/m³ | WHO limit (µg/m³) | Comments |
| PA1 | 502.25 | 10.2 | 40 (1 year) | Encountered on ground, dirt In tube, and discoloured upon extraction | 64.8 | 125[3] (24 hours) | Encountered on ground |
| PA2 | 501.00 | 5.3 | | - | 14.5 | | - |
| PA3 | 498.25 | 6.4 | | - | 6.4 | | - |
| PA4 | 498.67 | 6.2 | | Spider's web found | 4.8 | | - |

Concentrations of $NO_2$ and $SO_2$ in the mining area were found to be below the levels set by the World Bank Group (World Bank General Environmental Guidelines, IFC, 2007).

The results for PA1 are not considered reliable, as the tube was encountered on ground and could have been contaminated by ashes present after the recent burning of the field. The results for PA2 may have been affected by nearby activities related to the creation of a scout road for the future haul road development to the mine site.

Aside from these two locations, the monitored air quality is good and exhibits low pollutant concentrations. As expected, the levels correspond to Greenfield values.

[3] Target 1 for $SO_2$ limit (WBG)

### 6.2.2 Noise

A desktop study was conducted that included a review of the available information for the study area (Phase 1a) and a monitoring campaign was designed (Phase 1b) to assess the background noise levels in the study area. The campaign was carried out in February 2010.

The IFC – WBC (International Finance Corporation – World Bank Group) reference levels for ambient noise expressed in LAeq for residential, institutional and educational receptors is 55 dB(A) during the daytime (7:00 to 22:00) and 45 dB(A) during the night-time. For industrial areas, the reference level is 70 dB(A) any time of the day or night.

A noise survey was conducted with a Class I hand-held sound level meter and an ISO Tech sound level calibrator. The sound level meter measured the parameter LAeq, defined as the constant sound level that, in a given time period, would convey the same sound energy as the actual time-varying A-weighted sound level. Noise measurements were conducted during daytime hours.

The sampling scenario covered 20 locations for noise survey divided between the mine site, the port site and the transport corridor.  The distribution of the sampling locations is shown in Figure 6-2.

**Figure 6-2 Noise Monitoring Campaign Measurement Locations**


The ambient noise at the mine site might be generated by several naturally occurring sources and rural human sources: wind through the vegetation, animal and cattle noises, traffic in rural and populated areas, etc. The measurement locations at the Phase 1 mine site were selected based on the following criteria: in the project area outside the populated areas; and where measurements could be taken without interference from traffic or industrial noise.

Results of the Noise Survey are listed in Table 6-3.

**Table 6-3 Noise Monitoring Campaign in the Mining Area**

| Geographical Location | | LAeq (dB(A)) | Measurement Date | | Meteorological Data | | Remarks |
|---|---|---|---|---|---|---|---|
| ID | Coordinates | | Date | Hour | T (ºC) | Wind speed (km/h) | |
| N1 | 29 P 201282 991031 | 40.0 | 14/02 2010 | 13:00 | 37.2 | Light wind 1.6 – 2.4 | Birds singing |
| N2 | 29 P 201260 991116 | 44.8 | 14/02 2010 | 13:20 | 38 | Light wind 1.6 – 2.4 | Birds singing |
| N3 | 29 P 202017 993168 E | 34.6 | 14/02 2010 | 14:00 | 35 | 3 | - |
| N4 | 29 P 202067 993263 | 48.2 | 14/02 2010 | 14:25 | 35 | Calm, almost no wind | Wildlife noise intense |
| N5 | 29 P 204163 997066 | 31.7 | 14/02 2010 | 15:50 | 37 | Calm, almost no wind | Some birds singing |

All measurements were conducted during the daytime; therefore, the results listed in the table above are below the referenced Ambient Noise levels of 55 dB (A).

Results from measurements taken at locations N1, N2 and N4 are higher than at other locations, but the field observations confirmed that they correspond to natural environmental noise.

### 6.2.3 Archeology & Cultural Heritage

The significance of sites of archaeological value (in-situ) and cultural heritage factors has been initially screened by discussion with in-country ESHIA practitioners. The preliminary advice indicated that it was likely there would be limited and in some areas negligible sensitivity. Development of an understanding of the importance of marine and terrestrial archaeology, burial sites, Society Bush areas and other important heritage factors has already been included in a number of baseline studies. Integration of this information with a specialist assessment into a review of possible project impacts is still underway.

### 6.2.4 Ecology & Biodiversity

*Vegetation*

The area encompassing the Simbili deposit has been surveyed using Phase 1a, 1b and 2b study techniques during the wet and dry seasons in September and November 2009 and in February / March 2010. The area is situated in a tropical moist broadleaf forest zone, but is also close to a tropical grassland savannah zone and therefore displays some characteristics of each. The summit of Simbili is host to degraded forest, but the sub-ridge to the north of the summit is largely covered by grass with scattered tree species typical of the natural wooded grassland habitat. All the grasslands on Simbili are much disturbed with secondary grassland species dominant and with evidence of recent farming. Heavily degraded forest patches are present on the western slope of Simbili, although generally the species found there were characteristic of secondary forest. Only one species of concern was identified among these patches, the tree species *Cryptosepalum tetraphyllum* (IUCN: Vulnerable, VU). (See Appendix 8 for Preliminary Report on Phase 3 Vegetation Fieldwork - Prepared by SRK, Appendix 9 for Tonkolili Vegetation Survey and Inventory Report - Final - Prepared by Herbarium, Royal Botanic Gardens, Kew and Appendix 10 for Report on the Vegetation Map of the Tonkolili Project Area).

*Terrestrial Fauna*

A Phase 1b rapid assessment of eight sites within the mining area was conducted in March 2010 during the dry season. The natural forest cover of the mining area is heavily fragmented and does not appear to support viable populations of large mammals, with the exception of Western Chimpanzees that may be present in the forest patches to the south of the Farangbaia Forest Reserve. The existing habitats within the mining area support a range of bird species, including forest and non-forest species of conservation concern. (see Appendix 11 for Summary of Report, Phase 1 Study of Terrestrial Fauna at Tonkolili Mine Site, Sierra Leone prepared by the Wildlife Conservation Society)

*Aquatic Ecosystems*

A Phase 1b rapid assessment of two sites located in the vicinity of the southern boundary of the exploration licence area (the Tonkolili and Matoine Rivers) was undertaken in March 2010 during the dry season. Both sites have good in-stream habitat, however substantial clearing of riparian vegetation had occurred along the right-hand bank at the Matoine River site and there was evidence of in-stream artisanal gold mining. The waters at the sites surveyed generally had low conductivity and were slightly acidic, which means the waters have little or no buffering capacity against changes to pH from any acid inputs (For further information see Appendix 12 for Rapid Assessment of Aquatic Environments for the Tonkolili Project prepared by SRK).

### 6.2.5 Hydrology and Hydrogeology

Phase 1 mining activities will focus on the hematite cap of the Simbili deposit which straddles the two surface water catchments of the Tonkolili and Mawuru Rivers.

The Tonkolili catchment drains an area of approximately 165 km$^2$ and flows for approximately 48 km before it joins the larger Rokel River. The Tonkolili River flows throughout the year; minimum and maximum flow rates measured at 5 gauging stations in the vicinity of the mine and eastern transport corridor areas and corresponding to the dry and wet season of 2009 are given in Table 6-4 below. A figure of the gauging stations is given in Appendix 13.

During the dry season, river flow rates represent the base flow component contributed by groundwater.

**Table 6-4 Tonkolili River Flow Rates**

| | Tonkolili River Flow Rate ($m^3.sec^{-1}$) | |
|---|---|---|
| | **Apr-09** | **Sep-09** |
| RFT001 | 0.22 | 2.1 |
| RFT002 | 0.95 | 3.2 |
| RFT003 | 0.56 | 3.9 |
| RFT004 | 0.95 | 5.57 |
| RFT005 | 1.6 | 11.3 |

The Mawuru catchment drains an area of approximately 147 $km^2$ as it flows south along the eastern side of the Simbili deposit before joining the Pampana River. Maximum and minimum river flow measurements at two gauging stations in the mine vicinity are given in Table 6-5 below. A figure of the gauging stations is given in Appendix 13. The Mawuru River flows year-round suggesting the dry season flows measured in April 2009 represents base flow contributed by groundwater discharge (see Table 6-5).

**Table 6-5 Mawuru River Flow Rates**

| | Mawuru River Flow Rate ($m^3.sec^{-1}$) | |
|---|---|---|
| | **Apr-09** | **Sep-09** |
| RFM001 | 0.979 | 3.48 |
| RFM002 | 0.86 | 6.25* |

Field measured water quality parameters indicate relatively stable chemical conditions with little variation between the two catchments, and also between the wet and dry season. Electrical conductivity (EC) of Tonkolili River and Mawuru River water was generally below 20 $\mu S.cm^{-1}$ in both the wet and dry season. pH was found to remain neutral, ranging from 6.2 to 7.1 pH units with slightly lower pH values generally observed during the dry season.

Water quality samples were collected for laboratory analysis in the UK during the dry season, March 2010. In both rivers, the concentrations of iron ranged from 0.49 $mg.L^{-1}$ to 1.02 $mg.L^{-1}$ exceeding the UK drinking water guideline value of 0.2 $mg.L^{-1}$. Elevated concentrations of iron are suspected to be associated with the banded iron formation (BIF) deposits and iron rich soils.

A TPH (C24-C40) concentration of 0.012 $mg.L^{-1}$ was reported for a sample collected from the Mawuru River. The presence of a heavy TPH fraction suggests a degree of anthropogenic contamination most likely from a diesel, oil or grease source. However, the results from single sampling event carried out to date are not sufficient basis upon which to draw any conclusions at this time. Further sampling has taken place and a regular monitoring programme is being implemented. Results of the most recent sampling are awaited.

Numerous springs flowing from the upper slopes of the mountains flanking the Tonkolili and Mawuru Rivers contribute base flow throughout the year. The flow rate of five of these spring fed streams which discharge into the Tonkolili River have been monitored by SRK and AML using V-notch weirs for a period of 12 months commencing in April 2009. Flow rates vary between locations and are likely to be heavily controlled by the local geology and aquifer characteristics. A distinct pattern of peak and low flow periods are observed in the spring hydrographs and generally mimic the rainfall records with stable, low flow conditions existing between February and June/July at which time flows are between 0.1 and 4 $L.s^{-1}$. Flow rates increase in response to rainfall recharge during August and September to maximums of 8 to 24 $L.s^{-1}$, after which time, rates steadily decline.

Several spring-fed streams flow from the eastern flanks of Simbili discharging to the Mawuru River. Spring flow and water quality has been measured at one location, since April 2009. The spring flow during the wet season exceeded the capacity of the V-notch and readings could not be taken throughout August and September. Measure flow rates ranged from 0.5 $L.s^{-1}$ during the dry season to 7.7 $L.s^{-1}$ during the wet season; however maximum flow rates during August and September are likely to be much higher.

The EC value of spring water at both catchments ranged from <10 $\mu S.cm^{-1}$ to1210 $\mu S.cm^{-1}$. pH values were between 6.0 and 7.42 while redox potential indicated consistently oxidizing conditions. The chemical composition of water discharging from springs was found to contain slightly higher concentrations of certain dissolved metals. Arsenic (0.057 $mg.L^{-1}$) and selenium (0.236 $mg.L^{-1}$) were above their relevant UK drinking water guideline values while cadmium (0.0017 $mg.L^{-1}$) and lead (0.021 $mg.L^{-1}$) existed at higher concentrations than reported for the Tonkolili River. It is likely that the hematite cap overlying the BIF provides a source of various metal species which are leached by groundwater and discharged through these springs, before being diluted in the main river systems.

The maintenance of surface water flows year round is important to both local inhabitants and the natural environment (groundwater abstraction becomes more difficult during the dry season when groundwater levels gradually decline). East and south east of Simbili within the Mawuru catchment, no exploitation of groundwater has been observed and there is apparent total reliance on surface water from Mawuru tributary streams/ springs or the Mawuru itself in some cases (at the peak of the dry season) to meet village water demands.

Within the mine area the upper surface of the bedrock (Tonkolili Group) is thought to have weathered to a depth of between 40 m and 60 m. The uppermost 10-20 m is completely weathered to a laterite with rock becoming progressively fresher with depth. The weathered zone is thickest on the ridge tops and thins towards the valley bottoms. The ridge tops are sometimes characterised by hardpan (duricrust). The flanks of the hills are characterised by weathered material as well as transported boulders and soils (colluvium). Alluvial deposits of sands, silts, clays and conglomerate have been deposited in the Tonkolili and Mawuru valley bottoms, but it is not yet known how thick these deposits are.

SRK (2010) proposed the following conceptual model for groundwater flow in the mine area:

> *Recharge percolates through the laterite or duricrust into the weathered cap from where the majority of the groundwater flows laterally, at the contact with fresh rock, towards the ridge flanks and discharges through springs to the surface water network. The component of groundwater flow from the weathered cap to the colluvium is unknown but is considered low given the generally low permeability of the colluvium, Similarly, it is thought that groundwater flow from the weathered cap to the underlying BIF and amphibolite, which appears to be generally competent, is also low.*

The laterite / duricrust may act like a sponge, storing recharge and releasing it more slowly to the underlying aquifer as well as buffering through-flow to springs. This is an important process for groundwater-surface water interactions and would be seen on the Tonkolili and Mawuru river flow hydrographs as a tailing effect.

Water levels in the deposit area monitoring wells are generally within the weathered cap. Monitoring borehole GWM11 on the neighbouring Marampon deposit is artesian (flowing at 0.2-0.3 $L.s^{-1}$), possibly due to intersection of deeper fracture flow, which suggest local flow systems and high aquifer heterogeneity that may also exist within the Simbili deposit.

In the lower valleys and in the wider study area it is likely that colluvial and alluvial sediments act as aquifers of unproven thickness which discharge to the Tonkolili or Mawuru Rivers throughout the year. A deeper, fractured basement aquifer may be present throughout the study area, and if present would correspond with highly fractured, regional features (lineaments) mapped within the Precambrian basement rock (Akiwumi, 1988). The existence of these lineaments and the nature of groundwater flow in the basement rock are poorly understood. Fracturing in the upper strata was noted to reduce to zero within 30-40 m of the surface in the valley that now contains the Bumbuna Hydroelectric Dam.

Water levels have been monitored at weekly intervals since May 2009 at eight community groundwater wells which exploit the alluvial and colluvial aquifer. Depth to water ranges from 3.0 to 9.5 m below ground level (m bGL) during the dry season, rising to 1.0 to 6.5 m bGL during the wet season. The highest wet season water levels and the lowest dry season water levels were both measured in the lower Tonkolili catchment. The hydrograph response suggests that rainfall recharge infiltrates quickly to the aquifer with very little delay between the onset of the wet season and the initial rise in the water table.

Groundwater chemistry is expected to be fairly consistent across the study area, with the exception of groundwater within the weathered cap overlying the BIF. In general very little water-rock interaction is anticipated given the dominance of largely non-reactive basement rocks such as granites, schists, and greenstones.

The conceptual understanding of groundwater occurrence and flow in the lower valleys and in the wider study area is limited.

### 6.2.6 Soils & Land-use

Soils data have been derived from drilling and interpretation of superficial material. At most drill sites the top 2 m of material was cleared during preparation of the drill pad and therefore the baseline soil dataset is incomplete. The uppermost surficial material is dependent on the underlying geology. For the iron-ore protolith (quartz and silicate itabirites) a ferruginous hardcap or canga profile has developed, consisting of predominantly angular to subrounded fragments of hematite and pisoliths partially replaced by goethite and cemented by clays, reprecipitated silica and iron oxide. A simple laterite profile has developed over footwall or hangingwall acid to intermediate rocks, typically red in colour, comprising massive and colloform goethite-hematite, with common iron-oxide fragments cemented by clays, reprecipitated silica and iron oxides. (See Appendix 14 Tonkolili Soils and Laterite Profile - Prepared by SRK)

Preliminary qualitative information on land-use has been acquired during Phase 1b and Phase 2b biodiversity studies (flora, fauna and freshwater) in the mining area. While some remaining forest patches including Society Bush still exist in a mosaic land-use, in general human presence, slash and burn farming techniques, road and communal ground clearance (including clearance by AML) has driven a change in the area from forest and patches of grassland on the summits to primarily a mixture of agriculture and fallow land.

Agriculture comprises a wide range of crops on hill slopes and monocultures of rice or peanuts on periodically inundated land in the valley bottoms. Non-location specific bushmeat hunting grounds also occur.

### 6.2.7 Geology & Geomorphology

The Tonkolili ore body is situated in the greenstone belts of the Sula Mountains. The license area is dominated by rock units of the Sula Group, a greenstone belt that forms part of the Kambui Super Group. The Sula Group is comprised of two primary formations, the Sonfon and Tonkolili formations. The upper sequence of the Tonkolili Formation hosts the primary magnetite resource; however Phase 1 of the project is focused on the overlying hematite / goethite deposits. The iron content of the hematite / goethite ore can be increased to exportable grades through beneficiation. The geomorphology of the license area is characterised by smooth hill tops (that rise from 200 to 800 m in elevation) and plateaus that trend in a north-easterly direction and are deeply incised by the Tonkolili River drainage system which flows to the south east. (For further details see Appendix 15 for Geological and Geomorphologic Baseline Study - Prepared by SRK)

### 6.2.8 Socio-Economic & Human Health

The socio-economic and human health baseline of these areas has been characterised using a range of survey techniques at a coarse level and the results have been aggregated and described in a generalised manner in the regional overview. Although further baseline description is underway, it is assumed for the time being that the generalized description is an adequate characterization of the communities in the mine area and the baseline is not expected to be significantly different from the regional overview.

The baseline data collected from the field studies conducted in March 2010 for other relevant disciplines will also be considered for the health impact assessment. Water sampling program conducted in February identified elevated heavy metals concentrations (greater than WHO guidelines) for arsenic, barium, lead and selenium in samples from some wells in the mine area (Section 6.2.5). The results for increased concentrations of arsenic, barium, lead and selenium occurred in two samples (a groundwater well, and an artesian spring). The third groundwater sample was identified to well contain barium, lead, and selenium exceedances. These results may be an indication of elevated, naturally occurring metals in the area's geology which may pose a human health impact. Further assessment of the water chemistry in the mine pits and catchment areas is required before the potential health impact can be defined. The chemical results of soil, vegetation, fish tissue, and surface and groundwater samples collected during additional site visits will be studied and potential concerns highlighted in the next phase of works (see Section 8).

## 6.3 Transport Corridor

### 6.3.1 Air Quality

A short-term air quality monitoring campaign was carried out between the 13th and the 17th of February, 2010, as described in Section 6.2.1. The distribution of the sampling locations is shown in Figure 6-1.

During the field visits, industrial sources of air contamination were not observed. The identified contamination sources are the uncontrolled fires used in populated areas for cooking, waste burning or vegetation clearance for agricultural purposes; the diesel generators (found only at major settlements) used to supply electricity and the traffic.

Passive sampling diffusion tubes were used for the measurement of sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in the transport corridor area and its surroundings. The sampling locations and the diffusion tubes analysis results are listed below in Table 6-6and Table 6-7, respectively.

**Table 6-6 Locations for the Air Quality Monitoring Campaign along the Transport Corridor**

| Location | Coordinates | Remarks |
|---|---|---|
| PA5 | 29P 196599 990523 | On the proposed haul road alignment. In crops behind the health centre of Basaia, a medium-sized village. |
| PA6 | 29P 171639 970333 | Close to the transport corridor. Bashia Village, near Makeni, in crops on the side of the road Magburaka – Makeni, northwest of Magburaka. Near unpaved road to hamlet Makenilol. |
| PA7 | 28P 774644 967839 | On rail alignment. Close to the village of Furedugu on crops on the road to Petifu. |

| Location | Coordinates | Remarks |
|---|---|---|
| PA8 | 28P 751757965580 | Transport corridor. In a burned field near a small house on the side of the Rogbere – Port Loko road. |
| PA9 | 28P 733170 970048 | Transport corridor. On tall grass growing on top of the existing railway. The surrounding grasses had been burned. |

**Table 6-7 Results of Baseline $NO_2$ and $SO_2$ Concentrations on Air in the Transport Corridor**

| Loc. | Exposure time (hours) | $NO_2$ Analysis | | | $SO_2$ Analysis | | |
|---|---|---|---|---|---|---|---|
| | | µg/m³ | WHO limit (µg/m³) | Comments | µg/m³ | WHO limit (µg/m³) | Comments |
| PA5 | 481.92 | 6.1 | 40 (1 year) | | 6.1 | 125[4] (24 hours) | |
| PA6 | 478.25 | 6.0 | | | 4.4 | | |
| PA7 | - | - | | Missing | - | | Missing |
| PA8 | - | - | | Missing | - | | Missing |
| PA9 | - | - | | Missing | - | | Missing |

The diffusion tubes that were still present (PA5 and PA6) were collected, the chain of custody forms were completed and the tubes were sent to the Scientifics Laboratory for analysis. Based on the results from the analysis, air quality was found to be good.

### 6.3.2 Noise

A short-term noise monitoring campaign was carried out between the 13th and the 17th of February, 2010, as described in Section 6.2.2. The distribution of the sampling locations is shown in Figure 6-2.

Portions of the study area used to measure baseline sound pressure levels along the Phase 1 transport corridor are listed in Table 6-8.

**Table 6-8 Noise Monitoring Campaign in the Transport Corridor**

| Geographical Location | | LAeq (dB(A)) | Measurement Date | | Meteorological Data | | Remarks |
|---|---|---|---|---|---|---|---|
| ID | Coordinates | | Date | Hour | T (ºC) | Wind speed (km/h) | |
| N6 | 29 P 198355 987256 | 33.1 | 15/02 2010 | 10:00 | 29.4 | No wind | Some wildlife noises<br>Proximity to a road; no vehicles / persons observed |

[4] Target 1 for $SO_2$ limit (WBG)

| Geographical Location | | LAeq (dB(A)) | Measurement Date | | Meteorological Data | | Remarks |
|---|---|---|---|---|---|---|---|
| ID | Coordinates | | Date | Hour | T (ºC) | Wind speed (km/h) | |
| N7 | 29 P 197146 987988 | 36.7 | 15/02 2010 | 11:40 | 34.0 | Very light wind | Crops |
| N8 | 29 P 196599 990523 | 34.8 | 15/02 2010 | 12:30 | 36.3 | 2 – 5 | Crops very close to Basaia Village |
| N9 | 29 P 171639 970333 | 43.6 | 15/02 2010 | 17:30 | 34.2 | Strong winds 7 -15 | Measurement could have been affected by wind in nearby grasses |
| N10 | 28 P 795524 975669 | 39.4 | 13/02 2010 | 16:15 | 34.1 | 6 – 10 | Measurement could have been affected by wind in nearby grasses |
| N11 | 28 P 794702 975569 | 33.1 | 13/02 2010 | 17:00 | 34.1 | 3 – 5 | Birds singing |
| N12 | 28 P 752490 965133 | 41.4 | 16/02 2010 | 10:30 | 31.6 | Wind average speed 3.6 km/h | Old quarry site, surrounded by vegetation; wildlife noise was intense |
| N13 | 28 P 751743 965490 | 24.6 | 16/02 2010 | 10:00 | 31.2 | No wind | On an unpaved road, clear of vegetation. No traffic |
| N14 | 28 P 733170 970048 | 37.5 | 16/02 2010 | 15:00 | 37.6 | Wind speed approx. 3.5 km/h | Birds singing |

Results at locations N9, N10 and N12 are higher than the results at other locations. In the cases of points N10 and N12, field observations confirmed that the measurements correspond to natural environmental noise; however, in case of location N9, the wind speed reached 15 km/h. The noise level measured at N9 was likely due to wind through nearby grasses. For this reason, the result for N9 is rejected as an anomaly in the present noise baseline analysis.

### 6.3.3 Archeology & Cultural Heritage

The significance of sites of archaeological value (in-situ) and cultural heritage factors has been initially screened by discussion with in-country ESHIA practitioners. The preliminary advice indicated that it was likely there would be limited and in some areas negligible sensitivity. Development of an understanding of the importance of marine and terrestrial archaeology, burial sites, Society Bush areas and other important heritage factors has already been included in a number of baseline studies. Integration of this information with a specialist assessment into a review of possible project impacts is still underway.

### 6.3.4 Ecology & Biodiversity

*Vegetation*

A Phase 2b assessment was undertaken on the first 20 km of the haul road route, from the mine site to Rokel River at the end of the wet season in November 2009 and complemented by a new survey in March 2010, during the dry season. The transport corridor further west (proposed haul road route and existing rail line up to the Pepel Port facility) was surveyed using Phase 1b techniques in March 2010 (dry season). In the vicinity of the mine site, remnants of original forest vegetation, riverine forest, secondary forest, river channel communities and various secondary habitats are found. West of Rokel River, vegetation is largely characterized by a patchwork of inland valley swamps, secondary forest, farmbush, plantations, agricultural land, wild oil palm, grassland vegetation and inselbergs. Mangroves, freshwater ecosystems and agroforestry plantations are found in the Port Loko area.

Four habitats of conservation concern are present in the transport corridor. Riverine forest and river channel communities that have not been already highly disturbed are classified as of high conservation concern. Inland valley swamps and mangroves that have not been highly disturbed are classified as being of medium conservation concern. Species of conservation concern have been found in all these habitats of conservation concern, with the exception of mangroves. The presence of these conservation species indicates that the vegetation in these habitats is also likely to be relatively undisturbed and these habitats may also represent the last remaining examples of the natural climax vegetation in the study area. Although mangroves usually do not contain species of conservation concern and do not have high plant species richness, they are of considerable ecological value in terms of their structure and function, and are likely to harbour a wide variety of avifaunal and other animal assemblages.

*Terrestrial Fauna*

A Phase 1b assessment of 16 sites along the transport corridor was conducted during the dry season. As with the mining area, the natural forest cover is heavily fragmented, however, the continuous riparian forests do provide an important habitat for species that require more extensive habitat areas (such as large mammals). A diverse range of bird species exist within the remaining forest fragments, including species of conservation concern. The Port Loko Strict Nature Reserve, located to the north of the transport corridor does support small populations of two globally threatened mammals (the Western Chimpanzee and Western Pied Colobus). Western Chimpanzee Populations are also found in a forested area near the Lunsar Interchange.

*Aquatic Ecosystems*

The lowland areas are characterised by springs and small streams, which, based on Phase 1b surveys (March 2010) at two freshwater swamp areas around Pepel, are low to mid quality aquatic habitats, due to highly disturbed riparian vegetation and limited in-stream habitat types. In contrast, the aquatic habitats of the rivers surveyed are generally in good condition, with low turbidity, intact riparian vegetation and a range of in-stream habitat types. In particular, high quality aquatic habitats were identified along the Port Loko and Rokel Rivers.

Whilst no physical sampling was conducted, the Phase 1b literature review identified four freshwater fish species of conservation interest (one critically endangered species (*Pristis microdon*) and three endemic species (*Leptocypris taiaensis, Marcusenius meronai,* and *Prolabeo batesi*) that may be present in the aquatic environments along the transport corridor.

### 6.3.5 Hydrology & Hydrogeology

The transport corridor covers an approximate 200km linear section cross-cutting the country in a roughly east-west direction. The corridor crosses approximately 14 tributary catchments of the Pampana (also known as the Jong) and Rokel (also known as the Seli) river basins. The more significant tributaries in the project area include the Little Scaries, Bankasoka, Mabole, Pampana and Tonkolili Rivers. The upper courses of those rivers commencing in the Sula Mountains, and the interior plateaux region generally, are shallow during the long dry season, while the lower courses remain fuller and deeper presumably due to progressive influx of baseflow. The interior planes are subject to flooding during the wet season due to the relatively subdued relief of these areas. In the costal swamp area, rivers are affected by a tidal range of 2 to 3.5 m and experience severe flooding during the wet season.

The transport corridor commences at the mine-site in the Sula Mountains and loosely follows the Tonkolili River to its confluence with the Rokel, River. Flow in the Rokel River is controlled by the release of water from the Bumbuna hydroelectric dam, located approximately 11 km upstream from the confluence with the Tonkolili River. After crossing north over the Rokel River, the corridor loosely follows the drainage divide between the Rokel River to the south and the Mabole River to the north. Between the Rokel River crossing and Makeni, the corridor runs for approximately 30 km through an undulating topography of the interior plains. Water quality of the Tonkolili and Rokel Rivers in this region are typically fresh with neutral to slightly acidic pH. The Mabole River flows north east away from the transport corridor where it discharges to the Little Scarcies River.

From Makeni to Lunsar the corridor runs for 55 km through flatter topography where the major rivers, Mabole to the north and Rokel to the south meander through areas of low-lying swamp land. Many of the minor rivers crossing the corridor run northwards towards either the Mabole River or the Bankasoka River. During the dry season, most of the minor tributaries to the Mabole, Bankasoka and Rokel Rivers are dry with some of the larger tributaries containing either stagnant pools of water or very low flow. The Tabai and Bankasoka rivers (where crossed by the existing road) contained stagnant pools of water during February 2010 characterized by low EC (19 to 22 $\mu S.cm^{-1}$) and slightly acidic pH (5.76 to 6.09 pH units).

From Lunsar to Port Loko the landscape is characterised by low topographic relief and wetland areas. The corridor runs along the catchment boundary between the Bankasoka and Rokel Rivers. A higher occurrence of small ephemeral streams is noted in this area. On reaching Port Loko, the route crosses north over the Bankasoka River (Port Loko Creek) which is noted to have a high flow all year round. Water quality measurements taken at this location indicated the water to be fresh with an EC value of 22 $\mu S.cm^{-1}$, pH of 6.64.

From Port Loko to Pepel Island, the topographic relief is minimal and streams are inter-spaced with marshes and wetlands. This subtle change in topography and vegetation cover marks the progression into the coastal swamp and estuarine area with islands and sand bars. The corridor continues to follow the north-south catchment divide between the Little Scarcies River to the north, which becomes large as it enters tidally controlled water, and Bankasoka River (Port Loko Creek) to the south. Very few flowing rivers were observed in close proximity to the corridor during the dry season (February 2010).

The hydrogeological conditions along the transport corridor vary as the corridor crosses several of the major geological units present in Sierra Leone. However, the hydrogeology can be divided broadly into two main zones:

1. Basement outcrop - a weathered profile of thin Tertiary and/or Quaternary alluvial sediments are likely to form an upper, unconfined aquifer unit. Records indicate that the basement rock is, on average, 20 m bGL with the depth to water recorded at around 10 m bGL. The extent of weathering and the depth to basement will be variable across the corridor area and will be largely controlled by topography and basement geology. The majority of the transport corridor between the mine site and Port Loko is expected to encounter this conceptual hydrogeological setting;
2. Coastal sediments - The coastal sediments of the Bullom Group forms a belt along the entire length of Sierra Leone shown to reach at least 60 m thick, generally comprising layers of clays and sands. The sand layers represent either unconfined or confined freshwater aquifers. Groundwater flow is controlled by surface topography. Groundwater discharges either to swamp areas, freshwater streams or directly to the sea.

Within the basement outcrop zone, water levels are likely to fluctuate significantly between wet and dry season as rainfall infiltration provides annual recharge. Groundwater flow is expected to be controlled by a combination of surface topography and basement elevation, but will predominantly flow towards the major rivers draining the catchments.

Aquifer parameters are largely unknown for this region. Water quality is generally fresh with EC ranging from 100 to 200 $\mu S.cm^{-1}$ and pH from 5.9 to 6.8 pH units. This aquifer has been observed to be widely exploited by local communities who use hand dug wells to access a potable groundwater supply.

Within the coastal sediments zone which occupies the remaining western section of the corridor from Port Loko to Pepel., the sediments of the Bullom Group comprises gravels, grits, sands and clays of lacustrine, estuarine, deltaic and marine origin. This unit forms a coastal belt along the entire length of Sierra Leone and is likely to be encountered along the corridor at some point west of Port Loko.

The Bullom Group overlies the basement rocks of the Kasila Series and has been shown to be at least 60 m thick. The basement rocks outcrop in a few places in the estuaries of the Little Scarcies and Great Scarcies rivers and it is probable that the sediments are comparatively shallow throughout the greater part of this area. The sediments in the northern section of the belt consist of horizontally layered, cemented grits and sands, and recent river sands and silts. In this section of the belt, light to dark bluish-grey clays are overlain by brown, red or magenta, angular and poorly graded sands. The sandy layers of the Bullom Group represent either unconfined or confined freshwater aquifers. Rainfall recharge to the unconfined water table results in large annual fluctuations in the water levels which closely follow topography. Groundwater flow is controlled by topography with groundwater flow from higher to lower ground where groundwater discharges either to swamp areas, freshwater streams or directly to the sea. Aquifer properties are not well understood, however tests conducted in the Bullom Group suggest a hydraulic conductivity value of 5 x $10^{-4}$ $m.s^{-1}$ for the sand units. Groundwater is extremely fresh (< 100 $\mu S.cm^{-1}$) even in close proximity to the coast line and is generally slightly acidic with an average pH of 5.1. Groundwater of the Bullom Group is extensively used as a potable supply to local communities and is also exploited by the national water supply company SALWACO on the Tagrin peninsula.

### 6.3.6 Soils & Land-use

To date, no baseline studies to characterise the physio-chemical properties of soils have been undertaken in the transport corridor. Limited geotechnical investigation works including auguring and trial pitting are currently being carried out along the transport corridor and some drilling is proposed at potential river crossings. This work will allow development of soils descriptions and the Sierra Leone Agricultural department have been approached with regard to providing input based on their past and ongoing work as well as potential photo-interpretation of recent project imagery.

Preliminary qualitative information on land-use has been acquired during Phase 1b biodiversity studies (flora, fauna and freshwater) in the transport corridor. While some undisturbed habitats remain (e.g. remnant riverine primary forest), a significant proportion of land in the transport corridor is now used for subsistence agriculture, charcoal production and settlements. Non-location specific harvesting of medicinal plants and bushmeat hunting also occurs.

### 6.3.7 Geology & Geomorphology

Limited project-specific geotechnical drilling is currently being undertaken along the rail alignment within the transport corridor and reports will be available after presentation of this ESHIA document.

### 6.3.8 Socio-Economic & Human Health

The socio-economic and human health baseline of these areas have been characterised using a range of survey techniques at a coarse level and the results have been aggregated and described in a generalised manner in the Regional Setting chapter, Section 5.4. Although further baseline description is underway, it is assumed for the time being that the generalised description is an adequate characterization of the communities along the transport corridor and the baseline is not expected to be significantly different from the regional overview. The chemical results of soil, vegetation, fish tissue, surface water and groundwater samples collected during site visits will be studied and potential concerns highlighted in the next phase of works (see Section 8 for more information on the next stage of work).

## 6.4 Port Facilities

### 6.4.1 Air Quality

Pepel Port is currently not in use. The large majority of remaining plant and facilities at the time of the review were either in an abandoned state and/or disrepair. Preliminary enabling works associated with preparation for the refurbishment and re-engineering of the facilities is planned to commence in mid 2010. Potential sources of air emissions identified in this area are vehicle traffic (exhaust emissions and dust generated on unpaved roads) and fires caused by the population for different uses (cooking, waste burning, etc.).

During the air monitoring campaign, described in Section 6.2.1, passive sampling tubes were installed to monitor nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$). The sampling locations at Pepel Port, shown in Figure 6-1 are listed in Table 6-9. The pollutant concentrations of $NO_2$ and $SO_2$ obtained from the laboratory analysis are listed in Table 6-10.

**Table 6-9 Locations for Air Quality Monitoring Campaign at Pepel Port**

| Location | Coordinates | Remarks |
|---|---|---|
| PA10 | 28P 713986 948893 | Pepel Port. On a column of an abandoned building facing the sea. |
| PA11 | 28P 713608 948933 | Pepel Port. At the meteorological Station. |
| PA12 | 28P 714432 949659 | Pepel Port. In crops by a blue inhabited house on the seafront at the main settlement on the island. |
| PA13 | 28P 713850 950828 | Pepel Port. On the roadside from the Road to Pepel in a cleared area between the palm trees. |

**Table 6-10 Results of Baseline Air Quality Monitoring Campaign at Pepel Port**

| Loc. | Exposure time (hours) | $NO_2$ Analysis | | | $SO_2$ Analysis | | |
|---|---|---|---|---|---|---|---|
| | | $\mu g.m^{-3}$ | WHO limit ($\mu g.m^{-3}$) | Comments | $\mu g.m^{-3}$ | WHO limit ($\mu g.m^{-3}$) | Comments |
| PA10 | 458.58 | 4.2 | 40 (1 year) | Spider found (web removed from tube before dispatch) | 6.5 | 125[5] (24 hours) | - |
| PA11 | 458.33 | 3.7 | | - | 5.9 | | - |
| PA12 | 457.00 | 5.4 | | Spider found (web removed from tube before dispatch) | 8.1 | | - |
| PA13 | 457.33 | 3.1 | | - | 6.8 | | - |

[5] Target 1 for $SO_2$ limit (WBG)

The observed baseline atmosphere pollutant concentrations of $NO_2$ and $SO_2$ in the study area are an order of magnitude below the limits set for $NO_x$ and $SO_2$ by the World Bank (World Bank General Environmental Guidelines, IFC, 2007).

### 6.4.2 Noise

A noise baseline survey was conducted during the initial site visits using the locations N15 to N20 shown in Figure 6-2 as measurement points for the facilities at Pepel Port. The results of the baseline survey are listed in Table 6-11.

**Table 6-11: Results of Baseline Noise Monitoring Campaign at the Pepel Port Facilities**

| Geographical Location | | LAeq (dB(A)) | Measurement Date | | Meteorological Data | | Remarks |
|---|---|---|---|---|---|---|---|
| ID | Coordinates | | Date | Hour | T (ºC) | Wind speed (km/h) | |
| N15 | 28 P 714320 951474 | 28.2 | 17/02 2010 | 10:40 | 36.2 | No wind | On existing railway among mangrove forest at Pepel Creek |
| N16 | 28 P 713788 950900 | 36.9 | 17/02 2010 | 13:40 | 36.4 | No wind | In a forest clearing<br>Birds singing |
| N17 | 28 P 713515 948988 | 28.9 | 17/02 2010 | 12:40 | 35.2 | 4.3 | Isolated from background noise by Stockpiles |
| N18 | 28 P 713608 948933 | 41.8 | 17/02 2010 | 12.20 | 35.2 | 3.6 | Background noise (intense) from nearby (600 m) workers / people |
| N19 | 28 P 713986 948893 | 33.7 | 17/02 2010 | 11:40 | 34.7 | 3.8 | Background noise from birds and activity at Pepel Port |
| N20 | 28 P 714047 948879 | 30.2 | 17/02 2010 | 12:00 | 34.7 | 2.5 | Isolated site between Pepel buildings and shore |

Results at location N18 were higher than at other locations, but the field observations confirmed that they correspond to background noise from nearby workers / people at a distance of approximately 600 m.

### 6.4.3 Archeology & Cultural Heritage

The significance of sites of archaeological value (in-situ) and cultural heritage factors has been initially screened by discussion with in-country ESHIA practitioners. The preliminary advice indicated that it was likely there would be limited and in some areas negligible sensitivity. Development of an understanding of the importance of marine and terrestrial archaeology, burial sites, Society Bush areas and other important heritage factors has already been included in a number of baseline studies. Integration of this information with a specialist assessment into a review of possible project impacts is still underway.

### 6.4.4 Ecology & Biodiversity

*Vegetation*

The Pepel Port area is comprised of farmbush, plantations, settlements, vegetable gardens and wild oil palm. The wider Pepel Port land lease area and the rest of Pepel Island also hosts mangroves, mangrove / freshwater ecotone, oil palm and *Acacia mangium* plantations and grassland vegetation. The conservation significance of the mangroves is medium, while all other habitats are classified as low significance.

*Terrestrial Fauna*

A Phase 1b rapid assessment of six sites around the Sierra Leone River Estuary was conducted during the dry season. The area does not appear to have significant habitat value for terrestrial large mammals, reptiles or amphibians, however it does represent a very important (significant) wintering area for bird species. The significance of the area for bird species is reflected in the estuaries designation as a wetland of international importance under the Ramsar Convention (1971) and an Important Bird Area by BirdLife International.

*Aquatic Ecosystems*

During the Phase 1b rapid assessment, no freshwater aquatic environments were identified on Pepel Island.

### 6.4.5 Hydrology & Hydrogeology

Groundwater is the principle source of potable water supply to the inhabitant of Pepel Island. This is in part due to the lack of a dependable fresh surface water resource, and because Pepel Island is underlain by one of the most productive aquifers in Sierra Leone, the coastal deposits of the Tertiary Bullom Group. The group outcrops over the high ground in the form of elevated terraces and extends to depths of at least 60 m (SRK geotechnical investigation, 2009), possibly up to 120 m thick (Strasser-King, 1979). The groundwater beneath Pepel Island is expected to comprise a relatively thin lens of fresh water and become saline with depth; a common feature associated with coastal aquifers. It is interpreted that the lens is thickest under the elevated terraces, becoming thinner towards the coast as groundwater elevations approach mean sea level.

Groundwater samples were collected from wells on Pepel in and near the port area during a recent site visit (March/April 2010) to assess whether historical activities at the port may have had a detrimental effect on groundwater quality in the area. Background samples were collected from comparison from wells further north on the island where industrial activities are very unlikely to have impacted on groundwater quality. Water sampling locations are shown on the map of Pepel Island in Appendix 16.

The tests showed that at one location only (PPGW001) sulphate was elevated relative to the UK drinking water guideline value (250 $mg.L^{-1}$) south of the old stockpile area. Although arsenic concentrations in all soil sampling locations bar one, were above the detection limit arsenic in waters was below the guideline concentrations of 0.01 $mg.L^{-1}$ at all locations. No other potential contaminants of concern tested above concern levels.

During recent monitoring works, field parameters (electrical conductivity, pH, redox and temperature) were recorded at sampling locations. Electrical conductivity values ranged between 70 $\mu S.cm^{-1}$ and 200 $\mu S.cm^{-1}$ (an outlier of 500 $\mu S.cm^{-1}$ was measured in May 2010 at PPGW008 a recently drilled relatively deep water well,) representative of fresh water. A significant exception was the waters sampled from location PPGW001, located at the edge of the swamp area. The EC value for this water sample was above the maximum detection limit of the instrument (3900 $\mu S.cm^{-1}$), which is indicative of saline water. The location of this well suggests that it will be impacted by influx of saline water at high tides. The pH of the groundwater is acidic, ranging between 4.5 and 6.57 pH units.

There are no significant freshwater rivers present on Pepel Island; however, numerous ephemeral streams are present during the rainy seasons. Runoff from the high ground during the wet drains into the mangrove swamps. In the swamps themselves, there are a number of creeks discharging into the sea. Estuarine swamps lie at an elevation of less than 1 m above mean sea level (m amsl) and are subject to tidal flooding. The island is separated from the mainland by a channel, at least 100 m in width. One surface water sample was collected from a creek adjacent to Pepel Bridge. An electrical conductivity reading above the maximum detection limit (3900 $\mu S.cm^{-1}$) was recorded for this sample which is indicative of saline water.

### 6.4.6 Soils & Land-use

A baseline study to characterise the chemical properties of soils within the former Pepel Port facility was recently undertaken (March-April 2010). The study included the analyses of several surface soil samples collected from areas within the former port facility to characterise ground conditions associated with the site's former use as an industrial facility and hence provide the baseline reflecting the Brownfield character of this site. The sampling and analysis were designed to test for potential impact of historical contaminative activities associated with operation of the port (i.e. refuelling, fuel storage, power generation). Soil samples were also collected from outside former work areas to obtain information on the background soil characteristic of the area. Sampling locations are shown on the map of Pepel Island in Appendix 16.

As part of an initial screening exercise, soil concentrations were compared with suitable WorleyParsons (UK) derived generic criteria in order to identify contaminants of potential concern to human health. As part of the screening process, each contaminant is compared to three guideline values which were derived considering three different land use scenarios (i.e. residential land use with vegetable uptake and without vegetable uptake and commercial land use with hard cover).

The assessment found that none of the contaminant soil concentrations exceeded commercial land use guideline values. However, arsenic, benzo(a)pyrene and aliphatic compounds (C16-C35) concentrations exceeded the derived guideline values for residential land use with or without vegetable uptake at some locations which are discussed in more detail below.

Arsenic concentrations were above the detection limit of 0.6 $mg.kg^{-1}$ at all locations with exception of sampling location PPSS004 within the port area near the rail line but remote from any area of significant industrial activity. The highest concentration (197 $mg.kg^{-1}$) was measured at location PPSS006, which sampled soils in an historically coal tar lined gulley adjacent to the former powerhouse. This concentration is six times greater than the residential guideline value of 35$mg.kg^{-1}$ for areas with no vegetable uptake. It is possible that arsenic occurs naturally in local soils (the result of weathering of arsenic-rich bedrock, i.e. metamorphics). However, the occurrence of significantly higher concentrations within former port work areas indicates that these activities have contributed to arsenic levels in soils.

Aliphatic compounds (C16-C35) exceeded the residential guideline value (9.1 $mg.kg^{-1}$) at several locations within the former working areas. The highest concentration (1830 $mg.kg^{-1}$) was measured in the soils collected from location PPSS006 which is described above.

Benzo(a)pyrene concentration exceeded the residential guideline value at two locations (PPSS001 near the refurbished AML training room and PPSS013 adjacent to rail tracks by the former fuel storage tanks area). Benzo(a)pyrene is a contaminant often associated with coal tar. Heavily weathered tarry material is present at Pepel Port at a number of locations where a worker confirmed that coal tar was used to provide a seal to protect ground from being contaminated by spills of fuels in the vicinity of the former fuel depot.

Iron concentrations ranged between 9750 $mg.kg^{-1}$ (PPSS017) and 178000 $mg.kg^{-1}$ (PPSS013). These high concentrations are not considered to pose a risk to human health, as iron is not toxic to human health. However, elevated dissolved iron in surface waters with a low pH, can impact on aquatic life, especially in circumstance where acidic waters mix with more alkaline waters. Under these conditions, dissolved iron would start to precipitate out of solution to form an iron oxide orange stained sludge which will coat the river/stream bed. This coating will kill bottom dwellers, which in turn will have a knock on effect (e.g. reduced food source) on the larger aquatic environment.

Preliminary qualitative information on land-use has been acquired during Phase 1b biodiversity studies (flora, fauna and freshwater) in the Pepel Port facility area. In addition to remaining mangroves, land in the Pepel Port area is used for subsistence and commercial agriculture (oil palm and Acacia plantations), charcoal production and settlements.

Potential sources of contamination associated with the historical operation of the port remain and include stockpiled and dispersed hematite product from the former operations, hydrocarbons and solvents associated with fuel farms, workshops, loco sheds and the power house and transformer stations. Asbestos containing materials were also identified and tested and demonstrated to contain chrysotile asbestos.

### 6.4.7 Geology & Geomorphology

It is understood that limited project-specific geotechnical test pitting and auguring has been undertaken to date at the proposed port site and interpretation and reporting will be available after issue of this ESHIA report. Published data and recent drilling for water well installations confirm the presence of at least approximately 40m of sedimentary sequence of clay, silt and sand and consistent with the Bullom Group which outcrops along the entire length of the Sierra Leone coastline.

### 6.4.8 Socio-Economic & Human Health

The socio-economic and human health baseline of these areas have been characterised using a range of survey techniques at a coarse level and the results have been aggregated and described in a generalised manner in the Regional Setting chapter, Section 5.4. Although further baseline description is underway, it is assumed for the time being that the generalised description is an adequate characterization of the communities along the port area and the baseline is not expected to be significantly different from the regional overview.

Data collected from the field studies conducted in March 2010 for other relevant disciplines will also be considered for the health impact assessment. In the Pepel Port area, the pH levels measured at a number of wells and surface water sampling locations in the project area were outside of the generally accepted drinking water range of 6.5-8.5 (WHO 2007). WHO have not established a drinking water guideline for pH, stating that 'values in drinking-water are well below those at which toxic effects may occur'; they do, however, remark that pH is an important operational water quality parameter (WHO 2008). pH can have indirect effects on water quality and health. It is known that heavy metals and base cations can be mobilized by increasing acidity in groundwater and soil.

The number of samples collected for the baseline study was low. Better definition of the water chemistry, is required before potential health impacts can be fully defined. Additional testing be carried out in the next phase of works (Section 8) will more accurately define the surface and groundwater quality in the Pepel Port catchment area to ensure that appropriate health based guidelines are met. Testing should include metals, routine potability and microbial parameters.

The baseline soil and marine sediment programs identified elevated heavy metal concentrations below commercial international standards (CCME) in the Pepel Port area (Sections 6.4.6 and 6.5). Soil samples collected from the Port area contained concentrations of arsenic, benzo[a]pyrene, and hydrocarbons $C_{16}$-$C_{35}$ in concentrations greater than residential guidelines with or without vegetation uptake. Sediment samples and intertidal sediment samples were identified to contain arsenic, chromium and lead concentrations greater than international standards.

In addition, baseline surveys and in-country visits identified materials such as asbestos sheeting, presumably scavenged from Pepel Port and used in local communities as building materials.

The chemical results of soil, vegetation, fish tissue, surface water and groundwater samples collected during site visits will be studied and potential concerns highlighted in the next phase of works (see Section 8 for more information on the next stage of work).

## 6.5 Offshore & Coastal

### 6.5.1 Marine Physical Environment

**Ocean Climate**

Accurate bathymetry data for Pepel is not yet available. Although UK admiralty charts do exist, there are discrepancies between these charts and field observations. In particular, depths around the old navigation channel have reduced following the port's closure and discontinued maintenance dredging (Scott Wilson, 2009).

Located further inside the estuary, tidal variations at Pepel Island are less than in Freetown. Data from the UKHO (Admiralty Chart no. 625) shows a mean water variation of approximately 2.9m at spring tides and 2.2m at neap tides.

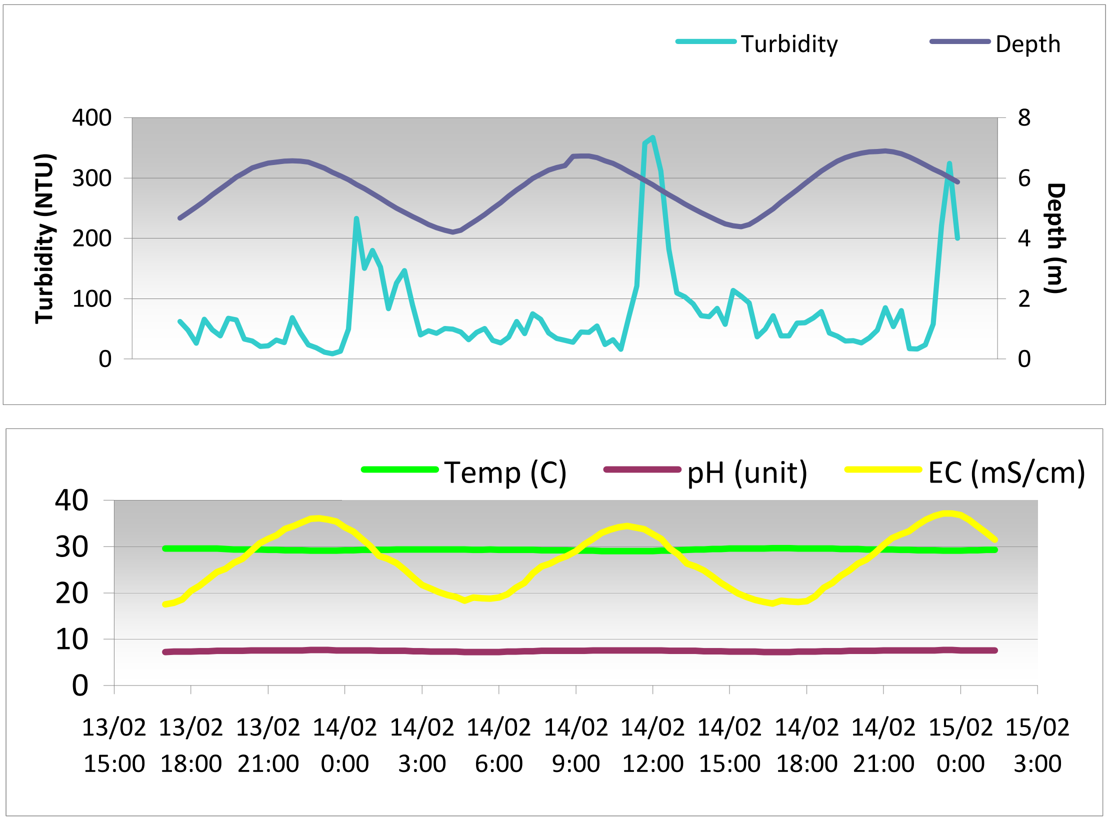
A 2D hydrodynamic model (DHI MIKE) developed for this project estimated the maximum current speeds (tides only) in the main channel at Pepel to be 0.82 m/s (WorleyParsons, 2010a). The model utilised charted bathymetry and predicted water levels and these values are treated with caution. The model will be improved and a more detailed analysis will be provided in the final ESHIA report based on calibration against observed data.

The influence of waves in the Pepel part of the estuary is expected to be very low as there is protection from the open waters of the Atlantic by Tagrin Point and sand banks and bars in the estuary mouth.

**Water and Sediment Quality**

Basic water quality parameters have been measured nearshore Pepel (site P1). Figure 6-3 shows the preliminary results from February 2010. Further data will be available for the Stage 2 ESHIA. The results show the variability in turbidity with the tidal cycle. The waters are highly turbid during mid-ebb flow, as expected.

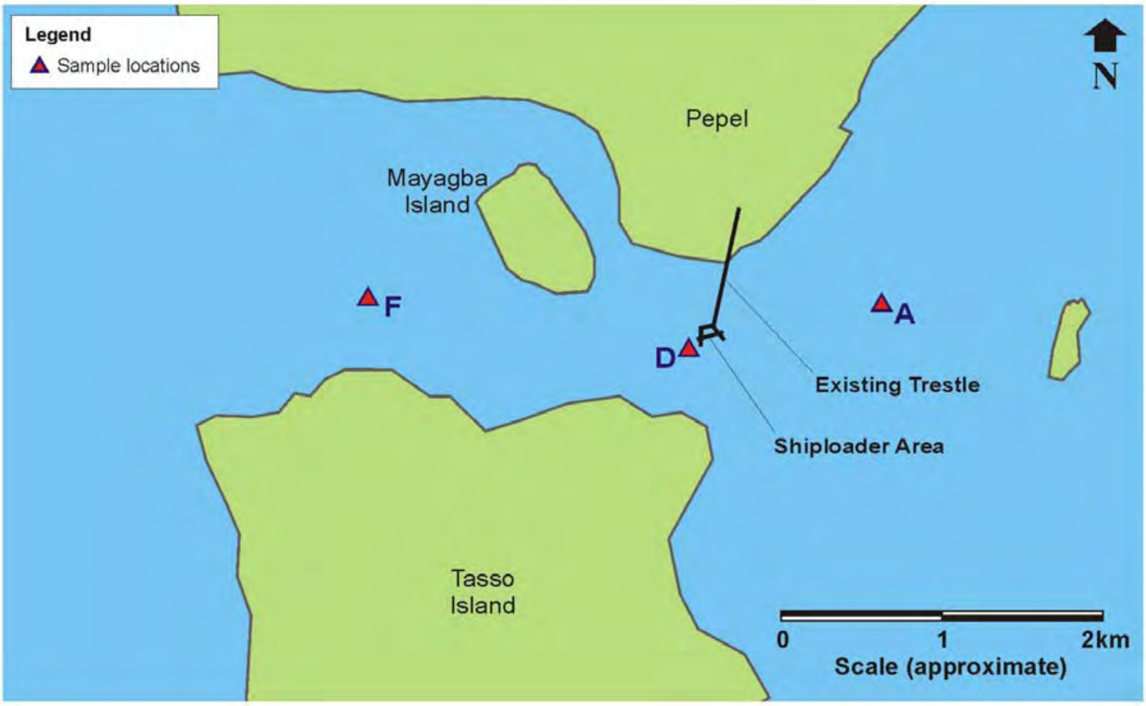
**Figure 6-3 Water quality plot at sample location P1, February 2010**




Dry season marine baseline assessment in March 2010 was undertaken around Pepel Island and the proposed dredge channel and spoil ground. The survey was undertaken over ten days and samples were collected from 12 sites. Sample locations around Pepel are shown in Figure 6-4.

Water and sediment samples were collected and analysed for their physical and chemical properties.

**Figure 6-4 Water quality and sediment sample locations close to Pepel**




None of the water samples taken during the March 2010 environmental survey reveal concentrations which are above international water quality guidelines for the protection of aquatic life. The baseline conditions of estuarine water quality at Pepel are therefore good.

Results for total suspended solids (TSS) describe conditions during the ebbing tide as more turbid than that of the flood. This is typical of surface run off carrying particulate matter into the estuary from river channels on the ebbing tide. In contrast, less turbid marine waters enter the estuary on the flood. Near Pepel measured TSS concentrations were < 5 mg/l around high water and approximately 40 mg/l at low water.

Sediment is well sorted in fast flowing sections of the estuary, ranging from good to moderate coarse sand. Reduced current speeds behind Mayaba Island at sample location F result in finer particles settling out of suspension resulting in a silt sediment.

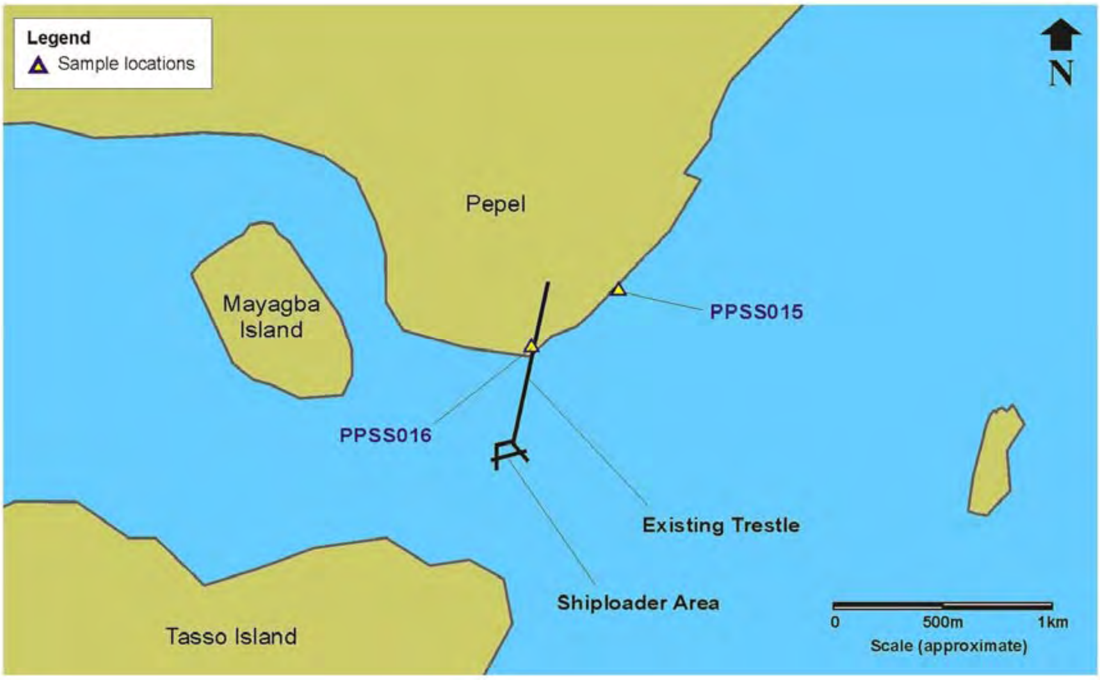
Hydrocarbon analysis of sediments sampled close to Pepel display an increase in total hydrocarbon concentration at location D. Location D is situated at the end of a trestle, which is part of the existing port structure. A possible explanation for increased hydrocarbon concentrations at this location is that vessels would have spent relatively long periods of time at the trestle whilst loading ore and fuel and or oil could have been spilt at this time. The trestle is also an area of shelter for fish and artisanal fishermen were observed fishing there during the survey. F fuel may have been accidentally spilt by these fishermen. A further potential source of hydrocarbon contamination at location D is transport from other locations, carried in the water column and deposited as the current slows at and around the protruding trestle – this is not supported by the sediment type however, which is indicative of a fast flowing location.

Sediment nutrient concentrations are comparatively elevated at sample Location D. The trestle at this location may be responsible for slowing the current and causing particulate matter to fall out of suspension. The trestle also provides habitat for fish, which may also deposit organic matter to the sediment.

Heavy metal concentrations in the sediment are elevated at Location F but not at Location D. Arsenic and Chromium concentrations are above international sediment quality guidelines (Canadian CCME) at Location F, but do not exceed the probable effects level.

Sediments were also collected from the intertidal and coastal zone in April 2010 as part of the soil monitoring campaign (see Figure 6-5).

**Figure 6-5 Intertidal sediment sample locations**




Results from the baseline survey of heavy metal contamination in the intertidal zone at Pepel show readings which indicate:

- Arsenic is above sediment quality guidelines[6] at location PPSS016. Arsenic is a toxin and can reduce benthic invertebrate abundance, increase mortality, and induce behavioural changes depending on its chemical form and resulting bioavailability (CCME, 2010).

[6] In the absence of national or international standards the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Update 2002) are used, which are based upon recognised toxicological methods.

- Chromium is above sediment quality guidelines in both locations. Chromium is a toxin and can decrease diversity and abundance, increase mortality, and induce behavioural changes in benthic organisms, among others (CCME, 2010).
- Lead is above sediment quality guidelines at locations PPSS015. Adverse biological effects of Lead in the benthos include increased mortality, decreased invertebrate abundance and diversity, and abnormal development (CCME, 2010).

Many of the contaminants are naturally associated with iron and are likely the remnants of past ore handling operations at the port (CCME, 2010).

### 6.5.2 Coastal and Marine Habitats

Pepel Port lies in an area of high ecological value associated with extensive mangrove forests within one of the core areas of the Sierra Leone Ramsar site.

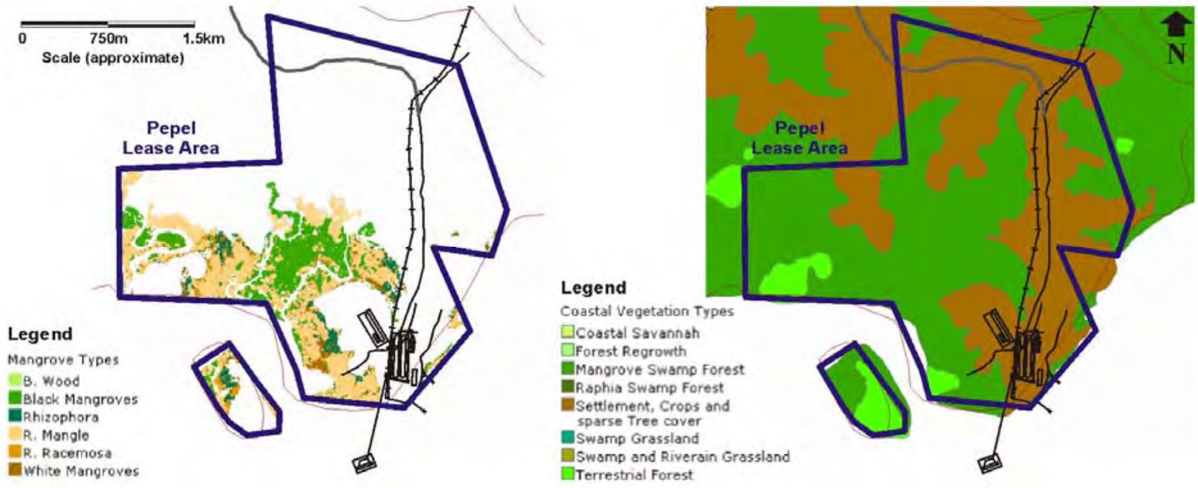
The coastal habitat of Pepel Islands consists of mangroves, mudfalts and sandflats and a small sandy beach near the community settlement. The habitats have been mapped based on high resolution aerial and satellite imagery. The results were ground-truthed during the marine environmental site survey.

**Figure 6-6 Mudflats located around Pepel Island. The Red shaped areas representing the location of the Mud Flats**


The Mangrove forest play an important ecological and socioeconomic role, particularly in relation to coastal fisheries for prawns and fish, as a source of wood products, as nutrient sinks, and for shoreline protection (Rönnbäck, 1999). The mangrove communities observed near Pepel Island were mostly comprised of more than one species. The mangrove cover was mostly comprised of low regrowth (up to 5 m high) with few trees of a large size (i.e. taller than 10 m). The dominant group of mangrove species that have been identified are the Black Mangroves (Avicennia germinans (africana)), White Mangroves (Laguncularia racemosa), Button mangroves (Conocarpus erectus) and Red mangroves (Rhizophora racemosa, Rhizophora mangle, Rhizophora x harrisonii).

Full mangrove mapping based on high resolution aerial surveys and field surveys is ongoing to identify the key mangrove species in Pepel Island. The preliminary results of this mapping are provided in Figure 6-7

**Figure 6-7 Mangrove species distribution at Pepel Island**




### 6.5.3 Marine and avifauna

The shallow waters of the mud flats in the mangroves are nursery grounds for shrimp species (Portconsult, 1996). Molluscs are found in the estuarine and mangrove creeks and include the mangrove oyster (*Crassostrea tulipa*), the brackish and estuarine intertidal cockle (*Senilia senilis*), and the sub-littoral rock oyster (*Crassostrea denticulate*) (Chaytor & Aleem 1976). The bivalves include *Iphigenia laevigatum, Tagelus angulatus* and *Tellina nymphalis*, and the gastropods include *Cymbrium spp*., *Tympanotonus fuscatus* and *Semifusus morio* (Lorax, 2009). No specific information is available regarding fish or shelfish species in the surroundings of Pepel Island. However, artisanal fishery, including shelfish collection activity, appears to play an important role in the local communities as observed during the field survey. Further survey and consultation will be included in the Stage 2 ESHIA.

A survey below the Pepel trestle during the marine environmental baseline survey found the sub-sea structures were covered with oysters (*Crassostrea* spp) and fish species Silver Dollar (*Metynnis* spp) was also observed.

No specific information is available on the marine mammals or sea turtles in the surroundings of Pepel Island. However, it is unlikely that they would inhabit areas this far up the estuary. Marine mammal and turtle studies will continue into the next phase of work.

Pepel Island is part of the core area of Sierra Leone’s only Ramsar site and there are expected to be wading birds on the mud/sand flats. The mangroves will provide further valuable habitat for birds. There are no specific ornithological records available that are specific to Pepel, although several bird counts have been conducted in the Tagrin-Pepel areas, which are described in Section 5.3.4. All of which highlighted species richness. A detailed bird survey at Pepel is underway.

# 7 POTENTIAL IMPACTS & MITIGATION

## 7.1 Impact Identification & Evaluation

### 7.1.1 Techniques for Impact Identification & Evaluation

***Methodology***

Baseline knowledge identifies the environmental and social parameters that may be affected by the proposed project. The potential positive and negative changes resulting from the project are predicted for the study area over the life of the project. These predicted changes (impacts) are then evaluated using a significance ranking process. An outline of the impact assessment procedure is as follows:

- Identification of the valued receptors;
- Identification of the key project activities;
- Impact evaluation; and
- Significance ranking.

The impact evaluation step included identification of potential activity-receptor interactions prior to the evaluation of impact significance (Aspects Identification).

***Valued Receptors***

A valued receptor (VR) is any element of the environment that is considered to be important or valuable and merits detailed consideration in the ESHIA process. In this context the broadest definition of 'the environment' is applied, such that VRs may be selected according to economic, social, aesthetic or ethical criteria, as well as by consideration of physical, ecological and biological characteristics. The process of selecting VRs may consider legal status, scientific or cultural value, and public perception; and may account for the views of national or local government, international, national or local non-governmental organisations, or the general public.

The selection of VRs is dependent on the nature of the proposed project; only those environmental components that have the potential to be affected (positively or negatively) by the project are selected. This depends on the types of interaction with the environment that the proposed project is expected to have, given its component activities and area of influence. VRs may include components affected by routine project activities as well as non-routine events.

In order to aid the impact significance rating process, each VR has been categorised as being of either low, medium or high environmental value. This is based on various factors, including the resilience of the receptor, its vulnerability to disturbance, its current status within the region of influence, and its value as a resource. The categorisation may also take into consideration local, national or international designations and legal protection status, if appropriate. The categorisation is designed to provide a broad ranking of the VRs, as follows:

- Low - a VR that is considered important but which may not be particularly sensitive to impact, and which is not subject to legal protection;
- Medium- a VR that may be sensitive to impact or of considerable local importance;
- High – a VR that is highly sensitive to impact, has national or international designations and/or legally protected features, or is otherwise regarded as being of great importance.

Based on the environmental baseline of the study area, VRs have been identified and are listed by category below in Table 7-1. It should be appreciated that these VRs have been chosen based upon the data available at present. A review and ranking of appropriate VRs was undertaken and the list below represents what was considered to be the most concise selection without becoming over-aggregated or simplified. The selection of a relatively limited number of VRs was made in recognition of the potential for a significant amount of cross-over in terms of secondary impacts between different areas. Using limited and standardised VR has helped clarify where aspects from one domain are capable of creating an impact in another domain.

**Table 7-1 Valued Receptors**

| VR | Code | Importance | Categorisation |
|---|---|---|---|
| Air Quality | A1 | Good air quality is required for local population health, soil, water and ecological health and quality | High |
| Climate changes | A2 | GHG are responsible for global climate change and the local climate is important for the local ecology | Medium |
| Noise | N1 | Ambient noise might disturb near residents and affect ecosystems | Medium |
| Soil | S1 | Soil quality is important for sustaining ecological services including agricultural productivity, biodiversity, water quality and human health. | Medium |
| Soil | S2 | Soil structure is an important aspect in preventing geo-hazards (mass wasting, erosion, slumping etc) | Medium |
| Groundwater | GW1 | Groundwater quality. Human Health. | High |
| Groundwater | GW2 | Groundwater quantity (resource) | High |
| Surface water | SW1 | Surface water quality. Human Health. | High |
| Surface water | SW2 | Surface water flow (resource) | High |
| Natural / Semi-natural | E1 | Forest / River Channel / Mountain Grasslands | High |

| VR | Code | Importance | Categorisation |
|---|---|---|---|
| vegetation | | species abundance, diversity and integrity for the maintenance of ecological services | |
| Farmbush / Plantations / Degraded Grasses | E2 | Human use, Vegetation cover - stabilising soils | Low |
| Terrestrial Fauna | E3 | Terrestrial species diversity and abundance and integrity for the maintenance of ecological services<br>Source of bushmeat<br>Avifauna | High |
| Aquatic Ecosystems | E4 | Aquatic species richness and abundance and integrity for the maintenance of ecological services<br>Subsistence fishing and food availability for local populations | High |
| Marine and Coastal Ecosystems | E5 | Marine species abundance, diversity and integrity for the maintenance of ecological services. Human Health. | High |
| Marine and Coastal Ecosystems | E6 | Coastal habitats – mangrove, mud-flat, beach | High |
| Marine and Coastal Ecosystems | E7 | Subtidal habitat. | Moderate |
| Marine and Coastal Ecosystems | E8 | Marine fauna | High |
| Visual Impact | V1 | Visual and aesthetics values including lighting and changes to structures & land forms | Low |
| Infrastructure Changes | I1 | Loss of access roads (-ve)<br>Increased facility & infrastructure investment (e.g. major roads, rail refurbishment, port expansion, shipping) (+ve) | High |
| Human - Local communities (e.g. potentially sensitive receptors such as infants and children, invalids) | H1 | Protection of the health of the general population is required. | High |

| VR | Code | Importance | Categorisation |
|---|---|---|---|
| Human - Employees of the Project (e.g. young adult and adult workers) | H2 | Protection of the persons living in work camps as well as in local communities is required; however, the healthy worker effect reduces sensitivity. | Medium |
| Human Development Potential | H3 | Increases in well-being not related solely to health including social cohesion, education, participation and good governance. Fisheries | High |
| Employment | H4 | Broader up-skilling of local workforce. Greater employment opportunity | Medium |
| Cultural Heritage | H5 | Marine archaeology, burial sites. Society Bush is recognised as having an important cultural significance. Society bush is protected on the basis of ecological principles as well and incorporated as such also under E1 and E3 | Low |

***Project Environmental Aspects***

The Project description provided in Chapter 3 of this document has been summarised into key environmental aspects that will occur throughout the life of the project. An environmental aspect is an element of the project's activities that can interact with the environment. The key environmental aspects associated with the Project activities are presented in Appendix 2 Environmental Aspect Register.

***Impact Evaluation***

An environmental impact can be considered as a change to the environment due to project activity. Such change can be positive or negative. Environmental impacts may occur where an environmental aspect (project activity) is denoted, and may be direct or indirect. The evaluation has been conducted using the following basic criteria for defining an impact:

- Magnitude: this is an indication of the proportion of the VR that will experience the impact in relation to the total resource within the project area. Impacts associated with project changes that are widely distributed by nature are considered separately;
- Spatial extent: the geographical area over which the impact is experienced (for some VRs this can be equivalent to magnitude of impact); and
- Duration: the length of time over which the impact will be experienced. An impact may be present only while a project activity is active, or it could persist long after the project activity has ceased, in which case the duration may be regarded as the time the VR needs to recover from the effect.

Each potential impact is evaluated by applying descriptors to each of the above criteria, based on qualitative or, to the extent possible, quantitative evaluation, as follows.

- The **magnitude** of impact is allocated one of the following categories:

| | |
|---|---|
| Very Low (1) | A very small proportion of the VR is affected; |
| Low (2) | A small proportion of the VR is affected; |
| Moderate (3) | A moderate proportion of the VR is affected; |
| High (4) | A large proportion of the VR is affected; |
| Very High (5) | A very large proportion or all of the VR is affected. |

- The **spatial extent** of impact is allocated one of the following categories:

| | |
|---|---|
| Very Low (1) | Local impact in the immediate area of the activity; |
| Low (2) | Local impact in the study area; |
| Moderate (3) | Regional scale impact; |
| High (4) | National scale impact; |
| Very High (5) | Transboundary scale impact. |

- **Duration** of impact is described by one of the following categories:

| | |
|---|---|
| Very Low (1) | less than one year; |
| Low (2) | one to five years; |
| Moderate (3) | five to ten years; |
| High (4) | greater than ten years; |
| Very High (5) | irreversible. |

Where there is any uncertainty, a higher figure is assigned to an impact criterion, so as to reduce the chance of underestimating an impact (i.e., the precautionary principle is applied), thereby minimising risk (Crowfoot *et al.* 1990).

Each potential impact is then allocated a '**basic impact index**' obtained by averaging the numerical values assigned respectively for magnitude, spatial extent and duration of impact. The average is rounded up to a whole number where necessary; thus the basic impact index is a number between 1 and 5. Potential positive effects are noted as such but are not subject to further numerical interpretation.

***Assessment of Impact Significance***

The final impact significance is the result of the combination of the basic impact index and the VR categorisation, as shown in Table 7-2. **Impact significance** is described as either insignificant, minor, moderate, major or catastrophic. These categories have been standardised with an overall Risk Matrix categorisation that has been developed in the project's feasibility study.

**Table 7-2 Impact Significance**

| | | Basic Impact Index | | | | |
|---|---|---|---|---|---|---|
| | | **Very Low** | **Low** | **Moderate** | **High** | **Very High** |
| | | **1** | **2** | **3** | **4** | **5** |
| **VR Category** | **Low** | Insignificant | Insignificant | Minor | Moderate | Moderate |
| | **Medium** | Insignificant | Minor | Moderate | Major | Major |
| | **High** | Minor | Moderate | Major | Major | Catastrophic |

Those impacts rated as moderate, major or catastrophic are considered to require additional mitigation to that contained in the project's base case design in order to eliminate the impact or, where this is not possible, to reduce its significance to minor or insignificant.

Summary impact evaluation and significance assessment tables have been provided for each of the discipline areas in the following sections.

### 7.1.2 Techniques for ESHIA Risk Assessment

Where it is recognised that a potential impact may occur on an infrequent basis, i.e. a non-routine unexpected event, then the magnitude of the impact will need to be evaluated through risk assessment and the results incorporated back into the impact assessment. For example, non-routine unexpected events might include:

- Accidental spillage
- Failure of impounding facilities (eg. Bunding, containment, etc)
- Geo-mechanical failure
- Traffic incidents
- Human error

The risk assessment takes into account the consequence of the hazard and multiples it by the likelihood of that consequence occurring to give a risk value. The risk assessment of identified non-routine, unexpected events will be undertaken in the next phase of the Tonkolili Project.

Impact assessments are still pending however from this assessment to date, at a qualitative level no specific process, chemical reagent, material or activity that would result in a catastrophic consequence due to an accidental or non-routine event occurring has been identified.

## 7.2 Mining Area

### 7.2.1 Air Quality

***Construction***

The most significant impacts on air quality may arise from dust emission generated during vegetation clearance and earth movements (e.g., creation of new access routes, extraction of borrow material at the mine, and surface grading and leveling for buildings and facilities construction). Pollutants emitted by these activities are mainly coarse particles that do not result in human health effects. Nevertheless, vegetation may be affected by particle deposition on leaves. Additionally, elevated sedimentation in streams could occur with ensuing effects on aquatic organisms. This impact can be mitigated by spraying the affected land surfaces with water under dry conditions.

Additionally, diesel generators used for power supply, vehicles and machinery exhaust gases will contain several air pollutants ($SO_2$, CO, $NO_2$ and fine particles: $PM_{10}$ and $PM_{2.5}$). The use of efficient machinery (vehicles, motors and pumps) and the use of a good practices policy will avoid unnecessary fuel consumption (e.g., limit journeys, switch-off machinery when not in use, and reduce diesel generators use to a minimum); and therefore, will minimise the potential impacts on air quality.

Other potential sources of air pollutants are uncontrolled fires used for cooking or heating and the associated risk of the fire propagating. This impact could be controlled by instructing and supervising construction contractors.

***Operations***

Activities undertaken in the mining area that may impact air quality are as follows:

- Excavation works: Operations that involve blasting, drilling, movement of soil or exposure of erodible surfaces will generate some volumes of fugitive dust. The majority of the particles generated during these activities will exceed 10µm in size and will not be easily respired; therefore, the emitted particles are not expected to generate impacts on human health. These activities may impact air quality at the project boundaries, disturbing the nearest populations and potentially reducing the photosynthesis capacity of vegetation by deposition on leaves. The application of the proposed mitigation measures (see below) will reduce the negative effects on air quality;
- Material processing: The Crushing and Loading facility will be located southwest of Simbili. The material processing emissions will be dependant on the mitigation measures to be applied; properties of the material being disturbed (e.g. particles size or moisture content); and meteorological conditions (wind speed and direction). Efficient mitigation measures at the point sources (filters) and at the storage areas (water, chemical foam, partial enclosure for screen or crushers and full enclosure) may reduce the potential effects;
- Power supply generation: Generators and engines will produce exhaust emissions, the amount of which will depend on the volume of fuel consumed and its sulphur content. The expected pollutants are SO2, NOx, CO and PM10. Since the power requirements are not

excessive and the project might use power from external suppliers, the impact's extension and magnitude are not expected to be high. Diesel generators should be designed to comply with the air quality standards for compliance with occupational health conditions and boundary sampling locations;

- Stockpiles: Total dust emissions from stockpiles result from various activities within the storage cycle: loading of aggregate onto the storage pile, wind erosion of the pile and loading of aggregate for continuing the process stream. Fines are easily released to the atmosphere upon exposure to air currents; however, moisture can aggregate and bond fines to the surfaces of larger particles and greatly reduce the potential of dust emission. Total particulate emissions can be reduced from aggregate storage operations up to 90 percent (USEPA, AP42 methodology, ref 13.2.4-1).

***Potential Mitigation Measures***

Generic recommendations for reducing impacts from construction and operational phase activities are listed below:

*Reduction of air quality impacts from dust emissions*:

- Suppress dust during dry periods by spraying water onto potential sources for airborne particles (e.g., unpaved roads, stockpiles, earth being moved);
- Cover truck loads to avoid dust emissions during transportation;
- Keep vehicle movements to a minimum and use paved areas, where possible;
- Minimise discharge heights from trucks (not to exceed 1 m) for fine particles and consider the use of dust suppression spray systems;
- Design stockpiles based on the wind pattern and consider installing windscreens;
- Considering the installation of filters in the design of the Crushing and Loading Facility.

*Reduction of air quality impacts from engine emissions:*

- Review machinery permits and ensure appropriate maintenance;
- Limit unnecessary journeys and adopt a policy of switching off machinery and equipment when not in use;
- Consider a choice of machinery, equipment, vehicles and materials that are fuel-efficient as part of the purchasing procedure.

*Reduction of impacts from controlled and uncontrolled fires (airborne emissions):*

- Avoid uncontrolled fires;
- Open fires will be prohibited. To limit air emissions, avoid accidents and reduce fire risk during the construction phase;

### Table 7-3 Mining Area - Air Quality

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | A1 | Dust emissions. Particles deposition on vegetation. Visibility reduction. | High | 2 | 1 | 1 | 2 | Moderate | Minor | Efficiency of dust suppression measures |
| Drilling, blasting and mining activities | A1 | Dust emissions. Particles deposition on vegetation. Visibility reduction. Health effects. | High | 3 | 2 | 2 | 3 | Major | Minor | Efficiency of dust suppression measures |
| Material processing | A1 | Dust emissions. Particles deposition on vegetation. Visibility reduction. Health effects. | High | 3 | 2 | 2 | 3 | Major | Moderate | Efficiency of dust suppression measures |
| Stockpiles | A1 | Dust emissions (coarse and fine particles). Particles deposition on vegetation. Visibility reduction. Health effects. | High | 3 | 2 | 2 | 3 | Major | Moderate | Moderate Efficiency of dust suppression measures |
| Power supply | A1 | Exhaust emissions ($SO_2$, CO, $NO_2$, $PM_{10}$ and $PM_{2.5}$). Health effects. | High | 3 | 2 | 4 | 3 | Major | Moderate | Mitigation measures should ensure AQ guidelines compliance |
| Power supply | A2 | Greenhouse gases emissions | Medium | 1 | 5 | 4 | 4 | Moderate | Moderate | Hard to mitigate |
| Land clearance | A2 | Local climate change due to vegetation removal | Medium | 4 | 1 | 3 | 3 | Moderate | Minor | Assumed that vegetation will be restored or |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | naturally recovered |
| Vehicles and machinery | A1 | Exhaust emission. Dust emissions in unpaved roads. Particles deposition on vegetation. Visibility reduction. Health effects. | High | 2 | 2 | 2 | 2 | Moderate | Minor | Efficiency of the proposed measures to minimize pollutant emissions |
| Vehicles and machinery | A2 | Greenhouse gases emissions | Medium | 1 | 5 | 3 | 3 | Moderate | Moderate | Hard to mitigate |
| Uncontrolled fires | A1 | Exhaust emissions (SO2, CO, NO2 , PM10 and PM2.5). Health effects. Risk of fire propagation. | Medium | 2 | 2 | 2 | 2 | Minor | Insignificant | Mitigation measures should avoid uncontrolled fires |

### 7.2.2 Noise

***Construction***

Sources of noise emissions associated with the construction phase may include noise from machinery engines, vehicles used for transport, loading and unloading of rock and materials, chutes and power generation. Potential impacts are not limited to the project boundaries and will propagate beyond. Mitigation measures described in this section should be applied near the populated areas located close to the potential noise sources. Of special interest are villages close to the roads where traffic will be high (Farangbaia, Wandugu and Furia).

***Operations***

The Phase 1 Mining Area spans the crest of Simbili and includes an area that extends 4 km southeast to southwest, as shown in the project description from which the following information can be drawn:

Potential impacts on the bottom and top camps were analysed in the same manner as for villages on the basis that residential use is projected for both camps. It is noted that the bottom camp will also be used for laundry, kitchen, offices and vehicle parking.

For the purposes of this ESHIA, the following qualitative analysis describes the likely impacts:

*Mining Activities*

Mining activities will result in an increase in sound levels due to the operation of machinery.

The equipment to be used will consist of 3 hydraulic shovels (operating weight 380 t) and 21 haul trucks (payload capacity 130-140 t). Blasting will occur twice per week and will generally be confined to within the top 20 m of the excavation.

Ancillary equipment will include 2 water carts (130 t capacity), three track dozers (Caterpillar D10 or equivalent), and 2 graders (Caterpillar 16 M or equivalent).

Machinery movements and motors will generate noise, but the potential impacts on ambient noise will be limited to within 500 m of the sources. Assuming that occupational health limits are maintained for noise power limits at the facility boundaries (85 dB(A)) then it is predicted that appropriate environmental noise standards will be met at a distance of 500m from the facilities.

The noise from a blasting explosion in a canyon between mountains can be propagated over large distances from the source, but as the blasting noise frequencies are low (2 to 25 Hz) the equivalent dB(A) will be much lower than the ambient noise values. Audible frequencies are above 20 Hz. If AML maintain blasting operation standards then the noise power and sound pressure at receptors should be limited to within acceptable environmental noise standards within a distance of 500m from the facilities.

If the expected safety measures are in place, the generated sound pressure levels dB(A) should not generate impacts at the nearest receptors located several kilometres from the site.

Noise impacts generated from blasting will be dependent on the following:

- Blasting conditions (e.g., amount of explosive, hole size and depth and rock type);
- Noise propagation conditions defined by the terrain.

*Contractors Workshop*

No specific information was available regarding the equipment that will be used in the workshop; however, the close proximity of this facility to the camps and to Farangbaia village will necessitate further layout planning to avoid noise impacts. Depending on the outcome of the lay-out planning further mitigation measures such as attenuation screens may be required.

The nearest residential areas are located approximately 600 m from the facility, so it is not expected that the populations will be significantly affected. Assuming that occupational health limits are maintained for noise power limits at the facility boundaries (85 dB(A)) then it is predicted that appropriate environmental noise standards will be met at a distance of 500m from the facilities.

*Crushing and Loading Facility*

No specific information was available regarding the acoustical emission of the equipment that will produce noise in the facility; however, the proximity to Furia and the cumulative effect expected from truck traffic indicate that mitigation measures should be applied or the village should be resettled.

*The Aircraft Stand*

Due to the proximity of the Aircraft Stand to villages and the camps, possible noise impacts, though limited, must be studied. The air strip is only expected to be used for transporting mine workers and hence aircraft movements will be scheduled according to staff mobilisation, as opposed to freight movement.

The Aircraft Stand will likely be used for urgent shipments and light-aircraft, and a noise buffer around the Stand and into the Farangbaia village should be considered. Aircraft noise is expected to be directed primarily in concert with the take-off direction, and to a lesser extent in the landing direction. Aircraft take-off routes should avoid populated or sensitive areas within 2 to 6 km, depending on the aircraft to be used and the take-off routes. A more detailed assessment should be conducted before the airstrip operations begin when the types and schedule of aircraft are known.

*Roads*

Both of the camps and the villages, Farangbaia, Wandugu and Furia, are located near unpaved roads on which the volume of vehicle and truck traffic will be high. Due to the high noise levels expected from these roads, noise at the camp accommodation buildings might exceed the Environmental, Health, and Safety (EHS) IFC Guidelines for residential areas (45 dB(A) at night and 55 dB(A) during the day). The camp design shall avoid locating the accommodation buildings and medical centres near the road.

***Potential Mitigation Measures***

Noise emissions may occur during each stage of the mine cycle, in particular during construction and operational activities.

Generic recommendations for reducing impacts from activities to be conducted during the construction phase of the project are listed below:

- Use machinery and generators with ‘quiet’, ‘muffled’ or ‘silenced’ settings, when available;
- Consider choices of machinery and equipment that guarantee low noise emissions;
- As long as hoppers and dumper boxes are more than 500m from residential areas there is no need for any special mitigation measure. If this machinery is within 500m then it is recommended that elastic coatings are used;
- Limit unnecessary journeys and adopt a policy of switching off machinery and equipment when not in use;
- Optimise internal-traffic routing to reduce the need to reverse vehicles (avoiding noise from the reversing alarm) and to allow the maximum distances possible between traffic and the nearest sensitive receptors;
- Conduct regular inspections and maintenance of construction vehicles and equipment to maintain smooth operation; and
- Limit vehicle speeds in the vicinity of populated areas.

The preventive and corrective measures to reduce the impact on noise pressure during the operational activities are defined below:

- Correct blast design and charging is essential and should include a survey of the face profile prior to design and continuous review of charge requirements.
- The setting-out and drilling of blasts should be as accurate as possible, the drilled holes should be surveyed for deviation along their lengths, and the blast design should be adjusted, if necessary.
- Particular care is necessary with a first blast. It may otherwise give rise to abnormally high overpressure and vibration because there is no free face to give relief to the forces produced. Blast noise is usually controlled by limiting the amount of explosive and employing staggered detonation. Problems may occur if there are faults in the strata and other forms of heterogeneity; blasting in tight corners; blasting near made ground; excessive charge and non-compliance with manufacturers' tolerances/errors in explosives or detonators. It is assumed that expert computerised firing sequence control would remove most risk associated with operator's error resulting in simultaneous detonation of more than one charge/hole/deck.
- Noise levels will need to be monitored under normal and blasting conditions considering the day and night noise limits. If cumulative noise levels are exceeding criteria for sensitive receptors, additional mitigation measures should be defined, such as sound barriers. If the source of noise will not bee effectively mitigated by these barriers (e.g. due to aircraft noise), then additional measures should be considered, such as noise isolation at the sensitive receptors.

### Table 7-4 Mining Area - Noise Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | Noise | Increase in noise levels due to machinery operations | Medium | 2 | 1 | 1 | 2 | Minor | Minor | Land clearance |
| Blasting and earth movement | Noise | Increase in noise levels due to blasting activities | Medium | 3 | 2 | 2 | 3 | Moderate | Minor | Appropriate blasting management should minimize the impact |
| Material processing | Noise | Increase in noise levels due to the mining process | Medium | 2 | 2 | 2 | 2 | Minor | Insignificant | Efficiency of noise isolation |
| Power supply | Noise | Increase in noise levels. | Medium | 2 | 1 | 2 | 2 | Minor | Minor | Power generation noise is hard to attenuate |
| Vehicles and machinery | Noise | Increase in noise levels. | Medium | 3 | 2 | 2 | 3 | Moderate | Minor | Efficiency of noise barriers |
| Airstrip | Noise | Increase in noise levels | Medium | 4 | 3 | 2 | 3 | Moderate | Moderate | Aviation noise is hard to attenuate |

### 7.2.3 Ecology & Biodiversity

***Construction***

It is noted that impacts associated with Phase 1 mining activities overlap with likely impacts from the other phases and may become more significant as the scale of the mining operations increases in the course of the next project phases.

*Vegetation*

The principal direct impacts will arise from the clearance of land within the footprint of the open pit and associated infrastructure and the burial of vegetation in waste dump areas which will have a long-term to permanent impact on the current vegetation coverage. Vegetation that is not cleared or buried may be indirectly impacted by alteration of drainage patterns and exposure to contaminated surface runoff (contaminants may include petroleum products from operations and also mobilised trace metals present in the hematite ore deposit). Further impacts may arise through the spread of invasive species. These may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive). An influx of people to the area will increase the pressure on resources (e.g. clearance of land for agricultural use, subsistence and commercial logging of timber). Impacts on fauna may further reduce natural colonisation by indigenous plant species where fauna play a role in seed dispersal. The impact classification of these impacts is influenced by the nature of the vegetation present in the area being impacted (defined as high and low conservation importance for semi-natural or degraded vegetation respectively):

| | | **Impact classification** | | | |
|---|---|---|---|---|---|
| | | **Major** | **Moderate** | **Minor** | **Insignificant** |
| **Conservation importance** | **High** | Land clearance; burial; drainage alteration; exposure to contaminated run-off; spread of alien invasive species | Increased local human population; reduced dispersion of seeds by fauna | - | - |
| | **Low** | - | Land clearance; burial; drainage alteration; spread of alien invasive species | Exposure to contaminated run-off | Increased local human population; reduced dispersion of seeds by fauna |

*Terrestrial Fauna*

The most significant potential impact is a change in species diversity and abundance (and potentially a loss of species of conservation concern) through habitat loss and fragmentation directly associated with the mining activities (such as vegetation removal) and indirectly through increased pressure due to population influx on the resources in the area (such as increased vegetation removal for timber supply and use as agricultural land). Displacement of terrestrial fauna may also occur through increased sensory disturbance as a result of the mining activities. Increases in local human populations may increase hunting and bushmeat consumption. Bushmeat is an important source of protein for local villages around the mining area. Food shortage has been identified in the social surveys as an issue facing many villages, and therefore any significant ecological impacts (such as ongoing displacement of fauna) as a result of the project-related activities may have indirect social impacts. The impact classification of these impacts is as follows:

- **Major:** habitat loss, habitat fragmentation, habitat disturbance and increase in hunting.
- **Moderate:** displacement of fauna.

*Aquatic Ecosystems*

The most significant potential impact is a decrease in species richness and abundance through deterioration of water quality in the area. Deterioration of water quality may occur through increased sedimentation in aquatic environments as a result of sediment mobilisation during construction and operation and / or changes in water chemistry that may arise from sediment runoff or acid rock drainage from the mining activities (depending on the geochemical characteristics of the overburden / ore). Direct modification of the aquatic environments within the vicinity of the Simbili deposit may also occur during Phase 1 (for example diversion or obstruction of surface waters), which may cause the loss of locally endemic species and concomitant impacts on subsistence fishing and food availability for local populations. All of these impacts are classified as major.

***Operations***

The primary impact during the operations phase will be caused by the increase in population. This will have regional significance for biodiversity and ecology receptors. This could create unintended consequential impacts associated with increase in access and demand for natural resources.

***Potential Mitigation Measures***

The following mitigation measures have been identified for significant ecology and biodiversity issues:

- Forest on hillslopes and Riverine forest are the most important habitats of conservation concern in the wider Simbili pit area. Mining infrastructure should be planned outside the forest patches and if this is not possible, a botanist should survey the affected forest well in advance of the construction work to allow possible adjustments to be made.
- Roads should be kept to the minimum width possible, commensurate with relevant design and safety standards.
- Minor in-stream infrastructure can constitute barriers to fish migration. Where possible, these should be designed to be compatible with the passage of migratory stream organisms, and crossings of any drainage lines or water bodies should have appropriate culverts built to international environmental standards.
- Plants belonging to species with conservation status Endangered (EN) or of Conservation Importance (CR) should at all times be left undisturbed. Plants belonging to species with conservation status Vulnerable (VU) should be left undisturbed as much as possible.

- Species of conservation concern which were found on the deposits or near proposed infrastructure should be relocated to suitable localities outside the project area, by way of seed collection and / or translocation of specimens.
- Replanting of vegetation should use indigenous species and should be based on silvicultural systems that promote natural ecosystem functions and that increase the probability that native species and ecological processes will be maintained. Planting of exotic species in natural forest areas should not be permitted.
- Establish and enforce a total ban on the hunting and capture of wildlife by company employees and contractors.
- Recognizing the importance of wildlife as a protein source to indigenous peoples, government and the company should cooperate with local communities in the development of sustainable, community-based wildlife management programs.
- Project affected communities should be supported in the development of improved animal husbandry techniques and provided with starter stocks. This would be a positive contribution to the livelihoods of people and also reduce demand for bushmeat and limit the impact of hunting restrictions on local communities.
- The project should investigate the potential for supporting local plantations, which would be beneficial to the project, local livelihoods and the remaining natural forests (and therefore, also for fauna).
- Work with government to explore opportunities to control and minimise the uncontrolled in-migration of people into areas newly opened-up by road construction, especially along the roads themselves. Uncontrolled in-migration will lead to further forest and wildlife losses and compound pressures on existing human communities.
- Consider biodiversity offsets to compensate for the unavoidable habitat loss (including vegetation and fauna).
- Increased sedimentation in the aquatic environments due to mobilization of sediments may subsequently result in a change in fish distribution, with more turbid-tolerant species becoming prevalent. Best practice erosion and sediment control measures should be implemented during construction to minimise the significance of this impact.

### Table 7-5 Mining Area – Ecology & Biodiversity Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | E1 | Loss of biodiversity and sensitive habitat | High | 5 | 3 | 5 | 4 | Major | Major | Area will be affected permanently |
| | E2 | Loss of biodiversity and habitat | Low | 4 | 3 | 5 | 4 | Moderate | Moderate | |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 3 | 5 | 4 | Major | Major | |
| | E4 | Decrease in species richness and abundance through deterioration of water quality in the area through increased sedimentation | High | 3 | 3 | 4 | 3 | Major | Moderate | Best international practice to be followed, pending further evaluation |
| Blasting and Earth Movement | E1 | Loss of biodiversity and sensitive habitat | High | 4 | 3 | 5 | 4 | Major | Major | Area will be affected permanently |
| | E2 | Loss of biodiversity and habitat | Low | 4 | 3 | 5 | 4 | Moderate | Moderate | |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 3 | 5 | 4 | Major | Major | |
| | E4 | Decrease in species richness and abundance through deterioration of water quality in the area through increased sedimentation or from runoff of excess nitrates (used in blasting) | High | 3 | 3 | 4 | 3 | Major | Moderate | Best international practice to be followed, pending further evaluation |
| Changes in drainage pattern | E1 | Loss of biodiversity and sensitive habitat | High | 3 | 3 | 5 | 4 | Major | Major | Area will be affected permanently |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | E2 | Loss of biodiversity and sensitive habitat | Low | 4 | 3 | 5 | 4 | Moderate | Moderate | |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 3 | 5 | 4 | Major | Major | |
| | E4 | Direct modification of the aquatic environments - loss of locally endemic species | High | 3 | 3 | 5 | 4 | Major | Major | Burial will be permanent |
| Waste generation | E1 | Loss of biodiversity through exposure to contaminated run-off | High | 2 | 1 | 4 | 2 | Moderate | Minor | Adherence to international best practice |
| | | Burial of vegetation | | 3 | 2 | 4 | 3 | Major | Major | Burial is irreversible |
| | E2 | Loss of biodiversity through exposure to contaminated run-off | Low | 2 | 2 | 4 | 3 | Minor | Insignificant | Adherence to international best practice |
| | | Burial of vegetation | | 4 | 3 | 4 | 4 | Moderate | Moderate | Burial is irreversible |
| | E4 | Decrease in species richness and abundance through changes in water chemistry from runoff of excess nitrates (used in blasting) or acid rock drainage from the mining activities | High | 3 | 4 | 4 | 4 | Major | Minor | Adherence to international best practice |
| Project induced influx of workers and job seekers | E1 | Increased pressure on timber | High | 3 | 4 | 4 | 4 | Major | Major | Mitigation will require co-operation between AML and local partners – pending further evaluation |
| | | Spread of alien invasive species | | 3 | 3 | 4 | 3 | Major | Major | Presently unknown |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | pending further evaluation |
| | E2 | Increased pressure on timber | Low | 2 | 3 | 2 | 2 | Insignificant | Insignificant | |
| | | Spread of alien invasive species | | 4 | 3 | 4 | 4 | Moderate | Moderate | |
| | E3 | Increase in hunting | High | 4 | 3 | 4 | 4 | Major | Major | |
| | | Displacement of fauna | | 2 | 2 | 3 | 2 | Moderate | Moderate | |

### 7.2.4 Hydrology & Hydrogeology

***Construction***

Assessment of potential impacts on the hydrological and hydrogeological setting have been conducted based on a Phase 2B – Reconnaissance Level baseline assessment carried out during February March and April 2010. The following potential impacts have been identified during the construction phase:

- Erosion of exposed surfaces and loose material by wind, water and construction activities generating higher sediment loads in surface runoff entering the Tonkolili and Mawuru Rivers and their tributaries.
- Increased potable and construction water demand may lead to over-abstraction of surface water from nearby rivers leading to impacts on environmental flows and/or downstream users.
- Uncontrolled discharge of sewage and other waste water to groundwater or directly to surface water contaminating freshwater aquifers, waterways and impacting on human health and/or aquatic ecosystems.
- Uncontrolled release of drilling fluids associated with ongoing exploration, geotechnical or hydrogeological drilling works. Potential impacts on aquatic ecosystems and downstream potable water supply.

***Operations***

- Modification and interruption of the existing hydrological regime of the Tonkolili and Mawuru catchments. Excavation of the weathered cap of Simbili will interrupt the flow of several springs discharging from the flanks of the deposit providing base flow to both rivers.
- Alteration to the natural hydrologic regime of both catchments as excess water produced during dewatering of the weathered cap is discharged.
- Increased flood risk and/or increased flow rates in rivers following storm events due to the loss of the buffering capacity of the Simbili weathered cap aquifer.
- Increased water demand on site may lead to over abstraction from surface water bodies leading to reduced environmental flows and impacts on downstream users.
- Generation of contaminated runoff where rainfall infiltration comes in contact with stockpiled waste rock. Rainfall infiltrating through the Phase 1 waste rock dump may become acidic and/or leach metals from the waste rock before entering groundwater and surface water. Low natural chemical buffering potential of groundwater and surface water exacerbates this risk.
- The use of specific units of waste rock that may potentially be acid generating for construction purposes could lead to surface and groundwater contamination.

- Increased recharge of rainfall to groundwater beneath waste rock dumps. The porous waste rock dump may promote greater rainfall recharge and create a localised groundwater mound beneath the dump potentially water-logging surrounding soils.
- Uncontrolled release of toxic chemicals to the environment. A range of chemicals will be stored and used during construction and mining activities. The most common chemicals likely to be used are hydrocarbons (diesel fuel, oil and grease) and solvents. Where toxic chemicals are present, the potential for spillages will exist.

***Potential Mitigation Measures***

The following mitigation measures have been identified for hydrology and hydrogeology issues that are considered to have a significant impact:

- Robust surface and groundwater monitoring programmes in order to establish comprehensive baseline and identify any impacts to flows, turbidity and chemistry.
- Treatment of all potentially contaminated wastewater sources prior to discharge to ground or surface.
- Acid Mine Drainage (AMD) study to assess likelihood of formation of acid waters from waste rock dumps or areas where waste rock may be used as a fill or construction material.
- Acid-base accounting of waste rock material to be applied in assessment of optimal dump locations.
- Appropriate engineering design measures to contain and capture potentially contaminated water escaping rock dumps.
- Detailed hydrological study to determine minimum required environmental flows in rivers which may be affected by construction and mining operations.
- Hydrochemical environmental study to determine potential sensitivity of local receptors to changes in surface water and groundwater chemistry.

### Table 7-6 Mining Area - Hydrology & Hydrogeology

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | SW1 | Higher sediment loads in surface runoff entering the Tonkolili and Mawuru rivers and their tributaries (construction) | High | 3 | 2 | 3 | 3 | Major | Moderate | Adherence to international best practice |
| Blasting and earthworks | SW2 | Reduced surface water resources (construction and operation) | High | 2 | 2 | 5 | 3 | Major | Major | Impact will be permanent |
| | SW2 | Flooding (operational) | High | 3 | 3 | 5 | 4 | Major | Moderate | Appropriate design and international best practice |
| | SW1 | Surface water contamination from uncontrolled use of acid generating waste rock for construction purposes (operational) | High | 2 | 2 | 4 | 2 | Moderate | Insignificant | Detailed studies, adherence to international best practice |
| | GW1 | groundwater contamination from uncontrolled use of acid generating waste rock for construction purposes (operational) | High | 2 | 2 | 4 | 2 | Moderate | Insignificant | Detailed studies, adherence to international best practice |
| | GW1 | Contamination of water resources from uncontrolled release of sewage and other waste waters (construction) | High | 3 | 3 | 2 | 4 | Major | Insignificant | Adherence to international best practice |
| | SW1 | Contamination of water resources from uncontrolled release of sewage and other waste waters (construction) | High | 3 | 3 | 2 | 4 | Major | Insignificant | Adherence to international best practice |
| | SW1 | Contamination of surface waters from uncontrolled release of drilling fluids (construction) | High | 2 | 2 | 2 | 2 | Moderate | insignificant | Adherence to international best practice |
| | SW1 | Contamination of surface water | High | 3 | 3 | 4 | 4 | Major | Moderate | Detailed |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | resources from contaminated runoff (acidic and/or high metal concentrations) (operational) | | | | | | | | studies, adherence to international best practice |
| | GW1 | Contamination of groundwater resources from contaminated runoff (acidic and/or high metal concentrations) (operational) | High | 3 | 2 | 4 | 4 | Major | Moderate | Detailed studies, adherence to international best practice |
| | GW2 | Water logging of soils around waste rock dump (operational) | High | 1 | 1 | 4 | 2 | Moderate | Insignificant | Engineering design and adherence to international best practice |
| Resource utilisation | GW2 | Reduced groundwater resources in vicinity of camps where water may be derived from groundwater (construction and operation). | High | 2 | 2 | 4 | 4 | Major | Insignificant | Detailed studies, appropriate design and location of abstractions and water resources management plan |
| Chemical / fuels storage and utilisation | SW1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | High | 3 | 3 | 2 | 4 | Major | Moderate | Engineering design and adherence to international best practice |
| | GW1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | High | 2 | 2 | 4 | 4 | Major | Minor | Engineering design and adherence to international best practice |

### 7.2.5 Soils & Land Use

***Construction***

The principal direct impact will arise from land clearance or sterilisation / burial, leading to long-term or permanent loss of soil resources and existing land-use capabilities at Simbili. Additional impacts on soils that are not cleared or sterilised include contamination by windblown dusts (from bare ground, blasting activities and plant movements), increased erosion or inundation due to the modification of drainage patterns, compaction from vibration and loading under temporary stockpiles/structures, contamination with hydrocarbons and other chemicals including diesel and lubricant oils and explosives residues. Invasive species may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive).

***Operations***

Operational stage works in the mine area will primarily result in ongoing impacts for soil and land use as defined for the construction stage. Land clearance or sterilisation will increase with development of the resource strip and associated infrastructure and expansion of waste dumps and access routes.

***Potential Mitigation Measures***

The following mitigation measures have been identified for soils and land use issues that are considered to have a significant impact:

- Minimise land / soil to be cleared or buried and concentrate such activities in areas with limited soil quality and land-use capability.
- Consider biodiversity offsets for unavoidable long-term and permanent soil / land clearance and soil / land burial. Integrate livelihoods components as necessary with offsets to replace lost land-use capability.
- Prior to commencement of mining, prepare a waste rock management plan and rehabilitation programme to include designs for progressive rehabilitation/re-vegetation of suitable areas throughout the mining lifecycle in order to minimise cleared / buried areas. Inspect and monitor rehabilitated surfaces to establish success of revegetation and soils recovery.
- Implement appropriate conservation and preservation of stripped top-soils and sub-soils from all areas to retain physical and chemical characteristics and seed-bank for subsequent use for rehabilitation activities.
- Implement required storm water drainage and control prior to prevent erosion of exposed areas and inundation of down-slope areas.
- Minimise access by vehicles to essential areas to reduce compaction of soils.
- Isolate and manage potential soil contaminants (including wind blown dusts and water-borne contaminants).

- Avoid disturbance / exposure of acid sulphate soils if present.
- Avoid deliberate introduction of alien invasive species during rehabilitation activities.
- Manage pathways by which alien invasive species can enter a disturbed area (including avoidance of non-indigenous plant species in rehabilitation activities).
- Undertake studies to determine appropriate recolonisation programme for impacted areas.

**Table 7-7 Mining Area - Soils and Land Use**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | S1 | Changes in quality/available land due to invasive species colonising disturbed areas | Medium | 2 | 3 | 4 | 4 | Major | Moderate | Appropriate design and international best practice |
| | S2 | Stripping of vegetation and surface soils overlying hematite may lead to increased soil erosion | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| Blasting and earthworks | S2 | Loss of soils/land available for other uses | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Long term rehabilitation and international best practice |
| | S2 | Compaction associated with vibration, loading | Medium | 2 | 2 | 4 | 3 | Moderate | Moderate | Appropriate site management and international best practice |
| | S1 | Areas in and around the mine may be impacted by wind blown dust from bare ground, earth moving, stockpiles and plant movements on unsurfaced roads. | Medium | 2 | 2 | 3 | 2 | Minor | Insignificant | Appropriate site management and international best practice |
| | S2 | Flooding (operational) | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate design and international best practice |
| Chemical / fuels storage and utilisation | S1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Engineering design and adherence to |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | international best practice |

### 7.2.6 Geology & Geomorphology

***Construction***

The impacts associated with major mine construction such as stripping of surface vegetation, soils, and deposits include changes in slope stability and topography and local drainage and spring flow.

***Operations***

Impact of the mining inevitably includes loss of the non renewable resource itself. Mining in general can commonly sterilise associated deposits of lower value or undiscovered resources making them effectively inaccessible beneath waste rock and tailings. Some of the low value 'sterilised' deposits may become economically viable in the future with increase in market value of the commodity.

There will be major changes to the landscape with the top of Simbili hill being effectively removed while substantial overburden and rock waste dumps will be formed nearby.

Stripping of overburden will be followed by mining of the hematite which will lead to further impacts on topography and drainage as it forms the upper Simbili hill outcrop. However the hematite also overlies BIF deposits that are to be mined under Phase 3 and ultimately the entire hill will be mined out and an opencast pit extend beneath ground level. Phase 3 and associated cumulative impacts will be addressed in a Stage 2 ESHIA report.

Mining of the upper hematite deposit will initiate changes in runoff patterns and erosion and sedimentation rates potentially impacting permanently on local geomorphology. Construction of mine infrastructure may have similar but lower level impacts.

Blasting of hard rock layers throughout the mining may destabilize soils and trigger landslides with very localized impacts on geomorphology.

***Potential Mitigation Measures***

The following mitigation measures have been identified for geology and geomorphology issues that are considered to have a significant impact:

- Although a major impact, the loss of the exploitable ore body is the purpose of the mining activity. The impact can be outweighed by the opportunity presented by exploitation of the resource though adherence to a resource management and mine plan which maximises the efficiency of resource extraction and ensures that stakeholders derive the maximum potential benefit. Without appropriate considered management through processes such as ESHIA and good governance, potential long term detrimental impacts on the local and national economy and community can outweigh the short term gains.
- Risk of sterilising future resources can be mitigated in part by ensuring adequate exploration has been completed both for definition of the ore body to be exploited and areas that will be

covered by waste rock, tailings and other major structures such as the raw water supply dam and associated inundation zone. However there is a limit to mitigation that can be applied to prevent sterilisation of low grade deposits that may become economically viable in the future. Such deposits may inevitably be lost as potential future resources due to burial beneath waste materials or further to flooding of mined out pits.

- Geomorphological mitigation measures include the preservation of watercourses (where possible) and diversion of watercourses around infrastructure to maintain downstream drainage patterns, rehabilitation and revegetation of disturbed areas, and re-contouring disturbed areas to original topography (to the extent possible).
- Appropriate management measures need to be addressed (see Commitments Register , section 12) to avoid instabilities include appropriate mine design (so that slopes do not fail), adopting the correct slope angle, benching of slopes, including appropriate drainage around the slopes (and the toe and crest of the slopes) and incorporating stand offs at the base of the slopes to prevent impacts on people if instabilities do occur.
- Reclaim and rehabilitate land disturbed during construction and operation by re-grading, re-contouring and replacing topsoil following closure and decommissioning.
- Reuse excavated material, where possible, for further construction and earth works, in order to minimise the necessity for construction-associated quarrying in the area.
- Reduce harmful effects on the shape of the landscape (scars) through minimising the development of potential geotechnical failure surfaces. Well-designed blasting programmes and mining techniques should be followed to minimise the creation of these geotechnical issues.

## Table 7-8 – Mining Area – Geology & Geomorphology

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | V1 | Mining and associated dumping of waste rock may sterilise areas of resources making them non economically viable for future exploitation. | Low | 2 | 2 | 5 | 4 | Moderate | Moderate | Long term rehabilitation and international best practice |
| | V1 | Changes to profile of Simbili and runoff may lead to increased sedimentation in some areas and changes in drainage patterns | Low | 2 | 2 | 5 | 4 | Moderate | Insignificant | Engineering design and adherence to international best practice |
| | V1 | Stripping of vegetation and surface soils overlying hematite and construction of mining roads may destabilise slopes and change soil water pressure regime leading to increased risk of landslides | Low | 2 | 2 | 5 | 5 | Moderate | Insignificant | Engineering design and adherence to international best practice |
| | V1 | Stripping and mining will change the landform and impact on the visual landscape. The hill which forms the hematite outcrop will ultimately be removed | Low | 3 | 3 | 5 | 5 | Moderate | Moderate | Irreversible. Long term rehabilitation and international best practice |
| Blasting and earthworks | V1 | Mining and associated dumping of waste rock may sterilise areas of resources making them non economically viable for future exploitation. | Low | 2 | 2 | 5 | 4 | Moderate | Insignificant | Long term rehabilitation and international best practice |
| | V1 | Blasting may destabilise soils and trigger landslides with risk enhanced by changes in topography and groundwater regime caused by other mining activities. Lidar data indicates the presence of past | Low | 2 | 2 | 5 | 5 | Moderate | Insignificant | Engineering design and adherence to international best practice |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | landslides in the area probably associated with relatively loose sediments / weathered material overlying solid bedrock on hill slopes and episodes of high rainfall | | | | | | | | |
| Waste Generation | V1 | Waste rock dumps will change the landform and impact on the visible landscape. | Low | 2 | 2 | 4 | 4 | Moderate | Insignificant | Long term rehabilitation and international best practice |

### 7.2.7 Socio-Economic

***Construction***

*Land acquisition*

Depending on the final footprint area for hematite mining, some villages may require resettlement. Villages on the periphery of mining area will suffer loss of land resulting in loss of shelter, loss of access to agricultural land, artisanal mining sites and natural resources leading to decrease in economic stability. There are also likely to be graves and sacred sites within the footprint area that will require relocation.

Land acquisition related impacts can result in long-term and severe impacts on social and economic well being of affected populations.

***Operations***

The socio-economic benefits of hematite mining (lasting about 8 years) will mainly be in the form of wages, disbursement for the procurement of supplies, social investments and payment of revenue to the government. The negative impacts will mainly be due to disturbance to land owners and influx of workers and job seekers.

*Economic aspects*

The economic impacts are mainly beneficial in nature:

- Mining will generate employment during both construction and operation phases. It will mainly benefit Kalansogia and neighbouring chiefdoms, although skilled manpower will also be sourced from other districts.
- Business opportunities for suppliers and contractors at the district and national levels.
- Payment to Government of Sierra Leone in the form of taxes, royalties and duties.

*Project induced influx of workers and job seekers*

The economic opportunities created by the Project are expected to lead to an influx of workers and job seekers (as has already happened in Farangbaia Village).  This can result in the following negative impacts:

- Pressure on social infrastructure and natural resources.
- Increases in social ills such as crime, alcoholism, drug abuse and prostitution.
- Increases in communicable diseases due to intermingling of the local population with outsiders.
- Increases in the cost of living and potential for conflict with migrants.

*Community investment*

The social investment programme of AML developed in consultation with local stakeholders is expected to result in the following benefits to the community:

- Increases in education and skills levels.
- Improvement in social infrastructure such as water supply, schools and health centres.
- Development of livelihood opportunities, independent of the mine.
- Other initiatives to address community needs.

*Mine closure*

Closure impacts have not been assessed for the Phase 1 project as completion of hematite mining will lead into the larger magnetite mining project.

***Potential Mitigation Measures***

***Construction***

The following mitigation measures are expected to reduce the intensity of the residual impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Preparation and implementation of a Community Development Plan.

***Operations***

*Project induced influx of workers and job seekers*

The following mitigation measures are expected to minimise the impacts from major to moderate/minor:

- Planning with relevant stakeholders to minimise speculative migration.
- Providing assistance to local government to increase (and improve) infrastructure services.
- Communication to minimise tensions associated with non-local recruitments.
- Providing assistance to local health department (and NGOs) to strengthen programmes for control of communicable diseases and educational programmes

## Table 7-9 Mining Area – Socio-economic Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Economic aspects (employment, procurement of services and supplies, and payment of taxes and revenue to government) | H1 | employment creation (construction) | High | 2 | 3 | 2 | 2.3 | Moderate | Moderate (+) | Priority given to locals during recruitment process although skills availability is expected to be limited |
| | | employment creation (operation) | High | 1 | 3 | 3 | 2.3 | Moderate | Major (+) | Priority given to locals during recruitment process |
| | | Training of workers | High | 1 | 3 | 3 | 2.3 | Moderate | Major (+) | Considerable skills enhancement injected into the area |
| | | Increase in business for suppliers (construction) | High | 2 | 4 | 2 | 2.7 | Major | Moderate (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in business for suppliers (operation) | High | 1 | 4 | 3 | 2.7 | Major | Major (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in government income | High | 1 | 4 | 3 | 2.7 | Major | Major (+) | Revenue from project taxes, royalties, etc expected to be major contributor to GoSL GDP |
| Land acquisition | H1 | Loss of land | High | 3 | 1 | 4 | 2.7 | Major | Low | Provision of alternative land |
| | | Loss of shelter | High | 2 | 1 | 4 | 2.3 | Moderate | Moderate (+) | Provision of replacement housing of superior quality in most circumstances |
| | | Loss of income | High | 3 | 2 | 4 | 3 | Major | Minor | Implement livelihood restoration plan |
| | | Loss of access route | High | 3 | 2 | 4 | 3 | Major | Moderate | Identify and provide alternative routes or crossing methods |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Reduced food security | High | 3 | 2 | 4 | 3 | Major | Minor | Provision of alternative land and transitional support mechanisms |
| | | Breakdown social support | High | 2 | 2 | 4 | 2.7 | Major | Minor | Relocate all villagers to the same host site village. |
| | | Increase in stress | High | 2 | 2 | 3 | 2.3 | Moderate | Minor | Regular consultation and publicising grievance mechanism with PAPs |
| | | Reduced access to services | High | 2 | 2 | 2 | 2 | Moderate | Moderate (+) | Provision of replacement social infrastructure likely to provide increased access to service |
| | | Community conflict | High | 2 | 1 | 2 | 1.7 | Moderate | Minor | Effective and broad stakeholder engagement |
| | | Pressure on social infrastructure due to increase in population | High | 4 | 2 | 3 | 3 | Major | Moderate (+) | Provision of replacement social infrastructure |
| Project induced influx of workers and job seekers | H1 | Pressure on natural resources due to increase in population | High | 4 | 2 | 3 | 3 | Major | Moderate | Effective and broad stakeholder engagement |
| | | Increase in social ills (crime, alcoholism and prostitution) | High | 4 | 2 | 3 | 3 | Major | Moderate | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in communicable diseases | High | 4 | 2 | 3 | 3 | Major | Moderate | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in cost of living | High | 3 | 2 | 3 | 2.7 | Major | Moderate | Influx management. |
| | | Tensions between locals and outsiders due to real or perceived unequal access to project benefits | High | 2 | 2 | 3 | 2.3 | Moderate | Minor | Influx management and regular consultation |
| Project induced Community investment | Community | Social infrastructure | High | 3 | 2 | 4 | 3 | Major | Moderate (+) | Provision of replacement social infrastructure |
| | | Education and skills | High | 3 | 2 | 4 | 3 | Major | Major(+) | Training programs |

| Aspect | VR | Impacts | VR Category | Magnitude | Exten t | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Livelihoods | High | 3 | 2 | 4 | 3 | Major | Major(+) | Increased income from direct and indirect employment |
| Mine closure | H1 | Loss of income for workers, | High | Closure impacts have not been assessed for the Phase 1 project as completion of hematite mining will lead onto the larger magnetite mining project. | | | - | - | - | - |
| | | Loss of businesses | High | | | | - | - | - | - |
| | | Loss of revenue to government | High | | | | - | - | - | - |
| | | Psychological impacts | High | | | | - | - | - | - |

### 7.2.8 Human Health

***Construction & Operations***

Based on the current available project and existing health information, preliminary impacts at Phase 1 have been identified for the mine area. It is important to note, that the Project description has not been finalized, nor has all the baseline data been analysed, therefore, the qualitative impact designations and significance may change as the Phase 1 details are finalized.

The preliminary health impacts associated with Phase 1 mine area are described below. Impacts relate to both phases of the project (construction and operation) unless otherwise stated.

Potential negative impacts of major significance:

- Community resettlement;
- In-migration related impacts (disease, food security, substance abuse, home violence);
- Increased burden of disease due project activities and water storage facilities (drinking water tanks, waste and raw water storage ponds);
- Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns); and
- Degradation of groundwater quality.

Potential negative impacts of moderate significance:

- Increased road traffic accident rate (during operation phase);
- Impacts of noise on health and well-being (blasting and heavy vehicle activity); and
- Reduction in quality or quantity of locally produced foods.

Potential negative impacts of minor or insignificant significance:

- Increased road traffic accident rate (during construction phase);
- Exposure to increased levels of particulate matter (PM) (diesel power generators, crushers, blasting, vehicles, road dust; assuming no thermal power generation requirements); and
- Acute exposure to elevated $SO_2$ and $NO_2$ in air (diesel power generators, heavy vehicle emissions) (assuming no thermal power generation requirements).

Potential positive impacts:

- Access to improved healthcare facilities (for general public);
- Health benefits to AML employees and through local employment;
- AML financed community development initiatives;

- Improved access to the region; and
- Positive aspects of resettlement.

A number of assumptions were made for the preliminary impact assessment specific to the Phase 1 mine area. It was assumed that all communities on or within 500 m of the Project area were resettled to a distance greater than 500 m before construction associated with each pit area is begun. Thus, the Health VR used in the preliminary impact assessment for exposure to particulate matter (PM), $SO_2$, and $NO_2$ was categorized as Medium (an AML employee, or HR2 see Table 7-1).

Also, with respect to PM, $SO_2$, and $NO_2$ emissions, it was assumed that a thermal power generating facility (a potentially significant generator of these types of emissions) will not be built at the mine site. If power generation arrangements are altered significantly from those described in Section 3, this preliminary impact will require re-assessment. Should a thermal power generator be implemented, the significance of the impact and the sensitivity of the VR would be expected to increase.

The positive class impacts associated with access to healthcare facilities only apply if AML undertake to provide these facilities.

Where there was uncertainty in significance designation, the more conservative assumption was selected so as to ensure that the preliminary potential impact of the Project was not underestimated.

***Potential Mitigation Measures***

Potential mitigation measures have been identified in association with each headline health impact as listed below. The headline impacts were identified with the assumption that no mitigating measures were applied. Thus, implementation of the recommended mitigating measures is expected to reduce the significance of the headline health issues and thus avoid potentially major health issues for persons living in the vicinity of the Phase 1 mine area.

Health related mitigation measures are listed below, however, it is important to note that mitigation recommended by the other disciplines, particularly socio-economic as well as other environmental assessments (e.g., air, surface and groundwater, flora and fauna) can also affect human health.

Alteration of the current project description and further monitoring results may result in the recommendation of additional mitigation measures, or modification of those currently recommended.

*Community resettlement*

- Social mitigation measures regarding loss of land and re-settlement (see social assessment results and mitigation measures).

*In-migration related impacts (disease, food security, substance abuse, home violence)*

- Adherence to the requirements of the Prevention and Control of HIV and AIDS Act.
- Appropriate education of workforce regarding transmittable diseases.
- Employing local labour where appropriate.

- Providing suitable healthcare facilities.
- See social assessment results and mitigation measures.

*Increased burden of disease due to project activities, and water storage facilities (drinking water tanks, waste and raw water ponds).*

- Awareness and control of mosquito breeding sites to prevent malaria incidence.
- Appropriate treatment of drinking water.
- Providing suitable healthcare facilities.
- Appropriate management of waste water ponds, including odour controls.

*Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns, dam construction)*

- Management and remediation of any contamination associated with storage of fuels, waste water and other hazardous materials.
- Management of surface and storm water run-off.
- Implementation of surface water management practices to prevent/reduce sedimentation, contamination, and changes in drainage patterns of local rivers and streams.

*Degradation of groundwater quality*

- Mining and deposition of the products of the mining operations are required to be conducted in such a way that the possibility of groundwater disruption or contamination is avoided.
- Remediation of pits, and waste piles.
- Monitoring of water quality in groundwater wells used for drinking water.

*Dug out pits (standing water, falling hazard, land slides, impede access to agricultural or fishing locations).*

- Implementation of controls to keep local persons and animals out of potentially dangerous areas during remediation of mined areas.
- Remediation of mined pits.

## Table 7-10 Mining Area – Health

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| Construction | H2 | Increased road traffic accident rate | Medium | 2 | 1 | 1 | 1.3 | Minor | | |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (potential emissions from diesel power generators, crushers and vehicles) | Medium [1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (from power generator, crushers and vehicles). | Medium [1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Health benefits through local employment[3] | Medium [1] | | | | | | | |
| | H1 | Community resettlement[2] | High | 4 | 3 | 4 | 3.7 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data (requires interpretation of social assessment with respect to Human health impacts) |
| | | In-migration related impacts (disease, food security, substance abuse, home violence) | High | 3 | 3 | 3 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown. |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | • Low confidence in data. |
| | | Increased burden of disease due to project activities (drinking water tanks, waste and raw water ponds) | High | 3 | 3 | 3 | 3.0 | Major | Moderate/ Minor | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Impacts of noise on health and well being (blasting and heavy vehicle activity) | High | 3 | 2 | 1 | 2.0 | Moderate | Minor | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage) | High | 4 | 3 | 3 | 3.3 | Major | Moderate | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Degradation of groundwater quality. | High | 2 | 3 | 4 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 3 | 1 | 3 | 2.3 | Moderate | Moderate/ Minor | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |
| Operation | H2 | Increased road traffic accident rate | Medium[1] | 2 | 1 | 2 | 1.7 | Moderate | Minor | • Compliance with recommended mitigation |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | measures.<br>• Level of public concern unknown.<br>• Low confidence in data (no traffic study). |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (potential emissions from diesel power generators, crushers and vehicles) | Medium[1] | 2 | 2 | 2 | 2.0 | Minor | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (from power generator, crushers and vehicles). | Medium[1] | 2 | 2 | 2 | 2.0 | Minor | | |
| | | Health benefits through local employment[3] | Medium[1] | | | | | | | |
| | H1 | Community resettlement[2] | High | 4 | 3 | 4 | 3.7 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data (requires interpretation of social assessment with respect to Human health impacts) |
| | | In-migration related impacts (disease, food security, substance abuse, home violence) | High | 3 | 3 | 3 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Increased burden of disease due to project activities (drinking water tanks, waste and raw water ponds) | High | 3 | 3 | 3 | 3.0 | Major | Moderate/ Minor | • Implementation of recommended malarial control measures and odour control measures for standing water.<br>• Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Moderate confidence in data. |
| | | Impacts of noise on health and well being (blasting and heavy vehicle activity) | High | 3 | 2 | 2 | 2.3 | Moderate | Minor | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage) | High | 4 | 3 | 3 | 3.3 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Degradation of groundwater quality. | High | 2 | 3 | 4 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 3 | 1 | 3 | 2.3 | Moderate | Moderate/ Minor | • Compliance with recommended mitigation measures including those associated with resettlement. |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | • Level of public concern unknown.<br>• Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |

[1] Assuming all communities are >500m away.
[2] Could be a positive impact if well compensated and/or moved to a better location.
[3] Positive impacts.
[4] Estimated for Impacts with Moderate or Major Significant only.

## 7.3 Transport Corridor

### 7.3.1 Air Quality

***Construction***

The air quality impacts produced during the haul road construction and rail refurbishment are common to the other project construction activities:

- Dust emissions during vegetation clearance along the haul road route and temporal access routes for the construction phase.
- Particles emissions caused by earth movements: creation of temporary access routes and grading and levelling of the haul road route.
- Material and waste management: dust emissions during loading and unloading activities and wind erosion of the stockpiles.
- Vehicles transport and operation of heavy equipment will generate exhaust emissions and increase dust due to movements over unpaved roads.

It should be noted that some sections of the transport corridor are close to populated areas. At these locations, mitigation measures described below should be implemented.

***Operations***

Air emissions will depend on the frequency and the fuel consumption of vehicles that travel the haul road (approximately 120 km long) and the train emissions between Marampa and Pepel. The contaminants of potential concern are listed below:

- Exhaust emissions from the vehicles and the train (NOx, SO2, PM10 and CO)
- Dust from the material transport and the haul road traffic. These emissions will be mainly coarse particulate matter larger than 10 µm with little effect on human health, but with potential effects on vegetation and on near residents due to disturbance.

Exhaust gas emissions can be controlled by minimising fuel consumption and maintaining train and truck motors. Dust emissions can be controlled by covering wagons and trucks to avoid airborne particulate matter.

The potential impact on air quality will be restricted to a buffer zone along the haul road and the railway. As detailed in the project description, all villages were provided with a clearance of at least 500 m during the route selection assessment. Topographical constraints do not allow for avoiding all of the residential areas along the haul road and the train corridor. For those populated areas located close to the transport corridor, additional mitigation measures should be implemented

Additionally, a stockpile with an approximate capacity of 4 million tonnes will be located at Lunsar Interchange. Storage piles may be sources of dust emissions during loading and unloading activities and due to wind erosion of the pile.

The potential for particles emissions will depend on the stored material size, the total stockpile surface and the wind speeds. Emissions can be reduced by up to 90 percent with appropriate mitigation measures (USEPA, AP42, ref 13.2.4-1).

Loading mining product onto the train wagons should be conducted using a Car Dumper Dust Collector to minimise dust emissions. The Car Dumper Dust Collector will filter dust emissions with an efficiency of 99%.

***Potential Mitigation Measures***

The following recommendations for reducing impacts on air quality from activities associated with transport corridor construction are generic mitigation measures that should be applied during the entire construction phase.

- Dust suppression measures should be applied, such as spraying water during dry seasons on unpaved roads and stockpiles. Vehicle movements should be minimised, truck loads should be covered with mesh to avoid dust emissions, and discharge heights from trucks should not typically exceed 1 m.
- Exhaust emissions should be minimised through the use of fuel efficient machinery and appropriate machinery maintenance. Unnecessary journeys should be avoided, and a policy of switching off machinery when not in use should be implemented. Uncontrolled fires will be prohibited.

The negative impacts on air quality during the operation of the transport corridor can be minimised through the following measures:

- Avoid unnecessary journeys and optimise transport traffic
- Regular maintenance of vehicles and machinery
- Avoid airborne dust during transport by covering the truck and train loads, and/or select closed wagons for transport by train
- Minimise discharge heights (not to exceed 1 m) for fine particles and consider the use of dust suppression spray systems
- Spray trailer boxes, wheels and undersides with water before leaving the mine site
- Suppress dust emissions from the stockpiles during dry periods by spraying the surface with water.

**Table 7-11 Transport Corridor – Air Quality Impacts**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance, earth movements and construction | A1 | Dust emissions. Particle deposition on vegetation. Visibility reduction | High | 2 | 2 | 1 | 2 | Moderate | Minor | Efficiency of dust suppression measures |
| Material transportation | A1 | Dust emissions. Particle deposition on vegetation. Visibility reduction. Health effects | High | 3 | 2 | 4 | 3 | Major | Minor | High efficiency of dust suppression measures |
| Stockpiles | A1 | Dust emissions (coarse and fine particles). Particle deposition on vegetation. Visibility reduction. Health effects | High | 3 | 2 | 4 | 3 | Major | Moderate | Moderate efficiency of dust suppression measures |
| Power supply at Lunsar | A1 | Exhaust emissions ($SO_2$, CO, $NO_2$, $PM_{10}$ and $PM_{2.5}$). Health effects | High | 2 | 2 | 4 | 3 | Major | Minor | Mitigation measures should ensure AQ guidelines compliance |
| Traffic (road train, rail train and other vehicles) | A1 | Exhaust emissions from combustion. Dust emissions in unpaved roads. Particle deposition on vegetation. Visibility reduction. Health effects | High | 1 | 2 | 4 | 3 | Major | Minor | Efficiency of emissions control measures |
| Uncontrolled fires | A1 | Exhaust emissions ($SO_2$, CO, $NO_2$ , $PM_{10}$ and $PM_{2.5}$). Health effects. Risk of fire propagation | High | 1 | 1 | 1 | 1 | Minor | Insignificant | Mitigation measures should avoid uncontrolled fires |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | A2 | Changes in the microclimatic conditions | Medium | 2 | 1 | 4 | 3 | Moderate | Minor | Assumed that vegetation will be restored or naturally recovered |
| Power supply at Lunsar | A2 | Global warming due to Greenhouse gases emissions from fuel consumption | Medium | 1 | 1 | 4 | 2 | Minor | Minor | Hard to mitigate |
| Vehicles and machinery | A2 | Global warming due to Greenhouse gases emissions from fuel consumption | Medium | 1 | 1 | 4 | 2 | Minor | Minor | Low magnitude but hard to mitigate |

### 7.3.2 Noise

***Construction***

The following noise emission sources during the transport corridor construction are common to almost all construction activities:

- Machinery engines used during construction activities, e.g., clearance, road widening, profiling and sealing
- Vehicles used for transport
- Loading and unloading rock, construction materials and waste
- Motors and other construction equipment (compressors, dozers, etc.)
- Diesel engines used for energy supply

It should be noted that some sections of the transport corridor are close to populated areas. At these locations, mitigation measures described below should be implemented.

***Operations***

Noise sources along the transport corridor will arise from road trains and railway stock that will use the existing railway line between Lunsar (Marampa) and Pepel.

The potential impact will be restricted to a buffer zone along the haul road and the railway. During the route selection assessment, all villages were provided a clearance of at least 500 m. Topographical constraints do not allow for avoiding all of the residential areas along the haul road and the train corridor. For those populated areas located close to the transport corridor, additional mitigation measures should be implemented where the sound levels might exceed the Environmental, Health, and Safety (EHS) IFC Guidelines for residential areas (45 dB(A) at night and 55 dB(A) during the day).

The design of the mitigation measures will require study before the beginning of the haul road and train operations considering the distance of the nearest buildings within the villages to the transport corridor.

Additionally, the loading and offloading of ore in the Lunsar Interchange area will constitute an important noise source, and mitigation measures should be applied.

Community safety regarding noise emissions as one of the environmental aspects will be addressed through a Community Safety Plan to be developed by AML and rolled out in conjunction with the EWCC.

***Potential Mitigation Measures***

Noise prevention measures for the construction phase include the use of machinery and equipment that guarantee low noise emissions and the regular inspections and maintenance of construction vehicles and equipment. Journeys will be limited to only those necessary and a policy of switching off machinery and equipment when not in use will be implemented. Vehicle speeds will be limited in the vicinity of populated areas.

Recommendations for reducing impacts on noise levels from the transport activities are listed below:

- Select vehicles and equipment that guarantee low noise emissions
- Avoid unnecessary journeys and optimise transport traffic
- Conduct regular inspections and maintenance of vehicles and equipment to maintain smooth operation.
- Limit vehicle speeds in the vicinity of populated areas

Mitigations measures, such as sound barriers, should be installed where ambient noise levels may be exceeded. When these barriers are not effective, additional measures should be considered, such as noise isolation at sensitive receptors.

### Table 7-12 Transport Corridor – Noise Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance, earth movements and construction | N1 | Increase in noise levels due to machinery operations. Noise at near residential areas. Fauna disturbance | Medium | 2 | 1 | 1 | 2 | Minor | Minor | Hard to mitigate |
| Material transportation and traffic | N1 | Increase in noise levels due to traffic activity. Noise at near residential areas. Fauna disturbance | Medium | 3 | 2 | 4 | 3 | Moderate | Minor | Efficiency of noise barriers |

### 7.3.3 Ecology & Biodiversity

***Construction and Operations***

*Vegetation*

The principal impact will arise from the land clearance required for road construction, leading to the removal of vegetation. Fragmentation of habitats may also occur. Outside the direct footprint of the road, localised clearance of vegetation may occur in borrow areas (potential sources for bridge construction materials). Invasive species may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive). Localised erosion or inundation of vegetated areas due to the modification of drainage patterns may occur. Impacts on vegetation may occur due to disturbance during the refurbishment of the Delco rail line. Impacts on rheophytes (aquatic plants) may occur at and downstream of river crossings as a result of changes in fluvial geomorphology. Impacts on fauna may further reduce natural colonisation by indigenous plant species where fauna play a role in seed dispersal. The classification of these impacts is influenced by the nature of the vegetation present in the area being impacted (defined as high, medium and low conservation importance):

| | | **Impact classification** | | | |
|---|---|---|---|---|---|
| | | **Major** | **Moderate** | **Minor** | **Insignificant** |
| **Conservation importance** | **High** | Land clearance; spread of alien invasive species; downstream impacts of river crossings | Habitat fragmentation; drainage alteration; reduced dispersion of seeds by fauna | Borrow pits; disturbance | - |
| | **Low** | - | Land clearance; spread of alien invasive species | Habitat fragmentation; downstream impacts of river crossings | Borrow pits; drainage alteration; disturbance; reduced dispersion of seeds by fauna |

*Terrestrial Fauna*

The most significant potential impact is a change in species diversity and abundance (and potentially a loss of species of conservation concern) through habitat loss and fragmentation directly associated with the construction of the transport corridor. Habitat alteration may occur through vegetation removal and the construction of physical barriers within the habitat range of species (for example the frequent train / vehicle movements may prevent migration across the transport corridor). Displacement of terrestrial fauna may also occur through increased sensory disturbance as a result of haul road traffic. The impact classification of these impacts is as follows:

- **Major:** habitat loss, habitat fragmentation, habitat disturbance and increase in hunting.
- **Moderate:** displacement of fauna.

*Aquatic Ecosystems*

The aquatic environments along the transport corridor could potentially be impacted by the construction of new road crossings and the re-development of existing rail crossings. The most significant impacts associated with the construction and redevelopment of crossings is uncontrolled sedimentation (and increased turbidity) in aquatic environments from in-stream (such as piling) and land disturbance activities (such as removal of riparian vegetation, construction of bridge foundations, sourcing borrow material), changes to fluvial geomorphology and the introduction of physical barriers to fish migration. Riparian vegetation can reduce runoff and trap potential water contaminants prior to entering the watercourse. The direct removal of riparian vegetation for the construction of the transport corridor may increase diffuse pollutant transport from the adjoining areas. The impact classification of these impacts is as follows:

- **Major:** changes to fluvial geomorphology, physical barriers.
- **Moderate:** sedimentation / increased turbidity, entry of diffuse pollutants.

The aquatic environments along the transport corridor are relied upon by local villagers for subsistence fishing. Food shortage has been identified in the social surveys as an issue facing many villages, and therefore fishing is undertaken to supplement diets. As such, any significant ecological impacts as a result of the project-related activities may have indirect social impacts.

***Potential Mitigation Measures***

The following mitigation measures have been identified for ecology and biodiversity issues that are considered to have a significant impact:

- Mining infrastructure should be planned outside the forest patches and if this is not possible, a botanist should survey the affected forest well in advance of the construction work to allow all possible adjustments to be made.
- Minimise tree felling at river crossings. The project should source all timber from certified plantations (i.e. not local sources of timber, which come only from the last remaining natural forests, which now require the highest level of protection).
- All roads should avoid sacred forests / bushes by at least 200 m.
- Roads should be kept to the minimum width possible, commensurate with relevant design and safety standards.
- Implement best practice sediment control measures during construction of river crossings.
- Where bridges are built, ensure they are designed in a manner that does not confine the river;
- Minor in-stream infrastructure can constitute barriers to fish migration. Where possible, these should be designed to be compatible with the passage of migratory stream organisms, and

crossings of any drainage lines or water bodies should have appropriate culverts built to appropriate environmental standards.

- Plants belonging to species with conservation status Endangered (EN) or Critically Endangered (CR) should at all times be left undisturbed. Plants belonging to species with conservation status Vulnerable (VU) should be left undisturbed as much as possible.
- Species of conservation concern which were found on the deposits or near proposed infrastructure should be relocated to suitable localities outside the project area, by way of seed collection and / or translocation of specimens.
- Replanting of vegetation for any purpose should use indigenous species and should be based on silvicultural systems that promote natural ecosystem functions and that increase the probability that native species and ecological processes will be maintained. Planting of exotic species in natural forest areas should not be permitted, with the possible exception of erosion control activities utilising species that are proven to be short-lived and non-invasive.
- Establish and enforce a total ban on the hunting and capture of wildlife by company employees and contractors.
- Recognizing the importance of wildlife as a protein source to indigenous peoples, government and the company should cooperate with local communities in the development of sustainable, community-based wildlife management programs.
- Project affected communities should be supported in the development of improved animal husbandry techniques and provided with starter stocks. This would be a positive contribution to the livelihoods of people and also reduce demand for bushmeat and limit the impact of hunting restrictions on local communities.
- The project should investigate the potential for supporting local plantations, which would be beneficial to the project, local livelihoods and the remaining natural forests (and therefore, also for fauna).
- Work with government to explore opportunities to control and minimise the uncontrolled in-migration of people into areas newly opened-up by road construction, especially along the roads themselves. Uncontrolled in-migration will lead to further forest and wildlife losses and compound pressures on existing human communities.
- Consider biodiversity offsets to compensate for the unavoidable habitat loss (including vegetation and fauna).
- The risk of injury to endangered species and other fauna from vehicle movements will be minimised by adopting safe speed limits, reducing night driving to the minimum possible, and restricting driving to marked access routes.
- The project should consider establishing a relationship with the Tacugama Chimpanzee Sanctuary and to work through it to enhance conservation of chimpanzees in the project area and more widely in Sierra Leone.

**Table 7-13 Transport Corridor – Ecology & Biodiversity Impacts**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land Clearance | E1 | Loss of biodiversity through removal of vegetation<br>Fragmentation of habitat | High | 4 | 4 | 4 | 4 | Major | Moderate | Careful planning to avoid damage to valuable vegetation |
| | E2 | Loss of biodiversity and Fragmentation of habitat | Low | 4 | 4 | 4 | 4 | Moderate | Minor | Avoidance of clearance through forest remains |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 4 | 4 | 4 | Major | Major | Presently unknown pending further evaluation' |
| | E4 | Decrease in species richness and abundance derived from uncontrolled sedimentation through land disturbance activities | High | 2 | 3 | 2 | 2 | Moderate | Moderate | Presently unknown pending further evaluation |
| Borrow / construction Materials | E1 | Localised clearance of vegetation – habitat loss | High | 1 | 1 | 2 | 1 | Minor | Insignificant | Avoid borrow areas on key habitats |
| | E2 | Habitat loss | Low | 2 | 1 | 2 | 2 | Insignificant | Insignificant | |
| | E3 | Habitat loss / disturbance | High | 2 | 2 | 3 | 2 | Moderate | Major | Presently unknown pending further evaluation' |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | E4 | Sedimentation / increased turbidity through land clearance | High | 2 | 2 | 2 | 2 | Moderate | Minor | Use of best practice sediment control measures |
| Earth Movements | E1 | Loss of biodiversity and sensitive habitat | High | 3 | 4 | 4 | 4 | Major | Minor | Avoid areas of valuable vegetation |
| | E2 | Loss of biodiversity and habitat | Low | 4 | 4 | 4 | 4 | Moderate | Minor | Avoidance of clearance through forest patches |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 4 | 4 | 4 | Major | Major | Presently unknown pending further evaluation' |
| | E4 | Sedimentation / increased turbidity through land clearance | High | 2 | 3 | 2 | 2 | Moderate | Minor | Use of best practice sediment control measures |
| Changes in drainage patterns | E1 | Impacts on rheophytes (aquatic plants) at and downstream of river crossings as a result of changes in fluvial geomorphology Localised erosion or inundation of vegetated areas | High | 2 | 2 | 3 | 2 | Moderate | Moderate | Presently unknown pending further evaluation |
| | E2 | Localised erosion or inundation of vegetated areas | Low | 2 | 2 | 3 | 2 | Insignificant | Insignificant | |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | Medium | 3 | 2 | 3 | 3 | Major | Major | Presently unknown pending further evaluation |
| | E4 | Decrease in species richness and abundance through changes to fluvial | High | 3 | 3 | 4 | 3 | Major | Major | Presently unknown |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | geomorphology | | | | | | | | pending further evaluation |
| Waste Generation | E1 | Vegetation disturbance | Low | 1 | 1 | 2 | 1 | Minor | Insignificant | Adherence to international best practices for waste management |
| | E2 | Vegetation disturbance | Medium | 1 | 1 | 2 | 1 | Insignificant | Insignificant | |
| | E4 | Decrease in habitat quality through entry of diffuse pollutants | High | 2 | 2 | 3 | 2 | Moderate | Minor | Use of best practice sediment control measures |
| Bridges / Culverts Construction | E1 | Loss of riparian forests<br>Impacts on rheophytes (aquatic plants at and downstream of river crossings as a result of changes in fluvial geomorphology | High | 4 | 3 | 4 | 4 | Major | Minor | Minimisation of construction work in riparian forests. Supervision by a botanist. |
| | E2 | Loss of habitat | Low | 3 | 3 | 4 | 3 | Minor | Insignificant | Minimisation of construction works in riparian habitats |
| | E4 | Changes to fluvial geomorphology and the introduction of physical barriers to fish migration | High | 3 | 3 | 4 | 3 | Major | Minor | Bridges to be designed in a manner that does not confine the |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | River. Selection of open box culverts with natural substrata rather than enclosed Culverts |
| Presence of the transport infrastructure | E3 | Habitat fragmentation | High | 3 | 4 | 4 | 4 | Major | Major | Presently unknown pending further evaluation |
| Project induced influx of workers and job seekers | E1 | Increased pressure on timber | High | 3 | 4 | 4 | 4 | Major | Major | Mitigation will require co-operation between AML and local partners – pending further evaluation |
| | | Spread of alien invasive species | | 3 | 3 | 4 | 3 | Major | Major | Presently unknown pending further evaluation |
| | E2 | Increased pressure on timber | Low | 2 | 3 | 2 | 2 | Insignificant | Insignificant | |
| | | Spread of alien invasive species | | 4 | 3 | 4 | 4 | Moderate | Moderate | |
| | E3 | Increase in hunting | High | 4 | 3 | 4 | 4 | Major | Major | |
| | | Displacement of fauna | | 2 | 2 | 3 | 2 | Moderate | Moderate | |
| Haul Road Traffic / Train Traffic | E3 | Loss of biodiversity<br>Habitat fragmentation | High | 3 | 4 | 4 | 4 | Major | Major | Presently unknown pending further |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | evaluation |

### 7.3.4 Hydrology & Hydrogeology

Potential impacts pertaining to local surface and groundwater have been determined based on the partial project descriptions available and field observation of early haul road construction and rail refurbishment activities.

***Construction***

- Construction works at or near watercourses may lead to increased runoff and erosion with increase in turbidity and reduction in water quality impacting aquatic environment and downstream users.
- Construction of temporary stream and river crossings includes creation of river bed crossings and infill with rock, soil and organic debris arising from the route clearance and stripping works. Construction process of these crossings and vehicles passing through river bed crossings disturb river bank and river bed sediments raising downstream turbidity, impacting on water quality and potentially increasing long term erosion in the vicinity of the crossing.
- Infill crossings lead to increased downstream turbidity impacting on water quality as fines are washed downstream by increasing flows with onset of the wet season.
- High rainfall events will carry larger infill material and similar materials deposited in general on road alignment adjacent to river banks and flood areas downstream - including rocks and trees which can destroy community foot crossing. High organic content in water courses may impact on water quality.
- Dewatering of aquifers leading to impacts on surface water hydrology and local communities. Groundwater will be abstracted to supply potable and construction water at various locations along the haul road and existing rail alignment. Surface water may also be abstracted for construction use. Over-exploitation of aquifers could locally reduce the water table and potentially dry nearby community wells, surface water streams and/or wetland habitats.
- Modification and interruption to the existing hydrological regime of the bounding catchments may occur. The raised haul road and diversion of storm water runoff may alter the natural drainage patterns of the various catchments.
- Erosion of exposed surfaces by wind, water and construction activities generating higher sediment loads in surface runoff entering the surrounding river catchments. This will be of particular concern in the vicinity of river crossing and wetlands.
- Alterations to the natural course of rivers may be required where major river crossing are planned. Deepening of river channels and alterations to the surrounding topography could alter the natural course or flow rates of rivers as well as the flood plain dynamics during the wet season.

- Potentially contaminated soil waste may be generated during the re-development of the existing rail alignment. Contaminants could be mobilised from excavated soils and migrate to surface or groundwater.

***Operations***

Assessment of potential impacts on the hydrological and hydrogeological setting have been conducted based primarily on a Phase 1B – Walkover baseline assessment supplemented with limited reconnaissance level assessment conducted during February 2010. Potential impacts associated with the project will be accurately quantified during the impact assessment but may include the following:

- Uncontrolled release of toxic chemicals to the environment. Diesel fuel, oil, grease and solvents will all be used during the operation and maintenance of vehicles using the haul road and rail. Accidental spillage and contact with rainfall runoff may lead to the pollution of groundwater and/or surface water bodies.
- Lack of hard surfacing of the haul road may lead to dusting and erosion and runoff carrying material into water courses where the road is nearby or at crossings. This may impact on turbidity and other water quality parameters. Groundwater and or surface water abstraction at permanent camps/facilities along the transport corridor may locally reduce the water table and potentially dry nearby community wells, surface water streams and/or wetland habitats.
- Dust and spillage of ore from haul road and rail wagons may enter water courses or leach into groundwater impacting water quality

***Potential Mitigation Measures***

The following mitigation measures have been identified for hydrology and hydrogeology issues that are considered to have a significant impact:

- Robust surface and groundwater monitoring programmes to establish baseline and ensure early identification of impacts.
- Treatment of all potentially contaminated wastewater sources prior to discharge to ground or surface.
- Rapid replacement of riverbed crossings and infill crossings with appropriately designed culverted/bridged crossings. Prohibit construction of similar crossings and ensure culvert and bridge crossings commence only when suitable plant and materials available on site.
- Strict adherence to Environmental Management Plans prepared in line with industry and international best practice.
- Appropriate hydrogeological/hydrological assessment of water resources and careful design of water abstraction points so as to minimise impacts on other users.
- Strict load level and moisture control of materials to be transported in open rail/road wagons

- Design to ensure potentially contaminating materials are not stored in proximity to surface water courses and adequate bunding for spill control. Prepare spill response plans and materials handling management plans. Avoid storage over potentially sensitive/important shallow aquifers and prepare engineered low permeability surfaces with drainage/runoff controls for storage and handling areas.

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**Table 7-14 Transport Corridor - Hydrology & Hydrogeology**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land Clearance | SW1 | Higher sediment loads in surface runoff entering rivers and their tributaries (construction) | High | 3 | 2 | 3 | 3 | Major | Moderate | Adherence to international best practice |
| Blasting and earthworks | SW1 | Construction phase river bed crossings and infill crossings may lead to increased turbidity and other changes in water quality. | High | 3 | 2 | 3 | 3 | Major | Moderate | Adherence to international best practice |
| | SW2 | Reduced surface water resources (construction and operation) | High | 2 | 2 | 5 | 3 | Major | Major | Impact will be permanent |
| | SW2 | Modification and interruption of existing hydrological regimes (construction and operation) | High | 3 | 3 | 4 | 4 | Major | Insignificant | Appropriate design and international best practice |
| | SW2 | Flooding (operational) | High | 3 | 3 | 5 | 4 | Major | Moderate | Appropriate design and international best practice |
| Waste generation | SW1 | Contamination of surface water resources from uncontrolled release of sewage and other waste waters (construction and operation) | High | 3 | 3 | 2 | 4 | Major | Insignificant | Adherence to international best practice |
| | GW1 | Contamination of groundwater resources from uncontrolled release of sewage and other waste waters (construction) | High | 3 | 3 | 2 | 4 | Major | Insignificant | Adherence to international best practice |
| | SW1 | Contamination of surface waters from uncontrolled release of drilling fluids (camp construction) | High | 2 | 2 | 2 | 2 | Moderate | Insignificant | Adherence to international best practice |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Resource utilisation | GW2 | Reduced groundwater resources in vicinity of camps where water may be derived from groundwater (construction and operation). | High | 2 | 2 | 4 | 4 | Major | Insignificant | Detailed studies, appropriate design and location of abstractions and water resources management plan |
| Chemical and fuels storage and utilisation | SW1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | High | 3 | 3 | 2 | 4 | Major | Moderate | Engineering design and adherence to international best practice |
| | GW1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | High | 2 | 2 | 4 | 4 | Major | Minor | Engineering design and adherence to international best practice |
| Vehicle movements | SW1 | Turbidity and other water quality impacts due to dusting and erosion from the operational haul road | High | 3 | 3 | 4 | 3 | Major | Insignificant | Engineering design and adherence to international best practice |
| | SW1 | Turbidity and water quality impacts from dust and spillage of ore from open rail and road wagons | High | 3 | 3 | 4 | 3 | Major | Insignificant | Engineering design and adherence to international best practice |

### 7.3.5 Soils & Land Use

***Construction***

While there are no baseline soil data currently available for the transport corridor, the preliminary identification and evaluation of impacts is possible based on field observations of baseline conditions as well as current haul road construction activities, qualitative land-use information and an understanding of Phase 1-related activities in this area.

- Land clearance including slash and burn of vegetation and surface soils strip being carried out for scout road construction and subsequent widening may lead to significant erosion.
- Temporary stream and river crossings include river bed crossings or 'infill' crossings where earth/rocks and vegetation have been pushed into the watercourse restricting the natural flow of water. Onset of the wet season will lead to severe erosion of river bank soils in the vicinity of these crossings and flooding associated with infill type crossings may lead to deposition of sediment on surrounding areas impacting on soils and land use.
- The construction of the road may constrain certain land-uses and / or access to land and leads to permanent loss of some land to former land use..
- Localised impacts may occur associated with borrow pit areas and quarries (potential sources for road and bridge construction materials).
- Invasive species may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive).
- Localised erosion or inundation may occur due to the modification of drainage patterns.
- Stripping of soils and shallow deposits has been carried out over much of the haul road scout route and to date the stripped material has been pushed to the sides of the road to form bunds mixed with cleared vegetation and subsoil and non-organic sediments. Unmanaged storage of soils can lead to a loss of the soils structure as well as wash out and erosion during high rainfall events leading to permanent loss of the soil.
- Temporary and minor impacts on soil resources and land-use during the refurbishment of the Delco rail line may also occur. Historical soil quality impacts are highly likely to have occurred during operation of the rail line and there are visible deposits of ore spillage in many areas along and immediately adjacent to the line. Renovation/construction works could lead to the spread or redistribution of this material.
- Soil resources and land-use in areas adjacent to the road may experience localised dust-related impacts from truck movements and earth moving activities during road construction.
- Compaction and permanent loss of soil structure may occur in the vicinity of the road construction due to the movement of plant and vehicles beyond the necessary work areas.

### *Operations*

Road haulage and renewed operation of the rail line is likely to result in spillage of some ore product for which detailed chemistry is not yet known. However the very narrow, linear form of the transport lines means that any impacts on soils are likely to be localised and limited.

Although the product grain sizes are not anticipated to lead to dusting in their own right, the heavily weathered nature of some of the material means that some abrasion and dust formation may occur. Dust may be blown from road and rail wagons and accumulate on local soils. Again, potential chemistry of any dust is not yet known. For now, limited impacts are assumed.

### *Potential Mitigation Measures*

The following mitigation measures have been identified for soils and land use issues that are considered to have a significant impact:

- Minimise land / soil to be cleared or buried and concentrate such activities in areas with limited soil quality and land-use capability. Given the advanced stage of design and construction the opportunity to apply this mitigation may not apply.
- Consider biodiversity offsets for unavoidable long-term and permanent soil / land clearance and soil / land burial. Integrate livelihoods components as necessary with offsets to replace lost land-use capability.
- Identify suitable storage locations and implement appropriate conservation and preservation of stripped top-soils and sub-soils from all areas to retain physical and chemical characteristics and seed-bank for subsequent use for rehabilitation activities. Where practical, soils can be formed as roadside bunds or caps to roadside bunds and be planted in order to maintain soil structure and quality. This mitigation can be retrospectively applied for road sections that have already been partially cleared where extensive mixing with unsuitable materials has not occurred.
- Implement required storm water drainage, culvert and bridge construction and flow control prior to construction and during the dry season to prevent erosion of exposed areas and inundation of low lying and down-stream areas. For crossings which have already been breached and either have river bed crossings or temporary infill crossings, install engineered crossings as soon as possible ahead of increasing rainfall and runoff.
- Restrict access by vehicles to essential areas only, in order to reduce compaction of soils.
- Isolate and manage potential soil contaminants (including wind blown dusts and water-borne contaminants) through careful selection of storage sites and moisture control prior to transport and during storage.
- Avoid deliberate introduction of alien invasive species during rehabilitation activities.
- Manage pathways by which alien invasive species can enter a disturbed area (including avoidance of non-indigenous plant species in rehabilitation activities).

**Table 7-15 Transport Corridor - Soils & Land Use**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | S1 | Changes in quality/available land due to invasive species colonising disturbed areas | Medium | 2 | 3 | 4 | 4 | Major | Insignificant | Appropriate design and international best practice |
| | S2 | Exposure of soils and stripping of vegetation in the vicinity of the road construction may lead to increased soil erosion | Medium | 3 | 3 | 4 | 4 | Major | Insignificant | Appropriate site management and international best practice |
| Earthworks | S2 | Change in land use leading to loss of farming land and some access restrictions may constrain some land use | Medium | 3 | 3 | 4 | 4 | Major | Moderate | Long term rehabilitation and international best practice |
| | S2 | Compaction and destruction of soils may occur due to plant movements and earthworks in the vicinity of the road | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| | S1 | Soils bounding the alignment may be impacted by spillage of ore, accumulated dust blown from rail and road wagons and generated by vehicle movements over the unsurfaced roads. | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| | S2 | Construction of temporary river crossings may lead to increased erosion and loss of soils | Medium | 2 | 2 | 3 | 3 | Moderate | Insignificant | Appropriate site management and |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | international best practice |
| | S2 | Failure to separately strip and stockpile and manage soils in an appropriate manner can lead to loss of structure as well as wash out and erosion. | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| | S2 | Construction of temporary infill river crossings or inadequately drained permanent crossings may lead to flooding and deposition of flood sediments over farmland | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate design, site management and international best practice |
| Chemical / fuels storage and utilisation | S1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Engineering design and adherence to international best practice |

### 7.3.6 Geology & Geomorphology

***Construction***

No project-specific baseline geological or geotechnical drilling or mapping has been undertaken to date along the rail route or haul road however limited information is available in published regional geological descriptions and from observations during field visits. Since the rail line is already established and was operated for many years, no further significant impacts on geology or geomorphology are anticipated. Construction of the haul road and re-instatement of the rail line will require quarrying of some construction materials for ballast, bridges and road base. Potential changes to watercourses and runoff and erosion patterns crossed by the road alignment may impact on local geomorphology. The eastern 20km stretch of road passes through the very hilly Sula range which are locally deeply incised by streams and rivers. Cut and fill requirements in this region will be much more significant than for the western road sections and will result in localised significant changes in geomorphology. However, overall, at this stage and based on limited design data reviewed to date, no major impacts to geology and geomorphology along the transport corridor are anticipated.

***Operations***

Operation of the transport corridor is not anticipated to have any significant impact on geology or geomorphology.

***Potential Mitigation Measures***

The following mitigation measures have been identified for geology and geomorphology issues that are considered to have a significant impact:

- Geomorphological mitigation measures include the preservation of watercourses (where possible) and diversion of watercourses around infrastructure to maintain downstream drainage patterns, rehabilitation and revegetation of disturbed areas, and re-contouring disturbed areas to original topography (to the extent possible).
- Design of the road should be optimised so as to minimise unnecessary cut and fill. It is understood that this is anyway consistent with one of the primary design aims for the road.

**Table 7-16 Transport Corridor - Geology & Geomorphology**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | V1 | Potential changes to watercourses and valley swamps drainage and erosion/deposition patterns may alter local geomorphology. | Low | 3 | 3 | 5 | 4 | Moderate | Moderate | Irreversible. Long term rehabilitation and international best practice |
| | V1 | Stripping of land surface will change the landform and impact on the visual landscape. | Low | 3 | 3 | 4 | 4 | Moderate | Moderate | Long term rehabilitation and international best practice |
| Blasting and earthworks | V1 | Cut and fill requirements for road construction in the Sula mountains area may result in localised changes in geomorphology. | Low | 2 | 2 | 5 | 4 | Moderate | Insignificant | Irreversible. Long term rehabilitation and international best practice |

### 7.3.7 Socio-Economic

***Construction***

*Land acquisition*

The impacts due to land acquisition for construction of the haul road (rail refurbishment will take place on the existing rail embankment) will range from loss of access to land-based resources to loss of shelter, all of which may potentially lead to a decrease in economic stability. These can include (but may not be limited to):

- Loss of income.
- Impact on dwelling units.
- Impact on community structures.
- Increases in physical and mental stress.

The haul road may pass through the sugar plantations to be developed as part of the Addax Biofuel Project. The compensation for potential impacts on the sugarcane plantations may require separate negotiations with relevant stakeholders. The mitigation measures given below are expected to reduce the impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Preparation and implementation of the CDAP.

*Project induced influx of workers and job seekers*

An influx of population will result from the arrival of workers and job seekers to the construction sites along the transport corridor. This influx is likely to lead to the following impacts:

- Pressure on social infrastructure, natural resources.
- Increases in social ills such as crime, alcoholism, drug abuse and prostitution.
- Increases in communicable diseases.
- Potential for conflict between the local community and outsiders.

Given the high level of unemployment in Sierra Leone, it will be difficult to control the influx of job seekers to villages and towns along the transport corridor. The following measures can reduce impacts from moderate to minor.

- Planning for self sufficient and closed workers camps to minimise intermingling of workers with local population.

- Providing assistance for the control of communicable diseases and for educational campaigns for prevention of social ills.
- Planning jointly with local Paramount Chief and other stakeholders to minimise speculative migration.

In the long term, the improved transport infrastructure may also lead to growth of industry and other economic activities along the corridor (more likely along the haul road), which may contribute to general economic development. The above benefit will be independent of the project and hence has not been evaluated.

***Operations***

The social impacts of the transport corridor are likely to occur mainly during the construction phase due to disturbance to the existing land users. The impacts on land are expected to occur during construction of a new 120 km haul road between Farangbaia and Lunsar and refurbishment of the existing rail line between Lunsar and Pepel Port.

*Economic aspects*

The economic impacts are expected to be mainly beneficial in nature as described below:

- Employment of workers for the construction and operation phases (with additional indirect and induced jobs with contractors and suppliers).
- Initial investment and sustaining capital for maintenance and operation of the railway line translated into business opportunities for contractors.
- Government income in the form of excise duties on imports (mainly during construction) and taxes.

*Community investment*

As part of its social investment programme, AML is expected to contribute towards development of social infrastructure in communities along the transport corridor. These could include safe drinking water, support to schools, construction of roads and other social infrastructure within the settlements along the rail line. No mitigation measures are suggested for these positive impacts.

*Closure of transport operations*

The use of the haul road and a refurbished rail line from Lunsar to Pepel Port is planned to be used for an initial period (at most 8 years). After this the transport activities will take place through a new rail corridor from the mine site to Tagrin Port as part of Phase 2 and 3. However it is not expected that there will be large scale retrenchment and consequent impacts as much of the workforce can be deployed at the new transport corridor or other project operations.

### Table 7-17 Transport Corridor – Socio-Economic Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Economic aspects (employment, procurement of services and supplies, and payment of taxes and revenue to government) | H1 | employment creation (construction) | High | 1 | 2 | 2 | 1.7 | Moderate | Moderate (+) | Priority given to locals during recruitment process although skills availability is expected to be limited |
| | | employment creation (operation) | High | 1 | 2 | 3 | 2 | Moderate | Major (+) | Priority given to locals during recruitment process |
| | | Training of workers | High | 1 | 3 | 3 | 2.3 | Moderate | Major (+) | Inject considerable skills enhancement into the area |
| | | Increase in business for suppliers (construction) | High | 1 | 4 | 2 | 2.3 | Moderate | Moderate (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in business for suppliers (operation) | High | 1 | 4 | 3 | 2.7 | Major | Major (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in government income | High | 1 | 4 | 3 | 2.7 | Major | Major (+) | Revenue from project taxes, royalties, etc expected to be major contributor to GoSL GDP |
| Land acquisition | H1 | Loss of land | High | 1 | 1 | 4 | 1.7 | Moderate | Low | Provision of alternative land |
| | | Loss of shelter | High | 1 | 1 | 4 | 2 | Moderate | Moderate (+) | Provision of replacement housing of superior quality in most circumstances |
| | | Loss of income | High | 1 | 2 | 4 | 2.3 | Moderate | Minor | Implement livelihood restoration plan |
| | | Loss of access route | High | 1 | 2 | 4 | 2.3 | Moderate | Moderate | Identify and provide alternative routes or crossing methods |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Reduced food security | High | 1 | 2 | 4 | 2.3 | Moderate | Minor | Provision of alternative land and transitional support mechanisms |
| | | Breakdown in social support | High | 1 | 1 | 1 | 1 | Insignificant | Insignificant | Villagers moved to other locations within existing village therefore not likely to suffer loss of cohesion |
| | | Increase in stress | High | 1 | 2 | 3 | 2 | Moderate | Minor | Regular consultation and publicising grievance mechanism with PAPs |
| | | Reduced access to services | High | 1 | 2 | 3 | 2 | Moderate | Moderate (+) | Provision of replacement social infrastructure likely to provide increased access to service |
| | | Community conflict | High | 1 | 1 | 1 | 1 | Insignificant | Insignificant | Villagers moved to other locations within existing village therefore not likely to suffer loss of cohesion |
| Project induced influx of workers and job seekers | H1 | Pressure on social infrastructure due to increase in population | High | 1 | 2 | 3 | 2 | Moderate | Moderate (+) | Provision of replacement social infrastructure |
| | | Pressure on natural resources due to increase in population | High | 1 | 2 | 3 | 2 | Moderate | Minor | Effective and broad stakeholder engagement |
| | | Increase in social ills (crime, alcoholism and prostitution) | High | 1 | 2 | 3 | 1.7 | Moderate | Minor | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in communicable diseases | High | 1 | 3 | 3 | 2.3 | Moderate | Minor | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in cost of living | High | 1 | 2 | 3 | 1 | Moderate | Minor | Influx management |
| | | Tensions between locals and outsiders due to real or perceived | High | 1 | 2 | 3 | 2 | Moderate | Minor | Influx management and regular consultation |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | unequal access to project benefits | | | | | | | | |
| Project induced Community investment | H1 | Social infrastructure | High | 2 | 3 | 3 | 2.7 | Major | Moderate (+) | Provision of replacement social infrastructure |
| | | Education and skills | High | 2 | 3 | 3 | 2.7 | Major | Major(+) | Training programs |
| | | Livelihoods | High | 2 | 3 | 3 | 2.7 | Major | Major(+) | Increased income from direct and indirect employment |
| Mine closure | H1 | Loss of income for workers, | High | It is anticipated that much of the workforce working on the transport corridor for the Phase 1 can be deployed at the new corridor or other project operations. Consequently, large scale retrenchment and associated impacts are not expected. | | | - | - | - | - |
| | | Loss of businesses | High | | | | - | - | - | - |
| | | Loss of revenue to government | High | | | | - | - | - | - |
| | | Psychological impacts | High | | | | - | - | - | - |

### 7.3.8 Human Health

***Construction & Operations***

Based on the current available project and existing health information, preliminary impacts for Phase 1 of the Tonkolili project have been identified for the transport corridor. It is important to note that the Project has not been finalized, nor has all the baseline data been analysed, therefore, the qualitative impact designations and significance may change as the Phase 1 details are finalized.

The preliminary health impacts associated with the Phase 1 transport corridor are described below. Impacts relate to both construction and operation of the transport corridor unless otherwise stated.

Potential negative impacts of major significance:

- Community resettlement (during construction);
- In-migration related impacts (disease, food security, substance abuse, home violence) (during construction); and
- Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns).

Potential negative impacts of moderate significance:

- Increased road traffic accident rate; and
- Reduction in quality or quantity of locally produced foods.

Potential negative impacts of minor or insignificant significance:

- Impacts of noise on health and well-being (heavy vehicle activity);
- Exposure to increased levels of particulate matter (PM) (diesel power generators vehicle emissions, and road dust); and
- Acute exposure to elevated $SO_2$ and $NO_2$ in air (diesel power generators, heavy vehicle emissions).

Potential positive impacts:

- Access to improved healthcare facilities (for general public);
- Health benefits to AML employees and through local employment;
- AML financed community development initiatives;
- Improved access to the region; and
- Positive aspects of resettlement.

A number of assumptions were made for the preliminary impact assessment specific to the Phase1 transport corridor. It was assumed that all communities on or within 500 m were to be resettled to a distance greater than 500 m. Thus, the Health VR used in the preliminary impact assessment for impacts associated with PM, $SO_2$, and $NO_2$ was categorized as Medium (an AML employee or HR2 see Table 7-1).

Also, with respect to PM, $SO_2$, and $NO_2$ emissions, it was assumed that a thermal power generating facility (a potentially significant generator of these types of emissions) will not be built in this area. Should the arrangements for power supply be altered from those described in Section 3, this preliminary impact will require re-assessment. Should a thermal power generator be implemented, the significance of the impact and the sensitivity of the VR would be expected to increase.

It was assumed that activities associated with the haul road construction and railway up-grade would be superficial and not impact groundwater along the transport corridor. Thus, an impact to groundwater was not included in preliminary impact assessment of the Phase 1 transport corridor.

The positive class impacts associated with access to medical facilities only apply if AML undertake to provide these facilities.

Where there was uncertainty in significance designation, the more conservative assumption was selected so as to ensure that the preliminary potential impact of the Project was not underestimated.

***Potential Mitigation Measures***

Potential mitigation measures have been identified in association with each headline health impact as listed below. The headline impacts were identified with the assumption that no mitigation measures were applied. Thus, implementation of the recommended mitigation measures is expected to reduce the significance of the headline health issues and thus avoid potentially major health issues for persons living in the vicinity of the Projects.

Health related mitigation measures are listed below, however, it is important to note that mitigation recommended by the other disciplines, particularly socio-economic as well as other environmental assessments (e.g., air, surface and groundwater, flora and fauna) can also affect human health.

Alteration of project descriptions and monitoring results may result in the recommendation of additional mitigation measures, or modification of those currently recommended.

*Increased road traffic accident rate*

- Implementation of sound health and safety measures during the construction phase, including safe driving practices.
- Road Health and Safety and awareness training for all employees.
- Assigned crossing areas for pedestrians.
- Lighting along dangerous sections of the road and busy intersections.
- Building good quality roads with adequate signage.
- Keeping Project-related night time traffic to a minimum.

- Protection fences on rail line to restrict movement of fauna.

Also see traffic assessment results and mitigation measures

*Community resettlement*

- Social mitigation measures regarding loss of land and re-settlement (see social assessment results and mitigation measures).

*In-migration related impacts (disease, food security, substance abuse, home violence)*

- Adherence to the requirements of the Prevention and Control of HIV and AIDS Act.
- Appropriate education of workforce regarding transmittable diseases.
- Employing local labour where appropriate.
- Providing suitable healthcare facilities.
- See social assessment results and mitigation measures.

*Increased burden of disease due to project activities, and water storage facilities (drinking water tanks, waste and raw water ponds).*

- Awareness and control of mosquito breeding sites to prevent increased malaria incidence.
- Appropriate treatment of drinking water.
- Providing suitable healthcare facilities.
- Appropriate management of waste water ponds, including odour controls.

*Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns, dam construction)*

- Management and remediation of any contamination associated with storage of fuels, waste water and other hazardous materials.
- Management of surface and storm water run-off.

## Table 7-18 Transport Corridor – Health

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| Construction | H2 | Impacts of noise on health and well being (train and road activity) | Medium[1] | 2 | 2 | 1 | 1.7 | Minor | | |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (potential emissions from diesel power generators and vehicles) | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (from power generator and vehicles). | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | | | | | | | | | |
| | | Health benefits through local employment[3] | | | | | | | | |
| | H1 | Increased road traffic accident rate | High | 3 | 1 | 1 | 1.7 | Moderate | Minor | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data (no traffic study). |
| | | Community resettlement[2] | High | 4 | 3 | 4 | 3.7 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data (requires interpretation |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | of social assessment with respect to Human health impacts) |
| | | In-migration related impacts (disease, food security, substance abuse, home violence) | High | 4 | 2 | 4 | 3.3 | Major | Minor | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Increased burden of disease due to project activities (drinking water tanks, waste and raw water ponds) | High | 3 | 3 | 1 | 2.3 | Moderate | Minor | • Implementation of recommended malarial control measures and odour control measures for standing water.<br>• Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Moderate confidence in data. |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage) | High | 5 | 3 | 4 | 4 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | H1 | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 2 | 2 | 1 | 1.7 | Moderate | Minor | • Land appropriation and clearance, and siltation or diversion of surface water will have a permanent impact.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Increase road and rail access to the region[3]. | High | | | | | | | |
| Operation | H2 | Impacts of noise on health and well being (train and road activity) | Medium[1] | 2 | 2 | 1 | 1.7 | Minor | | |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (road dust and road train emissions) | Medium[1] | 2 | 1 | 2 | 1.7 | Minor | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (emissions from road trains). | Medium[1] | 2 | 1 | 2 | 1.7 | Minor | | |
| | | Health benefits through local employment[3] | | | | | | | | |
| | H1 | Increased road traffic accident rate | High | 3 | 1 | 1 | 1.7 | Moderate | Minor | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data (no traffic study). |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage) | High | 5 | 3 | 4 | 4.0 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 2 | 2 | 2 | 2.0 | Moderate | Minor | • Land appropriation and clearance, and siltation or diversion of surface water will have a permanent impact.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Increase road and rail access to the region[3]. | High | | | | | | | |

[1] Assuming all communities are >500m away.
[2] Could be a positive impact if well compensated and/or moved to a better location.
[3] Positive impacts.
[4] Estimated for Impacts with Moderate or Major Significant only.

## 7.4 Port Facilities

### 7.4.1 Air Quality

***Construction***

Construction activities at Pepel Port will comprise a combination of existing asset refurbishment and new development.

Contaminants of potential concern are dust emissions and exhaust gases that will contain several pollutants ($SO_2$, CO, $NO_2$, $PM_{10}$ and $PM_{2.5}$).

Dust will be generated during vegetation clearance and earth movements (creation of new access routes, and surface grading and levelling for buildings and facilities construction). Pollutants emitted by these activities are mainly coarse particles (above 10 µm) without health effects. Nevertheless, vegetation in this area (mangrove ecosystems) may be affected by the deposition of particles on the leaves.

Dust (coarse particles) dispersion might travel up to 1 km depending on the wind characteristics, believed to be prevailing westerly.

Additionally, diesel generators used for power supply, vehicles and machinery will generate exhaust emissions. The use of efficient machinery (vehicles, motors and pumps) and a good practices policy (e.g., minimise journeys, switch-off machinery when not in use, and reduce diesel generators use to a minimum) will avoid unnecessary fuel consumption, minimising the potential impacts on air quality.

***Operations***

The most significant potential impacts may arise from two stockpiles located in the Port Facilities area, with a capacity of 200,000 tonnes each, and the diesel generators used for the power supply.

Total dust emissions from aggregate storage piles will result from the following distinct source activities during the storage cycle:

- Loading of aggregate onto storage piles (batch or continuous drop operations).
- Equipment traffic in the storage area.
- Wind erosion of the fines within the pile and ground surfaces around the piles.
- Loadout of aggregate for shipment or for return to the process stream (batch or continuous drop operations).

The quantity of dust emissions from aggregate storage operations will vary with the volume of aggregate passing through the storage cycle, the size of the particles, the surface of the stockpiles, the moisture content (moisture aggregates and bonds fines to the surfaces of larger particles) and the wind conditions.

Suspended particle emissions could be controlled with great efficiency if measures are applied (e.g., humidification or protection from wind). When the appropriate measures are not taken, negative effects will likely increase considerably.

Other potential sources of pollutant emissions (NOx, $SO_2$ and PM) are the transport ships, periodically present close to the port.

The project power requirements at the port will be supplied by small diesel generators. The installed power (currently undefined) and the fuel characteristics will define the pollutant emissions. The power generators should be specified to comply with the International Finance Corporation / World Bank Group HSE Ambient Air Quality guidelines.

***Potential Mitigation Measures***

Generic recommendations for reducing impacts from activities to be conducted during the construction phase of the project are listed below:

*Decrease air quality impacts due to dust emissions:*

- Suppress dust during dry periods by spraying with water the potential sources that could release airborne particles (unpaved roads, earth being moved)
- Cover truck loads to avoid dust emissions during the transport of excavated earth
- Keep vehicle movements to a minimum and use paved areas, where possible
- Minimise discharge heights from trucks (not to exceed 1 m) for fine particles and consider the use of dust suppression spray systems

*Decrease air quality impacts due to combustion emissions:*

- Review machinery permits and ensure appropriate maintenance
- Limit unnecessary journeys and adopt a policy of switching off machinery and equipment when not in use
- Consider a choice of machinery, equipment, vehicles and materials that are fuel-efficient as part of the purchasing procedure

*Controlled and uncontrolled fires (airborne emissions):*

- Open fires will be prohibited. To limit air emissions, avoid accidents and reduce fire risk during the construction phase.

The negative impacts on air quality during the operation of the Pepel Port facilities can be minimised through the following measures:

- Design stockpiles based on wind patterns and consider the installation of windscreen if dust emissions are observed.
- Suppress dust emissions from the stockpiles during dry periods by spraying the surface with water.

- Minimise discharge heights for fine particles and consider the use of dust suppression spray systems.
- Power generator emissions should be assessed to comply with Ambient Air Quality Standards. If a combustion power plant is constructed to supply power for the project, the pollutant emissions will affect the background air quality; and therefore, the emissions should be assessed and incorporated as part of the background.

### Table 7-19 Port Area – Air Quality Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Earth movements, grading and construction | A1 | Dust emissions. Particle deposition on vegetation. Visibility reduction. | High | 2 | 2 | 1 | 2 | Moderate | Minor | Efficiency of dust suppression measures |
| Material processing (unloading, loading) | A1 | Dust emissions. Particle deposition on vegetation. Visibility reduction. Health effects. | High | 3 | 2 | 4 | 3 | Major | Minor | Efficiency of dust suppression measures |
| Stockpiles | A1 | Dust emissions (coarse and fine particles). Particle deposition on vegetation. Visibility reduction. Health effects. | High | 3 | 2 | 4 | 3 | Major | Moderate | Moderate Efficiency of dust suppression measures |
| Power supply at Pepel | A1 | Exhaust emissions ($SO_2$, CO, $NO_2$ , $PM_{10}$ and $PM_{2.5}$). Health effects. | High | 3 | 2 | 4 | 3 | Major | Minor / moderate | Mitigation measures should ensure AQ guidelines compliance |
| Traffic (rail train and other vehicles) | A1 | Exhaust emissions from combustion. Dust emissions in unpaved roads. Particle deposition on vegetation. Visibility reduction. Health effects. | High | 1 | 2 | 4 | 3 | Major | Minor | Efficiency of emissions control measures |
| Uncontrolled fires | A1 | Exhaust emissions (SO2, CO, NO2 , PM10 and PM2.5). Health effects. Risk of fire propagation. | High | 1 | 1 | 1 | 1 | Minor | Insignificant | Mitigation measures should avoid uncontrolled fires |
| Power supply at Pepel | A2 | Global warming due to Greenhouse gases emissions from fuel consumption | Medium | 1 | 5 | 4 | 4 | Major | Moderate | Hard to mitigate |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Vehicles and machinery | A2 | Global warming due to Greenhouse gases emissions from fuel consumption | Medium | 1 | 5 | 4 | 4 | Major | Moderate | Low magnitude but hard to mitigate |

### 7.4.2 Noise

***Construction***

An increase in noise levels may be generated by machinery, engines, vehicles used for transport, loading and unloading of rock, materials and waste and power generation. Preventive and corrective measures for construction phase are described below.

***Operations***

Identified noise sources are ship traffic (motors, sirens, etc.), machinery movement, conveyors, loading and unloading activities at Dual Train Dumping Station, the Stacker Feed System, the Reclaim Feed System and the Shiploader Feed System.

Noise can affect receptors far from the sources, depending on the noise power and frequency. Industrial noise is typically reduced at 500 m to 1 km from the source as a consequence of the noise power attenuation, soil absorption and the elements affecting the noise propagation. Noise generated by offshore vessels might reach greater distances before being attenuated due to the low noise absorption capacity of the sea and the absence of barriers to the noise propagation.

The potentially sensitive areas near the port are the nearest villages, Kalangba and Mapota, and the Sierra Leone estuary fauna.

No specific information was available regarding the acoustical emission (noise power) of the equipment that will produce noise in the port facilities. The proximity to Kalangba, located adjacent to the facilities boundary, and the cumulative effect expected from truck traffic and railway corridor, suggests that noise emissions will require mitigation measures.

***Potential Mitigation Measures***

Generic recommendations for the construction phase include the use of machinery and equipment that guarantee low noise emissions and the regular inspections and maintenance of construction vehicles and equipment. Journeys will be limited to only those necessary and a policy of switching off machinery and equipment when not in use will be implemented. Vehicle speeds will be limited in the vicinity of populated areas.

The preventive and corrective measures to reduce the impact on noise pressure during the operational activities are defined below:

- Select vehicles and equipment that guarantee low noise emissions
- Conduct regular inspections and maintenance of vehicles and equipment
- Mitigations measures, such as sound barriers, should be installed where ambient noise levels may be exceeded. When these barriers are not effective, additional measures should be considered, such as noise isolation at the sensitive receptors.

- Noise impacts at nearest receptors (Kalangba) should be minimised through an appropriate layout plan. Community safety regarding noise as one of the environmental aspects will be addressed through a Community Safety Plan to be developed by AML and rolled out in conjunction with the EWCC.

### Table 7-20 Port Area – Noise Impacts

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Earth movements, grading and construction | N1 | Increase in noise levels due to machinery operations. Noise at near residential areas. Fauna disturbance | Medium | 5 | 4 | 4 | 2 | Minor | Minor | Hard to mitigate |
| Material processing (unloading, loading) | N1 | Increase in noise levels due traffic activity. Noise at near residential areas. Fauna disturbance | Medium | 3 | 2 | 4 | 3 | Moderate | Minor | Hard to mitigate |
| Traffic (rail train and other vehicles) | N1 | Increase in noise levels due traffic activity. Noise at near residential areas. Fauna disturbance | Medium | 3 | 2 | 4 | 3 | Moderate | Minor | Efficiency of noise barriers |

### 7.4.3 Ecology & Biodiversity

***Construction & Operations***

*Vegetation*

The principal impacts will arise from the potential clearance of mangrove during installation or refurbishment of infrastructure. Invasive species may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive). The release of acidity and metals from disturbed acid sulphate soils (if present) can cause the die back of vegetation in the localised area and hydraulically connected areas. Impacts on fauna may further reduce natural colonisation by indigenous plant species where fauna play a role in seed dispersal. The impact classification of these impacts is influenced by the nature of the vegetation present in the area being impacted (defined as high and low conservation importance).

| | | **Impact classification** | | | |
|---|---|---|---|---|---|
| | | **Major** | **Moderate** | **Minor** | **Insignificant** |
| **Conservation importance** | **High** | Land clearance; contamination; spread of alien invasive species; contamination; exposure to acidity / heavy metals | Reduced dispersion of seeds by fauna | - | - |
| | **Low** | - | Land clearance; spread of alien invasive species | Contamination; exposure to acidity / heavy metals | Reduced dispersion of seeds by fauna |

*Terrestrial Fauna*

The most significant potential impact is a change in species diversity and abundance (and potentially a loss of species of conservation concern) through habitat loss and fragmentation directly associated with land clearance and the refurbishment / construction of the port infrastructure. Although the area may not be significant for terrestrial mammals, reptiles and amphibians, the area is an important wintering spot for migratory bird species and therefore unnecessary habitat alteration should be avoided. Displacement of terrestrial fauna may also occur through increased sensory disturbance as a result of the mining activities. The impact classifications for these impacts are:

- **Major:** habitat fragmentation and habitat disturbance.
- **Moderate:** displacement of fauna.

*Aquatic Ecosystems*

During the Phase 1b rapid assessment, no freshwater aquatic environments were identified on Pepel Island (the location of the port infrastructure for Phase 1); therefore no impacts have been identified.

***Potential Mitigation Measures***

The following mitigation measures have been identified for ecology and biodiversity issues that are considered to have a significant impact:

- Mining infrastructure should be planned outside the forest patches and if this is not possible, a botanist should survey the affected forest well in advance of the construction work to allow all possible adjustments to be made.
- Roads should be kept to the minimum width possible, commensurate with relevant design and safety standards.
- Plants belonging to species with conservation status Endangered (EN) or Critically Endangered (CR) should at all times be left undisturbed. Plants belonging to species with conservation status Vulnerable (VU) should be left undisturbed as much as possible.
- Species of conservation concern which were found on the deposits or near proposed infrastructure should be relocated to suitable localities outside the project area, by way of seed collection and / or translocation of specimens.
- Replanting of vegetation for any purpose should use indigenous species and should be based on silvicultural systems that promote natural ecosystem functions and that increase the probability that native species and ecological processes will be maintained. Planting of exotic species in natural forest areas should not be permitted, with the possible exception of erosion control activities utilising species that are proven to be short-lived and non-invasive.
- In the localities with extensive areas of mangrove, such as at the Pepel Port lease areas, construction activities should be planned outside the mangroves as much as possible, and mangrove disturbance kept to a minimum where construction is unavoidable.
- Establish and enforce a total ban on the hunting and capture of wildlife by company employees and contractors.
- Recognizing the importance of wildlife as a protein source to indigenous peoples, government and the company should cooperate with local communities in the development of sustainable, community-based wildlife management programs.
- Project affected communities should be supported in the development of improved animal husbandry techniques and provided with starter stocks. This would be a positive contribution to the livelihoods of people and also reduce demand for bushmeat and limit the impact of hunting restrictions on local communities.
- The project should investigate the potential for supporting local plantations, which would be beneficial to the project, local livelihoods and the remaining natural forests (and therefore, also for fauna).

- Work with government to explore opportunities to control and minimise the uncontrolled in-migration of people into areas newly opened-up by road construction, especially along the roads themselves. Uncontrolled in-migration will lead to further forest and wildlife losses and compound pressures on existing human communities.
- Consider biodiversity offsets to compensate for the unavoidable habitat loss (including vegetation and fauna).

## Table 7-21 Port Area – Ecology & Biodiversity

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land Clearance | E1 | Loss of biodiversity and sensitive habitat | High | 3 | 3 | 4 | 3 | Major | Moderate | Careful planning to avoid damage to valuable vegetation |
| | E2 | Loss of biodiversity and habitat | Low | 4 | 3 | 4 | 4 | Moderate | Minor | Avoidance of clearance through forest remains |
| | E3 | Change in species richness and abundance habitat loss / disturbance / fragmentation | High | 3 | 3 | 4 | 3 | Major | Major | Presently unknown pending further evaluation' |
| Port Infrastructure Rehabilitation | E1 | Localised clearance of vegetation – habitat loss | High | 3 | 3 | 4 | 3 | Major | Minor | Avoid areas of valuable vegetation |
| | E2 | Habitat loss | Low | 4 | 3 | 4 | 4 | Moderate | Minor | Avoidance of clearance through forest patches |
| | E3 | Habitat loss / disturbance | High | 2 | 2 | 3 | 2 | Moderate | Major | Presently unknown pending further evaluation' |
| Waste Generation | E1 | die back of vegetation through exposure to acidity and heavy metals | High | 3 | 2 | 4 | 3 | Major | Major | presently unknown pending further evaluation' |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | E2 | die back of vegetation through exposure to acidity and heavy metals | Low | 4 | 3 | 4 | 4 | Moderate | Moderate | presently unknown pending further evaluation |
| Project induced influx of workers and job seekers | E1 | Increased pressure on timber | High | 3 | 3 | 3 | 3 | Major | Major | Mitigation will require co-operation between AML and local partners – pending further evaluation |
| | | Spread of alien invasive species | | 3 | 3 | 4 | 3 | Major | Major | Presently unknown pending further evaluation |
| | E2 | Increased pressure on timber | Low | 2 | 3 | 2 | 2 | Insignificant | Insignificant | |
| | | Spread of alien invasive species | | 4 | 3 | 4 | 4 | Moderate | Moderate | |
| | E3 | Displacement of fauna | High | 2 | 2 | 3 | 2 | Moderate | Moderate | |

### 7.4.4 Hydrology & Hydrogeology

Assessment of potential impacts on the hydrological and hydrogeological setting at Pepel Island has been conducted based on a Phase 2B – Reconnaissance Level baseline assessment conducted during February, March and April 2010 as well as observations on early works construction activities.

***Construction***

- Construction and pumping of new water wells may lead to salt water intrusion and permanent loss of water quality impacting other site and community wells if locations, depths or pumping rates are not appropriate to the local aquifer morphology. Scott Wilson (March 2010) have carried out a detailed non intrusive site study at Pepel that recommended installation of water wells only in the northern part of the Island where current groundwater utilisation is negligible. They also recommend a maximum installation depth of 25m and a pumping rate of 0.5 l/s in order to minimise saline intrusion. Two well have recently (April 2010) been installed in the Port Area to meet current construction and potable water demand. The wells extend to 32 and 42 mbgl and will be pumping approximately 2 l/s per well. Recently recorded electrical conductivity values which are higher than in any other groundwater wells.
- Modification and interruption to the existing hydrological regime may occur, particularly where new raised roads or railway alter the path of the natural surface water drainage network.
- Contamination of surface and / or groundwater due to loss of containment of fuels and other chemicals associated with mobile and static plant and vehicle maintenance.
- Mobilisation/solution of historical contaminants in soils including arsenic, oils and tars further to disturbance of soils and structures and ground cover on site may impact on groundwater and surface water runoff quality.
- Demolition/renovation of historical plant and structures may lead to loss of containment of historically present sources which include significant volumes of liquid hydrocarbons (fuels/insulating oils/lubricants) in storage tanks, transformers and sumps may impact on groundwater and surface water quality.

***Operations***

- Groundwater abstraction leading to reduced community access to potable water supplies. Groundwater will be abstracted at a rate of between 2.9 and 3.5 $L.sec^{-1}$ across a proposed network of nine groundwater bores. Over exploitation of the aquifer could locally reduce the water table and potentially dry nearby community wells.
- Induced salt water intrusion into freshwater aquifer through unsustainable groundwater pumping. Saline water may be drawn into the aquifer either horizontally from the coast or vertically from depth (if present) causing degradation of the freshwater resource.

- Contaminated runoff from stockpiled ore may cause sedimentation or heavy metal pollution to local groundwater and surface water resources.
- Loss of containment of fuel, solvents, lubricants and chemicals during transport or storage could lead to contamination of surface water and groundwater.

***Potential Mitigation Measures***

The following mitigation measures have been identified for hydrology and hydrogeology issues that are considered to have a significant impact:

- Robust surface and groundwater monitoring programmes to establish baseline and ensure early identification of impacts. Groundwater at Pepel Island is considered to be a highly sensitive receptor both to contamination through construction and operational activities and over exploitation. Failure to rigorously implement appropriate resource and environmental management and protective measures could readily lead to very long term damage to the aquifer beneath Pepel Port. The monitoring will allow mitigation measures to be refined and ensure they are appropriate and effective.
- Waste water treatment and testing to confirm compliance with relevant discharge standards.
- Strict adherence to Environmental Management Plans prepared in line with industry and international best practice.
- Appropriate hydrogeological/hydrological assessment and field testing of water resources and careful design of water abstraction points so as to minimise impacts on other users. This process has been initiated by Scott Wilson (March 2010)
- Detailed study and testing to determine whether recently drilled construction phase water supply wells pose a risk of saline intrusion and long term or permanent damage to the aquifer. In the event that a risk is established, carry out repair works to seal the base of the well/s with cement/bentonite or abandon the risk wells and redrill in line with recommendations of the Scott Wilson report or any subsequent study as per bullet point above.
- Design to ensure potentially contaminating materials are not stored in proximity to surface water courses and adequate bunding for spill control. Prepare spill response plans and materials handling management plans. Avoid storage of materials at locations overlying potentially sensitive/important shallow aquifers and prepare engineered low permeability surfaces with drainage/runoff controls for storage and handling areas.
- Perform leachate tests on ore to be stockpiled at the port to determine risks to groundwater from stockpiles and allow for design of suitable storage area.
- As part of routine baseline ESHIA studies, testing of surface soil scrapes, groundwater from available water supply wells and inspection of readily accessible historical plant and structures was carried out. Determination of mitigation measures to prevent potential impact on groundwater due to disturbance of and leaching from potential existing historically contaminated soils requires completion of more detailed understanding through site

investigation including intrusive investigation techniques to assess subsurface soils in any areas to be cleared or excavated as part of the proposed port development works.

- A detailed audit of potential point sources of contamination should be carried out by a suitable contractor and a site register prepared recording details of all risk areas such as location and condition of structures and plant containing oils and tars for example. All transformer oils should be tested for PCB's. All existing leaks of oils and tars or other potential contaminants to be repaired. All potential contaminating liquids currently within plant/structures with no secondary containment to be drained of and disposed of in a safe manner or provided with secondary containment or alternative storage facilities.
- All current and future development works should be permitted only after reference to the contamination register so that works can either avoid contaminated areas or go ahead after appropriate remedial measures have been implemented.
- Dependent on results of further sampling and testing, if appropriate, ensure that scraped surface soils and excavation arisings are disposed of in a safe, suitable manner or stockpiled in a suitable secure engineered location within the site boundary.
- Ensure stockpiles of any potentially contaminative materials including ore stockpiles are located in engineered low permeability bunded areas with surface drainage guided to catch pits and settling areas to prevent runoff of rainwaters and leachate from dispersing dissolved contaminants.
- Minimise land / soil to be cleared or excavated and concentrate such activities in areas of low soil quality and land-use potential.
- Implement required storm water drainage and controls prior to earthworks and construction activities to prevent release of potentially contaminated waters.

**Table 7-22 Port Area - Hydrology & Hydrogeology**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land Clearance | SW1 | Higher sediment loads in surface runoff entering watercourses and mangrove swamps (construction) | High | 3 | 2 | 3 | 3 | Major | Insignificant | Appropriate design and international best practice |
| Earthworks | SW1 | Higher sediment loads in surface runoff entering watercourses and mangrove swamps (construction) | High | 3 | 2 | 3 | 3 | Major | Insignificant | Appropriate design and international best practice |
| | SW2 | Modification and interruption to the existing hydrological regime (construction) | High | 1 | 1 | 4 | 1 | Minor | Insignificant | Appropriate design and international best practice |
| | SW1 | Contamination of surface water resources (construction and operation) | High | 3 | 3 | 2 | 4 | Major | Insignificant | Appropriate design and international best practice |
| | GW1 | Contamination of groundwater resources (construction and operation) | High | 2 | 2 | 4 | 4 | Major | Insignificant | Appropriate design and international best practice |
| Waste generation | SW1 | Contamination of surface water resources from uncontrolled release of sewage and other waste waters (construction and operation) | High | 2 | 2 | 2 | 4 | Major | Insignificant | Adherence to international best practice |
| | GW1 | Contamination of groundwater resources from uncontrolled release of sewage and other waste waters (construction) | High | 2 | 2 | 4 | 4 | Major | Insignificant | Adherence to international best practice |
| | SW1 | Contamination of surface waters from uncontrolled release of drilling fluids (construction) | High | 2 | 2 | 1 | 2 | Moderate | Insignificant | Adherence to international best practice |
| Resource utilisation | GW2 | Reduced groundwater resources in port area where water will be derived from | High | 2 | 2 | 4 | 4 | Major | Moderate | Detailed studies, |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | groundwater (construction and operation). | | | | | | | | appropriate design and location of abstractions and water resources management plan |
| | GW1 | Degradation of fresh groundwater resource due to saline intrusion (operations) | High | 2 | 2 | 5 | 4 | Major | Moderate | Detailed studies, appropriate design and location of abstractions and water resources management plan |
| Chemical and fuels storage and utilisation | SW1 | Uncontrolled release of fuels and toxic chemicals including residual historical sources (construction and operational) | High | 3 | 3 | 2 | 4 | Major | Moderate | Engineering design and adherence to international best practice |
| | GW1 | Uncontrolled release of fuels and toxic chemicals including residual historical sources (construction and operational) | High | 2 | 2 | 4 | 4 | Major | Moderate | Engineering design and adherence to international best practice |
| Vehicle/plant movements | SW1 | Turbidity and other water quality impacts due to dusting and erosion from plant movements on site | High | 3 | 3 | 4 | 3 | Major | Insignificant | Engineering design and adherence to international best practice |
| | SW1 | Turbidity and water quality impacts from dust and spillage of ore from open rail wagons and conveyors | High | 3 | 3 | 4 | 3 | Major | Insignificant | Engineering design and adherence to international |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | best practice |

### 7.4.5 Soils & Land Use

***Construction***

Baseline soil data for the historical industrial Pepel Port area has been collected for a few indicative surface samples only and indicates a probably relatively low level historical impact on quality, principally with some elevated levels of arsenic and some localised leakage or spillage of fuels and oils as well as coal tar related contamination. On the whole, the reinstatement of the Port is not considered likely to have a significant impact on the soils at or outside the port if works are designed and managed with due consideration given to current conditions.

Stripping of surface soils and other earthworks associated with preparation of new stockpile areas and foundations for new port infrastructure could potentially mobilise or expose historically present contaminants such as arsenic, asbestos and coal tar constituents. Full details of the proposed layout of the port are not yet available but there will be a requirement for some foundation construction activities. Working and disposal of excavated soils could potentially spread contamination to uncontaminated soils including areas of the port and surrounds where farming and grazing is still carried out.

Several sources of potential contamination remain on site since it was last operated as a port. These sources include significant volumes of liquid hydrocarbons (fuels/insulating oils/lubricants) in storage tanks, transformers and sumps. Coal tars are also present where they were used as sealants to reduce infiltration of spillage/leakage of fuels along pipe runs and around the fuel farm tanks area. Demolition and salvage and recycling works associated with development could lead to spillage and spread of contaminants which could significantly reduce soil quality in the vicinity.

Asbestos containing materials (ACM) have been identified on the site. Construction board and cement bound asbestos board and cement bound asbestos piping were used in buildings and underground infrastructure (wastewater piping). Some of the piping has also been used as bollards – placed in the ground as posts and filled with cement as observed on the boat jetty. Demolition and salvage and recycling works associated with development could lead to disturbance / break up of ACM and spread of asbestos fibres which could significantly reduce soil quality in the vicinity.

***Operations***

Operation of Pepel Port will include a number of activities with potential to impact on soils and land use at and near the Port. Transport, storage and handling of fuel, solvents, lubricants and chemicals as well as the ore itself could all impact on local soil quality including at residential areas adjacent to the port and cultivation and mangrove areas at and near the port.

***Potential Mitigation Measures***

The following mitigation measures have been identified for soils and land use issues that are considered to have a significant impact:

- Only sampling of surface soils, groundwater in available water supply wells and inspection of readily accessible historical plant and structures was carried out during ESHIA field studies. Mitigation measures to prevent potential impact on soils due to disturbance of potential existing historically contaminated soils requires completion of more detailed understanding through site investigation including intrusive investigation techniques to assess subsurface soils in areas to be cleared or excavated as part of the proposed port development works.
- A detailed audit of potential point sources of contamination should be carried out by a suitable contractor and a site register prepared recording details of all risk areas such as location and condition of structures and plant containing oils and tars for example. All transformer oils should be tested for PCB's.
- An asbestos survey should be carried out by a qualified contractor and professional guidance followed with regard to removal and safe disposal to ensure no spread of fibres. Asbestos survey should screen for free fibres in and near all areas where ACM has already been removed or is known or likely to have been located.
- Identify areas of ACM disposal from recent development/renovation works on site on the contamination register. Include these areas in the asbestos survey and seek surveyor recommendations for future management of disposed materials.
- Materials that pose a risk to soils and land use in their current condition (oil and tar leaks known to be present) should be removed and disposed of in a safe manner or secured and isolated.
- All current and future development works should be permitted only after reference to the contamination register so that works can either avoid contaminated areas or go ahead after appropriate remedial measures have been implemented.
- Dependent on results of further sampling and testing, if appropriate, ensure that scraped surface soils and excavation arisings are disposed of in a safe, suitable manner or stockpiled in a suitable secure engineered location within the site boundary.
- Ensure stockpiles of any potentially contaminative materials including ore stockpiles are located in engineered bunded areas with surface drainage guided to catch pits and settling areas to prevent runoff of rainwaters from dispersing soils/sediment loading.
- Minimise land / soil to be cleared or excavated and concentrate such activities in areas of low soil quality and land-use potential.
- Consider biodiversity offsets for unavoidable long-term and permanent soil / land clearance and soil / land burial. Integrate livelihoods components as necessary with offsets to replace lost land-use capability.
- Implement appropriate conservation and preservation of any good quality stripped top-soils and sub-soils from all areas to retain physical and chemical characteristics and seed-bank for subsequent use for rehabilitation activities.

- Implement required storm water drainage and controls prior to earthworks and construction activities to prevent erosion of soils or spread of potentially contaminated soils.
- Restrict access by vehicles and construction plant to essential areas to minimise erosion and compaction of soils.
- Isolate and manage potential soil contaminants (including wind blown dusts and water-borne contaminants).
- Avoid deliberate introduction of alien invasive species during rehabilitation activities.
- Manage pathways by which alien invasive species can enter a disturbed area (including avoidance of non-indigenous plant species in rehabilitation activities).

## Table 7-23 Port Area - Soils & Land Use

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance | S2 | Exposure of soils and stripping of vegetation in the port area may lead to increased soil erosion | Medium | 1 | 1 | 1 | 2 | Minor | Insignificant | Appropriate site management and international best practice |
| Demolition and Earthworks | S1 | Demolition / removal of structures and equipment and earthworks may mobilise (leaching/dusting) historically contaminated surrounding soils and impact on clean areas. | Medium | 2 | 2 | 3 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| | S1 | Demolition / removal / renovation of buildings with ACM may lead to release of asbestos fibres and contamination of soils. | Medium | 1 | 1 | 4 | 3 | Moderate | Insignificant | Asbestos survey and qualified contractor to remove ACM |
| | S1 | Earthworks may expose / damage buried pipes composed of ACM leading to release of asbestos fibres contaminating soils. | Medium | 1 | 1 | 4 | 3 | Moderate | Insignificant | Asbestos survey and qualified contractor to remove ACM |
| Ore transport and storage | S1 | spillage of ore, accumulated dust blown from rail wagons and stockpile. | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Appropriate site management and international best practice |
| | S1 | Surface water runoff from stockpiles and stockpile areas may lead to contamination of surrounding soils. | Medium | 2 | 2 | 4 | 3 | Moderate | Insignificant | Engineering design and adherence to international best practice |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Chemical / fuels storage and utilisation | S1 | Demolition / removal of historical structures containing fuels and oils could result in loss of containment/spillage and contamination of soils. | Medium | 1 | 1 | 4 | 3 | Moderate | Insignificant | Contamination survey and register, appropriate site management |
| | S1 | Uncontrolled release of fuels and toxic chemicals (construction and operational) | Medium | 1 | 1 | 4 | 3 | Moderate | Insignificant | Engineering design and adherence to international best practice |

### 7.4.6 Geology & Geomorphology

***Construction***

The impact on geology and geomorphology within the Pepel Port area is expected to be minor as the site has operated as a dedicated port facility servicing to a mine site in the past. Impacts on the geology and geomorphology would already have occurred. All details of the Port design are not yet known and there is potential for construction of new port facilities to impact on coastal geomorphology but given the significant historical development and operation of the port, additional facilities are not considered likely to greatly increase these impacts.

***Operations***

As with the construction phase, no operational activities are anticipated to impact significantly on geology or geomorphology.

***Potential Mitigation Measures***

- No significant impacts are considered likely based on current information with regard to construction and operation of Pepel Port and therefore no mitigation measures are proposed at this stage.

## Table 7-24 Port Area - Geology & Geomorphology

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Earthworks | V1 | Construction of new structures may impact on local Pepel Island geomorphology. | Low | 2 | 2 | 4 | 3 | Minor | Insignificant | Long term rehabilitation and international best practice |
| Stockpiling of iron ore | V1 | Iron ore stockpiles will change the landform and impact on the visible landscape. | Low | 2 | 2 | 3 | 3 | Minor | Insignificant | Long term rehabilitation and international best practice |

### 7.4.7 Socio-Economic

***Construction***

*Land acquisition*

The refurbishment of the Pepel Port may require additional land in its vicinity for construction and operational activities and facilities. The land near the port is currently used for dwellings, trading, agriculture and grazing. Potential impacts include impacts on the land base as well as sea based activities such as fishing.

The following mitigation measures are expected to reduce the intensity of the residual impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Preparation and implementation of the CDAP.

*Project induced influx of workers and job seekers*

The economic opportunities created at the Pepel Port are expected to lead to an influx of workers and job seekers mainly during the construction phase. This is likely to lead to:

- Pressure on social infrastructure and natural resources.
- Increases in social ills such as crime, alcoholism, drug abuse and prostitution.
- Increases in communicable diseases.
- Increases in the cost of living.

The following measures are expected to reduce the impacts from major to moderate/minor.

- Planning jointly with local government, Paramount Chief and other stakeholders to minimise speculative migration.
- Providing assistance to local government to increase (and improve) infrastructure services.
- Support for strengthening of programmes for control of communicable diseases and educational campaigns for prevention of social ills.

***Operations***

The refurbishment of the Pepel Port is expected to have predominantly beneficial socio-economic impacts during its construction and operation phase (up to 8 years).

*Economic aspects*

- The employment generation within Port Loko District and at national level.
- The investment for refurbishment of the port.
- Skill building of people employed at the port.
- Revenue earnings for the government.

No mitigation measures are required for these positive impacts.

*Community investment*

In line with its corporate policy, AML is expected to initiate a social investment programme in the Pepel Port area with the start of construction work. This is expected to mitigate to some extent the negative impacts on the affected communities. Potential benefits to the community are expected to include:

- Increases in education and skills levels.
- Improvement in social infrastructure such as water supply, schools and health centres.
- Development of livelihood opportunities, independent of the port.
- Other initiatives to address community needs.

*Closure of the port activities*

Once the Tagrin Port is constructed, operations at Pepel Port will be transferred to the new port. It is expected that the workers and contractors at Pepel Port may either be transferred and engaged at Tagrin Port or continue working at Pepel if it continues to operate as a facility under lease to another operator and therefore the negative socio-economic impacts associated with closure are expected to be avoidable.

## Table 7-25 Port Area – Socio-Economic

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Economic aspects (employment, procurement of services and supplies, and payment of taxes and revenue to government) | H1 | employment creation (construction) | High | 3 | 4 | 2 | 3 | Major | Moderate (+) | Priority given to locals during recruitment process although skills availability is expected to be limited |
| | | employment creation (operation) | High | 2 | 3 | 3 | 2.7 | Major | Major (+) | Priority given to locals during recruitment process |
| | | Training of workers | High | 2 | 3 | 3 | 2.7 | Major | Major (+) | Considerable skills enhancement injected into the area |
| | | Increase in business for suppliers (construction) | High | 3 | 4 | 2 | 3 | Major | Moderate (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in business for suppliers (operation) | High | 2 | 4 | 3 | 3 | Major | Major (+) | Priority given to locals during tender process although availability is expected to be limited |
| | | Increase in government income | High | 3 | 4 | 3 | 3.3 | Major | Major (+) | Revenue from project taxes, royalties, etc expected to be major contributor to GoSL GDP |
| Land acquisition | H1 | Loss of land | High | 2 | 1 | 4 | 2.3 | Moderate | Low | Provision of alternative land |
| | | Loss of shelter | High | 1 | 1 | 4 | 2 | Moderate | Moderate (+) | Provision of replacement housing of superior quality in most circumstances |
| | | Loss of income | High | 2 | 2 | 4 | 2.7 | Major | Minor | Implement livelihood restoration plan |
| | | Loss of access route | High | 2 | 2 | 4 | 2.7 | Major | Moderate | Identify and provide alternative routes or |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | crossing methods |
| | | Reduced food security | High | 2 | 2 | 4 | 2.7 | Major | Minor | Provision of alternative land and transitional support mechanisms |
| | | Breakdown social support | High | 1 | 2 | 4 | 2.3 | Moderate | Minor | Relocate all villagers to the same host site village. |
| | | Increase in stress | High | 2 | 2 | 3 | 2.3 | Moderate | Minor | Regular consultation and publicising grievance mechanism with PAPs |
| | | Reduced access to services | High | 2 | 2 | 3 | 2.3 | Moderate | Moderate (+) | Provision of replacement social infrastructure likely to provide increased access to service |
| | | Community conflict | High | 2 | 2 | 2 | 2 | Moderate | Minor | Effective and broad stakeholder engagement |
| Project induced influx of workers and job seekers | H1 | Pressure on social infrastructure due to increase in population | High | 3 | 2 | 3 | 2.7 | Major | Moderate (+) | Provision of replacement social infrastructure |
| | | Pressure on natural resources due to increase in population | High | 2 | 3 | 3 | 2.7 | Major | Moderate | Effective and broad stakeholder engagement |
| | | Increase in social ills (crime, alcoholism and prostitution) | High | 3 | 3 | 3 | 3 | Major | Moderate | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in communicable diseases | High | 3 | 3 | 3 | 3 | Major | Moderate | Effective and broad stakeholder engagement together with support from appropriately positioned NGOs |
| | | Increase in cost of living | High | 3 | 3 | 3 | 3 | Major | Moderate | Influx management. |
| | | Tensions between locals and outsiders due to real or perceived unequal access to project benefits | High | | 2 | 3 | 1.7 | Moderate | Minor | Influx management and regular consultation |
| Project induced Community | H1 | Social infrastructure | High | 3 | 2 | 3 | 2.7 | Major | Moderate (+) | Provision of replacement social infrastructure |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| investment | | Education and skills | High | 3 | 3 | 3 | 9 | Major | Major(+) | Training programs |
| | | Livelihoods | High | 3 | 2 | 3 | 2.7 | Major | Major(+) | Increased income from direct and indirect employment |
| Mine closure | H1 | Loss of income for workers, | High | It is planned to use Pepel Port for the export of hematite for a limited period, until a new port is built at Tagrin. Once the Tagrin port is ready the operations at Pepel Port will be transferred to the new port. Pepel Port may continue to be used for the import of materials required for the mining operation for the duration of the mine's life or other non-project related activity in accordance with the terms of the Pepel Port and infrastructure lease agreement. Consequently, as for the transport component, it is expected that workers and contractors at Pepel Port will largely be transferred and engaged at Tagrin Port or remain at Pepel port to avoid the negative socio-economic impacts associated with closure. | | | - | - | - | - |
| | | Loss of businesses | High | | | | - | - | - | - |
| | | Loss of revenue to government | High | | | | - | - | - | - |
| | | Psychological impacts | High | | | | - | - | - | - |

### 7.4.8 Human Health

***Construction & Operations***

Based on the current available project and existing health information, preliminary impacts for the construction and operation of Phase 1 have been identified for the Pepel Port facilities. It is important to note, that the Project description has not been finalized, nor has all the baseline data been analysed, therefore, the qualitative impact designations and significance may change as the Phase 1 details are finalised. In addition, the implications of incineration of waste at the Pepel Port site have not been assessed at this point in time. Assessment of this issue will be undertaken for the Stage 2 ESHIA.

The preliminary health impacts associated with the Pepel port facilities are described below. Impacts relate to both the construction and operation of the port unless otherwise stated.

Potential impacts of major significance:

- Community resettlement (during construction);
- In-migration related impacts (disease, food security, substance abuse, home violence) (during operation phase);
- Increased burden of disease due project activities and water storage facilities (drinking water tanks, waste and raw water storage ponds);
- Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns); and
- Degradation of groundwater quality.

Potential impacts of moderate significance:

- In-migration related impacts (disease, food security, substance abuse, home violence) (during construction phase);
- Increased burden of disease due project activities and water storage facilities (drinking water tanks, waste and raw water storage ponds)(for construction phase);
- Impacts of noise on health and well-being (port and heavy vehicle activity); and
- Reduction in quality or quantity of locally produced foods.

Potential impacts of minor or insignificant significance:

- Increased road traffic accident rate;
- Exposure to increased levels of road dust and particulate matter (PM) (diesel power generators, crushers, blasting, vehicles, road dust)(assuming no thermal power generation requirements);

- Acute exposure to elevated $SO_2$ and $NO_2$ in air (diesel power generators, heavy vehicle emissions)(assuming no thermal power generation station); and
- Exposure to hazardous materials removed from the exiting port facilities to the local villages (e.g., materials containing asbestos).

Potential positive impacts:

- Access to improved healthcare facilities (for general public); and
- Health benefits through local employment.

A number of assumptions were made for the preliminary impact assessment specific to the Phase 1 port area. It was assumed that all communities on or within 500 m of the Project area were to be resettled to a distance greater than 500 m before the construction phase begins. Thus, the Health VR used in the preliminary impact assessment for exposure to PM, $SO_2$, and $NO_2$ was categorized as Medium (Human HR2 see Table 7-1 in Section 7).

With respect to PM, $SO_2$, and $NO_2$ emissions, it was assumed that a thermal power generating facility (a potentially significant generator of these types of emissions) will not be built at the Pepel port. As the precise method of power generation has not yet been determined, this preliminary impact will require re-assessment once the Phase 1 project details have been finalized. Should a thermal power generator be implemented, the significance of the impact and the sensitivity of the VR would be expected to increase.

The positive class impacts associated with access to medical facilities only apply if AML undertake to provide these facilities.

Where there was uncertainty in significance designation, the more conservative assumption was selected so as to ensure that the preliminary potential impact of the Project was not underestimated.

***Potential Mitigation Measures***

Potential mitigation measures have been identified in association with each headline health impact as listed below. The headline impacts were identified with the assumption that no mitigation measures were applied. Thus, implementation of the recommended mitigation measures is expected to reduce the significance of the headline health issues and thus avoid potentially major health issues for persons living in the vicinity of the Projects.

Health related mitigation measures are listed below, however, it is important to note that mitigation recommended by the other disciplines, particularly socio-economic as well as other environmental assessments (e.g., air, surface and groundwater, flora and fauna) can also affect human health.

Alteration of project descriptions and monitoring results may result in the recommendation of additional mitigation measures, or modification of those currently recommended.

*Community resettlement*

- Social mitigation measures regarding loss of land and re-settlement (see social assessment results and mitigation measures).

*In-migration related impacts (disease, food security, substance abuse, home violence)*

- Adherence to the requirements of the Prevention and Control of HIV and AIDS Act.
- Appropriate education of workforce regarding transmittable diseases.
- Employing local labour where appropriate.
- Providing suitable healthcare facilities.
- See social assessment results and mitigation measures.

*Increased burden of disease due to project activities, and water storage facilities (drinking water tanks, waste and raw water ponds).*

- Awareness and control of mosquito breeding sites to prevent increased malaria incidence (See Appendix 17 – Environmental Note of Malaria Control).
- Appropriate treatment of drinking water.
- Providing suitable healthcare facilities.
- Appropriate management of waste water ponds, including odour controls.

*Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns, dam construction)*

- Management and remediation of any contamination associated with storage of fuels, waste water and other hazardous materials.
- Management of surface and storm water run-off.

*Degradation of groundwater quality*

- Monitoring of water quality in groundwater wells used for drinking water.

**Table 7-26 Port Area – Health**

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| Construction | H2 | Increased road traffic | Medium[1] | 1 | 1 | 1 | 1.0 | Insignificant | | |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (potential emissions from diesel power generators and vehicles) | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (from power generator and vehicles). | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Health benefits through local employment[3] | | | | | | | | |
| | H1 | Community resettlement[2] | High | 4 | 3 | 4 | 3.7 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data (requires interpretation of social assessment with respect to Human health impacts) |
| | | In-migration related impacts (disease, food security, substance abuse, home violence) | High | 3 | 2 | 1 | 2.0 | Moderate | Minor | • Compliance with recommended mitigation measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | (requires interpretation of social assessment with respect to Human health impacts) |
| | | Increased burden of disease due to project activities (drinking water tanks, waste and raw water ponds) | High | 4 | 2 | 3 | 3.0 | Major | Moderate/ Minor | • Implementation of recommended malarial control measures and odour control measures for standing water. • Compliant will applicable legislation and guidelines for water storage and treatment of drinking and waste waters. • Provision of publicly accessible health care facilities. • Level of public concern unknown. • Moderate confidence in data. |
| | | Impact of noise on health and well being | High | 3 | 2 | 1 | 2.0 | Moderate | Minor | • Compliant with applicable legislation and guidelines. • Implement quieter operations time (e.g., at night, during important public/religious holidays). • Level of public concern unknown. Moderate confidence in data. |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage) | High | 4 | 2 | 3 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures. • Level of public concern unknown. • Low confidence in data. |
| | | Degradation of groundwater quality/quantity | High | 2 | 3 | 4 | 3.0 | Major | Moderate | • Compliance with recommended mitigation |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 3 | 1 | 3 | 2.3 | Moderate | Moderate/ Minor | • Compliance with recommended mitigation measures including those associated with resettlement.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |
| | | Increase road and rail access to the region[3] | High | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| Operation | H2 | Increased road traffic | Medium[1] | 1 | 1 | 1 | 1.0 | Insignificant | | |
| | | Exposure (inhalation) to increased levels of dust and particulate matter (PM) (potential emissions from diesel power generators and vehicles) | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Exposure (inhalation) to elevated sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$) in air emissions (from power generators and vehicles). | Medium[1] | 2 | 1 | 1 | 1.3 | Insignificant | | |
| | | Health benefits through local employment[3] | | | | | | | | |
| | H1 | In-migration related impacts (disease, food security, | High | 3 | 2 | 4 | 3.0 | Major | Minor | • Compliance with recommended mitigation |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | substance abuse, home violence) | | | | | | | | measures.<br>• Resettlement is permanent.<br>• Level of public concern unknown.<br>• Moderate confidence in data (still needs interpretation of social assessment with respect to Human health impacts) |
| | | Increased burden of disease due to project activities (drinking water tanks, waste and raw water ponds) | High | 4 | 2 | 3 | 3.0 | Major | Moderate/ Minor | • Implementation of recommended malarial control measures and odour control measures for standing water.<br>• Compliant will applicable legislation and guidelines for water storage and treatment of drinking and waste waters.<br>• Provision of publicly accessible health care facilities.<br>• Level of public concern unknown.<br>• Moderate confidence in data. |
| | | Impact of noise on health and well being | High | 3 | 2 | 2 | 2.3 | Moderate | Minor | • Compliant with applicable legislation and guidelines.<br>• Implement quieter operations time (e.g., at night, during important public/religious holidays).<br>• Level of public concern unknown. Moderate confidence in data. |
| | | Degradation and/or reduction of surface water (sedimentation/erosion, | High | 4 | 2 | 3 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures. |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation[4] | Reason for Change[4] |
|---|---|---|---|---|---|---|---|---|---|---|
| | | contamination, changes in drainage) | | | | | | | | • Level of public concern unknown.<br>• Low confidence in data. |
| | | Degradation of groundwater quality/quantity | High | 2 | 3 | 4 | 3.0 | Major | Moderate | • Compliance with recommended mitigation measures.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Reduction in quantity or quality of locally produced foods through land appropriation and clearance, potential siltation of rivers/streams) | High | 3 | 1 | 3 | 2.3 | Moderate | Moderate/ Minor | • Compliance with recommended mitigation measures including those associated with resettlement.<br>• Level of public concern unknown.<br>• Low confidence in data. |
| | | Access to improved healthcare facilities[3] | High | | | | | | | |
| | | Increase road and rail access to the region[3]. | High | | | | | | | |

[1] Assuming all communities are >500m away.
[2] Could be a positive impact if well compensated and/or moved to a better location.
[3] Positive impacts.
[4] Estimated for Impacts with Moderate or Major Significant only.

## 7.5 Offshore & Coastal

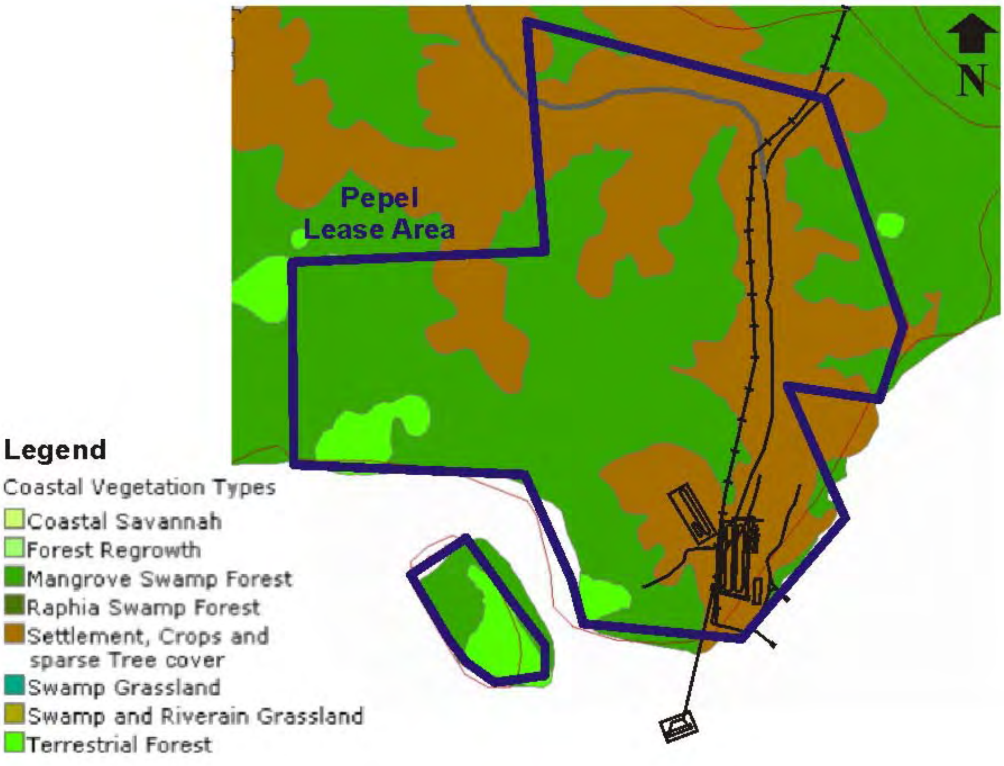
### 7.5.1 Port Layout

***Land Clearance and Earthworks***

The port will sit within the existing footprint and no land clearance is planned.

The proposed port infrastructure is located on a wetland within the Sierra Leone Estuary Ramsar site. The Ramsar site covers the majority of the estuary, and Pepel sits within one of the core areas. Coastal habitat includes mangrove and mudflats which provide important nesting and feeding grounds for marine fauna and avifauna, and serve as a nursery for marine fish and shellfish. Mangroves stabilise soils and marine sediment, and clearance can lead to increases in erosion and run-off. Any disturbance to these habitats may therefore have significant consequences on marine and coastal fauna and flora, as well as on the local communities that depend on them for food and resources. Figure **7-1** is a habitat map of the Pepel Island area; the proposed port layout is overlaid to give an initial indication of the potential impacts of any clearance of habitat.

**Figure 7-1 Pepel habitat map overlaid with the early port layout**



The baseline preliminary survey indicates that the coastal and marine habitat around Pepel is healthy and contains a high level of biodiversity. Land clearance and significant earthworks are not required but there are a number of potential impacts to the coastal habitat and mangrove in particular including altered hydrology and spill over of development effects to surrounding habitat.

The majority of the port infrastructure is already in place, and most of what is required is expected to be refurbished rather than constructed. As a result there should be no significant increase in the existing port footprint and no area of coastal habitat will have to be cleared. However, changes to hydrology and its affect on coastal habitat requires further investigation and the layout of the port must be finalised before the impact rating can be reduced to the minor that is expected..

The potential impact on the VR coastal habitat of clearance of the port footprint could be major if the existing port footprint is not maintained.

Mitigation measures:

- Ensure that the port remains within the existing footprint to avoid mangrove clearance and disruption; and
- Mangrove protection and management should be considered as compensatory measures within the next phase of the Tonkolili project.

***Pressure on the Use of Resources due to Population Increase***

The construction camp could increase pressure on local resources if all workers are not fully catered for, potentially affecting marine coastal habitat and fauna, including mangroves (used as a primary source for fuel) and fisheries. Currently the mangroves located in and around the island are in a healthy and diverse state, therefore the potential impact on mangroves is considered to be significant. The local fish populations are already subject to a high degree of exploitation from the local villages, so any increase in fishing activity is also viewed as significant.

Before mitigation the potential impact on VR coastal habitat is considered to be of major significance.

Before mitigation the potential impact on VR human development potential i.e. fisheries is considered to be of moderate significance.

Mitigation measures:

- Construction Management Plans must ensure that construction workers have access to appropriate facilities to avoid the need to use local resources, in particular relating to mangrove.

***Clearance of Existing Port including Stockpiles***

The current Port development plans do not require removal of old stockpiles that remain on site. Given that the two stockpiles located at the south west area of the former facility have been in place for a matter of decades, it is assumed that any significant dusting, washout of fines and leaching has already occurred and they do not pose a significant risk while they remain undisturbed. In the event that at some future point the existing ore stockpiles are to be removed this operation has the potential to lose material through dust dispersion and rainwater run-off, leading to direct impacts in estuarine water quality, and secondary impacts to coastal and subtidal habitats and fauna. Considering the large volume of old ore currently present at Pepel, these could potentially be significant, depending on the clearance and transport procedures put in place.

Whilst it has been shown that slight positive impacts associated with increased rates of growth (particularly in younger mangrove plants) have been associated with iron contamination, toxicity limits are not known and the potential for synergistic negative responses remain.

Alongi (2010) found that growth of five mangrove species from seedling to sapling stage were enhanced by increasing iron supply, although some species showed iron toxicity at higher supply rates. Paling *et al*., (2001) note that iron ore dust does not enter or damage the stomatal cells in leaves of the white mangrove (*Avicennia marina*). The authors concluded that if iron ore dust affects mangroves, “it must do so by some other mechanism, such as either increased temperature, shading or a restriction of transportation by the thickness of the dust on the abaxial surface”.

Over the past 24 years rain and wind activity has subjected the old stockpiles to leaching, and there is a chance that the percentage of leachable material remaining is now very low. Results of leachate tests on a single sample comprising principally ore filings from the stockpile support this assumption. This would substantially diminish the potential impact, and further assessment on the nature of the residual material is required before a full conclusion can be made. There is currently no evidence of any existing impact on the surrounding mangroves due to the presence of the residual hematite ore, although there are elevated levels of heavy metals in the nearshore soil samples (Hydrological baseline survey, April 2010).

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat is considered to be of moderate significance.

Mitigation measures:

- Undertake physical and chemical analysis of the residual iron ore prior to removal;
- Ensure appropriate collection and treatment of run-off during construction; and
- Implement an appropriate Waste Management Plan to guarantee minimal loss of material to the coastal and marine environment during removal.

### 7.5.2 Port Facilities

In general, port construction or refurbishment activities tend to disturb coastal and marine flora and fauna due to the generation of noise and dust, the continuous use of electric lighting, and changes in water quality from runoff and discharges of contaminants.

***Increased Noise***

The use of heavy machinery during construction tends to temporarily increase ambient noise levels, which can potentially result in disturbance of sensitive coastal fauna such as birds. The Ramsar site covers the majority of the estuary, and Pepel sits within one of the core areas. The current level of noise in Pepel is relatively low, due to the low human population and lack of any significant port activity. As a result, higher noise levels may result in significant impacts on birds. Further information is provided on the impacts to avifauna and terrestrial fauna in the terrestrial noise assessment.

Before mitigation the potential impact on VR avifauna is considered to be major

Mitigation measures:

- Adapt construction activities to avoid areas of high avifauna population, important nesting and feeding sites, and migratory and nesting seasons; and
- Avoid the most sensitive times of the day e.g. extended night operations.

***Increased Light Levels***

Persistent man-made light can be a major issue for a range of marine fauna, with birds in particular sensitive to increased and extended levels. Non-natural light can deter them from feeding, breeding and nesting, and can generally confuse their natural behaviour (Longcore and Rich, 2004, Lorne & Salmon, 2007, Witherington, 1992).

Due to the high density of wetland birds present in the project location, and its position inside a designated Ramsar site, increased light is a potentially significant impact, especially if construction work would take place during bird migratory or breeding seasons. The low levels of current man-made light at Pepel also contribute to this impact.

Before mitigation the potential impact on VR avifauna is considered to be major

Mitigation measures:

- Avoid strong lighting on any sensitive habitat areas, use shading methods wherever possible; and
- Evaluate the use of low-pressure sodium vapour lamps, as this wavelength does not disorient fauna as much as regular full spectrum lighting.

***Wastewater Discharge***

If appropriate collection and treatment systems are not in place, the presence of construction camps pose a threat to estuarine water quality due to wastewater discharge. Discharge of untreated wastewater into the estuary has the potential to affect water pH, colour, temperature, smell, dissolved oxygen, nutrient levels and bacterial contamination. This can create indirect impacts on the estuary ecosystem, as well as posing a health risk to local communities; especially if the discharge point is located near to beaches used by locals for fishing or bathing.

The significance of the impact of waste water discharge is highly dependant on the treatment system implemented in the project design, and the location of the discharge point in the estuary.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Design an appropriate wastewater collection and treatment system utilising the best available techniques;
- Install a temporary treatment plant to treat construction camp discharges;
- The treated water discharge point should be located away from sensitive locations such as mudflats, mangroves and areas of community use; in an area with strong tidal currents to increase dilution and removal; and
- In the absence of national legislation, the treatment system should meet World Bank discharge limits, to ensure the receiving water quality is within appropriate international standards.

A more detailed assessment of wastewater discharges is required to develop the mitigation methods further.

***Spills and Run-off of Oil and Chemical contaminants***

During construction and refurbishment there is a risk of increased run-off due to earthworks, and the use of heavy machinery, including the disturbance of contamination from the previous port operations. There is also a risk of oil and chemical contamination from fuel, lubricants and coatings used in construction machinery, and from potential oil spills.

The significance of this impact will depend upon the level of increased run off and/or spills, and their location and proximity to coastal habitat such as mangroves or mudflats; mangroves are particularly sensitive to oil spills.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Design an appropriate run-off collection and treatment system using the best available techniques prior to discharge. Coatings (e.g. anti-fouling) should be selected to minimize contamination risk;
- Develop and implement an appropriate Waste Management Plan that would define the best ways of dealing with waste oils, following the industry best practices;

- Management plans should ensure that the risk of accidental spillage is minimised, and contingency planning and emergency response measures should be in place. Follow industry best practices regarding refuelling activities, oil handling activities and machinery maintenance; and
- In the absence of national legislation, treatment systems to be implemented should be designed to meet World Bank discharge limits, to ensure the receiving water quality is within appropriate international standards.

The ESHIA process to date has already been influential in modifying the Pepel Port design so that earthworks at Pepel are designed to slope away from water and include a settling sump to collect sediment in run-off. This is subject to ongoing assessment and drainage design to manage run-off during construction stage. As such further modifications and improvement will be controlled through a management process in order to implement mitigation methods.

### 7.5.3 Marine Structures

In addition to the terrestrial port infrastructure, the refurbishment of marine structures has the potential to cause a range of additional effects on the marine environment. These include disturbance of coastal and subtidal habitat, changes in water quality and associated underwater noise.

***Refurbishment of Mooring Dolphins***

The refurbishment and potential construction of mooring dolphins, to enable the mooring of transshipment vessels will primarily impact on the sub-tidal habitat. The sub-tidal habitat directly beneath could be impacted through smothering, pile driving, and placement of rock material. At the time of writing, detailed information on the precise nature of sub-tidal habitat at the proposed locations of the dolphins had not been collected but is believed to be soft sediment, with no sensitive habitat. As the structures are relatively small, disturbance will be localised and restricted. No other major structures will be added to the existing loading jetties during port operations.

The impact on VR sub-tidal habitat without mitigation is considered to be minor.

No mitigation measures are required other than further characterisation of the subtidal habitat.

***Increased Turbidity***

The construction and refurbishment of marine structures could result in elevated turbidity within the immediate vicinity of the port. Activities such as piling can significantly disturb bottom sediments, introducing material into the water column. Increased turbidity can result in a number of direct and indirect impacts on coastal and marine ecosystems; for example, levels of photosynthesis can fall due to a drop in light penetration down through the water column. This can impact on marine flora, and on up through the marine fauna food chain, limiting the ability of organisms to grow, reproduce and survive.

The degree to which turbidity and smothering affects benthic species is dependent on pre-existing ambient water quality conditions and the tolerances of local species (ABP Research, 1999; Ellison, 1999). Coastal habitats such as mangroves can also be affected by high levels of turbidity, but specific tolerances vary with species (Ellison, 1999).

During the wet season, the Sierra Leone River Estuary is characterized by high rainfall, and associated run-off and riverine input. The estuarine water flowing through the project area experiences high levels of turbidity all year round and particularly during the wet season and on the ebb tide. This has been confirmed by a specific monitoring campaign. Therefore marine fauna and habitats in the Pepel area are likely to be resilient to increased turbidity, particularly over short durations such as that required for construction.

Before mitigation the impact on VR marine fauna is considered to be of minor significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of minor significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of minor significance.

Although the impact is expected to be minor the following mitigation measures should be considered:

- Use of floating turbidity barriers and/or silt curtains to contain turbidity plumes during marine construction activities; and
- Design construction activity to occur in periods of high dispersion (e.g. ebb tide).

***Disturbance of Contaminated Sediments***

Construction/refurbishment activity has the potential to disturb marine sediment. If the sediment retains any pre-existing contamination (e.g. hydrocarbons or metals) water quality may be impacted through the re-introduction of these contaminants into the water column. If these released contaminants are assimilated by marine flora or fauna (e.g. mangroves, fish and shellfish) they can accumulate in the food chain, impacting on many areas of the marine ecosystem and the local human population dependant on these resources.

Whilst showing elevated levels of hydrocarbons directly opposite the main loading jetty the sediment analysis from the preliminary marine baseline survey (March 2010) showed little signs of major contamination. However, the hydrological baseline survey (April 2010) sampled several onshore areas close to the high water mark, and showed high levels of arsenic, chromium, copper, lead and zinc[7]; potentially a result of the leached materials from the pre-existing port infrastructure. The area where the mooring dolphins are to be constructed lies between these two areas. At the time of writing, no detailed study has been completed on intertidal sediment quality and around the proposed dolphin locations but a survey covering this area is underway and will be reported in the Stage 2 report.

Undertake a detailed characterization of nearshore and intertidal marine sediments (Physical, Chemical and Biological) to assess the risk of contamination prior to construction; and

[7] Based on the values from Canadian Sediment Quality Guidelines

Before mitigation the potential impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the potential impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the potential impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Undertake a detailed characterisation of nearshore and intertidal marine sediments (physical, chemical and biological) to assess the risk of contamination prior to construction;
- Avoid disturbance of contaminated areas; and
- Conduct construction activities in a manner that minimises re-suspension of sediment.

***Increased Underwater Noise***

Underwater construction activities, in particular pile driving, can generate high levels of underwater noise with the frequency, intensity and persistence of underwater noise dictating its potential effects on different marine species. Whilst temporary, these levels of noise can disturb sensitive marine fauna.

Many marine organisms such as marine mammals, fish, and even some invertebrates use sound for a variety of purposes; for example in communication, to locate mates, to search for prey, to avoid predators and hazards, and for short- and long-range navigation (OSPAR, 2009). All these species and others such as turtles may alter their behaviour if subject to high noise levels. It is generally accepted that exposure to anthropogenic sound can induce a range of adverse effects on marine life, from insignificant impacts to significant behavioural changes, to in some cases stranding and death (OSPAR, 2009; Southall *et al.* 2007).

No evidence exists showing that cetaceans are present in the immediate project area, although heavy piling can affect whales and dolphins many kilometres away from the source. Manatees generally remain higher up the estuary, and do not venture as far down as Pepel, and no significant turtle presence is expected at Pepel. All these statements are subject to review following dedicated marine mammal and turtle surveys.

Heavy underwater noise could be expected to impact on small pelagic fish, particularly during spawning season, leading to indirect effects in fisheries. However, considering that the impact would be localized and temporary, impacts are not considered to be significant.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Design the construction activities to avoid critical spawning and breeding seasons; and

- Construction teams to understand the significance of marine mammal/turtle sightings during heavy construction e.g. piling, and to restrict activity wherever possible until the animals leave the area.

## 7.6 Operation

Many of the impacts associated with port operations are very similar to the ones predicted for the refurbishment\construction phase e.g. noise, light, wastewater discharges, run-off and spills.

### 7.6.1 Presence of Marine Structures

The coast is a dynamic environment and is subject to constant change; with natural processes such as tidal currents and wave action leading to coastal erosion, accretion and reshaping. Any changes to or construction of marine structures has the potential to alter these established physical processes.

Over time changes in the sediment transport regime may result, leading to alterations in general coastal morphology. These changes may have secondary impacts on marine ecology and human users of the sea e.g. fisheries nursery grounds.

However, this project is primarily a refurbishment of existing marine structures at Pepel. The marine structures have been in place for decades. The current coastal morphology has therefore developed to account for their presence. In addition, the two extra, if required, mooring dolphins are relatively small, and the degree of any disturbance to physical transport processes will be localised and restricted. No other major marine structures will be added to the existing loading jetties.

Before mitigation, the impact on VR coastal morphology is considered to be insignificant.

No mitigation measures are required

### 7.6.2 Port Operations

***Wastewater Discharges***

Impacts of operational wastewater discharges are as described in the section above. Only the flow rate and the duration of discharge differs.

The impact of the wastewater discharge is highly dependent on the treatment system implemented in the project design and the location of the discharge point in the estuary. Further assessment is required.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Design an appropriate wastewater collection and treatment system utilising the best available techniques;
- The treated water discharge point should be located away from sensitive locations such as mudflats, mangroves and areas of community use; in an area with strong tidal currents to increase advection and dispersion; and
- In the absence of national legislation, the treatment system should meet World Bank discharge limits, to ensure the receiving water quality is within appropriate international standards.

A more detailed assessment of wastewater discharges is required to develop the mitigation methods further.

***Handling of Iron Ore***

During bulk handling operations such as stockpiling, processing and transport, the potential exists for iron ore dust to enter the coastal and marine environment through wind and/or surface run-off. Iron is an essential trace element required by most organisms, but it can be toxic at extreme concentrations. There is little information currently available on toxicity for marine species, but iron forms colloidal suspensions of ferric hydroxide in the presence of oxygen, which can remain suspended in water or settle into sediment, causing problems with turbidity, light penetration and smothering of benthic organisms.

If not treated correctly, large volumes of dust and/or run-off have the potential to directly affect mangroves, by reducing photosynthesis and chemical impacting their root structures. Most mangrove species breathe via their surface roots, and wind and surface water-borne pollutants can easily affect this process. Additionally, iron supply often limits production in marine environments and can exert controls on the dynamics of plankton blooms (Boyd *et al*., (2007); a secondary impact on fish might be the occasional local increase in food availability for Bonga (*Ethmalosa fimbriata*) which feed on plankton. Inputs of iron to the marine environment can also create a visual impact, as the presence of high concentrations[8] can turn the water an ochre (red) colour.

Pepel Island is located in a core area of the Sierra Leone Estuary Ramsar site, and is considered an area of high ecological value. The potential impact of metal contamination on coastal and subtidal habitats, marine fauna and human users of the estuary i.e. fisheries is considered to be highly significant. Iron ore can possibly render fish to a higher risk of toxic effects from potentially harmful algal exudates. Bury and Grosell (2003) note that whilst iron is a vital micronutrient for teleost fish, in excess it can be toxic. Fish in SLRE may be exposed to increased iron levels in both dissolved and dietary phases (Bu-Olayan and Thomas, 2008). Mudskippers are prey for many predators and hence a path for bioaccumulation.

Bury *et al*., (2003) note that iron is an essential nutrient to almost all organisms. One of irons key cellular functions is to confer redox activity to the cytochromes involved in respiration, due to its ability

[8] Maximum concentrations for iron in marine waters in the US are 0.3 mg/l and in the UK 0.1 mg/l. These are believed to be primarily for aesthetic reasons.

to exchange electrons in aerobic conditions. A negative consequence of irons redox flexibility is that it produces oxygen free radicals that are toxic to the cell. Consequently, in excess, iron can be detrimental to health. In addition, excess waterborne iron may be toxic to fish, due to the formation of iron flocs on the gills, resulting in gill clogging and respiratory perturbations.

The current existence of a diverse and healthy mangrove environment at Pepel demonstrates that the coastal habitat can adapt in the long term to a certain level of metal contamination. Fish and shellfish sampling is ongoing and will yield information on iron contamination in fish.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Undertake a chemical assay of the proposed iron ore product to understand its constituents;
- Install a treatment plant to collect and treat possible discharges; and
- Design and implement an appropriate Transport Management Plan to guarantee minimal loss of material to the coastal and marine environment.

***Fuel Handling Operations***

Fuel for power generation will be transported by road and vessels will not refuel at Pepel, therefore no fuel handling operations are planned within the marine area of the port.

The movement and use of fuel oils for power generation is a potentially significant source of hydrocarbon contamination to local coastal and subtidal habitats. Mangroves are particularly susceptible to hydrocarbon pollution, which manifests itself in the intertidal and particularly affects the ability of pneumatophores (in particular) and prop roots to regulate salt content and for the mangrove to breathe. Therefore, if there are any fuel handling operations a detailed environmental management and contingency plans must be in place.

Any spills within the port facility have the potential to contaminate the coastal habitats via run-off or groundwater.

Before mitigation the impact on VR marine fauna is considered to be minor.

Before mitigation the impact on VR coastal habitat is considered to be moderate.

Before mitigation the impact on VR subtidal habitat is considered to be minor.

Before mitigation the impact on VR human development potential i.e. fisheries is considered to be minor.

Mitigation measures:

- Undertake a Quantitative Risk Assessment (QRA) of fuel handling operations; and

- Implement management and contingency / response plans to ensure any fuel spills within the land-side of the port do not enter the marine environment.

### 7.6.3 Associated Shipping Activities

As Pepel Port has been out of use for several years, its regeneration will increase marine traffic between Pepel Port and Freetown, creating disturbance to other marine users such as fishing boats. Ports may have a role in terms of appropriate reception facilities, guidance to port users and inspection of documentation.

***Navigation and Fishing***

The majority of marine traffic in the estuary is focussed around Freetown. Numbers from 2008 indicate that 368 vessels used the main commercial port, 352 of which were cargo ships, whilst the rest were industrial fishing, military and research vessels. In the wider estuary shipping is believed to be limited to small artisanal fishing boats and passenger vessels, and the Freetown to Tagrin ferry.

Transshipment operations are currently expected to involve Handymax transshipment vessels, which will transfer ore to a loading on anchorage point outside the mouth of the estuary. These vessels will be of a similar size to those previously using Pepel port. As the port has been inactive for some time, vessels of this size have not been used as far up the estuary as Pepel for a number of years.

However, only two transshipment vessels will be in operation and each will make one round trip per day. Although relatively large, the volume of movement of these vessels up and down the estuary will be low. Considering the amount of other commercial traffic and large cargo vessels using Freetown port, the impact of the transshipment operations on shipping in the estuary is not expected to be significant.

Consultation with the fishing community is ongoing and further assessment will be undertaken. The transshipment anchorage location is also yet to be finalised. Therefore it is considered to be a moderate impact within this assessment.

The impact on VR Infrastructure Changes – shipping is considered to be of minor significance.

The impact on VR Infrastructure Changes – shipping is considered to be of minor significance.

Mitigation measures:

- Further consultation with the fishing community (already underway).
- Navigation Guidance must be provided to vessels using the port and other shipping and fishing vessels in the area.

***Risk to Marine Fauna – Underwater Noise and Collisions***

As discussed in Section 7.5.2, underwater noise can impact on marine mammals, sea turtles and fish. Marine vessels, in particularly large bulk carriers are relatively loud sources of underwater noise. Their continued presence in the estuary, and the offshore area outside of the mouth, has the potential to affect the behavioural ecology of local marine fauna. In addition, many species of whales and dolphins may be vulnerable to collisions with vessels. Most reports of collisions involve large whales but collisions with smaller species also occur (IWC, 2009).

Very little published information currently exists on the abundance and distribution of marine mammals and turtles in the estuary and immediately offshore. As such it is difficult to estimate the likely significance of increased vessel traffic. An ongoing study is currently collecting information, which will be incorporated into the Stage 2 assessment. Potential species of concern include turtles, humpback dolphins and humpback whales.

Freetown port is a busy commercial marine environment and therefore the increase in noise and vessel collision risk from the TV and OGV may be of minor significance. A greater understanding of the abundance of marine mammals and turtles in the estuary and further assessment of potential transshipment anchorage locations is required before the potential impacts can be fully evaluated.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Mitigation measures:

- If initial surveys indicate abundance of species of conservation concern, further mitigation and monitoring will be required.

***Increased Light Levels***

Persistent man-made light from vessels, an operational port, and navigation aids throughout the channel could impact significantly on marine fauna; with birds in particular sensitive to increased and extended levels. Non-natural light can deter them from feeding, breeding and nesting, and can generally confuse their natural behaviour (Longcore and Rich, 2004, Lorne & Salmon, 2007, Witherington, 1992).

Due to the high density of wetland birds present in the project location, and its position inside a designated RAMSAR site, increased light is a potentially significant impact, especially as year round operations will continue during bird migratory and breeding seasons. The current low levels of man-made light at Pepel exacerbate this potential impact, particularly if bright navigation aids are to be placed in the approach channel to the port.

With respect to vessels moving up and down the estuary, there is already a large degree of light pollution at Tagrin and Freetown, and transshipment vessels are not expected to significantly increase the level of light at the mouth of the estuary. Closer to the port however, this impact may become significant.

Before mitigation the potential impact on VR avifauna is considered to be moderate

Before mitigation the potential impact on VR marine fauna is considered to be moderate.

Mitigation measures:

- During port operations, avoid strong lighting on any sensitive habitat areas, use shading tactics wherever possible;
- Consider use low-pressure sodium vapour lamps, as this wavelength does not disorient fauna as much as regular full spectrum lighting; and

- Use navigation aid lighting only when strictly necessary.

***Ballast Water and Marine Pests***

The introduction of invasive species is of concern during the operational phase with the increase in shipping activities. Before a voyage when they are not laden with cargo, ships take in a certain amount of water for stability. Once the ship arrives at its destination it may release the ballast water at the destination location. Ballast water can contain large amounts of sediment and microscopic organisms, eggs and larvae. International shipping is responsible for the majority of these alien species invading foreign waters. The effects of introducing new animals and plants can be almost undetectable, or conversely they can completely displace native communities.

The 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments (from which Sierra Leone is signatory) establishes that all ships using ballast water exchange should whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth. The transshipment vessels to be used in the estuary will only have to release foreign ballast water once on arrival, and as all bulk carriers arriving for ore loading will not be entering the estuary, this impact is considered to be minor as long as correct exchange procedures are followed.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat is considered to be of minor significance.

Before mitigation the impact on VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential – fisheries is considered to be of minor significance.

Mitigation measures:

- Ensure the 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments is strictly followed by all ships approaching the anchorage loading point; and
- A monitoring program to check for the presence of invasive species, and to undertake regular assessment of sensitive habitat areas.

***Vessel Waste Management and Discharges***

Routine discharges from vessels include uncontaminated deck drainage, potentially contaminated drainage from machinery spaces, engine cooling water and treated sewage / grey water. The potential effects on water quality are similar to the effects created by discharges from the port, such as changes in water pH, colour, temperature, smell, dissolved oxygen, nutrient levels and bacterial contamination.

The source of pollution in the case of barges/tugs is a moving source, with a potentially larger area of impact but a higher dilution rate, and therefore the impact is not considered to be significant.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential – fisheries is considered to be of moderate significance.

Mitigation measures:

- Ensure that the International Convention for the Prevention of Pollution from Ships (MARPOL) is strictly followed by all ships operating within the project area, estuary and the anchorage loading point;

***Transshipment Anchorage***

Loading on anchorage impacts during transshipment are generally associated with material spillages and dust dispersion, leading to impacts on water quality, coastal and subtidal habitats and marine fauna. Although the system is designed to be highly efficient, the cumulative impact over the life of the project could be significant.

The potential behaviour of the iron ore in the water will depend on the spillage particle size and its chemical composition. Generally, iron often forms colloidal suspensions of ferric hydroxide in the presence of oxygen, which can remain suspended in water or settle into the sediment. Potential impacts include increased turbidity, reduced light penetration, smothering of benthic organisms and aesthetic impacts (water discolouration). Iron is not generally toxic to marine fauna. A full chemical assay is required to understand if there are any other contaminants of concern within the hematite, although this is considered unlikely. Modelling can be used to assess concentrations within the water column for comparison to toxicity thresholds.

There is also a risk non-routine events such as a vessel collision leading to much larger spills into the estuary. It is considered pertinent to conduct a QRA to ascertain the level of risk associated with accidental spills at sea or within the Pepel Port area once details concerning shipping are confirmed.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential (i.e. fisheries) is considered to be of moderate significance.

Mitigation measures:

- Undertake a full assessment of the proposed iron ore product to understand its constituents; and
- Design and implement an appropriate Transport Management Plan to guarantee minimal loss of material to the coastal and marine environment.
- Undertake a QRA of port and shipping activities.

### 7.6.4 Associated Dredging Activities

Capital dredging will be required to open the navigation channel to access Pepel port. The capital dredging is expected to only remove infill that has occurred since the closure of Pepel Port to reinstate the previous channel. Ongoing maintenance dredging will then be required to keep the channel open but the volume required will be smaller. The total predicted dredging volume is approximately 1.5 million $m^3$ based on UKHO admiralty charts. As explained in the Project Description the dredging volume will be finalised following bathymetric and geotechnical surveys.

Key potential impacts from dredging activities include changes in water quality due to increased turbidity and disturbance of potentially contaminated sediments; removal and smothering of the benthos. There are also potential impacts from light and noise, particularly as 24 hour operations will take place. Secondary impacts can include changes in waves and currents due to changes in bathymetry. There is also a potential impact on fishing.

Sediment grabs from the dredge channel indicate that most of the channel is medium to coarse sand, which is expected given the strong tidal currents through the channel. Coarse silt was found at one location to the north-west of Tasso Island, this may be due to the slowing of the tidal currents around the bend in the channel. There is no evidence of any areas of reef in and around the channel and as the channel is being reinstated these sand and silt sediments are expected to exist throughout. Macrofaunal communities are typical of such sediments in an estuarine environment and are not of high biodiversity value.

The estuary is turbid in the area around the dredge channel due to the high sediment load from the tributaries and wetlands inputting to the estuary and the strong tidal currents. Suspended solids concentrations of up to 40 mg/l were measured in the lower part of the water column in the dredge channel. Turbidity of up to 350 NTU was measured in the channel close to Pepel, for comparison 25 NTU is considered murky. Although the dredging methodology has not been finalised there are mitigation measures inherent in the design to reduce the concentration and extent of any dredge plumes, in particular from the hopper overflow though the use of the adjustable overflow funnel and green valve described in the Project Description. Therefore the impact is expected to be minor. However, within the EMP any dredge plumes will be modelled and compared to background turbidity and suspended solids data.

The dredging will take place over a relatively short period and due to the type of dredger proposed underwater noise levels are expected to be comparable with those created by shipping.

As the dredging will involve only the reinstatement of the previous channel no significant changes in currents, sediment transport or morphology are expected. As the dredge channel is within the estuary waves are not an issue.

Consultation with local fishing communities is underway. There is some fishing activity in the vicinity of the channel and potential setting of nets. Further information is being collected through the consultation process. The period of dredging is relatively short but it will still be necessary to ensure that the fisherman and communities close to the dredge channel are informed of activities and procedures. This will be facilitated through the consultation process, which will be within the EMP.

The effects of dredged spoil disposal will be site specific and dependent on the characteristics of the dredged material and the hydrodynamic conditions in the area. The primary issues are the smothering and changing of the benthos and the risk of contamination of the disposal site. In addition, there is a risk of increased suspended sediment and turbidity. The finer the material and the greater the energy at the disposal site, the greater the possibility of increased suspended sediments and turbidity.

A video survey of spoil ground was undertaken during the marine environmental baseline survey. This found that the area was dominated by soft bottom sediments with no areas of reef. There are reef areas, such as Carpenter's rocks, to the south of the dredge spoil disposal ground but these are some distance away. Therefore an initial assessment indicates that the impact will be minor. Once the dredging methodology is finalised an assessment of the deposition of the dredge material will be undertaken including modelling of the dredge material to ensure that it is deposited within the spoil ground and any dredge plume does not impact the reef habitats that have been identified within the vicinity of the dredge spoil disposal ground.

There is evidence of sediment contamination around the existing Pepel port above sediment quality guidelines[9]. However, initial samples within the dredge channel indicate that the area of contamination does not extend that far from the port land-side. As part of the EMP cores will be taken and sub-sampled for environmental analysis to confirm whether there are any seabed sediment contamination issues and, if found appropriate action will be taken.

There is also a risk of dredging impacting on shipwrecks which may have Cultural Heritage. A review of the UK Hydrographic Office wrecks database does not indicate that there are any wrecks in the dredge channel or at the disposal site. The geophysical survey of the channel will confirm this.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

Before mitigation the impact on VR coastal habitat and VR subtidal habitat is considered to be of moderate significance.

Before mitigation the impact on VR human development potential i.e. fisheries is considered to be of moderate significance.

Before mitigation the impact on VR cultural heritage (marine archaeology) is considered to be insignificant.

Mitigation measures:

- The primary mitigation measure is to follow the London Convention of 1972 and subsequent protocol of 1976, to which Sierra Leone is a signatory (see Legislation and Guidance section). This includes guidance on the sampling of sediments for contamination and the selection of a dredged disposal site.
- Mitigation measures will be included within the dredging equipment and methods to minimise the extent of any dredge plumes.

[9] In the absence of national or international standards the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Update 2002) are used, which are based upon recognised toxicological methods.

- Within the EMP dredge plumes will be modelled and analysis and assessment undertaken to ensure that there is no risk of contamination from the dredge material.
- Consultation with the local fishing communities is underway and will continue via the EMP.

## Table 7-5 Port Area – Offshore & Coastal

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Land clearance and earthworks | E6 | Clearance of coastal habitat during construction activities | High | 2 | 2 | 3 | 2 | Major | Minor | Ensure no clearance |
| Pressure increase in natural resources | E6 | Increased pressure on the uses of mangrove due to increased population during construction | High | 4 | 2 | 4 | 3 | Major | Moderate | Best practices |
| | H3 | Increased pressure on fish resources due to increased population during construction | High | 2 | 2 | 2 | 2 | Moderate | Minor | Best practices |
| Clearance of old stockpiles and port site | E8 | Impacts on marine fauna | High | 1 | 2 | 2 | 2 | Moderate | Moderate | Construction Best Practice to ensure contaminants do not enter the marine environment |
| | E6 | Impacts on coastal habitat | High | 2 | 2 | 2 | 2 | Moderate | Moderate | Construction Best Practice to ensure contaminants do not enter the marine environment |
| Increased noise during construction works | E3 | Disturbance of avifauna | High | 2 | 1 | 2 | 2 | Major | Moderate | Management Plan |
| Increased light levels during construction works | E3 | Disturbance of avifauna | High | 2 | 1 | 2 | 2 | Major | Moderate | Management Plan |
| Waste water discharge during construction | E8 | Disturbance to marine fauna due to potential changes in water quality | High | 1 | 2 | 2 | 2 | Moderate | Minor | Appropriate collection and treatment |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | E6 | Impacts on coastal habitat due to potential changes in water quality | High | 3 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 3 | 2 | 2 | 3 | Moderate | Minor | Appropriate collection and treatment |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 1 | 2 | 2 | 2 | Moderate | Minor | Appropriate collection and treatment |
| Spills and run-off of oil and chemical contaminants during construction | E8 | Disturbance to marine fauna due to potential changes in water quality | High | 1 | 2 | 2 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E6 | Impacts on coastal habitat due to potential changes in water quality | High | 3 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 3 | 2 | 2 | 3 | Moderate | Minor | Appropriate collection and treatment |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 1 | 2 | 2 | 2 | Moderate | Minor | Appropriate collection and treatment |
| Refurbishment of mooring dolphins | E7 | Impacts on subtidal habitat due to underwater construction | Moderate | 2 | 2 | 1 | 2 | Minor | Minor | |
| Increased turbidity due to underwater construction | E8 | Disturbance to marine fauna due to changes in water quality | High | 1 | 1 | 1 | 1 | Minor | Minor | |
| | E6 | Impacts on coastal habitat due to changes in water quality | High | 1 | 1 | 1 | 1 | Minor | Minor | |
| | E7 | Impacts on subtidal habitat due to changes in water quality | Moderate | 2 | 2 | 1 | 2 | Minor | Minor | |
| | H3 | Impacts on fish stock due to changes in water quality | High | 1 | 1 | 1 | 1 | Minor | Minor | |
| Disturbance of contaminated sediments | E8 | Disturbance to marine fauna due to water contamination | High | 2 | 1 | 1 | 2 | Moderate | Moderate | |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| during underwater construction | E6 | Impacts on coastal habitat due to water contamination | High | 3 | 2 | 1 | 2 | Moderate | Moderate | |
| | E7 | Impacts on subtidal habitat due to water contamination | Moderate | 3 | 2 | 2 | 3 | Moderate | Moderate | |
| | H3 | Contamination of fish stock due to changes in water quality | High | 1 | 2 | 2 | 2 | Moderate | Moderate | |
| Increased underwater noise during underwater construction | E8 | Disturbance to marine fauna | High | 2 | 1 | 1 | 2 | Moderate | Moderate | |
| | H3 | Disturbance to fish stock | High | 2 | 1 | 1 | 2 | Moderate | Moderate | |
| Presence of marine structures | S2 | Changes in coastal morphology due to changes in estuary dynamics | Medium | 1 | 1 | 2 | 1 | Insignificant | Insignificant | |
| Wastewater discharge during port activities | E8 | Disturbance to marine fauna due to potential changes in water quality | High | 2 | 1 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E6 | Impacts on coastal habitat due to potential changes in water quality | High | 3 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 3 | 2 | 1 | 3 | Moderate | Minor | Appropriate collection and treatment |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 2 | 2 | 2 | 2 | Moderate | Minor | Appropriate collection and treatment |
| Handling of Iron Ore – dust dispersion and surface run-off | E8 | Disturbance to marine fauna due to changes in water quality | High | 1 | 2 | 3 | 2 | Moderate | Moderate | |
| | E6 | Disturbance due coastal habitat due to potential changes in water quality and dust settlement | High | 1 | 2 | 3 | 2 | Moderate | Moderate | |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 2 | 2 | 3 | 3 | Moderate | Moderate | |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 1 | 2 | 3 | 2 | Moderate | Moderate | |
| Fuel handling operation - spillages | E8 | Disturbance to marine fauna due to changes in water quality | High | 2 | 1 | 1 | 2 | Moderate | Minor | No marine fuel handling |
| | E6 | Disturbance due coastal habitat due | High | 2 | 2 | 1 | 2 | Moderate | Minor | No marine fuel |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| | | to potential changes in water quality | | | | | | | | handling |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 3 | 2 | 2 | 3 | Moderate | Minor | No marine fuel handling |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 3 | 2 | 2 | 2 | Moderate | Minor | No marine fuel handling |
| Navigation and shipping | I1 | Impacts on marine users and existing navigation patterns due to vessel movements | High | 1 | 1 | 2 | 1 | Minor | Minor | |
| | H3 | Disturbance to fishing vessels due to increase marine traffic | High | 1 | 1 | 2 | 1 | Moderate | Moderate | |
| Underwater noise and collisions with marine fauna | E8 | Impacts on Marine Fauna due to increase in marine traffic | High | 2 | 2 | 1 | 2 | Moderate | Moderate | |
| Increased light levels | E3 | Impacts on Avifauna at port, in the surroundings of vessels and navigation aids | High | 2 | 1 | 2 | 2 | Moderate | Moderate | Project design |
| | E8 | Impacts on Marine fauna in the surroundings of vessels and navigation aids | High | 2 | 1 | 2 | 2 | Moderate | Minor | Project design |
| Ballast Water and Marine Pests | E8 | Disturbance to marine fauna due to potential competition | High | 1 | 1 | 3 | 2 | Moderate | Minor | Follow MARPOL |
| | E6 | Impact on to coastal habitat | High | 1 | 1 | 2 | 1 | Minor | Insignificant | Follow MARPOL |
| | E7 | Impact on due to subtidal habitat | Moderate | 3 | 2 | 2 | 3 | Minor | Insignificant | Follow MARPOL |
| | H3 | Impact on of fish stock | High | 2 | 1 | 1 | 1 | Minor | Insignificant | Follow MARPOL |
| Vessel Waste Management and Discharges | E8 | Impact on marine fauna due to potential changes in water quality | High | 1 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E6 | Impacts on coastal habitat due to potential changes in water quality | High | 2 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality | Moderate | 2 | 3 | 2 | 3 | Moderate | Minor | Appropriate collection and treatment |
| | H3 | Impacts on fish stock due to potential changes in water quality | High | 2 | 2 | 1 | 2 | Moderate | Minor | Appropriate collection and treatment |

| Aspect | VR | Impacts | VR Category | Magnitude | Extent | Duration | Basic Impact Index | Significance | Residual Impact after Mitigation | Reason for Change |
|---|---|---|---|---|---|---|---|---|---|---|
| Transshipment Anchorage | E8 | Disturbance to marine fauna due to changes in water quality and potential toxicity | High | 2 | 2 | 1 | 2 | Moderate | Moderate | |
| | E6 | Disturbance due coastal habitat due to potential changes in water quality and potential toxicity | High | 3 | 2 | 1 | 2 | Moderate | Moderate | |
| | E7 | Impacts on subtidal habitat due to potential changes in water quality and potential toxicity | Moderate | 2 | 3 | 2 | 3 | Moderate | Moderate | |
| | H3 | Contamination of fish stock due to potential changes in water quality | High | 2 | 2 | 1 | 2 | Moderate | Moderate | |
| Dredging Activities | E8 | Impact on marine fauna | High | 2 | 3 | 1 | 2 | Moderate | Moderate | Dredging impact assessment |
| | E6 | Impact on coastal habitat | High | 3 | 2 | 1 | 2 | Moderate | Moderate | Dredging impact assessment |
| | E7 | Impact on subtidal habitat | Moderate | 3 | 2 | 4 | 3 | Moderate | Moderate | Dredging impact assessment |
| | H3 | Impact on fish stocks | High | 2 | 2 | 2 | 2 | Moderate | Moderate | Dredging impact assessment |
| | H5 | Impact on cultural heritage (marine archaeology) | Low | 2 | 1 | 2 | 2 | Insignificant | Insignificant | |

## 7.7 Distributed Impacts from Project

### 7.7.1 Bulk material management

Material required for ground improvement across the project will need to be sourced locally from multiple quarry sites and borrow pit. This has the potential for significantly broadening the impacts from the project. Consequently all bulk material activities will need to be managed through specific environmental management and be accountable through contract terms to a single, best-practice source of guidelines.

### 7.7.2 Demand on existing infrastructure & resources

The provision of goods and services to maintain the project, co-use of infrastructure such as roads, power and telecoms networks and the effect of a large logistics operation and mobilization throughout the project footprint has the potential to create significant impact and over-demand on the existing, fragile and undeveloped infrastructure and resources.

Logistics, programming, procurement and the provision and expectations for good and services are dealt with under a project's feasibility study and execution plan which is outside of the scope of this study.

Due to the broad scope of these activities it is not considered meaningful to suggest a single source of management to regulate this. Instead the project consultation and disclosure system coupled with a grievance system, established by the proponent will be utilized to ensure that project activities are announced publicly and that a response system is in place should problems arise. This has been described under the social management section.

### 7.7.3 Solid waste management

It is anticipated that sound waste management practice will have limited impact on the existing infrastructure within the region. Waste management proposals have been determined based on the proximity principle, locating facilities as close as possible to major waste generation sources. Delivery of the proposed incineration units should consider the existing road infrastructure.

The greatest impact is likely to arise from interim storage of wastes in particular pest, odour and litter control. During storage organic waste will decay and generate small volumes of methane gas which should be allowed to vent to the atmosphere.

Consideration should be made in waste storage areas for adequate drainage, particular during the rainy season. Run off from waste storage should be minimised and treated as leachate rather than being discharged into the conventional drainage system. Provision should be made for storage and evaporation ponds where existing infrastructure is inadequate.

***Potential Mitigation Measures***

- Implement a hierarchy of waste elimination at source, recycling, reuse, recovery, and – as a last resort - disposal;
- Destruct or treat hazardous waste to render it non-hazardous if possible;
- If the hazard cannot be eliminated, contain waste in a secure manner and monitor to ensure it cannot damage the environment;
- Segregate and quantify waste for effective management;
- Use a system of waste manifests to track generation, transportation, receipt and disposal;
- Audit waste transport or disposal companies prior to contracting.

# 8 ONGOING ASSESSMENT WORKS

Further ESHIA works required for this project (Stage 1) which will be reported in the Stage 2 assessment are set out in the Environmental Management Plan (EMP) in Appendix 18.

***Air & Noise***

Spot sampling of air quality parameters and baseline noise have been conducted to date. Detailed impact assessment requires a more accurate knowledge of the background air quality and a refined estimate of the project contribution to the existing background levels. For this purpose a second round of baseline data collection is currently being undertaken at the start of June 2010 and further seasonal coverage will be required which will involve works that extend into and beyond the Stage 2 ESHIA reporting period. Some targeted baseline data collection, interpretation and assessment can only be carried out after detailed Phase 1 designs are available including major power source designs/locations and airfield/aircraft details. Air assessment and design feedback to ensure compliance with air quality standards will be presented in the Stage 2 report. Based on the currently advised programme it is also assumed that some Tonkolili Phase 1 construction works will be underway and therefore monitoring data will be available to support the assessment. An air dispersion model will be developed in order to predict the expected air quality contributions from the routine operations of the project with assessment standards based on national and international guidelines.

Sampling to date has indicated (subject to verification) a predominantly non-industrial baseline for the project area. It is therefore reasonable to assume that there will not be additional significant air quality impact sources (i.e. from other industry) that could lead to a cumulative air quality loading in addition to project contributions. Therefore assuming that mitigation and management applied by AML is effective in mitigating air and noise sources this should mean that project contributions will not lead to excessive levels.

The impacts from the proposed development on noise quality will be assessed following a quantitative approach. Due to the large project area potentially affected by noise emissions, the target zones to be modelled will be limited to the surroundings with the predicted highest noise emissions: the perimeter of the mine facilities, the transport corridor (railway and roads) nearby populated areas and the Phase 1 power plant/plants. Where significant potential noise impacts are identified, specific mitigation measures will be suggested (e.g. construction of barrier panels) and tested in the noise model to ensure that the predicted noise impacts will be mitigated.

Noise modelling will be conducted with SoundPLAN, an industry standard noise prediction software used to calculate sound pressure levels and to generate noise mappings, considering reflections and diffractions of sound, the geometry of buildings at the site, topography and climatic conditions. The pressure levels calculated or interpolated for each point within the defined calculation area will be shown as a grid of sound pressure values, from which a contour map will be generated showing isophones (lines of equal sound pressure). The noise maps will show only the project contributions and the cumulative effects will be assessed adding the existing noise background conditions at sensitive receptors.

### *Ecology & Biodiversity*

*Vegetation*

Further work will concentrate on the assessment of species and habitats of conservation concern in the project area as well as on the study of habitats and localities that are not yet well documented or understood and that are likely to be impacted by the mining activities. Requisite works include:

- Detailed aerial image interpretation to determine whether there is additional riverine system of interest along the transport corridor that has not been previously identified or surveyed and may deserve consideration.
- Inland valley swamps have not yet been studied in detail and further surveys of selected inland valley swamps are required to assess the presence/absence of species of conservation concern.
- The freshwater river areas and saline / freshwater transition zone of Port Loko Creek will be surveyed in more detail, especially for rheophytes.
- Survey of Farangbaia Forest Reserve to determine the presence of species of conservation concern found on project affected areas and the potential as an offsetting area.
- Surveys outside the anticipated impacted project footprint aimed at confirming presence of species already identified as of conservation concern and so far found only on the Simbili deposit or near proposed infrastructure. This will allow reassessment and potential lowering of the conservation status of these species. This survey will also identify potential areas to be protected and used as offsetting zones or relocation zones if required.
- Inselbergs will be visited to assess remnant forest patches.
- Other localities and habitats of potential conservation concern that have not yet been studied in detail will be explored further. The most important localities and habitats are some parts of the Tonkolili River (focusing mainly on the western valley, where some infrastructure related to rail development may be located), the river channel community of the Tonkolili River near Farangbaia, Pepel Port land lease, Port Loko freshwater ecosystems, the Toka River, and some of the inland valley swamps along the rail / road corridor.

*Fauna*

In order to establish and validate pre-project baseline and trends the following supplementary Phase 2a and Phase 2b baseline studies are required and will be reported in the Tonkolili Stage 2 ESHIA or follow up study reporting where seasonal constraints entail later works:

- Assess potential conservation strategies for Western Chimpanzee populations.
- Assess the conservation value of extensive semi-natural seasonal wetlands and scattered forest patches along the Toka river valley, essentially those between Makeni and Lunsar, and the gallery evergreen forest along the Rokel upstream from Makeni to its confluence with the Tonkolili River. These investigations will be most productive if undertaken in May and November-December.

- Assess faunal-groups where observations and literature suggest that species of global importance may occur.
- Assess the transport corridor in detail. Surveys to be undertaken at both the beginning and the end of the wet season (June and November-December) when migrant intra-African birds, amphibian and insect populations would be at a much higher level.
- Assess mangrove vegetation along the Bankasoka River.
- Assess the significance of sacred forests / bush areas for fauna. This will require careful planning and early consultation and engagement with relevant local communities.
- Assess fauna present in the Pepel Railway area and adjacent mangroves.

*Freshwater*

The Phase 1b aquatic ecosystem studies to date are high-level, rapid assessments that represent a 'snapshot' of conditions at the site. Pre-project trends as seasonal variations (such as water levels, migration and breeding patterns) have not been investigated and defined. To establish pre-project trends the following supplementary Phase 2a and Phase 2b baseline studies are required:

- Wet and dry season aquatic surveys to describe the aquatic biota in the mining lease area and transport corridor.
- Aquatic fauna tissue metal survey to assess existing metal concentrations (that are likely to be influenced by activities of artisanal miners and natural mineralisation in the area).
- A comprehensive baseline water quality sampling programme will be undertaken in conjunction with the hydrology and hydrogeology studies and monitoring programme.
- Seasonal hydrological flow data collection, particularly for the downstream reaches of the Mawuru and Tonkolili Rivers (where dams are proposed) is required and will be collected in conjunction with the hydrology and hydrogeology studies and monitoring programme. Aquatic surveys have not yet been undertaken in this area which contains many small streams and brooks that may house endemic species and an aquatic fauna survey will describe establish baseline conditions. A long term monitoring survey programme will be implemented in order to assess effectiveness of any mitigation measures and allow remedial action in the event that negative impacts are detected.

***Hydrology and Hydrogeology***

Further to Stage 1 reporting, works required for completion of environmental studies include

- Ongoing monitoring of surface and groundwater quality to establish baseline and long term trends
- Ongoing flow monitoring of surface water to establish baseline, long term trends and surface and groundwater relationships including baseflow index and recharge estimates. Requires stream profile surveys and LIDAR interpretation to establish calibration / ratings curves for gauging points.

- Refine quality and flow monitoring programmes further to analysis of initial trends and improved understanding of baseline and development designs.
- Data interpretation to characterise water resources – quality and quantity, including seasonal variations, based on existing reports and monitoring data.
- Refine mass water balance. Assess whether there may be significant net change in the water balance of the various river systems in the project footprint due to stripping, mining, waste dumps, valley crossings etc.
- Calculate stream flow deficit durations
- Peak flood estimations
- Input to storm water management plan and surface water management plan
- Recurrent stream stability monitoring
- Potential Sediment Transport model.
- Input/interact with Acid Mine Drainage study to assess likelihood and impact of acid waters draining from waste dumps or areas of construction using waste rock.
- Input to solid waste management plan, surface water management plan, waste water management plan, waste rock management plan (potential acid waters and flooding/water logging issues) and spill response plan.
- Input to outline EMPs for future works including mining, drilling, waste storage, haulage, transfer and export where potential for impacts on surface and groundwater exist.
- Review and interpretation/inclusion of geotechnical pitting and drilling data as is becomes available.
- Review and analytical assessment and interpretation of water well drilling and testing data as it becomes available.
- Review and assessment of drainage designs.
- Identify significant impacts that may result either directly or indirectly from the use of surface or groundwater when detailed water demands and abstraction designs are available.
- Determine whether there will be any cumulative impacts on river and groundwater systems.
- Assess risk of polluting ground and surface water resources throughout the various project areas.
- Provide practical design recommendations/remedial measures where possible to avoid any of the identified impacts.

***Soils and Land Use***

Ongoing works involve preparation of a soils and land use mapping based on recently acquired full detailed aerial photo coverage of the proposed development. This will include input from Agricultural

Department, Sierra Leone, on soil types and agricultural areas and any mitigation or offsetting recommendations where loss of land use and erosion impacts have been identified in particular. Ongoing geotechnical field investigations may allow some site specific descriptions and assessment of soils for localised areas. Full Stage 1 and Stage 2 ESHIA information will be presented in the Stage 2 preliminary ESHIA and where relevant in the EMP.

***Geology and Geomorphology***

Ongoing works including detailed literature review and summary of local geology are to be finalised. Detailed mine planning will optimise resource utilisation and minimal requirement for further ESHIA works are foreseen for Phase 1

***Human Health***

Human health impact assessment is an iterative process that requires input from a number of other disciplines. The work presented in this Stage 1 document represents a preliminary screening assessment based on baseline information and project description available at this point in time. The Human impact assessment will be developed as more definitive project information and field data becomes available. Ongoing ESHIA work will refine and build upon the findings of Stage 1, incorporating new data and information to be presented in the Stage 2 ESHIA. Further works will involve:

- Detailed definition of baseline pertaining to human health. This will include incorporation of the results of chemical analysis of environmental media (soils, air, surface and groundwater), food (plant and fish tissue) as well as other factors (noise, traffic etc) that have the potential to impact human health;
- In-country data collection. A site visit will be conducted by a senior health assessor for field survey/overview and meetings with government officials and medical representatives in order to facilitate completion of medical and governmental health questionnaires;
- Definition of chemicals of potential concern (COPCs). COPCs for the project will be generated and undergo preliminary screening. This will involve data collection and implementation of selection processes, including discussion with project engineers.
- Health impact assessment. The list of health impacts developed during Stage 1 will be re-evaluated and refined in light of the most up-to-date project details and the health-related inputs received from other assessment disciplines; and
- Reporting in the Tonkolili Preliminary/Stage2 ESHIA document.

***Socio-Economic***

The SIA for Stage 2 is considered to be an evolution of the Stage 1 report with some additional geographic scope based on the larger footprint. As such, the following work will be conducted primarily for the purposes of the Stage 2 ESHIA but at the same time providing an opportunity to review and, if required, enhance Stage 1 ESHIA:

- Further socio-economic baseline studies are planned for the next phases of the Tonkolili project which will provide additional detail to the present understanding of socio-economic conditions in the project area including the Phase 1 footprint which shares many of the same attributes.
- Use the RPF as the foundation for developing a RAP including a detailed household asset survey which will provide an opportunity to better understand the full extent of resettlement impacts. This process will incorporate direct consultation with PAPs and other stakeholders throughout implementation. There may be circumstances that require retroactive execution of the RAP to ensure that benefits for PAPs are delivered fairly and equitably.
- Work with local NGO's and GoSL to initiate livelihood restoration programs.
- Implement the measures set out in the CDAP through consultation with local communities and GoSL stakeholders. This consultation process will itself evolve to encompass communities across both Stage 1 and Stage 2 footprints so that community development strategies can be prepared that address broader community requirements whilst at the same time focusing on implementing viable and cost-effective building projects and social programs.
- Through an overall AML management policy initiative, develop a Community Safety Plan to address safety issues that may result from project activities interacting with local communities such as public access across rail tracks and haul roads.

***Offshore & Coastal***

Based on the key environmental issues identified in the preparation of this report, further data collection and analysis is required to fully assess the severity of each impact and to finalise appropriate mitigation measures that will provide input to the Environmental Management Plan.

Additional studies required in order to support impact assessment include the following:

- Hydrodynamics, sedimentary transport and coastal morphology - Development of higher resolution hydrodynamic and sediment transport model, based on the results from metocean data collection and geotechnical survey (including bathymetry survey);
- Sediment quality - Laboratory analysis of samples already collected; additional sediment sampling; sub-sampling and analysis of sediment vibrocores to assess contamination and acid sulphate soil risk; modelling of fate of sediments from dredging and construction activities;
- Water quality - Laboratory analysis of samples already collected; Longer term in-situ water quality monitoring as part of the MetOcean survey; Additional targeted surveys around potential discharge locations; MIKE 21 model development and water quality modelling of wastewater discharges, run-off and dredging activities;

- Marine habitat studies - More detailed mapping of subtidal and mangrove habitats using quantitative techniques and assessment of mangrove health; Quantification of habitat clearance; Identification of habitat conservation status and growth patterns; Additional survey of inter-tidal areas (mudflats), spoil ground #1 and transshipment anchorage.
- Benthic fauna studies - Laboratory analysis of samples already collected; In-situ chlorophyll measurement as part of MetOcean survey; Wet season measurements;
- Plankton studies - Laboratory analysis of water samples;
- Cetaceans studies - incidental MMO during other marine activities; information gathering through consultation; additional MMO or acoustic monitoring, dependant on initial findings;
- West African manatee studies - Consultation with villagers and fishermen in key areas;
- Avifauna studies - Consultation of local specialists; birds survey (observation) in the study area and analysis of field results;
- Fish and shellfish studies - Consultation with fisherman around key landing sites and markets; Consultation and collation of data from Ministry of Fisheries; Ecological assessment of the affect of habitats impacts on fish stocks; Collection of fish and shellfish samples to support health assessment.
- Marine Archaeology study - Expert review of geophysical datasets and wrecks database to assess impact; and
- Shipping and navigation - Collation of data from Freetown Port Authority; Consultation with key stakeholders and marine users; Mapping of existing and projected shipping.

Outcome of these detailed studies will be reported within the Stage 2 ESHIA

**Table 8-1 Ongoing Assessment Works Register**

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| Air Quality | Spot sampling for NOx, SOx | Systematic baseline sampling (passive, active, extended time) & dust. | Full baseline prepared for Stage 2 ESHIA | Further air quality monitoring and modelling to refine management practices. | As required | ESHIA Consultant |
| Air Quality | Assess air emissions from mining activities, stockpiles and power generation. | Air Assessment to ensure compliance with Air Quality standards (including background) using dispersion models. | Preliminary models in Stage 2 ESHIA | Project monitoring, modeling residual impacts to go into EMS. | Refined models throughout operations. | ESHIA Consultant with Project owners team |
| Air Quality | Assess noise from Airstrip at the mine once defined location and aircrafts are defined. | Noise assessment and Action plan for conflict areas. | Before Airstrip operation start up. | Project monitoring, modeling residual impacts to go into EMS. | Ongoing. | ESHIA Consultant with Project owners team |
| Noise | Assess noise from traffic (train and | Noise assessment and noise barrier | Before mineral transport start up. | Project monitoring, modeling residual | Ongoing | ESHIA Consultant with Project owners |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| | haul road), material processing at the mine site and port activities at populated areas. | design. | | impacts to go into EMS. | | team |
| Marine | Extensive hydrodynamics, water quality, sediment quality, mangrove mapping, ecological work & sub-tidal video already undertaken. | More detailed habitat mapping and surveys where residual impacts identified including avifauna survey, marine mammals observation, manatees and fisheries consultation. | Full baseline prepared for Stage 2 ESHIA | Project monitoring, residual impacts to go into EMS. | Ongoing | ESHIA Consultant with Project owners team |
| Marine | Initial hydrodynamic and sediment transport model built. | Refinement of hydrodynamic and sediment transport model. Set up of water quality model. Wet season | Preliminary models in Stage 2 ESHIA. | Refinement and updates to the models due to additional data availability and any changes to project description. | Refined models before operations start up. | ESHIA consultant and marine and coastal engineering team with Project owners team |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| | | metocean data to be collected. Use of model to assess water and sediment quality and sediment transport including wastewater, dredging plumes and accidental discharges. | | | | |
| Marine | Preliminary dredging assessment complete | Specific dredging impact assessment in development, including contamination analysis of cores and modeling of dredge plumes. | Timely completion of dredging impact assessment once required data becomes available, Stage 2. | Project monitoring and residual impacts to go into EMS. | Ongoing | ESHIA Consultant with Project owners team |
| Marine | Preliminary assessment of transshipment complete | Survey and assessment of transshipment anchorage once | Survey and assessment for inclusion in Stage 2 report. | Project monitoring and residual impacts to go into EMS. | Ongoing | ESHIA Consultant with Project owners team |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| | | options are identified | | | | |
| Waste | Practice guidelines drafted. | Review and update waste model based on Contractors estimates. | Before construction begins | Develop standalone Phase 1 waste infrastructure during construction and operations. | Before construction begins | ESHIA Consultant with Project owners team and requires detailed contactor management plans. |
| Ecology - Flora | Partially completed the study work predominantly at the mine area only and sections of the haul road. | Specialists scheduled to complete a program in June addressing Inland valley swamps along transport corridor) and target further areas. | To complete by Stage 2 ESHIA. | Conservation measures, set asides, capacity programmes etc – all need to be developed in conjunction with Stage 2. | To complete by Stage 2 ESHIA. | ESHIA Consultant with Project owners team |
| Ecology - Fauna | Dry season survey only. | Transitional wet-dry season survey and supporting study work with others | To complete by Stage 2 ESHIA. | Conservation measures, set asides, capacity programmes etc – all need to be | To complete by Stage 2 ESHIA. | ESHIA Consultant with Project owners team |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| | | (Tacugama) | | developed in conjunction with Stage 2. | | |
| Ecology - Aquatic | Walk over surveys in transitional dry-wet season only. | Dry season survey required | To complete after Stage 2 ESHIA - supplementary studies during the next dry season. | Project monitoring. There has been no opportunity for full dry season survey (which is regarded as critical for some phyla). | To complete after Stage 2 ESHIA - supplementary studies during the next dry season. | Seasonal differences in spawning behaviour, breeding habits, fish migration etc. |
| Soil and land-use | Collected samples from soils in targeted locations at mine, none from rail corridor, and at Pepel. Not yet assessed. Preliminary land-use cover information available | Future stock-pile materials (leachability) pending AMD study. Review of transport corridor aerial photography for land-use classification on transport corridor. | To complete by Stage 2 ESHIA. | Land-use management plans. | To complete by Stage 2 ESHIA. | ESHIA Consultant with Project owners team |
| Hydrology / | 2 rounds of | Completion of | Preliminary | Water management | Refined models | ESHIA Consultant |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| Hydrogeology | groundwater and surface water sampling and review across Phase 1 project. Sampling from available bores and community wells and streams (dry-season). | analysis and modeling for impact assessment. Further pump test results and logs from AML supply bores and further impact assessment. | models in Stage 2 ESHIA | plans required. Project monitoring, modeling residual impacts to go into EMS. | throughout operations. | with Project owner's team. |
| Human Health | Desk top study of human health baseline for Sierra Leone | Baseline health for regional populations | For Phase 1 ESHIA | Continued support of health and social mitigation measures (e.g., health clinics) | On-going | AML with social and health consultation. |
| Human Health | Evaluation of other discipline baseline results as they apply to human health impacts air, soil, water and food quality/quality, socio-economic | Further Baseline health and animal and plant tissue sampling. Contingent<br>on other studies<br>such air & noise, | Phase 2<br>ESHIA | Project monitoring, residual impacts to go into EMS.<br><br>Reviewing dependencies and determining health | On-going | AML with ESHIA team experts relevant to human health. |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| | status.) | land and sampling. | | impact strategy. | | |
| Human Health | Establish air baseline | Evaluation Phase 1 construction and operation activities effects through evaluation of the air dispersion model results. | Phase 2 ESHIA | Confirmation of predicted dispersion air modelling results with monitored air data. | On-going. | AML consultation with air and noise and human health teams. |
| Social (Baseline) | S-E baseline initiated (limited to 100 randomised, aggregated results), | Further baseline required. Prepare livelihood restoration plan. | To complete by Stage 2 ESHIA. | Project monitoring, modeling residual impacts to go into EMS. Maintaining living standards of PAPs at the same level or preferably higher than before relocation. | Ongoing | ESHIA Consultant with Project owner's team. |
| Social (Engagement) | Stakeholder Engagement Plan is ready | Allow PAPs to present their grievances in an open and | To complete by Stage 2 ESHIA and prior to relocation of | Project monitoring, modeling residual impacts to go into EMS. Maintain | Ongoing | Project owner's team. |

| **Discipline** | **Component Complete / Available** | **Component proposed before Stage 2 ESHIA** | **Timing** | **Component post Stage 2 ESHIA (i.e. go into EMP)** | **Timing** | **Responsibility** |
|---|---|---|---|---|---|---|
| | Consultative Committees operational. | unintimidating manner with predefined response timing explained to them in advance. Prepare grievance redress mechanism in consultation with local stakeholders. | PAPs. When resettlement committee is established. | grievance mechanism | | |
| Social (Resettlement) | RPF drafted. | Prepare RAP in consultation with local stakeholders | Prior to relocation of PAPs | Addressing impacts resulting from the resettlement process | Ongoing | Project owner's team/local stakeholders. |
| Community Development | CDAP for Haul Road already submitted.Loss of community infrastructure and meeting legislated community development requirements. | Prepare and implement CDAP. | Ongoing | Project monitoring, modeling residual impacts to go into EMS. | Ongoing | Project owner's team/local stakeholders. |

| Discipline | Component Complete / Available | Component proposed before Stage 2 ESHIA | Timing | Component post Stage 2 ESHIA (i.e. go into EMP) | Timing | Responsibility |
|---|---|---|---|---|---|---|
| Community safety | Outline issues identified | Prepare and implement community safety plan for construction phase of the Project. | Ongoing | Prepare and implement community safety plan for operational phase of the Project | Ongoing | Project owner's team/local stakeholders. |
| Cultural / Heritage | Pending consultations | Part of Social Commitment | Ongoing | Local – in country specialists to carry out | Ongoing | Project owner's team/local stakeholders. |
| EMPs | Haul Road EMP completed | In some areas will have to be addressed through risk register instead. | Ongoing | Specific EMPs for Mining, Pepel & Marine required | Ongoing | Project owner's team/local stakeholders. |

# 9 MANAGEMENT

An Environmental Management Plan (EMP) has been developed for the project (Appendix 18). The EMP will interact with the project feasibility study and the ongoing ESHIA. The EMP includes provisions for the control, mitigation, monitoring, reporting and auditing necessary to prevent or limit potentially adverse environmental, social and health effects from the construction and operation of the Project.

The EMP has been developed in parallel to the Stage 1 ESHIA. The intention is that the ongoing ESHIA process will inform the EMP as requisite monitoring data becomes available. The EMP provides a combination of environmental management practices as well as guidance on the principles and elements to be included as the EMP develops over time and becomes more substantive with the inclusion of further impact assessment information and data.

It is critical that an EMP is developed with the full participation of the owner/operators of the Project in order that appropriate management and monitoring responsibility is embedded and communicated to those who will be responsible for implementing these plans. AML have contributed significantly to the development of this EMP document in terms of fully endorsing the intent of the EMP and its content and structure. AML will be using the EMP as their environmental management reference for the project.

The EMP should be treated as a 'live' document that requires updating and ongoing development during all stages of the project. It is envisaged that the EMP would also in part be defined by, and implemented through, the Environmental Management System (EMS) adopted by AML.

In addition, the EMP at this stage aims to provide a basis for the development of component-specific (thematic) environmental management plans, which may be developed according to the requirements of the project schedule giving priority to early works.

## 9.1 Construction vs. Operational Management Plans

Construction management plans have already been developed as part of the current ESHIA works program. This includes the materials prepared for the haul road which were presented to SLEPA at an early stage to ensure the fast-tracked elements of the project are managed correctly. A Solid Wastes Management Practice Guidelines has also been produced for Phase 1 of the Tonkolili project.

Further management plans will be required for the construction, operations and closure of specific project components and facilities. An over-arching Environmental Management Plan (see Appendix 18) is needed to set out common approaches to standardise the specific plans. As the project progresses management plans will be developed to address potential issues during the construction, operations and closure phases and may include some of the following examples:

- Site Specific Social & Environmental Management plan (Site specific EMPs could be developed for numerous elements within the project, for example, processing plant, mine, tailings facilities, waste rock dumps, etc) (construction phase)
- Integrated Waste Management Plan (operational phase)
- Emergency Preparedness Management Plan (operational phase)
- Environmental & Social Monitoring Programme (operational phase)
- Security Management Plan (operational phase)
- Community Development Action Plan (operational phase)
- Closure and Decommissioning Plan (closure phase)

The following sections provide an overview of the management procedures, predominantly construction orientated that are being considered during the Phase 1 project activities. The operational stage management plans listed above are referenced in the Commitments Register and will need to be further defined and scoped as part of the Stage 2 ESHIA.

## 9.2 Soil management

***Introduction***

Many of the construction activities associated with the Phase 1 project will require some land clearance however this will depend on features that materialize such as community land use, environmental or community assets and/or ground conditions.

The haul road construction will involve clearance of a scout track for survey, ca. 6m width, followed by widening, either symmetrically or asymmetrically depending on environmental and social considerations. The scout track, but particularly the widening process will involve clearing of scrub predominantly (as routing through well wooded areas has been minimised wherever possible) and non-woody vegetation, followed by topsoil stripping. Topsoil is an important environmental and social resource, as it is key to supporting natural vegetation and farming processes. In addition, where vegetation is reasonably diverse, it contains the seeds and other propagules that under the right circumstances can allow recolonisation of the original vegetation assemblage, hence reducing the adverse effects on ecological resources.

There are other reasons for promoting rapid revegetation of disturbed areas not required for trafficking, such as reducing erosion and preventing washout and scouring of cuts and embankments, minimising fugitive dust emissions and contributing to landscape and noise screening.

***Procedure***

In all areas where depths permit, topsoil will be stripped to a minimum depth of 300mm and stored in a berm (or two berms) parallel to the alignment, for later use. Topsoil shall not be stored where it would result in blockage of formalized and agreed accesses or encroach onto farmland or where it impedes water flow. It will not be stored where it can readily be washed into streams and rivers and cause pollution.

Following finalization of works the intention will be to cover non trafficked surfaces and in particular cuts and embankments with topsoil to allow natural vegetation colonization.

In the case of the haul road construction, the height of the road train vehicles and the large diameter of the curved bends, it is unlikely that vegetation will become a safety hazard due to reducing sight lines. However, vegetation growth will be monitored by AML and the appropriate maintenance will be introduced.

## 9.3 Borrow Pits

Borrow pits and quarries to be used for this project will be managed with due consideration to social and environmental concerns and after appropriate permits, where required, are in place. The contractor will:

- Obtain AML approval before sourcing material from quarries, not opening borrow pits without informing AML
- Not open borrow pits within 100m of riverbanks or well forested areas, where a risk to water quality or forest resources is foreseen

For any new borrow pits, topsoil has to be managed carefully to allow for restoration of some temporarily affected areas. Where possible topsoil will be stripped off to a typical depth of 300mm and stored in windrow or berm for later use (e.g. landscaping embankments to reduce erosion during wet season). Topsoil will not be mixed with low fertility subsoil to facilitate its use for restoration needs.

In the case of the haul road construction, where hills or hummocks along the transport route contain suitable material, the relevant permissions will be obtained from local authorities, such as the Paramount Chief, if applicable.

## 9.4 Water management

***Introduction***

Water is of considerable importance throughout the project area, from surface water resources used for irrigation, fishing, washing, bathing and in some cases potable supply. It is therefore necessary to manage the construction works in such a manner that they forecast potential adverse effects and either design them out or apply mitigation to minimize negative effects.

- Disturbance to river banks will be minimised by limiting the movement of machinery close to the river's edge;
- The areas to be cleared will be clearly defined before the start of works and no works/clearance will be conducted outside this. If bridges are to be build, only higher trees will be removed, leaving the low growth vegetation on site to avoid erosion issues and surface run-off.
- Clearing near to water courses will be conducted to minimise any materials or plant entering or damaging the water course.

- Wherever possible, free-spanning bridge structures will be used with piled / trestle bridges as a secondary option; solid embankment / causeway structures will not be used;
- Consideration will be given to wet season flow in designing watercourse crossings including potential for blockage by trees and debris etc
- Flume pipes or pre-fabricated culverts will be used for crossings in areas with lower flow
- Machinery and other construction materials will be stockpiled no less than 50m back from the river banks or otherwise to prevent pollution;
- A pre-construction photographic record will be recorded to establish a benchmark against which post construction site rehabilitation can be monitored, where applicable;
- Sampling of water quality upstream, at work locations and downstream; locations and parameters to be determined at a later date in the design of the haul road and subject to agreement with environmental regulators as may be appropriate.
- Each river crossing will be surveyed to ascertain whether the river course is used as a transport route by locals and / or a water source;
- The river bank either side of the crossing will be protected with sand bagging or other means as may be necessary.
- Drainage control/ runoff protection including settling areas to prevent sudden influx of high sediment from earthworks, will be implemented.

In view of the impending wet season, early identification of wet areas such as inland valley swamps will be undertaken and where feasible, consideration will be given to early installation of flume pipes. This will reduce potential pollution of water courses and damage to agricultural areas, as many of these low lying areas are farmed by communities with dry season crops prior to the wet season crops. These measures will also enable contractors to access their portion of the haul road without being hindered by wet ground conditions following the onset of rains. An example of a flume pipe installed on a haul road is presented below in Figure 9-1.

**Figure 9-1 Example of a flume pipe access**

## 9.5 Swamp Areas & Riverine Vegetation

The swamp areas and riverine ecosystems are considered to have a high fragility and often a high agricultural value and, therefore, impacts will be limited to the maximum extent possible.

Project activities will be limited to the maximum extent possible in close proximity to seasonally flooded areas (swamps), rivers and associated vegetation; advice will be sought from a local ecologist where necessary.

Mitigation measures to keep impacts within acceptable limits include the following:

- Keep earth movements to the minimum required near riverine vegetation areas
- Avoid excavating material (borrow pits) or landfills near watercourses or inundated areas, and especially through riverine forest areas
- Where a river is not to be crossed a minimum of 50 m buffer zone from the riverine area will be respected (100 m in case of the Rokel River), wherever feasible
- Where disturbance is necessary, clear only the minimum to facilitate safe access and work
- Ensure workforce is aware of environmental and/or community sensitivities
- It is recommended that the haul road is diverted if an area with higher trees density is found. Rivers and seasonally flooded areas will preferentially be crossed through locations where vegetation coverage is less dense and/or valuable

- Clearly define and mark the construction locations before activities begin and avoid construction outside the defined area
- Control vehicle movements and plan to minimise journeys
- Plan subsequent restoration requirements. Make photographic records of areas to be disturbed before development, to assist in after-use site restoration, as applicable
- Practice progressive site clean-up through the life of the project

The risk of contamination of permanent and temporary surface water bodies will be minimised by the adoption of appropriate operating procedures as follows:

- Potentially contaminating liquids, such as fuel, oil and chemicals, will be stored and handled according to manufacturers' recommendations/MSDS, good industry practice and HSE plan stipulations (this also applies to subcontractors delivering supplies)
- Such liquids will be stored away from seasonally flooded areas and rivers
- Spill response equipment and procedures will be in place in all areas where the potential for spills exists
- Settlement pits excavated for the treatment of liquid waste will not be located near permanent or temporary surface water bodies and the pits will be appropriately lined; and
- To preserve surface water bodies from accidental spills or leakages, no temporary camps will be located within a preferential radius of 500m of the nearest river / water body; ground conditions to determine distance.

## 9.6 Work in Proximity to Communities

***Introduction***

The most important mitigation for potential negative impacts to the local community is to ensure that people are aware of the start of the activities and ensure their protection. This will be achieved in consultation with local authorities in all affected communities before construction starts.

Appropriate authorities will be consulted with regard to access creation, temporary camp locations, and advice for dealing with any particular sensitivities including the existing infrastructure (community water wells, schools and roads), agricultural and grazing areas and society bush.

With the construction of the haul road there will be an increase in vehicle traffic in the area that will lead to potential increases in vehicle-related incidents or accidents. The health and safety of the local population is a primary concern throughout the project.

Mitigation measures designed to minimise the risks include the following:

- The adoption of driving regulations to be adhered to by all personnel including subcontractors
- Strict enforcement of speed limits

- Careful planning of all journeys, particularly in areas where members of the public may be encountered
- No night driving except in an emergency or with specific management measures
- Implement a journey management system

### 9.6.1 Noise emissions

Impacts on local air quality (noise) resulting from the use of heavy machinery and equipment and transport activities can be minimised by carefully planning vehicle movement and using machinery that has been certified and appropriately maintained.

Recommendations for minimising noise include the following:

- Carefully plan mobilisation of personnel and equipment to limit transport to essential travel;
- Noise-efficient vehicles and equipment will be used and serviced regularly (in accordance with the manufacturers' recommendations) to ensure efficient operation and minimal emissions;
- Keep operations as distant from populated areas as possible and limit operations during morning and evening times to avoid causing nuisance. Restrict the number of engines working at night;
- In general, plan the project so that equipment and vehicle use are minimised (e.g. in terms of staff movements and the delivery of supplies);
- Switch off generators and engines whenever equipment or vehicles are not in use; and
- Avoid running engines at excessive speed.

### 9.6.2 Air Quality (Air Emissions)

Local reductions in air quality will result from a number of factors, including the use of diesel powered equipment, dust generation during civil works and potential vapour emissions during fuel transfer or maintenance activities or from hazardous material handling and storage.

Air quality may be reduced by waste incineration. In order to minimise the impact on air quality from waste incineration, these activity will be reduced when conditions are such that impacts could be exacerbated (e.g., during calm and high pressures situations that might help accumulate air pollutants at one area). In addition, the general aim will be to minimise the quantity of waste to be incinerated.

General procedures for minimising impact to air quality from vehicle emissions will be in place for the duration of the programme, including the following:

- Consider fuel efficiency when selecting equipment and vehicles;
- Many of the items listed in the noise section above.

### 9.6.3 Dust & Particles Generation

Dust generation (from heavy vehicle use, line clearance, earth movement, etc), may also contribute to a degradation of local air quality. Dust and particulate emissions will be mitigated by observing the following dust suppression measures, as appropriate:

- Use of water trucks for regular watering of unsealed roads
- Operator awareness training on the causes of dust and how it can be minimised (in particular to unpaved surfaces and stockpiles)
- Use of surface binding/sealing agents on high-traffic surfaces
- Minimise traffic on unsealed roads
- Strictly enforce speed limits when driving on unpaved roads
- Limit civil works involving earth movements during periods of high winds
- Cover truck loads of earth or excavated materials
- Minimise dust generating activities when conditions could exacerbate the impacts (e.g., during high winds)
- Avoid off-track driving
- Minimise vehicle use

## 9.7 Work near Society Bush, Thick Forests & Protected Areas

Society bush areas are important both for local communities, due to the use of these areas, and for conservation purposes, since these areas host important flora and fauna.

The importance of vegetation in the area will be clearly communicated to all project personnel. Other remaining thick forest areas are also important in terms of conservational values since they represent the last remnants of what used to be the main habitat in the project areas. Protected areas, independent of their state of conservation, are safeguarded by Sierra Leone laws and works will not be undertaken in these areas unless appropriate permits issued by the Ministry of Lands, Country Planning and the Environment are in place, as applicable. The general rule is that no Society Bushes (or large trees in any areas) are to be disturbed except in exceptional circumstances.

A local ecologist and a local community representative will view the proposed haul road locations where a Society Bush / thick forest is located or flora of particular interest has been observed.

General recommendations for vegetation clearance include:

- Avoid clearance through thick forests
- If clearance is required, consult with AML to ensure appropriate permits have been obtained in advance

- Consult with communities and AML community liaison to identify "no-go" areas (e.g. Society Bush)
- Do not cut trees for firewood
- Cut large trees with chainsaw rather than bulldozing, to avoid unnecessary soil disturbance

Fires will be strictly prohibited outside temporary camp sites, and fires within the camps will be appropriately controlled. Local wood will not preferentially be used as fuel for temporary camp activities.

Recommendations to prevent deterioration of habitats may be provided by a local ecologist / zoologist (or an ecology survey team) and will be followed.

Furthermore, the following measures will be considered:

- Inform personnel that hunting during their time in the area will be prohibited.
- Raise and maintain personnel awareness of the importance of not damaging plants and animals. For example, most of the monkeys that could be encountered are likely to face conservation threats.
- Control personnel movements. Restrict personnel from the most sensitive areas.
- Create and implement a site restoration plan to mitigate impacts on Society Bushes or any other forest areas with significant tree growth to the greatest extent possible.
- Access roads locations will be selected in a way that minimises effects on sensitive fauna. Block access routes that could lead poachers to areas where endangered species might roam.

The risk of injury to fauna from vehicle movements will be minimised by the adoption of safe speed limits and a ban on night driving, except in emergency situations.

Neither temporary camps nor waste disposal areas will be established near society bush / thick forests / protected areas (100 metres buffer zone). Mature trees stands will be avoided as far as possible, except if the main trees in the stands are palm trees.

Noise, air pollutant emissions and dust generation may also impact forested areas.

Impacts on local fauna likely to inhabit Society Bush areas and other forested strips resulting from noise generation produced through the use of heavy machinery and equipment and transport activities can be minimised by carefully planning vehicle movement and using machinery that has been certified by international standards and appropriately maintained.

Dust generation (from heavy vehicle use, line clearance, earth movement, etc), may also contribute to a degradation of the floral community. To avoid impact on flora from dust and particulate emissions the dust suppression measures previously presented will be applied.

## 9.8 Waste management

The development of construction and mine workers camps will generate significant quantities of typical household solid waste, at varying times throughout the project. It is recommended that an approach to dealing with waste is developed prior to the construction of the camps and that the following high level principles are adopted:

- Where possible waste will be managed in accordance with the waste hierarchy;
- Potential disposal sites will be identified at the outset and an assessment made of the most appropriate treatment / disposal method, based on the availability and of fit for purpose disposal sites;
- Waste will be separated at source, the extent of which to be determined by the availability of local recycling markets and final disposal options;
- Local community will be engaged to develop a mechanism for recycling materials back into the local area;
- Liaise with AML CLO to identify suitable locations for temporary waste facilities and identify existing waste facilities in project areas that can be used for waste disposal
- Waste storage and collection provision will make consideration for local climate, and in particular for pest and odour control;
- Locate waste collection areas at least 1km from populated areas and 500m from agricultural areas
- Do not discharge any waste into rivers; grey and black waters to be disposed in lined pits sited close to workers' camp(s) or otherwise as appropriate so as to avoid contamination
- Do not leave any waste on site: workers must carry bags to collect all wastes for return to camp waste storage facility
- Consideration will be made for composting of organic fractions;
- It is understood that burning of waste is widespread practice through the region, this will not be undertaken without due consideration for the appropriate air quality standards;
- The local waste regulatory body will be engaged at the earliest opportunity with respect to any waste management proposals;
- Ultimately an integrated approach will be adopted with respect to all worker camps waste management.
- Litter and waste collection systems are to be implemented and litter bins covered at all sites. Hard waste at site has to be removed to the central camp for sorting and burying/ burning/ re-use as appropriate.

Vegetation clearance will generate almost exclusively organic wastes that will be suitable for self biodegradation in the surrounding forest.

- Set down areas for any useful timber will be identified at the outset, including engagement with the local community as to suitability of location;
- The vegetation may contain elements of valuable hardwood, where possible this will be separated at source by machine and procedures set in place in order that the local community can safely recover elements of hardwood;
- Small fractions of vegetation may become contaminated with diesels, hydraulic oils etc. these will be stockpiled separately and disposed to an appropriately facility to be determined in liaison with AML;
- Given the volume of organic waste likely to be generated the potential for composting will be considered and additional proposals may be developed accordingly.

## 9.9 Fuel & Spillages

### 9.9.1 Refueling & Maintenance Procedures

Oil and fuel storage and refuelling activities will be guided by the following principles:

- Store all fuels and oils within secondary containment (double skinned tanks, impermeable bunds, drip trays or plastic sheeting on sand bags)
- Provide a sealed surface refuelling (or spill prevention) and machinery maintenance area at the workers' camp(s)
- Do not carry out refuelling or maintenance works outside designated area
- Carry spill response and clean-up materials to deal with any accidental spills of fuels and lubricants
- Train designated workers in fuels storage and handling and spill clean up
- Do not store quantities of fuels and oils within 100m of water courses, swamps or drainage ditches

It is envisaged that some refuelling and maintenance requirements will generate hazardous wastes such as hydraulic oils, heavy metals, lubricants etc. These will be identified, removed and kept separate from other waste materials to avoid further contamination and be disposed of in accordance with all relevant legislation and best practice guidelines at point of origin or at an alternative suitable site.

### 9.9.2 Spill response

Accidental events have the potential to cause major impacts. Mitigation will include the following guiding principles and are discussed further below:

- Prevention: Following standard protocols and procedures adhering to best practice will help avoid accidental event occurrence. Best practice includes personnel training and setting adequate health, safety and security measures.
- Quick response: Preparing an Emergency Response Plan (ERP) for implementing countermeasures against non-routine events.

***Spill Prevention Control and Countermeasure***

Vehicles and equipment shall be serviced regularly in a manner which minimises spills and leaks. Service areas will be designated and shall be used for vehicle maintenance. Heavy equipment (e.g., large trucks) will produce large quantities of waste oils and lubricants that need to be stored in labelled containers and removed from the site. Use drip pans, or trays, for protection from leaks during vehicle maintenance. Machinery maintenance and refuelling will only take place at designated, preferably lined areas; the construction of dykes and berms may be appropriate at the site in a manner that will contain any fluid spills that might occur during camp operations.

- A written procedure for inspecting and testing pollution prevention equipment and systems will be prepared and maintained at the worker's camp. The procedures will form part of the overall spill prevention control and countermeasure plans.
- All tanks to be subject to periodic integrity testing (visual inspection), taking into account tank design and use.
- Spill cleanup and emergency response equipment to be centrally located and staff trained in its proper use.
- Personal protection equipment to be located at all fluid handling points, i.e. in vehicle yard, generators and workshops
- Relevant emergency response equipment to be located at working points, equipment to include as a minimum: First aid - including eyewash; Fire extinguishers; Sorbents; and Personal protection equipment (hardhats, visors, gloves, aprons, face mask)

***Contingency and Emergency Response Plan***

Contractors shall develop an Emergency Response Plan (ERP) to deal with incidents that occur during the construction programme.

Facilities and procedures to prevent spills shall be in place during operations, including:

- Provide safe oil and chemical packaging and storage;
- Provide containment around oil-containing areas and equipment;
- Use efficient oil/water separators where necessary; and
- Operate safe fuel transfer procedures.

Emergency response plans that address spill incidents shall be prepared during the planning phase for specific locations. Plans shall include the following:

- Identification of sensitive resources and priority protection areas;
- Identification of internal emergency organisations, responsibilities and resources (human and equipment and materials) for spill response. A clear chain of communication to ensure a rapid emergency response will be established. Periodic refreshers will be conducted;
- Training of personnel at the beginning of the construction programme on health, safety and security requirements with clear guidance on emergency responses; and
- Spill response and cleanup strategies.

In case of a spill, contaminated soil materials will be identified, removed and kept separate from other construction waste materials in order to avoid further contamination and will be disposed of in accordance with all relevant legislation and best practice guidelines at point of origin or at an alternative suitable site.

A chemicals and hazardous materials management plan shall be adopted, taking into account relevant regulatory requirements and environmental considerations that include the following:

- Provision of Material Safety Data Sheets (MSDS) and handling procedures for hazardous chemicals and materials;
- Carry spill clean-up material on large vehicles in case of fuel and hydraulic fluid leaks;
- Provision of segregated and contained storage areas; and
- Use of low impact chemicals and materials as far as practicable.

## 9.10 Agricultural areas

- The details of the haul road construction activities will be discussed with local authorities prior to construction start and this process in currently ongoing concomitant with the design. The discussions will include concerns regarding disturbance to agricultural and grazing areas and activities planned near human settlements.
- AML CLOs are in ongoing contact with relevant local residents prior to commencing works in an area
- Agricultural land is to be avoided to the maximum extent possible; and contractors/AML are and will continue to document and photographically recorded agricultural activity prior to commencing work in or near agricultural land
- Agricultural and grazing areas will be avoided unless adequate compensation or alternative land schemes are agreed; this is an ongoing initiative with the EWCC mechanism.
- Residents will be allowed to recover material and private property prior to commencing works, if applicable
- Land inventories will be developed and agreed with local authorities. These will include records of location, land area, crops grown and allocated owner. Photographic records will be employed.

- Temporary workers' camps construction and borrow pits will avoid agricultural areas.
- No waste disposal will be permitted in the vicinity of agriculture areas (within a 50m radius).

## 9.11 Site Selection for Camps

***Introduction***

This section is included here to address the issues associated with establishment of any temporary camps and facilities required during construction. Currently contractors are accommodated in existing hotels, such as in Makeni or AML guest houses or at the mine camp, however as staff numbers ramp up there will be a need to establish camps along the route local to the work site.

***Procedure***

Site selection for temporary workers' camps will be guided by the following principles:

- Camps must, as far as possible be located on previously cleared or sparsely vegetated, flat areas along road alignment
- Agree location of workers' camps with local chiefs; liaise with AML Community Liaison Officer(s) (CLO) designated to the area
- Camps must be located at least 500m from villages and well outside active agriculture areas where feasible
- Camps must be located at least 100m from densely forested areas and 100m from rivers / swamps
- Personnel movement outside camps will be restricted
- Hunting will be prohibited
- A photographic record of camp(s) area(s) will be made prior to site clearance

Access roads to be opened for accessing temporary working facilities and infrastructure will follow these principles:

- Use existing roads as access roads wherever possible taking into account health and safety of other (community) users
- Align new access roads, to the maximum extent possible, along the haul road alignment to avoid excessive vegetation clearance
- Access roads must avoid forest and riverine vegetation wherever possible
- Minimise width of access roads and give attention to potential wash-out and offsite pollution

### 9.11.1 Transport Activities / Equipment Use

Transport activities will be regulated by the following principles:

- Restrict vehicle movement to marked tracks only
- Avoid night time driving wherever possible or implement measures to reduce accidents, such as flagmen and signage
- Enforce speed limits (30km/h maximum near villages); lower through villages
- Track and road crossings:

  - Ensure advance liaison via CLO; activities must not start without prior notification of proposed works to local communities

  - Ensure safety of road users via use of flagmen and signage

Furthermore, to avoid nuisances to local communities and impacts to fauna and flora, the following will be adhered to:

- Always cover trucks carrying material likely to generate dust or otherwise ensure dust is not an issue
- Turn engines off when machinery is not in use / stationary
- Limit illumination sources and generator use at night

Carrying out construction operations during the night is potentially dangerous and will only be undertaken if the contractor considers the activity absolutely necessary due to time constraints (i.e., to avoid the start of the wet season), and under the following conditions:

- Where a prior investigation of the area to be surveyed has been carried out during the daytime so that tracks and GPS co-ordinates are known to the crew
- Where drivers have received night driving training

### 9.11.2 Camp Site Decommissioning

Once construction is completed, temporary facilities will need to be removed. Site restoration / site rehabilitation will be undertaken following best-practice and ensuring local authorities are informed of the process; some facilities may be left for future community use and this will be determined at a later date.

In order to complete effective restoration measures, the following principles will be followed:

- Remove all waste from site and dispose of in an appropriate facility
- Grade all areas to original topography as far as possible
- Infill all borrow pits and landfills with natural material and cover the abandoned site with topsoil to allow vegetation re-growth
- Compare final state of camp area after decommissioning with pre-clearance photographic record
- Determine need for further restoration based on “before and after” comparison

For further information see Appendix 1 for the Haul Road Environmental Management Plan.

# 10 STAKEHOLDER ENGAGEMENT PROCESS & RESETTLEMENT PLANNING

## 10.1 Stakeholder Engagement

### 10.1.1 Background

A program of consultation should be established to allow for stakeholder engagement that will inform regional authorities and local communities in the run-up to implementation and beyond. This process has already been initiated. This section provides an outline of the activities intended to deliver a participatory approach to dealing with social aspects of the Phase 1 component of the Tonkolili Iron Ore Project.

As the Phase 1 Development program is primarily along a linear corridor, this consultation package is designed primarily to address issues relating to replacement of agricultural land and compensation for agricultural crops. Impacts on structures and houses have been minimized during the design but some instances of relocation have been identified.

The modalities of relocating these structures away from the alignment are embedded into the consultation process as described below.

### 10.1.2 Affected Chiefdoms

The following chiefdoms will play host to sections of the Phase 1 program:

1. Tonkolili District
    a. Kalansongoia
    b. Kafe Simiria
2. Bombali District
    a. Safroko Limba
    b. Makari Gbanti
3. Port Loko District
    a. Buya Romende
    b. Maforki
    c. Lokomasama

### 10.1.3 Early Works Chiefdom Committee

Preparation meetings were held with the paramount chief of each of the listed chiefdoms. The need for a chiefdom level committee was discussed with local authorities (district council chairmen) and a draft of the Early Works Chiefdom Committee (EWCC) terms of reference (see Section 11.3.2 below) and preliminary participation lists prepared.

***EWCC Structure***

*Membership*

The EWCC will be tasked with high level discussions on relocation, identifying alternative agricultural land and compensation deliverables. In order to achieve this, the committees include the following key players:

1. Paramount Chief
2. Relevant Section Chiefs
3. District or government heads of department ensuring that all departments responsible for all valuations are represented.
4. Political leaders (MP's and Councillors)
5. AML
6. NGO's, women's and youth groups

This was subject to deliberations within the introductory EWCC meetings held in March 2010.

Minutes of EWCC meetings held to date are included in Appendix 19.

*Scheduling*

The EWCC will sit once a month in accordance with the schedule agreed at the EWCC introductory session. It is envisaged that Community Sensitisation Meetings will be held under the guidance of each Section Chief in the period between EWCC meetings.

Additional meetings will be held at any level if the need arises.

*EWCC Operating Philosophy*

The EWCC will achieve progress through the consensus of it's members.

***EWCC Terms of Reference***

The EWCC will act as the primary executive body in all matters relating to social issues facing the early works program. It will be constituted in such a manner as to be regarded as the primary representative voice of those affected by the early works program and recognised by AML as such. Under the overall authority of the Paramount Chief, its reporting officer, the EWCC has the following functions:

- To act as the primary channel of communication between the various interest groups/organisations involved in the social aspects of the early works programs. In particular, it will serve to facilitate communication between AML and the affected population;
- To serve as the court of first appeal to solve any problems that may arise relating to the early works program. If it is unable to resolve any such problems, it is to channel them through the appropriate grievance procedures;
- To establish access to alternative agricultural land and if necessary, locations for housing and structures of affected households;
- To establish compensation mechanism based on best practice and national legislation. This will include asset inventories, entitlements, valuations, compensation methodology and timing;
- To implement the agreed measures in relation to relocation (land and structures).

AML will provide both the financial input into the compensation process as well as significant additional managerial and technical expertise into supporting the process. The following is anticipated to be the role played by AML. It will:

- Ensure maximum participation of the affected people in the planning of their own relocation circumstances;
- Accept financial responsibility for payment of compensation and other designated relocation related costs;
- Pay the affected farmers compensation to the amounts agreed or establish mechanisms that allow for replacement of assets when it is preferable to do so;
- With the EWCC, ensure monitoring and evaluation of the affected households and the undertaking of appropriate remedial action to deal with grievances and to ensure that income restoration is satisfactorily implemented and food security achieved.

### 10.1.4 Community Sensitisation Meetings

The purpose of these meetings is to provide closer links to the directly affected communities to ensure their participation in the decisions that will affect their future. It will also allow for more efficient planning for surveys and relocation and establish a forum in which compensation for personal and community assets such as society bush can be discussed.

These meetings will be coordinated through the EWCC and attendance will be limited to selected GoSL departments, the relevant section chief, AML, NGOs that may operate in the area, the village chief and open attendance for village residents.

### 10.1.5 Grievance Mechanism

A grievance mechanism will be discussed with the EWCC which will define the protocol for receiving and responding to questions and concerns raised by the villagers.

Grievance forms will be made available at predetermined locations within a reasonable distance from the villages. Suitable staff will be required at each location in order to allow for accurate translation into English.

### 10.1.6 Resource Requirements

This section describes the resources that will be provided to undertake stakeholder engagement for the Phase 1 program.

1. Staff – On top of existing community relations staff at the mine site and Pepel, AML has employed sixteen community liaison staff (Community Liaison Officers or CLOs). Training of these CLOs has been undertaken by senior AML staff and WorleyParsons. A Social Coordinator has been assigned by AML with the task of coordinating consultation over all areas.

2. Resettlement Specialist – AML have engaged the services of a suitably experienced resettlement/social specialist to lead the social team through the three phases of the Tonkolili Project.

3. Field Staff Equipment – Each field team should have a GPS and a camera to record location and condition of land and structures. It would be advisable for the construction contractors to be equipped with cameras to record their progress as well.

It is recognized that to achieve efficiencies in mitigating social impacts resulting from the implementation of the Phase 1 Program, AML will also provide:

- Offices or contact points/persons in all Phase 1 project areas to ease communication. These should be open to all stakeholders.

- Agricultural extension services – Loss of agricultural land is possibly the most severe impact on affected persons as their livelihoods revolve around farming. Although alternative land is defined as a mitigation measure, access may be reduced for them and others in surrounding communities. Because of this it may become necessary to provide the services of an agricultural extension worker to train them on improved agricultural techniques designed to increase yields and ensure food security.

- Community Safety Plan – As community safety has been highlighted as a concern by various stakeholders a formal Community Safety Plan should be developed.

### 10.1.7 Freetown Stakeholder Forum

AML presented a project update and overview to a broad spectrum of high level stakeholders at the Taia Resort Hotel in Freetown on Monday 17th of May. This event was well attended and provided significant insight into local expectations and concerns. A record of the proceedings of the presentation is included in Appendix 19.

The presentation was attended by the following people and organisations:

**Chiefdoms**

1. Kaffu Bullom
2. Maforki
3. Makari Gbanti Chiefdom
4. Buya Romende
5. Bombali Shebora
6. Safroloko Limba
7. Kalansogoia
8. Kafe Simiria
9. Sambia Bendugu

**Media**

1. Sierra Express Media
2. Sierra Leone Broad Casting
3. Global Times
4. Standard Times
5. Awoko News Paper
6. Radio Democracy
7. Peep Magazine
8. Exclusive Newspaper
9. Spectator Newspaper
10. UN Radio
11. State House Press

**District Councils**

1. Port Loko
2. Bombali
3. Tonkolili

**Government**

1. Ministry of Education, Youths and Sports
2. National Revenue Authority (NRA)

3. Office of National Security (ONS)
4. Ministry of Information
5. Ministry of Energy and Water Resources
6. Sierra Leone Environmental Protection Agency (SLEPA)
7. Ministry of Mineral Resources and Political Affairs
8. Ministry of Presidential Affairs and Public Relations
9. Ministry of Agriculture, Forestry and Food Security
10. Land and Water Division
11. Oversight Committee on Minerals (House of parliament)
12. Oversight Committee on Environment (House of parliament)
13. Members of Parliament (affected areas)
14. NaCSA
15. Oversight Committee on Agriculture (House of parliament)
16. Sierra Leone Extractive Industries Transparency Initiative (SLEITI)

**Other Institutions**

1. CEMMAT
2. CSSL
3. National Farmers Federation Sierra Leone (NAFFSL)
4. ENFORAC
5. T.S. Company
6. Coalition Network for the Protection of the Environment (CNWPE)
7. Campaign for Good Governance (CGG)
8. Youth Coalition
9. National Movement for Just Mining (NMJD)
10. National Coalition on Extractives (NACE)
11. Green Scenery
12. Sierra Labor Congress
13. United Miners Union
14. Sierra Port Authority

## 10.2 Resettlement Policy Framework

The Resettlement Policy Framework (RPF) outlined in this report provides guidelines for the compensation of those who will be affected by physical and/or economic displacement. In line with IFC Performance Standard 5, it aims to:

- Clarify the legal requirements and principles for compensation for loss of property, livelihood and relocation or resettlement (of directly affected people) in order to ensure that project affected people (PAP) will not be negatively affected by resettlement or economic displacement.
- Describe the social context in which the resettlement will take place.
- Identify affected parties.
- Define the actions and tasks that need to be undertaken to plan the resettlement programme.
- Define the roles and responsibilities necessary to develop a full RAP.
- Describe the arrangements for funding resettlement and compensation as well as a timeline for activities.

These objectives are addressed in the RPF document (Appendix 20). Key action items arising from this are summarised below.

### 10.2.1 Resettlement Planning Actions

This section of the RPF sets out the main tasks and procedures required to develop a RAP for the Project. It outlines the procedures for identification of affected people, assessment of eligibility for compensation, identification of host areas for resettlement, procedures for resettling and compensation, budget categories, procedures for monitoring and evaluating the resettlement process and the necessary institutional arrangements for execution of the resettlement and compensation process.

It is important to note that this conceptual document differs from a RAP, which sets out in detail the strategies for resettling people affected by land acquisition. In order to develop a full scale RAP there are several additional requirements:

- Detailed final information about the mining process and the location of the different project components.
- A detailed social baseline.
- The RPF needs to be debated and approved by the various stakeholders.

### 10.2.2 Minimising Resettlement

The IFC standards require that resettlement be minimised as far as possible. The primary reason for resettlement in the mine area is the location of the mineral resource and technologies for its exploitation, in this case open pit mining. The location of the pits is fixed by the location of the mineral resource; and will invoke involuntary resettlement. As such, resettlement cannot be minimised in this area.

More broadly resettlement will be influenced by the development and location of project infrastructure in the mine area, the transport corridor and at the port facility. Such infrastructure includes rock dumps, processing plant, tailings storage facility, stockpiles, offices, workshops, stores, power generation, housing, the railway line and port facilities. Resettlement is also influenced by health and safety considerations (e.g. human settlements should be an appropriate distance from hazards).

AML's engineering and environmental and social consultants should be working in tandem to ensure that infrastructure across the Project area is developed and located in a way that minimises resettlement.

The following has been done in this respect:

- The rail loop, which requires a large area, has been positioned at the mine site where population density is lower than at Tagrin, the other option;
- The rail and haul road alignment has been designed to avoid villages using Quantum optimisation software;
- Construction and operations camps are planned in areas with low population densities;
- Waste rock dumps have been optimised to minimise additional area required beyond the fly rock zone;
- Refurbishment of the Pepel rail and port is to be undertaken on the existing footprint to minimise the need to acquire more land for project operations;
- At this stage, nonetheless, it is certain that there will be a requirement to relocate villages either partially or entirely.

### 10.2.3 Identifying Eligibility for Compensation

The definition of eligibility requires an assessment of the type and number of people residing or using the affected area and the types of loss they incur. This is outlined below.

***Project Affected People***

Project affected people (PAP) can be divided into two categories:

1. Affected household: households[10] are affected if one or more of its members suffer loss of assets, land and property, and/or access to natural and/or economic resources as a result of the project activities;
2. Host area households: households in any of the host resettlement sites (sites where people may be resettled), whose infrastructures and/or resources will be impacted.

[10] For the purposes of this RPF a household consists of people who are economically dependent on each other and who typically live in the same compound and eat from the same pot.

***Types of Loss***

PAP may incur a loss or disruption of access to the following assets and resources:

1. Buildings, homesteads and related structures (such as storage facilities, graves);
2. Land;
3. Permanent or temporary use of agricultural land;
4. Sacred sites;
5. Mining deposits (artisanal mining);
6. Natural plant and animal (including fish) resources;
7. Small enterprises;
8. Communal infrastructure (wells, boreholes, irrigation works, schools, clinics);
9. Access routes (between villages, to towns and other resources i.e. fishing beaches).

A detailed description of the number and type of beneficiaries in terms of the various eligibility criteria will need to be provided once the exact location of the Project infrastructure is known and a census has been conducted. At this stage, however, the following information is available:

***Homesteads***

It is envisaged that 47 villages will have to be partially or entirely resettled. It is estimated that 2,441 houses and related structures will be affected.

***Land***

It is envisaged that 12 674 ha will be affected by the Project; 11,507 ha at the mine site, 288 ha along the rail corridor and 880 ha at the Port. These belong to various villages/towns. A land survey will need to be conducted to assess which land belongs to which villages and to which landowning families.

***Agricultural Crops***

Approximately 215.30 ha of currently cultivated land will be affected by the Project; 95 ha at the mine site, 56 ha along the rail corridor and 64 ha at the Port. A survey will have to be conducted to assess the number and size of fields of affected households, as well as the crops cultivated.

***Tree Plantations***

Approximately 21 ha of current plantation will be affected by the Project; 8 ha along the rail corridor and 12 ha at the Port. A survey will have to be conducted to assess the number and size of plantations of affected households, as well as the trees/plants cultivated. The main plantations are palm, mango, banana and pineapple.

***Forests***

Some forested areas may be affected. These serve several needs. For instance sacred bushes are an important cultural heritage of the local people in the Project area and significant for their spiritual well being. It is likely that several sacred bushes will be affected. Sacred bushes will need to be identified along with other potential uses of the forest.

***Sacred Sites***

Sacred sites include such sites or places/features that are important for customary practices, tradition and culture, and thus considered sacred. Sacred sites include tombs, graves and cemeteries and ritual sites.

In general people bury their deceased in tombs near their homestead. Resettlement of villages may involve the relocation of graves.

***Artisanal Mining***

The social description of the affected villages in the mine lease area shows that households maintain a mixed livelihood consisting of mining as well as farming.

There are a significant number of artisanal miners (exact figures be established during RAP preparation) working in and around the concession area, including in the areas which will be required for the mining infrastructure. Consequently these miners may lose their livelihoods.

***Natural Plant and Animal Life***

Some areas used by local residents for collection of natural resources (fire wood, wild foods, timber, medicinal plants, game) may be affected by the mining and transport infrastructure. Generally, however, natural resources used by the local population are plentiful in the larger area and the loss of the area needed for the project may not require compensation. This will however need to be verified by the census conducted as part of the RAP.

The port lease area may impact on the access of fishermen to the beach (i.e. homesteads of fishermen may need to be moved or access to the landing and fishing beach may be constrained or removed).

***Small Enterprises***

The villages and towns affected by resettlement are host to several small businesses. These businesses are generally run from small structures near the homestead or from the homestead itself. The exact number of small businesses affected will need to be identified.

***Social Infrastructure***

The villages affected by physical resettlement are host to schools, clinics, community halls, drying areas and potentially other communal infrastructure. The RAP census will need to identify all communal infrastructure which may be affected.

***Access Routes***

The mining and transport infrastructure may have impact on communications between villages and towns and villages and agricultural fields, cutting some residents off from their resources. Loss of livelihoods as a result of this communication severance will need to be assessed and compensated for.

See Appendix 20 for the full Resettlement Policy Framework.

# 11 AUDITING, MONITORING & CONTINUAL PERFORMANCE IMPROVEMENT

## 11.1 Introduction

This section gives details of the monitoring and reporting elements of the environmental and social management process, which forms part of the overall management system that is under development by AML, in conjunction with design of the project as a whole.

To date the ESHIA has focussed on providing the ‘assessment’ stage and setting out the scope of potential impacts with plans or commitments setting out how to manage and mitigate the impacts associated with the project.

According to best practice principles (Equator Principles and IFC Performance Standards) the assessment and management plans should be incorporated through a Social and Environmental Management System (SEMS). Such a system is required to make sure that environmental and social activities are coordinated, resourced and focused and audited. This has been initiated through the EMP (section 9), which provides a framework for environmental management and delivery of mitigation and will be continually developed and expanded as detailed designs and assessments progress.

## 11.2 Monitoring

Monitoring is an essential element in evaluating performance to agreed targets and objectives, as it provides information on the observed effects (positive and negative), allowing feedback to those responsible for carrying out the task monitored.

For the Phase 1 project it is envisaged that the monitoring will involve:

- Ongoing site-based inspections by AML Environment and social staff, who will be auditing performance and compliance to contract document scopes of work and preparing advice / instructions to guide the Phase 1 works;
- Inspection visits and audits by Environmental regulators such as SLEPA and/or their nominated monitoring agents (also see Appendix 1, project monitoring and audit arrangements);
- Inspection visits and audits by independent consultants, appointed by AML, who will produce monitoring reports that SLEPA can access and comment on. Currently this is being managed under the ESHIA process with in-country consultants (CEMMATS) responsible for developing the monitoring data.

An Environmental Information System (EIS) will be established to record the results of monitoring and evaluation of compliance to EMPs and project standards. This EIS will be managed by AML Environmental staff, in conjunction with effective liaison with the road contractors, who are also charged with an element of self-monitoring.

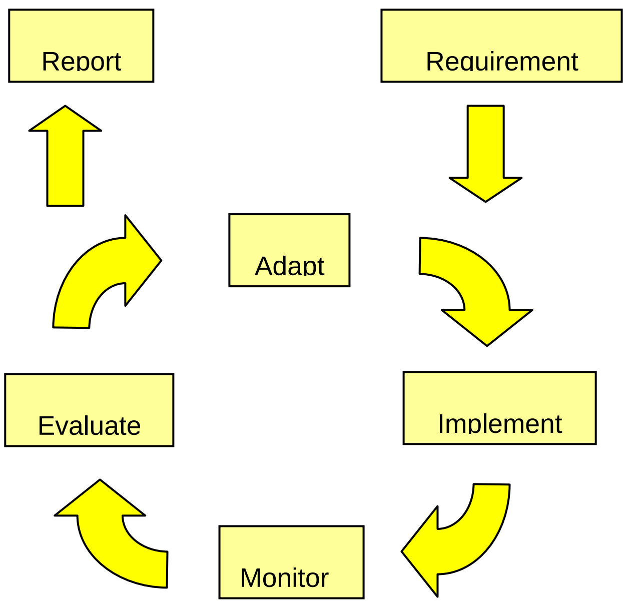
Inspections and surveillance of work activities and sub-contractors will be undertaken on a day-to-day basis by staff with environmental responsibilities, i.e. Environmental Officers as well as Foremen/Superintendents, Project Engineers and Construction Managers.

The activities will be monitored for compliance with the HSE and SEMS and will include:

- Compliance with contractual requirements
- Knowledge of and compliance with the EMP, work procedures and environmental controls used on site
- General work practices
- Effectiveness of environmental protection measures
- Maintenance of environmental protection measures

The monitoring strategy proposed for the project can be termed "Adaptive Environmental Monitoring". It is adaptive in the sense that the responsible party must adapt its methods and activities to the ongoing design and implementation and prevailing environmental conditions in a continuous process. Adaptive Environmental Monitoring is in fact a cyclic process as illustrated in Figure 11-1.

**Figure 11-1 The cycle of adaptive environmental monitoring**



## 11.3 Incident Investigation and Reporting

All incidents will be documented, investigated and action plans established in order to prevent reoccurrence if possible. Where lessons are learnt and/or current procedures are identified as being ineffective, the EMP will be revised accordingly.

An environmental or social investigation includes the following basic elements:

- Identifying the cause, extent and responsibility of the incident
- Identifying and implementing the necessary corrective action
- Identifying the personnel responsible for carrying out the corrective action
- Implementing or modifying the controls necessary to avoid a repeat occurrence of the incident
- Recording any changes in written procedures required
- Advising the environmental authorities if any substantial pollution has occurred.

All personnel are required to report all incidents as it is regarded as a valuable method of addressing shortcomings in procedures, training and equipment, and is an opportunity for improvement.

All Incident Investigation Reports and associated documentation will be distributed to the Environment Manager, the Construction Manager and Project Manager. All incident reports and documentation will be stored in the EIS.

## 11.4 Non-compliance: Corrective and Preventive Actions

An environmental non-compliance will be detected through processes such as monitoring, inspections, audits and receipt of complaints. Non-compliance covers incidents which do not conform to the EMP and procedures as well as incidents which violate statutory obligations.

The process for managing environmental non-compliance will be as follows:

- When an environmental non-compliance is detected the nature of the event will be evaluated by the environmental staff as specified in the relevant procedure, the effectiveness or need for new/additional controls will be reviewed and strategies identified to prevent recurrence. Corrective actions will subsequently be identified and logged. Details of the non-compliance, the corrective actions proposed and the responsibilities and timing for completion of the actions will be entered.
- Once an action is completed, the form will be updated to close the action including input of comments and completion date.
- The Environmental Compliance Tracking and Corrective Action forms will be reviewed weekly by the appropriate member of the construction/environmental team to ensure actions are completed in time.

In addition to the above, where an incident is of a more serious nature, has been identified repeatedly or constitutes a violation of statutory regulations, the following will apply:

- When required, the work on the identified operation or site will be stopped until remedial action is taken to eliminate the issue.
- An incident report will be completed and logged in the EIS.
- The incident report will be forwarded to the Environment Manager, and if deemed non-compliant with statutory regulations, to the environmental authorities.

## 11.5 Social and Environmental Management System (SEMS)

AML are building up a functioning environmental and social management capability with sufficient resources to oversee the project's construction and operations and ensure that contractor's performance is also of a high standard.

At the same time, the monitoring and reporting systems are still under development while AML continues to recruit staff to cover environmental and social management in the field, incorporate baseline information from the ESHIA and eventually develop a project information system.

SEMS will provide a structured, effective means to manage environmental, social and economic commitments throughout the life of the project. The SEMS provides a consistent framework for social and environmental management through the project life-cycle: construction, operation to decommissioning. SEMS enables an operator to develop operating standards and continual improvement targets that help define and maintain performance standards.

The development of a SEMS by AML is a comprehensive undertaking that will take several years to fully implement. It is recommended that AML aim to attain compliance requirements with a recognised standard such as ISO 14001 before Phase 3 operations commence so that the appropriate control and audit systems are in place to regulate environmental issues and maximise efficiency in energy, water and material management.

SEMS need to function within the standard management system structure so as to integrate environmental, social and economic considerations into business and project operations. Continual improvement in overall environmental performance is a fundamental principle in SEMS and is accordingly defined within respective standards, such as ISO14001. The principle is one that allows for phased improvement (achievable over a period). It also helps to 'build in' and sustain achieved improvements. An effective SEMS will enable organisations to target, achieve and demonstrate continuous improvement in environmental performance as one integrated management process.

SEMS will require development of policies and goals which are currently missing other than achievement of compliance and general principles associated with good corporate citizenry. Possible generic environmental objectives that could be applied are:

- Comply with legislation and good international industry practice;
- Design, construct and operate the facilities in a manner that protects human health and minimises impacts on the environment;
- Encourage and promote waste minimisation, the sustainable use of natural resources, recycling, energy efficiency, resource conservation and resource recovery;

- Environmental objectives are the responsibility of all staff;
- Monitor and review procedures regularly and strive for 'beyond compliance' performance;
- Recognise and respond to the local community's questions or concerns

## 11.6 Auditing

SEMS audits are typically conducted in accordance with ISO 14001 guidance and procedures, and oriented toward continuous improvement in managing the environmental impacts of an organisation, site, process, product, supply chain or input-output balances.

The Sierra Leone 2009 Mining Technical Assistance Project (MTAP) report includes a section on monitoring requirements including the following statement:

"It is expected that monitoring will be conducted during all phases of each project venture – preconstruction, start-up, operations, closures and post closure. The program is expected to play a pivotal role in ensuring that the trends for specific parameters are tracked and it will provide information on compliance with legislative norms, set guidelines or desirable operational limits; and form the basis for corrective actions and modification of activities if necessary. GOSL will ensure that part of the cost is borne by the Mining agencies."

Therefore, in addition to in-house performance audits as required to maintain accreditation for ISO 14001, there is also a requirement for independent, government-led audit that seeking to evaluate performance, improvement and achievement of commitments.

An SEMS needs to take into account and provide access for 3$^{rd}$ party auditing and evaluation. It is recommended that Audit takes place depending on project phase to provide an opportunity for continual improvement using a lessons learnt approach. Therefore it would be reasonable to expect at least an annual audit during the construction phases of the project, with frequency to be modified depending on the timing and location of the subsequent development activities and the results derived from the monitoring data.

In summary therefore, continuous evaluation and auditing (both internal and independent) is requred in order to ensure continuous improvement in all aspects of the project and minimise environmental impacts.

Environmental auditing is used to certify whether practice is in accordance with standard procedures and to determine how processes or systems under review can be improved. The main environmental auditing techniques are:

- examination of records and documentation relating to impacts, actions taken to manage them and aspects of performance;
- interviews with management and line staff to corroborate factual information and probe areas of concern; and
- site inspection to check that environmental measures and controls are operating as described and intended.

A distinction can be made between environmental audits conducted as part of ESHIA and EMS implementation, respectively. ESHIA related audits, typically, are ad hoc, project-by-project in approach and use non-standardised methodology. However, both ESHIA and EMS audits have objectives, elements of approach and information sources in common.

# 12 COMMITMENTS REGISTER

The following register lists the environmental and social commitments that will be required beyond the impact assessment stage. Unlike the section describing the requirements for ongoing assessment works, these commitments represent systems and assets that the proponent (AML) will need to develop and take forward through the life of the project.

Key commitments such as undertaking and acting on Risk Assessments and an SEMS require the definition of corporate policy and standards. It is recommended the project SEMS first establishes the following:

- Ongoing monitoring so as to be able to compare against the ESHIA baseline;
- Monitoring targets, monitoring frequency definition and a charter to pursue continual environmental and social performance improvement;
- Establishment of rigorous and transparent performance indicators.

**Table 12-1 AML Commitments Register**

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| General | 4.7 | Institutional Capacity Development | Requires resources and energy from owner. | Adherence to commitments such as multi-partite monitoring, the extractive industries transparency initiative and key alliances with Ministries where there is mutual benefit for improved data collection and management (such as meteorology). |
| General | 7.1 | Non-routine, unplanned events are not well understood. | Maintain Risk Register and undertake Risk Assessments for key risk items including:<br>• Spillages of Fuel and /or hazardous chemicals<br>• Transport accidents<br>• Ship collision, capsizing<br>• Geotechnical stability / failure | Risk Register and Risk Assessments to be developed for Stage 2 ESHIA and maintained / refined thereafter. |
| Air | 7.2.1 | Reduction of air quality impacts from dust & engine emissions | Water spraying, wheel wash, truck covers, mine fleet management | Dust Suppression and Vehicles and Plant Emissions Control Management Plan.<br>Robust air monitoring programmes |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| Noise | 7.2.2 | Excessive Noise generation | Design-in appropriate noise controls at equipment specification and procurement stage.<br>Vehicle speed control and maintenance.<br>Correct blast design and charging. | Compliance with Environmental Basis of Design.<br>Rock blasting management plan.<br>Robust noise monitoring programmes |
| Ecology | 7.2.3, 7.3.3. | Destruction of habitat areas.<br>Relocation of Species of conservation concern.<br>Habitat depletion through unintended increase in human access and influx. | Appropriate mine layout and avoidance.<br>Community development initiatives in animal husbandry and plantations as well as regulation of influx in conjunction with neighbouring communities.<br>Possibly elevating the conservation status of the Farangbaia Forest Reserve and/or identification of other offsetting opportunities. | Further ecological studies and develop understanding of ecosystem behaviour.<br>Avoidance of protected areas and areas of high ecological value (where feasible)<br>Ecological Conservation Plan.<br>Biodiversity offset and management plan.<br>Sediment and hydraulic control measures for works adjacent to surface water courses and for river crossings/bridges.<br>Sourcing timber from certified plantations<br>Community development and monitoring. |
| Water | 7.2.4 | Over-abstraction, water quality changes, river diversions and | Complete predictive groundwater and surface water models including ongoing ARD | Integrated mine water management planning. |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | | flooding. | work. Appropriate waste water treatment. | Up to date Spill Response Plan.<br>Site specific surveys and register of existing contaminants / sources at brownfield locations.<br>Robust surface and groundwater monitoring programmes. |
| Soil / Land | 7.2.5 | Land take, loss in soil productivity, erosion and degradation through compaction. Contaminated land issues. | Appropriate mine layout and avoidance.<br>Progressive rehabilitation and top soil use / offset. Good practice in terms of fuel and reagent storage and management. | Further environmental studies.<br>Life-of-mine waste management plan.<br>Closure and Decommissioning Plan.<br>Site specific surveys and register of contaminants / sources at brownfield locations. |
| Geology | 7.2.6 | Topographic and geo-stability issues | | Progressive rehabilitation and an overall mine waste management plan |
| Social | 7.2.7 | It is recognised there will be socio-economic benefits in the form of employment, goods and supplies, social investments and | Detailed studies and RAP ahead of construction.<br>At the operational stage the maintenance of | Preparation of a Resettlement Action Plan (RAP).<br>Preparation of a livelihood restoration |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | | payment of revenue to the government. Negative impacts will mainly be due to disturbance to land owners and influx of workers and job seekers | a community liaison and planning approach in partnership with communities will minimise impacts.<br><br>Continued monitoring and improvement is required to ensure that resources are appropriately directed and used. | plan.<br><br>Implementation of a grievance mechanism.<br><br>Robust socio-economic monitoring programmes<br><br>Preparation and implementation of a Community Development Plan.<br><br>Ongoing community liaison plan and full support and robust defence of an Extractive Industries Transparency Initiative Plan. |
| Health | 7.2.8 | Community resettlement;<br><br>In-migration related impacts (disease, food security, substance abuse, home violence);<br><br>Increased burden of disease due project activities and water storage facilities (drinking water tanks, waste and raw water | Appropriate education of workforce regarding transmittable diseases<br><br>Malaria control initiatives (e.g. awareness and control of mosquito breeding sites to prevent increased malaria incidence). Monitoring of community rates of water related diseases and infections.<br><br>Provision of suitable healthcare facilities. | RAP<br><br>A specific community health protection strategy should be developed in conjunction with the preparation and implementation of a Community Development Plan.<br><br>Robust health monitoring programmes. |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | | storage ponds);<br><br>Degradation and/or reduction of surface water (sedimentation/erosion, contamination, changes in drainage patterns); and<br><br>Degradation of groundwater quality.<br><br>Increased road traffic accident rate | Water treatment and security of supply.<br><br>Maintain condition of roads and rail road, including bridges, under passes, and smaller manual crossing arms.<br><br>Road health & safety and awareness training for all new employees.<br><br>Protection of local food sources (fish, agriculture, bushmeat). | Integrated mine water management planning.<br><br>Traffic impact assessment and management<br><br>Health & Safety training<br><br>Site specific surveys and register of contaminants / sources at brownfield locations. |
| Marine | 7.5.5 | Clearance of coastal habitats including mangrove within Ramsar site | Ensure port footprint is not expanded and no mangrove is cleared | Project design |
| | 7.5.5 | Light Pollution in Ramsar site | Design port night-lights to diminish the direct disturbance on birds | Marine Management Plans with Risk Assessments |
| | 7.5.4 | Impacts arising from dredging | Dredging Impact Assessment | Separate impact assessment to comply with London Convention and Protocol |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | 7.5.5 | Sewage and waste water impacts to estuary | Design appropriate wastewater treatment system and outfall to minimise the impact of port wastewater | Compliance with project Basis of Design including World Bank EHS standards |
| | 7.5.5 | Routine discharges from vessels include deck drainage, potentially contaminated drainage from machinery spaces, engine cooling water and treated sewage/grey water can lead to contamination of estuary | Control and Management of Ships' Ballast Water and Sediments | Port Project Proponent (AML) must regulate and enforce MARPOL 73/78 |
| | 7.5.5 | Oil, chemical and material spillage (accidental) | Quantitative Risk Assessments and Management Plans ensure that the risk of accidental spillage is minimised. However emergency response measures need to be in place to manage an unforeseen event | Oil Spill Contingency Plans |
| | 7.6.1 | Impacts arising from quarrying, borrow pits and ground improvement | Accountable through contract terms to a single, best-practice source of guidelines | bulk material environmental management plan |
| | 7.6.2 | Impact from over-demand on the existing, fragile and undeveloped infrastructure and resources | Logistics, programming, procurement and the provision and expectations for goods and services are dealt with under a project's | AML project consultation and disclosure system coupled with a grievance system, established by the proponent will be |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | | | feasibility study and execution plan. Need for a PR and activity announcement system. | utilized to ensure that project activities are announced publicly and that a response system is in place should problems arise. |
| | 7.6.3 | Waste management - greatest impact is likely to arise from interim storage of wastes in particular pest, odour and litter control. | Site selection and operation of project-specific waste management facilities. | Integrated Waste management plans including hazardous. |
| General | 9.1 | Scope and develop operational management system with integration with other project management systems including<br>• Occupational Health and Safety Management Plan (operational phase)<br>• Emergency Preparedness Management Plan (operational phase)<br>• Environmental & Social Monitoring Programme | Site Specific Social & Environmental Management plans under an over-arching SEMS. Site specific EMPs should be developed over time in conjunction with SEMS for numerous elements within the project, for example, processing plant, mine, tailings facilities, waste rock dumps, etc | Develop and invest in a SEMS for life-of-project. |

| | Section Reference | Issue | Action Required | Form of Commitment |
|---|---|---|---|---|
| | | (operational phase)<br>• Security Management Plan (operational phase) | | |

# 13 CONCLUSION

The project has been evaluated using a rigorous impact assessment methodology.

This includes a review of the legislation framework associated with environmental, social and health management and assessment. The ESHIA considers the Phase 1 project, the existing physical conditions i.e. the environmental and human baseline and the likely impacts that may arise, both positive and negative. Where there are impacts identified that could cause adverse effects, the ESHIA considers alternatives, mitigating measures and what the likely remaining or residual impact will be after such intervention.

The environment and social impact assessment has been applied systematically to the project affected areas and the following conclusions have been determined:

## 13.1 Mine Area Impact Assessment

***Air & Noise***

Air quality impacts comprising both dust and exhaust emissions arising from land clearance, mining, dusting from stock-piles and machinery have been identified as primary emission sources. The implementation of standard mitigation measures involving covering of loads during haulage, dust suppression by water spraying, extractive covers at key point sources and machinery selection should result in no major impacts.

Noise sources will be variable but blasting, crushing, potential transport noise including aircraft are considered to be the most important sources of impact. Assuming that occupational noise limits are maintained within facility boundaries (85 dB(A)) then it is predicted that appropriate environmental noise standards will be met at a distance of 500m from the facilities.

Appropriate choice of location for key noise-emitting site facilities such as workshops is still required and should adhere to the minimum noise buffer recommendations included in this report. Further mitigation and management, where considered necessary is predominantly associated with selecting machinery with noise limiters maintaining equipment to run quietly and ensuring that blast design is optimised and doesn't create excessive noise power. There are no major impacts expected after mitigation although further study work is required to review the effects of an airstrip, should this option go ahead.

***Ecology & Biodiversity***

Ecological impacts at the mine have been evaluated and found to be significant primarily due to the high level of biodiversity and conservation value of plants at the mine-sites and along the Tonkolili River valley. The Farangbaia Forest Reserve, which is in close proximity to the project is considered to be currently only of moderate conservation value. This area by virtue of its protected status and location may be a suitable site for a replanting, off-set and conservation programme.

Principal direct impacts will arise from the clearance of land within the footprint of the open pit and associated infrastructure and the burial of vegetation in waste dump areas which will essentially be permanent impacts to the current vegetation coverage with little to no recourse for mitigation. Vegetation that is not cleared or buried may be indirectly impacted by alteration of drainage patterns and exposure to contaminated surface runoff (contaminants may include petroleum products from operations and also mobilised trace metals present in the hematite ore deposit). Further impacts may arise through the spread of invasive species. These may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive). An influx of people to the area will increase the pressure on resources (e.g. clearance of land for agricultural use, subsistence and commercial logging of timber).

The residual post-mitigation impacts of habitat loss and fragmentation will remain significant to fauna. Opening access and influx to the area to the extent envisaged could lead to significant further loss of fauna through habitat destruction and increased hunting. With the exception of burial (which is an irreversible impact), residual (post-mitigation) impacts on aquatic ecosystems should be minor if appropriate international best practice preventative and mitigation measures are put in place.

The most significant potential impact for fauna and the aquatic ecosystem is a change in species diversity and abundance (and potentially a loss of species of conservation concern) through habitat loss and fragmentation directly associated with the mining activities. Indirectly this may also occur through increased pressure due to population influx.

Avoidance of areas of ecological value is the primary tool that is being used to minimise impacts. As the impact of land clearance and burial in the primary mining and rock dump areas can not be avoided if the project is to go ahead because of the immovable location of the ore bodies, nor can it be mitigated against then the only measure remaining is for the project proponent to undertake a commitment to attempt seed collection, replanting, habitat renewal and protection at alternative selected conservation site(s). This offset or equivalence approach will not alter the primary ecological loss and cannot realistically overcome the direct impact resulting from clearance of forest and vegetation. However, in combination with avoidance wherever possible in the first place then an off-set conservation programme could help to lower the overall residual impact to a moderate level.

Further evaluation of habitat areas is required and understanding of ecosystem dynamics and behaviour is required if ecological management initiatives are going to be effective. As this remains unknown pending further evaluation, the expert view on residual impact magnitude in association with fragmentation, loss of species richness and abundance from disturbance has been conservatively set as remaining as an impact of major significance. It is therefore essential for AML and its contractors to minimise and avoid areas of ecological importance where possible

Assuming avoidance of sensitive areas is rigorously followed by AML, then in conjunction with a number of conservation off-set measures, the residual (post-avoidance and post-mitigation) impacts on ecology and biodiversity should be minor. However, this is reliant on AML also immediately adopting a conspicuous and pro-active policy to restricting any habitat disturbance within their concession area and developing programmes that support alternative food supply to local people including animal husbandry and farming to reduce the reliance on hunting and frontier fuel-wood collection.

### *Hydrology and Hydrogeology*

Assessment of surface water and groundwater impacts has identified a range of water resources and water quality issues that may be expected to arise from the project. This includes an increase in suspended sediments in rivers, alteration of river channels and changes in catchment behaviour leading to flooding as well as a variety of contamination issues that could arise from the project. These issues can be mitigated through a comprehensive environmental management plan. The most significant issue identified is the increased potable and construction water demand that may lead to over-abstraction of surface water from nearby rivers leading to impacts on environmental flows and/or downstream users.

Residual, post mitigation impacts will include some permanent loss of flow from springs and streams on Simbili feeding the Tonkolili and Mawuru Rivers and loss of the storage effect of the overburden and weathered cap rocks of the hematite deposit. Waste rock dumps will develop their own surface and groundwater systems and dependent on location may supplement baseflow to the rivers. Even with controls, there may be some acid drainage and other factors contributing to changes in groundwater and surface water chemistry, especially given the low buffering capacity and high sensitivity of the local waters. More significant changes in local hydrology and hydrogeology are expected in Phase 3 which will require a significantly higher water demand.

There will be localized residual but reversible impacts on surface and groundwater resources due to abstraction for construction and operational demands. This is the only residual water impact that has been assessed as remaining as major. The rationale behind this is that although water treatment and re-use will return a component of the water to the catchment. There will inevitably be a net reduction as water is removed from the catchment and conveyed away in either the form of retained water in product, alteration in drainage patters and losses due to water use from activities like dust spraying.

### *Soils & Land Use*

Soil impacts will arise during construction and operational phases as a consequence of land clearance or sterilisation / burial, increased erosion or inundation due to the modification of drainage patterns, compaction from vibration and loading under temporary stockpiles/structures, contamination hydrocarbons and other chemicals including diesel and lubricant oils and explosives residues. Some soil resource can be rehabilitated if progressive mine reclamation is applied, although it is also recognised that irreversible loss of soil can occur in this tropical setting where there is also high potential for vegetation loss, erosion and run-off. Invasive species colonising disturbed land and also propagating to undisturbed land is recognised as a major impact. Residual impact may be only moderate through appropriate implementation of mitigation measures.

These impacts may constrain or modify existing land-uses in the mine area. The residual (post-mitigation) impacts of land clearance and sterilisation / burial on soil resources and land-use are likely to remain significant and extremely long-term or permanent in the mine area. Other residual impacts should be minor if appropriate international best practice preventative and mitigation measures are put in place.

Mining will inevitably include loss of the non renewable resource of ore itself and deposition of wastes can sterilise associated deposits of lower value or undiscovered resources making them effectively inaccessible beneath waste rock and tailings. There will be major changes to the landscape with the top of Simbili hill being effectively removed while substantial overburden and rock waste dumps will be formed nearby leading to visual and landscape changes. None of these impacts have been assessed as major however and mitigation in the form of appropriate mine planning and dump design should ensure that only moderate to insignificant impacts remain.

***Socio-Economic***

Socio-economic effects are strongly dependent on project phase. During construction some villages may require resettlement. Villages on the periphery of mining area will suffer loss of land resulting in loss of shelter, loss of access to agricultural land, artisanal mining sites and natural resources leading to a decrease in economic stability. There are also likely to be graves and sacred sites within the footprint area that will require relocation. During operations however there is a mix of economic benefit and social disturbance. Benefits (lasting about 8 years) will mainly be in the form of wages, disbursement for the procurement of supplies, social investments and payment of revenue to the government. Negative impacts will mainly be due to disturbance to land owners and influx of workers and job seekers bringing pressure on social infrastructure and natural resources and possible increases in social ills. Furthermore there is likely to be a localised disruption in the cost of living which could significantly disadvantage those who are disenfranchised from the project and create potential for conflict with migrants. Mitigation measures are dependent on establishing transparent and effective social management processes including harm minimisation, compensation and long-term community development mechanisms. The following mitigation measures are expected to reduce the intensity of the residual impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Preparation of a Community Development Action Plan.

In some instances these community mitigation measures co-opt support from NGOs .

***Human Health***

The preliminary health impacts associated with Phase 1 construction and operations of the mine have been identified as those related to community resettlement, worker in-migration, increased burden of disease due project activities and water storage facilities, potential changes to surface and groundwater, vehicle traffic, noise, and changes in locally produced foods. Beneficial impacts such as access to improved healthcare facilities, health benefits through local employment, increased access to the region, and community re-settlement have also been identified.

Implementation of the recommended mitigative measures regarding community resettlement and worker in-migration, malaria control measures, and programs designed to control the spread of communicable diseases such as HIV/AIDs and cholera is expected to reduce the significance of the health impacts and thus avoid potentially major health issues for persons living in the vicinity of the Project.

It is important to note that impacts to health cannot be mitigated in isolation. Therefore the mitigation measures recommended by other disciplines such as socio –economics, air, surface and groundwater, flora and fauna.would also help in reducing health impacts.

## 13.2 Transport Corridor Impact Assessment

***Air & Noise***

Principal air and noise issues along the transport corridor are related to earthworks and vehicle movement during the construction and operational phases respectively. Potential issues may be associated width dust control and emissions from a power source at the Lunsar interchange. Standard mitigation measures such as road dampening to reduce dust levels and imposing appropriate buffer zones will have the effect of reducing impacts to minor or insignificant level.

The proximity of the proposed transport route in relation to villages and residential areas remains a key issue. Whilst a principle of avoidance of resettlement wherever possible has been upheld, the combination of public safety and dust and noise nuisance issues means that in some instances, even though mitigation measures may be partially effective, it has been considered more appropriate and responsible to pursue a resettlement solution. The maintenance of a buffer zone should be sufficient for most residential areas, in exceptional cases where resettlement is not feasible, additional mitigation measures (e.g. noise barriers or noise isolation) at sensitive receptors will minimize the impacts. A buffer zone of 500m has generally been accepted for the project, if communities lie within this zone then a review of either resettlement or mitigation is required.

Stockpiles and operations at Lunsar Interchange could create moderate residual impact however detailed design for the stockpile should alleviate this impact through optimizing the siting and orientation of the stockpile.

***Ecology & Biodiversity***

The principal impact on vegetation will arise from the land clearance required for road construction, leading to the removal of vegetation. Fragmentation of habitats may also occur. Outside the direct footprint of the road, localised clearance of vegetation may occur in borrow areas (potential sources for bridge construction materials) and also through consequential influx to areas that have been cleared and access opened. Invasive species may spread along the area of disturbed land and propagate beyond into undisturbed land. Impacts on rheophytes (aquatic plants) may occur at bridges and downstream of river crossings.

Habitat loss and fragmentation directly associated with the construction of the transport corridor as described above could lead to a reduction in fauna species diversity and abundance (and potentially a loss of species of conservation concern). Habitat alteration may also occur as a result of disruption of migration across the transport corridor. The residual (post-mitigation) impacts should be minor if habitat hot-spot avoidance is used as a first principle and appropriate international best practice preventative and mitigation measures are put in place. Particular care and control associated with bridge works is required, including the use of containing coffer dams to minimise impact (se below).

The most significant impacts to aquatic ecosystems are associated with the construction and redevelopment of crossings resulting in uncontrolled sedimentation (and increased turbidity from in-stream (such as piling) and land disturbance activities. This may be compounded by removal of riparian vegetation which will increase diffuse pollutant transport from the adjoining areas. Residual (post-mitigation) impacts should be minor if appropriate environmental engineering control and design is applied.

Any significant ecological impacts as a result of the project-related activities may have indirect social impacts.

Avoidance of key habitat areas has already been attempted with interaction between the haul road designers and environmental specialists (see Haul Road EMP, WorleyParsons 2010). In instances where there is close proximity or unavoidable overlap (for example at River Crossings) between the transport corridor and sensitive habitat then residual impacts should be minor if appropriate international best practice preventative and mitigation measures are put in place. Restoration of the transport corridor is unlikely following completion of Phase1 as the road will be retained as a mine service road.

Further evaluation of habitat areas, transport design and routing and ecological management is required. As this remains unknown pending further evaluation, the expert view on residual impact magnitude in association with fragmentation, loss of species richness and abundance from disturbance has been conservatively set as remaining as an impact of major significance. It is therefore essential for AML and its contractors to demonstrate good design in selecting the route and avoiding areas of ecological importance. It is also essential that further habitat study and review is completed so that there is better understanding of ecosystem behaviour. This is essential if management approaches are going to be relied upon.

Assuming avoidance of sensitive areas is rigorously followed by AML, then in conjunction with a number of conservation off-set measures, the residual (post-avoidance and post-mitigation) impacts on ecology and biodiversity should be minor. However, this is reliant on AML also immediately adopting a conspicuous and pro-active policy to restricting any habitat disturbance within their concession area and developing programmes that support alternative food supply to local people including animal husbandry and farming to reduce the reliance on hunting and frontier fuel-wood collection.

***Hydrology and Hydrogeology***

Potential impacts pertaining to local surface and groundwater along the transport corridor are predominantly associated with increase in turbidity and reduction in water quality during both construction and operations phases. There is a requirement for risk assessment to evaluate the likelihood and potential consequences associated with accidental spillage. The transport corridor may also result in changes to drainage patterns due to diversions and alterations.

Mitigation measures significantly reduce potential impacts on surface water and groundwater. Residual, post mitigation impacts will include some potentially long term changes to valley swamp drainage systems that are crossed by the road. There will be localized residual but reversible impacts on surface and groundwater resources due to abstraction for construction and operational demands.

***Soils & Land Use***

The principal impact will arise from the land clearance including slash and burn of vegetation and surface soils strip being carried out for road construction. The construction of the road may also constrain certain land-uses and / or access to land. Temporary and minor impacts on soil resources and land-use during the refurbishment of the Delco rail line may also occur.

The residual (post-mitigation) impacts of land clearance on soil resources and land-use are unlikely to be significant if appropriate design and site management is applied. Change in land use leading to loss of farming land may remain as a moderate residual impact as access restrictions may constrain land use.

***Socio-Economic***

The social impacts of the transport corridor are likely to occur mainly during the construction phase due to disturbance to the existing land users. Rail refurbishment will take place on the existing rail embankment. Impacts will range from loss of access, land-based resources, and loss of shelter, all of which may potentially lead to a decrease in economic stability

The haul road may pass through the sugar plantations to be developed as part of the Addax Biofuel Project. The compensation for potential impacts on the sugarcane plantations may require separate negotiations with relevant stakeholders.

The mitigation measures given below are expected to reduce the residual impacts from major to moderate/minor.

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Preparation and implementation of the CDAP

Given the high level of unemployment in Sierra Leone, it will be difficult to completely control an anticipated influx of job seekers to villages and towns along the transport corridor. However, the following measures can reduce impacts from moderate to minor.

- Planning for self sufficient and closed workers camps to minimise intermingling of workers with local population.
- Providing assistance for the control of communicable diseases and for educational campaigns for prevention of social ills.
- Planning jointly with local Paramount Chief and other stakeholders to minimise speculative migration.

In the long term, the improved transport infrastructure may also lead to growth of industry and other economic activities and benefits including employment, investment and revenue along the corridor (more likely along the haul road), which may contribute to general economic development.

All social impacts can be mitigated against which could result in either the development of beneficial opportunities or minimisation of residual impact to a minor level. However, it is noted that this strategy is reliant on rapid implementation of a challenging social management programme which will require support and collaboration from stakeholders including local government, people's organisations and NGOs.

***Human Health***

The preliminary health impacts associated with the Phase 1 construction and operation of the transport corridor have been identified as those related to community resettlement, worker in-migration, increased burden of disease due project activities and water storage facilities, potential changes to surface water, vehicle traffic, and changes in locally produced foods. Beneficial impacts such as access to improved healthcare facilities, health benefits through local employment, increased access to the region, and community re-settlement have been identified.

Implementation of the recommended mitigative measures regarding community resettlement and worker in-migration, malaria control measures, programs designed to control the spread of communicable diseases such as HIV/AIDs and cholera, and traffic regulation is expected to reduce the significance of the major and moderate health impacts and thus avoid potentially major health issues for persons living in the vicinity of the Project.

It is important to note that impacts to health cannot be mitigated in isolation. Therefore the mitigation measures recommended by other disciplines such as socio –economics, air, surface and groundwater, flora and fauna would also help in reducing health impacts.

## 13.3 Port Impact Assessment

***Air& Noise***

Construction activities at Pepel Port will comprise a combination of existing asset refurbishment and new development.

Air emissions arising from land clearance (dust), power generation and wind dispersal of fines from stockpiles can be mitigated to moderate /minor residual significance by dust suppression, machinery emission control and good design and orientation of stockpiles.

An increase in noise levels may be generated by machinery, engines, vehicles used for transport, loading and unloading of rock, materials and waste and power generation. Further operational phase identified noise sources are ship traffic (motors, sirens, etc.), machinery movement, conveyors, loading and unloading activities at the Dual Train Dumping Station, the Stacker Feed System, the Reclaim Feed System and the Shiploader Feed System

Generic recommendations for the construction phase include the use of machinery and equipment that guarantee low noise emissions. Noise impacts at nearby community receptors (Kalangba) should be minimised through an appropriate layout plan. If further mitigation measures are required then sound barriers could be installed. The residual impacts on air quality and noise are classified as Minor.

***Ecology & Biodiversity***

The principal impacts to vegetation will arise from the potential clearance of mangrove during installation or refurbishment of infrastructure. Invasive species may also spread to undisturbed land following natural colonisation or deliberate introduction in disturbed areas (where such species tend to thrive). The release of acidity and metals from disturbed acid sulphate soils (if present) can cause the die back of vegetation in the localised area and hydraulically connected areas. Impacts on fauna may further reduce natural colonisation by indigenous plant species where fauna play a role in seed dispersal.

The residual (post-mitigation and post-closure) impacts on terrestrial fauna should be minor if appropriate international best practice preventative and mitigation measures are put in place and the site is rehabilitated on closure of Phase 1 of the Tonkolili project.

There are no major or moderate impacts expected to affect aquatic ecosystems in the Pepel Port area on the basis that to surface water systems were encountered. However, it is noted that groundwater and potential freshwater spring discharges in the inter-tidal zone could be significant to the maintenance of the mangrove ecosystem and will be vulnerable to pollution or contamination at Pepel. Furthermore groundwater abstraction and the movement of the saline interface could also affect specialised ecological communities. The adoption of stringent water quality guidelines and further hydrogeological review is being used to also assess and protect dependent ecosystems.

Further evaluation of habitat areas, port design and construction techniques and ecological management is required. As this remains unknown pending further evaluation, the expert view on residual impact magnitude in association with fragmentation, loss of species richness and abundance from disturbance has been conservatively set as remaining as an impact of major significance. It is therefore essential for AML and its contractors to avoid areas of ecological importance. It is also essential that further habitat study and review is completed so that there is better understanding of ecosystem behaviour. This is essential if management approaches are going to be relied upon.

Assuming avoidance of sensitive areas is rigorously followed by AML, then in conjunction with a number of conservation off-set measures, the residual (post-avoidance and post-mitigation) impacts on ecology and biodiversity should be minor. However, this is reliant on AML also immediately adopting a conspicuous and pro-active policy to restricting any habitat disturbance within their concession area and developing programmes that support alternative food supply to local people including animal husbandry and farming to reduce the reliance on hunting and frontier fuel-wood collection.

***Hydrology and Hydrogeology***

Impacts at Pepel are predominantly associated with groundwater contamination through chemical spillage and conventional contaminated land pollutant linkages. In addition, the coastal setting and use of groundwater creates a risk associated with saline intrusion.

Groundwater at Pepel Island is considered to be a highly sensitive receptor and requires a detailed groundwater management to protect it otherwise the operations could lead to long term damage to the aquifer beneath Pepel Port. Monitoring will be critical to ensure that mitigation measures can be refined and are appropriate and effective. Residual, post mitigation impacts are anticipated to be minimal if regulated through a well developed management plan - localized residual impacts are expected to be reversible as surface and groundwater resources should recover through high rates of recharge after abstraction.

***Soils & Land Use***

Baseline soil data for the historical industrial Pepel Port area has been collected for a few indicative surface samples only and indicates a probably relatively low level historical impact on quality, principally with some elevated levels of arsenic and some localised leakage or spillage of fuels and oils as well as coal tar related contamination.

Stripping of surface soils and other earthworks associated with preparation of new stockpile areas and foundations for new port infrastructure could potentially mobilise or expose historically present contaminants.

On the whole, the reinstatement of the Port is not considered likely to have a significant impact on the soils at or outside the port if works are designed and managed with due consideration given to current conditions. Measures are described in the ESHIA that set out a contamination material inventory and methods for the appropriate handling of soils after reference to a site-specific contamination register.

Further studies to better delineate contamination and appropriate remediation if required is recommended. Residual (post-mitigation) impacts should be minor if this is implemented.

***Socio economic***

The refurbishment of Pepel Port may require additional land in its vicinity for construction and operational activities and facilities. The land near the port is currently used for dwellings, trading, agriculture and grazing. Potential impacts include resettlement, and reduction in the available community land base as well as sea based activities such as fishing

The economic opportunities created at the Pepel Port are expected to lead to an influx of workers and job seekers mainly during the construction phase. The refurbishment of Pepel Port is expected to have predominantly beneficial socio-economic impacts during its construction and operation phase (up to 8 years).

Mitigation measures are expected to reduce the intensity of the residual impacts from major to moderate/minor. This includes

- Preparation of a Resettlement Action Plan (RAP).
- Preparation of a livelihood restoration plan.
- Implementation of a grievance mechanism.
- Planning and coordination with local government, Paramount Chief and other stakeholders to minimise speculative migration and maximise opportunity for local communities through provisioning goods and services, education and skill-building.

In line with its corporate policy, AML is expected to initiate a social investment programme in the Pepel Port area with the start of construction work. This includes improvement in social infrastructure such as water supply, schools and health centres and development of livelihood opportunities, independent of the port.

***Human Health***

The preliminary health impacts associated with Phase 1 relate to both construction and operation of the Pepel port have been identified as those related to community resettlement, worker in-migration, increased burden of disease due project activities and water storage facilities, potential changes to surface and groundwater, noise, and changes in locally produced foods. Beneficial impacts such as access to improved healthcare facilities, health benefits through local employment were identified.

Implementation of the recommended mitigative measures regarding community resettlement and worker in-migration, malaria control measures, and programs designed to control the spread of communicable diseases such as HIV/AIDs and cholera is expected to reduce the significance of the major and moderate health impacts and thus avoid potentially major health issues for persons living in the vicinity of the Project.

It is important to note that impacts to health cannot be mitigated in isolation. Therefore the mitigation measures recommended by other disciplines such as socio –economics, air, surface and groundwater, flora and fauna.would also help in reducing health impacts.

## 13.4 Offshore & Coastal Impact Assessment

***Mangrove Clearance***

The baseline preliminary survey indicates that the coastal and marine habitat around Pepel is healthy and contains a high level of biodiversity. There are a number of potential impacts including: reduction and clearance of habitat areas for access and enabling works to support the predominantly brownfield refurbishment, altered soil elevations, altered hydrology and spill over of development effects to surrounding areas. Land clearance and significant earthworks are not required. However, alteration of hydrology requires further investigation.

However, the majority of the port infrastructure is already in place, and most of what is required will be refurbished rather than constructed from new. As a result there will be no significant increase in the existing port footprint, and therefore no significant area of coastal habitat will have to be cleared. The currently proposed development footprint for the Pepel leasehold area will result in reasonably minor losses of mangroves.

Therefore the residual impact is considered to be of minor significance if the port remains within the existing footprint and avoids mangrove clearance and disruption; and compensatory measures for mangrove protection are undertaken through the life of the Tonkolili project.

***Effects of Iron Ore Release into Estuary***

Whilst it has been shown that slight positive impacts associated with increased rates of growth (particularly in younger mangrove plants) have been associated with iron contamination, toxicity limits are not known and the potential for synergistic negative responses remain.

Over the past 24 years rain and wind activity has subjected the old stockpiles at Pepel to leaching, There is currently no evidence of any existing impact on the surrounding mangroves due to the presence of the residual hematite ore, although there are elevated levels of heavy metals in the near shore soil samples (Hydrological baseline survey, April 2010).

***Increased Noise and Light Levels***

The use of heavy machinery during construction will increase ambient noise levels, and potentially result in disturbance of sensitive coastal fauna such as birds. The current level of noise in Pepel is relatively low, due to the low human population and lack of any significant port activity. As a result, higher noise levels may result in significant impacts on birds which are a key aspect of the Ramsar designation.

Persistent man-made light can be a major issue for a range of marine fauna, with birds in particular sensitive to increased and extended levels. Non-natural light can deter them from feeding, breeding and nesting, and can generally confuse their natural behaviour. Due to the high density of wetland birds present in the project location, and its position inside a designated Ramsar site, increased light is a potentially significant impact, especially if construction work would take place during bird migratory or breeding seasons.

Mitigation measures need to consider both of these issues as impacts with potentially major significance and adapt construction activities to avoid sensitive habitat areas (eg high avifauna population, important nesting and feeding sites, and migratory and nesting seasons). Adaptations include use of shading and avoiding of strong lighting use of low-pressure sodium vapour lamps and limiting activity during sensitive times of the day e.g. extended night operations.

***Wastewater Discharges***

Discharge of untreated wastewater into the estuary has the potential to affect water pH, colour, temperature, smell, dissolved oxygen, nutrient levels and bacterial contamination. This can create indirect impacts on the estuary ecosystem, as well as posing a health risk to local communities; especially if the discharge point is located near to beaches used by locals for fishing or bathing. The significance of the impact of waste water discharge is highly dependant on the treatment system implemented in the project design, and the location of the discharge point in the estuary. A more detailed assessment of wastewater discharges is required to develop the mitigation methods further. Mitigation measures to be considered should include installation of temporary treatment plant to treat construction camp discharges. Ensuring treated water discharge is located away from sensitive locations and in areas of strong tidal currents to increase dilution and removal; and compliance with World Bank discharge limits as specified in the Stage 2 Environmental basis of Design document.

### *Spills and Run-off of Oil and Chemical contaminants*

During construction and refurbishment there is a risk of increased run-off due to earthworks,  and a risk of oil and chemical contamination from disturbance of existing contaminated land, and new incidents of fuel, lubricant and coating spills used in construction machinery, and from potential oil spills.

The significance of this impact will depend upon the level of increased run off and/or spills, and their location and proximity to coastal habitat such as mangroves or mudflats; mangroves are particularly sensitive to oil spills.

Before mitigation the impact on VR marine fauna is considered to be of moderate significance.

A more detailed assessment of run-off during construction is required to develop the mitigation methods further.  It should include run-off collection and treatment systems, waste management planning, spill response plans (contingency planning and emergency response measures should be in place). Industry best practice regarding refuelling activities, oil handling activities and machinery maintenance;

### *Refurbishment of Mooring Dolphins*

The refurbishment and potential construction of mooring dolphins, to enable the mooring of transshipment vessels will primarily impact on the sub-tidal habitat. The sub-tidal habitat directly beneath could be impacted through smothering, pile driving, and placement of rock material. No mitigation measures are required other than further characterisation of the sub tidal habitat

### *Increased Turbidity*

The construction and refurbishment of marine structures could result in elevated turbidity within the immediate vicinity of the port. Activities such as piling can significantly disturb bottom sediments, introducing material into the water column.  Increased turbidity can result in a number of direct and indirect impacts on coastal and marine ecosystems; for example, levels of photosynthesis can fall due to a drop in light penetration down through the water column

However, given the natural conditions of the estuary particularly during wet season conditions it is considered that the habitat is likely to be resilient to increased turbidity levels over the short duration of the construction programme at Pepel.

Although the impact is expected to be minor the following mitigation measures should be considered:

- Use of floating turbidity barriers and/or silt curtains to contain turbidity plumes during marine construction activities; and
- Design construction activity to occur in periods of high dispersion (e.g. ebb tide).

### *Disturbance of Contaminated Sediments*

Construction/refurbishment activity has the potential to disturb marine sediment.  There are some indications that sediment in the vicinity of Pepel retains pre-existing contamination (e.g. hydrocarbons or metals).  If sediment is disturbed there is a risk the contaminants could be released and assimilated by marine flora or fauna (e.g. mangroves, fish and shellfish) and there is a risk of bio-accumulation.

The potential impact on both marine habit and human receptors is considered to be of moderate significance and it is recommended that a detailed characterisation of near shore and intertidal marine sediments is undertaken prior to construction. Thereafter avoid disturbance of contaminated areas.

***Increased Underwater Noise***

Underwater construction activities, in particular pile driving, can generate high levels of underwater noise Marine mammal and the impact of underwater noise and ship collisions remains as a moderate impact due to lack of information at this stage but surveys are underway.

***Fuel Handling Operations***

Fuel for power generation will be transported by road and vessels will not refuel at Pepel, therefore no fuel handling operations are planned within the marine area of the port.

***Navigation and Fishing***

The majority of marine traffic in the estuary is focussed around Freetown. Trans-shipment operations are currently expected to involve Handymax transshipment vessels, which will transfer ore to a loading on anchorage point outside the mouth of the estuary. The impact of the transshipment operations on shipping in the estuary is not expected to be significant.

***Ballast Water and Marine Pests***

The location of the trans-shipment anchorage is not currently confirmed. Therefore there remains a possibility that cargo vessels could introduce invasive species during the operational phase by releasing ballast water at the destination location, particularly important if this occurs within the estuary or near enclosed waters rather than off-shore. If an anchorage is selected that makes this impact viable then AML will need to ensure the 2004 International Convention for the Control and Management of Ships' Ballast Water and Sediments is strictly followed.

***Vessel Waste Management and Discharges***

Routine discharges from vessels may have effects on water quality similar to the effects created by discharges from the port, such as changes in water pH, colour, temperature, smell, dissolved oxygen, nutrient levels and bacterial contamination. Mitigation of these effects will need to be achieved through ensuring the prevention of pollution from shipping (MARPOL), i.e. diligent regulation of the port authority / contractors.

***Trans-shipment Anchorage***

Loading at the anchorage during transshipment, although designed to be highly efficient will create a cumulative impact over the life of the project. The potential behaviour of the iron ore in the water will depend on the spillage particle size and its chemical composition. Generally, iron often forms colloidal suspensions of ferric hydroxide in the presence of oxygen, although the hematite particle size will probably preclude wide spread dispersal. It is recommended that a full assessment of the proposed iron ore product is undertaken to understand its constituents.

***Dredging***

Capital dredging will be required to open the navigation channel to access Pepel port. Ongoing maintenance dredging will be required to keep the channel open.

Dredging remains as a moderate impact awaiting a more detailed dredging impact assessment once the required data are available.

## 13.5 Distributed Impact Assessment

***Bulk Materials***

Bulk materials such as earth and fill for ground conditioning will be controlled through activity-specific management plans and protocols and contractors will be accountable for adherence to the plans and protocols.

***Demand on Existing Infrastructure***

The project's dependency on existing infrastructure will be limited. There will be initial reliance on imported goods and contractor services for food, accommodation and camps with opportunities for goods and services to create livelihood benefits for project communities. Adherence to prior and clear project announcements is expected.

***Solid and Liquid Waste Management***

The greatest impact is likely to arise from interim storage of wastes in particular pest, odour and litter control. AML will be required to ensure its contractor's implement a hierarchy of waste elimination at source, recycling, reuse, recovery, and as a last resort – disposal. In addition provision for destroying or treating hazardous waste is required to render it non-hazardous if possible.

## 13.6 Commitments, Management and Performance

This ESHIA has been prepared for submission for approval on the understanding that elements of the study are not yet fully developed. In recognition of this, the proponent (AML) has committed to undertake the completion of the study work in Stage 2 and meanwhile apply comprehensive environmental and social (E&S) management to project design, construction and development. It is recommended that rigorous risk review is used from this point, in the interim ahead of final ESHIA Stage 2 submission so as to identify appropriate E&S management measures.

A significant volume of assessment work has been achieved and the impact assessment has been completed to a sufficient level for regulatory decision making. It is recognised that further work is required, including further project definition in order to be able to define more specific impacts and mitigation measures and develop effective management strategies.

Where generic construction management plans can be implemented from the currently available information then these have been provided. In other instances, the management plans will need to be formulated pending further work and all that can be given now is an outline of the management plan purpose.

This is particularly important for the terrestrial and marine eco-systems that could be affected by the project. To date it has been recognised that areas under the direct footprint of the project contain either recognised high conservation value species or habitat that is of major significance. An integrated approach involving additional assessment, avoidance wherever possible of critical areas, mitigation, development of compensatory programmes and community development programmes is required. Further study work is required and will be included in a Stage 2 ESHIA later in 2010 that will provide more specific design and definition to these programmes.

It is also important that management plans take into account consequential impacts that will be created many of which will be unintended and difficult to control. This includes the impact associated with speculative influx of migrant workers and accelerated degradation of habitat in areas that was hitherto relatively inaccessible and sparsely populated. Management plans need to develop a clearer understanding of how compensation, alternative livelihood schemes, regulation and sustainable community development can be effectively implemented to reduce secondary impacts.

Recommendations are given for ongoing monitoring, auditing and performance evaluation of the environmental and social elements of the project so that continued improvement, adherence to agreed standards and effective liaison with SLEPA is maintained.

Monitoring will involve both internal and external inspections and auditing of performance and compliance to contract documents. Where a degree of capacity building is required to ensure that inspection visits and audits by the competent authority (SLEPA) can be achieved then it is understood and has been recorded (Appendix 1) that AML will provide provision for this. In addition inspection visits and audits by independent consultants, appointed by AML, will produce monitoring reports that SLEPA can access and comment on. Currently this has been done by the ESHIA consultants and their baseline data collection.

The monitoring strategy proposed for the project can be termed "Adaptive Environmental Monitoring". It is adaptive in the sense that the responsible party must adapt its methods and activities to the ongoing design and implementation and prevailing environmental conditions in a continuous process.

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# APPENDIX 1

## Project Monitoring and Audit Arrangements

African Minerals Limited
Victoria Place
31 Victoria Street
Hamilton HM 10
Bermuda

F.A.O. S.S.J. Jusu
Acting Executive Director
Sierra Leone Environment Protection Agency
Sierra Leone Government
3rd Floor, Youyi Buildings
Brookfields, Freetown
Sierra Leone

30 March 2010

Dear Mr Jusu

**Re: Tonkolili Iron Ore Project**

We refer to your letter dated 4th December 2009 which states the requirement for a full Environmental Impact Assessment (EIA) for the above project, and your letter of March 2010 in response to our submission of the EIA Screening Form. We confirm that a comprehensive Environmental, Social and Health Impact Assessment (ESHIA) is currently being undertaken for the project that includes both the Early Cash Flow component and the main Tonkolili mining project. The ESHIA will meet the requirements of the Environmental Protection Act, 2008 and address the life-of-mine project activities.

As an overview of how we intend to approach this work, we are pleased to submit a document titled EIA Scoping and Procedure, which provides details of the ESHIA that we are conducting, including information on the scheduling of the various studies and the deliverables. We would greatly appreciate your feedback so as to develop an agreed set of terms of reference. Once this is done, we can then produce a more formal scoping document in conjunction with the EPA containing more detail on work programmes, plans and coverage of areas of interest so as to meet the requirements of a wider set of project stakeholders.

It is our intention to submit an ESHIA covering the ECF works in June 2010 for your consideration, with an ESHIA (preliminary) for the Tonkolili project around the third quarter of 2010.

In recognition of the fast-track approach, necessitated by seasonal constraints for these projects, we would be pleased to accept your proposals for conducting periodic monitoring and auditing of project implementation by one or two of your senior staff.

We recognise that the EPA, as a new Agency has not yet secured all the necessary equipment or logistic capability to facilitate environmental monitoring for a project at this scale. Accordingly we would consider the purchase and supply to you of essential field equipment, such as hand held air, noise and water quality meters.

Furthermore, AML recognises that successful multi-partite monitoring for this project is an essential part of meeting key objectives and continued improvement in the performance of our community and environmental management programme. Consequently we recognise that AML is in the best position to initiate and provide some logistical support to a monitoring team. At the outset this means we would be willing to consider assisting EPA in terms of project transport and limited cover for accommodation and meals for field personnel at remote project locations to enable them to carry out their duties with respect to this project.

If such an approach for equipment and logistics is considered appropriate and useful, please include it in your response.

In view of the scale of the project and the staffing constraints of EPA, we seek your views on any independent monitoring that you may require, for our consideration.

We look forward to receiving your thoughts on this proposal and assure you of our intention to implement the project with due regard to sound environmental and social standards.

Yours sincerely,

Steve Allard
**Vice President - Infrastructure**

# APPENDIX 1

## Public Consultation

# AML WORKSHOP

**Date: 17th May, 2010**

**Agencies in attendance: SEE ATTACHED**

## Commencement of the meeting

The meeting was declared open by the Corporate Manager of AML, Mr Mustapha J. Kamara as he introduced a representative of the organization, Think Tank. The representative went on to attributing her visit to Sierra Leone to the level of religious tolerance expressed in the bi-religious prayers said at the beginning of meetings. This was immediately followed by individual Christian and Muslim prayers by two paramount chiefs, including P.C Bai Shebora of Kafu Bullom chiefdom.

The Chairman of the Port Loko District council, Mr Hamid Fofanah introduced the Paramount Chiefs present; Hon. Bineh Bangura followed suite in introducing the members of Parliament. The list of all the organizations present at the meeting was read, as were the presenters from AML. The Acting Director of Mines introduced the ministers.

## The Chairman`s Opening Remarks

The Deputy Minister of Mines was introduced as Chairman of the meeting, and he gave his opening remarks recognizing important members of organizations such as the 4th estate present. He started by saying 'AML has discovered the largest iron ore deposit in the world' and that the company called the meeting to officially present their story to important stakeholders, all of which, according to him, were present. He looked forward to AML discussing the present state of the mining project with the community; discuss timelines and schedules; and the benefit of the mines to Sierra Leoneans and the government. He assured Sierra Leoneans to be proud of the amount of ore in the deposit already found and still being explored in the Sula Hills. He briefly elucidated the process from exploration to definite feasibility studies, mining and shipment abroad, and that AML will be discussing road construction for mining operations, the benefits in terms of income generation and employment to Sierra Leoneans. And that the meeting would culminate in an open discussion, question and answer period.

## Presenter - Mining Operations, John Blanning

Following tea break, John Blanning, the Chairman of mining operations of AML led the presentation by showing an impressive animation of the entire mining process and shipping operation. He gave an overview of the area of the 3 sites housing the ore and that, in which the ore is concentrated; the road trains that will be transporting the mine product to Lunsar for transfer onto rail trains bound for Pepel, where it will be stacked and transported on conveyor belts to the jetty for shipment. He mentioned Sierra Leone's competitive advantage over other suppliers like Brazil, by way of shorter distance (half the distance) for the shipment of the ore to China and Europe. He further discussed the refurbishment of the defunct Marampa mines' railways and some of their rail cars. According to him, 2 rails will be involved: a refurbished one to Pepel and a brand new rail; a new port will also be constructed at Targrin. John B. further iterated that the exploration and drilling for the magnetite is completed, whilst that for the hematite is underway. He also discussed the mining, drilling and blasting process, the engineering and design details. He went on the talking about the equipment, locomotives and rolling stock to be purchased and the cars for the railway that are being constructed in South Africa. Following Mr Blanning, the Chairman gave a summary of his talk.

**<u>Presenter - Infrastructure (Steve)</u>**

Steve the infrastructure manager started his talk by declaring that AML creates value through exploration and that the company holds an extensive mining portfolio. He gave all the statistics: ore tonnage, potential number of employees, expenditure ESHIA process and social community, revenue for government, local and regional development. As for Phase 2, he discussed mining (blast, mine haul), processing input (power, water), infrastructure (water supply, tailings dam, accommodation, support services which will be large), heavy haul railway ore hauled down to targrin port, at targrin, the ore is offloaded from the train, to conveyor belts and channelled to a stockyard to be loaded on ship; lots of dredging 30 million tons of materials hauled out for navigation,

**<u>Presenter - ESHIA studies (Andrew Huckbody)</u>**

He stated that there is an intensive study underway for both phases of the project in the following areas: flora, mine site, haul road, inland valley swamps, coastal habitats, marine ecology, birds with special reference to the RAMSAR site, inter-tidal and sub-tidal, hydrodynamic model of estuarine processes, terrestrial fauna – birds, mammals, bats; hydrology, hydrogeology- surface and groundwater quantity and quality; Waste management – poor facilities, strategies required; air quality, noise; health impact assessment; and Soils and geomorphology.

He intimated that US$ 2.5 million has been spent on ESHIA studies so far, and that the conclusion of the studies will have seen some US$ 3 million spent. Organizations participating in the studies include: WP, SRK, CEMMATS, CSSL, NU, FBC, Kew Gardens, WCS, Hydrobiology, the Meteorology office etc.

The timeline is as follows: Phase 1 (hematite) studies underway, report to be submitted in June and Phase 2 to be submitted in September

**Presenter – Employment and Stakeholder Engagement (Colin Forbes):**

Sierra Leone has one of the most stringent legislations for employment in the West African region; The recruitment coverage include, in order of decreasing preference, local, national personnel and Sierra Leoneans in the diaspora and then lastly, international. However, local personnel with the requisite skills within the country are seriously lacking. There are good resources in the diaspora, that notwithstanding. The skilled labour required for the construction stage will be in excess of 10,000, but most of the jobs will likely end up in the hands of foreigners, since trained people are few and far between. Most contractors also feel obliged to bring their staff with them. In any case, given the typical 1:10 paradigm in mining communities, ten (10) other Sierra Leoneans could benefit from ancillary jobs within the community for every person employed by AML. The company`s primary focus in the operational phase is training of local personnel through vocational skills development, with the objective of replacing foreign staff with Sierra Leoneans.

Regular community meetings during exploration phase with stakeholders within the operational areas. Socio-economic baseline surveys to address community concerns is on going at the moment and this has resulted in the set in up of committees. Early Works Chiefdom Committees (EWCC) has been formed to address the immediate impacts of the Haul Road Construction and the railway refurbishment. The committees have got a well defined scope of work and mandate. EWCC membership include Government departments, paramount and section chiefs, political leaders (Members of Parliament and district councillors), youth leaders and NGOs. District Consultative Forums would also be set up with the same defined scope of work and mandate as the EWCC but with expanded membership. Several sub-committees would be set up to include compensation, community development, public awareness, monitoring and evaluation, influx management and Host site identification.

**Presenter - Community project (Mr Mustapha Karama)**

Mr Kamara went through a list of community projects already been being funded by AML: Infrastructure, roads, bridges, water, health, signs for road safety, assisting with water projects, initiatives for diseases like malaria, scholarships (800 to Tonkolili this year alone, primary and secondary), agriculture training projects, sports, donation to mosques, over 4 billion leones on community projects in Sierra Leone.

There are plans for extensive stakeholder engagement, GoSL district consultative forum, subcommittees to deal with social aspect of the project, (compensation, host site identification, community development, employment and training and influx management).

Social and community departments that are overseen by community liaison officers (16 in all) will play an active role in community development projects.

## QUESTION AND ANSWER SESSION

**Qu**: How many jobs will be provided by AML?

**Ans:** Not everyone will get a job at AML. Trained personnel are lacking in Sierra Leone, but efforts are being made to bring in Sierra Leoneans working abroad and so far, the venture has proven successful. In areas where trained Sierra Leoneans are unavailable, AML will temporarily employ an expatriate until a Sierra Leonean has been sufficiently trained to replace him. Training at AML has been and will be an on-going process, and the employees are encouraged to be multi-skilled.

**Qu:** How will AML stack up against competitors from other parts of the world such as Brazil and India?

**Ans:** To start with, the market for iron and steel will not be saturated in the foreseeable future. If for example, everyone in China buys a dishwasher and a laundry machine as the Chinese economy grows to projected levels, no amount of steel in the world will meet such demand. As for now and in the future, the demand for iron remains high, albeit it does fluctuate. AML capitalizes on the fact that Sierra Leone has a world class iron ore deposit in the form of magnetite, as a good enough reason to try and stay ahead of the competition, a concept that would be relied upon when global demand for iron dips. Much of the benefit would come from the cost-effectiveness of mining the ore that is concentrated in a small area, within 28km. At this point, it is fair to state that at 50-62% iron, the ore may not be the best in the world, but it could be the most cost-effective to mine.

**Qu:** When would the haul road be constructed?

**Ans:** Some major contractors are being brought in right now from South Africa; WBHN will cover the Tonkolili axis, whilst two others will be in charge of the Port Loko and Bombali area. There is not enough equipment in the country to undertake such a gargantuan task. As we speak, there are mitigation measures being put in place to carry on operations in the rainy season. A bridge designer is currently in the country and we are on track to complete that part of the project at the end of December. The old Marampa rail tracks are undergoing refurbishment that we expect to complete by the end of the year. Although rail cars are being constructed in South Africa at the moment, some old cars at Pepel are being refurbished for the trains. The cars from South Africa are being prepared for shipment to Sierra Leone and will be here in the next 2-3 months.

**Qu:** Where does AML plan to obtain all the energy required for this work?

**Ans:** That's the challenge! As for phase 1, no additional power is needed, the 4-5MW required for this phase is sufficient. Phase 2 will be the major challenge. We hope to be able to derive energy from a renewable source, supplemented by fossil fuel, i.e., mixing thermal with hydro energy. We do need an independent power provider.

**Qu:** What is your plan for dealing with scrap metals?

**Ans:** Our mission is to mine iron ore and ship it oversees. We will be having no dealings with scraps.

**Qu:** In the area of needs assessment for the affected communities, is mapping done to target actual needs?

**Ans:** AML is at an exploratory stage, and this implies that needs met are those requested by the communities. Nonetheless, the company intends to hold consultative meetings with community representatives, authorities and affected people when the need for mapping arises, consequent upon AML is moving to the mining phase.

**Qu:** How do you classify the 10.1 billion tons of magnetite, measured or indicated?

**Ans:** The 10.1 billion tons of iron ore is an indicated and inferred resource. 80 million tons of indicated and inferred resource have been registered so far. The classification of hematite is more complicated at this stage.

**Qu:** Do you intend to register with indigenous insurance company?

**Ans:** AML plans to first seek local insurance companies and we look forward to working with them.

**Qu:** If you accidentally discover other minerals, such as diamonds or gold, would you include their mining in your operations?

**Ans:** No diamonds have been found at any of the sites. There are small amounts of bauxite and nickel, but our focus and operations will be exclusively in the mining and export of iron ore. We have not found any gold either.

**Qu:** Since you would be trucking huge quantities of loose ore through communities, how would you ensure that people will not be in danger of being affected by the dust particles in the air?

**Ans:** Measures will be put in place to minimize dust released into the atmosphere. The ore, for starters, will be wet, and there will also be wetting of roads. The road trains that would be transporting mined materials from the mine at the Sula Mountains to Lunsar are huge vehicles, which makes stopping in an emergency situation very difficult. AML will sensitise the communities of the transportation process and the dangers involved. There will be sufficient road and warning signs.

**Qu**: How about the environmental disasters that lurk in the dark, land reclamation, release of toxic materials?

**Ans**: An ESHIA study is underway, as earlier iterated by Mr Andy Huckbody. All details pertaining to the environment will be addressed by the reports that are due in June and September, respectively. But we can safely say that no toxic chemicals will be employed in the process plants producing magnetite. We anticipate no huge environmental risk resulting from our operations as health and safety measures have been put in place in the conduct of our operations.

**Qu:** Under what category of license is AML operating? How do we ensure that AML will not be a repeat of the National Diamond Mining Company?

**Ans:** AML is an exploratory company as at yet. There will be no unrealised promises, unlike NDMC. We have a world class mineral in our hands and so much to offer. We are guided by statutory rules and regulations by which we will strictly abide. An ESHIA study is going on right now, and the environmental impacts of our work will be done and publicly disclosed. In that document, post operation activities such decommissioning and land reclamation plans will be discussed.

**Qu:** How do you plan to raise money for such a massive operation?

**Ans:** The project has commenced with an early cash flow (ECF) that involves the initial mining of the hematite that overlies the magnetite deposit in Tonkolili. Following the construction of a haul road from the mine site to Lunsar and the rehabilitation of the defunct Marampa-Pepel rail track, the hematite will be transported and shipped overseas. Proceeds from this project will help build the momentum for the second phase of the project, which is the mining and export of magnetite. The world class nature of the magnetite deposit could provide a basis for additional funding to be solicited.

**Qu:** Where would you obtain the water needed for your operations?

**Ans**: The water requirement for Phase 1 is minimal and is adequately met. For Phase 2, 150 engineers are involved in the feasibility studies to ensure that water is available for the project without any significant impact on other (downstream or riparian) users or the environment.

## OTHER COMMENTS EMERGING FROM THE MEETING WORTH MENTIONING

**Deputy Director of SLEPA**

He spent time discussing the ESHIA process as is highlighted in the SLEPA Act 2008. He commented that the delay in conducting a study is the reason for too many questions being raised at the meeting.

**Mr Andrew Keili (CEMMATS Group Ltd)**

He discussed the ESHIA process, and the reasons for the delay in conducting a study. He gave details of the content of the report that would be written at the end of the study: the Community Development Action plan (CDAP), the public disclosure plan, mine reclamation and rehabilitation, environmental management and monitoring. He also discussed the inadequate capacity of the Sierra Leone Environmental Protection Agency (SLEPA) and the potential for AML to help in capacity building for the agency. He appeased all present that there will be enough time for comments to be made on the ESHIA report.

**Representative of the Civil Society**

She made a number of comments and observations that included: the scale and promising future of AML and likened it to NDMC and the failure of the latter to meet their promises, leaving local communities destitute and having to deal with the environmental consequences of their (the company`s) actions; the class of license that has been issued to AML, exploratory or mining; the inadequacy of the capacity of SLEPA to deal with environmental issues such as the ones likely to be generated by AML operations, and monitoring of their operations.

**Mr Mohamed S. Kabiru, Representative for the National Secretary General of the Farmers Federation**

His concern was in the area of community resettlement programs and how they would affect land use.

**Vote of Thanks by P.C. Bai Kurr from Masimgbe**

He thanked AML for given everyone present an opportunity to hear about the progress made by AML so far. He also thanked the representatives of invited organizations for attending. The PC expressed his excitement at the prospect of a world class mineral found in the country and the implications for national revenue and employment.

African MINERALS

# Tonkolili Iron Ore Project

## Update and Overview

# Introduction to AML

- African Minerals aims to create value through exploration, discovery and development
- The Company holds an extensive portfolio of mineral rights in Sierra Leone – actively investing since 2003
- Tonkolili iron ore project, 10.5 Bt of magnetite - the world's largest reported JORC compliant magnetite resource
- Additional exploration has confirmed the potential for 500 Million tonnes of hematite mineralisation
- Currently have around 740 employees in Sierra Leone
- Expenditure to date circa $100m US
- International Year of Planet Earth Award December 2009

# Today's Objectives

African MINERALS

- Project overview
- ESHIA process
- Social and community

# Project Benefits

- Employment
- Large scale investment in Sierra Leone
- Government revenues
- Community investment and development
- Contribution to local and regional development
- Project-wide training initiatives

New Clinic at Mabonto built by African Minerals

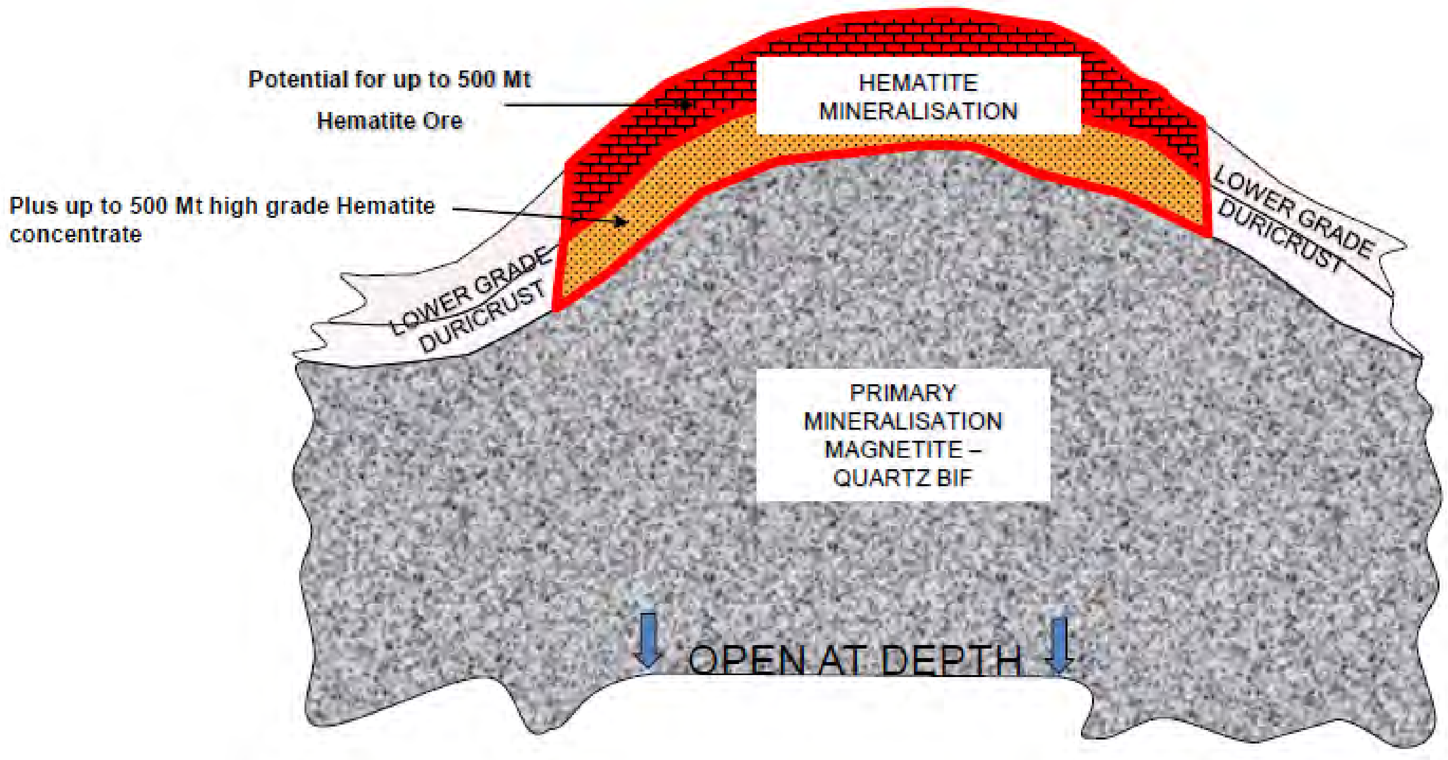
# Project phases and targets

African MINERALS

## Exploration ongoing since 2006

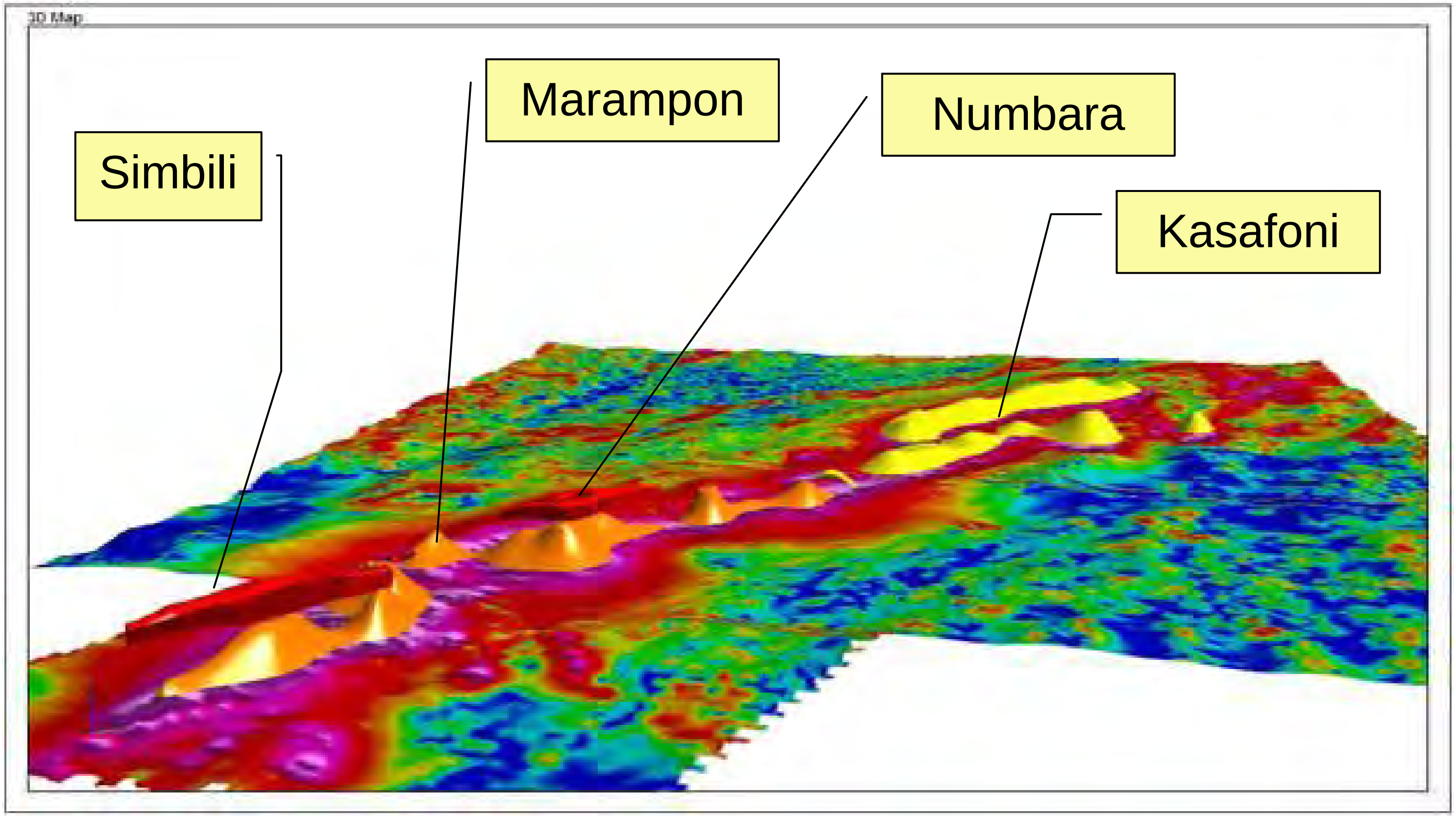
# Project phases and targets

## Phase 1 – 8mtpa of hematite

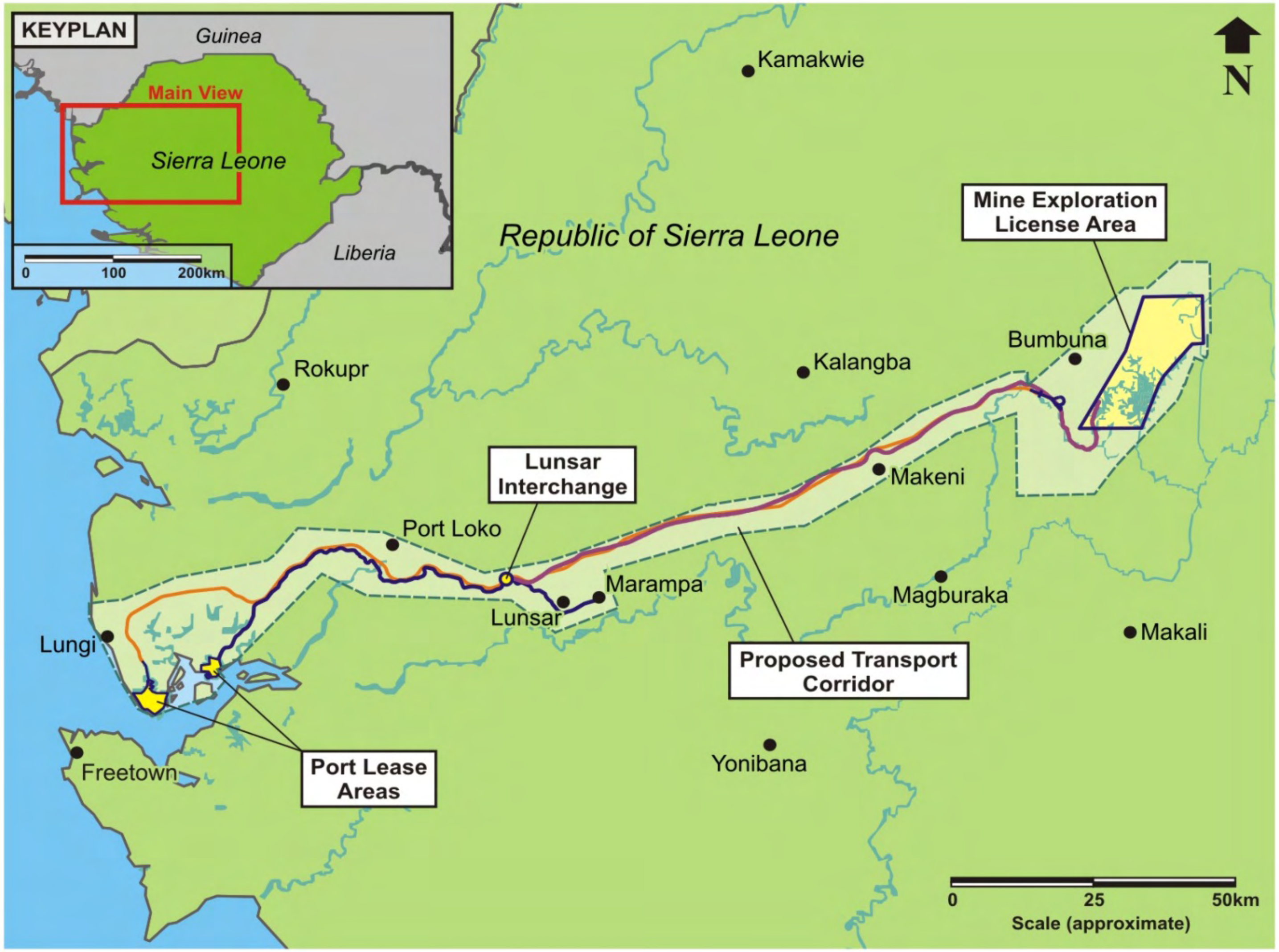


# Project phases and targets

# Phase 2 – 45mtpa of magnetite



# Location


KEYPLAN
Guinea
Main View
Sierra Leone
Liberia
0
100
200km
Kamakwie
N
Republic of Sierra Leone
Mine Exploration License Area
Bumbuna
Kalangba
Rokupr
Makeni
Lunsar Interchange
Port Loko
Marampa
Lunsar
Magburaka
Lungi
Makali
Proposed Transport Corridor
Freetown
Port Lease Areas
Yonibana
0
25
50km
Scale (approximate)

# Phase 1 Process Description

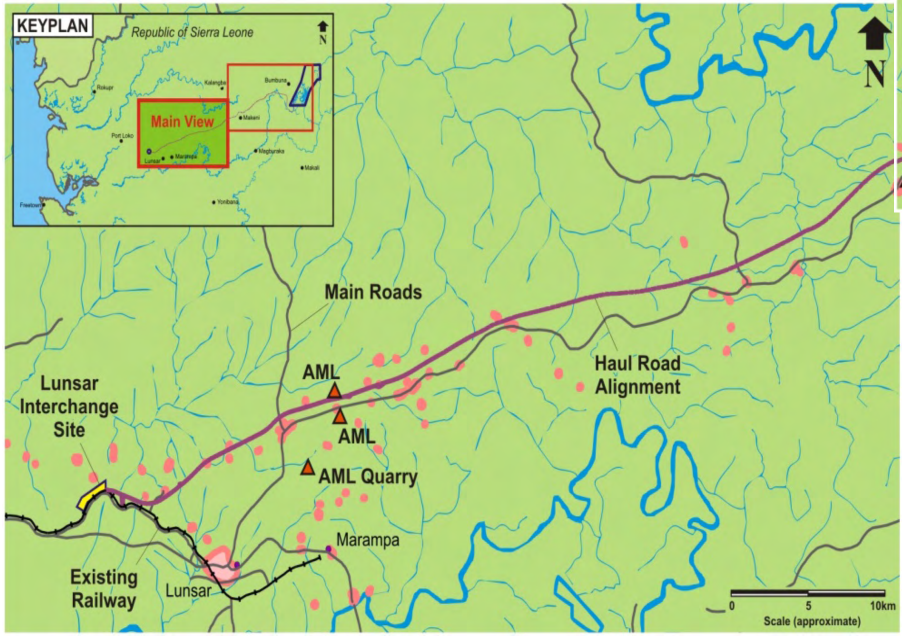
- Mining
  - Conventional truck and shovel mining method, drilling and blasting
  - Minimal beneficiation required to produce export grade hematite
  - 8mtpa target tonnage
- Road Transport
  - Hauling of ore by road train trucks to Rogbom (near Lunsar)
- Rail Transport
  - Transport of ore to Pepel along rail line
- Shiploading and Export
  - Loading of 50,000 DWT transhipment vessels
  - Transhipment to 170,000 DWT vessels off shore

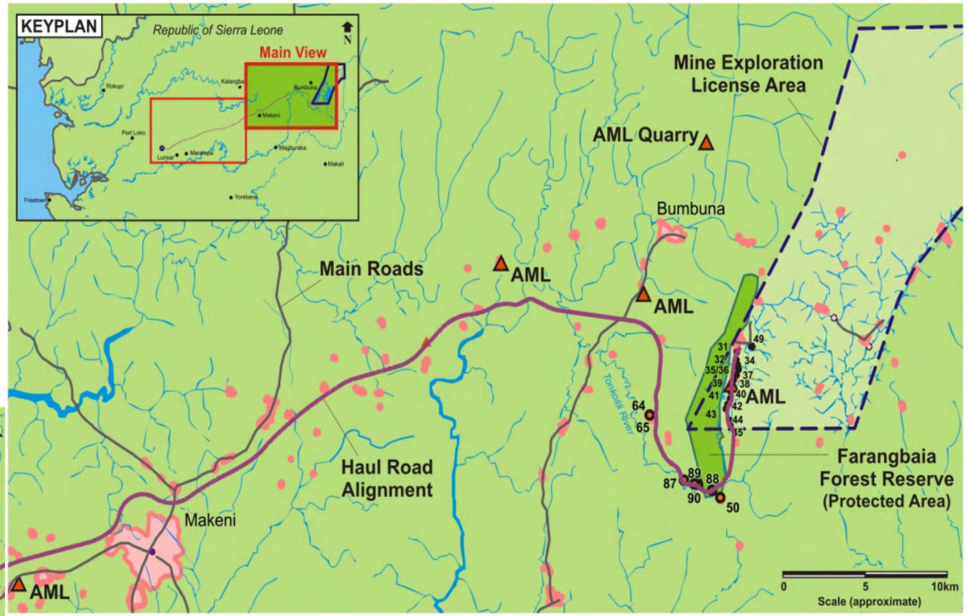
# Phase 1

Haul Road

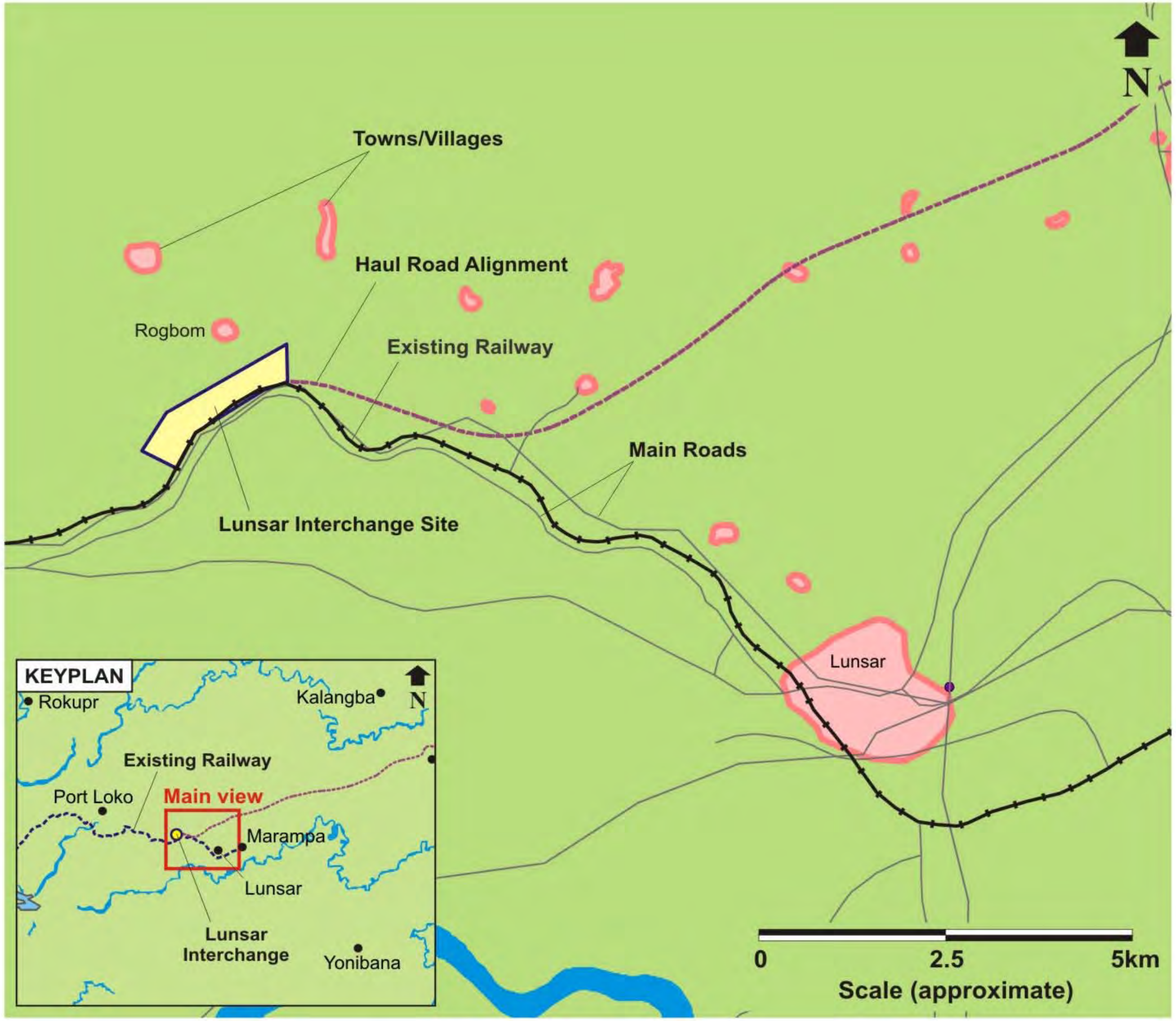
- Design
  - 122 km haul road
  - Farangbaya to Rogbom (near Lunsar)
  - Routing to avoid major social and environmental constraints
  - Major river crossings including the Rokel
  - 16.5 m wide including 1 m berm on either side
- Construction
  - 3 contractors to work on road
  - Preference for local employment and goods and services
- Operations
  - 4 to 5 trailer unit road trains with 400 ton payload
- Community safety programme

# Haul Road

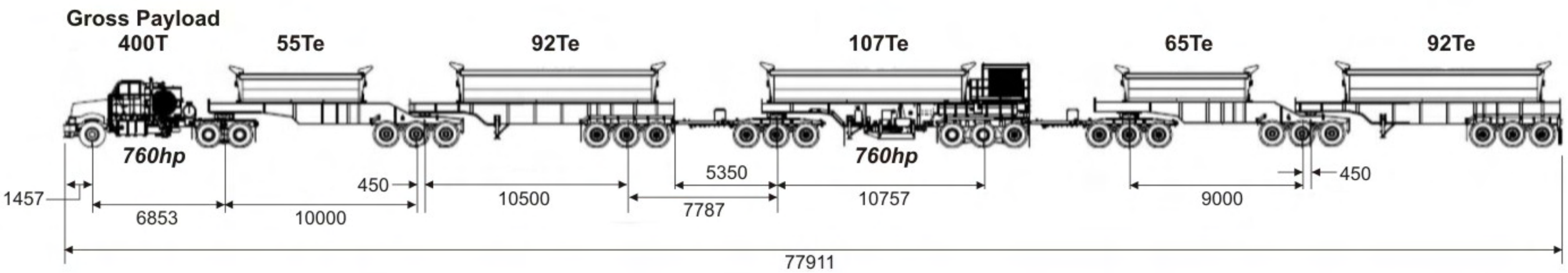

KEYPLAN
Republic of Sierra Leone
Main View
N
Main Roads
AML
AML
AML Quarry
Lunsar Interchange Site
Haul Road Alignment
Marampa
Existing Railway
Lunsar
0 5 10km
Scale (approximate)


KEYPLAN
Republic of Sierra Leone
Main View
N
Mine Exploration License Area
AML Quarry
Bumbuna
Main Roads
AML
AML
AML
Haul Road Alignment
Makeni
AML
Farangbaia Forest Reserve (Protected Area)
0 5 10km
Scale (approximate)

# Haul Road, Rail Interchange

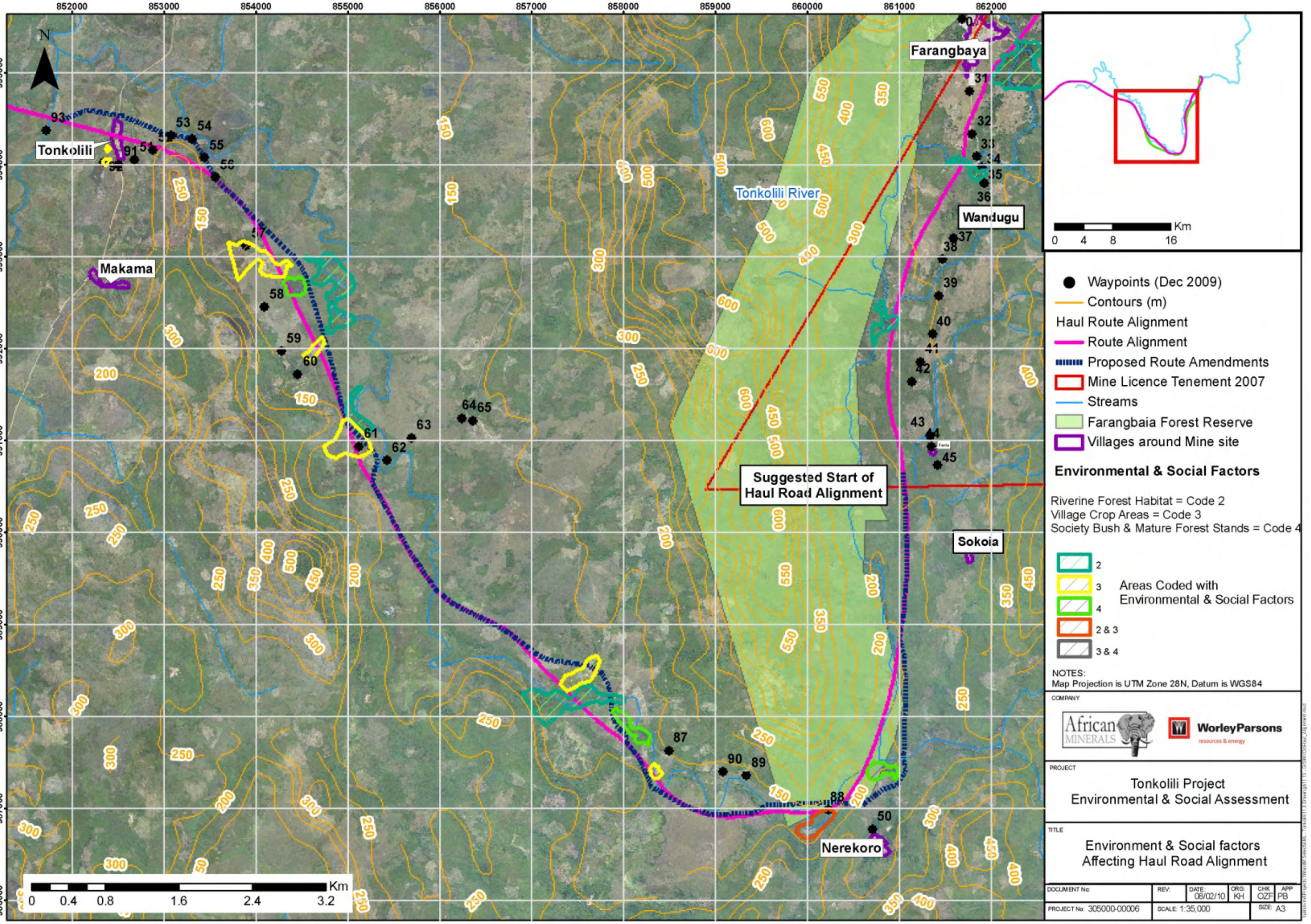


# ECF-Road Train




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | **Totals** |
| **TARE** | 7.8 | 22.7 | 22.2 | 17.0 | 16.2 | 26.1 | 16.7 | 22.2 | 17.0 | **168.0** |
| **PAYLOAD** | 1.1 | 27.6 | 50.9 | 58.4 | 59.4 | 47.6 | 41.9 | 52.7 | 58.4 | **398.0** |
| **GROSS** | 8.9 | 50.3 | 73.1 | 75.4 | 75.7 | 73.7 | 58.6 | 74.9 | 75.4 | **566.0** |
| **ALLOWED** | 12.0 | 50.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | 75.0 | **587.0** |

# Altered Haul Road Alignment Due to Social & Environmental Considerations



# Phase 1

Pepel Railway

- GoSL granted AML 99 year lease to operate Pepel port and railway
- Original narrow-gauge Delco Marampa to Pepel railway to be refurbished
- New rolling stock to be purchased
- Issues
  - Considerable expense to replace lost materials
  - Agriculture and structures have intruded into RoW since railway became defunct
  - Community safety

# Existing Rail

# Phase 1

Pepel Port

- Work underway to re-establish accommodation and training facilities
- Combination of new and refurbished equipment to be used to modernise and upgrade shiploading facility
- Shipping channel to be dredged to accommodate transhipment vessels
- Operations will be 24 hour

# Pepel Port Facilities

# Phase 2

- Mining
  - Blast, mine, haul
- Processing Inputs
  - Power
  - Water
- Infrastructure
  - Water supply
  - Tailings dam
  - Accommodation
  - Support services

# Phase 2

- Heavy Haul Railway
- Tagrin Port
  - Car Dumper
  - Stockpile
  - Conveyor
  - Jetty
  - Berthing Facility
  - Shiploading Equipment

# Tagrin Port

N
Port Road
Port Rail Option
Tagrin Lease Area
Train unloaders
Helipads
IPP Conveyor Corridor
Levee
Port Construction Camp
IPP Stockyard
HV Switchyard
Admin & Workshops
Power Plant
Rail Laydown & Bunded Store
Construction, Laydown & Light Industrial Area
Fuel Storage
Tug Berth
Service dock
Laydown Area
Stockyard
Dredged Area
Drainage Basin
Trestle
Causeway
0
1
2km
Scale (approximate)

# Rail to Tagrin Port

# ESHIA - Studies

Progress of specialist studies:

- Flora - phase 1, 2 studies; mine site, haul road, inland valley swamps, coastal habitats
- Marine ecology – birds (Ramsar site), inter-tidal and sub-tidal infauna, marine mammals, turtles, underwater video, hydrodynamic model of estuarine processes
- Terrestrial fauna – birds, mammals, bats, inverts, herpetofauna
- Hydrology, hydrogeology – surface and groundwater – wells, quantity and quality
- Waste management – facilities, strategies
- Air quality, noise
- Health Impact Assessment
- Soils and geomorphology
- Social Impact Assessment

# ESHIA - Studies

- Expenditure to date:
  - ESHIA studies 2.5 million USD and ongoing
  - 20 monitoring wells and installation of 3 automated weather stations 1 million USD.
- Organisations involved include:
  - WorleyParsons
  - SRK
  - CEMMATS
  - CSSL
  - Kew Gardens
  - Wildlife Conservation Society
  - Hydrobiology

# ESHIA Process

## Phase 1 ESHIA

- Various studies underway or completed
  - haul road
  - railway
  - Pepel
  - marine environment
  - ESHIA report June

# ESHIA Process

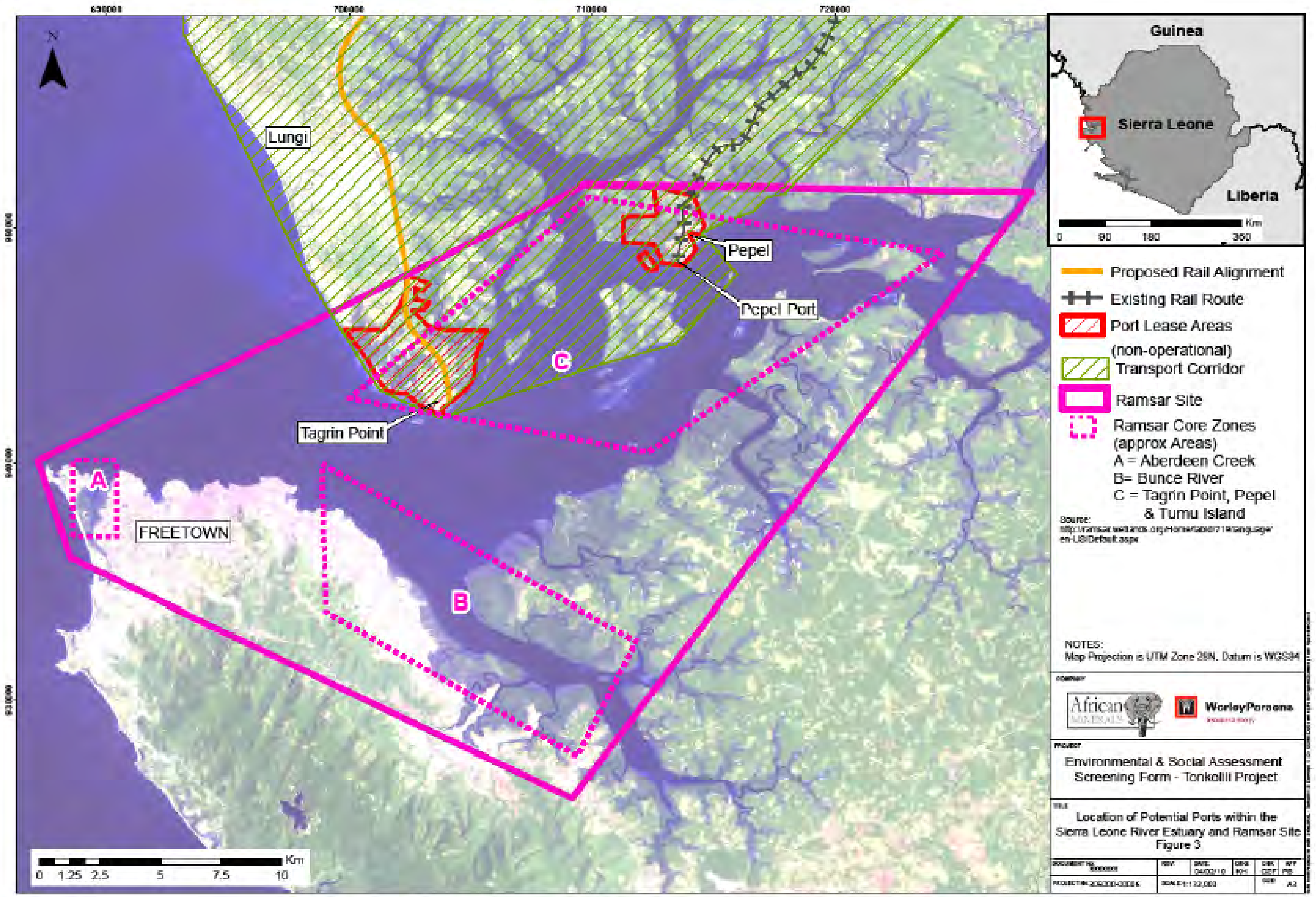
## Phase 2 ESHIA

- Screening Form
- Scoping Report
- ESHIA report due Sept
- Consultations throughout
- Statutory review period after publication of Gazette notice and newspaper advertisement

# ESHIA - Aspects

- Air Quality – dust, process residues
- Ecology – Terrestrial, Coastal and Marine; flora and fauna
- Human Population, socio-economic, resettlement, employment, community development
- Agriculture
- Health impact assessment
- Soil - quality, erosion
- Water – surface and groundwater, quality, water resources, drainage
- Noise
- Landscape and geomorphology
- Special Habitats – protected areas (Forest Reserves, Ramsar)

# Ramsar Site



Lungi
Pepel
Pepel Port
Tagrin Point
FREETOWN
A
B
C
Guinea
Sierra Leone
Liberia
Proposed Rail Alignment
Existing Rail Route
Port Lease Areas
(non-operational)
Transport Corridor
Ramsar Site
Ramsar Core Zones
(approx Areas)
A = Aberdeen Creek
B= Bunce River
C = Tagrin Point, Pepel
& Tumu Island
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
Environmental & Social Assessment
Screening Form - Tonkolili Project
Location of Potential Ports within the
Sierra Leone River Estuary and Ramsar Site
Figure 3
WorleyParsons
Km
0 1.25 2.5 5 7.5 10

# Social and Community

African Minerals corporate ethos

- Spirit of partnership with Sierra Leone
- Add value to neighbouring communities
- Build the foundations for mutually beneficial relationships
- Create transitional climate to address expectations over the long term

# Employment

- Recruitment priorities
  - Local
  - National and diaspora
  - International
- Skills assessment
  - Identified shortage of skilled personnel for both construction and operations
  - Recognised opportunities for improving existing skills
- Anticipated personnel requirements
  - Construction phase in excess of 10,000
    - Unfortunately, large proportion likely to be foreign nationals
    - Strategies in place to mitigate effects within project schedule
  - Operation around 3,000 for over 60 years
- 1:10 ratio of induced employment

Employment office in Bumbuna

# Training

Project wide training initiatives

- African Minerals primary focus on operational phase
- Objective is to replace foreign staff through
  - Vocational skills development
  - Occupational training
  - Experience-based competencies
- Contractors
  - Obliged to implement training programs
  - Construction phase limitations due to schedule
- Training to benefit broader community

# Stakeholder Engagement

- Consultation to date
  - Regular community meetings during exploration phase with Paramount Chiefs and local communities
- Socio-economic baseline survey
  - Primary objective to gauge community concerns
  - Survey conducted using:
    - Individual interviews
    - Village information sheets
    - Household surveys
    - Stakeholder group interviews
  - Data collection process including:
    - Administrative personnel
    - Traditional authorities
    - Community members
    - AML employees

# Stakeholder Engagement

Phase 1

- Early Works Chiefdom Committee (EWCC)
- Membership includes:
  - GoSL district heads of department
  - Paramount Chiefs
  - Section Chiefs
  - Political leaders
  - Women's and youth leaders
  - NGO's
  - AML
- Act as primary channel of communication
- Establish and implement compensation methodology
- Community sensitisation

EWCC Safroko Limba held in Binkolo

# Stakeholder Engagement

Phase 2

- District Consultative Forum
- Same function as EWCC but with expanded membership
- Sub-committees:
  - Compensation
  - Host Site Identification
  - Community Development
  - Employment and Training
  - Influx Management
  - Public Awareness
  - Monitoring and Evaluation

# Social and Community Department

Staffing levels recently increased to meet project demands during implementation:

- 16 Community Liaison Officers
- Community Liaison Manager
- Social and Community Coordinator
- Social and Community Manager
- Corporate Office Manager (Freetown)

# Community Projects

- Infrastructure
  - Roads
    - Improvement of regional road network
    - Road safety initiatives
  - Bridges
    - Rehabilitation of road bridges
    - Assistance with community river crossings
  - Water
    - Provision of safe drinking water to local communities
    - Rehabilitation of wells
- Health
  - Extension of health facilities in local chiefdoms
  - Provision of medical equipment
  - Support for malaria control initiative aimed at developing long term solutions to remote communities
  - Medical assistance to nearby villages

# Community Projects

- Education
  - Schools
  - Equipment
  - Teachers
  - Scholarships

# Community Projects

- Agricultural assistance
  - Training in sustainable farming practices
  - Providing farm equipment
- Sports
  - Support for East End Lions and other regional clubs
  - Sponsorship of Premier League, AML Cup and other sporting activities
- Arts & Entertainment
  - Sponsoring concerts, beauty pageants and cultural programmes
  - Rehabilitation of social halls and entertainment venues
- Community assistance
  - Transportation
  - Food security
  - Emergency response to fire in local community

Donating strip to Golden Dragons of Tonkolili District

# Community Projects

- African Minerals has undertaken these projects to assist the government of Sierra Leone and it’s people in their drive to reduce poverty and achieve sustainable development.
- Company expenditure to date on these projects is approximately SLE 4 billion
- African Minerals remains committed to continually implementing social and community development in consultation with project stakeholders in Sierra Leone throughout the project lifecycle

Construction of new mosque in Bumbuna currently underway

African MINERALS

THANK YOU VERY MUCH FOR COMING

–

WE DUN DUN

# APPENDIX 1

## Excerpts from Interim ESHIA Documents

WorleyParsons
resources & energy

African MINERALS

**AFRICAN MINERALS LIMITED**

## Tonkolili Iron Ore Project

# Environmental Management Plan - Draft

305000-00006 – Document Number

29 April 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

# SYNOPSIS

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of iron ore concentrate. WorleyParsons Europe has been engaged as the PMC Contractor to assist AML with the definition of the project that will include a Definitive Feasibility Study report supported by capital and operating costs.

*This section of the document is to be updated by the originator as the responsible person to provide a summary as to the key purpose of the report*

*NOTE: all red italic notes in this document template are for guidance only. Please delete them before issuing the document*.

### Disclaimer



**PROJECT 305000-00006 - REPORT TITLE**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Squad Check | A Huckbody | A Reviewer | N/A | 28-04-2010 | N/A | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# CONTENTS

## Appendices

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# 1 INTRODUCTION

## 1.1 General

This document presents an Environmental Management Plan (EMP) for the haul road element of the Early Cash Flow Project and has been prepared following a request by the Sierra Leone Environmental Protection Agency (SLEPA). The term EMP is used here as synonymous with Environmental & Social Management Plan (ESMP), as the current international approach is to prepare a management document that addresses both environmental and social issues during construction and into operation.

This report builds on and extends the 'Environmental and Social Management principles for haul Road Development for ECF', which was originally produced in February 2010 as guidance to AML for use with haul road planning and implementation and the document was reproduced (as Appendix 13) in the Haul Road Scoping Document issued 15 April 2010, which was sent to and reviewed by SLEPA.

The report cited above contains many elements of an Environmental Management Plan and was produced in advance of completion of the ESHIA for the Early Cash Flow (ECF) project, as an environmental management response to early works implementation. It was informed by the early scoping of potential issues associated with haul road design and construction and much of it is still valid and appropriate at this stage in the development of the haul road. Consequently, much of the content is common to the EMP presented in this document.

Since the design of the haul road is still ongoing it is not possible at this stage to finalise all the potential environmental or social effects, therefore the present report is **preliminary** and will be a living document, which will be updated periodically in line with the design and potential effects as they arise.

The need for preparation of specific EMPs for individual project infrastructure components has not yet been determined and in fact it is envisaged that an ESHIA will be prepared for the ECF project as a whole and will include an EMP or ESMP, to describe the management of potential impacts and the delivery of mitigation for environmental and social issues. This particular EMP has been requested to cover only the haul road and it must be considered as a part of an ongoing ESHIA process for ECF and Tonkolili and is therefore not 'stand alone', but part of a larger project and process. This is particularly the case for many of the social elements, which are addressed through a range of initiatives, such as Social Impact Assessment, Resettlement Policy Framework, Resettlement Action Plan, Stakeholder Engagement Plan (equivalent to a Public Consultation and Disclosure Plan) – all associated with the main Tonkolili project. In addition, there are some initiatives for the ECF, which include the Early Works Chiefdom Committees (EWCC); see later in this document.

The social aspects for the haul road alone are being addressed in a separate document, specifically requested by SLEPA, namely a Community Development Action Plan (CDAP). The CDAP should be referred to for the latest update on the status of community initiatives, such as ongoing community consultation and community development actions.

## 1.2 Objective of the EMP

The objective of the EMP is to ensure that any potentially negative environmental and social impacts during construction are kept at an acceptable level. It sets out to ensure that all aspects of the works comply with the relevant legislation and good practice, and that measures to mitigate impacts identified in the scoping documents are implemented. An EMP implements appropriate environmental controls and monitoring procedures during construction and after the work is completed. An EMP (or ESMP) is normally produced towards the end of an ESHIA process, when potential impacts and their mitigation have been determined. In this case it has been prepared in a very short timescale at the request of SLEPA, specifically for the haul road and has consequently not had the benefit of the rest of the ESHIA process. It has therefore been informed by the scoping of potential issues that has been undertaken for the haul road and in-country knowledge and experience of the consultants.

## 1.3 Project Description

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of magnetite concentrate with a grade containing not less than 69% iron (Fe) and less than 3% silica ($SiO_2$)with a minimum particle size (P80) of 38 micron, from a resource deposit identified containing 5.1 billion tonnes of recoverable ore.

The mine project area is located approximately 200 km east of Freetown, the capital city of Sierra Leone.

The project will comprise the mine and process plant facilities supported by a rail network to transfer the concentrate product to the stockyards and handling facilities at the port area which is located at Tagrin Point adjacent to Lungi airport to the north of Freetown.

Three ore bodies have been identified for production; Simbili, Marampon and Numbara. It is envisaged that staged development will be undertaken dependent on the exploration activities which are currently underway, to maximize the return on the investment. It is likely that additional ore bodies will subsequently be developed as the understanding of the geological conditions and the mine reserves mature.

To commercialise the Tonkolili Resource, AML will execute an integrated greenfield development through the construction of new facilities which include:

- A new mine and ore processing plant at Tonkolili, to produce 45 Mtpa of magnetite concentrate;
- Approximately 200 km of new standard gauge, heavy haul railway from Tonkolili to Tagrin Point;
- A new deepwater port and associated infrastructure at Tagrin Point suitable for loading vessels up to Cape size for the export of 45 Mtpa magnetite concentrate; and,
- All associated support infrastructure to deliver and operate the project safely and successfully.

At the mine, the project development will comprise an open cut mine, ROM pad, the minerals processing facilities and support infrastructure such as power, water, access roads, air terminal, accommodation facilities, workshops, warehouses, laboratories and administration buildings and train loading facility.

## 1.4 Location

The following figure provides an indication of the mine site location relative to the coast and the borders with Guinea and Liberia. The mine site at Tonkolili is approximately 200km ENE of the capital of Freetown and the port location at Tagrin Point.

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## Tonkolili Iron Ore Project - Haul Road

# Community Development Action Plan

305000-00006 –

29 April 2010


Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

**AFRICAN MINERALS LIMITED**
**HAUL ROAD COMMUNITY DEVELOPMENT ACTION PLAN**
**TONKOLILI IRON ORE PROJECT - HAUL ROAD**

# SYNOPSIS

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of iron ore concentrate. WorleyParsons Europe has been engaged as the PMC Contractor to assist AML with the definition of the project that will include a Definitive Feasibility Study report supported by capital and operating costs.

### Disclaimer



**PROJECT 305000-00006 - HAUL ROAD COMMUNITY DEVELOPMENT ACTION PLAN**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Squad Check | A Huckbody | A Reviewer | N/A | 28-04-2010 | N/A | |
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# 1 INTRODUCTION

## 1.1 General

This document presents a Community Development Action Plan (CDAP) for the haul road element of the Early Cash Flow Project and has been prepared following a request by the Sierra Leone Environmental Protection Agency (SLEPA).

This report builds on the 'Haul Road Scoping Report' issued 15 April 2010, which was sent to and reviewed by SLEPA.

The report cited above sets out the consultation mechanism established through discussions with local authorities (District Councils and Paramount Chiefs) to address social issues related to the Early Cash Flow (ECF) project as a social management response to early works implementation. .

Since the consultation process for this component of the ECF program is still ongoing it is not possible at this stage to finalise all the issues that would normally feature conclusively in a document of this nature. Furthermore, this report is preliminary and will be a living document, which will be updated periodically in line with ongoing consultation and adoption the outcomes as they arise.

The need for preparation of a specific CDAP for the haul road has been brought by SLEPA. Broader community development issues will need to be considered at the appropriate time to cover the Tonkolili phase of the Project so this CDAP is therefore not 'stand alone', but part of a larger project and process. This is particularly the case for many of the social elements, which are addressed through a range of initiatives, such as Social Impact Assessment, Resettlement Policy Framework, Resettlement Action Plan, Stakeholder Engagement Plan – all associated with the main Tonkolili project. In addition, there are some initiatives for the ECF, which include the Early Works Chiefdom Committees (EWCC); see later in this document.

## 1.2 Scope of the CDAP

The scope of this CDAP is to identify assistance methodology that the haul road project will provide to local and affected communities in compliance with local legislation and define how AML will extend such assistance beyond compliance. In many cases these additional measures are associated with the need to deal with impacts that the haul road may have from both a social and environmental perspective.

The CDAP sets out to ensure that programs are established to enhance socio-economic development and in the process mitigate impacts identified in the scoping documents. It also helps to focus project resources on stakeholder agreed deliverables which assist the proponents planning and implementation process. To achieve this level of stakeholder participation a CDAP is normally produced towards the end of an ESHIA process, when potential impacts and their mitigation have been determined. In this case it has been prepared in a very short timescale at the request of SLEPA, specifically for the haul road and has consequently not had the benefit of the rest of the ESHIA process. It has therefore been informed by the scoping of potential issues that has been undertaken for the haul road and in-country knowledge and experience of the consultants.

## 1.3 Project Description

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of magnetite concentrate with a grade containing not less than 69% iron (Fe) and less than 3% silica ($SiO_2$)with a minimum particle size (P80) of 38 micron, from a resource deposit identified containing 5.1 billion tonnes of recoverable ore.

The mine project area is located approximately 200 km east of Freetown, the capital city of Sierra Leone.

The project will comprise the mine and process plant facilities supported by a rail network to transfer the concentrate product to the stockyards and handling facilities at the port area which is located at Tagrin Point adjacent to Lungi airport to the north of Freetown.

Three ore bodies have been identified for production; Simbili, Marampon and Numbara. It is envisaged that staged development will be undertaken dependent on the exploration activities which are currently underway, to maximize the return on the investment. It is likely that additional ore bodies will subsequently be developed as the understanding of the geological conditions and the mine reserves mature.

To commercialise the Tonkolili Resource, AML will execute an integrated greenfield development through the construction of new facilities which include:

- A new mine and ore processing plant at Tonkolili, to produce 45 Mtpa of magnetite concentrate;
- Approximately 200 km of new standard gauge, heavy haul railway from Tonkolili to Tagrin Point;
- A new deepwater port and associated infrastructure at Tagrin Point suitable for loading vessels up to Cape size for the export of 45 Mtpa magnetite concentrate; and,
- All associated support infrastructure to deliver and operate the project safely and successfully.

At the mine, the project development will comprise an open cut mine, ROM pad, the minerals processing facilities and support infrastructure such as power, water, access roads, air terminal, accommodation facilities, workshops, warehouses, laboratories and administration buildings and train loading facility.

## 1.4 Location

The following figure provides an indication of the mine site location relative to the coast and the borders with Guinea and Liberia. The mine site at Tonkolili is approximately 200km ENE of the capital of Freetown and the port location at Tagrin Point.

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## Tonkolili Iron Ore Project

# Haul Road Scoping Report

305000-00006 – 305000-00006-0000-EN-REP-0014

15 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

# SYNOPSIS

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of iron ore concentrate. WorleyParsons Europe has been engaged as the PMC Contractor to assist AML with the definition of the project that will include a Definitive Feasibility Study report supported by capital and operating costs. In addition WorleyParsons are responsible for preparing an Environmental, Social and Health Impact Assessment for the project.

This document represents a scoping report covering one element (the haul road) of the project. The report is intended to provide sufficient information on this element so that appropriate terms of reference for the ESHIA study can be defined and the full ESHIA can be successfully implemented.

**Disclaimer**

*This report has been prepared on behalf of and for the exclusive use of African Minerals Limited, and is subject to and issued in accordance with the agreement between African Minerals Limited and WorleyParsons Services Pty Ltd. WorleyParsons Services Pty Ltd accepts no liability or responsibility whatsoever for it in respect of any use of or reliance upon this report by any third party.*

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*The following sections of this report have been prepared by our project partners SRK:. Ecology and biodiversity, Soils and land-use, Geology and geomorphology and Socio-economic environment. SRK maintain that while the standard of work has been completed with consideration of in-country requirements and relevant international standards and guidelines. The scope of the work is limited geographically and / or in terms of level of detail and therefore the work reported does not meet the criteria for a baseline study. This work is considered to only be the starting point for baseline characterisation for the Tonkolili Iron Ore Project. SRK and its sub-consultants considered that significant supplementary work is required taking cognisance of seasonal variations (as a minimum 12 months) is required to fulfil international requirements for a baseline study.*

**PROJECT 305000-00006 - HAUL ROAD SCOPING REPORT**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| 0 | Issued for Use | A Huckbody | P Burris | N/A | 20/04/2010 | N/A | |
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## EXECUTIVE SUMMARY

This document has been prepared at the request of the Sierra Leone Environmental Protection Agency (EPA) and serves to provide additional information on the potential environmental and social effects associated with the proposed Haul Road which is part of the Early Cash Flow component of the Tonkolili Iron Ore Project. This report must be viewed within the context of the overall Environmental, Social and Health Impact Assessment (ESHIA) process which is underway for the Tonkolili project as a whole.

To date, the Tonkolili ESHIA process has undergone the following procedural steps:

- A screening stage was undertaken in February 2010 during which a project screening form, compliant to in-country procedures was submitted to the EPA. This provides information on the project and potential Environment & Social issues.
- Following this, agreement was sought with the EPA on the terms of reference for the ESHIA study. A report submitted to the EPA in March 2010, in the form of a discussion document which set out a proposed plan describing the area of interest of the project and the methodology and type of study work that could be undertaken. The discussion document contained a considerable amount of information on the approach to the ESHIA, including scopes of work for the various specialist studies, examples of rapid assessment surveys and information on the location and preliminary design of key project facilities.
- Further to this discussion document, it was agreed that a specific scoping report should be produced for the haul road which represents a fast-track project element. The scoping report (this document) would comprise an element of a larger scoping process that would encompass the entire Tonkolili project.

Section 1 of this report provides an introduction; section 2 gives definitions and abbreviations; section 3 lists referenced documents; section 4 provides a project description; section 5 outlines relevant legislation; section 6 gives information on baseline conditions, but not full information, as this is only a scoping document; sections 7 and 8 give information on the potential impacts and preliminary mitigation that can be identified at this early stage in the assessment process, commensurate with the early level of design information and route selection available to date.

In recognition of the dynamic phasing of the project, driven by investment processes and other factors, it is envisaged that the EPA and other authorities can work together with the project as formal stakeholders, with formal permissions being issued in parallel with the implementation of the enabling works of the ECF.

# 1 INTRODUCTION

This document has been prepared at the request of the Sierra Leone Environmental Protection Agency (EPA) and serves to provide additional information on the potential environmental and social effects associated with the proposed Haul Road which is part of the Early Cash Flow component of the Tonkolili Iron Ore Project. This report must be viewed within the context of the overall ESHIA process which is underway for the entire Tonkolili project. ***Similarly, many of the baseline surveys and scoping of potential impacts have been focused on either the ECF or the Tonkolili project as a whole and given the very short notice for preparation of this scoping report it is not feasible in all cases to dis-aggregate data and present aspects specifically for the haul road alone***.

The document presents a scoping of Environmental, Social and Health issues associated with the Haul Road, which is one component of the Early Cash Flow (ECF) works, which are considered as enabling works for the Tonkolili Iron Ore Project.

Conventionally a scoping document is prepared as part of the overall Environmental, Social and Health Impact Assessment (ESHIA) process for a major project, leading on to agreement of the issues to be addressed in the ESHIA (terms of reference) and then evaluation of potential impacts and development of mitigation and reporting and approvals. In this case a scoping document for the overall Tonkolili project is underway and is due to be presented to AML and then EPA at the end of April 2010. This follows on from submission of the Screening Form for the project to EPA in February 2010. The Screening Form submission triggers screening by EPA and agreement of the terms of reference for the ESHIA study.

The Screening Form was followed in March 2010 by submission of a discussion document to the EPA that contained a considerable amount of information on the approach to the ESHIA, including scopes of work for the various specialist studies, examples of rapid assessment surveys and information on the location and preliminary design of key project facilities.

As part of the discussion document it was suggested that an ESHIA report for the ECF component could be submitted to AML and EPA, with ESHIA studies and reports to follow for Tonkolili later in the year.

The haul road is to be constructed to link the mine site at Tonkolili with the refurbished railway line that runs to Pepel Port. The haul road is intended to connect to a railhead that will be located in Lunsar. In view of the dynamics of the project and in particular the ECF works, the route selection of the haul road (‘alignment’) is still being designed. An initial alignment has been determined in principle using a constraints analysis that incorporates topography, maximum road curvature, ground conditions as well as social and environmental constraints. The procedure being implemented is that a scout or survey track is being cleared at ca. 6m width, which will allow surveyors good access and enable ground conditions to be assessed, following which the final alignment and eventual widening will take place.

A range of environmental and social (E&S) studies have been undertaken covering the haul road alignment, some of which are still ongoing. In addition, several baseline studies have either been completed or are ongoing which cover large parts of the ECF and Tonkolili study areas. These studies have been carried out together where the transport corridor from the mine site towards Lunsar area is common to both ECF and Tonkolili and the haul road lies entirely within this wider common transport corridor.

In recognition of the dynamic phasing of the project, driven by investment processes and other factors, it is envisaged that the EPA and other authorities can work together with the project as formal stakeholders, with formal permissions being issued in parallel with the implementation of the enabling works of the ECF.

## 1.1 Tonkolili Scoping Introduction

This section provides the context of the haul road in relation to the overall approach of the ESHIA process, of which the haul road and its scoping is but one component. The full scoping for the overall Tonkolili project is nearing completion and is due to be submitted to AML and EPA at the end of April 2010.

A project-wide Scoping report in currently in preparation to provide the following:

- A description of the scope of works;
- The basis for the full terms of reference of the ESHIA;
- An overview of potential environmental impacts and early identification of environmental and social risks that can be identified at this stage associated with the Tonkolili project.

This report also covers the above requirements for the Early Cash Flow (ECF) project. The scoping report follows on from the Screening Form that was completed and submitted to EPA in February 2010, as per in-country procedures.

The main Tonkolili Iron project will consist of open cast mining, transportation of concentrate by rail to a port at Tagrin Point, near the mouth of the Sierra Leone River Estuary. The ECF project involves mining of the hematite cap overlying the magnetite deposit and transporting the product via dedicated haul road and refurbished railway to Pepel Port. In the report the Tonkolili project is segregated into four elements: Mining Area, Transport Corridor, Port Facilities and Offshore. The elements that constitute the ECF project are dealt with separately.

The report identifies relevant legislation and institutional bodies, provides a description of the existing environment within the project area, an overview of potential impacts, and scope of works and methodology for the development of the ECF ESIA and the Tonkolili ESHIA. The document outlines the topics that will be covered and how each topic will be assessed in future works, including the preparation of an implementation strategy of environmental and social baseline programs and a regulatory schedule.

This report will feed into and inform the ongoing Project design and will also form a common basis for consultation on the scope and methodology for the ESHIA process. The report outlines the future deliverables for the project, ie the ECF ESIA that is scheduled to be produced in mid-June and the Tonkolili Preliminary ESHIA Report that will be submitted at the end of August as part of the Front End Engineering Design (FEED). The environmental and social inputs will also be included in the Definitive Feasibility Study (DFS) that will be submitted by the end of April.

### 1.1.1 Distribution and Intended Audience

The Scoping Report is intended to inform statutory bodies including the EPA and other stakeholders about the process and methodology for conducting the ECF ESIA and Tonkolili ESHIA projects.

Although it is not a legislative requirement the report sets out a framework for the future deliverables that will be provided to the EPA in order to satisfy the legal requirements for Environmental Impact Assessment.

# 2 DEFINITIONS AND ABBREVIATIONS

## 2.1.1 General Definitions

The Tonkolili Project – Tonkolili Iron Ore Project is the open pit mining operation and transportation of concentrate by rail to a newly developed port at Tagrin Point from which it is loaded out to global markets.

The convention used in this report for describing location along the haul road (the 'chainage') assumes that 'Km 0' is at the western end near Lunsar whilst Km 122 terminates at the mine site.

## 2.1.2 Abbreviations

| | |
|---|---|
| EPA | Sierra Leone Environment Protection Agency |
| GOSL | Government of Sierra Leone |
| GVWC | Guma Valley Water Company |
| DfID | UK Department for International Development |
| EHS | Environmental, Health and Safety |
| EITI | Extractive Industries Transparency Initiative |
| ESHIA | Environmental, Social and Health Impact Assessment |
| HIA | Health Impact Assessment |
| ICMM | International Council on Mining and Metals |
| IFC | International Finance Corporation |
| ILO | International Labour Organisation |
| IMO | International Maritime Organisation |
| IUCN | International Union for Conservation of Nature |
| MAFF | Ministry of Agriculture and Forestry and Food Security |
| MEP | Ministry of Energy and Power |
| MFMR | Ministry of Fisheries and Marine Resources |
| MLHCPE | Ministry of Lands, Housing, Country Planning and the Environment |
| MMR | Ministry of Mineral Resources |
| MoE | Ministry of the Environment |
| MoH | Ministry of Health |

| | |
|---|---|
| MTA | Ministry of Transport and Aviation |
| MTAP | Mine Technical Assistance Project |
| MTC | Ministry of Tourism and Culture |
| MWI | Ministry of Works and Infrastructure |
| NWRB | National Water Review Board |
| OP | Operational Policy |
| PM | Particulate Matter |
| SALWACO | Sierra Leone Water Company |
| UNCTAD | United Nations Conference of Trade and Development |
| UNEP | United Nations Environment Program |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| US EPA | United States Environmental Protection Agency |
| WBG | World Bank Guidelines |
| WHO | World Health Organisation |

### 2.1.3 Sources

This haul road scoping document has been developed from various sources. Listed below are the references to these sources. Information in the body of this document that is derived from these sources is noted by a code.

| Code | Source Name |
|---|---|
| AML | African Minerals Limited - General Information, Data and Instructions |
| WP | WorleyParsons |
| Ausenco | Process Plant Design Engineer |
| TQ | Technical Query |
| GoSL | Government of Sierra Leone |
| EHS | World Bank  Environmental, Health, and Safety Guidelines (2007) |
| SRK | SRK Consulting (UK) Ltd  - project sub-consultants |
| STAT | Statutory Requirements |

# 3 REFERENCED DOCUMENTS

**Document Title**

WorleyParsons, 3 Feb 2010, Environmental and Social Management Principles for Haul Road Development for ECF
Ndomahina E.T. 2008. Republic of Sierra Leone Mineral Sector Technical Assistance Project Environmental and Social Impact Assessment (ESIA) Study.

SRK Consulting. June 2009, Tonkolili Iron Ore Project: Environmental and Social Initiation Study

Nippon Koei UK, BMT Cordah and Environmental Foundation for Africa. January 2005. Bumbuna Hydroelectric Project Environmental Impact Assessment.

Ayibotele N. B. March 2005, National Policy Guideline and Action Plan on Water Supply and Sanitation: Water Supply and Sanitation for Sierra Leone.

NBSAP. 2002. Convention on Biological Diversity, National Biodiversity Strategy and Action Plan (NBSAP)

WorleyParsons. February 2010. Environmental Impact Assessment Screening Form

Nimba Research & Consulting Co. Ltd., June 2008, Mining Sector Technical Assistance Project, Resettlement Policy Framework

Government of Sierra Leone, Sept. 2008. Environment Protection Agency Act, 2008. As presented in the Supplement to the Sierra Leone Gazette Vol. CXXXIX, No. 44 dated 11th September 2008.

Kew Gardens, February 2010, Report on the Vegetation Survey & botanical Inventory of the Tonkolili project area, Sierra Leone

Kew Gardens, April 2010, Report, Phase 3 of the vegetation studies at the Tonkolili mine site, Sierra Leone

Kew Gardens, October 2009, Report on the botanical reconnaissance survey of the Tonkolili project area, Sierra Leone

# 4 PROJECT DESCRIPTION

## 4.1 Project Overview

African Minerals Limited (AML) has been exploring an extensive magnetic anomaly in the Sula Mountain range in Sierra Leone and in 2009 confirmed the presence of a world-class magnetite iron ore deposit. The mine project area is located approximately 200 km east of Freetown, the capital city of Sierra Leone.

The Tonkolili Project focuses on the three magnetite banded iron formation (BIF) targets that occur in the southern portion of the northeast – southwest trending anomaly. These deposits are named Simbili, Marampon and Numbara and the current combined ore estimate is 5.1 billion tonnes.

Exploration to date also indicates that the Simbili-Marampon-Numbara magnetite anomaly is overlain with a hematite deposit, estimated to be in the order of 800 million tonnes.

To commercialise the Tonkolili Resource, AML will execute an integrated greenfield development through the construction of new facilities which include:

- A new mine and ore processing plant at Tonkolili, to produce 45 Mtpa of magnetite concentrate;
- Approximately 200km of new standard gauge, heavy haul railway from Tonkolili to Tagrin Point,
- A new deepwater port and associated infrastructure at Tagrin Point suitable for loading Cape size vessels for the export of 45 Mtpa of magnetite concentrate; and,
- All associated support infrastructure to deliver and operate the project safely and successfully.

In addition to the proposed Tagrin Point port, AML has signed a 99 year lease agreement with the Government of Sierra Leone (GoSL) to reconstruct, manage and operate Pepel Port and the Pepel – Marampa Railway. AML is working toward mining hematite ore found in the Tonkolili deposits during the initial stages of the project and exporting the product via Pepel Port. A dedicated haul road (approximately 120 km in length) will be built from the mine site to a railhead near Lunsar and the existing railway line refurbished between Marampa and Pepel while the Tagrin Point export route infrastructure is under construction. These works form what is referred to as the Early Cash Flow (ECF) project.

## 4.2 Location

The following figure provides an indication of the mine site location relative to the coast and the borders with Guinea and Liberia. The mine site at Tonkolili is approximately 200km ENE of the capital of Freetown and the port location at Tagrin Point.

**Figure 4-1: Overview Location Map showing the Haul Road Alignment**


## 4.3 Early Cash Flow (ECF) Project

The principal elements of the ECF project are described below:

- Mining Area - hematite deposits from the ECF project are located along the crown of the Simbili formation. Supporting mine infrastructure, accommodation facilities and mining plant will be located in the Mawuru and Tonkolili valleys south of Simbili.
- Transport Corridor – a haul road is under construction from the mine site to Lunsar (approximately 120 km). Ore is then transported by narrow-gauge rail transport to Pepel along the same rail trace as occupied by the original Delco rail line;
- Port Facilities – ore will be exported from Pepel port using a combination of new facilities for a rail dumper, ore handling and stockpiling and the wharf interface including refurbishment of the existing ship-loading jetty, fuelling jetty and fuel farm and power house.
- Offshore – the base-case option assumes panamax sized shipping will berth and be loaded from the primary Pepel jetty.

### 4.3.1 ECF Project status

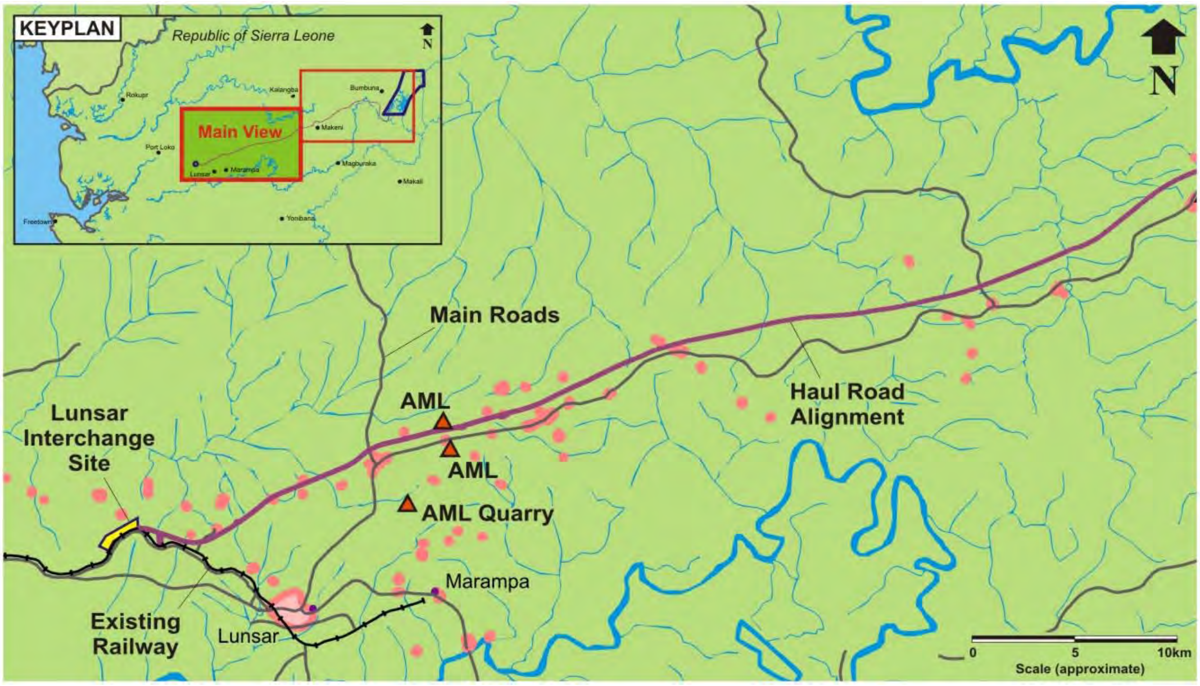
In view of the seasonal constraints of working on earthworks during the wet season, work has commenced on the haul road in March 2010. Minor refurbishment works to buildings have commenced in the Pepel port compound, using locally recruited and specifically trained labour.

In late January development work on the mine haul road (specifically vegetation clearing in some of the easement / Right of Way (ROW)) commenced in the eastern reaches of the haul road adjacent to the mine.

## 4.4 Haul Road

The ECF project will transport iron ore using a 122.6 km long haul road built from the mine site to a railhead near Lunsar. The haul road commences about 8Km North-West of Lunsar (where it ties in with the existing railway which is to be refurbished) and extends about 122Km to the mine at Tonkolili.

**Figure 4-2: Map 1 of Haul Road Alignment**



# APPENDIX 1

## ESHIA Scoping Document

African MINERALS

**AFRICAN MINERALS (SL) LIMITED**

6th April, 2010

Acting Director
Sierra Leone Environmental Protection Agency (SLEPA)
Ministry of Lands, Environment and Country Planning
3RD Floor Youyi Building
Freetown

**Dear Sir,**

**APPLICATION FOR A MEETING WITH THE SIERRA LEONE ENVIRONMENTAL PROTECTION AGENCY (SLEPA)**

The engineering design for the proposed Tagrin Point Port, Rail Haul Road and other infrastructures is being undertaken by WorleyParsons on behalf of African Minerals Ltd. is progressing. Currently, plans are being finalized to carry out a thorough data collection in all aspects to cover the requirements of an all encompassed Environmental Assessment of the whole project.

With reference to the above and the submission of our scoping document to you on the 22nd March 2010, AML is officially requesting a meeting with SLEPA in the earliest possible time to discuss matters arising and finalize the Terms of Reference (TOR) with the related activities already planned for Environmental Impact Assessments (EIA) study for the entire project. It is our hope that after this meeting, issues mentioned below would have been discussed and agreed upon and begin our impact assessment study in earnest.

1. Legal Frame of the EIA and ESHIA of the project
2. Environmental Management and Decommissioning Plan
3. Best Practice Guidelines base on TOR and SOW
4. Public Disclosure Frame Work
5. Alternative interim plans and anticipated studies and issues such as demographic etc
6. Consultation with and inclusion of MDAs such as Ministry of Transport and Aviation, Ministry of Local Government and Internal Affairs, Ministry of Labour, Employment and Social Security and Ministry of Tourism.

Following the outcome of such meeting, AML would put the machinery in place to start the organization of a series of workshop and consultative meetings to discuss these Terms Of Reference (TOR) and Scope Of Work (SOW) of all the different aspects that would make up the complete EIA for the project with other multi stakeholders. The road map of the EIA and ESHIA scoping, procedures and timings and management plan of our Early Cash Flow (ECF) project would also be presented.

## AFRICAN MINERALS (SL) LIMITED

AML at the moment is identifying and collaborating with the appropriate authorities of the areas including chiefdoms, sections and villages and also identifying the various MDAs that would serve as reference points for some of the issues that would be raised up during the various processes of the EIA.

Thanks for your usual co-operation and timely response

Yours truly,
**For African Minerals (SL) Limited (AML)**

**Mustapha J. Kamara**
**Manager – Corporate Department**

Cc: General Manager – African Minerals (SL) Limited

**Sierra Leone**
154 Wilkinson Road
Freetown
Sierra Leone
Telephone: +232 22 230 536

**United Kingdom**
11-12 Saint James's Square
London
SW1Y 4LB
Telephone: +44 20 7024 2280

Website: www.african-minerals.com

WorleyParsons
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EcoNomics

# Tonkolili Iron Ore Project
## EIA scoping and procedure

305000-00006
15 Mar 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com


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# SYNOPSIS

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of iron ore concentrate. WorleyParsons Europe has been engaged as the PMC Contractor to assist AML with the definition of the project that will include a Definitive Feasibility Study report supported by capital and operating costs.

This ESIA scoping document has been prepared to facilitate discussions of the ESIA deliverables with EPA.

### Disclaimer



**PROJECT 305000-00006 - TONKOLILI IRON ORE PROJECT**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | | A Huckbody | P Burris | N/A | 15-3-2010 | N/A | |
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## Appendices

# 1. INTRODUCTION

## 1.1 Background

African Minerals Limited (AML) has been exploring an extensive magnetic anomaly in the Sula Mountain range in Sierra Leone and recently confirmed the presence of a world-class magnetite iron ore deposit. The Tonkolili Project focuses on the three magnetite banded iron formation (BIF) targets that occur in the southern portion of the northeast – southwest trending anomaly.

## 1.2 Purpose of this document

The Tonkolili project requires an EIA or ESIA (hereinafter referred to as an Environmental, Social, Health Impact Assessment, ESHIA), as it constitutes a Category A project, requiring ESHIA. The Screening Form required by the EPA has been completed and submitted to EPA in February 2010, as per in-country procedures. The process is that the EPA agrees with the project proponent a terms of reference for the ESHIA, prior to completing the studies. In the case of Tonkolili, there is a need for advanced or enabling works which centre on extracting hematite from a deposit overlying the magnetite deposit. These works are termed the Early Cash Flow (ECF) component. In addition, the ECF component requires advanced construction of a new haul road prior to start of the wet season.

In recognition of the fast moving nature of the project, it is necessary to establish a programme of ESHIA deliverables in line with implementation of the early components of the project. This 'Regulatory Road Map' is required to be agreed with the Government of Sierra Leone (GoSL) and specifically with the EPA, as competent authority and lead agency in environmental and social management planning. This document presents details of the project and its implementation, along with details of the scopes of work for the various elements of the ESHIA and their status and should be of use during discussions regarding ESHIA.

## 1.3 Project Description

### 1.3.1 The project

African Minerals Limited (AML) has been exploring an extensive magnetic anomaly in the Sula Mountain range in Sierra Leone and recently confirmed the presence of a world-class magnetite iron ore deposit. The Tonkolili Project focuses on the three magnetite banded iron formation (BIF) targets that occur in the southern portion of the northeast – southwest trending anomaly. These deposits are named Simbili, Marampon and Numbara and are illustrated in Figure 1 below. The current combined ore estimate is 5.1 billion tonnes. Exploration to date also indicates that the Simbili-Marampon-Numbara magnetite anomaly is overlain with a hematite deposit, estimated to be in the order of 800 million tonnes.

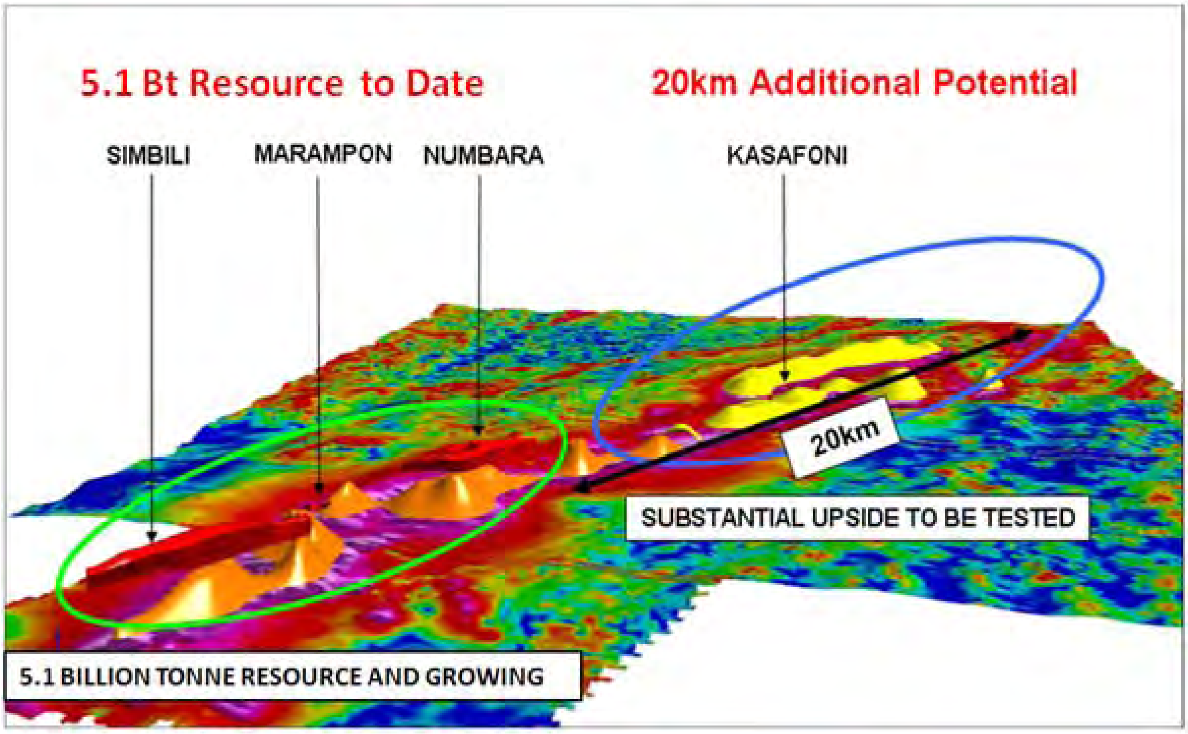



**Figure 1 Project deposits**

The Project will consist of mining operations with an ore-production rate of about 167 million tonnes / year and a total material movement in the order of 270 million tonnes / year. A concentrate will be produced on site at a rate of about 45 million tonnes / year. The life of the mine is expected to be in excess of 50 years at these production rates. The feasibility of increased production will be subject to studies in subsequent phases of project development.

Mining will be open cast method and will produce a concentrate to be transported by rail to a port at Tagrin Point, near the mouth of the Sierra Leone River Estuary. Rail infrastructure will be required to link Tonkolili with Tagrin Point (a distance of ca. 200 km). The proposed port facility will be a deep water port comprising a causeway, trestle and berths located between 700-800 m offshore. The location of the Tonkolili Project facilities is shown in Figure 2 and preliminary, indicative designs are presented in Appendix A.

In addition to the proposed Tagrin Point port, AML has signed a 99 year lease agreement with the Government of Sierra Leone (GoSL) to reconstruct, manage and operate Pepel Port and the Pepel – Marampa Railway. AML is working toward mining hematite ore found in the Tonkolili deposits during the initial stages of the project and exporting the product via Pepel Port. A dedicated haul road (approximately 120 km in length) will be built from the mine site to a railhead near Lunsar and the existing railway line refurbished between Marampa and Pepel while the Tagrin Point export route infrastructure is under construction. These works form what is referred to as the Early Cash Flow (ECF) project.

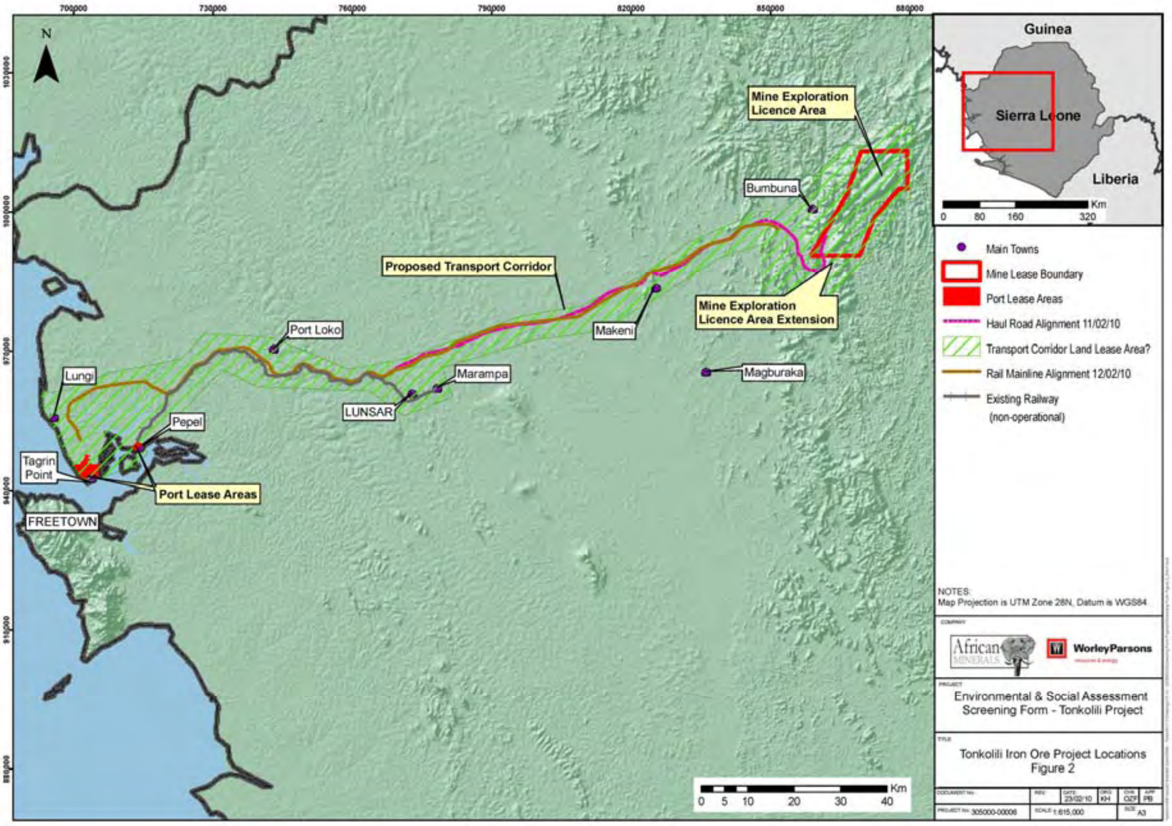



**Figure 2 Project location**

At the mine, the project development will comprise an open cut mine, ROM pad, the minerals processing facilities and support infrastructure such as power, water, access roads, air terminal, accommodation facilities, workshops, warehouses, laboratories and administration buildings and train loading facility.

### 1.3.2 Early cash flow

As described earlier there is a need to undertake advanced works for the overall Tonkolili project, comprising a haul road, refurbishment of Pepel railway line and refurbishment of Pepel Port. In view of the seasonal constraints of working on earthworks during the wet season, work has commenced on the haul road in March 2010. Minor refurbishment works to buildings have commenced in the Pepel port compound, using locally recruited and specifically trained labour.

## 1.4 Key Project groups

### 1.4.1 Project proponent

The roles of the primary entities involved in Phases 2 and 3 of the development include the following:

- African Minerals Limited;
- WorleyParsons Europe;
- WorleyParsons Services Pty Ltd;
- Ausenco Limited; and,
- SRK Consulting, Cardiff Operation.

### 1.4.2 Key stakeholders

The Project is aiming to follow recognised standards for the interaction with the community, including an inclusive approach to consultations at the various levels.

| Group | Status | Notes |
|---|---|---|
| Competent authorities | | |
| EPA – decision maker for EIA<br><br>Sectoral Ministries – Forestry, Fisheries, Agriculture, Mining and Mineral Resources | Initiated – as per this document | |
| Land issues | | |
| Paramount Chiefs – project | AML has a team of Public | Socio-economic surveys |

| | | |
|---|---|---|
| affected people (PAP)<br><br>Private | Relations Officers (PROs) on the ground working with communities on liaison, sensitisation to works and resettlement (physical and economic) issues | commenced and Resettlement Policy Framework is to be prepared. |
| Community issues | | |
| Consultations<br><br>Health<br><br>Employment and labour<br><br>Community development | Consultative Committees established<br><br>Health Impact Assessment commenced via questionnaires and desk study<br><br>AML has ongoing project systems in place, including job training and Health and Safety systems | Early works committees established and AML are managing. |

# 2. EIA PROCEDURES

## 2.1 EIA legislation

As part of the ongoing studies WorleyParsons has undertaken a review of relevant legislation in the country and has also undertaken a gap analysis as part of the Environmental Basis of Design Study, which informs engineering designs for process plants, water treatment and equipment procurement.

## 2.2 Project ESHIA deliverables

The following deliverables are suggested as to the way forward.

| Time line | | |
|---|---|---|
| April 2010 | June 2010 | September 2010 |
| DFS<br><br>Scoping study | ECF ESHIA | Tonkolili ESHIA (preliminary) |

The Definitive Feasibility Study for the Tonkolili Project will cover all aspects of the project (engineering, mine processing, cost etc) and the Environmental and Social Scoping Study will cover baseline conditions and identification of issues and potential impacts identified from the work to date. It is suggested that the ESHIA for the ECF component is brought forward to around June, to allow evaluation and consideration by EPA. There is a final deliverable (under WorleyParsons current arrangements with AML) of a preliminary ESHIA for Tonkolili Project as a whole, as part of FEED.

# 3. ESHIA SCOPE OF WORK

## 3.1 Project Schedule

Please see attached chart in Appendix C

## 3.2 Descriptions of thematic studies

As shown on the Gant chart a range of environmental and social investigations are currently underway, with a view of obtaining baseline conditions, potential impacts associated with the project and ultimately mitigation where necessary. The studies are outlined below, comprising air and noise, ecology (marine, flora and fauna), hydrobiology, social, health, water and soils.

## 3.3 Environmental Studies

### 3.3.1 Air and Noise

**AIR**

**BASELINE METHOD STATEMENT**

The scope of this initial monitoring campaign is to obtain background data on air quality in the project area. The sampling will be conducted with passive monitoring devices (diffusion tubes to be installed in the field for a period of 15 days, collected and sent to the laboratory for analysis) due to their the lower cost compared with active sampling devices (complex analysers with an active air intake and internal pollutant monitoring).

**SCOPE**

Nitrogen Oxides ($NO_x$) and Sulphur Dioxide ($SO_2$) will be monitored during this first air monitoring campaign. Although it would be convenient to simultaneously monitor Particulate Matter ($PM_{2.5}$ and $PM_{10}$), commercial passive particulate matter monitoring devices are not currently available. Consequently, the monitoring of particulate matter will be conducted during future monitoring campaigns using experimental passive devices or commercial active devices.

**METHOD OF ASSESSMENT**

Ambient air measurements will be conducted using passive diffusion tubes to measure sulphur dioxide ($SO_2$) and nitrogen dioxide ($NO_2$). For passive sampling, the use of diffusion sampling tubes is recommended due to their low cost, their ease of use and their utility for baseline and screening studies. Appropriate diffusion tubes will be obtained from Scientifics laboratory in the UK. Each tube has a unique identification number to aide in tracking.

If possible, the diffusion tubes will be exposed for the preferable period of two (2) weeks (15 days), which represents the minimum required period by the European Union for air quality monitoring. In the case that the 15-day exposure is not possible, a minimum period of one (1) week will be used. All diffusion tubes will be collected and returned to the laboratory, accompanied by completed and signed chain-of-custody forms.

For QA/QC purposes, one travel blank will be included in the measurements to assess exposure of the tubes to contaminants during transport.

Additionally, the following actions shall be undertaken:

- The coordinates of the locations will be noted using GPS hand-held kits.
- Photographs of the monitoring locations shall be taken.
- Notations shall be made of any activity or contaminant source in the surroundings of the selected locations during the monitoring campaign.
- The date and hour of installation and removal of the tubes will be clearly noted.
- Pertinent meteorological and climatological information may be obtained from the local weather department to support the interpretation of the data from the monitoring campaign and the assessment of the pollution potential of the area.

### COVERAGE

The sampling scenario will cover 12 locations divided between the mine site, the port site and the mine access road, distributed as follows:

- 2 locations at each of the ports in the area: 8 tubes (4 for $NO_x$ and 4 for $SO_2$)
- 6 points, 2 tubes at each point (12 tubes total) along the railway and roads corridor through the following:

- Pepel
- Petifu
- Port Loko or nearby city closer to rail alignment

- Rugbere
- Lunsar
- Makeni
- Tonkolili village or another important populated centre in close proximity of the rail alignment near the mine site

- 4 locations at the mine site (possibly Simbili and surroundings): 8 tubes

In each location, one tube for $NO_x$ and one tube for $SO_2$ will be installed.

For the installation of the passive diffusion tubes, the following recommendations, which are included in the ASTM Standards relative to Air Sampling, should be considered:

- The individually numbered diffusion-sampling tubes shall be placed at a minimum height of 1.5 m above ground and in sites where land use, topography and meteorology are preferably common and representative of the regional area.
- The specific monitoring locations shall be selected so as to avoid undue influence by any local source that may cause local elevated concentrations that are not representative of the project area.
- Particulate Matter samplers (for future monitoring campaigns) shall be sited at locations that are greater than 200 m from unpaved streets or roads.
- Monitoring sites shall be located away from population centres. A recommended distance of 1 km per 1000 persons.
- The passive diffusion tubes shall be placed no closer than 100 metres from intensive agricultural, waste treatment activities, open or surface storage of agricultural or industrial products, and transportation related sources of emissions. This distance shall be increased in proportion to increases in traffic volume and diversity.
- Prominent discontinuities in terrain, such as large bodies of water, isolated hills or valleys and cliffs shall be located at least 5 km from the diffusion tubes.

- Monitoring sites shall be located on open level areas that are naturally vegetated or grass-covered,. Ground cover shall be homogeneous and the area shall slope no more than 15%.
- The distance from the passive sampling devices to any object greater than the height of the sampling device should be at least twice the height of the object (2:1).
- Passive diffusion tubes shall be oriented towards the annual averaged prevailing wind. In the absence of site-specific wind direction information, the orientation of the tubes should be standardised to one direction.

### Reporting Standards

As per company procedures. EPA and IFC/WBG standards will be followed in the preparation of the reports where applicable.

### Potential Issues

Largely yet top be determined. At this preliminary stage of the project design, the power plant has been identified as a potential significant source of emissions and it could affect future air quality values. As the power plant is outside of the current Tonkolili project assessment, it should be considered as part of the future background pollutant concentrations.

## NOISE

### Baseline Method Statement

The overall acoustic impact on the environment should consider the background noise levels. A noise monitoring campaign should be undertaken to consider the baseline conditions previous to the project activities.

### Scope

Screening noise measurements will be conducted during daytime hours at various representative locations:

- Port: eight positions, four at each of the two ports.
- Train railway system and access roads: six positions along the railway corridor.

- Mine: six positions surrounding the projected mine site.

These locations will coincide with the locations selected for the air quality sampling programme, as they are considered to be representative and will facilitate the monitoring campaign.

Two measures will be taken at each position to assure that a noise event (e.g., animal sounds or vehicle movements) do not invalidate the results. The total number of noise measurements will be forty (40).

The duration of the measurements will be five (5) minutes.

### METHOD OF ASSESSMENT

A Class II hand-held sound level meter and ISO Tech sound level calibrator will be used to conduct the noise survey. The readings acquired from the sound meter will be analysed and compared to relevant guidelines and set as the baseline for reference during further monitoring activities.

The sound level meter will measure the parameter LAeq, defined as the constant sound level that, in a given time period, would convey the same sound energy as the actual time-varying A-weighted sound level.

Some factors need to be taken into account when taking measurements to assure the quality of the results since sound levels vary as a function of height above ground level and can be perturbed depending on the distance between the point of measurement and facades or obstacles. These requirements must be noted and applied by taking measurements:

- Away from facades and other obstacles at a minimum distance of 1.5 meters;
- Away from noise sources;
- Downwind;
- Utilising a sound level meter with an anti-wind protection (normally provided by the supplier).
- In dry conditions with a wind speed of less than 5 m/s.
- With the microphone 1.2 - 1.5 m above ground level.

Based on the screening results, the following monitoring campaign will be designed.

### COVERAGE

Relevant project areas.

## REPORTING STANDARDS

A full and coherent report will require detailed notes based on careful attention paid to the actual situation under which the measurement is conducted.
ISO 1996 lays out the framework for what information must be recorded and what information is recommended to record. This standard states that the following information must be recorded:

- Results
- Measurement technique
- Type of instrumentation used
- Measurement procedure used
- Calculations used
- Prevailing conditions
- Atmospheric conditions (wind direction and speed, rain, temperature, atmospheric pressure, humidity)
- Nature/state of ground between source and receiver
- Source variability
- Calibration data
- Measurement date, start and stop time
- Number of measurements made
- Description of the sound sources under investigation

It is also advisable to include additional information, such as:

- The purpose of the measurement

- The standard used

- Equipment used, including serial numbers

Map showing position of sound sources, relevant objects and observation points

#### POTENTIAL ISSUES

To be determined.

### 3.3.2 Marine ecosystem

#### PRECEDING WORKS

This work builds on a previous study conducted in 2009 (LORAX, 2010) which comprised a rapid overview of the main physical, chemical and ecological characteristics of the Estuary. This survey has enabled at least one wet-season monitoring event to be completed before the current phase of work.

#### BASELINE METHOD STATEMENT

We are following the overarching methodology of desk based 1a through to data collection 2b. In addition, to providing a broad understanding of the existing marine environment, the specific aims of the baseline are:

- Mapping of key marine and coastal habitats
- To identify any existing impacts, for example contamination, and to understand how the environment has reacted
- Provide a baseline for monitoring through the project life cycle

The marine baseline covers all habitats up to high water plus any species that are marine in origin e.g. that inhabit the mangroves.

#### SCOPE

The following areas are being covered:

- Sediment Quality
  Sediment grab samples are taken throughout the study area and analysed for the following:
    - Physico-chemical
    - In-fauna

In addition, cores taken through out the dredge area will be assessed for contamination following the guidelines of the London Protocol 1996.

- Water quality
  Water samples and in-situ profiles to understand:
  - Chemical
  - Biological
- Benthic habitat
  Towed video and diver surveys to evaluate:
  - Reef
  - Inter-tidal mud flats
  - Seagrass
- Sediment Transport and Coastal Morphology
  Hydrodynamic and physical sediment data to evaluate sediment transport pathways. Aerial photography (existing) to identify morphological features to assist in the prediction of impacts.
- Marine fauna
  Literature review and use of expert local knowledge plus survey as follows:
  - Marine mammals – dolphins
    - Incidental observation during survey operations
  - Marine mammals – manatees
    - Public consultation around estuary
  - Birds
    - Times counts at key locations around Tagrin and Pepel. At Tagrin this will cover all seasons.
  - Turtles
    - Public consultation plus beach surveys (beach surveys limited as desk review indicates that beaches within study area are not used due to human disturbance)
- Fisheries
  Information on fisheries data is being collected. This will be aligned with the ecological data collection to evaluate impacts on fisheries resource availability. The following methods are used:
  - Survey of fishing communities and markets
  - Data collection form Ministry of Fisheries and Marine Resources
- Mangroves
  - Mapping via satellite imagery
  - Ground truthing surveys including marine fauna within study area

### METHOD OF ASSESSMENT

In addition to the survey methods discussed above a range of methods will be used to assess impacts. These include:

- Water and sediment quality
    - Modelling of all wastewater discharges to assess area of impact and for comparison with receiving water quality standards defined in the Basis of Design.
    - Modelling of dredge plume to assess impacts on turbidity
- Benthic habitat
    - Assessment of potential habitat loss and degradation. This will be clear mapped and quantified.
    - Assessment of how water quality may affect benthic habitat. For example potential increased suspended sediment and reduced light penetration.
- Sediment Transport and Coastal Morphology
    - Sediment transport modelling to assess the impact of the development on sediment transport pathways and coastal morphology. This will include shoreline evolution maps.
- Marine fauna
    - Assessment of potential effects of water and sediment quality and habitat loss and degradation on marine fauna.
    - Assessment using exiting literature of the impacts of underwater noise on marine mammals, from both construction (piling) and operation. Estimation of sound source from activities required.
    - Assessment of potential increase in risk of ship collision
- Fisheries
    - Assessment of potential impacts on fisheries resource due to changes in water and sediment quality or habitat loss and degradation
    - Assessment of potential impedance of fisherman from development (for example, navigation channels)
- Mangroves
    - Assessment of potential habitat loss and degradation. This will be clear mapped and quantified.
- Navigation
    - Assessment of existing use of the estuary by shipping and the affect of vessel movements to support the development.

## COVERAGE

The study area includes:

- The lease area at Tagrin Point plus neighbouring beaches to the north west and coastal area based on extent of potential impacts, for example discharge plume.
- Lease area on Pepel Island plus coastal area based on extent of potential impacts.

- Dredge channels and area within potential dredge plume
- Proposed dredge disposal sites

#### REPORTING STANDARDS

The findings of these surveys will provide input to an Environmental, Social and Health Impact Assessment (ESHIA) which is being undertaken for the Tonkolili Project and also for ECF.

#### POTENTIAL ISSUES

Time and logistics – rapid assessment means that the number of samples etc is lower than we would ideally do for such a project and may not meet some international guidance.
Seasonality – we will be limited, particularly for ECF on the seasonality of the environmental baseline, for example birds.
Information – we must ensure that we have detailed information on construction and operation to undertake the impact

### 3.3.3 Flora

#### PRECEDING WORKS

This work builds on previous studies conducted under licence within Sierra Leone comprising a desk-top review of the Simbili-Marampon-Numbara habitat areas with rapid reconnaissance of the surrounding areas (phases 1a and 1b). Phase 2a and 2b studies comprise respectively consultation with key stakeholders and the general public to understand key biodiversity issues and return visits to areas of interest.

#### BASELINE METHOD STATEMENT

Phase 3 of the vegetation studies for the Tonkolili Iron Ore Project (the Project) in Sierra Leone, West Africa. Phase 3 will consist of detailed vegetation surveys of Simbili and part of the haul road, and a rapid assessment programme of the preferred tailings area and transport corridor associated with the Project.

#### SCOPE

The overall objective of Phase 3 is to characterise the baseline in areas likely to be affected by early construction works prior to disturbance and to understand the biodiversity value of the transport corridor. Phase 3 will also aim to identify any areas or species of high ecological importance that require specific consideration or management during the construction activities or subsequent phases of project design.

## METHOD OF ASSESSMENT

Desktop review, in-field observation and limited sample collection (with subsequent sample identification / confirmation at Kew Gardens).

## COVERAGE

The study area for the Phase 3 rapid assessment will cover the areas affected by the Tonkolili Project. This includes haematite extraction from Simbili, other proposed extraction sites, preferred tailings option, new haul road from the mine site to Lunsar and an existing railway line from Lunsar to Pepel Port. In order to avoid overlap between the terrestrial and marine studies, Mean High Water Springs has been selected as the cut off point for the terrestrial studies at Pepel Port.

The Phase 3 vegetation survey will be separated into two tasks:
Phase 3a: detailed characterisation of baseline conditions at the mine site and the first 20 km of the haulage road; and
Phase 3b: rapid assessment field surveys of the preferred tailings option, remainder of the haulage road to Lunsar, existing rail corridor, and Pepel Port.

The survey will also include rheophytic communities located in the rivers with low water levels.

Two team comprising staff from Kew Gardens, supported by local specialists will undertake the field work. One team will work from Pepel Port and Tagrin point eastwards towards Rokel River, while the other will cover the mine site area and work westwards towards Rokel River.

## REPORTING STANDARDS

The findings of the Phase 3 surveys will provide input to a high level Environmental, Social and Health Impact Assessment (ESHIA) which is being undertaken for the Tonkolili Project. A report will be prepared containing an assessment and interpretive discussion on the character, condition and conservation importance of habitats in the study area including transition areas or ecotones; identification of sensitive or potentially critical habitats that need immediate consideration by the project team; lists of the key species present within the various habitat types; and assessment of the likelihood and actual presence of rare species. A combined report of the faunal, floral and freshwater studies will also be prepared, using consistent classification and impact assessment schemata, will be prepared. This will include preliminary identification and definition of impacts and mitigation measures for Project activities at the construction and operational stages.

## POTENTIAL ISSUES

The detailed surveys are limited to flowering species only due to the difficulty of plant species identification outside of the flowering period.

### 3.3.4 Fauna

#### BASELINE METHOD STATEMENT

Phase 1 of terrestrial fauna studies for the Tonkolili Iron Ore Project (the Project). Phase 1 will consist of a rapid assessment programme of the potential mine site, tailings location, haul road alignment and preliminary railway corridor associated with the Project.

#### SCOPE

The Phase 1 rapid assessment for fauna will provide input directly to the ESHIA(s) so that areas of high ecological value can be defined prior to completion of the engineering design.

The main objectives of Phase 1 rapid assessment are as follows:
Understand the biodiversity value of the study area (as defined below);
Identify areas of high ecological value that require consideration during project design;
Identify any areas of potentially critical habitat;
Identify any red flag issues for the Project in the context of fauna species; and
Provide recommendations for further detailed studies to characterise baseline conditions in the study area.

#### METHOD OF ASSESSMENT

Primarily direct observation, supplemented (where time allows) by camera-traps, sampling and opportunistic village-based interviews.

#### COVERAGE

Two teams comprised of staff from WCS and WorleyParsons, with assistance from local specialists will cover approximately 31 sites from the mine site to Pepel Port and Tagrin Point via the proposed haul road route and existing railway line. In order to avoid overlap between the terrestrial and marine studies, Mean High Water Springs has been selected as the cut off point for the terrestrial studies at Pepel Port. Faunal groups that span this divide will be separated into the terrestrial or marine studies on a case-by-case basis. A rapid survey of migratory birds will be undertaken at Tagrin Point.

#### REPORTING STANDARDS

A high-level report with a brief assessment and interpretive discussion on ecological value, protection status and potential impacts will be prepared for fauna. A combined report of the faunal, floral and freshwater studies, using consistent classification and impact assessment schemata, will be prepared. This will include a preliminary biodiversity impact assessment associated with Project activities at the construction and operational stages.

#### POTENTIAL ISSUES

Potential for some faunal groups to be overlooked through localised human-related disturbances. The presence of local communities in observation and sampling areas will be taken into consideration in reporting data.

### 3.3.5 Freshwater Ecology

#### BASELINE METHOD STATEMENT

High level rapid assessment of selected freshwater sites covering the mine site, coast locations and interim sites of potential interest along the proposed haul road route and existing rail line.

#### SCOPE

High level rapid assessment of potential aquatic ecological impacts from proposed mine operations, in particular a haul road and rail corridor.

#### METHOD OF ASSESSMENT

Habitat assessment using suitable guidelines; photographic record of site location including significant aquatic habitat types and, if practical, sediments; observations on water quality, existing stressors and any species visible. Field work will be supplemented by discussions with locals on species caught in different areas and trends in catches and observations at local markets.

#### COVERAGE

One team comprised of staff from Hydrobiology and SRK will cover approximately 32 sites from the mine site to Pepel Port and Tagrin Point via the proposed haul road route and existing railway line.

#### REPORTING STANDARDS

A high-level report with a brief assessment and interpretive discussion on potential aquatic ecological impacts from proposed mine operations. A combined report of the faunal, floral and freshwater studies, using consistent classification and impact assessment schemata, will be prepared. This will include preliminary identification and definition of impacts and mitigation measures for Project activities at the construction and operational stages.

#### POTENTIAL ISSUES

Potential limitation to species identification: at this stage, fieldwork will not involve any species sampling, with the emphasis on a trained eye overview and identification of issues. Suggestions on further sampling requirements will be provided in field reports.

### 3.3.6 Water Resources

#### BASELINE METHOD STATEMENT

Collation of information relating to current use/importance of potable and agricultural river and groundwater, distribution and quality. Information from in-country institutions, field visits to selected areas, social questionnaires.

#### SCOPE

Describe the importance of ground and surface water resources to local users.
Assess the potential impacts of mine-related development works.
Identify the measures recommended to control the potential impacts.

#### METHOD OF ASSESSMENT

Desk study of existing published literature, documentation from in-country institutions, information from field visits and other Tonkolili investigation studies.

#### COVERAGE

Scope of work will cover the following construction and operational elements, where information is available:

- Mine development area
- Pepel haul road alignment
- Pepel rail refurbishment
- Pepel port refurbishment
- Heavy haul rail alignment
- Tagrin Point

#### REPORTING STANDARDS

The water resources impact assessment will be developed in accordance with WorleyParsons standard template and form part of the ESHIA report.

#### POTENTIAL ISSUES

Limited in-country legislation pertaining to protection of groundwater and surface water resources.
Construction work currently ongoing without prior studies for protection of groundwater and surface water resources.

### 3.3.7 Geomorphology and Soils

#### BASELINE METHOD STATEMENT

Baseline assessment of the land-form, soil conditions and identify preliminary impacts associated with changes from mining activities.

#### SCOPE

Baseline description of geology (shallow, deep, structural and economic);
Baseline description of soil-types and erosive and geochemical potential;
Baseline description of current landform, slope stability and geo-hazard potential; and
Outline of potential aspects from the hematite project that are of consequence to this baseline including effect on soil potential.

#### METHOD OF ASSESSMENT

Desktop review of borehole data and related literature;
Review of terrain hazard assessment conduct by SRK to date; and
GIS assessment if possible.

#### COVERAGE

Focus on mine area, specifically the deposit areas. Transport corridors and port areas excluded

#### REPORTING STANDARDS

Baseline study for geology. Soils will not be to baseline standard at this stage.

#### POTENTIAL ISSUES

Coverage of areas outside the deposits will require extrapolation of data at this stage until physical sampling is undertaken.

## 3.4 Social and Community Studies

### 3.4.1 Stakeholder Engagement

Works are already underway to ensure that a public consultation and disclosure plan (PCDP) is conducted in an appropriate way. This is essentially a stakeholder engagement plan that combines identification of key stakeholders with preparation of a clear and consistent project statement on which future decisions, views and consultation can be based. The PCDP enables the correct community representatives to be identified and the correct language and approaches to be used when contacting them.

### 3.4.2 Socio-Economic Baseline Study and Preliminary Social Impact Assessment

**BASELINE METHOD STATEMENT**

Perform a socio-economic baseline study to identify the existing conditions in all Project areas and allow for the consideration of social impacts (both positive and negative) that the Project will impose on neighbouring communities.

**SCOPE**

Preliminary social impact assessment associated with Project activities at the construction and operational stages. Consideration will be given to the decommissioning stage at a conceptual level.
Desktop review;
Survey design;
Data collection and analysis;
Preparation of preliminary social baseline report; and
Preparation of preliminary impacts assessment report.

**METHOD OF ASSESSMENT**

Field survey to be conducted by SRK team in conjunction with CEMMATS. SRK will provide oversight, implementation training and supervision of field work as necessary.

**COVERAGE**

Mine site, linear infrastructure corridors, Pepel Port and Tagrin Point. FGDs (10 - 14 villages), household interviews (40 - 56), short quantitative survey across about 42 settlements in the study area.

**REPORTING STANDARDS**

Provisionally to a suitable level for a DFS.

**POTENTIAL ISSUES**

The social survey at this stage will focus on collecting preliminary baseline information and will not visit all settlements in the project area. A combination of in-depth qualitative data from a selected sample and basic quantitative data from across the project area using a short questionnaire will be collected.

### 3.4.3 Resettlement Policy Framework

#### BASELINE METHOD STATEMENT

Desktop study to develop a Resettlement Policy Framework (RPF) in accordance with Equator Principles, Sierra Leone legislation and AML policies for implementing an acceptable and participatory resettlement process.

#### SCOPE

RFP to be developed taking into account the Equator Principles, Sierra Leone legislation and AML corporate policies. The RPF will also align with requirements outlined during the TRW. The study will include:
Review of legislation;
Determination of data needs and design survey method;
Data collection and analysis; and
Preparation of RPF.

#### METHOD OF ASSESSMENT

Desktop study.

#### COVERAGE

Tonkolili project.

#### REPORTING STANDARDS

Desktop study based on international good practice.

### 3.4.4 Human Health Impact Assessment (HIA)

#### BASELINE METHOD STATEMENT

Health Impact Assessment is "a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population" (ECHP 1999). Currently, there is no one authority defining HIA methodology; however, most agencies have adopted similar procedures. For the Early Cash Flow (ECF) and Tonkolili ESHIAs, the HIA approach applied will be as described by the World Health Organization (WHO 2005) and the International Finance Corporation (IFC 2009).

#### SCOPE

The tasks necessary for the completion of the proposed HIAs are listed in Table 1 along with their respective due-dates. It is important to note that results from other components of each ESHIA are required before the health sections can be finalized (e.g. socio-economic report; air monitoring and modelling results; groundwater and surface water monitoring results, etc.). Timely receipt of these results will be important in order to meet the deadlines set out.

Table 1. HIA Tasks and Due Dates

| **Task** | | **Sub-Tasks** | **Date / Deadline** |
|---|---|---|---|
| Phase 2 (ECF Project) | | | |
| | Development of HIA strategy to inform ToR | White Paper | 24th Feb 2010 |
| | | Definition of methodology | 12th March 2010 |
| | Design of data acquisition and questionnaires | List of data sources | 5th March 2010 |
| | | Public questionnaire | 1st March 2010 |
| | | Medical professional questionnaire | 1st March 2010 |
| | | Health authority questionnaire (to be written if required) | Middle March |
| | Team integration / Coordination | Integration with socio-economic baseline team | ASAP after 5th March 2010 |
| | | Revision of Public questionnaire for addition to socio-economic field team's questionnaires | 9th March 2010 |
| | | Coordination with other teams regarding: ground and surface water, air, local food, soil, social, and traffic | Ongoing |
| | Review of available national; regional health data | Review of source documents | 26th March 2010 |
| | Development of preliminary baseline HIA for the ECF ESHIA | Report | 26th March 2010 |
| | Finalise a rapid HIA and management approach for the ECF ESHIA | Report | 15th April 2010* |
| | Identification of key impacts and outline of plausible mitigation and management with associated capital and operational cost estimate ($\pm$ 15%) for the Tonkolili ESHIA. | Identification of headline health impacts | 15th May 2010 |
| | | Mitigation and management | 15th May 2010 |

| Task | | Sub-Tasks | Date / Deadline |
|---|---|---|---|
| | Development of draft health chapter in the Tonkolili ESHIA scoping report | Reporting | 15th May 2010 |
| | Review and comment on relevant contextual aspects of the Tonkolili ESHIA scoping / baseline report | Review and comment | End of May 2010 |
| Phase 3 (Tonkolili Project) | | | |
| | Complete baseline assessment based on data gaps identified in Phase 2, develop a field sampling program for health assessment (to be developed by the health team and the field work will be undertaken by other disciplines) | | June / July 2010 |
| | Development of the preliminary Tonkolili ESHIA | | End of August 2010 |

Health Impact Assessment is an iterative process. Typically, the first steps involve a semi-quantitative approach or 'Rapid HIA', which uses all available data so as to quickly identify those impacts which require more quantitative evaluation and those which are adequately described qualitatively. Based on the outcome of the Rapid HIA, the methodology may then become progressively more detailed as the assessment focuses on more accurately defining potential impacts. In this manner, more detailed, quantitative assessment is applied to a smaller list of potential impacts. There are clear benefits to applying this kind of phased approach since some projects only require qualitative or semi-quantitative appraisal while others require a fully quantitative detailed assessment

## TIMING

Maximum benefit of conducting an HIA occurs when it comes before the final engineering design specifications and before the construction contract is locked in. Also its important to conduct and HIA along with an social and environmental impact assessment and not as a standalone assessment.

## COVERAGE

Based on the project information available to date, the coverage of the HIA conducted for the ECF Project will include impacts on persons assumed to be at four locations: the mine site (including worker camp), the haul road, the existing railroad, and the renovated port facilities. Persons to be included in the assessment will include those living at camp facilities at the mine, as well as those not directly involved in the Project operations, but living in the vicinity of each of the four locations.

The coverage of the HIA for the Tonkolili project will be defined at later date once more concrete project information becomes available.

## Reporting Standards

International organizations such as the World Bank, the IFC, and the WHO endorse the completion of an HIA at the beginning of a project's lifecycle. Increasingly, HIAs are becoming a requirement for regulatory and financial approvals of industrial activities such as those proposed for the ECF and Tonkolili Mining Projects. In 2009, the IFC published "Introduction to Health Impact Assessment" which provides good practice guidance for conducting HIAs to determine all potential impacts on community health as a result of a proposed development.

Where possible, the HIAs planned for the ECF and Tonkolili ESHIAs will employ regulatory standards as described by the Sierra Leone Environmental Protection agency (SL EPA). In addition, other internationally recognised standards/guidelines will be applied if and when required (e.g. WHO, Health Canada (HC), US EPA, and RIVM) for the completion of the HIA and used in the HIA with the approval of SL EPA.

## Potential Issues

Health Impact Assessment (HIA) is a real-world tool which must function within time and budget constraints. As such, it is to be expected that there will be certain limitations. Some common examples include a lack of availability of baseline monitoring data for the region of the proposed development (e.g. air, soil and water), or difficulty in obtaining detailed health information for persons living in the proposed region before implementation of a new policy or activity.

The limitations and recommendations of the HIAs will be defined at each reporting Phase.

## References

European Centre for Health Policy (ECHP)., 1999, Health Impact Assessment: Main concepts and suggested approach (Gothenburg Consensus Paper), Brussels:
http://www.who.dk/document/PAE/Gothenburgpaper.pdf

International Finance Corporation (IFC)., 2009. Introduction to Health Impact Assessment, April 20, 2009.
http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_Handbook_HealthImpactAssessment

World Health Organization (WHO)., 2005. Environmental Health Impact Assessment of Development Projects.

### 3.4.5 Solid Waste Management

#### Baseline method statement

Review of information available indicates no waste management infrastructure in-country. No consideration appears to have been made at this stage for waste management provision through the development of the scheme.

#### Scope

Develop ECF Practice Guidelines - complete
Develop Accommodation Camps Strategy - complete
Develop Solid Waste Management Plan – ongoing first draft due 01.04.10

#### Method of assessment

N/A, in-country assessment of existing waste management infrastructure has been commissioned, understood to be negligible.

#### Coverage

Scope of work will cover the following construction elements, where information is available.
Pepel haul road alignment
Pepel rail refurbishment
Pepel port refurbishment
Heavy haul rail alignment
Tagrin Point

#### Reporting standards

Documents detailed in section 1.2 will be developed in accordance with WorleyParsons standard template and sit within the appendices of the ESHIA.

#### Potential issues

No / Limited in-country legislation pertaining to solid waste management.
No / Limited in-country existing waste management infrastructure.
Construction work currently ongoing with no consideration from waste management.
Given the lack of in-country infrastructure, it is likely that specific waste management infrastructure will require developed. The scope and process for this is currently unclear.

# 4. ECF MANAGEMENT

The ECF phase comprises haul road, rail line and Pepel port refurbishment. To date, the haul road has started due to wet season constraints and the assessment and management of environmental and social issues has included:

### PRACTICE GUIDES

Practice guidelines have been prepared as a way of achieving good practice during haul road construction, in advance of the more conventional evaluation and management planning approach, due to the rapid implementation schedule. These have been rolled out to the haul road contractors prior to work commencement. The guides and a management plan can be made available at a later date.

### SOCIAL MANAGEMENT, CONSULTATIVE COMMITTEES

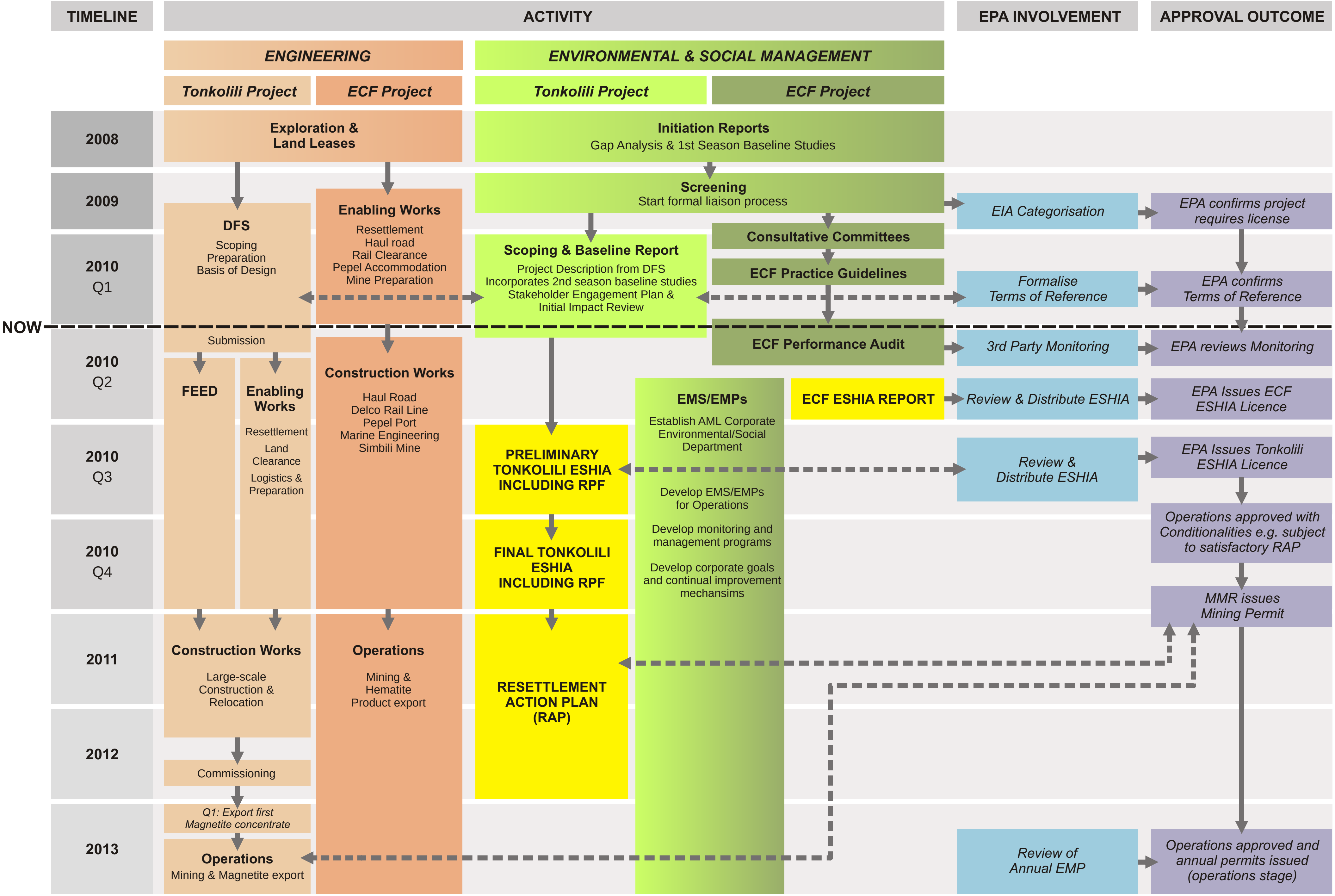
A series of Early Works Chiefdom Committees (EWCC) have been established throughout the project area, with participation from Paramount Chiefs, Section Chief, Councillors, NGO and women's and a youth leader. These EWCC are designed to ensure that communities are consulted about the proposed project works. Further details can be made available if required. The meetings are also to be attended by district officers from EPA and representatives of the MPs.

## 5. WAY FORWARD

The purpose of this document is for it to be used as part of ongoing discussions with the EPA regarding the environmental and social regulatory approval process that EPA is the competent authority for in Sierra Leone.

# APPENDIX A
## Preliminary, indicative designs

# APPENDIX B
# Organisational arrangements for ESHIA studies



TIMELINE
ACTIVITY
EPA INVOLVEMENT
APPROVAL OUTCOME
ENGINEERING
ENVIRONMENTAL & SOCIAL MANAGEMENT
Tonkolili Project
ECF Project
Tonkolili Project
ECF Project
2008
Exploration & Land Leases
Initiation Reports
Gap Analysis & 1st Season Baseline Studies
2009
Screening
Start formal liaison process
EIA Categorisation
EPA confirms project requires license
DFS
Scoping
Preparation
Basis of Design
Enabling Works
Resettlement
Haul road
Rail Clearance
Pepel Accommodation
Mine Preparation
2010 Q1
Scoping & Baseline Report
Project Description from DFS
Incorporates 2nd season baseline studies
Stakeholder Engagement Plan &
Initial Impact Review
Consultative Committees
ECF Practice Guidelines
Formalise Terms of Reference
EPA confirms Terms of Reference
NOW
Submission
ECF Performance Audit
3rd Party Monitoring
EPA reviews Monitoring
2010 Q2
FEED
Enabling Works
Resettlement
Land Clearance
Logistics & Preparation
Construction Works
Haul Road
Delco Rail Line
Pepel Port
Marine Engineering
Simbili Mine
EMS/EMPs
Establish AML Corporate Environmental/Social Department
ECF ESHIA REPORT
Review & Distribute ESHIA
EPA Issues ECF ESHIA Licence
2010 Q3
PRELIMINARY TONKOLILI ESHIA INCLUDING RPF
Develop EMS/EMPs for Operations
Develop monitoring and management programs
Develop corporate goals and continual improvement mechansims
Review & Distribute ESHIA
EPA Issues Tonkolili ESHIA Licence
2010 Q4
FINAL TONKOLILI ESHIA INCLUDING RPF
Operations approved with Conditionalities e.g. subject to satisfactory RAP
MMR issues Mining Permit
2011
Construction Works
Large-scale Construction & Relocation
Operations
Mining & Hematite Product export
RESETTLEMENT ACTION PLAN (RAP)
2012
Commissioning
2013
Q1: Export first Magnetite concentrate
Operations
Mining & Magnetite export
Review of Annual EMP
Operations approved and annual permits issued (operations stage)

# APPENDIX C
# ESHIA schedule

# APPENDIX D
## Extracts from ESHIA study zones

# APPENDIX 1

## ESHIA Screening Form

**SIERRA LEONE GOVERNMENT**
**SIERRA LEONE ENVIRONMENT PROTECTION AGENCY**
**3RD FLOOR, YOUYI BUILDING BROOKFIELDS, FREETOWN,**
**SIERRA LEONE.**

**Ref: SLEPA/ADM/02**

24th February, 2010.

**Addressed to See Below:**

Dear Sir/Madam,

**APPLICATION FOR AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) LICENCES**

I wish to refer to your application for an EIA licence coupled with the submission of your EIA statement and remind you about the relevant sections (23-29) of the Sierra Leone Environment Protection Act, 2008 relating to the acquisition of Environmental Impact Assessment Licence.

Consequently, you are entreated to submit ten (10) copies of your Environmental Impact Assessment statement to the undersigned ensuring to be opened for public inspection, comments and gazetting, and to enable professional bodies, non-governmental organizations and the public at large to make their input into the document before a final decision is taken.

I enclose herewith copies of the relevant sections of the SLEPA Act, 2008 for ease of reference.

I thank you for your understanding and cooperation.

Yours faithfully,

S. S. J. Jusu
**Ag. Executive Director**
**Sierra Leone Environment Protection Agency**

**APPLICATION FORM FOR THE ACQUISITION OF AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) LICENSE**

1. NAME of Institution/Company African Minerals Limited
2. TYPE OF BUSINESS Mineral exploration company
3. BUSINESS REGISTRATION NO. 800/2004/BRL552
4. CONTACT ADDRESS: 154 Wilkinson Road, Freetown, Sierra Leone

   E-MAIL OR TEL NO: +232 33 605829, +232 33 623157
5. NATIONALITY: Registered in Sierra Leone
6. PROPOSED DEVELOPMENT

   (ATTACH PROPOSAL)
7. PROPOSED LOCATION

   (INCLUDE RELEVANT MAP)
8. COST OF PROPOSAL
9. ESTIMATED DURATION OF DEVELOPMENT ACTIVITIES: Construction – 36 Months, Operations – 50+ years
10. STATE THE IMPACT OF ACTIVITIES OF THE FOLLOWING:

    TICK THE APPROPRIATE COLUMNS

| | Positive | Negative |
|---|---|---|
| a. SUBSTANTIAL IMPACT ON ECOSYSTEM OF THE LOCALITY | | √ (note 1) |
| b. SOCIAL | √ | √ (note 1) |
| c. AESTHETIC | | √ (note 1) |
| d. SCIENTIFIC | √ | |
| e. HISTORICAL | | Unknown |
| f. STATE OTHER IMPORTANT ENVIRONMENTAL PARAMETERS | Economic Development<br>Infrastructure | Surface and groundwater quality<br>Air Quality |

note 1: Potential impacts exist and they will be minimised during the design stage & by specific mitigation.

**Signed:**

**EXECUTIVE DIRECTOR/HEAD**

# ENVIRONMENTAL IMPACT ASSESSMENT SCREENING FORM

## SECTION 1: INFORMATION ON THE CONTACT PERSON

| | |
|---|---|
| Name: | Andrew Huckbody |
| Institutional Affiliation: | WorleyParsons (UK) |
| Business Title / Position: | Tonkolili Iron Ore Project<br>Environmental & Social Programme Manager |
| Business Address | Parkview<br>Great West Road<br>Brentford<br>London<br>TW8 9AZ<br>United Kingdom |
| Telephone: | +44 (0)208 326 5000 |
| Email: | andy.huckbody@worleyparsons.com |

## SECTION 2: DESCRIPTION OF THE INDUSTRY / FACTORY / COMPANY / PROJECT AND OR PROPOSED PROJECT

*Name:* Tonkolili Iron Ore Project (Tonkolili Project)

*Date Operations started*

Exploration commenced in and has been ongoing since 2003. Construction of mining infrastructure is due to begin in 2010.

*Description of the project*

African Minerals Limited (AML) has been exploring an extensive magnetic anomaly in the Sula Mountain range in Sierra Leone and recently confirmed the presence of a world-class magnetite iron ore deposit. The Tonkolili Project focuses on the three magnetite banded iron formation (BIF) targets that occur in the southern portion of the northeast – southwest trending anomaly. These deposits are named Simbili, Marampon and Numbara and are illustrated in Figure 1 below. The current combined ore estimate is 5.1 billion tonnes. Exploration to date also indicates that the Simbili-Marampon-Numbara magnetite anomaly is overlain with a hematite deposit, estimated to be in the order of 800 million tonnes.

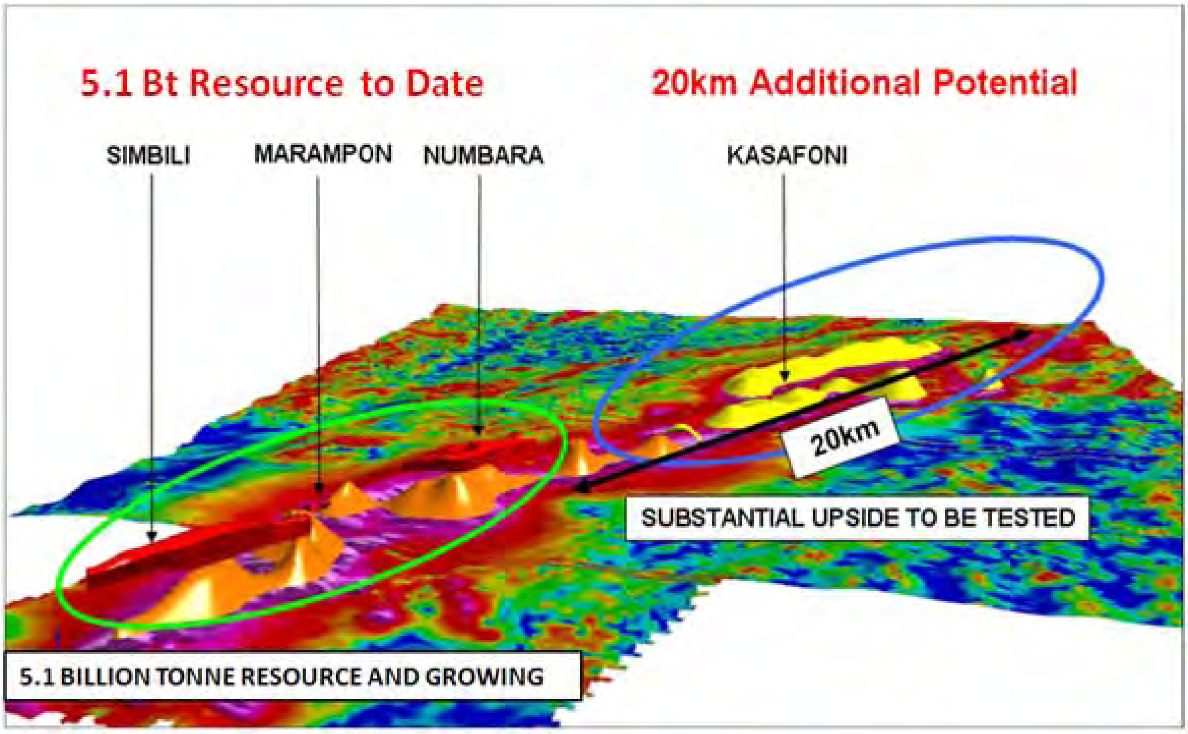



**Figure 1: Relative Locations of Resources in the Tonkolili Exploration Licence Area**

The Kasafoni deposit, which extends over a length of approximately 20 km north of Numbara has the potential to double the size of the total ore resource to over 10 billion tonnes. Ongoing exploration work is focussed on the Kasafoni area, with the objective of identifying additional BIF mineralisation to realise the resource target of 10 billion tonnes. At this stage however, the Kasafoni resource is not included in the Tonkolili Project.

The Tonkolili deposit is covered by an exploration licence (Exploration Licence No:EXPL:05/06) in the name of AML's wholly owned subsidiary, Tonkolili Iron Ore (SL) Limited. The Licence was renewed on the 1st of July, 2009 for a period of two years. The bounding coordinates stated on the licence encompass an area covering approximately 209 km$^2$.

*Proposed Operations*

The Project will consist of mining operations with an ore-production rate of about 167 million tonnes / year and a total material movement in the order of 270 million tonnes / year. A concentrate will be produced on site at a rate of about 45 million tonnes / year. The life of the mine is expected to be in excess of 50 years at these production rates. The feasibility of increased production will be subject to studies in subsequent phases of project development.

Mining will be open cast method and will produce a concentrate to be transported by rail to a port at Tagrin Point, near the mouth of the Sierra Leone River Estuary. Rail infrastructure will be required to link Tonkolili with Tagrin Point (a distance of ca. 200 km). The proposed port facility will be a deep water port comprising a causeway, trestle and berths located between 700-800 m offshore. The location of the Tonkolili Project facilities is shown in Figure 2 and Figure 3.

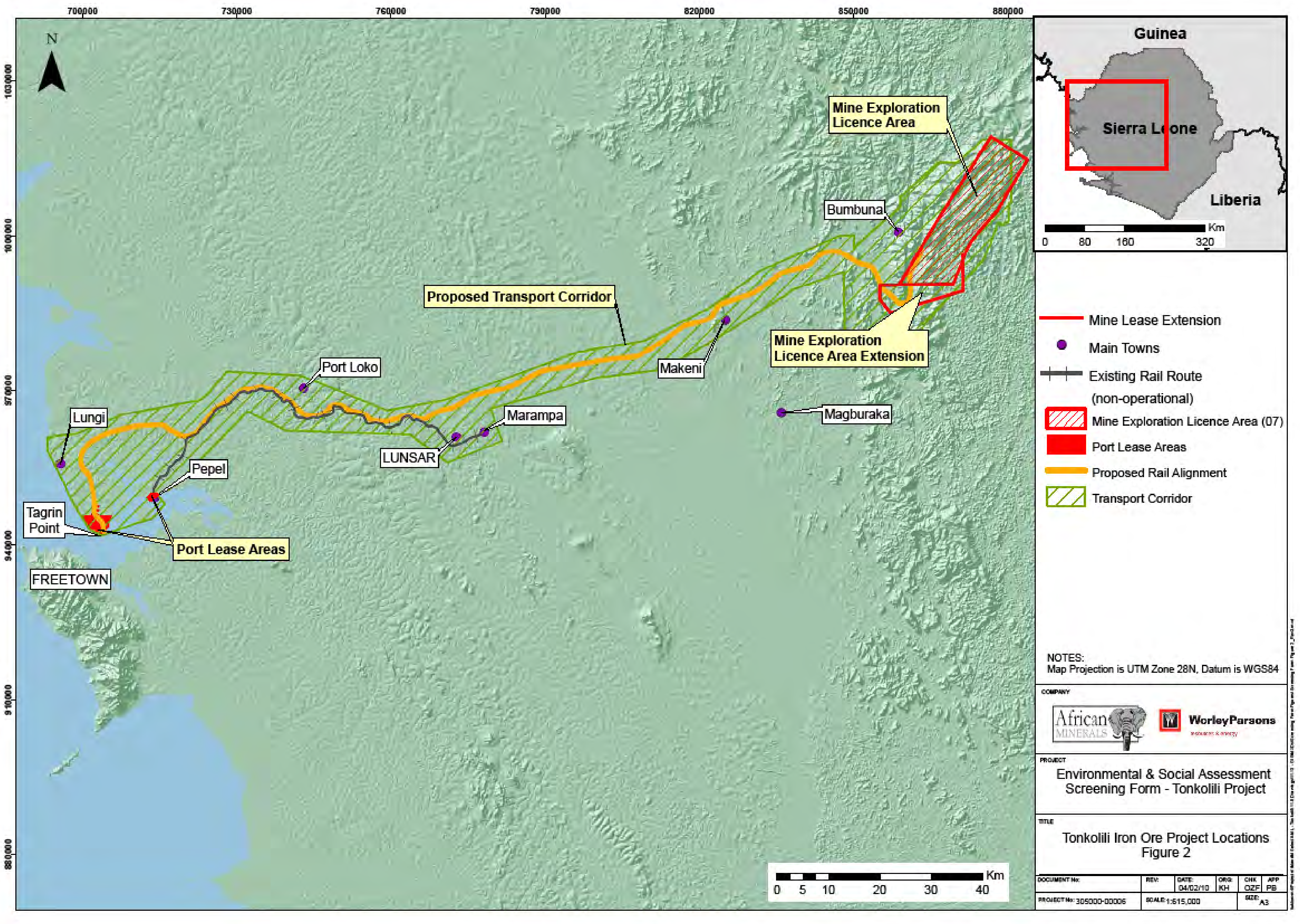
In addition to the proposed Tagrin Point port, AML has signed a 99 year lease agreement with the Government of Sierra Leone (GoSL) to reconstruct, manage and operate Pepel Port and the Pepel – Marampa Railway. AML is working toward mining hematite ore found in the Tonkolili deposits during the initial stages of the project and exporting the product via Pepel Port. A dedicated haul road (approximately 120 km in length) will be built from the mine site to a railhead near Lunsar and the existing railway line refurbished between Marampa and Pepel while the Tagrin Point export route infrastructure is under construction.

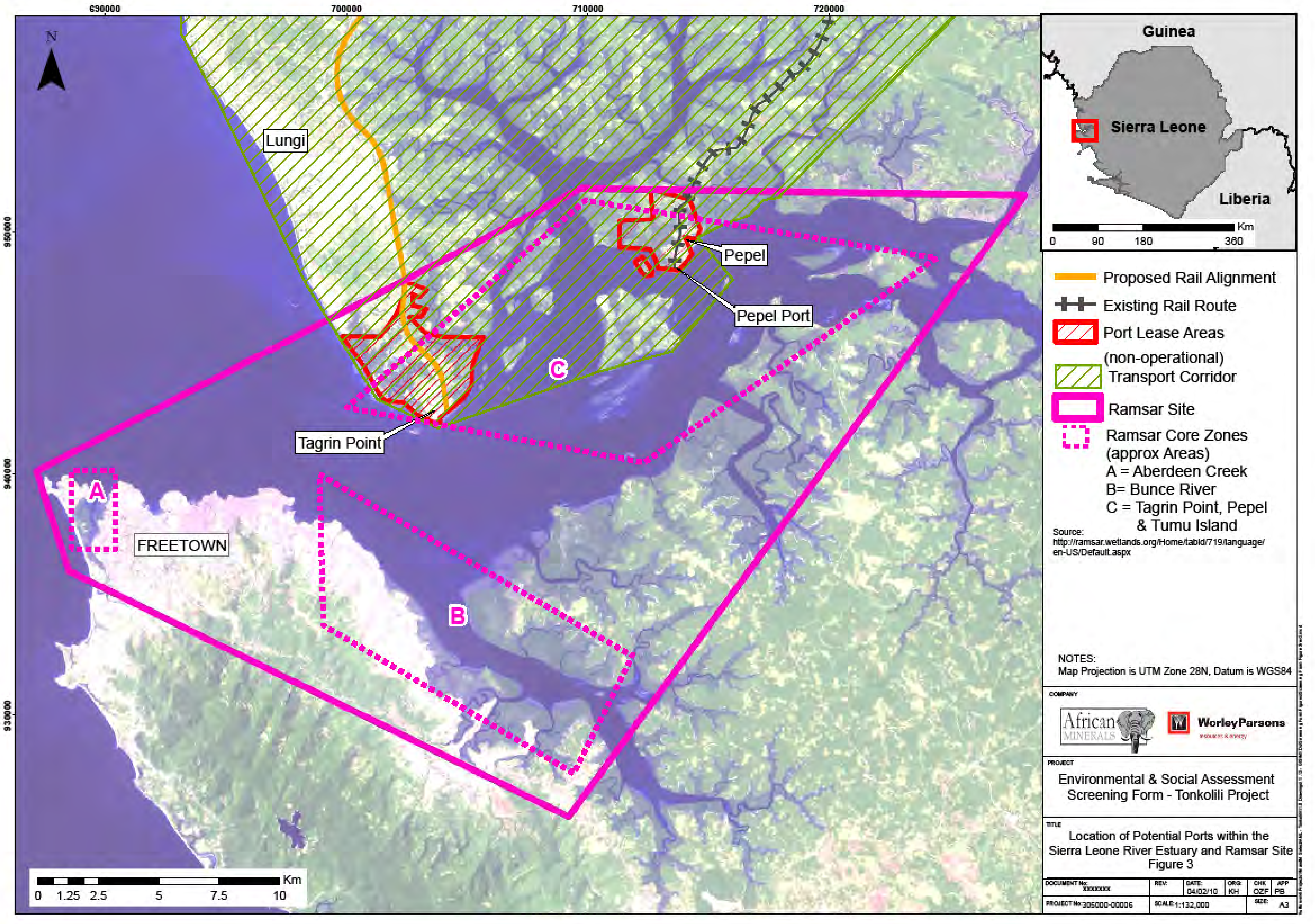
*Mine Design and Associated Infrastructure*

AML have commissioned WorleyParsons and SRK to undertake preliminary engineering studies on the mine pits, mine infrastructure and potential tailings dams for the Tonkolili Project. The pit outline limits and possible sites for the tailings dams are illustrated in Figure 4.

It is anticipated that about 120 million $m^3$ of tailings will be produced per year for an ore production rate of 45 million tonnes / annum. The study shows that the tailings dam will be positioned largely within the existing exploration lease. Alternative tailings dam sites have been considered however a site has been selected as the preferred options based primarily on engineering and geotechnical considerations.

The acceptability of the preferred tailings facility site will be confirmed once existing environmental and social baseline conditions with the area are more fully and thoroughly understood.


Guinea
Sierra Leone
Liberia
Mine Exploration Licence Area
Bumbuna
Proposed Transport Corridor
Port Loko
Mine Exploration Licence Area Extension
Makeni
Lungi
Marampa
Magburaka
LUNSAR
Pepel
Tagrin Point
Port Lease Areas
FREETOWN
Mine Lease Extension
Main Towns
Existing Rail Route (non-operational)
Mine Exploration Licence Area (07)
Port Lease Areas
Proposed Rail Alignment
Transport Corridor
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
Environmental & Social Assessment Screening Form - Tonkolili Project
Tonkolili Iron Ore Project Locations
Figure 2
WorleyParsons
African Minerals


690000
700000
710000
720000
950000
940000
930000
N
Lungi
Pepel
Pepel Port
Tagrin Point
FREETOWN
A
B
C
0 1.25 2.5 5 7.5 10 Km
Guinea
Sierra Leone
Liberia
0 90 180 360 Km
Proposed Rail Alignment
Existing Rail Route
Port Lease Areas
(non-operational) Transport Corridor
Ramsar Site
Ramsar Core Zones (approx Areas)
A = Aberdeen Creek
B= Bunce River
C = Tagrin Point, Pepel & Tumu Island
Source: http://ramsar.wetlands.org/Home/tabid/719/language/en-US/Default.aspx
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
COMPANY
African MINERALS
WorleyParsons
PROJECT
Environmental & Social Assessment Screening Form - Tonkolili Project
TITLE
Location of Potential Ports within the Sierra Leone River Estuary and Ramsar Site
Figure 3
DOCUMENT No: XXXXXXX
REV:
DATE: 04/02/10
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CHK: OZF
APP: PB
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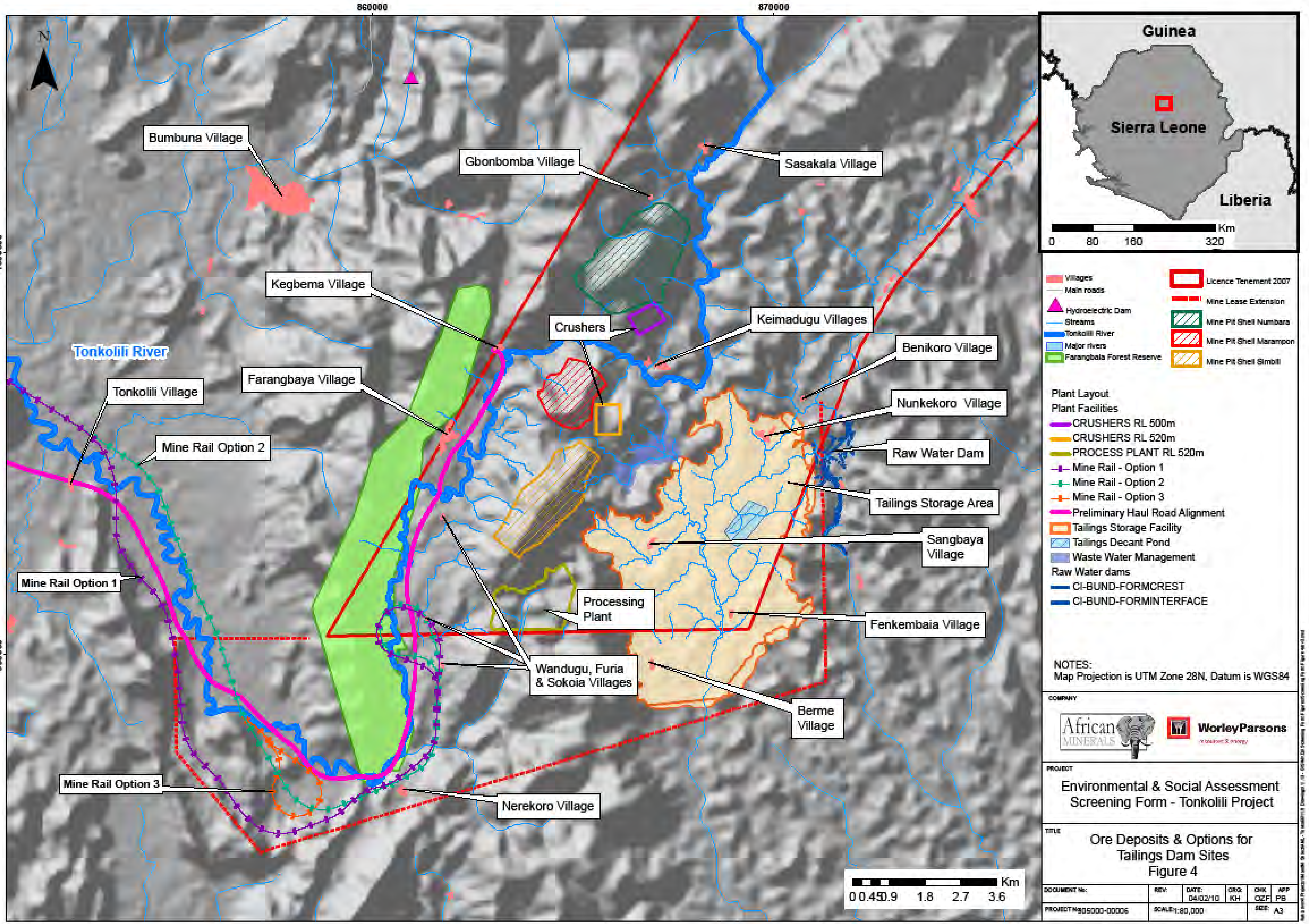
860000
870000
100000
990000
N
Bumbuna Village
Gbonbomba Village
Sasakala Village
Kegbema Village
Crushers
Keimadugu Villages
Benikoro Village
Tonkolili River
Tonkolili Village
Farangbaya Village
Nunkekoro Village
Mine Rail Option 2
Raw Water Dam
Tailings Storage Area
Sangbaya Village
Mine Rail Option 1
Processing Plant
Fenkembaia Village
Wandugu, Furia & Sokoia Villages
Berme Village
Mine Rail Option 3
Nerekoro Village
0 0.45 0.9 1.8 2.7 3.6 Km
Guinea
Sierra Leone
Liberia
0 80 160 320 Km
Villages
Main roads
Hydroelectric Dam
Streams
Tonkolili River
Major rivers
Farangbaia Forest Reserve
Licence Tenement 2007
Mine Lease Extension
Mine Pit Shell Numbara
Mine Pit Shell Marampon
Mine Pit Shell Simbili
Plant Layout
Plant Facilities
CRUSHERS RL 500m
CRUSHERS RL 520m
PROCESS PLANT RL 520m
Mine Rail - Option 1
Mine Rail - Option 2
Mine Rail - Option 3
Preliminary Haul Road Alignment
Tailings Storage Facility
Tailings Decant Pond
Waste Water Management
Raw Water dams
CI-BUND-FORMCREST
CI-BUND-FORMINTERFACE
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
COMPANY
African MINERALS
WorleyParsons
PROJECT
Environmental & Social Assessment Screening Form - Tonkolili Project
TITLE
Ore Deposits & Options for Tailings Dam Sites
Figure 4
DOCUMENT No:
REV:
DATE: 04/02/10
ORG: KH
CHK: OZF
APP: PB
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SCALE: 1:80,000
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***Current Land Use***

*Mine Site*

Much of the land around the mine site has been subject to slash-and-burn agricultural practices. There are tracts of forest land comprising a mixture of secondary and mature forest notably along the north-western margin of Simbili, south of the village of Kegbema and in the Tonkolili River valley east of Farangbaya village. During the dry season farming is restricted to valley flood plains which retain high soil moisture content and permit at least two cropping seasons. During field investigations undertaken for the Tonkolili Project environmental and social work programme, cassava, plantain, sweet potato, ground nut and sweet corn were all observed growing across the concession and fruits including pineapple, banana, orange, and mango were also observed. In the rainy season rice is a staple crop. Palm wine tapping is evident and fishing is also common in rivers and streams. Artisanal gold mining activity was observed in the Tonkolili River and is carried out by area residents and transient labourers.

*Railway Route*

Most of the rail route and the port site are on the coastal plain. Land use and primarily agriculture, has altered the natural vegetation and most of the route is now typified by wooded grassland, secondary palm tree forests and swamp areas where different crops are grown. Part of the rail route is along a previously existing railway line, the Marampa-Pepel line, originally developed by the Sierra Leone Development Corporation (DELCO) in the 1930s as a mineral railway to transport ore from the Marampa Iron Ore Mine

The railway has not operated since 1985, when the last iron ore shipment was made. Since that time, the GoSL has assumed ownership and management of the disused rail line. The remaining infrastructure is the subject of the AML / GoSL 99-year lease agreement referred to above.

*Port*

A car and passenger ferry service is in operation between Tagrin Point Ferry Terminal across the estuary to the Kissy Ferry Terminal located 4 km to the east of central Freetown. This service provides a link between Freetown and the Lungi Airport located 16 km from the Tagrin Point Ferry Terminal. Passenger-only ferry services also run on a daily basis from Port Loko to Tagrin and Kissy using large pirogue vessels.

The area is estimated by local authorities to have a population of upto 9,000 as of November 2009. It is anticipated that commercial activity near the ferry terminal supports further livelihoods in the wider region. Approximately 35 fishing boats operate from a fish landing facility adjacent to the ferry terminal. Fishing is an important socio-economic activity in the area.

***Describe any possible alternative site(s)***

The location of the ore at Tonkolili is fixed and the preferred locations of the logistics infrastructure, transportation routes and ancillary features such as tailings facilities have been selected based predominantly on engineering factors and will be evaluated for their environmental and social effects, along with any feasible alternatives, in accordance with Best Practice. These will be the subject of more detailed studies prior to selecting the final sites and routes. In terms of the project's linear features, adherence as far as possible to existing / pre-existing rail and road routes will be a priority where feasible to minimise environmental and social impacts.

Although Pepel Port is under consideration as a short term solution for export of the hematite product, it is not considered a viable long-term option to the proposed Tagrin Point Port development due to the port being unsuitable for cape-sized vessels (i.e. approximately 19 m draft) and dredging that may be required to maintain deep water access through the channel.

As with the Marampa-Pepel railway, Pepel Port has not been operated since 1985 but infrastructure is still present in the area including housing and office facilities, a power plant, fuel tanks, conveyer belts and a jetty / ship loader. The current and predominant land use around the existing railway and port facilities is agriculture. Fishing activities and passenger ferries operate in Pepel Town and nearby Tasso Island, while Bunce Island, located 1.8 km off Pepel Port, has some tourist potential.

***Describe other types of industries or facilities (including health centres and schools), which are located within 100 metres of the site, or are proposed to be located near the facility. Indicate the proximity of the industrial, factory or project site and or proposed site to residential areas, national parks or areas of ecological, historical or cultural importance.***

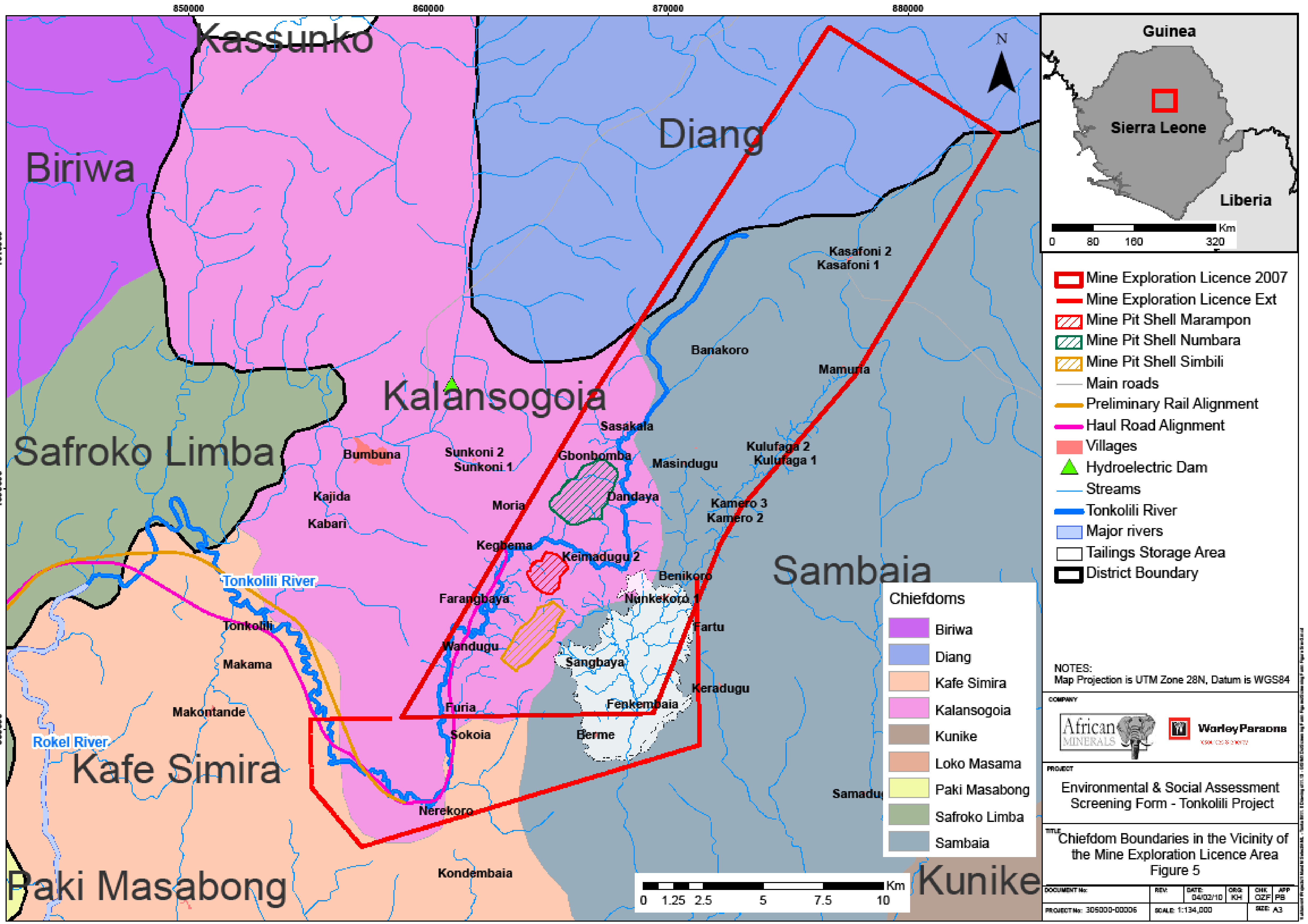
*Proximity to residential areas*

The Tonkolili Project ore bodies lie largely within the Kalansogia Chiefdom. Potentially affected villages include Kalansogia, Kafe-Simiria and Sambia-Bendugu Chiefdoms (Figure 5). The nearest villages to the ore bodies are Farangbaya, Kegbema, Keimadugu 1, Keimadugu 2 and Gbonbomba. These villages are most likely to fall within the project's direct footprint and hence may have to be relocated prior to commencement of mine development. Several other villages in the lease area may lie within the project affected area depending on the final design and location of mine infrastructure.

The railway corridor extends across several chiefdoms (Figure 6). There are several settlements along the railway corridor and there are households situated next to the existing railway Right of Way (ROW).

There are numerous villages and settlements at and in the vicinity of Tagrin Point, most of which are located along the road from Lungi to the ferry terminal at Tagrin Point itself. Many of these settlements will fall in the project affected area and as such, may also require relocation.

The project will consider community investment options in the vicinity of project developments including programmes that would enhance the reliability of supply and quality of drinking water, medical facilities, employment, schooling and livelihood schemes in project affected areas.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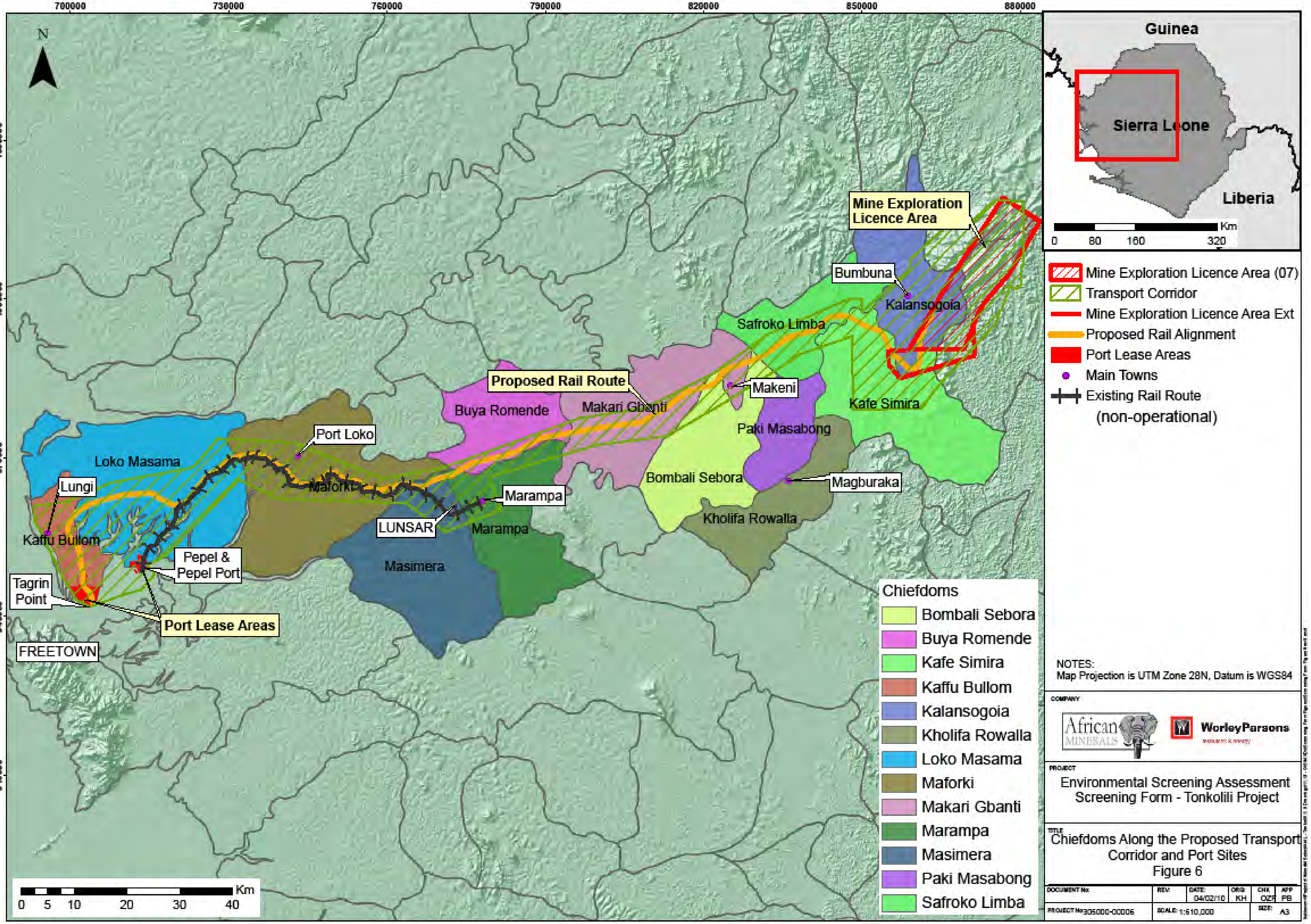
Kassunko
Biriwa
Diang
Kalansogoia
Safroko Limba
Sambaia
Kafe Simira
Paki Masabong
Kunike
Kasafoni 2
Kasafoni 1
Banakoro
Mamuria
Sasakala
Bumbuna
Sunkoni 2
Sunkoni 1
Gbonbomba
Masindugu
Kulufaga 2
Kulufaga 1
Kajida
Kabari
Moria
Dandaya
Kamero 3
Kamero 2
Kegbema
Keimadugu 2
Tonkolili River
Benikoro
Farangbaya
Nunkekoro 1
Tonkolili
Fartu
Wandugu
Makama
Sangbaya
Keradugu
Makontande
Furia
Fenkembaia
Rokel River
Sokoia
Berme
Samadu
Nerekoro
Kondembaia
N
Guinea
Sierra Leone
Liberia
Km
0 80 160 320
Mine Exploration Licence 2007
Mine Exploration Licence Ext
Mine Pit Shell Marampon
Mine Pit Shell Numbara
Mine Pit Shell Simbili
Main roads
Preliminary Rail Alignment
Haul Road Alignment
Villages
Hydroelectric Dam
Streams
Tonkolili River
Major rivers
Tailings Storage Area
District Boundary
Chiefdoms
Biriwa
Diang
Kafe Simira
Kalansogoia
Kunike
Loko Masama
Paki Masabong
Safroko Limba
Sambaia
Km
0 1.25 2.5 5 7.5 10
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
COMPANY
African MINERALS
WorleyParsons
PROJECT
Environmental & Social Assessment
Screening Form - Tonkolili Project
TITLE
Chiefdom Boundaries in the Vicinity of
the Mine Exploration Licence Area
Figure 5
DOCUMENT No:
REV:
DATE: 04/02/10
ORIG: KH
CHK: OZF
APP: PB
PROJECT No: 305000-00006
SCALE: 1:134,000
SIZE: A3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Km
0 80 160 320
Mine Exploration Licence Area
Bumbuna
Kalansogoia
Safroko Limba
Proposed Rail Route
Makeni
Buya Romende
Makari Gbanti
Kafe Simira
Paki Masabong
Port Loko
Loko Masama
Lungi
Maforki
Marampa
Bombali Sebora
Magburaka
Kholifa Rowalla
LUNSAR
Kaffu Bullom
Pepel & Pepel Port
Masimera
Tagrin Point
Port Lease Areas
FREETOWN
Km
0 5 10 20 30 40
Mine Exploration Licence Area (07)
Transport Corridor
Mine Exploration Licence Area Ext
Proposed Rail Alignment
Port Lease Areas
Main Towns
Existing Rail Route (non-operational)
Chiefdoms
Bombali Sebora
Buya Romende
Kafe Simira
Kaffu Bullom
Kalansogoia
Kholifa Rowalla
Loko Masama
Maforki
Makari Gbanti
Marampa
Masimera
Paki Masabong
Safroko Limba
NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84
COMPANY
African MINERALS
WorleyParsons
PROJECT
Environmental Screening Assessment Screening Form - Tonkolili Project
TITLE
Chiefdoms Along the Proposed Transport Corridor and Port Sites
Figure 6
DOCUMENT No:
REV:
DATE: 04/02/10
ORIG: KH
CHK: OZR
APP: PB
PROJECT No: 305000-00006
SCALE: 1:610,000
SIZE: A3

<u>*Proximity to Ecological Areas*</u>

There are two designated forest reserves within the vicinity of the project; the Farangbaya Forest Reserve (12.6 ha), which has a rainforest ecosystem and is located approximately 10 km south-east of the town of Bumbuna and the Malal Hills (3.39 ha), located 10 km south of the alignment east of the town of Marampa (Figure 4). The Port Loko Strict Nature Reserve (2.16 ha) is located approximately 4.5 km north of the proposed ore transport corridor nearby to Port Loko town.

Within the mine concession, there are mainly two habitats of conservation interest both of which have limited distribution within the existing exploration lease area:

- Forest patches on slopes in limited locations, notably Simbili and Kegbema, some of which are associated with Society Bush areas access which is restricted to local communities; and
- Riverine forest strips along river valleys, notably well preserved east of Farangbaya village.

The proposed port location at Tagrin Point is situated within the Sierra Leone River Estuary which is characterised by substantial areas of mudflats and mangrove forests. It is the receiving environment for the Rokel / Seli Rivers. The larger estuarine environment is a designated Ramsar (wetlands conservation) site acknowledging its international importance for palae-arctic migrant wader birds that are present in large numbers on the rich feeding ground mudflats during northern hemisphere winter periods. The estuary is known to support at least 36 over-wintering wader species, the most common being the Curlew Sandpiper, Red Shank and Ringed Plover as reported by Birdlife International.

Rail lines at Port Loko that are proposed for upgrading, traverse an area of high ecological value associated with extensive mangrove forests along Port Loko Creek and at Pepel Island, both of which are within the Sierra Leone River Estuary designated Ramsar site. Birdlife International reports that a total of 36 wader species have been recorded in the estuary and numbers are known to exceed 20,000 regularly during the migration season. The IUCN also reports, among other species of conservation value, populations of West African Manatee (*Trichechus senegalensis*) in the estuary.

<u>*Proximity to Areas of Historical and /or Cultural Importance*</u>

Refurbishment of the Pepel Port facility and export of iron ore product will lead to the rejuvenation of marine traffic between Taso Island and Pepel Island. The port itself is approximately 1.8 km from Bunce Island, which was declared a national monument in 1948 for its historical links to the Atlantic slave trade and is a focus of international interest.

***Indicate whether adequate infrastructure exists at the location and / or proposed location and whether old or new buildings, roads, electricity and water lines or drainage systems exist at the location and / or proposed site.***

Current infrastructure at the mine site is limited to unpaved roads and community infrastructure such as water wells, social halls and market buildings within a few villages. Although the Bumbuna Hydroelectric facility is nearby, it provides no electricity distribution in the immediate project area.

Sealed roads are situated along a portion of the proposed rail ROW adjacent to the main Makeni-Freetown highway and the Lungi-Tagrin Ferry road. Water and electricity supplies are not available in these areas.

Infrastructure development is required across all project areas and is the subject of current design studies. The new infrastructure required includes:

- Power generation / distribution infrastructure;

- Water storage and supply infrastructure;
- Storm water and effluent management systems;
- Mine waste and tailings management facilities;
- Road infrastructure including site access roads and internal roads at loading / unloading facilities;
- Railway infrastructure (both new and upgraded);
- Construction and operations waste management facilities;
- Port infrastructure including both new and upgraded facilities (i.e. offshore berths / material transfer facilities and container storage and fuel storage facilities.)
- Supporting infrastructure at the mine site including offices, change houses, laboratories, workshops, stores, fuel depot, heating and cooling systems, lighting, mine rescue station, fire station, medical facilities, non-mining waste management facilities, hazardous materials management storage areas, sewage treatment facilities, communication systems and security and staff accommodation facilities.

## SECTION 3: EMPLOYEES AND LABOURERS

***Number of people employed***

The Tonkolili Iron Ore Project, currently in the exploration phase, already employs approximately 700 people making it a significant employer in Sierra Leone. When the Project advances to the construction phase a substantial increase in workforce numbers is envisaged. Current estimates indicate total construction phase employment (comprising international and national project personnel) will be around 5,000. This work-force will be spread across all project locations (i.e. mine site, processing plant, transport routes and port facilities) according to the construction schedule. It is therefore important to note that certain areas may be more active at an earlier stage than others during the infrastructure development phase of the project. Construction is expected to take approximately 36 months to complete.

While some production will be generated during the project construction phase, when construction reaches completion, the Project will enter the fully operational phase during which employment will stabilise at a lower level than during the construction phase. Although fewer in number, jobs available during the operational phase will represent long-term opportunities with the potential to support families and communities over the lifetime of the mining operations

***Indicate whether you have or plan to construct housing / sanitation facilities for temporary or permanent workers.***

It is envisaged that temporary construction camps will be built to house the project construction workforce during the construction phase. The housing needs for the construction workforce will be evaluated in consultation with local community leaders and stakeholders. Facilities associated with these construction camps (such as on-site sewerage treatment plants and waste management facilities) will be required and are being designed by current studies.

During operations, accommodation for international and TCN employees will be provided possibly in the scaled down construction camps. All infrastructure requirements such as access roads, power supply, water and sanitation, security and waste management will feature in the project development plans as they are progressed.

## SECTION 4: DESCRIPTION OF INDUSTRIAL PROCESS

***Briefly describe the type and nature of industrial processes at the installation and / or proposed installation.***

The mining process will follow industry standards for open cast mining and will include drilling, blasting, loading, hauling and primary crushing.

Following excavation, ore will be loaded onto large haul trucks for transfer to the primary crushers. It is envisaged that at least six primary crushers will be utilized before product is conveyed to a Run of Mine (ROM) stockpile.

Hematite ore will undergo beneficiation consisting of segregation and sorting with limited enrichment or processing. Magnetite ore will undergo additional milling to achieve a finer size fraction. This will be followed by further processing including magnetic separation and flotation to produce a concentrate.

Finally, the concentrate or beneficiated ore stockpiled at the mine location will be transported by rail to the port facility for export.

Tailings will be pumped to the tailings facility from the ore process plant.

***State the type and quantity of energy used (including the origin of the energy i.e. public utility, on site generator, wood, solar, wind etc.)***

At this stage, AML are assessing a number of different options for energy supply, including hydro-electric power from existing sources available in-country and a new power supply (fuel choice as yet undefined). It is likely that the power supply for the Tonkolili Project will come from a combination of sources. The project power requirements currently under assessment but will be a minimum of 450 MW.

***Estimate the quantity of water used***

Water supply for the Tonkolili Project will be derived from a combination of surface and groundwater sources. At the mine, water will be supplied from a purpose built reservoir (Mawura) which will have a sufficiently large water storage capacity (currently assumed to be 20Gl) for the project to have security of supply through dry season conditions. Outflow from the tailings facility may have a net positive benefit to downstream users by regulating flow during the dry season. It is assumed that make-up water will be needed during the initial 18 months of production before the reservoir achieves design storage capacity. Water losses from evaporation, seepage and retention of moisture in the tailings and concentrate will be met by drawing down impounded, excess wet season flow. A project water balance is currently being confirmed. Groundwater abstraction is the preferred water supply option for other infrastructure elements of the project.

***List the type and quantity of raw material (s) used per year in the production process (including soil, sand, cement, aggregates, wood, animals etc). Identify the source (s) of raw material (s).***

Significant quantities of raw materials including water, cement, sand, aggregate, steel and timber will be required for the construction and operation of the Tonkolili Project. At the time of writing, details regarding the quantities and sources of raw materials are still being assessed.

***List all of the chemical (s) used in the production process or expected to be used for any aspect of the production process.***

Chemicals used in iron ore production and processing include explosives, binders and flotation chemicals, although a variety of other products will also be required including fuels, lubricants, dust control agents and water treatment chemicals. At the time of writing, a full inventory of chemicals and the quantities required is being prepared as part of design works.

## SECTION 5: PRODUCTS

***Briefly state the nature of the product (s) or output of the facility and or proposed facility, and the expected quantities on a quarterly or annual basis. Indicate the use and or intended use of the product (s).***

| NAME | DESCRIPTION OF USES | OUTPUT |
|---|---|---|
| Hematite iron ore | Products will be shipped to offshore markets for the manufacturing of steel and associated products. | 5 – 10 MT/year |
| Magnetite iron ore concentrates | Products will be shipped to offshore markets for the manufacturing of steel and associated products. | 45 MT/year with the possibility for increasing to 90MT/year after a project Stage II development |

## SECTION 6: BY PRODUCTS, WASTE MANAGEMENT AND DISPOSAL

***Specify the nature of each waste or by-product and the quantity generated or to be generated.***

Waste from mining operations is primarily waste rock excavated to expose the ore bearing material and tailings comprised of water and unwanted (unrecoverable and uneconomic) minerals. Current estimates suggest that approximately 120 million tonnes / annum of tailings will be produced . Waste volumes are dependent on density and bulk water content and final project waste volumes will be determined as part of the current project design works.

Other hazardous and non-hazardous waste streams include vegetation wastes (i.e. wood waste and green wastes from vegetation clearance), hydrocarbon wastes, domestic wastes (both biodegradable and non-biodegradable), medical waste and chemical wastes. Wastes inventories (i.e. types and volumes) have not yet been determined but will be calculated during later stages of the project design process.

Liquid waste will be present in the form of wastewater from the mine site facilities and camp including sewage and grey water, mine wastewater derived from dewatering activities in the mine pits and supernatant from the tailings facility. Treated wastewater will be used as process make-up water as far as practicable.

No major gaseous emissions are expected from the project however diesel powered machinery and processors will produce exhaust gases emissions including carbon dioxide ($CO_2$), NOX, and SOX and PM10 (particulates). Fugitive dust control will be implemented especially during the dry season.

Details on the quantity of project-related liquid wastes and gaseous emissions are the subject of ongoing studies and appropriate waste management plans focusing on minimisation, re-use, recycling in preference to straight disposal, will be developed for each waste stream.

***State the method of disposal or management (e.g. dump site, burning, bury etc).***

Details of waste management strategies have not yet been finalised. All hazardous and non-hazardous wastes will however, be collected, transported, processed, recycled or disposed of in a manner that meets the requirements of the GoSL and Good International Industry Practice as defined in IFC's Performance Standard 3 on Pollution Prevention and Abatement.

Waste rock will be placed in engineered waste rock dumps within the mining lease

Tailings will be discharged to a tailings facility. Tailings dams will be engineered for the storage of these wastes and to maximise the volume of water available for reclamation for re-use as process make-up water.

***Indicate the sources of noise pollution, the type / quality of noise (i.e. machinery / repetitive pounding etc).***

Noise pollution sources will vary between the different project phases (i.e. construction, operation and decommissioning). Noise sources will include equipment noise (both stationary and non-stationary), blasting noise and vibration and will be both sporadic and continuous as detailed below.

| SOURCE OF NOISE | TYPE OF NOISE |
|---|---|
| Equipment | Continuous |
| Vehicles/Transport activities | Sporadic |
| Processing plant | Continuous |
| Blasting | Sporadic |
| Vibration | Sporadic |
| Stockpiling | Sporadic but at regular intervals |
| Piling during construction | Sporadic |

## SECTION 7: ENVIRONMENTAL IMPACTS

***Please indicate environmental impact (s) that may occur as a result of the factory / industrial process and or the process of proposed project.***

Potential environmental and social impacts associated with the Tonkolili Project have been identified at a preliminary level and are presented in the following table. Impacts have been identified via an initial screening process based on the present understanding of project design and its environmental and social setting. Knowledge gained from previous experience with similar projects has also been used.

| NATURE OF IMPACT | Y/N | BRIEF DESCRIPTION OF ANTICIPATED IMPACTS |
|---|---|---|
| **Air Quality** | Y | Dust and particulate emissions associated with mine operations including ore loading, transport and crushing and processing and vehicular movements.<br><br>Gaseous emissions from diesel powered equipment – sulphur oxides ($SO_X$), nitrous oxides ($NO_X$), carbon monoxide (CO) and carbon dioxide ($CO_2$). |
| **Surface Drainage** | Y | Alteration of surface drainage patterns and systems as a result of the development of project-related surface infrastructure including mine pits, tailings facility, buildings, roads and railways.<br><br>Alteration of surface drainage flows due to the impoundment of water for use in ore processing and other mine related activities (e.g. wetting down during dry seasons). |
| **Landscape** | Y | Changes to the visual environment of the mine, haul road corridor and port facility. |
| **Forest cover** | Y | Potential loss of some forest areas and associated habitats. |
| **Vegetation** | Y | Improved understanding and knowledge of flora through specialist ESHIA studies will be undertaken to gather greater knowledge and improve understanding for management / protection of the project area ecosystem.<br><br>Loss to vegetation cover due to construction of:<br><br>• Waste rock dumps and tailings facility;<br><br>• Mine site infrastructure including offices, stores, workshops and accommodation camps; |

| NATURE OF IMPACT | Y/N | BRIEF DESCRIPTION OF ANTICIPATED IMPACTS |
|---|---|---|
| | | and<br><br>• Haul road and railway line.<br><br>Indirect impacts on vegetation as a result of changes to project area hydrological regime.<br><br>Increased pressure on forest and related resources as a result of increased population (i.e. formal and speculative workers and their families) at and near to the project development sites. |
| **Human Population** | Y | Increased job opportunities and socio-economic improvements associated with direct and indirect project benefits.<br><br>Skills transfer through training and sourcing labour and goods and services locally where possible.<br><br>Improved access to markets and social infrastructure through project induced infrastructure programs (i.e. through construction of road and rail routes.<br><br>Increased national profile through world class development and size of resource.<br><br>Government national revenue from taxes and royalties.<br><br>Relocation of families, homesteads, villages and loss of community infrastructure.<br><br>Loss of agricultural land or access to land in some project affected communities / population centres.<br><br>Potential for loss of community cohesion during the resettlement process.<br><br>Potential disturbance of sacred sites and graves.<br><br>Changes to livelihoods whether physically relocated or economically affected.<br><br>Potential interference with fishing and fish marketing activities (infrastructure at port, vessel movements, |

| NATURE OF IMPACT | Y/N | BRIEF DESCRIPTION OF ANTICIPATED IMPACTS |
|---|---|---|
| | | dredging).<br><br>Effects on any artisanal mining activity being undertaken at project sites.<br><br>Nuisance due to increased traffic and general community health and safety issues associated with project activities such as blasting, transportation, stockpiling, etc.<br><br>Population influx and changes in the demographics of the area.<br><br>Changes in the community health profile due to increased / additional exposure to social pathologies..<br><br>Long-term vulnerability of mine dependent livelihoods at decommissioning stage.<br><br>Potential impact on natural resources – hunting and fishing grounds, Society Bush, sources of medicinal plants, firewood, construction materials. |
| **Animal Population** | Y | Improved understanding and knowledge of fauna through specialist ESHIA studies may lead to identification of new species and generally greater knowledge and management / protection of the surrounding ecosystem.<br><br>Potential impact on habitat and populations of endemic species of conservation importance.<br><br>Increased migrant and long term population with increase in hunting. Increase in hunting activities in previously difficult to access areas. |
| **Soil quality** | Y | Potential soil contamination due to accidental loss of containment of liquid substances. |
| **Soil erosion** | Y | Altered stability of soils increasing erosion.<br><br>Potential for sedimentation and pollution of watercourses.<br><br>Permanent loss of soil cover over developed areas. |

| NATURE OF IMPACT | Y/N | BRIEF DESCRIPTION OF ANTICIPATED IMPACTS |
|---|---|---|
| **Water quality** | Y | Potential for acid or alkaline waste rock and / or tailings resulting in the need to consider potential for acid mine drainage.<br><br>Potential seepage from mine and mineral-processing residue disposal facilities.<br><br>Potential seepage from waste water holding facilities at the project site.<br><br>Discharges from the project site during storm events.<br><br>Accidental release of chemicals, fuels, polluted water, sewage etc at project sites. |
| **Water resources** | Y | Potential changes in water resources for downstream users due to use of water by mining operations. |
| **Noise** | Y | Potential for disturbance of sensitive receptors in the vicinity of the development during construction and mining operations.<br><br>Potential for ground vibration during blasting operations causing disturbance. |
| **Special Habitats** | Y | Possible losses of habitats of conservation importance<br><br>Loss of some mangrove / intertidal habitats due to port construction / expansion.<br><br>Habitat fragmentation due to road / rail construction. |
| **Other** | Y | *Infrastructure development*: Advantages for improved access, leading to development and growth of local businesses and economy. Ports / rail development may make smaller mineral deposits in the area more economically viable.<br><br>*Archaeology and cultural heritage*: Potential disturbance of sites of archaeological, historic or cultural importance.<br><br>*Marine water and marine environment*: Potential changes to benthic communities as a result of offshore dredging and associated spoil disposal activities. |

| NATURE OF IMPACT | Y/N | BRIEF DESCRIPTION OF ANTICIPATED IMPACTS |
|---|---|---|
| | | Potential changes in coastal hydrodynamics due to port development works.<br><br>*Major accidents:* Accidental events associated with project facilities (e.g. landslides and slippages, dam failures, holding pond facilities, hydrocarbon spills). |

## SECTION 8: PROPOSED MITIGATION MEASURES

***Indicate the measures (s) employed to mitigate against damage likely to be caused by the factory / industrial process and / or proposed project to humans and /or the environment.***

At this stage of the project, only a preliminary screening and scoping of potential environmental and social impacts has been possible. As baseline studies and impact assessments have not been completed, potential risks / impacts cannot be fully quantified. Mitigation measures are therefore, still to be fully defined but will be guided by the principles outlined in the table below.

| NO | LIKELY DAMAGE TO | MITIGATION MEASURES |
|---|---|---|
| 1 | **Air Quality** | Consider fuel efficiency when selecting equipment and vehicles.<br><br>Avoidance of incineration as a waste disposal method.<br><br>Implement dust control measures during dry season.<br><br>Prepare and implement an Emissions Management Plan. |
| 2 | **Drainage** | Baseline studies of hydrology and hydrogeology to ensure effective design outcomes.<br><br>Minimise diversion of surface water drainage.<br><br>Prepare and implement a Water Management Plan. |
| 3 | **Landscape** | Develop a Rehabilitation Management Plan including mine restoration programme.<br><br>Minimise earth works for road / rail construction and prioritise naturally flat areas for the siting of the transport corridor and the establishment of camps / project infrastructure. |
| 4 | **Forest cover** | Minimise disturbance to established and presently undisturbed forest areas.<br><br>Prepare and implement a Rehabilitation Management Plan including off-setting protocols. |
| 5 | **Vegetation** | Conduct further baseline studies to understand and assess relative conservation values of resident floral species.<br><br>Minimise disturbance to areas with well developed vegetation coverage.<br><br>Prepare and implement a Rehabilitation Management Plan. |
| 6 | **Human Population** | Establish buffer zones around populated areas to avoid nuisance disturbance.<br><br>Conduct comprehensive stakeholder consultation in a “free, prior and informed” manner.<br><br>Prepare and implement a Resettlement Action Plan (RAP) including comprehensive household asset surveys and |

| NO | LIKELY DAMAGE TO | MITIGATION MEASURES |
|---|---|---|
| | | consultative entitlement determination.<br><br>Implement a Social Management Plan to maximise benefits to local population and economy. This will include a focussed and cost effective community investment program to replace community infrastructure lost as a result of resettlement and to augment existing infrastructure in neighbouring communities and host resettlement sites.<br><br>Community Heath and Safety Plan to set out steps required to minimise risk associated with project activities.<br><br>Training programs for local employees and entrepreneurs. |
| **7** | **Animal Population** | Baseline studies to understand potential impacts on local ecosystems.<br><br>Strictly ban hunting among project employees.<br><br>Establish buffer zones around important habitats for fauna.<br><br>Minimise (control) movements of personnel to avoid disturbance.<br><br>Prepare and implement an Ecological Management Plan to protect and where possible enhance populations of endemic / indigenous and particularly protected species. |
| **8** | **Soil quality** | Baseline studies.<br><br>Develop a Spill Prevention and Response Plan and a Waste Management Plan to prevent soil, groundwater and / or surface water contamination.<br><br>Prepare and implement an Ecological Management Plan including soils management protocol (stripping, stockpiling and re-use). |
| **9** | **Soil erosion** | Minimise effects on the stability of land and land capability through management of vegetation removal and detailed engineering of the development.<br><br>Prepare Ecological Management Plan including soils protocol. |
| **10** | **Water quality** | Prepare and implement a Spill Prevention and Response Plan and a Waste Management Plan to prevent water |

| NO | LIKELY DAMAGE TO | MITIGATION MEASURES |
|---|---|---|
| | | contamination. |
| **11** | **Water resources** | Prepare a project water balance.<br><br>Ensure that water project –realted water abstraction / use does not jeopardize water supply for any population or pre-existing (domestic / community) water well.<br><br>Prepare and implement a Water Management Plan with linkages to the Community Investment Plan. |
| **12** | **Noise** | Prioritise use of noise-efficient vehicles and equipment.<br><br>Minimise equipment and vehicle use.<br><br>Prepare and implement an Emissions Management Plan. |
| **13** | **Special Habitats** | Offsetting of habitats potentially disturbed / damaged by the project activities.<br><br>Establishment of buffer zones around special habitats close to project sites.<br><br>Prepare and implement an Ecological Management Plan that includes a protected / sensitive areas protocol.<br><br>Institutional strengthening of a Ramsar site management system. |
| **14** | **Others** | *Agriculture and grazing areas:* Minimise disturbance of agricultural and grazing areas / establishment of buffer zones or compensation mechanisms through Resettlement Action Plan.<br><br>*Archaeology and cultural heritage*: Avoid disturbance of sites of archaeological, historic or cultural importance.<br><br>*Marine water and marine environment*: Prepare and implement a Marine Environment Management Plan to minimise disturbance of marine habitats and minimise the risk of marine pollution events.<br><br>*Fishing*: Minimise disturbances to existing fishing activities and infrastructure.<br><br>*Health issues*: Prepare and implement a Community Health |

| NO | LIKELY DAMAGE TO | MITIGATION MEASURES |
|---|---|---|
| | | Management Plan. |

***State any and all experience you have with implementing the above mentioned mitigation measure (s). If you do not have prior experience, what skill (s) do you possess to implement these mitigation measures?***

WorleyParsons has considerable experience in conducting Environmental and Social Impact Assessments (ESIA) processes globally across all regions of the world. A list of recent ESIA projects conducted by WorleyParsons is attached. Projects included the development and implementation of mitigation and management measures for large industrial (including mining) operations.

***What staff training is provided or will be provided to ensure compliance with health and safety standards?***

Health and Safety training will be provided by AML to ensure that all activities associated with the Tonkolili Project are undertaken in accordance with the requirements of the GoSL and GIIP. Health and Safety training will be compulsory for all employees, prior to commencing any work.

## SECTION 9: TESTIMONY

I confirm that the information provided herein is accurate to the best of my knowledge. I will also endeavour to provide additional information and facilitate a site visit if required.

| **FOR OFFICIAL USE ONLY** | |
|---|---|
| Reviewed by:<br><br>Classified A B C | Date: |
| Reasons for the Classification: | |
| | |
| | |
| Endorsed by:<br><br>Approved by Director | Date:<br><br>Date: |

**WorleyParsons Selected Environmental and Social Projects**

A list of previous projects undertaken by WorleyParsons of a similar nature to this project is listed in the Environmental, Social & Health Impact Assessment Capability & Experience Brochure. WorleyParsons is undertaking this ESHIA study in conjunction with Sierra Leone and International Project partners currently comprising CEMMATS Group (Freetown, SL), SRK International (Cardiff, UK) and Kew Gardens (London, UK), among others.

# APPENDIX 1

## ESHIA Pre-Screening Announcement & Correspondence

# SIERRA LEONE GOVERNMENT

**OFFICE OF THE EXECUTIVE DIRECTOR**
**Sierra Leone Environmental Protection Agency**
**Youyi Building, Freetown**

4th December, 2009

The Chief Executive Director
African Minerals Limited
Freetown.

Dear Sir,

RE: APPLICATION FOR AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) FOR THE TONKOLILI IRON ORE PROJECT

I wish to refer to the above subject matter and to acknowledge receipt of your proposal and application dated 13th November, 2009 for an EIA Licence to start operations of the Tonkolili Iron Ore Project.

In a bid to enable your Company complies with the provisions of the Environmental Protection Agency Act, 2008 and EIA Procedures you are required to collect and complete both application and screening forms to ensure the determination of the level of EIA to be carried out prior to the commencement of the project.

Nonetheless, after a careful look at the proposal your project has been classified under category A. In view of this, you are required to carry out an Environmental, Social and Health Impact Assessment (ESHIA) Study within the project location and its environs. You are also required to submit ten copies of the ESHIA report with a comprehensive environmental management plan to the Office of the Acting Executive Director of the Sierra Leone Environmental Protection Agency in a bid to facilitate the process of issuance of an EIA Licence to your Company.

We look forward to receiving your cooperation.

S. S. J. Jusu
**Acting Executive Director**

## APPLICATION FORM FOR THE ACQUISITION OF AN ENVIRONMENTAL IMPACT ASSESSMENT (EIA) LICENCE

1. NAME of Institution/Company..........................................................

..................................................................................................

2. TYPE OF BUSINESS.............................................................................

3. BUSINESS REGISTRATON NO...........................................................

4. CONTACT ADDRESS...........................................................................
e-MAIL OR Tel No.

..................................................................................................

..................................................................................................

5. NATIONALITY.........................................................................................

6. PROPOSED DEVELOPMENT..................................................................
(ATTACH PROPOSAL)

7. PROPOSED LOCATON.............................................................................
(INCLUDE RELEVANT MAP)

8. COST OF PROPOSAL...............................................................................

9. ESTIMATED DURATION FO DEVELOPMENT ACTIVITIES.........................

10. STATE THE IMPACT OF ACTIVITIES ON THE FOLLOWING:
TICK THE APPROPRIATE COLUMNS

| | | POSTIVE | NAGATIVE |
|---|---|---|---|
| a) | SUBSTANTIAL IMPACT ON ECOSYSTEM OF THE LOCALITY | ...................... | ............................. |
| b) | SOCIAL | ...................... | ............................. |
| c) | AESTHETIC | ...................... ... | ............................. |
| d) | SCIENTIFIC | ........................ | ............................. |
| e) | HISTORICAL | ...................... ...... | ............................. |
| f) | STATE OTHER IMPORTANT ENVIRONMENTAL PARAMETERS. | | |

Signed:...............................................
**EXECUTIVE DIRECTOR/HEAD**

## ANNEX 2: EIA Screening Form

Serial No. __________

## ENVIRONMENTAL IMPACT ASSESSMENT SCREENING FORM

Please type or print clearly, completing this form in its entirety. You may provide additional information on a separate sheet of paper if necessary. Kindly note that the information you are to provide is required by the National Environment Protection Act of 2000 for the issuance of an EIA License.
Section 15 (2).

**SECTION 1:** **INFORMATION ON THE CONTACT PERSON**

Name ______________________________

Institutional Affiliation ______________________________

Business Title/position ______________________________

Business Address: ______________________________t

Telephone ______________ Email: ______________

**SECTION 2:** **DESCRIPTION OF THE INDUSTRY/ FACTORY/COMPANY/PROJECT AND OR PROPOSED PROJECT**

Name ______________________________

Date operations started ______________________________

Location of establishment and/or project ______________________________

Location of proposed project (if any-------)

______________________________

(Attach a map or maps, covering the proposed site and surrounding 5 km radius)

Land Area ______________________________

**Current Land use (Describe how the land is being used at present)**

**Describe any possible Alternative Site (s)** __________

**Describe other types of industries or facilities (including health centers and schools), which are located within 100 metres of the site, or are proposed to be located near the facility. Indicate the proximity of the industrial, factory or project site and or proposed site to residential areas, national parks or areas of ecological, historical or cultural importance.**

______________________________________________

______________________________________________

______________________________________________

______________________________________________

**Indicate whether adequate infrastructure exists at the location and/or proposed location and whether old or new building, roads, electricity and water lines, or drainage systems exist at the location and/or proposed site.**

______________________________________________

______________________________________________

______________________________________________

## SECTION 3: EMPLOYEES AND LABOURERS

**Number of people employed:**

| Employees and Labourers | Duration Operation |
|---|---|
| FULL – TIME | |
| PART – TIME | |

Indicate whether you have or plan to construct housing/sanitation facilities for temporary or permanent workers.

SECTION 4: DESCRIPTION OF INDUSTRIAL PROCESS

Briefly describe the type and nature of industrial processes at the installation and or proposed installation.

State the type and quantity of energy used (including the origin of the energy i.e. public utility, on site generator, wood, solar, wind etc).

| Type (s) | Quantity | Period (per day/week etc). |
|---|---|---|
| | | |
| | | |
| | | |

Estimate the quantity of water used for the following:

| Use (s) of water | Quantity | Period | Source |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

List the type and quantity of raw material (s) used per year in the production process (including soil, sand, cement, aggregates, wood, animals etc). Identify the source (s) of raw material (s).

| Type | Quantity | SOURCE |
|---|---|---|
| | | |
| | | |
| | | |

**List all of the chemical (s) used in the production process or expected to be used for any aspect of the production process (A separate list may be attached with more detailed information).**

| Name/Type | Description | Quantity |
|---|---|---|
| | | |
| | | |
| | | |

**SECTION 5: PRODUCTS**

**Briefly state the nature of the product (s) or output of the facility and or proposed facility, and the expected quantities on a quarterly or annual basis. Indicate the use and or intended use of the product (s).**

| NAME | DESCRIPTION OF USES | OUTPUT |
|---|---|---|
| | | |

**SECTION 6: BY PRODUCTS, WASTE MANAGEMENT AND DISPOSAL**

**Specify the nature of each waste or by-product and the quantity generated or to be generated.**

| Type | Description | Quantity in 1g per weeks/ |
|---|---|---|
| **Solid (Bulk)** | | |
| **Solid particulate** | | |
| **Liquid** | | |
| **Gaseous** | - | |
| **Other** | - | |

**State the method of disposal or management of waste (e.g. dump site, burning, bury etc).**

| Type of waste | Method of disposal/management |
|---|---|
| | |
| | |
| | |

**Indicate sources of noise pollution, the type/quality of noise (i.e. machinery/repetitive pounding etc).**

| Source of Noise | Type of Noise |
|---|---|
| | |
| | |
| | |

## SECTION 7: ENVIRONMENTAL IMPACTS

**Please indicate environmental impact(s) that may occur as a result of the factory/industrial process and or the process of proposed project.**

| Nature of impact | Y/N | Brief description of the anticipated impacts |
|---|---|---|
| Water quality | | |
| Drainage | | |
| Landscape | | |
| Forest cover | | |
| Vegetation | | |
| Human POP | | |
| Animal POP | | |
| Soil quantity | | |
| Soil Erosion | | |
| Water quality | | |
| Noise | | |
| Special Habitants | | |
| Other | | |

## SECTION 8: PROPOSED MITIGATION MEASURES

**Indicate the measure (s) employed to mitigate against damage likely to be caused by the factory/industrial process and/or proposed project to human and/or the environment.**

**Briefly describe these measures**

| NO | LIKELY DAMAGE TO | MITIGATION MEASURES |
|---|---|---|
| 1 | Air Quality | |
| 2 | Drainage | |

| | | |
|---|---|---|
| 3 | Landscape | |
| 4 | Forest Cover | |
| 5 | Vegetation | |
| 6 | Human Population | |
| 7 | Animal Population | |
| 8 | Soil Quality | |
| 9 | Soil Erosion | |
| 10 | Water Quality | |
| 11 | Tranquility/Noise | |
| 12 | Special Habitats | |
| 13 | Others | - |

**State any and all experience you have with implementing the above mentioned mitigation measure (s). If you do not have prior experience, what skill (s) do you possess to implement these mitigation measures (s)?**

**What staff training is provided or will be provided to ensure compliance with health and environmental safety standards?**

| SECTION 9: | TESTIMONY |
|---|---|

I confirm that the information provided herein is accurate to the best of my knowledge. I will also endeavour to provide additional information and facilitate a site visit if required.

| For Official Use Only | |
|---|---|
| Reviewed by: | Date: |
| Classified A B C | |
| Reasons for the Classification: | |
| | |
| | |
| Endorsed by: | Date: |
| Approved by Director: | Date: |

E.I.A Procedural Guidance Notes
from COMMATS . Dec '09

## MINING AND ON-SITE MINERAL PROCESSING

### DESCRIPTION OF THE PROJECT

**Purpose and Physical Characteristics of the Proposed Project**
Name, description, and specific location of resource to be mined in this location appropriate scale, e.g.1.10,000)
Quantity of known or proven reserves of the resources to be mined in this location.
Production capacity at normal operation.
Expected operational life of project
Cost and economic viability of project
Proposed access route and transport arrangements
Number of people to be employed.

**Land Use Requirement of the Proposed Project**
**(Area and Depth of Excavation)**
During construction
During normal operation
For depositing mine spoils
During decommissioning

**Operational Features of the Proposed Project**
Proposed mining method; surface/open-cast or deep/underground.
Type, source and quantities of water, energy and other materials that will be required:

a) During construction,
b) During normal operation, and
c) For land restoration

Effluent discharges and toxic air emissions by type, quantity, and composition during construction and operation
Chemical residues by types, composition and strength during construction and operation.
Description of earth moving machinery to be utilized.
Type and amounts of explosive to be explicit regarding frequency of usage and indicate time of year/month/day.

**Alternative Sites and Processes Considered**
Note the main alternative site considered when selecting this project. Also discuss alternative process which were considered state reasons for selecting the proposed approach and site and reasons for rejecting others.

## DESCRIPTION OF THE SITE AND ITS ENVIRONMENT

**Physical Features of the Proposed Site**

Human population and settlement patterns and the proximity of he proposed development to residential areas.

Landscape and topography.

Source of water, i.e. aquifers and water course, including creeks, belongs (and discharges), and shoreline

Type and quality of soil, i.e. agricultural and mechanical properties, and mineralogy.

Flora and fauna including habitats and typical species present (accounting for seasonal variation if necessary).

Monuments and sites of cultural and historic significance

Present land use of the proposed site (include a land use map within a 500 m zone around the proposed site). The presence of farms, schools, hospitals, and other nearby institutions should be reflected.

Any other relevant environmental features.

**Legislative and Policy Framework**

Information sha.. be provided in the environmental statement on all .elevant statutory designations such as national parks, forest parks, nature reserves related buffer zones and national monuments that are likely to affect or to be affected by the proposed project or that are otherwise situated in the vicinity of the site identified for the proposed project.

The proposed project and site should be in conformity with national, divisional district and local development plans.

Reference should be made to all applicable national legislation such as the , Part VI of the National Environment Protection Act of 2000, the Minerals Act, the Public Health Act of 1990, the L.bour Act of 1990, the Wildlife Conservation Act of 1977, and any other relevant laws and guidelines

Where applicable, reference should be made to relevant international treaties, conventions, and /or other agreements to which Sierra Leone is a Party.

## IDENTIFICATION AND DESCRIPTION OF THE IMPACTS

**Impact on Human Beings and the Human-Made Environment Damages During Construction and Normal Operations**

Impact on public health (e.g. respiratory ailments, water contamination, noise pollution, increase traffic and road accident etc)

Impact on the social and cultural fabric (including compulsory acquisition of properties and or the displacement of nearby communities).

Impacts of the development on the local economy.

Impacts of the development on local transportation.

Levels types, and effects of air emissions including dust from the development.

Quantities concentrations, types, and effects of effluent discharges from the development.

Type and levels of noise and liberations.

**Impact on the Land**

**Land Use**

a) Area and type of agricultural land to be affected;

i) Directly through loss of the land

ii) Through water erosion, siltation and wind erosion.

b) *Impact of the development on surrounding* land (arable, pastoral, residential, industrial, recreational (including beaches), etc.

c) Other alternate or possible alternative of the land.

**Impact on Water Resources**

Impact of wastes and pollutants on surface water quality (chemical, biological, thermal, etc) Impact of water use on ; the aquifer (in terms of both quality and quantity). Change of the existing hydrological regime.

a) Surface drainage.

b) Ground water level

c) Flow of underground water.

**Impact on Air Quality and Climate**

Possible effects of hazardous air emissions including dusts and other particulate on public health.

Dusts and other particulates and their impact on the well-being of wildlife and vegetations

Offensive odours.

Climate impacts (Stratospheric ozone depletion, global warning, etc)

**Impacts on Flora and Fauna**

Damage to or loss of habitats and pla:.t and animal species, both terrestrial and aquatic (special :.ference should be made to the potential impacts on ha' .ats of protected, rare or endangered species)

Impact on nearby nature reserves, mangroves, beaches, forest parks, buffer zones, etc.

Any other ecological impacts.

**Other Indirect and Secondary Impacts**

Impact of other developments/consequences associated with the project including new roads, high tension cables, water supply, processing industries, etc.

Relationship between the proposed project and other existing and other existing or proposed development.

Encroachment into areas supporting critical habitants or significant biodiversity, rare and /or protected species ad destruction of or damage to terrestrial wildlife habitats, migratory routes, biological resources or ecosystems that should be preserved.

Impacts of the interaction of all the direct impacts listed above.

## INFORMATION GAPS AND REMAINING UNCERTAINTIES

**Significance of Impacts**

Based on the information and data provided under Par 3, and analysis is required to determine the significance of potentially negative environmental impacts. For example, it a number of potential are identified in the identification and description stage, the magnitude of those impacts needs to be determined and an analysis conducted to determine the severity of those impacts.

Since specific environmental standards have not yet been defined in The Gambia, additional analysis is required to determine acceptable level in the local context. For mining in general there are four types of indicators of environmental impact significance environmental standards, environmental values, health and welfare of local people;, and conflicts of interest.

a) Ambient admission standards for water and air quality
b) National and local planning regulations
c) International conventions
d) Occupational Health and Safety Standards

Certain natural resources, though valued by groups in society, are not subject to environmental standards. To determine the significance of environmental impacts, account should be taken of the environmental values held by governments, organizations and the public. Insights into environmental priorities and preference may be found in:

a) Government policy
b) Regional and international agreements between governments and /or official organizations (.e. Montreal Protocol on Substances that Deplete the Ozone Layer)
c) Policies of international and national non-governmental organizations
d) Representations at public enquires

Since formal standards do not yet exist in Sierra Leone, the EIA Working Group will follow internationally accepted guidelines and practice for standards. Standards for each project will be reviewed on a case-by –case basis during the scoping phase. These cases will then be compiled to establish a set of environmental standards.

**Mitigating Measures**

When a developer is required to submit an environmental statement to the agency, it should amongst other things, provide a detailed description of measures that shall be adopted to avoid, reduce or remedy all those significant adverse impacts identified by the environmental study. This should include motoring and evaluation, risk management and auditing. This part of the Environmental Statement shall provide inter alias, information on the following:

**AFRICAN MINERALS LIMITED**

**TONKOLILI IRON ORE PROJECT**

Date: 13 November 2009

**ENVIRONMENTAL PROTECTION AGENCY (EPA)**

**Attn. Mr Jusu**

**Director of the Environment, EPA**

**3rd Floor, Youyi Building**

**Freetown, Sierra Leone**

Re: Tonkolili Iron Ore Project

Dear Mr Jusu,

African Minerals Limited (AML) is pleased to announce our intention to develop the Tonkolili iron ore mine in Sierra Leone. We would like to request the EPA formally consider this project in terms of regulation of environmental and social aspects.

Due to the project's size and significance AML anticipate that an Environmental Impact Assessment (EIA) will be required in accordance with the regulations set out in the Environment Protection Act 2008.

Additionally, AML understands that in order to transition from exploration activities to operational mining, a lease is required from the Ministry of Mineral Resources. The lease application needs to be accompanied by an EIA with proposals for mitigation of identified environmental impacts. We therefore realise the EIA could be a critical aspect of the project schedule.

It is understood that we may only undertake EIA under licence from the EPA. We are also aware that the EPA is required to screen the project and advise on statutory procedures. We wish to launch the environmental and social process as quickly as possible so that EIA work can interact with the engineering design which is currently being assessed in a Feasibility Study due to be completed in 2010. To this purpose we are attaching a brief project description of the planned activities in Sierra Leone.

AML are committed to maintaining the highest corporate and ethical standards throughout the life of this project. It is anticipated that the EIA will address not only environmental but also social and health aspects, subject to EPA's determination. We would therefore kindly request the EPA to consider the project and advise on the appropriate screening and further procedures to obtain an EIA licence, if required.

We believe this project will be of national significance and convey significant benefits to Sierra Leone through increasing local employment, infrastructure, government revenue, institutional capacity building and commitment to high standards of environmental and social practice. AML has already invested significantly in the exploration activities at Tonkolili and are confident of developing a world-class iron project. The project is aiming to produce 45 Mtpa of iron ore from a resource that has currently has been proven to contain more than 5.1 Bt of recoverable ore making it one of the world's largest magnetite deposits.

We have nominated the company WorleyParsons as EIA contractor for this project who will be represented in Sierra Leone by a local agent to facilitate the regulatory approval and maintain in-country continuity. We request that your response is emailed to the following:

Mr Steve Allard (AML) – steve.allard@african-minerals.com

Mr Philip Burris (WorleyParsons) – philip.burris@worleyparsons.com

We sincerely look forward to working with the EPA on this project and developing good environmental outcomes by furthering the opportunities for sustainable development in conjunction with the Government of Sierra Leone.

Yours sincerely,

Steve Allard

VP Infrastructure - African Minerals Limited

# TONKOLILI IRON ORE PROJECT DESCRIPTION

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone. The Project is planned to produce 45 Mtpa of iron ore comprising:

- Predominantly magnetite with a grade containing 68% to 70% Fe with a minimum particle size of 38 µm from a resource deposit identified containing 5.1 Billion tonnes of recoverable ore.
- Some Hematite (lump and fines)

The mine project area is located approximately 200 km east of Freetown, the capital city of Sierra Leone.

The project will comprise the mine and process plant facilities supported by a rail network to transfer the concentrate product to the stockyards and handling facilities at the port area which is to be located in the Tagrin Point area, North of Freetown and South of the Lungi airport.

Three ore bodies have been identified for production and it is envisaged that staged development will be undertaken, dependent on the exploration activities which are currently underway to maximize return on the investment. It is likely that additional ore bodies will subsequently be developed as the understanding of the geological conditions and the mine reserves mature.

To commercialise the Tonkolili Resource, AML will execute an integrated greenfield development through the construction of new facilities which include:

- A new mine and ore processing plant at Tonkolili, to produce 45 Mtpa of magnetite;
- A new deepwater port and associated infrastructure at Tagrin Point suitable for loading Cape size vessels for the export of 45 Mtpa iron ore;
- Approximately 200km of new standard gauge, heavy haul railway from Tonkolili to Tagrin Point, and
- All associated support infrastructure to deliver and operate the project safely and successfully.

At the mine the project development will comprise three open cast mines, ROM pads, the central minerals processing facilities and support infrastructure such as power, water, access roads, air terminal, accommodation facilities, workshops, warehouses, laboratories, administration buildings and train loading facility.

The port will initially be capable of 45MTPA which will be expandable to 90MTPA plus. At the port a rotary train unloader will convey the concentrate to stockpiles. Reclaimers in the 2 stockyards will collect the product and convey to the open water port which will then be loaded onto a ship via the ship loader.


## Mine and Process Plant

The Mine and Process Plant will be sited to enable the extraction and processing of the iron ore resource body to enable overland transport by rail to the Port for the export of the iron concentrate. Current mine processing site selection is about to commence and as such various options are to be investigated. The facilities to be provided for the overall development include:

- Development of three open cast pits to access the ore deposits at Simbili, Marampon and Numbara;
- Overburden waste management;
- Location of the Run of Mine (ROM) pad;
- Primary Crushing facilities
- Secondary Crushing facilities;
- Product Screening facilities;
- Tertiary Crushing facilities;
- Primary and Fine Grinding;
- Flotation;
- Tailings Storage Facility;

- Product Handling;
- Train Loading Facility;
- Reagent Storage Facility;
- Laboratory and Sample Stations;
- Airport;
- Power Plant;
- Water Treatment Plant;
- Waste Water Treatment Plant; and
- Administration, Training, Maintenance and Warehousing Facilities.

## Rail

The Tonkolili rail encompasses the construction of approximately 200km of heavy haulage railway and associated infrastructure from the Tonkolili mine to Tagrin Port. The aim is to develop the rail infrastructure with a minimum capacity of 45 Mtpa. The design of the railway and associated facilities needs to be able to be readily expanded to 90 Mtpa while ensuring sufficient space is available to expand the operation to an ultimate development capacity of 200 Mtpa plus.

The rail alignment will be designed to best suit the project with regards to construction costs and social impact.

Key areas of the rail are the Port, Mine and marshalling yards.

## Access Roads

An access road will run the full length of rail alignment from port to mine. The utilisation of this road is to be determined whether it will be the main Tonkolili mine access road or be a rail maintenance road.

Construction of a temporary haul road for hauling product from Tonkolili to the existing railway at Marampa is envisaged as a separate project to the current Project. Synergies however will need to be encompassed and it would seem likely that the temporary haul road will follow the proposed Tonkolili rail alignment and the balance between rail and road will be optimized once the heavy haul rail system is operational.

## Port Facilities

A port facility with a capacity of 45 Mtpa will be developed. The design of the facilities needs to ensure sufficient capacity for increased expansion in future. This port facility will likely become the paramount Port facility in the West African region. The overall port layout needs to provide sufficient space to enable an ultimate development of a total capacity of 200 Mtpa.

The port is separated into In-Loading and Out-Loading circuits separated by the product stockpiles.  There is the ability to through load built into this system, i.e. there is a direct ore path from the Car Dumpers to the Ship loaders.

- The In-Loading circuit is defined as the area and equipment between the ore wagon and the stockpiles.  There is one In-Loading circuit constructed as part of initial port with a second In-loading circuit (for the 90 Mtpa) being incorporated in the design of the facilities.

- The stockpiles rows will consist of 5 stockpiles each of a nominal 200 kt live capacity. The length of the live stockyard is nominally 1,100 m.  The 45 Mtpa yard will require 2 live stockyard rows which will result in 4 total stockyard rows, the outer two being dead rows (which can be stacked but not reclaimed).  The 90 Mtpa expansion will add an additional 2 live stockyard rows which will result in 6 stockyard rows, the outer two will be dead rows (which can be stacked but not reclaimed).

- The Out-Loading circuit is defined as from the stockpiles to the ship.  There is one Out-Loading circuits constructed as part of 45 Mtpa.  The Out-Loading circuit will have the ability to be able to feed either ship loader from either reclaimer for the 90 Mtpa design.

# APPENDIX 2

## Environmental Aspects Register

# Draft ENVID Table - Construction

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| **Port** | Development of port infrastructure/ rehabilitation activities | Resettlement | Relocation of families, homesteads, villages and community infrastructure | Disturbance on terrestrial and coastal ecosystems due to relocation<br>Loss of biodiversity | Loss of access to common property resources<br>Loss of access to cultural resources.<br>Human rights abuses (related to resistance of displacement).<br>Psychological impacts on individuals manifesting as apathy, helplessness and a sense of inadequacy.<br>Breakdown of social networks and community cohesion (community disarticulation)<br>Food insecurity.<br>Civil unrest and instability.<br>Exacerbation of inequality.<br>Increase in availability of jobs | General health |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity & sensitive habitat<br>Changes in wetland pattern | Changes in food stock | General health |
| | | | Variation of Microclimatic conditions | Habitat changes | | |
| | | | Disturbance archaeological, historic or cultural important sites | | Loss of information and values to current and future generations. | |
| | | Borrow pits | Loss of biodiversity and agricultural land | Disturbance of ecosystem | Impoverishment of land users | |
| | | Vehicles and machinery | Dust and particulate emissions | Changes in air quality<br>Disturbance of ecosystem | Problems with public health | Respiratory health |
| | | Cranes and equipment | Lighting | Disturbance of ecosystem | Disturbance of surrounding land users. | General health |
| | | Construction Noise | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the community | |
| | | Clearance of area (Ore stock piles and scrap metal) | Dust and particulate | Changes in air quality<br>Disturbance of ecosystem | Problems with public health | Respiratory health |
| | | | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the community | General health |
| | | | Rainwater run-off & oil spills | Disturbance Marine ecosystem<br>Water and sediment quality<br>Groundwater quality | Problems with public health | |
| | | | Disposal of contaminated soils | Groundwater contamination<br>Soil contamination | Problems with public health | |
| | | | Handling of acid sulphate soils | | Problems with public health | |
| | | Expansion of Fuel | Potential spillage from | soil contamination | | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | Farm facilities. | Potential spillage from refuelling /leakage | estuary contamination | | |
| | | | | groundwater contamination | | |
| | | Marine structures construction/ rehabilitation | Physical presence | Changes in Sediment transport & coastal landforms | Changes in fisheries | Food resources |
| | | | | Disturbance of estuary hydrodynamics & changes in habitats | Changes in navigation | |
| | | | | Increase nearby bottom scouring | temporary displace fisheries and other estuary resources | Food resources |
| | | | | Disturbance Marine ecosystem | | |
| | | | Rainwater run-off & oil spills | Water and sediment quality | Problems with public health | Food resources, general health |
| | | | | Disturbance Marine ecosystem | Changes in fisheries | |
| | | | Preservatives in installed structures | Contamination of water body | Contamination of fish resource with heavy metals | |
| | Capital dredging | Dredging | Increased turbidity | Reduced visibility, available oxygen & sunlight penetration | Effect on fisheries | Food resources, general health |
| | | | Contaminated sediments | Changes in water quality | | |
| | | | Disturbance of seabed | Changes in bottom biota | | |
| | | | Changes in bathymetry | Changes in hydrodynamics | Effect on navigation | |
| | | | | Changes in salt wedge intrusion and consequent change in ground water quality | Problems with public health | |
| | | | | Changes in sediment transport (erosion and deposition pattern) | Effect on fisheries | |
| | | | | changes in downstream shoreline | | Food resources, general health |
| | | | Ship discharges & oil spills | Changes in water quality | Problems with public health | |
| | | Disposal at sea | Smothering of benthos | loss of bottom biota | | |
| | | | | biological recolonization rates | | |
| | | | changes in current patterns | Changes in hydrodynamics | Effect on navigation | |
| | | | | Accelerated shoaling | | |
| | | | Contaminated sediments | Changes in water quality | | |
| | Workers Camp | Resettlement | Relocation of families | | Loss of access to common property | |
| | | Workers accommodation | | | Problems with surrounding communities; Disturbance of community structures. | Food resources, general health (immigration issues) |
| | | | Presence of workers | Impact on habitat / resources | Population uncontrolled influx; increase of prostitution and STD | |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | | |
| | Water resources | Abstraction of groundwater | Reduction in groundwater discharge to creeks and estuary | Changes in groundwater quality (saline intrusion) | Deterioration of water quality for potable and agricultural use in local communities | |
| | | | | Deterioration of habitats and biota in freshwater streams & creeks | | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | Lowering of groundwater levels | | Reduction of water availability from shallow wells in local communities - e.g. dry out earlier in dry season | General health |
| | | | Potential destabilization of the ground due to water extraction | Ground subsidence | | |
| | | Use of surface water | Reduced river flows | Deterioration of habitats and biota in freshwater streams & creeks | Reduction of water availability from rivers for local community potable and agricultural use | |
| | Sanitation and waste production | Waste water | discharges to estuary | Changes in water quality<br>Disturbance Marine ecosystem | Problems with public health<br>Effect on fisheries | General health |
| | | | Odour | Changes in air quality | Disturbance of surrounding | |
| | | Solid waste | Discharges to estuary | Disturbance of marine ecosystem<br>Water quality | Problems with public health<br>Effect on fisheries | Food resources, general health |
| | | | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | | Land disposal | Groundwater contamination<br>Habitat disruption / Land occupation<br>Soil contamination | Problems with public health<br>Reduction of agricultural land<br>Effect in agriculture & human health | |
| | | | Fly tipping | Soil / Groundwater contamination | Problems with public health | |
| | | | Inappropriate storage | Soil / Groundwater contamination | Problems with public health / vermin control | |
| **Mine** | Implementing site | Resettlement | Relocation of families, homesteads, villages and | Disturbance on ecosystems due to relocatio<br>Loss of biodiversity | Loss of access to common property resources.<br>Loss of access to cultural resources.<br>Human rights abuses (related to resistance of displacement).<br>Psychological impacts on individuals manifesting as apathy, helplessness and a sense of inadequacy.<br>Breakdown of social networks and community cohesion (community<br>Food insecurity.<br>Civil unrest and instability.<br>Exacerbation of inequality. | General health |
| | | | | | Increase in availability of jobs | Positive health impact |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | | |
| | | | Disturbance of artisanal mining activity | | Deterioration in health | |
| | | | Disturbance archaeological, historic or cultural important sites | | Loss of information and values to current and future generations. | Food resources, general health |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | | | Destruction of cultural resources and sacred sites.<br>Inability to perform usual rites.<br>Loss of cultural values. | |
| | | | Disturbance of grave sites | | Offended descendants | Food resources |
| | | | Loss of agricultural land capability | | Impoverishment of land users.<br><br>Food insecurity. | |
| | | | Disruption of migration routes | Impacts on animals that migrate across the mine site. | Impacts on nomads that traverse the mine site. | Food resources, general health |
| | | | Loss of biodiversity and/or ecological function | Loss of habitats and species of conservation importance. | | |
| | Excavations and structures | Blasting & earth movement | Risk of accidents | Disturbance of ecosystem | Potential injuries | Safety |
| | | | Noise | Disturbance of ecosystem | Disturbance of surrounding communities | General health |
| | | Visual | Intrusive effect on landscape | | Adversely affect other land uses such as tourism | |
| | | | Lighting | Disturbance of ecosystem | Disturbance of surrounding land users. | General Health |
| | | Changes in drainage patterns | Sedimentation of watercourses | Changes in water quality<br>Availability to downstream water to ecosystems | Changes in stability of land and land capability.<br>Water availability to downstream users | General health |
| | | | Loss of groundwater storage due to removal of material above bedrock | Reduction in river baseflows through dry season | Water availability to downstream users | |
| | | | Local reduction in groundwater levels and discharge to rivers | Disturbance of ecosystems | Reduction in water available for local agriculture and potable use | |
| | | | Increased erosion | Changes in water quality<br>Disturbance of ecosystem | Loss of land | |
| | | Leakage through and below tailings dam | Contaminated (caustic) water enters groundwater | Contamination of rivers and wetland areas | Deterioration of well and river water quality for potable and agricultural use in local communities | |
| | Workers Camp | Resettlement | Relocation of families<br><br>Disturbance of the ecosystem | Loss of biodiversity / increased pressure | Loss of access to common property resources.<br>reduction of resources | |
| | | Workers accommodation | | | Problems with surrounding communities? Disturbance of community structures? | General health (immigration issues) |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | | Food resources |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | Construction of water supply dam | Blasting & earth movement | Risk of accidents | Disturbance of ecosystem | Potential injuries | Safety |
| | | | Noise | Disturbance of ecosystem | Disturbance of surrounding communities | General health |
| | | | Sedimentation of watercourses | Changes in water quality downstream | | |
| | | Water capture | Change in sediment transport | Disturbance of estuary dynamics<br>Increased erosion downstream | | |
| | | | Changes in river flows | Availability to downstream water to ecosystems | Water availability to downstream users | |
| | Groundwater resources | Abstraction of groundwater | Reduced availability of groundwater | Disturbance of ecosystem<br>Changes in water quality | Disturbance of surrounding land users | General health |
| | | | Potential destabilization of the ground | Ground subsidence | | |
| | Waste Generation | | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | | Land disposal | Groundwater contamination<br>Soil contamination | Problems with public health<br>Effect in agriculture | |
| | | | Fly tipping | Soil / Groundwater contamination | Problems with public health | |
| | | | Inappropriate storage | Soil / Groundwater contamination | Problems with public health / vermin control | |
| **Rail / road** | Implementing route | Resettlement | Relocation of families, homesteads, villages and community infrastructure | Disturbance on ecosystems due to relocation<br>Loss of biodiversity | Loss of access to common property resources.<br>Loss of access to cultural resources.<br>Human rights abuses (related to resistance of displacement).<br>Psychological impacts on individuals manifesting as apathy, helplessness and a sense of inadequacy.<br>Breakdown of social networks and community cohesion (community disarticulation)<br>Food insecurity.<br>Deterioration in health.<br>Civil unrest and instability.<br>Exacerbation of inequality. | General health |
| | | | | | Increase in availability of jobs | Positive impact on general health |
| | | Opening of new routes | Access for vehicles | Disturbance of ecosystem<br>Potential increase of hunting patterns / increase pressure from poachers | Access to remote locations | Positive impact due to increased access. |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | Protection fences construction | Barriers for fauna moves: rupture of migration routes for mammals, fauna communities isolation and amphibian displacements | | Food resources, general health |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | | Food resources, general health |
| | | | Disturbance of artisanal mining activity | | Deterioration in health | |
| | | | Disturbance archaeological, historic or cultural important sites | | Loss of information and values to current and future generations.<br>Destruction of cultural resources and sacred sites.<br>Inability to perform usual rites.<br>Loss of cultural values. | |
| | | | Disturbance of grave sites | | Offended descendants | |
| | | | Loss of agricultural land capability | | Impoverishment of land users.<br>Food insecurity | |
| | | | Disruption of routes | Impacts on animals migration routes | Impacts on nomads that traverse the mine site.<br>Loss of access to food/crop resources. | Food resources, general health |
| | | | Loss of biodiversity and/or ecological function | Loss of habitats and species of conservation importance. | | |
| | | Borrow / construction materials | Loss of biodiversity and agricultural land | | Impoverishment of land users | Food resources, general health |
| | | Vehicle emissions | Dust and particulate emissions | Deterioration of air quality<br>Disturbance of ecosystem | Potential injuries<br>Problems with public health | Food resources, respiratory health |
| | | Stack emissions | Dust and particulate emissions | Reduced visibility | Problems with public health | Respiratory health |
| | Excavations and structures | Blasting & earth movement | Risk of accidents | Disturbance of ecosystem | Potential injuries | Safety |
| | | | Dust generation | Changes in Air Quality | | Respiratory health |
| | | | Vibration | Disturbance of ecosystem | Damage of structures & dwellings near to construction sites | General health |
| | | Changes in drainage patterns | Sedimentation of watercourses | Changes in water quality<br>Availability to downstream water to ecosystems | Changes in stability of land and land capability.<br>Water availability to downstream users | Food resources, general health |
| | | | Increase erosion | Changes in water quality<br>Disturbance of ecosystem | Loss of land | |
| | | Noise | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the vicinity of the development. | General health |
| | Workers Camp | Resettlement | Relocation of families | | Loss of access to common property resources. | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | Workers accommodation | | | Problems with surrounding communities? Disturbance of community structures? | Food resources, general health |
| | | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | Reduction of Resources | |
| | Construction of bridges | Land clearance | Disturbance of the ecosystem | Loss of biodiversity | | Food resources, safety, general health |
| | | Earth movement | Risk of accidents | Disturbance of ecosystem | Potential injuries | |
| | | | Noise | Disturbance of ecosystem | Disturbance of surrounding communities | |
| | | | Disturbance of watercourses | Changes in water quality downstream disturbance for river ecosystem | | |
| | Water resources | Abstraction of groundwater | Lowering of groundwater levels | Disturbance of ecosystems (wetlands) | Reduction in water available for local agriculture and potable use | |
| | | | Changes in water quality | Disturbance of ecosystems | Deterioration of water quality for potable and agricultural use in local communities | |
| | | | Potential destabilization of the ground due to water extraction | Ground subsidence | | |
| | | Use of surface water | Reduced river flows | Disturbance of ecosystems (particularly river ecosystems and wetlands) | Reduction of water availability from rivers for local community potable and agricultural use | |
| | Search for water sources | Abstraction of water | Reduced availability of water | Disturbance of ecosystem<br>Changes in water quality<br>Disturbance of ecosystems (particularly river ecosystems and wetlands) | Disturbance of surrounding land users<br>Lowering water table below current well depths | General health |
| | General - Waste Generation | Waste | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | | Land disposal | Groundwater contamination<br>Soil contamination | Problems with public health<br>Effect in agriculture | |
| | | | Fly tipping | Soil / Groundwater contamination | Problems with public health | |
| | | | Inappropriate storage | Soil / Groundwater contamination | Problems with public health / vermin control | |

# Draft ENVID Table - Operations

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| **PORT** | Presence of the port | Marine structures and causeway | Footprint and Sediment Transport | Changes in coastal morphology and habitat e.g. beach, mangrove<br>Changes to estuary hydrodynamics, salinity<br>Increase nearby bottom scouring<br>Increase in turbidity and reduction in light in water column and at seabed impacts on marine ecosystems e.g. mangrove | Changes in fisheries<br>Changes in navigation<br>Changes in public resources such as beaches<br>Loss of land<br>Increased availability of jobs | Impact on food resources, recreation, and general public health |
| | | | Rainwater run-off | Water and sediment quality<br>Disturbance Marine ecosystem/ biodiversity | Problems with public health<br>Changes in fisheries<br>Reduction in quality of swimming/bathing areas | Impact on food resources, recreation, and general public health |
| | | | Paints/anti-fouling on marine structures | Contamination of water body | Contamination of fish resource with heavy metals | Impact on food resources |
| | | | Maintenance | Water and sediment quality | Changes in fisheries | Impact on food resources |
| | Bulk handling | Stockpiling, processing & materials handling | Motor exhausted gases emission. | Changes in air quality | | Respiratory impacts |
| | | | Iron ore dust and particulate emissions | Changes in air quality<br>Increased primary production in marine environment due to input of iron | Problems with public health due to increased dust<br>Impact on fish supplies | Respiratory impacts<br>Impact on food resources |
| | | | Noise | Disturbance of terrestrial ecosystem | Disturbance of community | general public health |
| | | | Rainwater run-off | Disturbance Marine ecosystem<br>Water and sediment quality<br>Groundwater quality | Problems with public health | Impact on food resources, and general public health |
| | | | Disposal of contaminated soils | Groundwater contamination<br>Soil contamination | Problems with public health<br>Problems with public health | general public health |
| | | | Handling of toxic material | | Problems with public health | Safety |
| | | Presence of piles | Land occupation | Disruption of terrestrial habitats | Disturbance of community/agriculture land | |
| | Power generation | Cooling water system | Thermal discharge | Changes in ecology due to temperature increase | Effect on fisheries | Impact on food resources |
| | | | Intake of seawater | Changes in water quality | | |
| | | | Physical presence | Intake (fish) | | |
| | | Engines | Air emissions | Changes in air quality | Reduction in air quality | Respiratory impacts |
| | | | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the community | general public health |
| | | Waste generation | Disposal of fly ash | Disturbance of ecosystem | Problems with public health | general public health |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | Maintenance dredging | Dredging | Increased turbidity | Reduced visibility, available oxygen & sunlight penetration | Effect on fisheries | |
| | | | Contaminated sediments | Changes in water quality | Effect on fisheries | |
| | | | Disturbance of seabed | Changes in bottom biota | Effect on fisheries | |
| | | | Changes in bathymetry | Changes in hydrodynamics<br>Changes in salt wedge intrusion and consequent change in ground water quality<br>Changes in sediment transport (erosion and deposition pattern)<br>changes in downstream shoreline | Effect on navigation<br>Problems with public health<br>Effect on fisheries<br>Effect on tourism | Impact on food resources, and general public health |
| | | | Noise | Fauna disturbance | Disturbance of sensitive receptors in the community | Are there cattle/farming activities ?? |
| | | | Ship discharges & oil spills | Changes in water quality | Problems with public health | general public health |
| | | Disposal at sea | Smothering of benthos | loss of bottom biota | Effect on fisheries | Impact on food resources |
| | | | changes in current patterns | biological recolonization rates<br>Changes in hydrodynamics<br>Accelerated shoaling | Effect on navigation | |
| | | | Contaminated sediments | Changes in water quality | | general public health |
| | Marine activities | Vessels | Increased marine traffic | Disturbance of marine ecosystem<br>Creation of new channels | disturbance of marine users<br>changes in fishing and ship traffic patterns | |
| | | | Refuelling oil spill | Changes in water quality | Problems with public health | Impact on food resources, recreation, |
| | | | Wastewater to estuary | Changes in water quality<br>Disturbance of marine ecosystem | Problems with public health<br>Effect on fisheries | |
| | | | Ballast water | Changes in water quality<br>Invasion of new species | Problems with public health<br>Effect on fisheries | |
| | | | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the community | Impact on food resources, and general public health |
| | | | Exhaust emissions | Changes in air quality | | |
| | | Vessels cargo | Iron ore dust dispersion | Changes in air quality<br>Water and sediment quality<br>Disturbance of terrestrial ecosystem<br>Disturbance of marine ecosystem | Problems with public health<br>Effect on fisheries | Respiratory impacts |
| | | | Accidental discharge of iron ore | Water and sediment quality<br>Disturbance of terrestrial ecosystem<br>Disturbance of marine ecosystem | Effect on fisheries<br>Problems with public health | Impact on food resources |
| | | Navigation aids | Lights | Disturbance of marine ecosystem | Increase night navigation | |
| | | Trans-shipment | Accidental discharge of iron ore | Water and sediment quality<br>Disturbance of terrestrial ecosystem<br>Disturbance of marine ecosystem | Effect on fisheries<br>Problems with public health | Impact on food resources |
| | | | Iron ore dust dispersion | Changes in air quality | Problems with public health | Respiratory impacts |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | | Water and sediment quality<br>Disturbance of terrestrial ecosystem<br>Disturbance of marine ecosystem | Effect on fisheries | Impact on food resources |
| | | | Physical presence | | disturbance of marine users | |
| | General port operations | Vehicle emissions | Dust and particulate emissions | Changes in air quality<br>Disturbance of ecosystem | Problems with public health | Respiratory impacts |
| | | Staff presence | Consumption of resources | Increased impact on resources (water, wood, food) | | |
| | | | Occupation of land | | Impact on communities - Influx pressure | |
| | | Lighting | Visual impact | Disturbance of ecosystem | Disturbance of surrounding land users. | |
| | | Noise | Noise | Disturbance of ecosystem | Disturbance of sensitive receptors in the community | |
| | Workers Camp | Workers accommodation | Workers from other areas | | Problems with surrounding communities?<br>Disturbance of community structures? | general public health |
| | Water use | Abstraction of groundwater | Reduction in groundwater discharge to creeks and estuary | Changes in groundwater quality (saline intrusion)<br>Deterioration of habitats and biota in freshwater streams & creeks | Deterioration of water quality for potable and agricultural use in local communities | |
| | | | Lowering of groundwater levels | | Reduction of water availability from shallow wells in local communities - e.g. dry out earlier in dry season | |
| | | | Potential destabilization of the ground due to water extraction | Ground subsidence | | |
| | | Use of surface water | Reduced river flows | Deterioration of habitats and biota in freshwater streams & creeks | Reduction of water availability from rivers for local community potable and agricultural use | |
| | Sanitation and waste production | Waste water | discharges to estuary | Changes in water quality<br>Disturbance Marine ecosystem | Problems with public health<br>Effect on fisheries | |
| | | | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | Solid waste | Discharges to estuary | disturbance of marine ecosystem<br>Water quality | Problems with public health<br>Effect on fisheries | |
| | | | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | | Land disposal | Groundwater contamination<br>Land occupation / Habitat disruption<br>Soil contamination | Problems with public health<br>Pressure on settlements / agriculture land<br>Effect in agriculture | |
| | | | Fly tipping | Soil / Groundwater contamination | Problems with public health | |
| | | | Inappropriate storage | Soil / Groundwater contamination | Problems with public health / vermin control | general public health |
| **Mine** | Presence of the mine | Industrial mining activity | Disturbance of existing artisanal mining | | Loss of land | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | | | loss of livelihood | |
| | | Mine area | Disruption of migration routes | Disturbance of animal migration routes | Disturbance of nomads | |
| | | | Habitat disruption | Fragmentation of plant and animal habitats | | |
| | | Visual | Intrusive effect on landscape | | Adversely affect on tourism | |
| | | | Lighting | Disturbance of ecosystem | Disturbance of surrounding land users.<br>availability of jobs and expectations related to employment | general public health |
| | Excavations activity | Blasting & earth movement | Risk of accidents | | Potential injuries | safety |
| | | | Altered stability of land | Disturbance of ecosystem | Potential risk to mine & surrounding communities | safety |
| | | | Noise & vibrations | Disturbance of ecosystem | Disturbance of surrounding communities<br>Damage of structures near to sites | general public health and respiratory |
| | | | Dust creation | Disturbance of ecosystem | Disturbance of surrounding communities | |
| | | Changes in drainage patterns | Sedimentation of watercourses | Changes in water quality<br>Availability to downstream water to ecosystems | Changes in stability of land and land capability<br>Water availability to downstream users | general public health |
| | | | Loss of groundwater storage due to removal of material above bedrock | Reduction in river baseflows through dry season | Water availability to downstream users | |
| | | | Increase erosion | Changes in water quality<br>Disturbance of ecosystem | Loss of land | |
| | | Vehicle emissions | Dust and pollutant emissions | changes in air quality<br>impact on photosynthesis of plants due to dust deposition | disturbance of surrounding community | |
| | | Stack emissions | Dust emissions | Reduced visibility | Health problems from inhalable and respirable dust. | |
| | | Engine and generators emissions | Gaseous emissions– sulphur dioxide (SO2), nitrous oxides (NOx), carbon monoxide (CO) and carbon dioxide (CO2) | Changes in air quality<br>Transboundary impacts – acid precipitation (SO2 and NOx) & greenhouse (CO2 and Nox) | Public Health problems | Respiratory impacts |
| | Point sources | Runoff / seepage | Seepage from mine and mineral-processing residue disposal | Pollution of surface water resources and wetland areas downstream of the project<br>Pollution of groundwater resources downgradient of the project site.<br>Impact on biota | Deterioration of well and river water quality for potable and agricultural use in local | |
| | | | Discharges from the project site during storm events | Water contamination<br>Soil contamination | Public Health problems | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | | Disturbance of ecosystem | | |
| | | | Exposure to polluted water in dirty water holding facilities | Water contamination<br>Disturbance of ecosystem | Adverse effects on public health | general public health |
| | Dam | Operation of Dam | Risk of eutrophisation | Disturbance of ecosystem<br>water contamination | Public Health problems | |
| | | | Change in sediment transport | Changes in water quality downstream<br>Disturbance of estuary dynamics<br>Disturbance of marine ecosystem<br>Increased erosion downstream | | |
| | | | Changes in river flows | Availability to downstream water to ecosystems | Water availability to downstream users | general public health |
| | Workers Camp | Workers accommodation | Workers from other areas | | Problems with surrounding communities?<br>Disturbance of community structures? | |
| | | Generation of domestic waste | Odour | Changes in air quality | Disturbance of surrounding communities | |
| | | | Land disposal | Groundwater contamination<br>Soil contamination | Problems with public health<br>Effect in agriculture | |
| | | | Fly tipping | Soil / Groundwater contamination | Problems with public health | |
| | | | Inappropriate storage | Soil / Groundwater contamination | Problems with public health / vermin control | |
| | | Generation of sewage | Inappropriate disposal in soil | Soil / Groundwater contamination | Problems with public health | |
| | | | discharges to estuary | Changes in water quality | Problems with public health | general public health |
| | Groundwater resources | Abstraction of groundwater | Reduced availability of water | Disturbance of ecosystems (wetlands)<br>Changes in water quality | Reduction in water available for local agriculture and potable use<br>Disturbance in agriculture | |
| | | | Potential destabilization of the ground due to water extraction | Ground subsidence | | |
| | Industrial Waste | Waste rock and tailings dumps | Rock geochemistry is unsuitable for vegetation growth | Disturbance of terrestrial ecosystem<br>Potential impact on future land recovery | | |
| | | | Waste rock and/or tailings are potentially acid forming resulting in long term environmentally hazardous run off. | Disturbance of river ecosystems. | Public Health problems | general public health |
| **Rail / road** | Presence of the railway | Railway tracks | Disturbance of routes | Disturbance on animals migration routes<br>barrier effect on herpethofauna population | Disturbance in access to food/crop resources. | Food resources, general public health, positive - increased accessibility |
| | | Rail Formation | Damming effect of surface water run off during periods of high rainfall | Increase erosion<br>Changes in drainage patterns | Loss or damage to property<br>Loss/damage to crops<br>Human safety | general public health, safety |
| | | Visual | Intrusive effect on landscape | | Adversely affect on tourism | |

| Project Component | Project Activity | Action/ Aspect | Consequence/related issues | Potential impacts - Bio-physical | Potential impacts - Social | Potential impacts - Health |
|---|---|---|---|---|---|---|
| | | | Lighting | Disturbance of ecosystem | Disturbance of surrounding land users. | |
| | | Maintenance vegetation clearance | Loss of biodiversity and/or ecological function | Loss of habitats and species of conservation importance. | Loss of vegetation with ethnobotanical significance | general public health |
| | Railway | Vehicle emissions | Dust and pollutant emissions | Deterioration of air quality<br>Disturbance of ecosystem | Problems with public health | Respiratory impacts |
| | | Trains | Accidents | Injured/killed live stock and native wildlife | Injury / death to humans using track as<br>Diseases associated with killed animals | safety, general public health |
| | | Waste | Waste oils discharge | Soil / Groundwater contamination | Problems with public health | |
| | Railways crossings | Presence of crossing | Access for vehicles | Disturbance of ecosystem<br>Potential increase of hunting patterns | | |
| | | Trains run-offs | accidental discharge & spills | Water and sediment quality<br>Impact on aquatic fauna<br>changes in estuary downstream | Effect on fisheries | general public health |
| | | Iron ore dust | Iron ore dust dispersion | Changes in air quality<br>Water and sediment quality<br>Disturbance of terrestrial ecosystem<br>Disturbance of marine ecosystem | Problems with public health<br>Effect on fisheries | |
| | | landscape maintenance clearance | landscape clearance | disturbance of ecosystem | | Respiratory impacts, food |
| | | | Increased erosion patterns | increased sediment volumes downstream | | |

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## APPENDIX 3

## Preliminary Concepts for Solid Waste

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AFRICAN MINERALS LIMITED

African MINERALS

EcoNomics

## Tonkolili Iron Ore Project

# Preliminary Concepts for Solid Waste

305000-00006-2440-EN-REP-0001

13 April 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

# SYNOPSIS

This document is provided as a preliminary guide to the waste infrastructure proposals, for both operational and construction phases of the Tonkolili Mine project. This document should be treated as a guide only in order that adequate provision is made at the earliest stage for waste infrastructure.

### Disclaimer



**PROJECT 305000-00006 - PRELIMINARY CONCEPTS FOR SOLID WASTE**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | R Smyth | E Carey | N/A | 04-Mar-10 | N/A | |
| B | Re issued for Internal Review | R Smyth | E Carey | N/A | 13-Apr-10 | N/A | N/A |
| | | | | | | | |
| | | | | | | | |

# CONTENTS

## Appendices

# 1 ADMINISTRATION AND PLANNING

## 1.1 Introduction

This document has been produced for the development of the Tonkolili project on behalf of African Minerals Limited (AML). To ensure that were possible all waste is managed, stored and disposed of in an appropriate manner in accordance with all relevant in-country legislation and global best practice.

This is a live document and requires ongoing review and revision. Given the extent and complexity of the project, the project scope is subject to change and the concepts will require to be updated to reflect any changes as necessary.

The purpose of this report is to enable the issue of operational and construction waste production to be dealt within a structured and auditable manner from the commencement of the project during the design stage, through construction to its operation and monitoring and beyond. This ensures that the aim of waste minimisation is emphasised from the outset of the project, in addition to ensuring that the waste produced is dealt with in accordance with the principles outlined within the Waste Hierarchy (reduction, reuse, recovery and recycling). Given the absence of any existing in-country infrastructure the report will also look to recommend a waste management infrastructure development base case, for the project.

Construction waste will arise from either surplus materials imported to site, those generated on site or day to day operational activities. Imported materials are those which are brought to the project for inclusion into the permanent works. Generated materials are those which exist on the project such as topsoil, sub-soil, stabilized fill, trees and materials from demolition works etc. An overview of waste arising from workers construction and operational camps is also addressed in this report.

Operational wastes will vary per facility, although will predominate around the port and mine facilities and are described within this report.

This document should be read in conjunction with the “ECF Solid Waste Management Practice Guidelines” and the “Tonkolili Accommodation Waste Management Strategy”, although it should be understood that the recommendations of this document superceed the recommendations made in these documents.

## 1.2 Site Location

The following figure provides an indication of the mine site location relative to the coast and the borders with Guinea and Liberia. The mine site at Tonkolili is approximately 200 km ENE of the capital of Freetown.


**Figure 1-1 Sierra Leone Map**

## 1.3 Proposed Development Description

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of magnetite concentrate with a grade containing 68% - 70% Fe with a minimum particle size to be confirmed from a resource deposit identified containing approximately 5.1 Billion tonnes of recoverable ore.

The mine project area is located approximately 200 km north east of Freetown, the capital city of Sierra Leone.

The project will comprise the mine and process plant facilities supported by a rail network to transfer the concentrate product to the stockyards and handling facilities at the port area which is located at Tagrin Point adjacent to Lungi airport to the north of Freetown.

Three ore bodies have been identified for production; Simbili, Marampon and Numbara. It is envisaged that staged development will be undertaken dependent on the exploration activities which are currently underway, to maximize the return on the investment. It is likely that additional ore bodies will subsequently be developed as the understanding of the geological conditions and the mine reserves mature.

To commercialise the Tonkolili Resource, AML will execute an integrated Greenfield development through the construction of new facilities which include:

- A new mine and ore processing plant at Tonkolili, to produce 45 Mtpa of magnetite concentrate;
- Approximately 200km of new standard gauge, heavy haul railway from Tonkolili to Tagrin Point;
- A new deepwater port and associated infrastructure at Tagrin Point suitable for loading vessels up to Cape, sized for the export of 45mtpa of iron ore concentrate; and;
- All associated support infrastructure to deliver and operate the project safely and successfully.

The port will initially be capable of handling 45 Mtpa which will be expandable to 90 Mtpa plus.

The rail component encompasses the construction of approximately 200km of heavy haulage railway and associated infrastructure from the Tonkolili mine to Tagrin Port.

For the purposes of this report the development elements have been broken down into the following areas:

- Rail
- Haul Road
- Pepel Port
- Targin Port
- Workers Camps

SRK Consulting have been engaged to undertake the mine pit waste design, as such it is anticipated that they will develop a separate waste management plan for this element of the works. All process waste issues will be addressed by Ausenco Ltd and are excluded from this report. Issues associated with sewage waste are also excluded.

## 1.4 Project Information

| | | | | | | |
|---|---|---|---|---|---|---|
| **Client** | African Minerals Limited | | | | | |
| **Principal Contractor** | TBC | | | | | |
| **Person in charge of project** | TBC | | | | | |
| **Author of SWMP** | Ryan Smyth | | | | | |
| **Project title/reference** | Tonkolili Iron Ore Project | | | | | |
| **Project location** | Sierra Leone | | | | | |
| **Project cost (estimated)** | TBC | | | | | |
| **Start date** | **Day** | TBC | **Month** | TBC | **Year** | 2010 |
| **Completion date** | **Day** | TBC | **Month** | TBC | **Year** | TBC |
| **Description of project scope** | See section 1.3 | | | | | |
| **Waste Management Champion** | TBC from AML | | | | | |
| **Document controller** | TBC | | | | | |
| **Version number and date** | V1_Tonkolili_03/10 | | | | | |

## 1.5 Local Legislation

Irrespective of the lack of waste management infrastructure in-country, a high level legislative review has been undertaken. The following in-country legislation is considered applicable to the development:

- The Environment Protection Agency Act, 2008

With respect to waste management the act sets out very general guidance and policy statements as listed below, detailing the Agency's responsibilities with respect to permitting and control of facilities.

"Subject to the Act, the Agency shall perform the following functions:-

- Secure, in collaboration with such persons it may determine the control and prevention of discharge of waste into the environment and the protection and improvement of the quality of the environment;
- Issue environmental permits and pollution abatement notices for controlling volume, types, constituents and effects of waste discharges, emissions, deposits or other sources of pollutants and of substance which are hazardous or potentially dangerous to the quality of the environment or any segment of the environment;
- Prescribe standard and guidelines relating to ambient air, water and soil quality, the pollution of air, waste land and other forms of environmental pollution including discharge of wastes and the control of toxic substances;
- The Agency shall take all necessary and appropriate measures to monitor, control and regulate the manufacture, sale, transportation, handling or disposal of toxic and hazardous substances including toxic and hazardous wastes;

- The introduction or importation of toxic or hazardous wastes into Sierra Leone for storage of disposal by any means whatsoever if prohibited;

A license if required for the projects whose activities involve or include the following

(g) Waste management and disposal (e.g. sewerage systems and treatment plants, landfills, treatment plants for house hold and hazardous waste.)

No specific waste management regional strategies or directives were determined; this is not untypical of developing regions. Although research indicates that there are moves by development agencies such as the United Nations to further understand the waste management issues in-country, and ultimately fund improvement schemes. These schemes are in their infancy and there is no visibility of what assets are likely to be delivered if any.

Irrespective of the legislation it should be recognised that good waste management practice through both the construction and operation of facilities will provide heath, social and economic benefits to the project.

# 2 WASTE MANAGEMENT

## 2.1 Existing Waste Management Settling

There is very limited information with respect to the national waste picture. It is understood that there is currently no or limited waste management throughout Sierra Leone with most waste simply being discarded in unregulated dumping areas around cities or burnt in make shift pits. WorleyParsons is unaware of any regulated landfill facilities in-country.

It is envisaged that there will be immature markets for dry recyclates in the local community, focusing around metals and larger plastic containers. It is unclear if these will be re-use or recycling, irrespective it should be a priority to maximise recycling/re-use where possible and to benefit the local community. It is anticipated that there will be no market for other dry recyclates such as paper, card, plastics and certain types of wood, due to the level of development within Sierra Leone, although this should remain under constant review.

## 2.2 Waste Generation Forecasting

In the absence of a definitive description for some elements of works to be undertaken as part of the project at the time of this report, it is not possible to generate an accurate waste model for the entire scheme. A waste model has been developed for both construction and operational workers camps and is included in Appendix 3. For construction waste, tables included in Appendix 1 should be populated by the contractors who are better placed to advise of waste generation based on construction materials to be used, construction methods etc. Detailed in the preceding sections is a generic summary of the types of waste that are likely to be generated by the different elements of the work.

Whilst not a specific waste issue it is noted that the proposals are likely to generate issues with respect to dust, further details of dust management should be provided in the Dust Management Plan.

**Figure 2-1 Project Location Plan**

### 2.2.1 Workers Camps

There will be six camps developed for construction activities including:

- Rail Workers Camp (1) – 355 persons;
- Rail Workers Camp (2) – 355 persons;
- Rail Workers Camp (3) – 355 persons;
- Mine Workers Camp (1) – 8000 persons;
- Mine Workers Camp (2) – 2000 persons;
- Port Workers Camp – 2250 persons

In addition there will be two operational camps at both the Mine and the Port, housing 1644 and 367 people respectively. It is envisaged that these camps will reduce in population as the operations are progressively run by indigenous population, resident in the surrounding area.

Based on the projected camp's population at full capacity, a waste arisings model has been generated the output of which is shown in table 2-1. Full waste composition and a list of assumptions used developing the model are included within Appendix 3.

**Table 2-1 Camp Waste Arisings**

| | Residential Waste Generation (T/yr) | Commercial and Industrial Waste Arisings (T/yr) | Total Waste arisings (T/yr) |
|---|---|---|---|
| **Rail Const Camps Workers (1)** | 179 | 89 | **268** |
| **Rail Const Camps Workers (2)** | 179 | 89 | **268** |
| **Rail Const Camps Workers (3)** | 179 | 89 | **268** |
| **Mine Const Camp 1 Workers** | 4030 | 2015 | **6044** |
| **Mine Const Camp 2 Workers** | 1007 | 504 | **1511** |
| **Port Const Camp Workers** | 1133 | 567 | **1700** |
| **Mine Operations Camp** | 833 | 417 | **1250** |
| **Port Operations Camp** | 185 | 92 | **277** |

### 2.2.2 Rail

A 6km wide corridor from the proposed mine to Targin port has been approved by the Sierra Leone government for the construction of the proposed railway. The rail route is proposed to run from the Tonkolili mine site, south through the Tonkolili Valley before turning west at the end of the ranges of Targin Port.

AML wish to undertake early construction of the mine access road to Lunsar for the early shipment of ore through Pepel Port. This will be achieved by refurbishing elements of the existing railway from Lunsar to Pepel Port. To minimize costs the haul road is proposed to be constructed along the proposed rail access road.

Primary waste types arising from the construction of the new railway and refurbishment of the existing railway line include:

- off cuts from rail;
- broken sleepers;
- contaminated ballast;
- existing rail wagons (some containing full loads of ore)

In addition there are four bridge crossings required in excess of 25m spans and a further seven minor bridge crossings. The likely primary waste type arising from construction of these crossings is concrete depending on the construction method adopted.

There is anticipated to be limited wastes arising from operational activities of the railway. These are likely to be focused around refurbishment of equipment and waste oils; there may also be a small element of municipal waste arisings from passengers.

### 2.2.3 Haul Road

As detailed in section 2.2.2, the haul road is to be constructed between the Mine and Lunsar to facilitate early extraction of the ore. Whilst there is no definitive route available and it is understood that the route of the haul road is under constant refinement, cut and fill calculations have been undertaken.

Quantum analysis undertaken by WorleyParsons indicates that the proposed haul road development will generate 1,500,000m$^3$ of cut and 810,000m$^3$ of fill. This is based on a 12.5m wide haul road, with 2m shoulders on fills and 4m shoulders in cuts. Whilst there is still significant uncertainly around these numbers and the percentage of material that could potentially be re-used is unknown, there will based on the current proposal be significant spoil arising that will require management and disposal.

The construction detail of the haul road is unknown, but it is considered that there will also be an element of waste generated from contaminated, unsuitable and surplus materials.

There is anticipated to be no waste waste arisings from the operation of the haul road.

### 2.2.4 Pepel Port

*Construction*

At the Port, the project development will comprise a materials handling facility, and relevant support infrastructure such as power, water, access roads, accommodation facilities, workshops, warehouses, laboratories and administration buildings, train unloading facility, stockyard and wharf. This will comprise a combination of existing asset refurbishment and new development.

Mayer International Machines South Africa has been commissioned by AML and visited the inoperative Iron Ore plant at Pepel port producing a study detailing the works required to reinstate the plant included components that should be refurbished, replaced or where a totally new installation is appropriate. An extract from the study detailing the structures to be refurbished or replaced is shown in Appendix 2. It is anticipated that the primary component of these wastes will be metals that will have a residual scrap value either locally or could be readily exported in sufficient quantities. There is also likely to be significant quantities of hazardous waste in the form of oils and other industrial wastes which should be disposed of to a suitable facility, this is discussed further in section 2.5.2.

*Operation*

Waste will be generated by the ongoing process activities at the port. Primary waste generated from these activities will include:

- Waste oils;
- Metals from refurbishment of plant;
- Packaging, plastics and pallets;
- Lead acid batteries;
- Waste electrical and electronic equipment waste.

In addition there is estimated to be 367 operational staff at the Port (*AML Camp Site Locations & Accommodation Requirements Summary (7 Apr 10, 0800 hours).xls*), that will generate general office and municipal waste, for the purposes of this report it is assumed that they will be equally split between Targin and Pepel.

### 2.2.5 Targin Port

*Construction*

The works to be undertaken in the port marine at Targin Port are extensive including the development of a new Port facility with consideration for navigation and ship-handling, this will include Port structures for a ship-loader jetty at the primary port and structures for service berths at the secondary port, in addition to Navigation aids. Waste generation from these activities are likely to be concrete, rubble, metals etc, refer to Appendix 1 for full details.

The proposed works at Targin port will generate significant dredged material that will be addressed through a separate disposal strategy, at the time of this report it is understood that the dreging may be suitable for offshore disposal. No additional consideration has been made for waste dredging within this report.

*Operation*

It is anticipated that the same types of waste will be generated from the ongoing operations as that of Pepel Port, notably:

- Waste oils;
- Metals from refurbishment of plant;

- Packaging, plastics and pallets;
- Lead acid batteries;
- Waste electrical and electronic equipment waste.

### 2.2.6 Power

Dependent on the ability to attract external investment, a Power plant may be constructed to meet some of the projects power requirements; however there is almost no detail available on this aspect and as such it is excluded from this report. Depending on the type of plant to be adopted this may present a disposal route for some of the operational wastes, this should remain under constant review.

## 2.3 Proposals for minimization

Given the lack of available appropriate in-country disposal routes, a strong focus should be placed on waste minimization at source. Although waste types will vary significantly between the different elements of the project. Generally by volume the majority of the waste will arise mainly from construction through demolition and site clearance, excavation and any unavoidable construction waste. The proposed scheme will require specific construction materials (such as rail, railway sleeper, ballast, specialist components etc) to be imported to the site.

Actions to be taken to facilitate resource efficiency throughout the project and therefore minimise the waste produced are detailed below:

- Excavated soils and clay will be carefully stored in segregated piles for subsequent reuse on the site. The soils and clay will be reused as deposition material for infilling or landscaping. Any surplus soils and clay will be removed from site for direct beneficial use elsewhere;
- Concrete waste will be source segregated, for subsequent separation and re-use were appropriate e.g. as hardcore;
- Wood will be source segregated for subsequent recovery through the local community, contaminated woods such as shuttering and metal film pallets should be disposed of to an appropriate facility (see section 2.8);
- Hazardous wastes including any contaminated soil materials will be identified, removed and kept separate from other Construction and Demolition (C&D) waste materials in order to avoid further contamination and will be disposed of to an appropriate licensed facility;
- Metals will be collected in receptacles, for subsequent recovery through the local community;
- Plastic container (for example anything above 2 litres) will be collected in receptacles, for subsequent recovery through the local community.

## 2.4 Construction Resource Efficiency

This section outlines the actions to be taken for material resource efficiency during each construction phase of the project. Table 2.2 highlights the resource efficiency actions to be taken during the life of the project and gives a designated person the responsibility to ensure this is undertaken.

**Table 2-2 Resource Efficiency Actions**

| Planning waste minimisation during construction | Waste minimisation decisions taken | Resource saving | Responsibility | Date action commenced |
|---|---|---|---|---|
| Design | Enabling the purchase of materials in shape/dimension and form that minimises the creation of off-cuts/waste.<br><br>Specifying materials and producing the Bills of Quantities that allow wastage to be minimised.<br><br>Due to potential contamination, chemical testing would need to be undertaken to determine composition of the material and subsequent opportunities for re-use or remediation. | Minimal waste produced[1] | Project manager | From the design outset |
| Construction methods | Sequencing the works such that re-use of materials can be undertaken. | Minimal waste produced | Project manager | During design and planning stages and implemented during the construction. |
| Materials | Assess the quantities of materials required on site.<br>Just in time delivery (as needed basis) to prevent over supply. | Prevents lost time in re-ordering of damaged equipment, reduces need for storage if over ordering takes place. | Project manager/Principal contractor | During construction planning and throughout the project construction. |

[1] This table demonstrates the components and decisions involved in ensuring a reduction in the amount of waste and surplus materials being produced during any works on site. This has the effect of minimising the amount of material which would traditionally be sent to landfill and to ensure a cradle to cradle approach.

| Planning waste minimisation during construction | Waste minimisation decisions taken | Resource saving | Responsibility | Date action commenced |
|---|---|---|---|---|
| | Secure storage to minimise the generation of damaged materials/theft.<br><br>Keeping deliveries packaged until they are ready to be used. Inspection of deliveries on arrival.<br><br>Increase the use of recycled content; this could include traditional use of recovered material such as crushed concrete demolition waste and by procuring mainstream manufactured products with higher recycled content than their peers. Quick win areas of the project in which to implement this for could be concrete frames, flooring and brick/block work. | An increase in the demand for such products would reduce the quantity of waste going to landfill.<br><br>Recycled material use results in a reduction in demand for extraction of virgin materials and subsequently the carbon and environmental footprint. | Project manager | During design and throughout the procurement/construction stages of the project. |

## 2.5 Waste Storage and Collection

Appropriate consideration should be made for waste storage through the scheme, particularly the workers camps and it is suggested that should the recommendations of this report be adopted that all waste infrastructure, consolidation centers, incinerators and recycling areas be co-located. Thought should be made early in the design for the location of the waste consolidation centers, making consideration of living quarters, easy access for removal of recyclates and proximity to surrounding villages. It is likely that recyclates will be removed from camps and work areas on a site by site basis. All waste storage areas should be adequately sized taking account of the estimated waste generation presented in this report. Waste storage and collection provision should also take account of local climate and in particular pest and odour control.

### 2.5.1 Waste Segregation

It is essential that the construction and operational activities are carried out closely with the waste management contractors, in order to determine the best "on the ground" techniques for managing waste and ensure a high level of recovery of materials for recycling. WorleyParsons is not aware of any global waste management companies operating in the region as a result due diligence is recommended on any proposed contractor in order to ensure that wastes are dealt with in a manner that is compliant with in-country legislation and the best practice outlined in this document.

Alternatively the project may employ operatives directly to collect and transport waste to an appropriate facility.

On a site by site basis set down areas should be developed and labeled to facilitate the separation of materials, where possible, for potential recycling, salvage, reuse and return. Recycling and waste bins are to be kept clean and clearly marked in order to avoid contamination of materials. Skips for segregation of waste identified currently are:

- Mixed Inert (e.g. concrete and rubble), for re-use in construction;
- Hazardous (e.g. asbestos, Poly Chlorinated Bi-phenols), for disposal to an appropriate facility;
- Mixed non-hazardous (biodegradable waste), for disposal to an appropriate facility;
- Metal (e.g. copper and iron), for return to the local community, or re-use;
- Wood (e.g. fencing/hoarding), for re-use in construction or return to the local community

It is recommended that waste is removed regularly, perhaps daily, depending on the phasing of the project. As such there should be a robust process in place for removing waste from site prior to the commencement of the project.

### 2.5.2 Hazardous Waste

It is likely that different elements of the project will generate small quantities of hazardous wastes such as healthcare, waste oils and some electronic equipment. Solid hazardous waste should be stored in sealable clip-top drums (25-205 liter capacity) and hazardous liquid wastes stored in sealable bung-top drums (25-205 liter capacity). Hazardous wastes must remain in their original, labeled containers. Bulking of hazardous wastes should not occur in storage areas.

The small quantities of Hazardous waste that are generated should be disposed to an incineration unit were possible (see section 2.8), were this is not the case they may require temporary storage prior to shipping to an appropriate facility. It is understood that there are small local crushing mills that can be used for disposal of medical waste, specifically syringes.

## 2.6 Re-use of Materials

Uncontaminated material will be reused where possible within the proposed construction works for site leveling and fill.

Any contaminated materials, which will not be re-used on-site, will be treated in accordance with all relevant legislation and best practice guidelines at the point of origin or at an alternative suitable site prior to disposal.

Surplus inert excavated materials with some engineering strength (e.g. stone, bricks, clay, rubble, rock) can be suitable for crushing and re-use as hardcore through the project.

## 2.7 Waste Disposal Categorization

Global best practice, classifies waste streams as Inert, Non-Hazardous, and Hazardous. Responsibility for the basic classification of waste rests with the producer and waste operator.

## 2.8 Disposal and Treatment Options

The inherent difficult with dealing with waste within Sierra Leone is the lack of an appropriate disposal routes, coupled with a lack of recyclate markets, requires a waste infrastructure solution be developed specifically for this project.

WorleyParsons have developed a base case for the DFS, which should be reviewed and refined as more information becomes available.

### 2.8.1 Base Case

From this study it is recognised that there will be significant wastes generated during primarily the construction of the project but also during operation. In developing the base case it is important to consider the “Tonkoliil Accommodation Solid Waste Management Strategy”, summary recommendations of which are shown in Table 2.3, also identified within the table is the anticipated spare capacity of the recommended infrastructure proposals to address waste arisings from the accommodation camps, which could be utlised to address some of the waste resulting from operational and construction activities.

**Table 2-3 Accommodation Camps Waste Infrastructure Proposal**

| | **Residual t/year** | **Treatment / Disposal** | **Procurement / Facility Development** | **Spare Capacity** |
|---|---|---|---|---|
| **Rail Const Camps Workers (1)** | 178 | Uncontaminated organics to jungle or suitable site landfill residual | Initially 500m3 lined landfill cell (No 1) per year | 322m3 / yr |
| **Rail Const Camps Workers (2)** | 178 | Uncontaminated organics to jungle or suitable site landfill residual | Initially 500m3 lined landfill cell (No 2) per year | 322m3 / yr |
| **Rail Const Camps Workers (3)** | 178 | Uncontaminated organics to jungle or suitable site landfill residual | Initially 500m3 lined landfill cell (No 3) per year | 322m3 / yr |
| **Mine Const Camp 1 Workers** | 4012 | Uncontaminated organics to jungle or suitable site, incinerate residual | Incinerator A, for the purposes of DFS FS1000 should be costed, 1000m3 Lined landfill cell (No 4) | 241t/yr Incinerator, approx 250m3 landfill |
| **Mine Const Camp 2 Workers** | 1003 | Uncontaminated organics to jungle or suitable site, incinerate residual | Incinerator A, for the purposes of DFS FS1000 should be costed, 1000m3 Lined landfill cell (No 4) | 241t/yr Incinerator, approx 250m3 landfill |
| **Port Const Camp Workers** | 1128 | Uncontaminated organics to jungle or suitable site, incinerate residual r | Incinerator B, for the purposes of 2 No DFS FS200 should be costed, 1000m3 lined landfill cell | 138t/yr Incinerator, approx 850m3 Landfill |
| **Mine Operations Camp** | 829 | Uncontaminated organics to jungle or suitable site, incinerate residual | Incinerator A, for the purposes of DFS FS1000 should be costed, 500m3 Lined landfill cell (4) | 4427t/yr Incinerator, approx 400m3 landfill |
| **Port Operations Camp** | 184 | Uncontaminated organics to jungle or suitable site, incinerate residual | Incinerator B, for the purposes of 2 No DFS FS200 should be costed, 1000m3 lined landfill cell | 999t/yr Incinerator, approx 950m3 Landfill |

Notes:

*Assumed Metals are recovered from waste stream. Plastic containers will also be removed for recovery back into the locally community, although no allowance is made within the table.*

*No consideration has been made for diversion factors (due to contaminated recyclates) given the fluidity of the population within the accommodation camps.*

*Plant down time assumed to be 10%, median processing rate over median maximum daily operating time, has been used in calculation*

*Spare capacity based on a worst case i.e. when all camps are fully populated.*

*Residual ash from incineration assumed to be 15%.*

*Assumed there is no overlap between Construction and Operational camps*

*Assumed no in-country landfill lining available, or skills to weld liners. Concrete or butyl liners will be used in landfill cell construction. Similar approved lining system can be adopted at discretion of waste engineer and regulatory body.*

*"Uncontaminated organics" excludes food waste, which will be targeted at the incinerator. This may require mixed with drier wastes such as wood chip.*

Discussed in the preceding sections are the primary waste arisings from both construction and operational activities, they are by no means exhaustive but intended to give sufficient information for pricing to be generated for the DFS.

*Rail*

It is not anticipated that the operation of the rail facility will generate significant waste arisings. Municipal waste arisings are likely to be in order of 100's of tones per year and will be accommodated by the temporary landfill cells proposed as part of the rail workers construction camps. Construction waste arisings and proposed disposal targets are shown in table 2.4.

**Table 2-4 Rail Construction Waste Arisings**

| Primary Waste arisings | Volume | Treatment / Disposal |
|---|---|---|
| Rail off cuts | Unknown, estimated 0.1% of all rail laid | Residual scrap value through community |
| Broken Sleepers | Unknown | Concrete sleepers to be crushed and re-used as hardcore in other areas of the project. Wooden sleepers to be returned to the community, or chipped and transported to camp incinerator |
| Contaminated Ballast | Unknown, likely to be negligible volume | Utilise landfill cells developed for rail workers construction camps |
| Existing rail wagons | Unknown, estimated 25 No. | Residual scrap value through local community, or may require shipped depending on number |
| Ore within, rail wagons | Unknown | Processed through new ore facilities |
| Broken Pallets | Unknown, potentially in the order of 100's of tonnes | Chipped and transported to closest camp incinerator |
| Waste Oils | Unknown, likely negligible volume | Waste oil burner (1 unit per workers camp) |

| | | |
|---|---|---|
| Miscellaneous | Unknown | Utilise temporary landfill's for rail workers construction camps |

There is currently 1005t/yr of spare capacity within the temporary landfill cells proposed as part of the Rail construction workers camps which coupled with the proposed incineration unit at the mine are anticipated to accommodate the majority of waste arisings. Landfill cell volumes should remain under constant review, with further cells to be developed should the need arise.

*Haul Road*

It is anticipated that the haul road will generate negligible operational waste. The primary waste arising from the construction will be spoil potentially in the region of 800,000m$^3$ based on preliminary cut and fill calculations. This waste is considered to be inert and does not require an engineered facility for disposal; however areas should be outline at outset for stockpiling and bunding. Where possible the road should be designed to achieve a cut and fill balance. As minimum land areas should be set aside for spoil disposal, there may be an opportunity to re-use spoil in some any port reclamation works.

*Pepel Port*

Construction waste arisings and proposed disposal targets are shown in table 2.5 below:

**Table 2-5 Primary Waste Arisings, volumes and disposal routes from Pepel Construction**

| Primary Waste arisings | Volume | Treatment / Disposal |
|---|---|---|
| Concrete | Unknown | To be crushed and re-used as hardcore on other areas of the project. Proximity principle to be applied |
| Waste Oils | Unknown | Waste Oil burners for workshops, larger volumes, decommissions etc to be sent to incinerator |
| Broken Palletting / Formwork | Unknown, volume may be significant | Chipped and transported to closest camp incinerator |
| Metals | Unknown | Residual scrap value through local community, or may require shipped depending on number |
| Packaging | Unknown, volume may be significant | Were possible utilise incineration, other unsuitable to landfill |
| Miscellaneous | Unknown | Were possible utilise incineration, other unsuitable material to landfill |

**Table 2-6 Primary Waste Arisings, volumes and disposal routes from Pepel Operation**

| Primary Waste arisings | Volume | Treatment / Disposal |
|---|---|---|
| Municipal Solid Waste | Approximately 55 tonnes /year | Camp Incinerator, residual ash to landfill |
| Waste Oils | Unknown | Waste Oil burners for workshops, larger volumes, decommission etc to be sent to camp incinerator |
| Metal from plant refurbishment | Unknown | Residual scrap value through local community, or may require shipped depending on volume |
| Packaging | Unknown, volume may be significant | Camp Incinerator, residual ash to landfill |
| Lead acid batteries | Unknown, anticipated small volumes | Send to camp landfill or shipped |
| Waste Electronic | Unknown, anticipated small volumes | Send to camp landfill or shipped |

*Targin Port*

It is understood that there will be significant dredging undertaken during the development of Targin port, this will be disposed of to sea. In the absence of detailed information it is assumed that the waste generation rates and composition during the construction and operation will not be dissimilar to that produced at Pepel, and the same treatment and disposal routes should be adopted.

# 3 REFERENCED DOCUMENTS

| Document Number | Document Title |
|---|---|
| 830-REP-002 Rev C | Mayer "Pepel Project Refurbishment Study Report" |
| SLE/RFO/2010/003 | Unite Nations Development Programme, Notices and Documents |
| 305000-00006-00-PM-RPT-0001, REV C | Tonkolili Iron Ore – Concept Definition Report |

# 4 RECOMMENDATIONS

## 4.1 Procurement/Development

On review, the infrastructure recommendations for the construction and operational camps will go some way to addressing the waste arisings of both the construction and operation of the proposed facilities.

The volumes of waste generated by the operation and construction of the ports and mine in particular remain a relative unknown, but will progress with the development of the project. By increasing the landfill capacity at each of the camps and re-sizing the incineration unit at the Port Operation camp to a unit capacity of 1-1.25t/hr over a 10-16hr shift, we believe that this we meet the initial waste management demands of the facilities. It should also be considered that as the construction population and activities decrease the operational activities will increase presenting fluctuating waste generation volumes and type, several years into the project .The facilitates that have been recommended have been developed with this is mind.

In addition given Allterrain Services will be managing the camps, its is recommended that an integrated approach is adopted to avoid replication of infrastructure and other equipment. A summary of the procurement / delivery items to support waste management is shown in table 4.1 below:

**Table 4.1 Waste Infrastructure Procurement Development Items**

| | **Procurement / Development Items** | | |
|---|---|---|---|
| **Location** | **Collection** | **Storage** | **Disposal** |
| Rail Construction Workers Camp 1 | Waste collection operator | 4 No, 6 cubic yard skips | 500m$^3$ landfill cell |
| | | Temporary transfer station | |
| Rail Construction Workers Camp 2 | Waste collection operator | 4 No, 6 cubic yard skips | 500m$^3$ landfill cell |
| | | Temporary transfer station | |
| Rail Construction Workers Camp 3 | Waste collection operator | 4 No, 6 cubic yard skips | 500m$^3$ landfill cell |
| | | Temporary transfer station | |
| Mine Construction Camp 1 | Waste collection operator | 8 No, 12 cubic yard skips | None |
| | | Temporary transfer station | |

| | | | |
|---|---|---|---|
| | | Compactor / Baler | |
| Mine Construction Camp 2 | Waste collection operator | 4 No, 12 cubic yard skips | None |
| | | Temporary transfer station | |
| | | Compactor / Baler | |
| Port Construction Camp | Waste collection operator | 5 No, 12 cubic yard skips | None |
| | | Temporary transfer station | |
| Mine / Mine Operations Camp | Waste collection operator | 5 No, 12 cubic yard skips | Incinco DFS 1000 Incinerator |
| | | Transfer station | 1 No waste oil burner per workshop |
| | | Wood Chipper | 1 No 2000m$^3$ landfill cell |
| | | Compactor / Baler | |
| Port / Port Operations Camp | Waste collection operator | 4 No, 6 cubic yard skips | Incinco DFS 1000 Incinerator |
| | | Transfer station | 1 No waste oil burner per workshop |
| | | Wood Chipper | 1 No 2000m$^3$ landfill cell |
| | | Compactor / Baler | |
| Targin and Pepel Ports | | 10 No, 12 cubic yard skips | |
| Miscellaneous | | Concrete crusher, with Rebar magnet | |

*Notes: Skip sizes are provided for the purposes of pricing only and should be advised by the waste operator.*

*Procurement items exclude all supporting civils, e.g. concrete plinths, foundations etc.*

*Information provided in Table 4.1 is for information only and in no way a recommendation or validation by WorleyParsons on the technology vendor to be selected.*

*Any incineration unit proposed must comply with EU Waste Incineration Directive, or similar approved regulator standard.*

*Given the issues associated with in-country infrastructure particualry to accommodate hazardous waste, any incineration units should be specified to include addressing as much of the hazardous waste stream as possible.*

## 4.2 Further Work

It should be noted that in the absence of detailed material take offs, significant assumptions have been made in the waste infrastructure recommendation in the report. It is recommended that on completion of Appendix 1, by the contractors that this report and recommendations are reviewed and the infrastructure recommendations amended accordingly. A comprehensive waste strategy should also be developed with respect to the operation of the facilities particularly the ports.

Given the uncertainly surrounding the permitting process for any waste infrastructure in-country, all proposals should be afforded adequate time in the programme and dialogue commenced with the local regulatory bodies at the earliest opportunity. The delivery process associated with waste infrastructure, as shown indicative figure 4.2 should not be under estimated.


**Figure 4-1 Waste Infrastructure Delivery Methodology**

Programme for the delivery of these facilities will be key. There will be a feasibility entry point for the incineration technologies, which should be understood based on the construction programme. Lead and procurement times should also be clearly understood in the delivery of these facilities. Once the construction programme is known consideration may also be given to leasing, for example incineration units during construction, to benefit from a lower cost based during operation.

There may be an opportunity for the local community to benefit from the installation of waste infrastructure, given the currently lack of in-country provision.

# Appendix 1 Construction Waste Tables

## Example table to be completed by contractors

| Type | Materials | Forecast estimated quantities ($m^3$) | On-site reuse/recycling (%) | Recovery (%) | Disposal (%) |
|---|---|---|---|---|---|
| Inert | Concrete | TBC | TBC | TBC | TBC |
| | Timber | TBC | TBC | TBC | TBC |
| | Rubble | TBC | TBC | TBC | TBC |
| | Topsoil/Subsoils | TBC | TBC | TBC | TBC |
| | Sand and gravel | TBC | TBC | TBC | TBC |
| | Boulder clay | TBC | TBC | TBC | TBC |
| Non-hazardous | Soils (suitable for reuse onsite) | TBC | TBC | TBC | TBC |
| | Bricks and blocks | TBC | TBC | TBC | TBC |
| | Mixed waste | TBC | TBC | TBC | TBC |
| | Metal | TBC | TBC | TBC | TBC |
| | Timber | TBC | TBC | TBC | TBC |
| | Plasterboard | TBC | TBC | TBC | TBC |
| | Packaging | TBC | TBC | TBC | TBC |
| | Cable & wiring | TBC | TBC | TBC | TBC |
| | Glass | TBC | TBC | TBC | TBC |
| | Green waste/vegetation | TBC | TBC | TBC | TBC |
| | Other | TBC | TBC | TBC | TBC |
| Hazardous | Asbestos | TBC | NA | NA | TBC |
| | Contaminated soils- unsuitable for reuse | TBC | NA | NA | TBC |
| | Other | TBC | TBC | TBC | TBC |

# Appendix 2 PEPEL PORT, REFURBISHMENT STUDY

| Sl No | Structure | Refurbish | Replace | New Installation |
|---|---|---|---|---|
| 1 | Dump Station | √ | | |
| 2 | Dump station hopper | √ | | |
| 3 | Dump station feeder | | √ | |
| 4 | CV001 | | √ | |
| 5 | TT001 | √ | | |
| 6 | CV002 | | √ | |
| 7 | TT002 | | √ | |
| 8 | CV003 | | | √ |
| 9 | TT003 | | | √ |
| 10 | CV004 | | | √ |
| 11 | TT004 | Not required | | |
| 12 | CV005 | | | √ |
| 13 | TT005 | | √ | |
| 14 | CV006 | | | √ |
| 15 | TT006 | √ | | |
| 16 | Sampling Station (1 No.) | | | √ |
| 17 | CV007 | √ | | |
| 18 | TT007 | √ | | |
| 19 | CV008 | √ | | |
| 20 | TT008 | Not required | | |
| 21 | CV008 | √ | | |
| 22 | CV009 | √ | | |
| 23 | Ship Loader | √ | | |

| Sl No | Structure | Refurbish | Replace | New Installation |
|---|---|---|---|---|
| 24 | Butterfly Stacker (1 No.) | | | √ |
| 25 | Mobile Hopper (4 No.) | | | √ |

# Appendix 3 ACCOMODATION WASTE MODEL

# APPENDIX 4

## Solid Wastes Management Practice Guidelines

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# Tonkolili Early Cash Flow Project

## Solid Wastes Management Practice Guidelines

305000-00006-0000-EN-REP-0019

01 March 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ
London
UK
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com
ABN 61 001 279 812

WorleyParsons
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**TONKOLILI EARLY CASH FLOW PROJECT**
**SOLID WASTES MANAGEMENT PRACTICE GUIDELINES**

Do not delete this line

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**PROJECT - TONKOLILI EARLY CASH FLOW PROJECT**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CUSTOMER APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for internal review | R Smyth | A Reviewer | N/A | 20-Sep-09 | N/A | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# CONTENTS



## Appendices

# 1. INTRODUCTION

## 1.1 Project Description

African Minerals Limited (AML) is developing a new iron ore mine identified as the Tonkolili Iron Ore mine in Sierra Leone on the west coast of Africa. The Project is planned to produce 45 Mtpa of magnetite concentrate with a grade containing 68% - 70% Fe with a minimum particle size to be confirmed from a resource deposit identified containing approximately 5.1 Billion tonnes of recoverable ore.

The mine project area is located approximately 200 km north east of Freetown, the capital city of Sierra Leone.

The Early Cash Flow Element (ECF) of the project will comprise the select development of the mine, approximately 100km of haul road to Lunsar, were ore will be transported by the Delco rail line which will ultimately be refurbished to Pepel Port were it will be shipped. It is anticipated that the immediate works will comprise the haul road construction through the surrounding jungle and the existing processing facilities at Pepel port would be refurbished to accept the ore.

This report provides high level waste management principles that should be adopted throughout the project but given the immediately of the construction of the haul road and refurbishment of infrastructure and processing plant at Pepel Port, is targeted at driving waste management best practice through these elements of the work. Given the uncertainly and availability of time for the development of these guidelines they should be treated as a guide only and are anticipated to be supplemented by more comprehensive guidance in due course.

## 1.2 Project Location

The following figure provides an indication of the mine site location relative to the coast and the borders with Guinea and Liberia. The mine site at Tonkolili is approximately 200 km ENE of the capital of Freetown.

## 2. PRACTICE GUIDELINES

The objectives of the practice guidelines are to:

1. Reduce waste arisings from all activities associated with the Tonkolili development resulting in economic and environmental benefit;
2. To provide a framework to ensure development for facilities, that would enable waste to be managed in accordance with the waste hierarchy;
3. To encourage the sustainable use of waste, in terms of benefit for both the local community and for the project;
4. To begin the process of developing an integrated mix of techniques with respect to managing waste in accordance with the proximity principle. Delivering the optimum balance of environmental and economic costs and benefits, whilst minimising the risk of immediate and future environmental pollution and harm to human health (Best Practicable Environmental Option, BPEO);
5. To ensure compliance with local regulatory waste legislation environmental legislation and international best practice, and
6. To protect the immediate health of the construction workers

In the absence of detailed waste generation rates, the guidelines are intend to provide a generic high level guide to deal with the types of waste likely to arising from the construction proposals.

### 2.1 Waste Arisings

Given the relatively unknown scope of the project waste forecasting is difficult at this stage. However we would anticipate the following waste types will be generated, with construction of the Haul Road and refurbishment of Pebel Port:

- Jungle Clearance, considered 100% organic, elements of hardwood may be present
- Spoil arising
- Construction waste
    - Packaging (Wood, Plastics, Metals, Cardboard)
    - Contaminated stone
    - Potential for contaminated land
    - Hydraulic Oils
    - Fuel

- Worker Municipal Solid Waste
- Demolition waste, concrete and steel
- Hazardous Wastes from plant decommission / refurbishment

Given the extent of the project and the potential for wastes arising it is recommended that a Waste Management Strategy be developed for the entire scheme, part of which a comprehensive waste modelling exercise will be required, detailing volume and waste types.

## 2.2 High level Guidelines

1. Waste management consideration should be made at the earliest opportunity in the project in order to be effectively implemented on site;
2. Decisions regarding waste management, should in broad terms , be based on that of the waste hierarchy shown below:

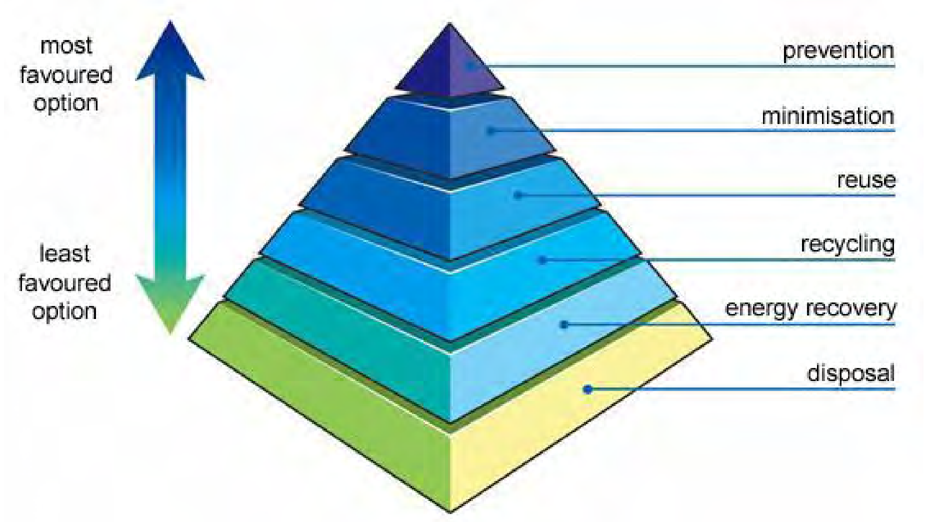


Image Courtesy of: Wasteonline

The aim of the guidelines is to focus waste management throughout all activities at the top of the hierarchy;

3. A detailed set of waste Key Performance Indicators (KPI) based on the waste hierarchy should be adopted.
4. Waste collection will be key to the successful delivery of the project. An integrated approach should be adopted throughout all waste collection activities eliminating the in-efficiencies caused by a piecemeal approach;

5. Early and continued engagement of local regulatory bodies should be adopted throughout the project;
6. Reduction in waste generation is key to the financial and environmental success of the project. As part of the overarching strategy education measures should be implemented in waste minimisation techniques;
7. A reuse strategy should be developed including:
    a. Identify opportunities for re-use and repair;
    b. Stimulate / create in-country markets for re-use and recycling;
    c. Help facilitate reuse partnerships between the construction activates and the local community;
8. There should be review of existing and consideration for provision of new waste facilities, targeted at the waste forecast;
9. Separation of wastes should be adopted at source through the project, given the type of waste and availability of cheap labour in the region this is likely to be undertaken by hand;
10. Engagement with the local community should be sought at the earliest opportunity and a partnering approach developed;
11. Incentives should be provided to contractors who meet or exceed waste KPI targets;
12. As part of the ongoing engagement, the client or clients representative will work proactively with the local regulatory body to reduce the amount of fly tipping generated by the project;
13. The client will take steps to enure that waste produced by its own organisation on site is minimised and recycling opportunities are maximised;
14. All intended disposal facilitates should be named at outset and verified as suitable for use, by a suitably experience practitioner;
15. Responsibilities for all waste management activities should be clearly set out at the outset of the project;
16. A spoil movement methodology should be developed by earthworks contractors or as part of the waste management strategy, this will include detailed calculation of spoil generated, targets and movement patterns;
17. There will be a Waste Management Strategy produced which will form the framework for the management of all wastes arising from the development of Tonkolilli Mines and associated infrastructure from construction, through to operation and final closure. This Strategy should be reviewed and updated at appropriate intervals to be

determined during the development of the strategy to include changes in waste management legislation, best practice and reviewing waste generation forecasts.

## 2.3 Specific Recommendations

### 2.3.1 Waste Minimisation

Waste will arise from the project mainly from demolition and site clearance, excavation and any unavoidable construction waste. The proposed scheme will require specific construction materials to be imported to the site. Actions to be taken to facilitate resource efficiency throughout the project and therefore minimise the waste produced are non-exhaustively detailed below:

- Excavated soils and clay should be carefully stored in segregated piles for subsequent reuse during construction. The soils and clay will be reused as deposition material for infilling or landscaping. Any surplus soils and clay will be removed from site for direct beneficial use elsewhere.

- Concrete waste will be source segregated, for subsequent separation and recovery;

- Masonry and wood will be source segregated for subsequent separation and recovery;

- Any packaging waste will be source segregated for recycling or returned to suppliers;

- Hazardous wastes including any contaminated soil materials will be identified, removed and kept separate from other Construction and Demolition (C&D) waste materials in order to avoid further contamination and will be disposed of in accordance with all relevant legislation and best practice guidelines at point of orgin or at an alternative suitable site prior to disposal

- Other C&D waste materials will be collected in receptacles with mixed C&D waste materials, for subsequent separation and disposal;

- Given the volume or organic waste likely to be produced, the market for compost should be investigated and potential for mobile composting units considered.

### 2.3.2 Resource Efficiency

Table 2.1 below highlights various resource efficiency actions to be taken during the life of the project and gives a designated person the responsibility to ensure this is undertaken as much as possible. Responsibilities are shown for the purposes of example only and should be confirmed in the Strategy.

Table 2.1

| Planning waste minimisation during construction | Waste minimisation decisions taken | Resource saving | Responsibility | Date action commenced |
|---|---|---|---|---|
| Design | Enabling the purchase of materials in shape/dimension and form that minimises the creation of off-cuts/waste.<br><br>Specifying materials and producing the resulting Bills of Quantities that allow wastage to be minimised. | Minimal waste produced[1] | Project manager | From the design outset |
| Construction methods | Sequencing the works such that re-use of materials can be undertaken. | Minimal waste produced | Project manager | During design and planning stages and implemented during the construction. |
| Materials | Assess the quantities of materials required on site.<br><br>Just in time delivery (as needed basis) to prevent over supply.<br><br>Secure storage to minimise the generation of damaged materials/theft. | Prevents lost time in re-ordering of damaged equipment, reduces need for storage if over ordering takes place. | Project manager/Principal contractor | During construction planning and throughout the project construction. |
| | Keeping deliveries packaged until they are ready to be used. Inspection of deliveries on arrival.<br><br>Increase the use of recycled content; this could include traditional use of recovered material such as crushed concrete demolition waste and by procuring mainstream manufactured products with higher recycled content than their peers. Quick win areas of the project in which to implement this for could be concrete frames, flooring and brick/block work. | In increase in the demand for such products would reduce the quantity of waste going to landfill or similar disposal.<br><br>Recycled material use results in a reduction in demand for extraction of virgin materials and subsequently the carbon and environmental footprint. | Project manager | During design and throughout the procurement/construction stages of the project. |

[1] This table demonstrates the components and decisions involved in ensuring a reduction in the amount of waste and surplus materials being produced during any works on site. This has the effect of minimising the amount of material which would traditionally be sent to landfill and to ensure a cradle to cradle approach.

### 2.3.3 Waste Segregation

It is essential that the construction and demolition/refurbishment work is carried out closely with the waste management contractors, in order to determine the best techniques for managing waste and ensure a high level of recovery of materials for recycling. This is also true of community engagement as it recognised that there is high level of re-use and recycling often referred to as scavenging in this region.

Specific areas shall be laid out and labelled to facilitate the separation of materials, where possible, for potential recycling, salvage, reuse and return. Recycling and waste bins are to be kept clean and clearly marked in order to avoid contamination of materials. Skips / set down areas for segregation of waste identified currently are:

- Mixed Inert (e.g. concrete and rubble)
- Hazardous (e.g. asbestos, Poly Chlorinated Bi-phenols)
- Mixed non-hazardous (biodegradable waste)
- Metal (e.g. copper and iron)
- Wood (e.g. fencing/pallets)
- WEEE (Waste electrical/electronic equipment e.g. cables, very limited volumes anticipated)

It is recommended that waste is removed regularly, depending on the phasing of the project. As such the contractor should ensure that they have a robust process in place for recording any waste that is removed from site.

### 2.3.4 Waste Re-use

Uncontaminated material will be reused where possible within the proposed works for site levelling and fill. It is unlikely that there will be a requirement for importation of additional bulk fill materials for the project although this should be confirmed on receipt of further design information.

Any contaminated materials, which will not be re-used on-site, will be treated in accordance with all relevant legislation and best practice guidelines at the point of origin or at an alternative suitable site prior to disposal.

# 3. REFERENCE

The Sierra Leone Environmental Protection Agency was created by an act of Parliament in 2008. All waste management practice must comply with local legislative and regulatory standards and this is reflected in the practice guidelines.

It is currently unclear to what extent they have been able to develop waste management guidance and regulatory framework. In the absence of local guidance, US EPA guidance should be referenced including:

US EPA Part 260 - 282 – Hazardous Waste Management System: General

US EPS Part 239 - 258 – Municipal and Industrial Solid Waste Management: General resources & energy

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## APPENDIX 5

## List of Legislation Applicable to Environmental and Social Impacts from Phase 1 of the Tonkolili Project

**Table 1: Sierra Leone legislation pertinent to the environment and sustainable development**

| Issue addressed | Legislation | Policy |
|---|---|---|
| Environment and sustainable development | The Environment Protection Agency Act, 2008 (No. 11 of 2008) | National Environmental Policy (1994) |
| Mineral resources and mining | National Reconstruction and Development Act, 1999 (No. 5 of 1999)<br>Mines and Minerals Act, 2009 | Core Mineral Policy of the Government of Sierra Leone (2008) |
| Water | The Water (Control and Supply) Act, 1963<br>Sierra Leone Water Company Act, 2001 (No. 6 of 2001) | National Water and Sanitation Policy (August 2008) |
| Biodiversity and biological resources | Wildlife Conservation Act, 1972 (No. 27 of 1972) | National Biodiversity Strategy and Action Plan (developed in accordance with the requirements of the convention on biodiversity) |
| Forestry | Forestry Regulations, 1989 (P.N. No. 17 of 1990)<br>Forestry Act, 1988 | |
| Marine environment | Sierra Leone Maritime Administration (Amendment) Act, 2007 (No. 14 of 2007) | |
| | Merchant Shipping Act, 2003 (No. 3 of 2003) | |
| | Sierra Leone Maritime Administration Act, 2000 (No. 11 of 2000 | |
| | Maritime Zones (Establishment) Decree, 1994 (N.P.R.C. Decree No. 11 of 1996) | |
| | Registration of Shipping Act, 1965 (Act No. 26) | |
| Fishing and marine resources | Sierra Leone Fisheries (Management and Development) (Amendment) Act, 2007 (No. 10 of 2007) | |
| | Fisheries Regulations, 1995 | |
| | Fisheries (Management and Development) Decree, 1994 | |
| | Fisheries (Amendment) Regulations, 1994 (P. N. No. 4 of 1994) | |
| | Fisheries Management and Development (Amendment) Act, 1992 (No. 7 of 1992) | |
| | Fisheries Regulations, 1990 (Public Notice No. 15 of 1990) | |
| | Fisheries Management and Development (Amendment) Act, 1990 (Act No. 9 of 1990) | |

| | | |
|---|---|---|
| | Fisheries Management and Development Act, 1988 (Act No. 4) | |
| | Fisheries (Operation of Foreign Motor Fishing Vessels) Regulations, 1985 (P.N. No. 1 of 1986) | |
| Land | Devolution of Estates Act, 2007 (No. 21 of 2007) | National Lands Policy (2005) |
| | Land Commission Act (not promulgated yet) | |
| | Commercial Lands Act (not promulgated yet) | |
| Radiation | Protection from Radiation Act, 2001 (No. 14 of 2001) | |
| Occupational environment | The Factories Act, 1974 (1974) deals with the safety, security and welfare of factory employees | |
| Local government | Local Government Act, 2004 (2004): An Act which enables the establishment of nineteen local councils and provides for decentralisation and devolution of functions, powers and services to local councils. | |
| Resettlement | Mines and Minerals Act 2009 | MTAP Resettlement Policy Framework |
| Consultation | Public Lands Act (Cap 166). The Unoccupied Lands Act (Cap 117) and the Provincial lands Act (Cap 122). | |

**Table 2: United Nations treaties on human rights and endorsement of these by Sierra Leone (SRK Consulting, 2009)**

| **United Nations Treaties** (List from from the United Nations Treaty Series (http://untreaty.un.org/ ) | **Date** | **In force** | **Endorsement by Sierra Leone** Ratification, Accession (a), Signature (s) |
|---|---|---|---|
| 1. Convention on the Prevention and Punishment of the Crime of Genocide | 1948 | 1951 | |
| 2. International Convention on the Elimination of All Forms of Racial Discrimination | 1966 | 1969 | 1967 |
| 2.a. Amendment to article 8 of the International Convention on the Elimination of All Forms of Racial Discrimination | 1992 | Not yet | |
| 3. International Covenant on Economic, Social and Cultural Rights | 1966 | 1976 | 1996(a) |
| 4. International Covenant on Civil and Political Rights | 1966 | 1976 | 1996(a) |
| 5. Optional Protocol to the International Covenant on Civil and Political Right | 1966 | 1976 | 1996(a) |
| 6. Convention on the non-applicability of statutory limitations to war crimes and crimes against humanity 1968 1970 | 1968 | 1970 | |
| 7. International Convention on the Suppression and Punishment of the Crime of Apartheid | 1973 | 1976 | |
| 11.b. Optional Protocol to the Convention on the Rights of the Child on the involvement of children in armed conflict | 2000 | 2002 | 2002 |
| 11.c. Optional Protocol to the Convention on the Rights of the Child on the sale of children, child prostitution and child pornography | 2000 | 2002 | 2001 |
| 12. Second Optional Protocol to the International Covenant on Civil and Political Rights, aiming at the abolition of the death penalty | | | |
| 13. International Convention on the Protection of the Rights of All Migrant Workers and Members of their Families | 1990 | | |
| 14. Agreement establishing the Fund for the Development of the Indigenous Peoples of Latin America and the Caribbean | 1992 | 1993 | |
| 15. Convention on the Rights of Persons with Disabilities | 2006 | Not yet | 2007 (s) |
| 15.a. Optional Protocol to the Convention on the Rights of Persons with Disabilities | 2006 | Not yet | 2007 (s) |
| 16. International Convention for the Protection of All Persons from Enforced Disappearance | 2006 | Not yet | 2007 (s) |

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## APPENDIX 6

## Literature Review of Available Information and Data - Stage 1 -Prepared by the Met Office

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## Tonkolili Iron Ore Project

# Literature Review of Available Information and Data - Stage 1 - Prepared by the Met Office

305000-00006 – 305000-00006-0000-EN-REP-0004

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

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**LITERATURE REVIEW OF AVAILABLE INFORMATION AND DATA - STAGE 1 - PREPARED BY THE MET OFFICE**

**TONKOLILI IRON ORE PROJECT**

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**PROJECT 305000-00006 - LITERATURE REVIEW OF AVAILABLE INFORMATION AND DATA - STAGE 1 - PREPARED BY THE MET OFFICE**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
| | | | | | | | |
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Met Office

# Climate studies for Tonkolili, Sierra Leone: Stage 1 – Literature review of available information and data

For: Worley Parsons
Date: March 2010
Authors: Matthew Perry and James Dent

Prepared by: Matthew Perry (Scientific Consultant)
and James Dent (Senior Hydrologist)

Reviewed by: Catrina Johnson (Manager, Scientific Consultancy)

Authorised for issue by: Philip Beauvais (International Business Manager)

# Contents

# 1. Background

Worley Parsons are undertaking a Definitive Feasibility Study for the Tonkolili Iron Ore Project on behalf of African Minerals Limited. The proposed mine site is located in the Sula Mountain range in the Tonkolili District of Sierra Leone. A railway line is planned between the mine site and Tagrin Point, which includes the refurbishment of an existing railway from Lunsar. Tagrin Point is the location for a proposed new deep water port within Freetown Harbour at the estuary of the Sierra Leone River. In addition, the refurbishment of existing port facilities at Pepel and mine works at Marampa are planned.

A weather and climate study is required as part of the Environmental and Social Impact Assessment (ESIA). This study needs to cover four geographic areas as follows:
Area 1: The mine and mine-infrastructure area.
Area 2: Tagrin Point and Pepel Port, including the marine conditions at offshore and estuary locations.
Area 3: The railway alignment zone.
Area 4: The Sierra Leone River catchment area.

Information on the spatial and temporal variations in rainfall is particularly important, with the aim of estimating rainfall quantities for different durations and recurrence intervals. This is required in order to estimate the supply of water available to the planned water impoundment for processing at the mine site, and for the design of structures, e.g. tailings, dams and cross-drainage. Information on mean wind speed and direction and gust speeds are also required for the design of storage and stockpiling facilities, both at the mine site and at the port. Also included in the study are averages of air temperature, wet-bulb and dry-bulb temperature, relative humidity and evaporation. Finally information on dust levels during Harmattan Winds is required.

In this first stage of the meteorological study, a literature review has been carried out to determine what data and information is already available, and its integrity and reliability. This report will be split into sections covering each of the four areas specified above, and will provide an overview of the climate of each of these areas as well as details about the sources of data available.

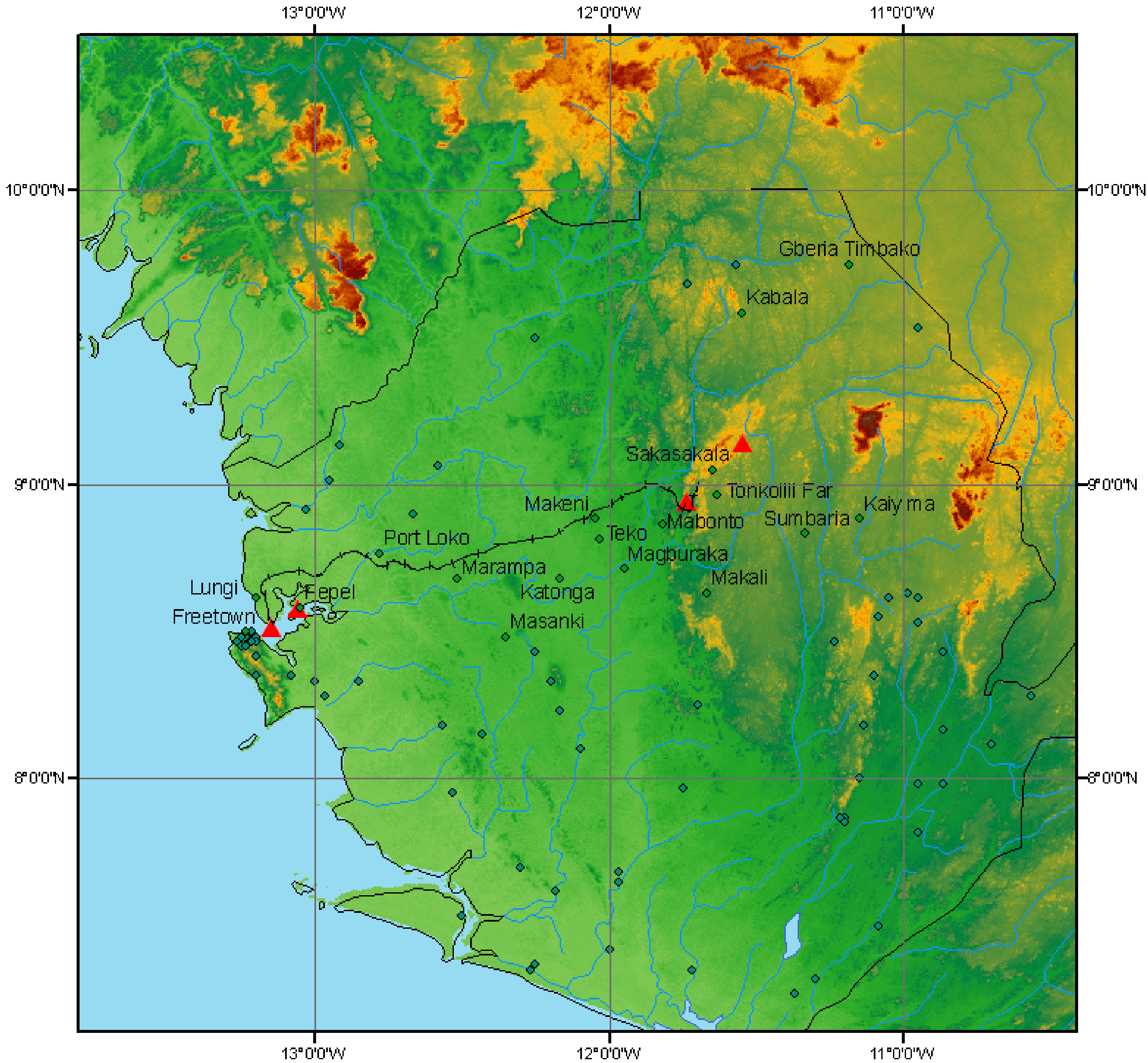


Figure 1: Map of the area of interest, showing the mine site, Pepel Port and Tagrin Point as red triangles, joined by the railway alignment. Meteorological stations are marked, with relevant stations labelled.

## 2. Climate Overview

This section has been synthesised from standard texts on West African climate, for example Ojo (1977) and Hayward & Oguntoyinbo (1987), as well as reports and papers specific to Sierra Leone including Mukharjee and Massaquoi (1973), and a 1941 report from the Sierra Leone Meteorological Service.

Sierra Leone has a tropical monsoon climate, modified by local influences such as decrease in temperature with altitude and variation in rainfall distribution induced by topography. Characteristic of 'monsoon' climates are a wet season and a dry season each year - driven by the annual cycle in the latitude at which the sun's diurnal sky trajectory passes directly overhead. Latitudinal and smaller-scale spatial differentials in the sun's heat energy distribution are the fundamental driving force for all weather and seasons. In the case of West African countries close to the Gulf of Guinea, the latitude of overhead sun-path (and hence maximum heating potential) lies out to sea to the south in the northern hemisphere winter but over the Sahara Desert to the north in the northern hemisphere summer. Given that air density is inversely proportional to temperature, the latitude of maximum heating becomes a zone of rising air into which surface winds converge. This zone is known as the Inter-Tropical Convergence Zone (ITCZ). Hence, in the northern hemisphere winter, the ITCZ lies out to sea to the south and dry north-easterly winds, originating over the Sahara desert, blow towards it across Sierra Leone. Conversely, in the northern hemisphere summer, the ITCZ lies to the north and moist south-westerly winds from the Gulf of Guinea are drawn across Sierra Leone.

Between March and November, a broad, east-west-aligned, rain-prone belt associated with the moist air from the Gulf of Guinea advances northwards across Sierra Leone and then retreats southwards again, drawn in the direction of the ITCZ. However, this simplistic explanation for Sierra Leone's wet season fails to explain all of its features. For instance, the axis of rain-prone belt is not co-incidental with the surface position of the ITCZ, but displaced some 300-400 km to the south. In some years there is a brief lull in the rains in the middle of the wet season while the entire rain-belt lies to the north, despite there being a plentiful supply of moist Gulf air. The assumed direct coupling between the ITCZ and the position of main seasonal rain belt has been questioned, and the factors involved are complex and still not fully understood. To the north of the main monsoon rain belt is a zone where thunderstorms and line squalls develop, and move from east to west with the tropospheric winds.

Hayward and Oguntoyinbo (1987) provide an overview of the climatology of the different weather elements experienced in West Africa which results from the mechanisms discussed above. Sunshine duration is greatest in the winter period, and much reduced in the rainy season as cloudy days predominate. There is a slight increase in sunshine from the south to the north in Sierra Leone. There is little seasonal variation in mean air temperatures, with slightly hotter conditions in April and May. Altitude influences temperature as well as other weather variables, with temperatures generally decreasing with altitude. Mean wind speeds are generally low, and high impact gusts are rare. The greatest wind speeds in the dry season occur when the 'Harmattan' wind blows from the east or north-east, while in the wet season higher wind speeds are associated with storms and squalls. The prevailing wind direction is from the south-west for most of the year, especially near to the coast and especially during the monsoon. Annual average rainfall is greatest along the coast, and decreases with distance inland. The authors make a rough estimate of mean annual potential evaporation of 1000 mm for the Sierra Leone area, with a peak in March. This is likely to be higher for inland areas than on the coast.

## 3. Review of Other Relevant Literature

Kamara and Jackson (1997a) apply a classification of rain days and dry days based on soil-moisture to 8 stations in Sierra Leone. Days are divided into rain days (≥ 0.25 mm) and dry days and sub-divided into "deficit", "limiting", "adequate" and "surplus" soil moisture. In order to classify days based on soil moisture, a simple water balance model based on rainfall and estimated evapotranspiration was used. The results, based on the 1948 to 1977 period, show that the most frequently occurring days are dry days with deficit soil moisture and rain days with surplus soil moisture. This indicates a climatic regime characterised by extreme conditions of dryness and wetness, which has hydrological implications. The percentage of days in each category for three stations, representative of the mine area, the railway and the port respectively, are shown in Table 1. The percentage of dry days ranges from 54 % at Makeni to 62 % at Kabala. There is also some analysis of seasonality in the different types.

| Station | Dry, deficit | Dry, limiting | Dry, adequate | Rain, deficit | Rain, limiting | Rain, adequate | Rain, surplus |
|---|---|---|---|---|---|---|---|
| Kabala | 41 | 5 | 16 | 5 | 3 | 15 | 17 |
| Makeni | 34 | 4 | 16 | 4 | 1 | 13 | 28 |
| Freetown | 39 | 4 | 13 | 4 | 2 | 14 | 24 |

Table 1: Percentage of rain and dry days, based on 1948 to 1977 data, categorised by soil moisture.

In a companion paper, Kamara and Jackson (1997b) use the classification above together with maximum spells of these categories to divide Sierra Leone into eight agro-hydrologic regions using cluster analysis. The mine site is located near to the boundary between their Eastern Highlands region and Mid West region. Most of the railway is covered by the Mid West region, except a small area around Port Loko which is in the Northwest region. The port area is in their West Coast region.

Le Barbé et al (2002) analyse rainfall variability over West Africa during the 1950 to 1990 period. Although they do not include any data from Sierra Leone in their study, their results that the 1951 to 1970 period was wet while the 1971 to 1990 period was dry are likely to apply also to Sierra Leone. They estimate that the rainfall deficit of the latter period compared to the former is 180 mm per year, which is fairly consistent over the area. A similar result is obtained by Owusu and Waylen (2009), who find a 200 mm deficit in the 1981 – 2000 period compared to the 1951 – 1970 period in Ghana. Nicholson el al (2000) found that West African rainfall from 1968 to 1997 was 10 to 20 % lower than that for 1931 to 1960. However, the greatest decreases have occurred further north in the Sahel and sub-humid areas. For the Soudano-Guinean region which includes Sierra Leone, 29 out of 30 years from 1969 to 1998 had annual rainfall below the long term mean. Most of the decrease was concentrated in the months of June and September. Bowden (1980) analysed rainfall data from Sierra Leone for the 1949 to 1976 period, also finding a decreasing trend with a particularly dry period from 1970 to 1975 compared to a wet period from 1949 to 1955. Since 2000, however, the rainfall has shown signs of increasing again (Owusu and Waylen, 2009).

## 4. Data Sources

### 4.1 Land Observations

The National Meteorological Library in Exeter holds a significant amount of meteorological records from Sierra Leone in its archives. This is mostly in the form of bound hard copy paper records. The records relate mainly to the period from 1874 to 1968; Sierra Leone was a British Colony until 1961 when it gained its independence. The records are of observations of a range of weather variables including air temperature, rainfall, wind speed and direction, humidity, thunderstorms, sunshine and evaporation. There are records for many stations throughout Sierra Leone, but most of the records are only at monthly time resolution, and many are only recorded for short periods of time and have periods of missing or unreliable data. Daily records are available for some stations, especially for Freetown and the airport at Lungi. A selection of the available records has been digitised as part of this project, and full details of these data can be found in Appendix 1.

The data is of high quality as it has been recorded by professional observers using standard recording instruments. This is especially true for the main synoptic stations at Freetown, Lungi, Makeni and Kabala. The digitisation of the paper records has been carried out using double entry which has enabled careful quality checks to be made.

A weakness of this data is that the most recent records we currently have available to us are over 50 years old, so that recent trends such as those caused by human-induced climate change will not be accounted for. In particular, in light of the results of Le Barbe et al (2002) and Nicholson et al (2000), it seems that the period for which we have most data was significantly wetter than has been experienced in more recent decades. Some more recent data has been obtained from contacts in the country however, and this has enabled the data from Makeni and Lungi to be updated to 2009 (albeit with some missing data). In addition, the spatial and temporal resolution of the observations is not generally as high as is required for the applications involved in this project.

There is little data available for direct measurement of evaporation; the only data we have is for 23 years from Lungi, and 3 years from Kortright. Hayward and Oguntoyinbo (1987) explain the difficulties with measuring evaporation, with significant differences depending on the measurement method used (Piché evaporimeters or raised or sunken tank evaporimeters). Lungi used a Piché evaporimeter, while Kortright has data from all three methods. Piché measurements generally underestimate evaporation in high humidity conditions.

Three Automatic Weather Stations (AWS) have been set up for this project, two at the mine site (Farangbaya and Numbara), and one at Pepel Port. They only have very short data records so are likely to be of limited use, but could be useful for storm analysis if 10-minute rainfall data can be obtained. Griffiths (2010) presents graphically data for September to November 2009. This report also mentions the intention to monitor dust levels.

## 4.2 Numerical Model

Another source of data used in this study is numerical model data. The model used is the Met Office Unified Model® (the MetUM), the forecast model used operationally by the Met Office to produce numerical weather forecasts both regionally and across the entire globe. The Global model has a horizontal resolution of approximately 50 km in the region of interest, and analysis data from this model was extracted for four grid points, for the port, two locations along the railway and the mine site. The period for which data is available is 2000 to 2009.

Numerical model data provides a full representation of atmospheric conditions for a recent time period. It will be particularly useful for variables such as wind, temperature and humidity. The coarse resolution of the global model means, however, that small scale features and local orography will not be well represented. It would be possible to carry out high resolution modelling simulations of the area to generate much more accurate results, but this would be an extremely computer intensive exercise.

# 5. Area 1: Mine site

## 5.1 Climate overview

The mine site is located 165 km inland from the coast at Lungi in an ENE direction, and is shown on the map (Figure 1) by red triangles marking the SW and NE extents of the mine site. The Sula mountain range rises up to about 1000 m above sea level from an extensive, gently undulating plateau of 300 m to the west and 400 m to the east.

The dry season runs from December to March, with very little rain or cloud. Especially during December and January, the 'Harmattan' wind may occur, a dry wind blowing from the east or north-east which leads to poor visibility due to the dust which it carries, as well as a reduction in humidity.

Rainfall at the mine site is spread much more evenly throughout the wet season than at the coast. In the early wet season, thunderstorms start to develop in the highlands, particularly during the afternoons. These thunderstorms are accompanied by strong easterly squalls which may occasionally reach gale force in gusts. The monsoon rains are shorter and less intense than further south and towards the coast, but there are still some longer periods of rain during July and August.  Thundery activity resumes from September to November as the wet season recedes.

### 5.2 Data Sources

There is very little observed data available for the mine site itself as it is a very remote and mountainous area.  We have short records of monthly data from Sakasakala (1936 to 1937), located at 576 masl (metres above sea level) in the centre of the mine site, and from Tonkolili Farangbaira (1957 to 1961), also located in the mine area at 852 masl.  To supplement this, we have longer records from sites which are likely to be representative of the mine area.  The longest record comes from Kabala, which is 50 km to the north of the mine site at an altitude of 444 masl.  From this site we have a 50 year record (1913 to 1968) for a range of weather variables including rainfall, temperature, humidity and wind.  We also have 25 years of data from Mabonto, which is just to the south-west of the mine area at the foot of the mountain range (129 masl).  In addition, we have monthly rainfall data from two sites on the plateau to the east, Sumbaria and Kaiyima. The Sumbaria record has been extended from 20 years to a reconstituted series of 50 years for a study related to the Bumbuna Hydroelectric Project.

There is very limited daily data representative of the mine site, although the initial hydrological assessment of the Tonkolili iron ore project (Griffiths, 2010) states that daily rainfall data are available for Bumbuna (1991 – 1992) and Kabala (1951 – 1979).  We have not found any evaporation data representative of the mine area, or any solar radiation data which would be required for its calculation.  There is also no data available on dust levels.

## 6. Area 2: Tagrin Point and Pepel Port

### 6.1 Climate overview

Tagrin Point and Pepel Port, marked by red triangles on the map (Figure 1) are located on the northern side of the Sierra Leone harbour, opposite the Freetown peninsula.  The Freetown peninsula reaches an altitude of 800 m and provides some shelter to the harbour.  Tagrin Point is at the end of the railway alignment, 165 km WSW from the mine site.

Sea temperatures off the coast of Freetown are around 27 °C with little seasonal variation. Air temperatures also have little seasonal variation as the location is only 8.5° north of the Equator. They remain hot throughout the year with a peak in April and May.

The dry season runs from December to March, and is characterised by fine days, with perhaps a little cloud drifting in from the sea. The Harmattan wind sometimes reaches the coast from the east, causing a reduction in visibility. Land breezes (from the north-east) often occur after sunrise, before the flow reverts to the prevailing south-westerly by noon, reaching its peak speed in the early afternoon.

April to June is the early wet season or the 'pre-monsoon' season. Some convective thunderstorms start to develop (but less than further inland), carried from the east by the easterly winds at mid-levels. These storms are often accompanied by strong easterly winds which can cause choppy seas in the harbour. The rain showers in June and October can be particularly intense. From July through to September is the monsoon season, with large amounts of cloud and long periods of rain, at times occurring with high intensity. The south-west (ocean-facing) side of the Freetown peninsula has an annual average rainfall of 5000 - 6800 mm, while the north-eastern side of the peninsula and the area on the opposite side of the harbour receive only an annual average of 3000 – 3500 mm due to the rain shadow effect of the peninsula's orography. Rainfall increases with altitude, especially in the rain shadow, and decreases with distance from the coast (Hayward and Clarke, 1996; Kamara and Jackson, 1997b).

Humidity is high throughout the year, but is especially high during the monsoon season. The steady prevailing wind flows from the south-west during this period, especially during the afternoon and evening. The persistence of SW winds may cause large waves (swell). During October and November the wet season rapidly subsides, with further convective showers occurring.

### 6.2 Data Sources

We have data from a weather station which operated at Pepel Port from 1933 to 1967, recording observations of rainfall, temperature and humidity. There is a significant amount of missing data within this record however, and a better record comes from the site at Lungi Airport which is 12 km north of Tagrin Point. We have a 60 year record for the 1947 to 2007 period, which includes daily and monthly rainfall and wind speed and direction data, as well as monthly averages of temperature and humidity. Freetown is located just on the opposite side of the harbour entrance from Tagrin Point, and we have a long record of daily rainfall data from here, running from 1916 to 1948. We also have a 60 year record of monthly data from Freetown, covering rainfall, temperature, humidity and wind speed. Other nearby stations for which we have shorter records include Kissy Dockyard and Cline Town.

The availability and analysis of any relevant marine data will be investigated in the next stage of the project.

# 7. Area 3: Railway alignment

## 7.1 Climate overview

The railway alignment will run from the south-west of the mine area WSW for about 170 km to Tagrin Point, at the entrance to the harbour. It goes from the edge of the highlands, at an altitude of about 400 masl, and passes through the interior low plains which are rolling lowlands of swampy grasslands to the coastal lowland plain. The proposed railway is marked on the map (Figure 1) as a black crossed line.

The decrease in altitude, the move towards the coast, and the movement to the WSW with respect to the ITCZ means that there is a gradual change in the climate along the length of the railway. Annual average rainfall decreases towards the coast, but most of this decrease occurs during the height of the rainy season in July and August due to a decreasing influence of the south-west monsoon. However, there is an increase in rainfall in the centre of the country around Makeni, as the escarpment which forms the mine area triggers instability in the moist south-westerly winds (Kamara and Jackson, 1997b). There is also a slight increase in average cloudiness and humidity closer to the coast. During February to April, fog sometimes forms in valleys after a calm night.

## 7.2 Data Sources

There are several meteorological stations for which we have some data records located near to the railway alignment at fairly regular spatial intervals. Starting from the mine site and proceeding to the coast, we have a good rainfall record from Mabonto, near to the mine site. The railway then passes through Makeni, a large city of around 100,000 people from where we have a long record (over 50 years) of rainfall, temperature and humidity data, as well as a short record of wind speed and direction. Further rainfall data is available from Teko, just to the south of Makeni. The next major stop for the railway is Marampa, the location of existing mine works. We have a 34 year record of rainfall, temperature and humidity data from here. The railway next passes Port Loko, which is situated on Port Loko Creek, which flows into the Sierra Leone River. We have a good record of rainfall data form here, as well as a shorter record of temperature and humidity.

## 8. Area 4: Sierra Leone River catchment

The Rokel River is the largest river in Sierra Leone, and passes near to the mine area as it flows in a south-westerly direction down to the Sierra Leone River estuary (Freetown Harbour). It follows a similar path to the railway but further to the south. A smaller river, Port Loko Creek, also feeds into the estuary, having crossed the railway at Port Loko. Consequently the climate overview and data sources from the previous sections, especially section 7 on the railway alignment, are also applicable to the river catchment. This section provides a review of hydrological methods relevant to the applications required and the data available.

### 8.1 Hydrological Applications

The hydrometeorological and climate data that has been acquired has potential for a number of uses to assist the hydrological design and planning of the different facets of the Tonkolili Mine Project.

The extensive historic rainfall record is useful in a number of respects. The availability of long records of daily rainfall at Freetown and Lungi will provide useful information on rainfall frequency and the estimation of probabilities (return periods). Aspects such as persistence of wet and dry periods can be extracted from such data, which will be helpful in determining the significance of dry season duration for water supply requirements. However, both sites are close to the coast (Area 2), and may not be directly applicable to the river catchment.

The extensive array of monthly rainfall should prove useful for the examination of the range of seasonal conditions which will be important in planning water supply to the mine camp, and broader aspects of water management, such as effluent disposal and runoff control. These can be of particular importance to ecological management, where tailings disposal to rivers is involved. An empirical means of estimating catchment runoff from annual average rainfall and catchment area is available from studies by the former UK Institute of Hydrology (Meigh et al 1997). The basic equation produces an estimate of mean annual flood (MAF), which can be adjusted by growth factor to return periods of 5 to 200 years. These will provide good first estimates for design floods at a range of infrastructure, including cross-drainage along the railway line.

The monthly data provided (see Appendix 1) also include the maximum daily fall in each month. At least one station within each area of interest has records of 50 years or more. These record lengths should be capable of producing estimates of rainfall probabilities at 20-year and 50-year with some confidence. These data should also produce reasonable estimates out to the 100-year probability, which may in turn provide verification and refinement of estimates from empirical relationships.

The estimation of runoff from small catchments where no flow or rainfall measurements are available commonly uses the well-established US Soil Conservation Service method (WMO 2009). Selection of rainfall input in the estimating method allows for the rainfall to be distributed over time, i.e. a storm profile. The example of data so far provided from the AWS's at the mine site present rainfall integrated over 10-minute intervals. Although there is only a short record, if they contain a selection of discrete storm events these data should provide some information to assist in identifying a representative storm profile for local conditions. The data could also confirm or otherwise whether standard design storm rainfall profiles, e.g. SCS or FSR (NERC 1975), could be applied. There are also two published papers with storm hyetographs for locations on the Freetown Peninsula which may be used for comparison (Davies et. al., 1966; Barrie, 2007). Davies et. al. used sub-daily data from Freetown, while Barrie used annual maximum daily rainfall amounts from Guma Valley, converted into shorter durations using a reduction formula.

Some critical infrastructure such as tailings dams, which require a high level of safety in their design, will require an estimate of extreme rainfall. For large dams, or those where failure presents a high risk to life, it is common practice to estimate a probable maximum flood (PMF). This requires the estimation of probable maximum precipitation (PMP), and a recognised means of providing this is done by the Herschfield method (WMO 2009), which uses the following equation:

$$R_{max} = R_{mean} + KS_d$$

where; Rmax is the PMP for a given duration

Rmean is the mean of the annual maximum rainfall series

K is a factor determined by Rmean and duration

Sd is the standard deviation of the annual maximum rainfall series.

Annual maximum daily rainfall from the longest available records at Freetown, Makeni and Kabala should prove suitable for this estimation.

## 9. Conclusions

This report reviews the currently available literature on the climate of Sierra Leone, and describes a range of data sources which have been found to be available. The report focuses especially on four areas of interest; the mine area, the port area, the railway alignment linking the mine to the port, and the river catchment.

The data and methods described in this report will be used to provide more detailed analysis of the climate of the areas of interest. This further analysis will focus on the requirements of Worley Parsons as stated in the proposal. Although a large amount of information has been obtained, data on some aspects are not sufficient to meet the requirements. The types of analysis expected to be included in the next stage of the project are as follows:

**Rainfall:** Long-term averages of monthly rainfall representative of each of the areas of interest. Recent trends will be incorporated using data form Makeni and Lungi. Analysis of intra-annual variability of rainfall, including return periods of wet and dry years. Extreme value analysis of daily data, using annual maximum values, and PMP estimation. Estimation of design storm profiles (return periods for sub-daily durations), making use of limited daily and sub-daily rainfall data together with estimation methods.

**Wind:** Frequency analysis of wind speed and direction, which will include seasonal variations and the likelihood of occurrence of winds speeds exceeding certain thresholds. Data from Kabala, Makeni, Lungi and Freetown will be used to make inferences about the areas of interest.

**Temperature and humidity:** Long-term averages of daily maximum, minimum and mean temperature and relative humidity representative of each of the areas of interest, including seasonal variations. Recent trends will be incorporated using data from Makeni and Lungi.

**Evaporation:** Long-term averages of monthly evaporation from Lungi (as measured by a Piché evaporimeter).

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# Appendix 1

### Hourly Data

| Station | Variables | Date from | Date to | Length of record |
|---|---|---|---|---|
| Freetown | Rainfall | 1944 | 1948 | 5 years |

Table 2: Digitised hourly data

### Daily Data

| Station | Variables | Date from | Date to | Length of record |
|---|---|---|---|---|
| Freetown | Rainfall | 1921 | 1948 | 25 years |
| Lungi | Rainfall, wind | 1949 | 1968 | 20 years |
| Makeni | Rainfall | 1943 | 1948 | 6 years |
| Kabala | Rainfall, wind | 1943 | 1944 | 1 year |

Table 3: Digitised daily data

### Monthly Data (Mine Area)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Kabala | Rainfall, temperature, humidity, wind | 1913 | 1968 | 50 |
| Mabonto | Rainfall | 1936 | 1962 | 25 |
| Sumbaria | Rainfall | 1948 | 1968 | 21 |
| Tonkolili | Rainfall, temperature, humidity | 1957 | 1961 | 5 |
| Sakasakala | Rainfall | 1936 | 1937 | 2 |
| Makali | Rainfall, temperature, humidity | 1950 | 1955 | 5 |
| Kaiyima | Rainfall | 1927 | 1931 | 5 |

Table 4: Digitised monthly data from the mine area

### Monthly Data (Port Area)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Lungi | Rainfall, temperature, humidity, wind, Piché evaporation | 1947 | 2007 | 59, 23 (evap) |
| Freetown | Rainfall, temperature, humidity, wind | 1909 | 1968 | 59 |
| Pepel | Rainfall, temperature, humidity | 1933 | 1967 | 29 |
| Kissy Dockyard | Rainfall, temperature, humidity | 1949 | 1959 | 10 |
| Cline Town | Rainfall | 1949 | 1960 | 12 |

Table 5: Digitised monthly data from the port area

### Monthly Data (Railway Alignment)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Makeni | Rainfall, temperature, humidity, wind | 1923 | 2009 | 74 (rain), 67 (RH), 55 (temp), 18 (wind) |
| Marampa | Rainfall, temperature, humidity | 1934 | 1968 | 34 |
| Port Loko | Rainfall, temperature, humidity | 1936 | 1968 | 27 (rain), 13 (temp, RH) |
| Teko | Rainfall | 1942 | 1968 | 17 |
| Katonga | Rainfall | 1957 | 1966 | 9 |
| Magburaka | Rainfall, temperature, humidity | 1954 | 1960 | 2 |

Table 6: Digitised monthly data from the area of the railway alignment and the river catchment

| | |
|---|---|
| **Met Office** | Tel: 0870 900 0100 |
| FitzRoy Road, Exeter | Fax: 0870 900 5050 |
| Devon EX1 3PB | enquiries@metoffice.gov.uk |
| United Kingdom | www.metoffice.gov.uk |

# APPENDIX 7

## Stage 2 – Climate Assessment and Data Analysis - Prepared by the Met Office

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## Tonkolili Iron Ore Project

# Stage 2 - Climate Assessment and Data Analysis - Prepared by the Met Office

305000-00006 – 305000-00006-0000-EN-REP-0006

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

AFRICAN MINERALS LIMITED

STAGE 2 - CLIMATE ASSESSMENT AND DATA ANALYSIS - PREPARED BY THE MET OFFICE

TONKOLILI IRON ORE PROJECT

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**PROJECT 305000-00006 - STAGE 2 - CLIMATE ASSESSMENT AND DATA ANALYSIS - PREPARED BY THE MET OFFICE**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
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# Climate studies for Tonkolili, Sierra Leone: Stage 2 – Climate assessment and data analysis

For: Worley Parsons
Date: March 2010
Authors: Matthew Perry and James Dent

Prepared by: Matthew Perry (Scientific Consultant)
and James Dent (Senior Hydrologist)

Reviewed by: Catrina Johnson (Manager, Scientific Consultancy)

Authorised for issue by: Helen Bye (Senior Business Manager)

## Contents



 

# 1. Background

Worley Parsons are undertaking a Definitive Feasibility Study for the Tonkolili Iron Ore Project on behalf of African Minerals Limited. The proposed mine site is located in the Sula Mountain range in the Tonkolili District of Sierra Leone. A railway line is planned between the mine site and Tagrin Point, which includes the refurbishment of an existing railway from Lunsar. Tagrin Point is the location for a proposed new deep water port within Freetown Harbour at the estuary of the Sierra Leone River. In addition, the refurbishment of existing port facilities at Pepel and mine works at Marampa are planned.

A weather and climate study is required as part of the Environmental and Social Impact Assessment (ESIA). This study needs to cover four geographic areas as follows:
Area 1: The mine and mine-infrastructure area.
Area 2: Tagrin Point and Pepel Port
Area 3: The railway alignment zone.
Area 4: The Sierra Leone River catchment area.

Information on the spatial and temporal variations in rainfall is particularly important, with the aim of estimating rainfall quantities for different durations and recurrence intervals. This is required in order to estimate the supply of water available to the planned water impoundment for processing at the mine site, and for the design of structures, e.g. tailings, dams and cross-drainage. Information on mean wind speed and direction and gust speeds are also required for the design of storage and stockpiling facilities, both at the mine site and at the port. Also included in the study are averages of air temperature, relative humidity and evaporation. Also required if available is information on dust levels during Harmattan Winds, and marine conditions offshore from Tagrin Point.

In the first stage of the meteorological study, a literature review was carried out to determine what data and information is already available, and its integrity and reliability. This second stage report will be split into sections covering each of the four areas specified above, and will provide an overview of the climate of each of these areas, details about the sources of data available, and a summary of analysed data.

 

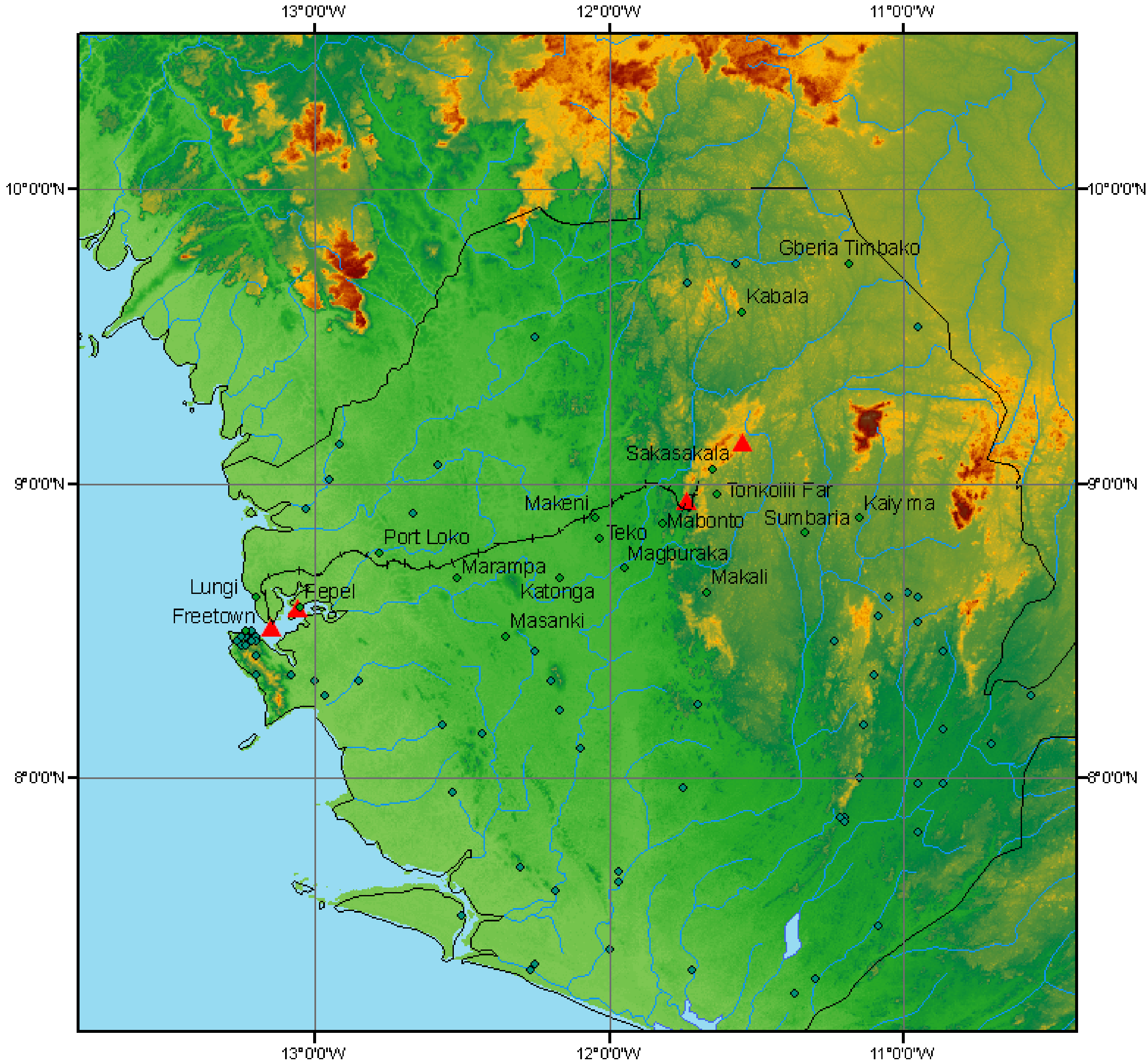


Figure 1: Map of the area of interest, showing the mine site, Pepel Port and Tagrin Point as red triangles, joined by the railway alignment. Meteorological stations are marked, with relevant stations labelled.

## 2. Climate Overview

This section has been synthesised from standard texts on West African climate, for example Ojo (1977) and Hayward & Oguntoyinbo (1987), as well as reports and papers specific to Sierra Leone including Mukharjee and Massaquoi (1973), and a 1941 report from the Sierra Leone Meteorological Service.

Sierra Leone has a tropical monsoon climate, modified by local influences such as decrease in temperature with altitude and variation in rainfall distribution induced by topography. Characteristic of 'monsoon' climates are a wet season and a dry season each year - driven by the annual cycle in the latitude at which the sun's diurnal sky trajectory passes directly overhead. Latitudinal and smaller-scale spatial differentials in the sun's heat energy distribution are the fundamental driving force for all weather and seasons. In the case of West African countries close to the Gulf of Guinea, the latitude of overhead sun-path (and hence maximum heating potential) lies out to sea to the south in the northern hemisphere winter but over the Sahara Desert to the north in the northern hemisphere summer. Given that air density is inversely proportional to temperature, the latitude of maximum heating becomes a zone of rising air into which surface winds converge. This zone is known as the Inter-Tropical Convergence Zone (ITCZ). Hence, in the northern hemisphere winter, the ITCZ lies out to sea to the south and dry north-easterly winds, originating over the Sahara desert, blow towards it across Sierra Leone. Conversely, in the northern hemisphere summer, the ITCZ lies to the north and moist south-westerly winds from the Gulf of Guinea are drawn across Sierra Leone.

Between March and November, a broad, east-west-aligned, rain-prone belt associated with the moist air from the Gulf of Guinea advances northwards across Sierra Leone and then retreats southwards again, drawn in the direction of the ITCZ. However, this simplistic explanation for Sierra Leone's wet season fails to explain all of its features. For instance, the axis of rain-prone belt is not co-incidental with the surface position of the ITCZ, but displaced some 300-400 km to the south. In some years there is a brief lull in the rains in the middle of the wet season while the entire rain-belt lies to the north, despite there being a plentiful supply of moist Gulf air. The assumed direct coupling between the ITCZ and the position of main seasonal rain belt has been questioned, and the factors involved are complex and still not fully understood. To the north of the main monsoon rain belt is a zone where thunderstorms and line squalls develop, and move from east to west with the tropospheric winds.

Hayward and Oguntoyinbo (1987) provide an overview of the climatology of the different weather elements experienced in West Africa which results from the mechanisms discussed above. Sunshine duration is greatest in the winter period, and much reduced in the rainy season as cloudy days predominate. There is a slight increase in sunshine from the south to the north in Sierra Leone. There is little seasonal variation in mean air temperatures, with slightly hotter conditions in April and May. Altitude influences temperature as well as other weather variables, with temperatures generally decreasing with altitude. Mean wind speeds are generally low, and high impact gusts are rare. The greatest wind speeds in the dry season occur when the 'Harmattan' wind blows from the east or north-east, while in the wet season higher wind speeds are associated with storms and squalls. The prevailing wind direction is from the south-west for most of the year, especially near to the coast and especially during the monsoon. Annual average rainfall is greatest along the coast, and decreases with distance inland. The authors make a rough estimate of mean annual potential evaporation of 1000 mm for the Sierra Leone area, with a peak in March. This is likely to be higher for inland areas than on the coast.

## 3. Review of Other Relevant Literature

Kamara and Jackson (1997a) apply a classification of rain days and dry days based on soil-moisture to 8 stations in Sierra Leone. Days are divided into rain days (≥ 0.25 mm) and dry days and sub-divided into "deficit", "limiting", "adequate" and "surplus" soil moisture. In order to classify days based on soil moisture, a simple water balance model based on rainfall and estimated evapotranspiration was used. The results, based on the 1948 to 1977 period, show that the most frequently occurring days are dry days with deficit soil moisture and rain days with surplus soil moisture. This indicates a climatic regime characterised by extreme conditions of dryness and wetness, which has hydrological implications. The percentage of days in each category for three stations, representative of the mine area, the railway and the port respectively, are shown in Table 1. The percentage of dry days ranges from 54 % at Makeni to 62 % at Kabala. There is also some analysis of seasonality in the different types.

| Station | Dry, deficit | Dry, limiting | Dry, adequate | Rain, deficit | Rain, limiting | Rain, adequate | Rain, surplus |
|---|---|---|---|---|---|---|---|
| Kabala | 41 | 5 | 16 | 5 | 3 | 15 | 17 |
| Makeni | 34 | 4 | 16 | 4 | 1 | 13 | 28 |
| Freetown | 39 | 4 | 13 | 4 | 2 | 14 | 24 |

Table 1: Percentage of rain and dry days, based on 1948 to 1977 data, categorised by soil moisture.

In a companion paper, Kamara and Jackson (1997b) use the classification above together with maximum spells of these categories to divide Sierra Leone into eight agro-hydrologic regions using cluster analysis. The mine site is located near to the boundary between their Eastern Highlands region and Mid West region. Most of the railway is covered by the Mid West region, except a small area around Port Loko which is in the Northwest region. The port area is in their West Coast region.

Le Barbé et al (2002) analyse rainfall variability over West Africa during the 1950 to 1990 period. Although they do not include any data from Sierra Leone in their study, their results that the 1951 to 1970 period was wet while the 1971 to 1990 period was dry are likely to apply also to Sierra Leone. They estimate that the rainfall deficit of the latter period compared to the former is 180 mm per year, which is fairly consistent over the area. A similar result is obtained by Owusu and Waylen (2009), who find a 200 mm deficit in the 1981 – 2000 period compared to the 1951 – 1970 period in Ghana. Nicholson el al (2000) found that West African rainfall from 1968 to 1997 was 10 to 20 % lower than that for 1931 to 1960. However, the greatest decreases have occurred further north in the Sahel and sub-humid areas. For the Soudano-Guinean region which includes Sierra Leone, 29 out of 30 years from 1969 to 1998 had annual rainfall below the long term mean. Most of the decrease was concentrated in the months of June and September. Bowden (1980) analysed rainfall data from Sierra Leone for the 1949 to 1976 period, also finding a decreasing trend with a particularly dry period from 1970 to 1975 compared to a wet period from 1949 to 1955. Since 2000, however, the rainfall has shown signs of increasing again (Owusu and Waylen, 2009).

# 4. Data Sources

## 4.1 Land Observations

The National Meteorological Library in Exeter holds a significant amount of meteorological records from Sierra Leone in its archives. This is mostly in the form of bound hard copy paper records. The records relate mainly to the period from 1874 to 1968; Sierra Leone was a British Colony until 1961 when it gained its independence. The records are of observations of a range of weather variables including air temperature, rainfall, wind speed and direction, humidity, thunderstorms, sunshine and evaporation. There are records for many stations throughout Sierra Leone, but most of the records are only at monthly time resolution, and many are only recorded for short periods of time and have periods of missing or unreliable data. Daily records are available for some stations, especially for Freetown and the airport at Lungi. A selection of the available records has been digitised as part of this project, and full details of these data can be found in Appendix 1.

The data is of high quality as it has been recorded by professional observers using standard recording instruments. This is especially true for the main synoptic stations at Freetown, Lungi, Makeni and Kabala. The digitisation of the paper records has been carried out using double entry which has enabled careful quality checks to be made.

A weakness of this data is that the most recent records we currently have available to us are over 50 years old, so that recent trends such as those caused by human-induced climate change will not be accounted for. In particular, in light of the results of Le Barbe et al (2002) and Nicholson et al (2000), it seems that the period for which we have most data was significantly wetter than has been experienced in more recent decades. Some more recent data has been obtained from contacts in the country however, and this has enabled the data from Makeni and Lungi to be updated to 2009 (albeit with some missing data). In addition, the spatial and temporal resolution of the observations is not generally as high as is required for the applications involved in this project.

There is little data available for direct measurement of evaporation; the only data we have is for 23 years from Lungi, 3 years from Bumbuna and Kortright. Hayward and Oguntoyinbo (1987) explain the difficulties with measuring evaporation, with significant differences depending on the measurement method used (Piché evaporimeters or raised or sunken pan evaporimeters). Lungi used a Piché evaporimeter and Bumbuna used a 'Class A' pan, while Kortright has data from all three methods. Piché measurements generally underestimate evaporation in high humidity conditions.

Three Automatic Weather Stations (AWS) have been set up for this project, two at the mine site (Farangbaya and Numbara), and one at Pepel Port. Five months of 10-minute data is available for Farangbaya (400 masl) and Numbara (800 masl). Due to the short data records currently available these are of limited use, but will provide an indication of likely conditions and data for storm analysis. Griffiths (2010) presents graphically data for September to November 2009. This report also mentions the intention to monitor dust levels, which was not proceeded with.

### 4.2 Numerical Model

Another source of data used in this study is numerical model data. The model used is the Met Office Unified Model (the MetUM), the forecast model used operationally by the

Met Office to produce numerical weather forecasts both regionally and across the entire globe. The Global model has a horizontal resolution of approximately 50 km in the region of interest, and analysis data from this model was extracted for four grid points, for the port, two locations along the railway and the mine site. The period for which data is available is 2000 to 2009.

Numerical model data provides a full representation of atmospheric conditions for a recent time period. It was particularly useful for variables such as wind and humidity. The coarse resolution of the global model means, however, that small scale features and local orography will not be well represented. It would be possible to carry out high resolution modelling simulations of the area to generate much more accurate results, but this would be an extremely computer intensive exercise.

## 5. Hydrological Methods

The hydrometeorological and climate data that has been acquired has potential for a number of uses to assist the hydrological design and planning of the different facets of the Tonkolili Mine Project.

The extensive array of monthly rainfall is useful for the examination of the range of seasonal conditions which will be important in planning water supply to the mine camp, and broader aspects of water management, such as effluent disposal and runoff control. These can be of particular importance to ecological management, where tailings disposal to rivers is involved. An empirical means of estimating catchment runoff from annual average rainfall and catchment area is available from studies by the former UK Institute of Hydrology (Meigh et al 1997). The basic equation produces an estimate of mean annual flood (MAF), which can be adjusted by growth factor to return periods of 5 to 200 years. These will provide good first estimates for design floods at a range of infrastructure, including cross-drainage along the railway line.

The monthly data provided (see Appendix 1) also include the maximum daily fall in each month. At least one station within each area of interest has records of 50 years or more. These record lengths are capable of producing estimates of rainfall probabilities at 20-year and 50-year with some confidence. These data can also produce reasonable estimates out to the 100-year probability, and the 500-year probability with higher uncertainty. The Generalised Extreme Value (GEV) distribution has also been used to analyse extremes of annual rainfall totals in order to provide estimates of wet and dry years for probabilities ranging from 5 years to 500 years.

The estimation of runoff from small catchments where no flow or rainfall measurements are available commonly uses the well-established US Soil Conservation Service method (WMO 2009). Selection of rainfall input in the estimating method allows for the rainfall to be distributed over time, i.e. a storm profile.

The analysis of hourly rainfall data from Freetown (1944-47) and of 10-minute data from automatic weather stations (AWS) operating at the mine site since September 2009 have given some insight into the intensity-duration characteristics of storm rainfall. The data from Freetown suggests that there are two main types of rainfall event.

Firstly there are heavy downpours lasting a few hours, where one hour, usually in the early part of the storm has a significantly high rainfall. The rainfall in a single hour can amount to 70% of the storm total. It would appear that this type of storm is most prevalent in the early part of the rainy season, late May or early June, and at the end of the rains, in September and October. These convective rains are associated with the advancing and retreating ITCZ.

The second type of storm is of longer duration, from 8 to 15hours, where individual peak hourly intensities are lower than in convective storms, and moderate intensities may persist for 2 to 3 hours in a longer period of light rainfall. Peak hourly intensities are only 20-30% of the storm total. This type of storm appears typical of the main part of the wet season, July and August, when the ITCZ is to the north, and the equatorial rain band predominates, with large depressions being the main rainfall producing mechanism.

The recent data obtained from AWS records provide examples of heavy rainfalls in September and October. These are characteristically of short duration, matching the end of season pattern noted at Freetown. However, it cannot be assumed that the mid-season pattern will be the same, as orographic and local influences at the mine site may affect rainfall intensities. Analysis of the data has produced information on durations from 10 minutes to 3-4 hours. Neither source of data is sufficient to produce probability estimates at different durations, but maximum or “envelope” values have been obtained.

In the absence of enough recorded data, rainfall intensity-duration data may be obtained from generalised methods. Two are considered here:

1: From the Food and Agriculture Organisation (FAO, 1993). This reference provides a graph of intensity vs duration for a 1 in 10 event, compiled from data from Africa and Australia. Growth factors for 1 in 20 and 1 in 50 events are also provided. This information is summarised in Table 2. It may be noted that peak recorded intensities for the Numbara AWS have been 135.6 mm/hr in 10 minutes and 88.5 mm/hr for 20 minutes.

| **Return Period** | **Duration** | | | | |
|---|---|---|---|---|---|
| | **5-min** | **10-min** | **20-min** | **30-min** | **60-min** |
| 1 in 10 | 120 | 101 | 82 | 70 | 47 |
| 1 in 25 | 150 | 137 | 103 | 88 | 59 |
| 1 in 50 | 180 | 151 | 123 | 105 | 70 |

Table 2. Rainfall Intensity (mm/hr) for different durations

2: From the Flood Studies Report (FSR, 1975). The FSR carried out a detailed study of rainfall intensity and duration for the UK, and related the peaked-ness of profiles to frequency of occurrence. The more “peaky” profiles are related to convective activity, and it is suggested that the 90 percentile “summer” profile is suitable to apply to Sierra Leone. The information is presented as proportion of time relative to proportion of rainfall, as in Table 3. FSR notes that there is little change of the proportional distribution of rainfall with duration, so the profile could be applied to different lengths of design storm.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Cumulative percentage of storm duration | 4 | 10 | 20 | 40 | 60 | 80 | 100 |
| Cumulative percentage of rainfall | 36 | 63 | 82 | 92 | 96 | 98 | 100 |

Table 3. Relationship between rainfall and duration (FSR, 1975)

Applying the distribution in Table 3 to the maximum recorded storm with hourly data at Freetown, 220mm in 5 hours, gives the depth duration statistics in Table 4. Compared with the recorded rainfall this gives confidence that the synthetic profile would be suitable for design applications.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration, minutes | 12 | 30 | 60 | 120 | 180 | 240 | 300 |
| Rainfall depth, mm | 79 | 139 | 180 | 202 | 211 | 216 | 220 |
| Rainfall recorded 13/9/44 | - | - | 150 | 206 | 212 | - | 220 |

Table 4: Rainfall depth (mm) and duration for a 5-hour storm

These theoretical profiles can be adapted to apply to the conditions in Sierra Leone. From the characteristics of sub-daily rainfall information available, two storm durations are considered, of 15-hours and 8-hours. These profiles are applied to estimates from the annual maximum series of 1-day rainfalls, on the evidence that the 1-day data almost invariably represents a rainfall event which has duration of less than 24-hours. The examples from the Freetown record showed that heavy rainfall events can be of a short duration with intense peaks, or of longer duration with a more extended period of heavier rainfall.

The general intensity-duration relationship of the FSR profile (Table 4) has been distributed centrally to produce a 15-hour storm profile summarised in Table 5. Some slight reduction of the peak 1-hour proportion has been made, with the adjustment distributed to produce a “flatter” period of heavy rainfall, more representative of observed conditions.

| Hour no. | % rainfall | Hour no. | % rainfall |
|---|---|---|---|
| 1 | 0.5 | 9 | 11 |
| 2 | 1 | 10 | 6 |
| 3 | 2 | 11 | 4 |
| 4 | 3 | 12 | 3 |
| 5 | 4 | 13 | 2 |
| 6 | 6 | 14 | 1 |
| 7 | 11 | 15 | 0.5 |
| 8 | 45 | | |

Table 5: Hourly rainfall profile (%) for 15-hour storm

It has been noted that short duration storms are characterised by having the peak hourly rainfall intensity occurring in the first part of the storm. For the 8-hour storm, the FSR profile has been subjectively apportioned to give 90% of the storm occurring within the first 3 hours of the storm, and the peak rainfall occurring in hour 2. This is summarised in Table 6.

| Hour no. | % rainfall |
|---|---|
| 1 | 8 |
| 2 | 69 |
| 3 | 13 |
| 4 | 3 |
| 5 | 2 |
| 6 | 2 |
| 7 | 1 |
| 8 | 1 |

Table 6: Hourly rainfall profile (%) for 8-hour storm

To obtain estimates of typical sub-hourly rainfall depths, the intensity-duration relationship of the FAO curve has been used. This has been converted to a centrally distributed profile of 5-minute time-steps, as in Table 7. This profile has been applied to the estimates of the peak 1-hour rainfall for the 8-hour duration storms, for return periods of 10 and 50 years.

| 5-minute interval | % rainfall |
|---|---|
| 1 | 3 |
| 2 | 4 |
| 3 | 8 |
| 4 | 9 |
| 5 | 14 |
| 6 | 21 |
| 7 | 14 |
| 8 | 9 |
| 9 | 8 |
| 10 | 5 |
| 11 | 3 |
| 12 | 2 |

Table 7: 5-minute rainfall profile (%) for 1-hour storm

Some critical infrastructure such as tailings dams, which require a high level of safety in their design, will require an estimate of extreme rainfall. For large dams, or those where failure presents a high risk to life, it is common practice to estimate a probable maximum flood (PMF). This requires the estimation of probable maximum precipitation (PMP), and a recognised means of providing this is done by the Herschfield method (WMO 2009), which uses the following equation:

$$Rmax = Rmean + KSd$$

where Rmax is the PMP for a given duration, Rmean is the mean of the annual maximum rainfall series, K is a factor determined by Rmean and duration, and Sd is the standard deviation of the annual maximum rainfall series.

Annual maximum daily rainfall from the longest available records at Freetown, Makeni and Kabala should prove suitable for this estimation.

# 6. Area 1: Mine site

## 6.1 Climate overview

The mine site is located 165 km inland from the coast at Lungi in an ENE direction, and is shown on the map (Figure 1) by red triangles marking the SW and NE extents of the mine site. The Sula mountain range rises up to about 1000 m above sea level from an extensive, gently undulating plateau of 300 m to the west and 400 m to the east.

The dry season runs from December to March, with very little rain or cloud. Especially during December and January, the ‘Harmattan’ wind may occur, a dry wind blowing from the east or north-east which leads to poor visibility due to the dust which it carries, as well as a reduction in humidity.

Rainfall at the mine site is spread much more evenly throughout the wet season than at the coast. In the early wet season, thunderstorms start to develop in the highlands, particularly during the afternoons. These thunderstorms are accompanied by strong easterly squalls which may occasionally produce gusts at gale force. The monsoon rains are shorter and less intense than further south and towards the coast, but there are still some longer periods of rain during July and August. Thundery activity resumes from September to November as the wet season recedes.

## 6.2 Data Sources

There is very little observed data available for the mine site itself as it is a very remote and mountainous area. We have short records of monthly data from Sakasakala (1933 to 1937), located at 576 masl (metres above sea level) in the centre of the mine site, and from Tonkolili Valley / Farangbaya (1957 to 1960), also located in the mine area at 400 masl. There is also a short record of monthly rainfall and evaporation data from Bumbuna (1972 to 1975). The mining will take place at a higher altitude of about 800 masl, and we have 11 months of data from a site at 850 masl in the mine area, as well as 5 months of data from the AWS at Numbara.

To supplement this, we have longer records from sites which may be representative of the mine area. The longest record comes from Kabala, which is 50 km to the north of the mine site at an altitude of 444 masl. From this site we have a 50 year record (1913 to 1968) for a range of weather variables including rainfall, temperature, humidity and wind. We also have 25 years of data from Mabonto, which is just to the south-west of the mine area at the foot of the mountain range (129 masl). In addition, we have rainfall data from two sites on the plateau to the east, Sumbaria and Kaiyima.

## 6.3 Rainfall

The recent data from the AWS sites at Farangbaya and Numbara provide examples of heavy rainfall in September and October. These are characteristically of short duration, but it cannot be assumed that the mid-season pattern will be the same, as orographic and local influences at the mine site may affect rainfall intensities. Maximum values for durations from 10 minutes to one hour are shown in Table 8.

| Duration | AWS data | | | |
|---|---|---|---|---|
| | 10min | 20min | 30min | 60min |
| Depth | 22.6 | 29.5 | 29.7 | 32.3 |

Table 8: Maximum rainfall depths for given durations from analysed records at AWS sites

Extreme value analysis of annual maximum daily totals has been carried out on historic data from Sumbaria and Kabala to obtain daily rainfall totals for a range of return periods (Table 9). There is not enough daily or annual maximum data from the mine area itself to carry out similar analysis. Of the 7 years of annual maxima data available from the mine area, the average is 141 mm, with a range from 102 mm to 173 mm. This suggests that Sumbaria and Kabala are not representative of the mine area, having significantly lower rainfall intensities. The daily intensities from Makeni (Table 43) are most likely to be representative of the mine area, but rainfall intensities at the mining altitude of around 800 masl may be greater than those recorded at around 400 masl. The annual maximum series have also been used to estimate a Probable Maximum Precipitation of 566 mm for Makeni and 459 mm for Kabala.

| Return Period (years) | Sumbaria | | | Kabala | | |
|---|---|---|---|---|---|---|
| | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit |
| 10 | 141.4 | 120.6 | 162.1 | 131.2 | 117.1 | 145.2 |
| 20 | 157.0 | 130.8 | 183.3 | 146.9 | 129.2 | 164.6 |
| 50 | 177.2 | 143.5 | 211.0 | 167.3 | 144.4 | 190.1 |
| 100 | 192.5 | 153.3 | 231.6 | 182.6 | 156.1 | 209.0 |
| 500 | 227.5 | 176.2 | 278.8 | 217.8 | 183.2 | 252.5 |

Table 9: Estimated daily rainfall totals with 95 % confidence intervals for a range of return periods. Sumbaria analysis based on 20 years from 1948 to 1968 and Kabala based on 45 years from 1913 to 1968.

The theoretical profiles for 15 and 8 hour storms (Tables 5 and 6) have been applied to the estimates of 10 and 50 year return period 1-day rainfalls at Makeni and Kabala. The maximum 1-hour rainfall during these design storms is shown in Table 10, while the full design storms are provided in Appendix 2.

| Location | 1 in 10-year | | 1 in 50-year | |
|---|---|---|---|---|
| | 8-hour | 15-hour | 8-hour | 15-hour |
| Makeni | 115.6 | 76.5 | 147.6 | 97.7 |
| Kabala | 88.4 | 50.5 | 113.6 | 75.2 |

Table 10: Maximum 1-hour rainfall (mm) for design storms of 8 and 15 hours

The theoretical profile of 5-minute rainfall (Table 7) has been applied to the maximum 1-hour rainfall from the 8-hour storm, giving the estimates of maximum 5-minute rainfall in Table 11 (the full profile is provided in Appendix 2).

| Location | Rainfall, mm | |
|---|---|---|
| | 10-year | 50-year |
| Makeni | 24.3 | 31.0 |
| Kabala | 18.6 | 23.8 |

Table 11: Estimates of maximum 5-minute rainfall at Makeni and Kabala

Monthly averages of rainfall for the 1923 to 1968 period are shown in Table 12 for Mabonto, Sumbaria and Kabala. Where possible, missing monthly values have been estimated by linear regression against the best correlated neighbour stations. Mabonto has a surprisingly high rainfall, and is probably affected by rainfall which develops due to the orographic uplift of the mountain range of the mining area, which is just to the north-east. Sumbaria, and especially Kabala, have much less rainfall during the June to September period.

| **Month** | **Mabonto** | **Sumbaria** | **Kabala** |
|---|---|---|---|
| January | 14.0 | 9.7 | 9.1 |
| February | 20.8 | 21.0 | 13.1 |
| March | 59.0 | 81.3 | 47.1 |
| April | 111.4 | 122.0 | 102.4 |
| May | 240.8 | 268.0 | 196.4 |
| June | 403.0 | 329.8 | 318.3 |
| July | 570.4 | 404.4 | 316.5 |
| August | 746.4 | 421.3 | 381.3 |
| September | 600.8 | 420.7 | 407.3 |
| October | 426.4 | 390.2 | 343.6 |
| November | 208.5 | 184.1 | 111.2 |
| December | 29.5 | 32.4 | 17.7 |
| **Annual** | **3431.0** | **2684.8** | **2263.9** |

Table 12: Monthly averages of rainfall (mm) for Mabonto, Sumbaria and Kabala, 1923 to 1968.

Table 13 provides monthly rainfall averages for the short data records from the mine area itself. As these records are no more than 5 years in length, the values have high uncertainty, but they give an indication of the annual cycle of rainfall in the area and the different short records generally agree well. The combined series of these short records has an annual average rainfall of just over 3000 mm. This series has been correlated against other long periods stations (Table 14), and the best correlation is with Makeni. There is not enough data from the mine area to analyse trends over time, but there is very little trend at Makeni (Figure 7) so this may also be the case for the mine area.

 

| Month | Sakasakala (1933 – 1937) | Farangbaya (1937; 1957 – 1960) | Bumbuna (1972 – 1975) | Combined mine area series |
|---|---|---|---|---|
| January | 0.0 | 3.4 | 0.0 | 1.1 |
| February | 14.1 | 12.3 | 0.0 | 9.3 |
| March | 52.9 | 56.6 | 19.7 | 46.0 |
| April | 126.6 | 68.7 | 54.0 | 93.2 |
| May | 209.2 | 245.7 | 155.2 | 213.7 |
| June | 281.8 | 327.0 | 286.0 | 317.2 |
| July | 481.0 | 588.2 | 563.0 | 516.7 |
| August | 659.9 | 878.3 | 724.0 | 731.6 |
| September | 522.6 | 661.3 | 457.0 | 562.2 |
| October | 350.6 | 322.9 | 417.3 | 368.9 |
| November | 192.2 | 185.7 | 114.3 | 182.6 |
| December | 38.6 | 14.2 | 16.1 | 24.1 |
| **Annual** | **2929.3** | **3364.1** | **2806.6** | **3066.6** |

Table 13: Monthly averages of rainfall (mm) for locations in the mine area for different short periods, and a combined series.

| Station | Correlation Coefficient (r) |
|---|---|
| Makeni | 0.91 |
| Mabonto | 0.85 |
| Sumbaria | 0.83 |
| Kabala | 0.79 |

Table 14: Correlation coefficients of neighbour stations with the combined series of monthly rainfall for the mine area.

The combined series of annual rainfall values from the mine area has been extended by regression against data from Makeni, and extreme value analysis has been carried out on the resulting series in order to obtain estimated rainfall amounts for a range of recurrence intervals, both for wet years and dry years. The results, including 95 % confidence intervals for the estimates, are shown in table 15.

 

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2991 | 2907 | 3060 | 3398 | 3340 | 3456 |
| 10 | 2864 | 2746 | 2944 | 3488 | 3433 | 3548 |
| 20 | 2752 | 2583 | 2847 | 3552 | 3500 | 3621 |
| 50 | 2620 | 2371 | 2741 | 3611 | 3563 | 3697 |
| 100 | 2530 | 2216 | 2673 | 3643 | 3596 | 3736 |
| 500 | 2347 | 1855 | 2552 | 3690 | 3644 | 3802 |

Table 15: Annual rainfall dry year and wet year totals for a range of return periods, for a mine area series, extended by regression against data from Makeni (1923 to 2005).

## 6.4 Temperature

As the temperature varies much less from year to year than rainfall, it is possible to make good estimates of average temperature from only a few years of data. Table 16 and Figure 2 provide averages of daily maximum and minimum temperature for the mine area and for Kabala, which is 50 km to the north. Temperature is strongly dependant on altitude, so data from the mine area has been split into records coming from an altitude of 400 – 500 masl (4 - 5 years of data), and records coming from about 800 masl (1 - 2 years of data). The values compare well with those from Kabala (for the 30 year period 1939 to 1968), with the main differences being that Kabala get a bit hotter in the day-time in February and March, and colder at night in December and January. As the high altitude record is only 1 – 2 years, it has less confidence, but still gives a good indication of the effect of altitude in lowering the daily maximum temperatures by approximately 2 ℃. Daily minimum temperatures are also lower in t he wet season.

 

| Month | Mean daily maximum | | | Mean daily minimum | | |
|---|---|---|---|---|---|---|
| | Mine (c. 400m) | Mine (c. 800m) | Kabala | Mine (c. 400m) | Mine (c. 800m) | Kabala |
| January | 32.2 | 30.6 | 32.1 | 18.7 | 19.7 | 16.6 |
| February | 33.1 | 30.3 | 34.3 | 19.6 | 19.3 | 19.2 |
| March | 33.6 | 30.7 | 34.7 | 20.6 | 19.3 | 20.8 |
| April | 32.8 | 29.9 | 33.1 | 21.3 | 19.2 | 21.5 |
| May | 30.2 | 26.7 | 31.3 | 20.3 | 18.2 | 21.3 |
| June | 29.9 | 25.8 | 29.5 | 20.8 | 18.8 | 20.6 |
| July | 27.3 | 24.4 | 27.5 | 20.8 | 18.4 | 20.4 |
| August | 26.1 | 23.8 | 26.9 | 20.0 | 19.2 | 20.4 |
| September | 28.1 | 25.1 | 28.6 | 20.0 | 18.7 | 20.3 |
| October | 30.1 | 27.3 | 30.0 | 20.1 | 18.4 | 20.1 |
| November | 29.8 | 27.7 | 30.6 | 20.3 | 19.2 | 19.6 |
| December | 30.8 | 28.4 | 30.8 | 19.4 | 19.2 | 16.6 |
| **Annual** | **30.3** | **27.5** | **30.8** | **20.1** | **19.0** | **19.8** |

Table 16: Monthly mean daily maximum and daily minimum air temperatures for sites in the mine area at around 400 masl (4-5 years of data) and at around 800 masl (1-2 years of data), and for Kabala (1939 to 1968 period).

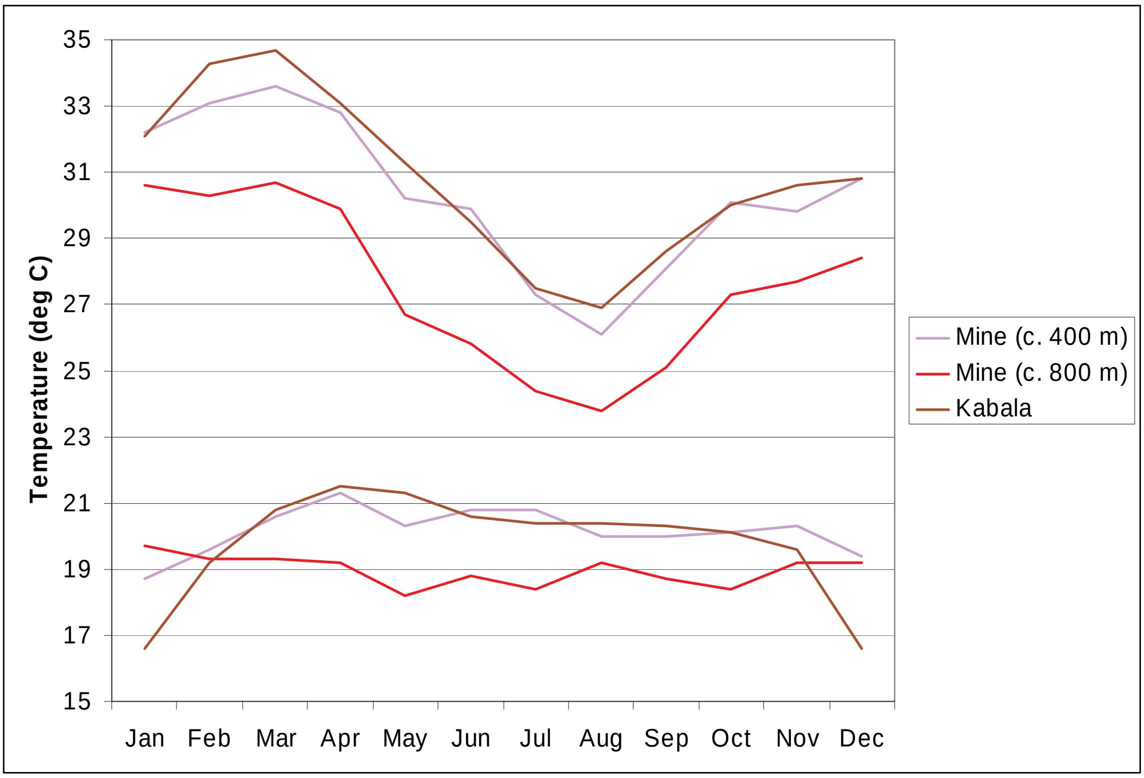


Figure 2: Monthly mean daily maximum and minimum air temperatures for Kabala (1939 to 1968), and for short records from the mine area at approx 400 masl and 800 masl.

Table 17 provides monthly statistics of mean temperature for Kabala. The 20th and 80th percentile values show that there is very little inter-annual variability.

| Month | 20th %ile | Median | Mean | 80th %ile |
|---|---|---|---|---|
| January | 23.9 | 24.5 | 24.5 | 25.0 |
| February | 26.3 | 26.7 | 26.8 | 27.1 |
| March | 27.5 | 27.9 | 27.9 | 28.2 |
| April | 27.1 | 27.6 | 27.5 | 27.9 |
| May | 26.1 | 26.4 | 26.6 | 27.2 |
| June | 24.7 | 25.1 | 25.2 | 25.6 |
| July | 23.7 | 24.2 | 24.2 | 24.7 |
| August | 23.3 | 23.8 | 23.9 | 24.3 |
| September | 24.2 | 24.4 | 24.6 | 24.9 |
| October | 24.7 | 25.0 | 25.1 | 25.4 |
| November | 24.7 | 25.2 | 25.2 | 25.5 |
| December | 23.1 | 23.6 | 23.8 | 24.6 |

Table 17: Monthly statistics of mean temperature for Kabala (1923 to 1968).

## 6.5 Relative Humidity

Table 18 shows monthly averages of morning (usually measured at 09 GMT) and afternoon (usually measured at 15 GMT) relative humidity (RH). The data from Kabala is for the period 1955 to 1968, while data from Farangbaya (a site in the mine area at 400 masl) is for 1957 to 1961. AWS data from the mine site for the period October 2009 to January 2010 has been added to this. According to model data for the mine area (Figure 3), 15 GMT is the time of minimum RH in the diurnal cycle, while 09 GMT is just after the time of maximum RH, which occurs at around 06 GMT. The maximum daily RH would be expected to be between 8 – 10 % higher than the 09 GMT values shown. The annual cycle of RH reaches a peak in August, while the time of lowest RH is in the afternoons of January to February when dry air is often brought from the north by the Harmattan wind.

| Month | Morning (09 GMT) | | Afternoon (15 GMT) | |
|---|---|---|---|---|
| | Kabala | Farangbaya | Kabala | Farangbaya |
| January | 73.7 | 78.1 | 28.1 | 48.0 |
| February | 75.4 | 80.7 | 29.3 | 42.7 |
| March | 77.6 | 83.3 | 35.3 | 49.0 |
| April | 80.0 | 79.7 | 47.4 | 56.3 |
| May | 86.3 | 89.0 | 61.4 | 69.0 |
| June | 90.6 | 91.0 | 69.1 | 80.0 |
| July | 93.0 | 95.3 | 74.4 | 83.3 |
| August | 94.6 | 96.0 | 78.6 | 88.3 |
| September | 93.0 | 94.0 | 72.6 | 79.5 |
| October | 90.8 | 86.9 | 67.3 | 74.3 |
| November | 91.8 | 89.2 | 58.6 | 73.5 |
| December | 81.6 | 77.9 | 39.0 | 59.1 |
| **Annual** | **85.7** | **86.8** | **55.1** | **66.9** |

Table 18: Monthly averages of morning (09 GMT) and afternoon (15 GMT) relative humidity at Kabala (1955 to 1968) and Farangbaira (1957 to 1961; 2009 to 2010)

Comparison of the very short data records available from higher altitude sites in the mine area suggests that RH is much lower in the December to March period at an altitude of approximately 800 masl. In the wet season, however, RH is similar to, and sometimes higher than at the lower altitude sites.

 

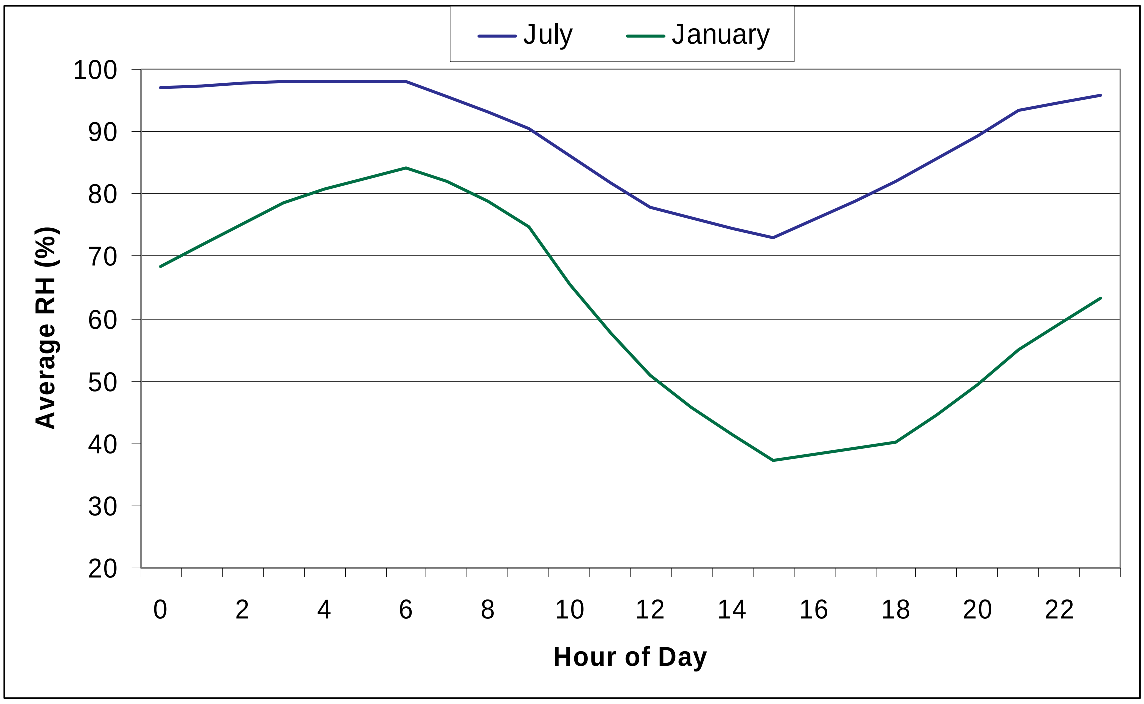


Figure 3: Average diurnal cycle of relative humidity (%) in the mine area (from model data), for July and January.

## 6.6 Evaporation

Monthly averages of evaporation for Bumbuna are given in Table 19. This shows that evaporation reaches a peak in the monthly cycle in March, and dips to a low in September. The actual values cannot be relied upon due to the short duration of the record and uncertainty in differences between the measuring methods.

| Month | Bumbuna |
|---|---|
| January | 185 |
| February | 200 |
| March | 242 |
| April | 193 |
| May | 182 |
| June | 135 |
| July | 125 |
| August | 106 |
| September | 102 |
| October | 115 |
| November | 143 |
| December | 164 |
| Annual | 1891 |

Table 19: Average monthly total evaporation (mm) from a ‘Class A’ land pan at Bumbuna (1972 to 1975)

## 6.7 Wind

Wind speed and direction data is available from Kabala for the period 1955 to 1968, but the speed is only recorded in categories of Beaufort Force. For details of the Beaufort Scale, see http://www.metoffice.gov.uk/weather/marine/guide/beaufortscale.html. Model data has been extracted for the mine area, and monthly averages are shown in Table 20 along with those from Kabala. Kabala has its highest mean wind speeds from January to March, while the model data has a double peak in the annual cycle, in March to April and July to August. The lowest mean speeds occur in November.

| Month | Kabala | Mine area (model) |
|---|---|---|
| January | 3.5 | 2.7 |
| February | 3.6 | 3.1 |
| March | 3.4 | 3.7 |
| April | 3.2 | 4.0 |
| May | 3.1 | 3.2 |
| June | 3.0 | 3.2 |
| July | 3.1 | 3.6 |
| August | 3.1 | 3.7 |
| September | 2.9 | 3.1 |
| October | 3.0 | 2.5 |
| November | 2.8 | 2.0 |
| December | 3.2 | 2.2 |
| **Annual** | **3.2** | **3.1** |

Table 20: Monthly mean wind speed (knots) at Kabala (1955 to 1968) and from model data for the mine area (200 to 2009).

Wind data from the AWS sites which have been operating since September 2009 is shown in Table 21. This clearly shows the effect of altitude and local exposure, as the exposed site at Numbara (800 masl) has much greater mean wind speeds than the site at Farngbaya (400 masl). The wind speeds at Numbara are also significantly greater than those which would be expected for Kabala or Makeni (the mean wind speed for November 2009 at Makeni was recorded as 1.3 knots). The maximum gust speeds at the two sites are similar, however. This is the only gust speed data available, and is not sufficient for further analysis, but does give an indication of the likely gust speeds in this mountainous area.

| Month | Farangbaya | | Numbara | |
|---|---|---|---|---|
| | Mean wind speed (knots) | Max gust speed (knots) | Mean wind speed (knots) | Max gust speed (knots) |
| 15-30 Sep 2009 | 1.7 | 44 | 4.7 | 41 |
| Oct 2009 | 1.6 | 47 | 4.1 | 40 |
| Nov 2009 | 1.1 | 33 | 4.0 | 25 |
| Dec 2009 | 1.0 | 26 | 4.6 | 38 |
| Jan 2010 | 0.7 | 27 | 4.7 | 32 |

Table 21: Monthly mean wind speed and maximum gust speed (knots) from the AWS sites in the mine area at Farangbaya and Numbara, September 2009 to January 2010.

The frequency of high wind speeds at Kabala is provided in Table 22, alongside comparative frequencies from the AWS sites. The short record at the AWS sites means that these values should not be considered at all robust, especially as they do not cover the windiest times of year.

| Wind speed | Kabala | Farangbaya | Numbara |
|---|---|---|---|
| > 11 knots | 2.85 % | 0.46 % | 2.58 % |
| > 17 knots | n/a | 0.13 % | 0.33 % |
| > 22 knots | 0.02 % | 0.03 % | 0.06 % |
| > 28 knots | n/a | 0.00 % | 0.00 % |
| > 34 knots | 0.00 % | 0.00 % | 0.00 % |

Table 22: Percentage frequency of mean wind speeds exceeding certain thresholds at Kabala (1955 to 1968), Farangbaya and Numbara (Sep 2009 to Jan 2010).

Table 23 provides the monthly frequency of directions from which the wind blows at Kabala. The dominant directions are southerly and south-westerly (February to November) and northerly and north-easterly (December to January). These northerly Harmattan winds bring dry air which lowers the humidity.

| Month | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| Jan | 35 | 19 | 3 | 6 | 11 | 11 | 3 | 5 |
| Feb | 17 | 12 | 2 | 10 | 22 | 25 | 4 | 5 |
| Mar | 6 | 6 | 3 | 13 | 29 | 30 | 3 | 5 |
| Apr | 5 | 4 | 2 | 15 | 35 | 29 | 2 | 4 |
| May | 7 | 6 | 1 | 12 | 31 | 30 | 3 | 5 |
| Jun | 8 | 5 | 2 | 14 | 31 | 28 | 2 | 4 |
| Jul | 5 | 2 | 0 | 9 | 38 | 37 | 2 | 2 |
| Aug | 2 | 1 | 0 | 6 | 40 | 43 | 2 | 1 |
| Sep | 8 | 6 | 2 | 11 | 30 | 29 | 3 | 6 |
| Oct | 14 | 11 | 4 | 14 | 22 | 19 | 3 | 7 |
| Nov | 15 | 11 | 3 | 14 | 22 | 19 | 3 | 6 |
| Dec | 30 | 21 | 2 | 6 | 10 | 13 | 1 | 7 |
| **Annual** | **13** | **9** | **2** | **11** | **27** | **26** | **3** | **5** |

Table 23: Monthly percentage frequencies of wind direction for Kabala (1955 to 1968).

# 7. Area 2: Tagrin Point and Pepel Port

## 7.1 Climate overview

Tagrin Point and Pepel Port, marked by red triangles on the map (Figure 1) are located on the northern side of the Sierra Leone harbour, opposite the Freetown peninsula. The Freetown peninsula reaches an altitude of 800 m and provides some shelter to the harbour. Tagrin Point is at the end of the railway alignment, 165 km WSW from the mine site.

Sea temperatures off the coast of Freetown are around 27 °C with little seasonal variation. Air temperatures also have little seasonal variation as the location is only 8.5° north of the Equator. They remain hot throughout the year with a peak in April and May.

The dry season runs from December to March, and is characterised by fine days, with perhaps a little cloud drifting in from the sea. The Harmattan wind sometimes reaches the coast from the east, causing a reduction in visibility. Land breezes (from the north-east) often occur after sunrise, before the flow reverts to the prevailing south-westerly by noon, reaching its peak speed in the early afternoon.

 

April to June is the early wet season or the ‘pre-monsoon’ season. Some convective thunderstorms start to develop (but less than further inland), carried from the east by the easterly winds at mid-levels. These storms are often accompanied by strong easterly winds which can cause choppy seas in the harbour. The rain showers in June and October can be particularly intense. From July through to September is the monsoon season, with large amounts of cloud and long periods of rain, at times occurring with high intensity. The south-west (ocean-facing) side of the Freetown peninsula has an annual average rainfall of 5000 - 6800 mm, while the north-eastern side of the peninsula and the area on the opposite side of the harbour receive only an annual average of 3000 – 3500 mm due to the rain shadow effect of the peninsula’s orography. Rainfall increases with altitude, especially in the rain shadow, and decreases with distance from the coast (Hayward and Clarke, 1996; Kamara and Jackson, 1997b).

Humidity is high throughout the year, but is especially high during the monsoon season. The steady prevailing wind flows from the south-west during this period, especially during the afternoon and evening. The persistence of SW winds may cause large waves (swell). During October and November the wet season rapidly subsides, with further convective showers occurring.

### 7.2 Data Sources

We have a high quality, long period record from Lungi Airport, which can be considered representative of Tagrin Point, although being 12 km to the north it may be less affected by the rain shadow of the Freetown Peninsula than Tagrin Point. The data runs from 1947 to 2007, although some variables are only available for part of this time. The record includes daily and monthly rainfall; wind speed and direction, as well as monthly averages of temperature, humidity and evaporation. Freetown is located just on the opposite side of the harbour entrance from Tagrin Point and we have a long record of daily rainfall data from here, running from 1916 to 1948, as well as 60 years of monthly data for a range of variables from 1909 to 1968. Other nearby stations for which we have shorter records include Kissy Dockyard and Cline Town.

We also have data from a weather station which operated at Pepel Port from 1933 to 1967, recording observations of rainfall, temperature and humidity. Although this stations is possible less reliable, and is a shorter record with some missing data, it will be useful for assessing the climate of Pepel Port.

## 7.3 Rainfall

The analysis of hourly rainfall data from Freetown (1944-47) has given some insight into the intensity-duration characteristics of storm rainfall. The maximum values for durations from 1 hour to 8 hours are shown in Table 24.

| **Duration** | 1hr | 2hr | 3hr | 5hr | 8hr |
|---|---|---|---|---|---|
| **Depth** | 150.0 | 206.2 | 212.5 | 220.4 | 226.6 |

Table 24: Maximum rainfall depths at Freetown for given durations from analysed records

Extreme value analysis of annual maximum daily totals has been carried out on historic data from Freetown, Lungi and Pepel to obtain daily rainfall totals for a range of return periods. Values for Freetown and Lungi (Table 25) are very similar, which places good confidence in using these results for Tagrin Point. The results show that Pepel is likely to experience less intense rainfall on a daily timescale (Table 26). The annual maximum series from Freetown has also been used to estimate a Probable Maximum Precipitation of 799 mm.

| **Return Period (years)** | **Freetown** | | | **Lungi** | | |
|---|---|---|---|---|---|---|
| | **Estimate (mm)** | **95 % confidence lower limit** | **95 % confidence upper limit** | **Estimate (mm)** | **95 % confidence lower limit** | **95 % confidence upper limit** |
| 10 | 249.1 | 224.6 | 273.6 | 251.5 | 207.7 | 295.3 |
| 20 | 280.0 | 249.1 | 310.9 | 285.2 | 229.8 | 340.6 |
| 50 | 320.0 | 280.2 | 359.8 | 328.8 | 257.7 | 400.0 |
| 100 | 350.1 | 303.9 | 396.2 | 361.5 | 278.9 | 444.2 |
| 500 | 419.2 | 358.8 | 479.7 | 436.9 | 328.7 | 545.2 |

Table 25: Estimated daily rainfall totals with 95 % confidence intervals for a range of return periods. Freetown analysis based on 59 years from 1909 to 1968 and Lungi based on 21 years from 1948 to 1968.

| Return Period (years) | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit |
|---|---|---|---|
| 10 | 199.9 | 165.3 | 234.5 |
| 20 | 227.9 | 184.2 | 271.6 |
| 50 | 264.1 | 207.8 | 320.3 |
| 100 | 291.3 | 226.0 | 356.5 |
| 500 | 353.9 | 268.5 | 439.3 |

Table 26: Estimated daily rainfall totals with 95 % confidence intervals for a range of return periods, for Pepel (based on 23 years data from 1941 to 1965).

The theoretical profiles for 15 and 8 hour storms (Tables 5 and 6) have been applied to the estimates of 10 and 50 year return period 1-day rainfalls at Freetown. The maximum 1-hour rainfall during these design storms is shown in Table 27, while the full design storms are provided in Appendix 2.

| Location | 1 in 10-year | | 1 in 50-year | |
|---|---|---|---|---|
| | 8-hour | 15-hour | 8-hour | 15-hour |
| Freetown | 152.7 | 101.1 | 190.5 | 126.1 |

Table 27: Maximum 1-hour rainfall (mm) for design storms of 8 and 15 hours

The theoretical profile of 5-minute rainfall (Table 7) has been applied to the maximum 1-hour rainfall from the 8-hour storm, giving the estimates of maximum 5-minute rainfall in Table 28 (the full profile is provided in Appendix 2).

| Location | Rainfall, mm | |
|---|---|---|
| | 10-year | 50-year |
| Freetown | 32.1 | 40.0 |

Table 28: Estimates of maximum 5-minute rainfall at Freetown

Monthly averages of rainfall for the 1923 to 1968 period are shown in Table 29 for Freetown, Lungi, Kissy Dockyard, Cline Town and Pepel. Where possible, missing monthly values have been estimated by linear regression against the best correlated neighbour stations. The table shows the strong seasonal cycle of rainfall, peaking in July and August, and with very little rainfall from December to March. The values for Freetown and Lungi are very similar, although Lungi had more rainfall in May and

August, while Freetown had more in July. Pepel stands out as having significantly less rainfall than the other locations in the June to September period. This may be because it is more sheltered from the monsoon rains by the Freetown Peninsula than the other locations.

Table 30 gives further monthly statistics for Freetown for the 1923 to 1968 period. The 20th and 80th percentile values give an indication of dry and wet months that have been experienced, equivalent to a 5 year return period.

| Month | Freetown | Lungi | Kissy Dock | Cline Town | Pepel |
|---|---|---|---|---|---|
| January | 10.2 | 10.0 | 9.4 | 7.9 | 6.5 |
| February | 8.8 | 4.0 | 8.1 | 4.6 | 5.3 |
| March | 19.2 | 24.5 | 16.6 | 12.0 | 20.2 |
| April | 67.3 | 73.1 | 54.5 | 62.4 | 64.8 |
| May | 179.0 | 219.4 | 210.4 | 189.4 | 189.8 |
| June | 396.4 | 390.1 | 371.6 | 378.4 | 302.8 |
| July | 848.1 | 789.9 | 773.8 | 809.8 | 538.5 |
| August | 829.6 | 861.8 | 825.6 | 786.8 | 620.6 |
| September | 599.2 | 606.9 | 603.6 | 599.6 | 431.3 |
| October | 277.2 | 307.6 | 298.8 | 276.2 | 289.8 |
| November | 134.8 | 148.7 | 171.1 | 159.0 | 137.6 |
| December | 34.1 | 38.7 | 30.3 | 28.8 | 27.2 |
| **Annual** | **3403.8** | **3474.4** | **3373.9** | **3314.9** | **2634.3** |

Table 29: Monthly averages of rainfall (mm) for stations in the port area, 1923 to 1968.

| Month | 20th %ile | Median | Mean | 80th %ile |
|---|---|---|---|---|
| January | 0.0 | 0.0 | 10.2 | 19.0 |
| February | 0.0 | 0.0 | 8.8 | 8.4 |
| March | 0.2 | 5.2 | 19.2 | 35.3 |
| April | 20.4 | 55.5 | 67.3 | 109.3 |
| May | 113.6 | 182.5 | 179.0 | 232.1 |
| June | 267.4 | 346.5 | 396.4 | 505.4 |
| July | 691.4 | 816.5 | 848.1 | 1037.5 |
| August | 622.8 | 860.3 | 829.6 | 1011.6 |
| September | 462.4 | 610.8 | 599.2 | 727.8 |
| October | 190.1 | 248.2 | 277.2 | 363.3 |
| November | 80.5 | 129.9 | 134.8 | 170.1 |
| December | 2.4 | 22.6 | 34.1 | 57.2 |

Table 30: Monthly statistics of rainfall for Freetown, 1923 to 1968.

Table 31 shows monthly statistics from Lungi for the 1971 to 2005 period. This shows that there was considerably less rainfall during this period than during the earlier period of 1923 to 1968. During the May to October period, the rainfall amount was 81 % of the 1923 to 1968 average, while for the November to April period it was just 56 %. The wet season has become shorter and less intense on average compared to the earlier period. Figure 4 shows that there has been a clear decreasing trend in rainfall over the whole period since 1923, and annual rainfall has rarely exceeded 3000 mm in the last 20 years.

| Month | 20th %ile | Median | Mean | 80th %ile |
|---|---|---|---|---|
| January | 0.0 | 0.0 | 5.1 | 0.2 |
| February | 0.0 | 0.0 | 3.8 | 4.5 |
| March | 0.0 | 0.6 | 5.9 | 11.4 |
| April | 3.5 | 34.1 | 41.6 | 78.6 |
| May | 109.0 | 159.6 | 160.1 | 213.3 |
| June | 244.8 | 303.8 | 322.7 | 401.7 |
| July | 494.7 | 605.3 | 628.0 | 747.9 |
| August | 539.7 | 712.7 | 700.0 | 868.3 |
| September | 355.8 | 419.3 | 468.3 | 626.7 |
| October | 207.8 | 278.5 | 296.6 | 329.2 |
| November | 49.4 | 83.5 | 90.7 | 137.3 |
| December | 0.0 | 5.3 | 20.2 | 36.0 |
| **Annual** | **2446.6** | **2764.9** | **2743.1** | **3099.1** |

Table 31: Monthly statistics of rainfall for Lungi, 1971 to 2005.

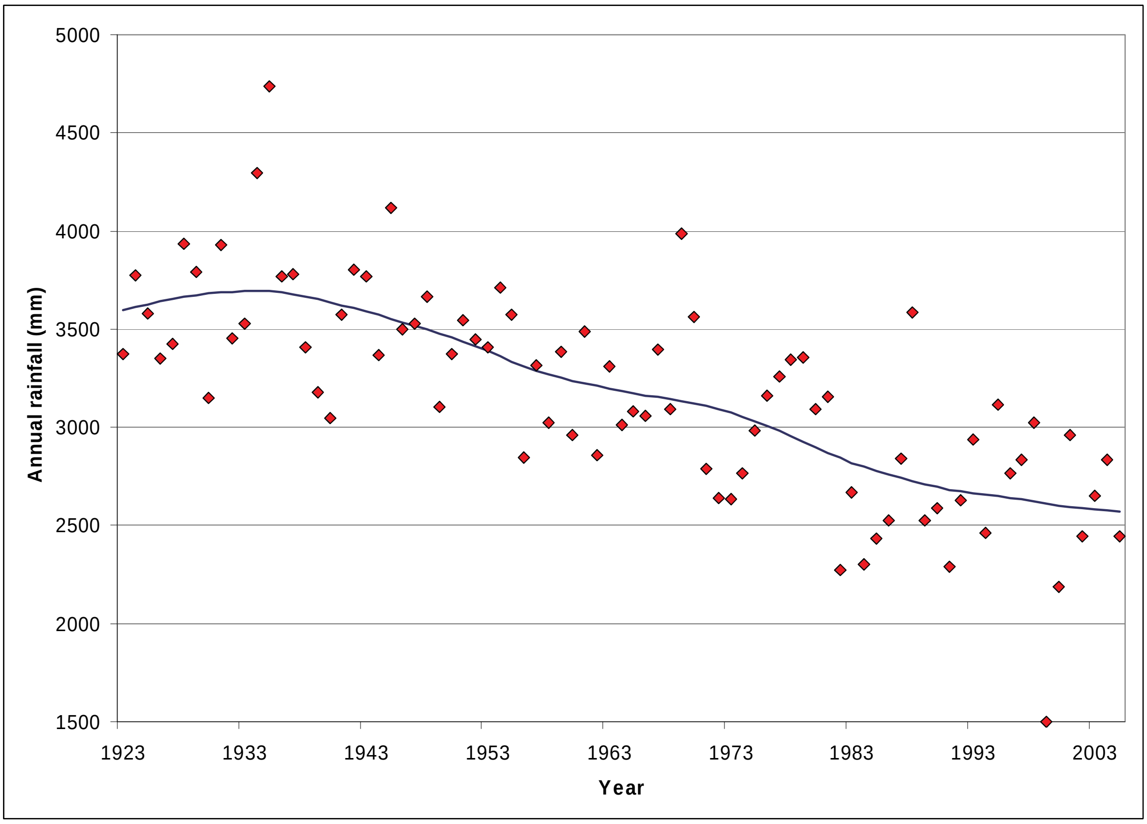


Figure 4: Time series graph of annual rainfall at Lungi, showing the variability and trend from 1923 to 2005.

An extreme value analysis of annual rainfall totals at Lungi and Pepel was carried out in order to obtain estimated rainfall amounts for a range of recurrence intervals, both for wet years and dry years. The results, including 95 % confidence intervals for the estimates, are shown in tables 32 and 33. The annual rainfall at Lungi for 1999 of just 1502 mm is estimated to be a very rare event of approximately 1 in 500 years. This is such an outlier (see Figure 4) that it may possibly be in error.

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2704 | 2550 | 2842 | 3635 | 3515 | 3803 |
| 10 | 2444 | 2257 | 2592 | 3890 | 3759 | 4078 |
| 20 | 2229 | 1995 | 2390 | 4092 | 3952 | 4317 |
| 50 | 1998 | 1680 | 2176 | 4306 | 4152 | 4594 |
| 100 | 1853 | 1473 | 2045 | 4436 | 4273 | 4762 |
| 500 | 1592 | 1078 | 1818 | 4661 | 4474 | 5088 |

Table 32: Annual rainfall dry year and wet year totals for a range of return periods, for Lungi (based on data for 1923 to 2005)

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2294 | 2070 | 2454 | 2909 | 2775 | 3055 |
| 10 | 2111 | 1802 | 2286 | 3034 | 2914 | 3220 |
| 20 | 1958 | 1571 | 2151 | 3119 | 3011 | 3313 |
| 50 | 1787 | 1249 | 2010 | 3196 | 3095 | 3437 |
| 100 | 1676 | 999 | 1926 | 3235 | 3136 | 3522 |
| 500 | 1467 | 426 | 1788 | 3289 | 3187 | 3673 |

Table 33: Annual rainfall dry year and wet year totals for a range of return periods, for Pepel (based on data for 1939 to 1965)

### 7.4 Temperature

Monthly averages of daily maximum and daily minimum air temperature for the 30 year period from 1939 to 1968 are shown in Table 34 and Figure 5. Again missing values have been estimated where possible. Pepel has the greatest diurnal variation and

Freetown the least. These differences could be partly due to the local exposure of the sites. There is little variability throughout the annual cycle, especially at Freetown. The highest temperatures occur in April.

| Month | Mean daily maximum | | | Mean daily minimum | | |
|---|---|---|---|---|---|---|
| | Freetown | Lungi | Pepel | Freetown | Lungi | Pepel |
| January | 29.2 | 30.5 | 31.5 | 24.1 | 22.3 | 21.8 |
| February | 29.6 | 30.6 | 32.3 | 24.4 | 23.4 | 22.2 |
| March | 30.1 | 30.8 | 32.7 | 24.8 | 24.2 | 23.0 |
| April | 30.3 | 31.0 | 32.7 | 25.2 | 24.6 | 23.1 |
| May | 30.2 | 30.6 | 32.1 | 24.7 | 23.9 | 22.9 |
| June | 29.6 | 29.4 | 30.5 | 23.7 | 23.0 | 22.3 |
| July | 28.2 | 27.8 | 28.9 | 23.1 | 22.7 | 22.0 |
| August | 27.7 | 27.2 | 28.3 | 23.1 | 22.9 | 22.2 |
| September | 28.4 | 28.3 | 29.4 | 23.3 | 22.9 | 22.3 |
| October | 29.2 | 29.4 | 30.7 | 23.4 | 22.6 | 22.3 |
| November | 29.4 | 30.1 | 31.2 | 24.0 | 22.9 | 22.4 |
| December | 29.2 | 30.3 | 31.3 | 24.5 | 22.6 | 22.5 |
| **Annual** | **29.3** | **29.7** | **31.0** | **24.0** | **23.2** | **22.4** |

Table 34: Monthly mean daily maximum and daily minimum air temperatures for the 1939 to 1968 period, for stations in the port area.

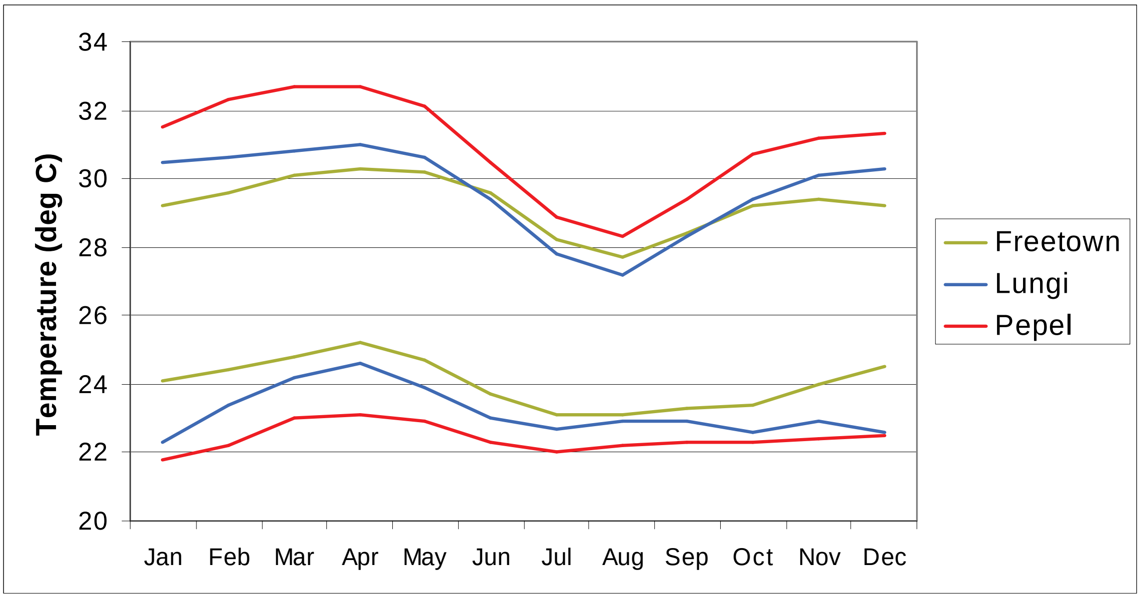


Figure 5: Monthly mean daily maximum and daily minimum air temperatures for the 1939 to 1968 period, for stations in the port area.

Table 35 provides mean temperature statistics for Lungi. The 20th and 80th percentile values show that there is very little inter-annual variability in mean temperature. Data for the 1991 to 2009 period from Lungi (also in Table 35) shows an increase in daily maximum temperature of 0.7 ℃ compared to the earli er period, but no increase in daily minimum temperature. The greatest increase has occurred in the July to December period.

| Month | 20th %ile | Median | Mean | 80th %ile | Mean (1991-2009) |
|---|---|---|---|---|---|
| January | 26.1 | 26.4 | 26.4 | 26.8 | 26.8 |
| February | 26.6 | 27.1 | 27.0 | 27.4 | 27.2 |
| March | 27.2 | 27.6 | 27.5 | 27.8 | 27.5 |
| April | 27.5 | 27.8 | 27.8 | 28.2 | 27.6 |
| May | 26.9 | 27.2 | 27.3 | 27.6 | 27.5 |
| June | 25.8 | 26.2 | 26.2 | 26.4 | 26.6 |
| July | 25.0 | 25.3 | 25.3 | 25.5 | 25.8 |
| August | 24.8 | 25.2 | 25.1 | 25.3 | 25.5 |
| September | 25.3 | 25.7 | 25.6 | 26.0 | 26.1 |
| October | 25.8 | 26.1 | 26.0 | 26.3 | 26.6 |
| November | 26.2 | 26.6 | 26.5 | 26.9 | 27.1 |
| December | 26.1 | 26.5 | 26.5 | 26.9 | 27.0 |

Table 35: Monthly statistics of mean temperature for Lungi (1939 to 1968), and monthly mean temperature for 1991 to 2009 for comparison.

### 7.5 Relative Humidity

Table 36 shows monthly averages of morning (usually measured at 09 GMT) and afternoon (usually measured at 15 GMT) relative humidity (RH). The data from Freetown and Pepel is for the 30 year period 1939 to 1968, while data from Lungi is for 1947 to 1968 and 1991 to 2009. There is less data for the afternoon, however, as these values were not recorded from 1939 to 1942 nor from 1943 to 1946. According to model data for the port area, 15 GMT is the time of minimum RH in the diurnal cycle, while 09 GMT is just after the time of maximum RH, which occurs at around 06 GMT. The maximum daily RH would be expected to be between 2 – 3 % higher than the 09 GMT values shown. The annual cycle of RH reaches a peak in August to September, while the time of lowest RH is in the afternoons of January to February.

| Month | Morning (09 GMT) | | | Afternoon (15 GMT) | | |
|---|---|---|---|---|---|---|
| | Freetown | Lungi | Pepel | Freetown | Lungi | Pepel |
| January | 82.0 | 87.4 | 88.2 | 69.7 | 59.7 | 61.9 |
| February | 80.6 | 84.1 | 88.0 | 69.2 | 62.2 | 59.6 |
| March | 80.7 | 79.7 | 85.9 | 70.7 | 64.3 | 59.5 |
| April | 81.1 | 78.5 | 83.8 | 71.5 | 65.7 | 64.2 |
| May | 83.2 | 82.7 | 86.1 | 74.7 | 70.2 | 70.2 |
| June | 87.2 | 88.1 | 88.4 | 77.8 | 77.9 | 77.0 |
| July | 89.9 | 91.0 | 89.9 | 80.9 | 81.6 | 80.8 |
| August | 90.2 | 91.0 | 91.4 | 81.9 | 83.5 | 81.7 |
| September | 90.5 | 91.1 | 90.1 | 80.7 | 80.4 | 79.6 |
| October | 87.7 | 88.6 | 88.6 | 77.4 | 75.5 | 73.4 |
| November | 85.7 | 87.6 | 88.4 | 76.4 | 72.7 | 71.6 |
| December | 83.1 | 88.3 | 87.7 | 71.9 | 65.1 | 66.8 |
| **Annual** | **85.2** | **86.5** | **88.0** | **75.2** | **71.6** | **70.5** |

Table 36: Monthly mean morning (09 GMT) and afternoon (15 GMT) relative humidity (%) for Freetown (1939 – 1968), Lungi (1948 – 1968; 1991 – 2009) and Pepel (1939 – 1968)

In a similar way to temperature, there is little inter-annual variability in RH, and can be seen in the regularity and consistency of the annual cycle from Lungi shown in Figure 6.

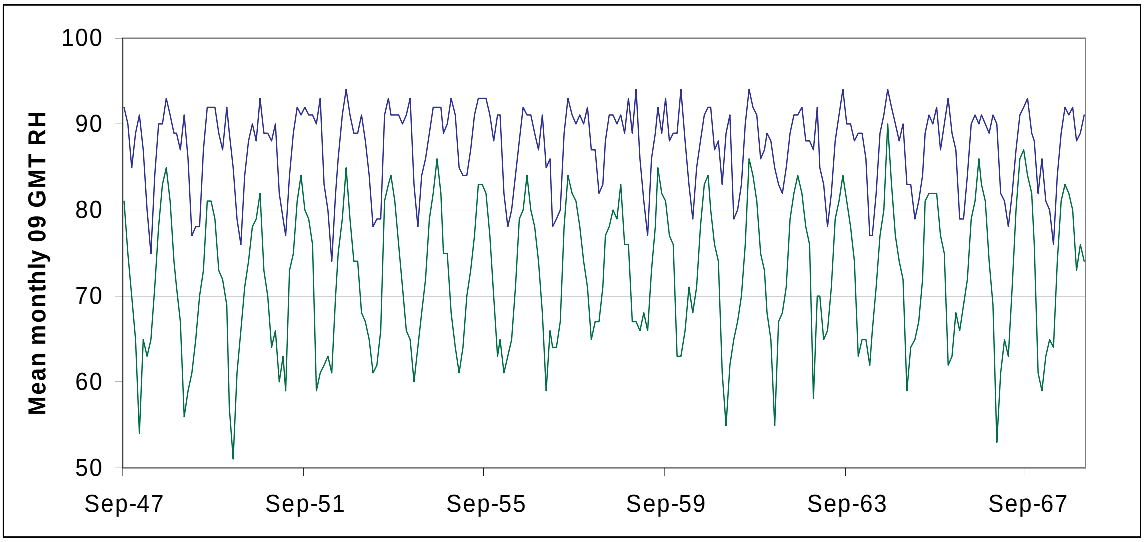


Figure 6: Monthly mean 09 GMT (blue line) and 15 GMT (green line) relative humidity at Lungi, 1947 to 1968.

## 7.6 Evaporation

Table 37 provides monthly averages of evaporation. Although the data from the Piche evaporimeters at Lungi and Kortright are expressed in different units, they seem to be roughly comparable. These values give a good indication of the annual cycle of evaporation, but are not directly comparable to free water measurements made using a pan or tank, and should only be considered as an index of evaporation. The annual cycle of evaporation at Lungi (Table 37) has a maximum in March and a minimum in August. Free water evaporations measurements such as those from the raised tank are known to be susceptible to over-reading during heavy rainfall events, and this seems to have occurred at Kortright giving dubious high values for July to September.

| Month | Lungi (Piché) | Kortright (Piché) | Kortright (raised tank) |
|---|---|---|---|
| January | 145 | 91 | 129 |
| February | 142 | 147 | 210 |
| March | 174 | 121 | 219 |
| April | 152 | 104 | 180 |
| May | 122 | 65 | 142 |
| June | 86 | 49 | 116 |
| July | 67 | 35 | 337 |
| August | 59 | 32 | 189 |
| September | 72 | 37 | 169 |
| October | 85 | 49 | 148 |
| November | 95 | 52 | 106 |
| December | 112 | 50 | 99 |
| Annual | 1310 | 832 | 2045 |

Table 37: Monthly averages of total evaporation at Lungi (1970 to 2007) from a Piché evaporimeter in $cm^3$; and Kortright (1968 to 1970) from a Piché evaporimeter and a raised tank (both in mm).

## 7.7 Wind

Wind speed and direction data recorded at three times during the day is available from Lungi for the period 1947 to 1968, but the speed is only recorded as a Beaufort Force. Although this makes precise analysis difficult, the Beaufort Force values have been converted into knots and monthly mean wind speeds are shown in Table 38. These values are higher than the monthly mean wind speeds for the 1984 to 2007 period, also from Lungi. The model data for the port area is more similar to the data from Lungi for the earlier period. Both of these sources show a double peak in the annual cycle, in March – April and July – August. The lowest mean speeds occur during the November to January period.

Monthly maximum gust speeds are also recorded at Lungi from 1954 to 1968, and averages of these are also shown in Table 38. May and June are the months with the highest gust speeds; these are the months when regular squalls pass through the area. The highest recorded gust speed was 62 knots in June 1966.

| Month | Lungi (1947-1968) | Lungi (1984 – 2007) | Model Data | Lungi Max Gust |
|---|---|---|---|---|
| January | 4.8 | 3.3 | 4.1 | 19 |
| February | 5.8 | 3.4 | 5.1 | 17 |
| March | 6.5 | 3.6 | 5.9 | 22 |
| April | 6.4 | 3.9 | 5.9 | 30 |
| May | 5.7 | 4.0 | 4.7 | 37 |
| June | 5.5 | 3.8 | 5.1 | 38 |
| July | 5.6 | 4.0 | 6.1 | 29 |
| August | 6.1 | 3.5 | 6.5 | 21 |
| September | 5.5 | 4.0 | 5.1 | 30 |
| October | 4.9 | 3.8 | 3.9 | 34 |
| November | 4.2 | 3.6 | 3.4 | 33 |
| December | 4.0 | 3.1 | 3.6 | 23 |
| **Annual** | **5.4** | **3.7** | **5.0** | **28** |

Table 38: Monthly average mean wind speeds (knots) for Lungi (1947 to 1968; converted from Beaufort scale), Lungi (1984 to 2007) and model data (2000 to 2009); average monthly maximum gust speed (knots) for Lungi (1954 to 1968).

The data from Lungi for 1947 to 1968 has been analysed for the frequency of high wind speeds (Table 39). This shows that high wind speeds of over 17 knots are rare (occurring less than once a year on average). Most of the occurrences of winds > 22 knots (forces 6+) were in May or June, but most of the force 5 winds (17 – 21 knots) were in July and August, especially in the afternoon. There were three events with wind speed of at least 28 knots recorded in the 20 year period.

| Wind speed | Frequency |
|---|---|
| > 11 knots | 11.9 % |
| > 17 knots | 0.6 % |
| > 22 knots | 0.1 % |
| > 28 knots | 0.01 % |

Table 39: Cumulative frequency of high wind speeds recorded at Lungi from 1947 to 1968.

Table 40 provides the monthly frequency of directions from which the wind blows at Lungi. The dominant directions are westerly (October to May) and south-westerly (June to September).

| Month | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| Jan | 3 | 10 | 13 | 5 | 1 | 14 | 40 | 9 |
| Feb | 3 | 5 | 7 | 4 | 1 | 17 | 49 | 11 |
| Mar | 2 | 3 | 4 | 2 | 2 | 17 | 51 | 18 |
| Apr | 3 | 3 | 4 | 3 | 1 | 15 | 52 | 18 |
| May | 3 | 6 | 9 | 6 | 3 | 17 | 39 | 13 |
| Jun | 2 | 6 | 13 | 11 | 6 | 27 | 25 | 5 |
| Jul | 2 | 3 | 9 | 12 | 12 | 33 | 20 | 4 |
| Aug | 1 | 1 | 5 | 8 | 12 | 43 | 22 | 5 |
| Sep | 2 | 3 | 10 | 8 | 7 | 32 | 27 | 5 |
| Oct | 2 | 6 | 16 | 11 | 5 | 24 | 27 | 5 |
| Nov | 2 | 7 | 15 | 9 | 3 | 18 | 35 | 6 |
| Dec | 2 | 12 | 17 | 6 | 2 | 15 | 33 | 7 |
| Annual | 2 | 5 | 10 | 7 | 5 | 23 | 35 | 9 |

Table 40: Percentage frequency of wind direction (from 8 sectors) by month for Lungi (1947 to 1968)

### 7.8 Marine

Significant wave heights have been extracted from model data for a grid point just off the coast from Freetown, and a summary of the analysis of this data is provided in this section.

Annually, most waves approach from the southwest or west-southwest, most of these (87%) 2.0 metres or less. Wave periods range from zero to 11 seconds with most waves (77%) having periods between 5 and 7 seconds.

Monthly frequencies of wave heights are provided in Table 41. The roughest month is July, with seas in the rough category: (2.6 metres to no higher than 3.5 metres) making up 0.6 % of the time. There is more directional spread in July and August with more waves approaching from the south or south-southwest (23% in July, 29% in August, reducing to 14% in September). Even during these months, the majority of waves approach from the southwest or west-southwest. The quietest month is December with 69% of waves heights modelled at 1 metre or below, compared to 9% in this category in July.

| **Month** | **0.6 to 1.0** | **1.1 to 1.5** | **1.6 to 2.0** | **2.1 to 2.5** | **2.6 to 3.0** | **3.1 to 3.5** |
|---|---|---|---|---|---|---|
| Jan | 64.4 | 35.6 | 0.0 | 0.0 | 0.0 | 0.0 |
| Feb | 33.6 | 63.8 | 2.2 | 0.5 | 0.0 | 0.0 |
| Mar | 26.0 | 70.4 | 3.6 | 0.0 | 0.0 | 0.0 |
| Apr | 12.4 | 81.2 | 6.4 | 0.0 | 0.0 | 0.0 |
| May | 20.2 | 69.6 | 10.2 | 0.0 | 0.0 | 0.0 |
| Jun | 16.2 | 67.2 | 15.4 | 1.2 | 0.0 | 0.0 |
| Jul | 9.0 | 60.2 | 27.3 | 2.9 | 0.5 | 0.1 |
| Aug | 3.9 | 55.2 | 33.2 | 7.3 | 0.4 | 0.0 |
| Sep | 13.3 | 67.4 | 18.4 | 0.8 | 0.0 | 0.0 |
| Oct | 41.6 | 55.0 | 3.4 | 0.1 | 0.0 | 0.0 |
| Nov | 56.5 | 41.8 | 1.7 | 0.0 | 0.0 | 0.0 |
| Dec | 69.3 | 30.2 | 0.5 | 0.0 | 0.0 | 0.0 |
| **Annual** | **30.2** | **58.0** | **10.6** | **1.1** | **0.1** | **0.0** |

Table 41: Monthly frequency of wave heights (m) off the coast of Freetown (from model data)

# 8. Area 3: Railway alignment

## 8.1 Climate overview

The railway alignment will run from the south-west of the mine area WSW for about 170 km to Tagrin Point, at the entrance to the harbour. It goes from the edge of the highlands, at an altitude of about 400 masl, and passes through the interior low plains which are rolling lowlands of swampy grasslands to the coastal lowland plain. The proposed railway is marked on the map (Figure 1) as a black crossed line.

The decrease in altitude, the move towards the coast, and the movement to the WSW with respect to the ITCZ means that there is a gradual change in the climate along the length of the railway. Annual average rainfall decreases towards the coast, but most of this decrease occurs during the height of the rainy season in July and August due to a decreasing influence of the south-west monsoon. However, there is an increase in rainfall in the centre of the country around Makeni, as the escarpment which forms the mine area triggers instability in the moist south-westerly winds (Kamara and Jackson, 1997b). There is also a slight increase in average cloudiness and humidity closer to the coast. During February to April, fog sometimes forms in valleys after a calm night.

## 8.2 Data Sources

There are several meteorological stations for which we have some data records located near to the railway alignment at fairly regular spatial intervals. Starting from the mine site and proceeding to the coast, we have a good rainfall record from Mabonto, near to the mine site. The railway then passes through Makeni, a large city of around 100,000 people from where we have a long record (over 50 years) of rainfall, temperature and humidity data, as well as a short record of wind speed and direction. Further rainfall data is available from Teko, just to the south of Makeni. The next major stop for the railway is Marampa, the location of existing mine works. We have a 34 year record of rainfall, temperature and humidity data from here. The railway next passes Port Loko, which is situated on Port Loko Creek, which flows into the Sierra Leone River. We have a good record of rainfall data form here, as well as a shorter record of temperature and humidity.

## 8.3 Rainfall

Extreme value analysis of annual maximum daily totals has been carried out on historic data from Port Loko, Marampa and Makeni to obtain daily rainfall totals for a range of return periods, and the results are shown in Tables 42 and 43. The annual maximum series at Makeni has also been used to estimate a Probable Maximum Precipitation of 566 mm.

| Return Period (years) | Port Loko | | | Marampa | | |
|---|---|---|---|---|---|---|
| | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit |
| 10 | 161.8 | 137.2 | 186.5 | 146.3 | 129.5 | 163.1 |
| 20 | 182.1 | 150.9 | 213.2 | 161.5 | 140.3 | 182.7 |
| 50 | 208.2 | 168.2 | 248.2 | 181.2 | 153.9 | 208.5 |
| 100 | 227.9 | 181.4 | 274.3 | 196.0 | 164.3 | 227.7 |
| 500 | 273.1 | 212.3 | 333.9 | 230.1 | 188.6 | 271.6 |

Table 42: Estimated daily rainfall totals with 95 % confidence intervals for a range of return periods. Port Loko analysis based on 24 years from 1937 to 1968 and Marampa based on 30 years from 1935 to 1968 (some years are missing).

| Return Period (years) | Estimate (mm) | 95 % confidence lower limit | 95 % confidence upper limit |
|---|---|---|---|
| 10 | 169.9 | 151.0 | 188.9 |
| 20 | 190.4 | 166.4 | 214.3 |
| 50 | 216.8 | 186.0 | 247.5 |
| 100 | 236.6 | 200.9 | 272.3 |
| 500 | 282.3 | 235.6 | 329.1 |

Table 43: Estimated daily rainfall totals with 95 % confidence intervals for a range of return periods, for Makeni (based on 42 years data from 1923 to 1968; some years are missing).

The theoretical profiles for 15 and 8 hour storms (Tables 5 and 6) have been applied to the estimates of 10 and 50 year return period 1-day rainfalls at Makeni. The maximum 1-hour rainfall during these design storms is shown in Table 44, while the full design storms are provided in Appendix 2.

| Location | 1 in 10-year | | 1 in 50-year | |
|---|---|---|---|---|
| | 8-hour | 15-hour | 8-hour | 15-hour |
| Makeni | 115.6 | 76.5 | 147.6 | 97.7 |

Table 44: Maximum 1-hour rainfall (mm) for design storms of 8 and 15 hours

The theoretical profile of 5-minute rainfall (Table 7) has been applied to the maximum 1-hour rainfall from the 8-hour storm, giving the estimates of maximum 5-minute rainfall in Table 45 (the full profile is provided in Appendix 2).

| **Location** | **Rainfall, mm** | |
|---|---|---|
| | **10-year** | **50-year** |
| Makeni | 24.3 | 31.0 |

Table 45: Estimates of maximum 5-minute rainfall at Makeni

Monthly statistics of rainfall for the 1923 to 1968 period are shown in Tables 46, 47 and 48 for the same three locations. Where possible, missing monthly values have been estimated by linear regression against the best correlated neighbour stations. The tables show the strong seasonal cycle of rainfall, peaking in August and with very little rainfall from December to March. Rainfall during the wet season is less than for the port area however, and is more evenly spread over the wet season months. The three locations have similar annual rainfall profiles, although Makeni has more rainfall, and Port Loko peaks slightly earlier in the year as it is closer to the port area. The 20$^{th}$ and 80$^{th}$ percentile values give an indication of dry and wet months that have been experienced, equivalent to a 5 year return period.

| **Month** | **20$^{th}$ %ile** | **Median** | **Mean** | **80$^{th}$ %ile** |
|---|---|---|---|---|
| January | 0.0 | 0.2 | 7.8 | 17.1 |
| February | 0.0 | 0.0 | 8.8 | 7.4 |
| March | 6.0 | 19.5 | 23.6 | 38.2 |
| April | 20.0 | 46.4 | 63.1 | 117.1 |
| May | 146.2 | 212.5 | 209.1 | 263.7 |
| June | 270.4 | 370.2 | 367.8 | 430.1 |
| July | 424.6 | 506.0 | 526.3 | 657.0 |
| August | 396.6 | 558.7 | 553.4 | 682.8 |
| September | 329.9 | 412.5 | 421.4 | 507.3 |
| October | 288.9 | 348.8 | 352.5 | 414.5 |
| November | 101.2 | 152.9 | 157.1 | 202.8 |
| December | 1.0 | 16.7 | 27.3 | 49.5 |

Table 46: Monthly statistics of rainfall for Port Loko, 1923 to 1968.

| Month | 20$^{th}$ %ile | Median | Mean | 80$^{th}$ %ile |
|---|---|---|---|---|
| January | 0.0 | 0.0 | 8.0 | 9.4 |
| February | 0.0 | 0.5 | 5.6 | 9.3 |
| March | 6.2 | 25.2 | 34.2 | 54.2 |
| April | 33.3 | 76.8 | 88.2 | 132.4 |
| May | 168.7 | 214.0 | 221.4 | 300.4 |
| June | 254.2 | 319.8 | 318.0 | 362.1 |
| July | 371.7 | 426.2 | 443.9 | 547.6 |
| August | 354.3 | 546.8 | 532.4 | 682.8 |
| September | 374.0 | 483.1 | 458.0 | 549.3 |
| October | 313.8 | 386.4 | 386.2 | 459.7 |
| November | 111.7 | 180.4 | 195.1 | 261.2 |
| December | 4.5 | 17.2 | 19.9 | 37.9 |

Table 47: Monthly statistics of rainfall for Marampa, 1923 to 1968.

| Month | 20$^{th}$ %ile | Median | Mean | 80$^{th}$ %ile |
|---|---|---|---|---|
| January | 0.0 | 0.0 | 9.0 | 21.1 |
| February | 0.0 | 2.2 | 9.1 | 20.2 |
| March | 8.9 | 32.3 | 39.7 | 63.9 |
| April | 54.4 | 98.3 | 101.5 | 162.3 |
| May | 163.5 | 227.5 | 235.6 | 316.7 |
| June | 307.8 | 393.7 | 402.2 | 471.1 |
| July | 382.3 | 457.2 | 493.2 | 613.5 |
| August | 490.7 | 602.7 | 614.5 | 733.7 |
| September | 468.5 | 520.7 | 538.6 | 627.4 |
| October | 324.2 | 421.6 | 415.1 | 490.8 |
| November | 142.4 | 190.7 | 203.8 | 276.2 |
| December | 1.7 | 23.0 | 26.7 | 49.1 |

Table 48: Monthly statistics of rainfall for Makeni, 1923 to 1968.

Table 49 shows monthly statistics from Makeni for the 1971 to 2009 period (note that this period has some missing data – 19% of months are missing – for example 1999 to 2002). In contrast to Lungi, this shows that there was very little difference in average annual rainfall compared to the earlier period of 1923 to 1968. However, like Lungi, there has been a decrease in rainfall during the dry season, with 68 % of the 1923 to 1968 period falling during the November to April period. This was compensated by a small increase in rainfall for the months of July and August in the recent period. Figure 7 shows that there has been no overall significant trend in rainfall over the whole period since 1923. Note however that the two driest years in the Lungi record (1999 and 2000) are missing from Makeni. There does seem to have been a greater variability of annual rainfall in the last 20 years.

| **Month** | **20th %ile** | **Median** | **Mean** | **80th %ile** |
|---|---|---|---|---|
| January | 0.0 | 0.0 | 1.6 | 0.6 |
| February | 0.0 | 0.7 | 8.5 | 17.6 |
| March | 0.2 | 8.9 | 17.2 | 27.8 |
| April | 48.6 | 75.6 | 84.6 | 115.9 |
| May | 150.7 | 219.6 | 217.1 | 274.2 |
| June | 300.8 | 373.9 | 398.4 | 465.9 |
| July | 472.2 | 543.2 | 566.4 | 686.8 |
| August | 532.5 | 680.6 | 672.7 | 802.5 |
| September | 379.8 | 504.8 | 536.8 | 674.0 |
| October | 324.6 | 387.1 | 398.8 | 468.6 |
| November | 74.1 | 132.4 | 137.8 | 178.5 |
| December | 0.0 | 2.6 | 17.0 | 25.7 |
| **Annual** | **2706.2** | **3074.0** | **3060.0** | **3330.5** |

Table 49: Monthly statistics of rainfall for Makeni, 1971 to 2009.

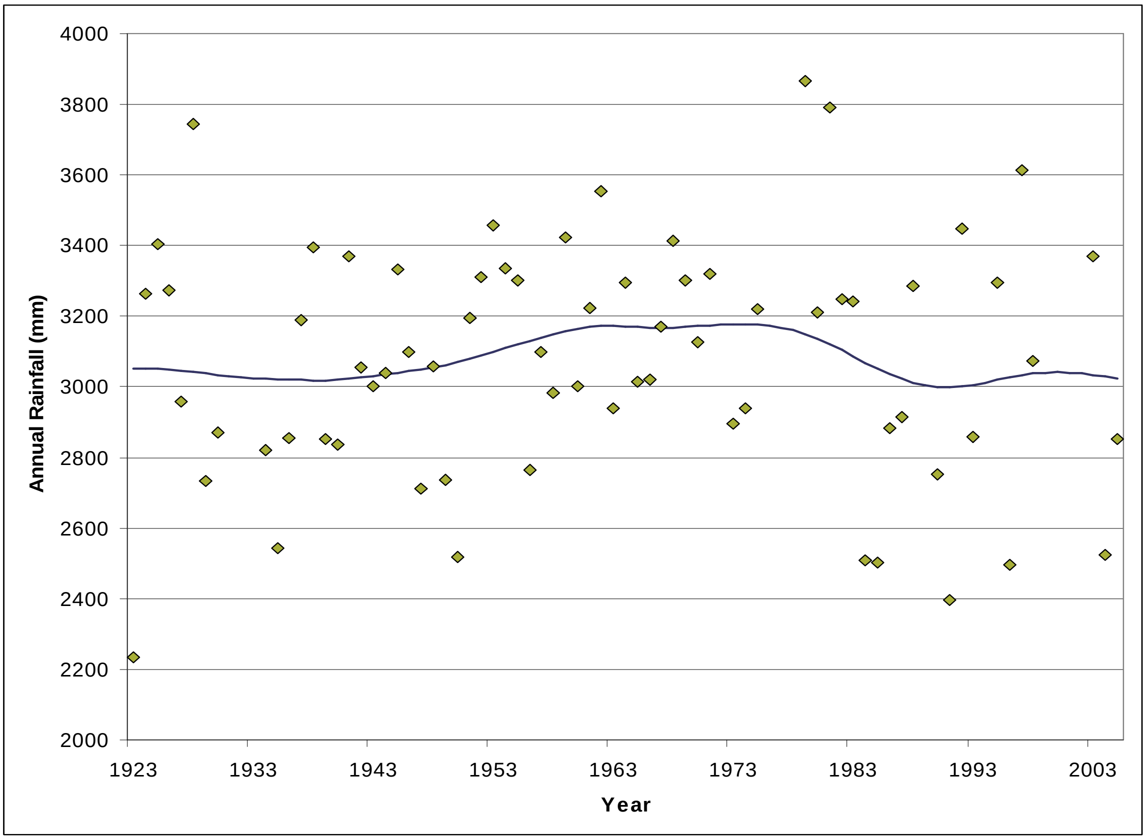


Figure 7: Time series graph of annual rainfall at Makeni, showing the variability and trend from 1923 to 2005.

An extreme value analysis of annual rainfall totals at the three sites was carried out in order to obtain estimated rainfall amounts for a range of recurrence intervals, both for wet and dry years. The results, including 95 % confidence intervals for the estimates, are shown in tables 50, 51 and 52.

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2431 | 2302 | 2545 | 2954 | 2834 | 3112 |
| 10 | 2303 | 2144 | 2416 | 3105 | 2973 | 3325 |
| 20 | 2205 | 2012 | 2318 | 3231 | 3085 | 3506 |
| 50 | 2109 | 1888 | 2222 | 3370 | 3204 | 3727 |
| 100 | 2053 | 1805 | 2167 | 3460 | 3277 | 3891 |
| 500 | 1964 | 1644 | 2082 | 3627 | 3400 | 4252 |

Table 50: Annual rainfall dry year and wet year totals for a range of return periods, for Port Loko (based on data for 1937 to 1968)

 

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2480 | 2416 | 2553 | 2874 | 2772 | 3021 |
| 10 | 2415 | 2347 | 2474 | 3006 | 2887 | 3231 |
| 20 | 2376 | 2305 | 2423 | 3128 | 2982 | 3452 |
| 50 | 2345 | 2271 | 2382 | 3278 | 3080 | 3793 |
| 100 | 2330 | 2248 | 2363 | 3385 | 3137 | 4081 |
| 500 | 2314 | 2210 | 2340 | 3616 | 3332 | 4833 |

Table 51: Annual rainfall dry year and wet year totals for a range of return periods, for Marampa (based on data for 1934 to 1968)

| Return Period (years) | Dry year estimate (mm) | Dry year 95 % confidence lower limit | Dry year 95 % confidence upper limit | Wet year estimate (mm) | Wet year 95 % confidence lower limit | Wet year 95 % confidence upper limit |
|---|---|---|---|---|---|---|
| 5 | 2792 | 2686 | 2881 | 3373 | 3284 | 3468 |
| 10 | 2636 | 2502 | 2731 | 3518 | 3428 | 3629 |
| 20 | 2511 | 2329 | 2614 | 3629 | 3537 | 3771 |
| 50 | 2378 | 2132 | 2497 | 3740 | 3643 | 3926 |
| 100 | 2296 | 1998 | 2429 | 3805 | 3703 | 4020 |
| 500 | 2153 | 1723 | 2323 | 3910 | 3794 | 4199 |

Table 52: Annual rainfall dry year and wet year totals for a range of return periods, for Makeni (based on data for 1923 to 2005)

## 8.4 Temperature

Monthly averages of daily maximum and minimum air temperature for the 30 year period from 1939 to 1968 are shown in Table 53 and Figure 8. Again missing values have been estimated where possible. Maximum temperatures are higher and minimum temperatures lower compared to the port area, meaning that there is a greater diurnal range. The highest temperatures occur in March, especially further inland at Makeni. The lowest minimum (night-time) temperatures occur in January and the highest in May.

 

| Month | Mean daily maximum | | | Mean daily minimum | | |
|---|---|---|---|---|---|---|
| | Port Loko | Marampa | Makeni | Port Loko | Marampa | Makeni |
| January | 32.8 | 32.3 | 33.1 | 20.0 | 20.3 | 19.0 |
| February | 33.8 | 33.9 | 34.7 | 20.7 | 20.9 | 20.1 |
| March | 34.4 | 34.7 | 35.6 | 21.5 | 21.8 | 21.6 |
| April | 34.3 | 34.4 | 34.9 | 22.4 | 22.4 | 22.5 |
| May | 32.5 | 32.9 | 33.0 | 22.6 | 22.4 | 22.8 |
| June | 31.0 | 31.1 | 31.6 | 21.8 | 21.9 | 22.4 |
| July | 29.5 | 29.1 | 29.7 | 21.5 | 21.8 | 22.3 |
| August | 28.4 | 28.3 | 28.7 | 21.7 | 22.0 | 22.2 |
| September | 29.3 | 29.9 | 30.3 | 21.5 | 22.0 | 22.3 |
| October | 31.3 | 31.1 | 31.4 | 21.0 | 21.6 | 21.8 |
| November | 31.8 | 31.3 | 31.8 | 21.1 | 21.6 | 21.9 |
| December | 31.9 | 31.3 | 31.9 | 21.0 | 21.1 | 20.4 |
| **Annual** | **31.7** | **31.7** | **32.2** | **21.4** | **21.7** | **21.6** |

Table 53: Monthly mean daily maximum and daily minimum air temperatures for the 1939 to 1968 period, for stations in the railway alignment.

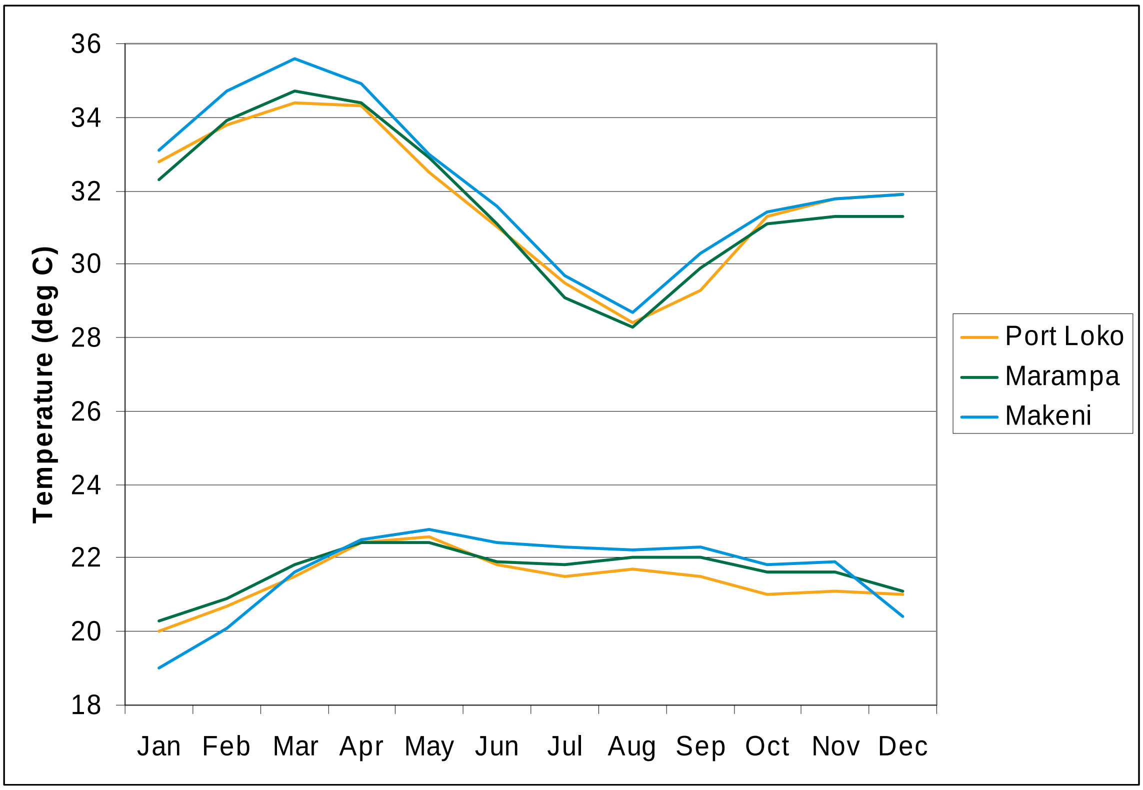


Figure 8: Monthly mean daily maximum and daily minimum air temperatures for the 1939 to 1968 period, for stations in the railway alignment.

Table 54 provides monthly statistics of mean temperature for Marampa. The 20th and 80th percentile values show that there is very little inter-annual variability.

| Month | 20th %ile | Median | Mean | 80th %ile |
|---|---|---|---|---|
| January | 25.6 | 26.4 | 26.3 | 27.1 |
| February | 26.8 | 27.4 | 27.4 | 28.1 |
| March | 27.9 | 28.2 | 28.3 | 28.6 |
| April | 28.0 | 28.5 | 28.4 | 28.8 |
| May | 27.3 | 27.6 | 27.7 | 28.1 |
| June | 26.3 | 27.5 | 26.5 | 26.8 |
| July | 25.1 | 25.6 | 25.5 | 25.9 |
| August | 24.7 | 25.2 | 25.2 | 25.7 |
| September | 25.7 | 26.0 | 25.9 | 26.3 |
| October | 25.8 | 26.4 | 26.3 | 26.7 |
| November | 26.0 | 26.3 | 26.5 | 27.0 |
| December | 25.8 | 26.3 | 26.2 | 26.8 |

Table 54: Monthly statistics of mean temperature for Marampa (1939 to 1968).

There is some temperature data available for Makeni from 1980 to 2009, but 30 % of months are missing. A time series of annual mean temperature is shown in Figure 9, which shows that there was very little inter-annual variability until recent years, when the temperature appears to have decreased. It seems most likely that this is due to inhomogeneity in the temperature measurement (e.g. changes in instrumentation or exposure) rather than a shift in the climate.

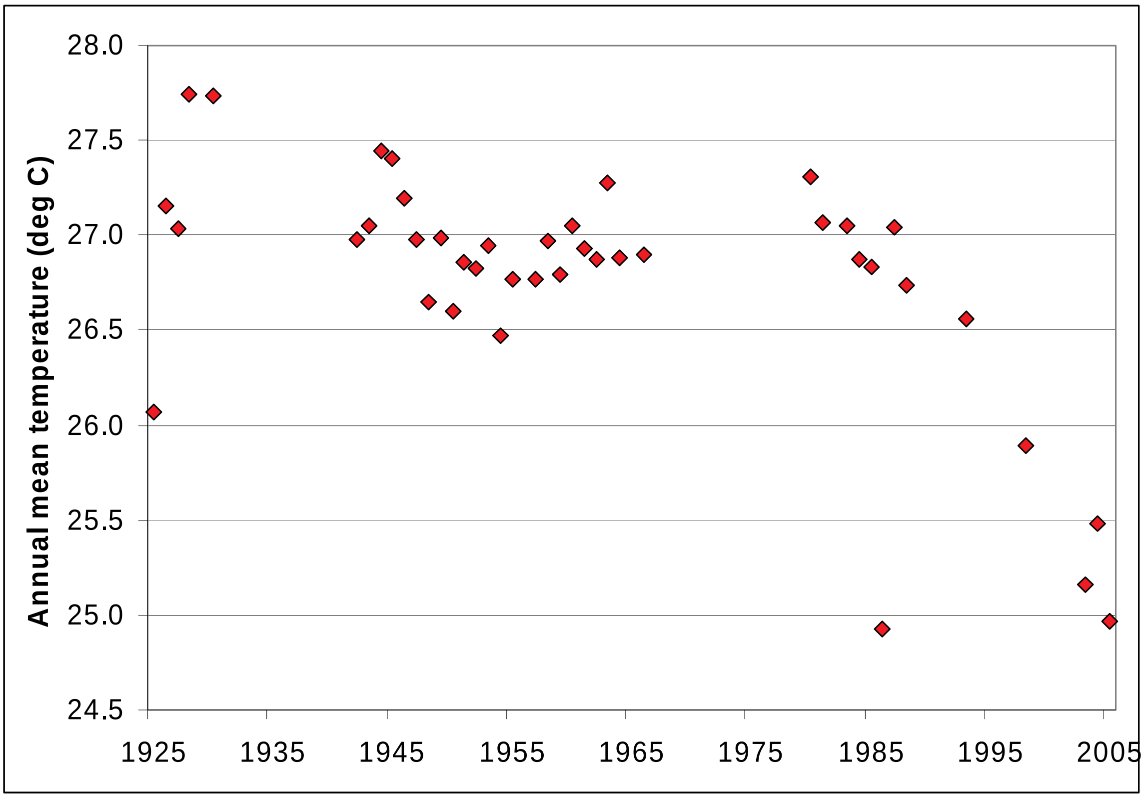


Figure 9: Time series of annual mean temperature at Makeni, 1925 to 2005.

## 8.5 Relative Humidity

Table 55 shows monthly averages of morning (usually measured at 09 GMT) and afternoon (usually measured at 15 GMT) relative humidity (RH). Values are provided for Port Loko (1954 to 1968), Marampa (1939 to 1968) and Makeni (1939 to 1968 and 1980 to 2009). There is less data for the afternoon, however, as these values were not recorded from 1939 to 1942 or from 1943 to 1946. According to model data for the Makeni area (Figure 10), 15 GMT is the time of minimum RH in the diurnal cycle, while 09 GMT is just after the time of maximum RH, which occurs at around 06 GMT. The maximum daily RH would be expected to be between 7 – 9 % higher than the 09 GMT values shown. The annual cycle of RH reaches a peak in August, while the time of lowest RH occurs in the afternoons from January to March. At this time, the humidity can vary considerably from year to year depending on the prevalence of the dry Harmattan wind. In January 1986, for example, the average RH at 15 GMT at Makeni was only 21 %, and model data shows the RH dropping below 10 % on occasions.

| Month | Morning (09 GMT) | | | Afternoon (15 GMT) | | |
|---|---|---|---|---|---|---|
| | Port Loko | Marampa | Makeni | Port Loko | Marampa | Makeni |
| January | 87.9 | 90.3 | 82.4 | 49.3 | 50.9 | 48.6 |
| February | 88.3 | 90.0 | 83.9 | 50.8 | 47.7 | 48.2 |
| March | 82.6 | 86.2 | 83.7 | 49.1 | 49.4 | 50.0 |
| April | 81.7 | 84.1 | 84.1 | 53.1 | 53.4 | 54.6 |
| May | 85.7 | 87.3 | 86.7 | 61.3 | 62.7 | 64.3 |
| June | 89.3 | 90.8 | 89.8 | 70.5 | 70.9 | 70.6 |
| July | 91.5 | 92.1 | 91.4 | 79.7 | 78.3 | 74.2 |
| August | 92.5 | 93.2 | 92.4 | 82.5 | 81.3 | 79.0 |
| September | 92.0 | 92.6 | 91.0 | 77.6 | 76.3 | 73.8 |
| October | 88.8 | 90.6 | 89.5 | 69.8 | 70.4 | 70.0 |
| November | 88.5 | 90.8 | 89.2 | 65.9 | 67.3 | 66.3 |
| December | 87.3 | 89.5 | 85.5 | 58.6 | 60.2 | 56.3 |
| **Annual** | **88.0** | **89.8** | **87.5** | **64.0** | **64.1** | **63.0** |

Table 55: Monthly mean morning (09 GMT) and afternoon (15 GMT) relative humidity (%) for Port Loko (1954 – 1968), Marampa (1939 – 1968) and Makeni (1939 – 1968; 1980 – 2009)

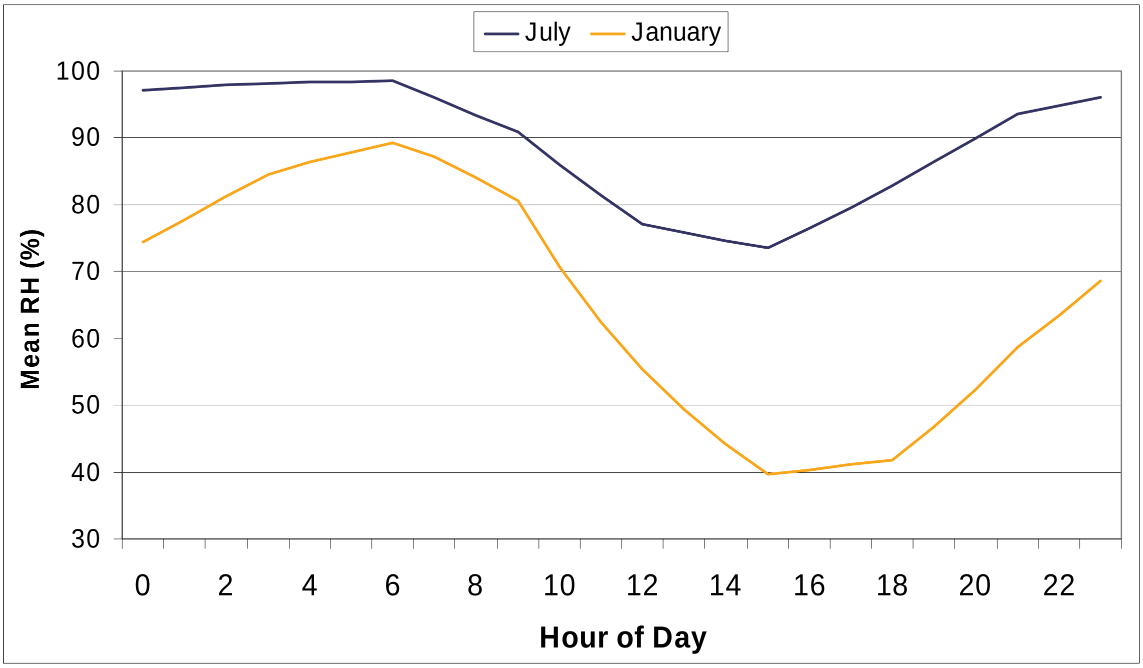


Figure 10: Diurnal cycle of relative humidity at Makeni (from model data) for January and July.

## 8.6 Evaporation

No evaporation data is available for stations along the railway alignment. Average evaporation is likely to be between that for Lungi (Table 37) and Bumbuna (Table 19).

## 8.7 Wind

Monthly wind speed and direction data is available from Makeni for the period 1949 to 1954, but the speed is only recorded in Beaufort Force categories. Also available are mean wind speeds for 1990 to 2009, but 40% of months are missing in this period. Model data has been extracted for Port Loko and Makeni areas. The model data is probably the best source of data for mean wind speeds, but it does not capture extremes well. The recent recorded data at Makeni gives surprisingly low wind speeds, possibly due to poor exposure of the anemometer. Table 56 shows that the model data has a double peak in the annual cycle, in March – April and July – August. The lowest mean speeds occur in November to December. The model mean wind speed at Makeni is lower than that at Port Loko, which in turn is lower than the mean wind speed at Lungi. This suggests that the mean wind speed decreases inland (in an easterly direction), and that the mean wind speed for Marampa is likely to be between that for Lungi and Makeni.

| Month | Makeni | Makeni (model) | Port Loko (model) |
|---|---|---|---|
| January | 1.2 | 2.6 | 3.3 |
| February | 1.2 | 3.2 | 4.1 |
| March | 1.4 | 3.8 | 4.9 |
| April | 1.5 | 4.0 | 5.0 |
| May | 1.5 | 3.1 | 3.8 |
| June | 1.4 | 3.0 | 3.9 |
| July | 1.6 | 3.3 | 4.4 |
| August | 1.7 | 3.5 | 4.5 |
| September | 1.4 | 2.9 | 3.8 |
| October | 1.6 | 2.3 | 3.1 |
| November | 1.3 | 1.9 | 2.7 |
| December | 1.2 | 2.0 | 2.7 |
| **Annual** | **1.4** | **3.0** | **3.8** |

Table 56: Monthly mean wind speed (knots) at Makeni (1990 to 2009), and using model data for Makeni and Port Loko (2000 to 2009).

The data from Makeni for 1949 to 1954 has been analysed for the frequency of high wind speeds (Table 57). This shows that high wind speeds of over 22 knots are very rare (occurring once every two years on average). Most of the occurrences of winds > 11 knots (forces 4+) were in February or March.

| Wind speed | Frequency |
|---|---|
| > 11 knots | 0.67 % |
| > 22 knots | 0.05 % |

Table 57: Cumulative frequency of high wind speeds recorded at Makeni from 1949 to 1954.

Table 58 provides the monthly frequency of wind directions at Makeni. The dominant directions are south-westerly (March to October) and north-easterly (December to February). Important secondary directions are southerly and south-easterly (June to November) and westerly and north-westerly (March to April).

| Month | N | NE | E | SE | S | SW | W | NW |
|---|---|---|---|---|---|---|---|---|
| Jan | 4 | 15 | 7 | 12 | 11 | 12 | 7 | 7 |
| Feb | 6 | 14 | 8 | 10 | 9 | 12 | 11 | 13 |
| Mar | 8 | 9 | 2 | 12 | 7 | 20 | 15 | 16 |
| Apr | 8 | 9 | 3 | 11 | 6 | 21 | 14 | 19 |
| May | 8 | 7 | 3 | 12 | 10 | 20 | 12 | 14 |
| Jun | 3 | 8 | 2 | 14 | 13 | 28 | 10 | 7 |
| Jul | 3 | 3 | 2 | 17 | 15 | 33 | 9 | 7 |
| Aug | 2 | 3 | 1 | 15 | 21 | 31 | 12 | 6 |
| Sep | 4 | 5 | 3 | 14 | 17 | 28 | 10 | 8 |
| Oct | 5 | 9 | 5 | 15 | 15 | 20 | 7 | 11 |
| Nov | 9 | 11 | 5 | 16 | 11 | 14 | 8 | 11 |
| Dec | 7 | 17 | 8 | 11 | 7 | 8 | 6 | 7 |
| **Annual** | **5** | **9** | **4** | **13** | **12** | **21** | **10** | **11** |

Table 58: Percentage frequency of wind direction (from 8 sectors) by month for Makeni (1949 to 1954).

 

## 9. Area 4: Sierra Leone River catchment

The Rokel River is the largest river in Sierra Leone, and passes near to the mine area as it flows in a south-westerly direction down to the Sierra Leone River estuary (Freetown Harbour). It follows a similar path to the railway but further to the south. A smaller river, Port Loko Creek, also feeds into the estuary, having crossed the railway at Port Loko. Consequently the climate overview and data sources from the previous sections, especially section 8 on the railway alignment, are also applicable to the river catchment, depending on which part of the catchment is of interest.

## 10. Conclusions

A large amount of information and data on the weather and climate of Sierra Leone has been gathered, and much of it digitised. This report presents a summary of the analysis which has been carried out on this data.

Although a large amount of data has been obtained, there are limitations in the data which may affect the results. In particular for the mine area, there is a lack of long series of data in the area, with the closest long period stations being Kabala and Makeni. Analysis has shown that Makeni is fairly representative of the mine area for rainfall, and that Kabala is fairly representative for relative humidity and wind. However, the mine area is mountainous and the climate is likely to change considerably on a small spatial scale. In particular, the climate at the mining site itself, which is approximately 800 masl, may be quite different to that at an elevation of 400 masl. The two AWS sites which are at different elevations in the mine area currently only have five months of data available, and it would be beneficial to re-visit the analysis once a record of at least one year has built up.

Available long series of rainfall data has enabled extreme value analysis to be carried out, both on annual maximum daily rainfall totals and on annual totals. Using the results from this analysis, rainfall estimates for return periods from 5 years to 500 years have been made, with increasing uncertainty as the return period increases. Theoretical storm profiles, corroborated by evidence from the small amount of available sub-daily data, have been used together with the estimated return levels of daily rainfall, to generate design storm profiles.  These have been used to estimate maximum 1 hour and 5-minute rainfalls for 10 and 50 years return periods.

Monthly averages of mean, daily maximum and minimum air temperature, and relative humidity have been provided.  Wet bulb temperature is not included as it was generally not recorded separately, but it can be derived from air temperature and relative humidity if required.  Evaporation data is limited, and the measurement methods used have their weaknesses.  Monthly averages have been included for the port and mine areas; these give a good indication of variations in the annual cycle but their accuracy cannot be relied upon.

In some cases, data from Met Office numerical models has been used to supplement available observations, and this has provided useful information on seasonal variations in mean wind speed and wave height.  The available wind data is not suitable for extreme value analysis due to the short records available of precise, short duration values.  The data has been used to provide guidance on frequencies of wind speed and direction.  No data on dust levels is available, but the wind direction results give an indication of the frequency of occurrence of the Harmattan wind at different times of year.

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# Appendix 1: Digitised data

## Hourly Data

| Station | Variables | Date from | Date to | Length of record |
|---|---|---|---|---|
| Freetown | Rainfall | 1944 | 1948 | 5 years |
| Farangbaya | Full range | Sep-2009 | Jan-2010 | 5 months |
| Numbara | Full range | Sep-2009 | Jan-2010 | 5 months |

Table A1: Digitised hourly data

## Daily Data

| Station | Variables | Date from | Date to | Length of record |
|---|---|---|---|---|
| Freetown | Rainfall | 1916 | 1948 | 30 years |
| Lungi | Rainfall, wind | 1949 | 1968 | 20 years |
| Makeni | Rainfall | 1943 | 1948 | 6 years |
| Kabala | Rainfall, wind | 1943 | 1944 | 1 year |

Table A2: Digitised daily data

## Monthly Data (Mine Area)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Kabala | Rainfall, temperature, humidity, wind | 1913 | 1968 | 50 |
| Mabonto | Rainfall | 1936 | 1962 | 25 |
| Sumbaria | Rainfall | 1948 | 1968 | 21 |
| Farangbaya | Rainfall, temperature, humidity | 1957 | 1961 | 5 |
| Sakasakala | Rainfall | 1933 | 1937 | 4 |
| Bumbuna | Rainfall, evaporation | 1972 | 1974 | 3 |
| Makali | Rainfall, temperature, humidity | 1950 | 1955 | 5 |
| Kaiyima | Rainfall | 1927 | 1931 | 5 |

Table A3: Digitised monthly data from the mine area

### Monthly Data (Port Area)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Lungi | Rainfall, temperature, humidity, wind, Piché evaporation | 1947 | 2007 | 59, 23 (evap) |
| Freetown | Rainfall, temperature, humidity, wind | 1909 | 1968 | 59 |
| Pepel | Rainfall, temperature, humidity | 1933 | 1967 | 29 |
| Kissy Dockyard | Rainfall, temperature, humidity | 1949 | 1959 | 10 |
| Cline Town | Rainfall | 1949 | 1960 | 12 |

Table A4: Digitised monthly data from the port area

### Monthly Data (Railway Alignment)

| Station | Variables | Date from | Date to | Length of record (yrs) |
|---|---|---|---|---|
| Makeni | Rainfall, temperature, humidity, wind | 1923 | 2009 | 74 (rain), 67 (RH), 55 (temp), 18 (wind) |
| Marampa | Rainfall, temperature, humidity | 1934 | 1968 | 34 |
| Port Loko | Rainfall, temperature, humidity | 1936 | 1968 | 27 (rain), 13 (temp, RH) |
| Teko | Rainfall | 1942 | 1968 | 17 |
| Katonga | Rainfall | 1957 | 1966 | 9 |
| Magburaka | Rainfall, temperature, humidity | 1935 | 1960 | 10 (rain), 2 (temp, RH) |

Table A5: Digitised monthly data from the area of the railway alignment and the river catchment

## Appendix 2: Design storm profiles

| Hr of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of total | 0.5 | 1 | 2 | 3 | 4 | 6 | 11 | 45 | 11 | 6 | 4 | 3 | 2 | 1 | 0.5 |
| 10-yr rain | 0.9 | 1.7 | 3.4 | 5.1 | 6.8 | 10.2 | 18.7 | 76.5 | 18.7 | 10.2 | 6.8 | 5.1 | 3.4 | 1.7 | 0.9 |
| 50-yr rain | 1.8 | 2.2 | 4.3 | 6.5 | 8.7 | 13.0 | 23.9 | 97.7 | 23.9 | 13.0 | 8.7 | 6.5 | 4.3 | 2.2 | 1.8 |

Table A6: 15-hour design storm for Makeni

| Hr of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of total | 0.5 | 1 | 2 | 3 | 4 | 6 | 11 | 45 | 11 | 6 | 4 | 3 | 2 | 1 | 0.5 |
| 10-yr rain | 0.7 | 1.3 | 2.6 | 3.9 | 5.2 | 7.8 | 14.3 | 58.5 | 14.3 | 7.8 | 5.2 | 3.9 | 2.6 | 1.3 | 0.7 |
| 50-yr rain | 1.1 | 1.7 | 3.3 | 5.0 | 6.7 | 10.0 | 18.4 | 75.2 | 18.4 | 10.0 | 6.7 | 5.0 | 3.3 | 1.7 | 1.1 |

Table A7: 15-hour design storm for Kabala

| Hr of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % of total | 0.5 | 1 | 2 | 3 | 4 | 6 | 11 | 45 | 11 | 6 | 4 | 3 | 2 | 1 | 0.5 |
| 10-yr rain | 1.1 | 2.2 | 4.5 | 6.7 | 9.0 | 13.5 | 24.7 | 101.1 | 24.7 | 13.5 | 9.0 | 6.7 | 4.5 | 2.2 | 1.1 |
| 50-yr rain | 1.4 | 2.8 | 5.6 | 8.4 | 11.2 | 16.8 | 30.8 | 126.1 | 30.8 | 16.8 | 11.2 | 8.4 | 5.6 | 2.8 | 1.4 |

Table A8: 15-hour design storm for Freetown

| Hour of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| % of total | 9 | 68 | 13 | 3 | 2 | 2 | 1 | 1 |
| 10-year rain | 15.3 | 115.6 | 22.1 | 5.1 | 3.4 | 3.4 | 1.7 | 1.7 |
| 50-year rain | 33.2 | 147.6 | 28.2 | 6.5 | 4.3 | 4.3 | 2.2 | 2.2 |

Table A9: 8-hour design storm for Makeni

| Hour of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| % of total | 9 | 68 | 13 | 3 | 2 | 2 | 1 | 1 |
| 10-year rain | 11.7 | 88.4 | 16.9 | 3.9 | 2.6 | 2.6 | 1.3 | 1.3 |
| 50-year rain | 19.5 | 113.6 | 21.7 | 5.0 | 3.3 | 3.3 | 1.7 | 1.7 |

Table A9: 8-hour design storm for Kabala

| Hour of storm | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| % of total | 9 | 68 | 13 | 3 | 2 | 2 | 1 | 1 |
| 10-year rain | 20.2 | 152.7 | 29.2 | 6.7 | 4.5 | 4.5 | 2.2 | 2.2 |
| 50-year rain | 56.6 | 190.5 | 36.4 | 8.4 | 5.6 | 5.6 | 2.8 | 2.8 |

Table A9: 8-hour design storm for Freetown

| 5-minute interval | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-year rain | 3.5 | 4.6 | 9.2 | 10.4 | 16.2 | 24.3 | 16.2 | 10.4 | 9.2 | 5.8 | 3.5 | 2.3 |
| 50-year rain | 4.4 | 5.9 | 11.8 | 13.3 | 20.7 | 31.0 | 20.7 | 13.3 | 11.8 | 7.4 | 4.4 | 3.0 |

Table A10: Peak one-hour design rainfall at Makeni

| 5-minute interval | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-year rain | 2.7 | 3.5 | 7.1 | 8.0 | 12.4 | 18.6 | 12.4 | 8.0 | 7.1 | 4.4 | 2.7 | 1.8 |
| 50-year rain | 3.4 | 4.5 | 9.1 | 10.2 | 15.9 | 23.8 | 15.9 | 10.2 | 9.1 | 5.7 | 3.4 | 2.3 |

Table A11: Peak one-hour design rainfall at Kabala

| 5-minute interval | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-year rain | 4.6 | 6.1 | 12.2 | 13.7 | 21.4 | 32.1 | 21.4 | 13.7 | 12.2 | 7.6 | 4.6 | 3.1 |
| 50-year rain | 5.7 | 7.6 | 15.2 | 17.1 | 26.7 | 40.0 | 26.7 | 17.1 | 15.2 | 9.5 | 5.7 | 3.8 |

Table A12: Peak one-hour design rainfall at Freetown

**Met Office**
FitzRoy Road, Exeter
Devon EX1 3PB
United Kingdom

Tel: 0870 900 0100
Fax: 0870 900 5050
enquiries@metoffice.gov.uk
www.metoffice.gov.uk

# APPENDIX 8

## Preliminary Report on Phase 3 Vegetation Fieldwork - Prepared by SRK

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## Tonkolili Iron Ore Project

# Preliminary Report on Phase 3 Vegetation Fieldwork - Prepared by SRK

305000-00006 – 305000-00006-0000-EN-REP-0005

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

**AFRICAN MINERALS LIMITED**

**PRELIMINARY REPORT ON PHASE 3 VEGETATION FIELDWORK - PREPARED BY SRK**

**TONKOLILI IRON ORE PROJECT**

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| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

SRK Consulting (UK) Ltd
5th Floor Churchill House
17 Churchill Way
Cardiff
United Kingdom
CF10 2HH
e-mail: cardiff@srk.co.uk
URL: www.srk.co.uk
Tel: + 44 (0)29 20 34 81 50
Fax: + 44 (0)29 20 34 81 99

# EXTERNAL MEMORANDUM

| | | | |
|---|---|---|---|
| **TO:** | Phil Burris | | |
| **FROM:** | Paul Mitchell on behalf of Craig Watt | | |
| **FILE REF:** | *P:\U4041 Tonkolili WP Framework\Task 5 ECF ESHIA Programme\Reps\Vegetation Study\SRK Memo to Worley Parsons - Preliminary Report on Phase 3 V 3.docx* | **DATE:** | 26 March 2010 |
| **SUBJECT:** | **SRK MEMO TO WORLEY PARSONS - PRELIMINARY REPORT ON PHASE 3 VEGETATION FIELDWORK** | | |

Dear Phil

Please find attached the preliminary report on the Phase 3 vegetation fieldwork, as prepared by Xander van der Burgt & Ben Pollard of the Herbarium, Royal Botanic Gardens, Kew.

Yours sincerely,

**Craig Watt**
**Principal Environmental Engineer**

SRK Consulting (UK) Ltd
Tel: +440292348180
Mob: +447841800102
Email: cwatt@srk.co.uk

# Summary of report, Phase 3 of the vegetation studies at the Tonkolili mine site, Sierra Leone

**Xander van der Burgt & Benedict John Pollard**
**Herbarium, Royal Botanic Gardens, Kew**

*Riverine forest and river with rocky areas suitable for rheophytes*

**March 2010**

**THIS REPORT IS PRELIMINARY AND CONFIDENTIAL**

## Executive Summary

Four habitats of high conservation value were identified by this study and the two preceding vegetation studies:

1. The strips of forest along the Tonkolili River and the river bed of this river, from Kegbema and Farangbaia up to the confluence with the Rokel River, and the strips of forest along the Rokel River near this confluence.
2. The forest patch to the southwest of the village Kegbema.
3. The summits of the Numbara deposit, due to the presence of a sizeable population of the conservation priority species *Pseudovigna sp. nov*.
4. The seasonally wet (seepage) grassland on the southern slopes of Marampon, which is host to a concentration of high conservation priority species.

The conservation status of the summit of the Numbara deposit may be lowered if further areas hosting *Pseudovigna sp. nov.* are identified outside the mining license area. Opportunities may exist for African Minerals to establish conservation measures for this species, e.g. seed collection and translocation of specimens from Numbara to a suitable locality outside the mining license area, which may also lower the conservation status of the species. Similar approaches may be relevant to the grassland on the southern slopes of Marampon.

Unlike the summits of Numbara, the high conservation status of the forest strips and forest patch noted above is now fixed and will not change as a result of further field studies. Translocation of tree species is not feasible; therefore infrastructure should be planned outside these areas where at all possible. Where work is essential in these areas, river crossings should be made with the greatest care, especially if there are trees present, or rocks in the river bed. Planned river crossing sites should be surveyed for plant species of conservation concern by a botanist and well in advance of construction work to allow the crossing location to be modified based on survey results (i.e. the proximity of haul road already constructed to the river should not be such that it constrains adjustments to the crossing point).

Apart from mining infrastructure, the forest patches are also threatened by an increase in construction wood extraction by local people. The increased demand for houses in the study area seems to be a cause of increased logging activities. Since the increased pressure on the last remaining forest patches seems at least partly linked to the activities of African Minerals, the company may wish to identify options with appropriate partners (e.g. the government of Sierra Leone) to prevent further damage to these forest patches. As part of this process, opportunities to compensate villagers for preserving the forest patch could be explored.

In addition, there are also several habitats of medium conservation value identified, including a forest strip along a small stream in the rail loop area; forests around Nerekoro; the forest patch on the western slopes of the Simbili deposit; mangroves in the Tagrin and Pepel Port lease areas and Port Loko; inland valley swamps in the Tagrin port camp and infrastructure area, railroad marshalling yard, Petifu Junction, Port Loko area and along the haul road route between Lunsar and the western bank of Rokel River, and forest in the area of the River Toka rail and road crossing points. The construction of any infrastructure in these habitats must be carefully planned and managed.

The results and recommendations in this summary are subject to changes based on the outcome of confirmatory identification of the 461 botanical samples collected. The conservation status of some habitats may also change as a result of any further detailed field studies that are undertaken.

# 1. Introduction

This is a summary of the Phase 3 vegetation studies for Tonkolili mine, Sierra Leone. For more information the reader is referred to the full fieldwork report (in preparation) and to the previous two reports on the vegetation studies at Tonkolili by the Royal Botanic Gardens, Kew (van der Burgt, 2009; Darbyshire & van der Burgt, 2010).

The Phase 3 vegetation survey was divided into two tasks:

- Phase 3a – detailed characterisation of baseline conditions at the mine site and the first 20 km of the haulage road.
- Phase 3b – rapid assessment field surveys of the preferred tailings option, remainder of the haulage road to Lunsar, existing rail corridor, Pepel port, railroad marshalling yards, Petifu Junction and Tagrin port.

Collectively the sites surveyed comprised key areas for the Early Cash Flow (ECF) project and the Tonkolili project.

Fieldwork was undertaken between 23 February and 12 March 2010, by *Abdulai Feika* and *Matthew James* from the Njala University Herbarium; *Kabbie Kanu* and *Julius Sesay* from the Fourah Bay College Herbarium; and *Xander van der Burgt*, *Benedict Pollard* and *Sue Frisby* from the Herbarium of the Royal Botanic Gardens, Kew.

A total of 461 botanical samples were collected during the present study. Most samples were preliminarily identified in the field; with confirmatory identification taking place at Kew. This report is based on the preliminary field identification data. The full report will describe species based on confirmed identification data.

# 2. Methods

The methodology of the present study is similar to that described in the two previous reports (van der Burgt, 2009; Darbyshire & van der Burgt, 2010). In summary, the Phase 3a methodology resembles that of Phase 2 and Phase 3b methodology resembles that of Phase 1.

Aerial photography, satellite imagery and drawings were used to pre-identify different vegetation types. These were visited methodically to characterise each major habitat type identified from the maps and identify key plant species. Habitat types of potential conservation concern were then assessed in more detail. Limited botanical specimen sampling was carried out to enable identification of typical or unusual species, and to record the presence of species thought to be of conservation concern. The conservation importance of a habitat (described here as high, medium or low) is preliminarily assessed in this report according to two factors, as described below.

1) The presence/absence of plant species assessed as being globally threatened, following the criteria set out in IUCN (2001):

    - **HIGH** if there are Endangered (EN) plant species present.

- **Medium** if there are Vulnerable (VU) plant species present.
- Low if there are no plant species of conservation concern present.

2) The ecological structure and function of a habitat (assessed qualitatively). Three habitat types that represent original vegetation are considered as being or as likely to be of **medium** conservation concern, especially where levels of disturbance are low:

   - **Forest vegetation**, which, in the study area and indeed in the whole of Sierra Leone, has become so rare that any more or less natural forest vegetation must be considered to be at least of medium conservation importance.
   - **Mangroves** are a species-poor habitat type botanically, but are of considerable ecological value in terms of their structure and function, and are likely to harbour a wide variety of avifaunal and other animal assemblages.
   - **Inland valley swamps** represent an ecologically rich habitat with a valuable structure and function, containing some rare plant species (notably *Aeschynomene deightonii*) and providing habitat for a broad range of plant species and other taxa, such as invertebrate groups (e.g. Coleoptera, Odonata etc). Further detailed surveys of selected inland valley swamps are required to better understand the overall plant species composition and more fully assess the presence/absence of potential species of conservation concern. Water flow and drainage within these valleys should not be significantly altered by AML during construction in this habitat type.

Three plant species from the list of conservation species (all VU) were found to be both common in the study area and to regenerate easily in disturbed habitats. Therefore, the presence of one or more of these species would not necessarily classify the habitat as being of medium conservation importance:

- ***Afzelia africana*** (IUCN: VU) is a tree that was often found near villages and in farmbush.
- ***Hallea stipulosa*** (IUCN: VU) is a tree that colonises inland valley swamps, and is expected to invade the tailings area and other swampy disturbed areas as once the level of disturbance declines.
- ***Terminalia ivorensis*** (IUCN: VU) is a secondary forest tree that was found to be abundant in some parts of the secondary vegetation in the study area.

# 3. Limitations and assumptions

- The results and recommendations in this summary are subject to changes based on the outcome of confirmatory identification of the 461 botanical samples collected.
- For some study areas aerial photography and/or satellite imagery was not available or of insufficient resolution to enable targeting of sampling locations likely to be of conservation concern.
- Phase 3b consisted of rapid assessment field surveys only. These rapid assessments should be followed by a detailed botanical inventory of the areas that were found to be of potential conservation concern. The conservation status of habitats may change subject to further detailed field studies.
- The survey was somewhat restrained by ongoing changes in the haul road alignment during the survey and by logistical constraints (limited time for fieldwork, limited

telecommunications facilities and a period of fuel shortages which prevented or delayed planned travel).

- Further limitations and assumptions are noted in the previous two reports (see van der Burgt, 2009 and Darbyshire & van der Burgt, 2010).

# 4. Preliminary results

Preliminary results for each of the Phase 3 locations are summarised in Table 1 below. The overall conservation importance has been assessed in terms of the actual or likely presence of plant species of conservation concern. Further information for each location is available in Appendix A.

**Table 1: Summary of locations surveyed**

| **Location** | **Description** | **Conservation importance** | **Recommendations** |
|---|---|---|---|
| *Survey type: Phase 3a* | | | |
| River Rokel crossing points | Riverine forest, river channel communities and various secondary habitats. The forest is one of the last remaining examples of the original forest vegetation in the study area. | **HIGH** | Select tree-free routes where possible. Minimise tree felling (for clearance and utilisation purposes). |
| Haul road, Rokel River to Nerekoro; airport, mine village, rail loop | Riverine forest, river channel communities and various secondary habitats. | **HIGH** (riverine forest)<br>**Medium** (forest strip along small stream in rail loop area, 8° 59' 40"N; 11° 46' 56"W; 120 m)<br>Low (remaining area). | For river crossings, select tree-free routes where possible. Planned river crossings should be surveyed for species of conservation concern by a botanist. |
| Haul road, Nerekoro to Farangbaia | Riverine forest, river channel communities and various secondary habitats. | **HIGH** (riverine forest)<br>**Medium** (forests around Nerekoro, e.g. 8° 54' 38"N; 11° 43' 08"W; 260 m and 8° 54' 37"N; 11° 43' 18"W; 250 m)<br>Low (remaining area) | |
| Farangbaia Forest Reserve | | **Medium** (*Cryptosepalum* population, e.g. at 9° 00' 38"N; 11° 42' 53"W; 880 m and 9° 00' 33"N; 11° 42' 50"W; 790 m) | |
| Kegbema forest patch | Forest, the best preserved example of the original forest vegetation in the area. | **HIGH** | Avoid. Explore (with appropriate partners, such as governments) options for preventing further damage at this location. |
| Numbara deposit | Natural grassland. | **HIGH** | Assess whether the endangered species found on Numbara is also found elsewhere in significant numbers. Collect seeds and translocate to suitable sites that will not be affected |

| Location | Description | Conservation importance | Recommendations |
|---|---|---|---|
| | | | by mining. |
| Marampon deposit | Hill summit (wooded) grassland, seasonally wet grassland, *Afrotrilepis* tussocks, secondary herbaceous *Chromolaena* scrub, secondary thicket and woodland. | **HIGH** (single plant of *Pseudovigna* at 8° 59' 45" N; 11° 40' 59" W; 650 m and *Bryaspis*, *Schizachyrium* and *Panicum* at 8° 59' 33" N; 11°41' 04" W; 560 m) | Consider measures to mitigate or offset the impact of species losses through a combination of ex situ conservation measures (seed storage and plant nursery schemes), translocation to secure sites and identification of comparable sites for protection and/or management. |
| Simbili deposit | Secondary forest, farmbush and secondary grassland. | **Medium** (location of *Entandrophragma* tree 8° 58' 42"N; 11° 41' 27"W; 710 m; *Cryptosepalum* population at 8° 58' 36"N; 11° 41' 22"W; 770 m) | Undertake additional fieldwork to fill gaps in the seasonal information acquired so far. Collect seed from the single large *Entandrophragma* tree, and sow in secure sites. |
| *Phase 3b* | | | |
| Tagrin Port land lease | Mangroves and associated species, farmbush, plantations and human settlements. | **Medium** (mangroves), e.g. N 08˚ 32’ 13.6” W 13˚ 09’ 18.8” Low (other habitats) | No further botanical surveys are required in this area. |
| Tagrin potential port camp and infrastructure area | Inland valley swamps, farmbush, plantations, settlements, vegetable gardens, wild oil palm and grassland vegetation. | **Medium** (inland valley swamps), e.g. N 08˚ 34’ 10.5” W 13˚ 09’ 54.6” Low (other habitats) | Further investigation of the inland valley swamps is required. |
| Railroad marshalling yard | Inland valley swamps, farmbush, settlements, vegetable gardens, wild oil palm and grassland vegetation. | **Medium** (inland valley swamps) , e.g. N 08˚ 40’ 02.9” W 13˚ 11’ 06.9” Low (other habitats) | |
| Petifu Junction | Inland valley swamps, secondary forest, farmbush, plantations, settlements, vegetable gardens, wild oil palm and grassland vegetation. | **Medium** (inland valley swamps), e.g. N 08˚ 42’ 15.3” W 13˚ 06’ 33.2” & N 08˚ 42’ 25.8” W 13˚ 05’ 54.9” Low (other habitats) | |
| Pepel Port terrestrial ecosystem | Farmbush, plantations, settlements, vegetable gardens and wild oil palm. | Low | No further botanical surveys are required in this area. |
| Pepel Port land lease, including Tasso island | Mangroves, mangrove / freshwater ecotone, farmbush, oil palm and Acacia plantations, settlements, vegetable gardens, wild oil palm, and grassland vegetation. | **Medium** (mangroves), e.g. N 08˚ 35’ 34.6” W 13˚ 03’ 42.0” Low (other habitats) | Further study of ecotones, especially mangrove/shrub transition, is required. Further land-based survey of Tasso Island may be required to supplement existing |

| Location | Description | Conservation importance | Recommendations |
|---|---|---|---|
| | | | boat-based observations. |
| Existing rail corridor Pepel to Lunsar | Grassland vegetation, farmbush, plantations, settlements, vegetable gardens and wild oil palm. | Low | No further botanical surveys are required in this area. |
| Port Loko area | Mangroves, freshwater ecosystems, inland valley swamps, farmbush, settlements, vegetable gardens, wild oil palm and grassland vegetation. | **HIGH (**colony of an undescribed new species of *Macropodiella* (Podostemaceae) identified from slow flowing river with rocky pools:<br>N 08˚ 45' 47.0"<br>W 12˚ 46' 19.2"<br><br>**Medium** (mangroves and inland valley swamps), e.g.<br>N 08˚ 44' 58.0"<br>W 12˚ 48' 07.1"<br><br>Low (other habitats) | The freshwater river areas and saline/freshwater transition zone of Port Loko Creek should be surveyed in more detail, especially for rheophytes. A survey of the new species should be conducted. Further investigation of the inland valley swamps is required. |
| Port Loko Strict Nature Reserve | Agroforestry plantations and grassland vegetation. | Low | No further botanical surveys are required in this area. |
| Haul road Lunsar to River Rokel western bank | Grassland vegetation, inland valley swamps, farmbush, plantations, settlements, wild oil palm, bamboo patches and inselbergs. | **Medium**, e.g.<br>*Nauclea diderrichii* at<br>N 08˚ 42' 07.5"<br>W 12˚ 36' 36.8",<br>and IVS at:<br>N 08˚ 43' 21.0"<br>W 12˚ 31' 00.7".<br><br>Several areas between<br>N 08˚ 50' 00.3"<br>W 12˚ 13' 22.6" &<br>N 08˚ 52' 15.9"<br>W 12˚ 06' 59.2" appear to represent IVSs | Conduct further survey work in inland valley swamps; visit inselbergs to assess remnant forest patches. |
| River Toka rail and road crossing points | Riverine/gallery forest, swampy patches and grassland vegetation. Forest is very rare across the surveyed area. | Low (potentially **medium**)<br>N 08˚ 48' 54.7"<br>W 12˚ 19' 06.9" &<br>N 08˚ 48' 49.0"<br>W 12˚ 19' 17.5" | Additional specimen sampling along the River Toka forest to confirm absence / presence of species of conservation concern. At road and rail crossing points, survey work of riverine vegetation should be extended beyond the crossing points for approximately 1 km in either direction to determine the presence or absence of conservation species. |
| Selected tailings option | A few forest patches, farmbush, plantations, inland | Low | No further botanical surveys are required |

| Location | Description | Conservation importance | Recommendations |
|---|---|---|---|
| | valley swamps and grassland vegetation. | | in this area (unlikely to reveal species of conservation concern). |

**Notes:**

1. Coordinates given in Table 1 are examples of points visited in surveyed areas and are not indicative of boundaries for the areas of high and medium conservation concern. Further work is required to accurately define boundaries.
2. Marampon and Farangbaia Forest Reserve were surveyed previously but are included here for comparative purposes.

# 5. Conclusions

Fieldwork has identified four habitats of high conservation value. Two of these habitats intersect with project activities that are fixed in space (the planned open pits at Numbara and Marampon) and for which avoidance options do not exist. Consequently, African Minerals may need to pursue alternative conservation measures for the plant species found in the affected habitats, such as seed collection and translocation of specimens to suitable localities outside the mining license area. The other two habitats intersect with project activities that are not fixed in space (e.g. construction of the haul road and related river crossings) and therefore avoidance can play a role in minimising impacts. Where work is essential in these habitats, care should be taken to minimise the felling of trees and to select river crossings with the least impact.

Fieldwork has also identified a number of habitats of medium conservation value around the mine area and along the transport corridor to the coast. The construction of any infrastructure in these habitats must also be carefully planned and managed. Where possible, habitats of medium conservation value should be avoided.

# 6. Recommendations

See Table 1 (above) for location-specific recommendations.

# References

Burgt, X.M. van der, 2009. Report on the botanical reconnaissance survey of the Tonkolili Project area, Sierra Leone. Herbarium, Royal Botanic Gardens, Kew, 1 October 2009.

Darbyshire, I & Burgt, X.M. van der, 2010. Report on the vegetation survey and botanical inventory of the Tonkolili Project area, Sierra Leone. Herbarium, Royal Botanic Gardens, Kew, 8 February 2010.

IUCN (2001). IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission, IUCN, Gland, Switzerland & Cambridge, U.K.

# ANNEX A

## *A.1 Results for Phase 3a*

Detailed characterisation of baseline conditions at the mine site and the first 20 km of the haulage road.

### A.1.1. River Rokel crossing points

**Key habitats:** riverine forest, river channel communities, various secondary habitats.
**Species of conservation concern:** *Aphanocalyx pteridophyllus, Copaifera salikounda, Dialium pobeguinii, Gilbertiodendron sp. nov.?.*
**Conservation importance:** the conservation value of the riverine forest strip is **HIGH**, not only because of the presence of conservation species, but also because of its structure and high species richness. This forest is one of the last remaining examples of the original forest vegetation in the study area.
**Recommendations:** river crossings should be made with the greatest care, especially if uprooting of trees is likely. During construction of bridges, tree felling should be kept to an absolute minimum. No tree trunks should be used for the construction of the bridge itself, for scaffolding or for temporary bridges.
**Notes on the haul road crossing:** The haul road crossing point selected by the South African contractor *Jeffares & Green,* 9° 00’ 59.5’’ N; 11° 49’ 53.5’’ W is situated close to the point selected by WorleyParsons. On the east side there is a large rock slab (visible on Google Earth) which has prevented the growth of trees. There is enough space here to construct a haul road bridge without uprooting any trees. However, in the forest strip immediately north and south of this point conservation species do occur. On the west side there is a narrow strip of forest with several species of conservation concern. Nevertheless, this locality seems most appropriate from a botanical point of view.
**Notes on the rail crossing:** Two possible rail crossing points were selected by the botanical teams, close to the point selected by WorleyParsons: Locality 1 at 9° 00’ 44.0’’ N; 11° 49’ 49.0’’ W and locality 2 at 9° 00’ 29.0’’ N; 11° 49’ 44.5’’ W. At locality 1 there is a narrow strip of forest on the east side. On the west side there is a palm plantation bordering the river, but just upstream there is a *Dialium pobeguinii* tree (a species of conservation concern). At locality 2 there is a small gap in the forest strip on the east side, and a strip of forest on the west side. No conservation species were seen. A number of trees will have to be felled here; a few of these may be of conservation concern although none were seen.

### A.1.2. Haul road, Rokel River to Nerekoro; airport, mine village, rail loop

**Key habitats:** riverine forest, river channel communities, various secondary habitats.
**Conservation importance: HIGH** (riverine forest), **medium** (forest strip along small stream in rail loop area), low (remaining area).
**Species of conservation concern:** *Dialium pobeguinii; Gilbertiodendron sp. nov.?;* a number of other species (which will be listed in the report).
**Recommendations:** river crossings should be made with the greatest care, especially if there are trees or rocks in the river bed. Planned river crossings should be surveyed for species of conservation concern by a botanist. If there are no trees and no large rocks in the river bed, a river crossing could be made.
**Notes:** Most of the strip of forest along the Tonkolili River in this area contains conservation species. Trees of *Dialium pobeguinii* (possibly EN) were found in most places on muddy soil

along the Tonkolili River from the village of Balaya up to the Rokel River, and along the Rokel River. The airport area was briefly surveyed; the area appears to be of low conservation concern. The location of the Mine village was not visited; the aerial photographs of the site do not show any forest and it also appears to be of low conservation concern. The rail loop was partly surveyed. The forest strip along a small stream in this area should be avoided, because of the presence of conservation species. This forest strip is classified as medium conservation concern, but the remaining area around the rail loop is probably of low conservation concern.

### A.1.3. Haul road, Nerekoro to Farangbaia

**Key habitats:** riverine forest, river channel communities, various secondary habitats.
**Conservation importance: HIGH** (riverine forest), **medium** (forests around Nerekoro), low (remaining area).
**Species of conservation concern:** *Neolemonniera clitandrifolia, Tessmannia baikiaeoides.* For further species see Darbyshire & van der Burgt, 2010.
**Recommendations:** river crossings should be made with the greatest care, especially if there are trees, or rocks in the river bed. Planned river crossings should be surveyed for species of conservation concern by a botanist.
**Notes:** During the stay of the botanical team in Farangbaia, *Jeffares & Green*, a contractor from Cape Town began the construction of the haul road. They made a new crossing of the Tonkolili River just south of Farangbaia. The contractor was determined to avoid uprooting trees, not only because this is time-consuming, but also because they are aware of the importance of forest in Sierra Leone from a conservation perspective. The contractor was planning to put the road alignment south of Nerekoro and south of the forest patches around this village. The road was then planned to turn to the northwest, towards the Rokel River, but beyond Nerekoro the exact route was not yet determined.
The locality of the second Tonkolili River haul road crossing on the map made by Worley parsons (issued 22 Feb 2010) is unsuitable from a botanical point of view, due to the presence of several species of conservation concern, two of which are new to the survey: *Neolemonniera clitandrifolia* (IUCN: EN) and *Tessmannia baikiaeoides* (possible VU or EN). In general, plant species of conservation concern are common along the Tonkolili River, but careful searching by a botanist may give a suitable crossing point.



### A.1.4. Farangbaia Forest Reserve

**Key habitats:** forest, farmland and secondary thicket.
**Conservation importance: medium**.
**Species of conservation concern:** *Cryptosepalum tetraphyllum*.
**Notes:** The Farangbaia Forest Reserve may be a good candidate for a habitat restoration project, with translocation of forest species from the deposit sites. This could provide a high profile positive conservation project for AML in collaboration with both national government and local communities.
**Recommendations:** Explore the potential use of Farangbaia Forest Reserve as an offset site in greater detail.

Farangbaia Forest Reserve was surveyed previously, but is summarised here for comparative purposes.

## A.1.5. Kegbema forest patch

**Key habitats:** forest.
**Conservation importance:** the conservation value of this forest patch is **HIGH**, not only because of the presence of conservation species, but also because of its structure and high species richness. This forest is one of the last remaining examples of the original forest vegetation in the study area.
**Species of conservation concern:** see previous report.
**Coordinates:** 9°00’26’’ N; 11°42’06’’W.
**Notes:** Plot 12, set up in the Kegbema forest patch southwest of the village of Kegbema, in December 2009, has been partly destroyed by local people extracting wood for use in construction. The activity of loggers in the area is increasing, supposedly because of increased demand for timber for construction of houses and furniture. This increased demand is possible linked to the inward migration of people to the study area in search of jobs at the Tonkolili project. The socio-economic team visited the village of Kegbema and may be able to develop an initial overview of the social context behind the destruction of Plot 12 (note: the socio-economic team has not reported at the time of preparation of this botanical report).
**Recommendations:** The Kegbema forest patch is the best preserved example of the original forest vegetation in the area, and is also inside the Farangbaia Forest Reserve. Since the increased pressure on the last remaining forest patches seems at least partly linked to the activities of African Minerals, the company may wish to identify options with appropriate partners (e.g. the government of Sierra Leone) to prevent further damage to these forest patches. As part of this process, opportunities to compensate villagers for preserving the forest patch could be explored.

## A.1.6. Numbara deposit

**Key habitats:** natural grassland.
**Conservation importance: HIGH**.
**Species of conservation concern:** *Pseudovigna sp. nov*.
**Recommendations:** establishment of in-situ and ex-situ conservation measures such as seed collecting and translocation to sites outside the mining license area. Further information is available in van der Burgt (2009) and Darbyshire & van der Burgt (2010).
**Notes:** The natural grassland on the summit area of Numbara was revisited to look for pyrophytes; plants that grow shortly after fire. Only a few were found. Some of the *Pseudovigna sp. nov.* plants were resprouting, while some others were still dormant.

## A.1.7. Marampon deposit

The Marampon deposit was not visited during the present trip, but was surveyed during previous fieldwork (see Darbyshire & van der Burgt, 2010).
**Key habitats:** Hill summit (wooded) grassland, seasonally wet grassland, *Afrotrilepis* tussocks, secondary herbaceous *Chromolaena* scrub, secondary thicket and woodland.
**Conservation importance: HIGH**
**Species of conservation importance:** *Pseudovigna sp. nov*. (single plant), *Bryaspis humularioides* subsp. *falcistipulata*, *Schizachyrium lomaense* and *Panicum glaucocladum*.
**Recommendations:** due regard should be given to measures to mitigate or offset the impact of species losses through a combination of ex situ conservation measures (seed storage and plant nursery schemes), translocation to secure sites and identification of comparable sites for protection and/or management.

**Notes:** The most important seasonally wet grassland for conservation identified to date is that on the S slopes of Marampon at the north end of the Simbili-Marampon saddle. The small area of seepage here holds three species of conservation concern including two potentially Endangered species: *Bryaspis humularioides* subsp. *falcistipulata* and *Schizachyrium lomaense* (the third, *Panicum glaucocladum*, is considered Vulnerable).

Marampon was surveyed previously, but is summarised here for comparative purposes.

### A.1.8. Simbili deposit

**Key habitats:** secondary forest, farmbush, secondary grassland.
**Conservation importance: medium**.
**Species of conservation concern:** *Cryptosepalum tetraphyllum*, *Entandrophragma cylindricum*, *Garcinia kola* and *Guarea cedrata*.
**Recommendations:** further fieldwork should be considered, covering times of the year that will supplement the timing of previous visits.

## *A.2. Results for Phase 3b*

Rapid assessment field surveys of the preferred tailings option, remainder of the haulage road to Lunsar, existing rail corridor, Pepel Port and Tagrin.



### A.2.1. Tagrin Port land lease

**Key habitats:** mangroves and associated species, farmbush, plantations, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance:** mangroves: **medium**; other habitats: low.
**Species of conservation concern:** *Hallea stipulosa*, *Terminalia ivorensis.*
**Recommendations:** it is suggested that no further botanical surveys are required here.

### A.2.2. Tagrin potential port camp and infrastructure area

**Key habitats:** inland valley swamps, farmbush, plantations, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance:** inland valley swamps: **medium**, other habitats: low.
**Species of conservation concern:** *Terminalia ivorensis.*
**Recommendations:** further investigation of the inland valley swamps is required in this area.

### A.2.3. Railroad marshalling yard

**Key habitats:** inland valley swamps, farmbush, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance:** inland valley swamps: **medium**, other habitats: low.
**Species of conservation concern:** none observed, but inland valley swamps may harbour some rare species.
**Recommendations:** further investigation of the inland valley swamps is required in this area.

### A.2.4. Petifu Junction

**Key habitats:** inland valley swamps, secondary forest, farmbush, plantations, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance:** inland valley swamps: **medium**, other habitats: low.
**Species of conservation concern:** none observed, but inland valley swamps may harbour some rare species.

**Recommendations:** further investigation of the inland valley swamps is required in this area.
**Note:** some small patches of maturing secondary forest or possibly remnant primary forest were located at and around 08° 42’ 15.3”N, 13° 06’ 33.2”W and 08° 42’ 16.5”N, 13° 05’ 54.2”W. Confirmatory identification of plant specimens at Kew should help to further assess the maturity and value of these very small patches, and inform any further conservation recommendations.

### A.2.5. Pepel Port terrestrial ecosystem

**Key habitats:** farmbush, plantations, settlements, vegetable gardens, wild oil palm.
**Conservation importance:** low.
**Species of conservation concern:** *Terminalia ivorensis.*
**Recommendations:** no further botanical survey work is required here.

### A.2.6. Pepel Port land lease, including Tasso island (brief visual assessment by boat)

**Key habitats:** mangroves and associated species, mangrove/freshwater ecotone, farmbush, oil palm and *Acacia* plantations, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance:** mangroves: **medium**; other habitats: low.
**Species of conservation concern:** *Afzelia africana.*
**Recommendations:** Pepel Port land lease: further study of ecotones, especially mangrove/shrub transition where *Afzelia africana* was observed. Additional rare species may occur in this partly undisturbed habitat type. Tasso Island may benefit from a land-based survey, particularly with regards to groups of quite large unidentified trees seen growing on the SW-facing side of the island. The area or type of usage of Tasso Island for the project is not fully understood by the survey team, and further information is required to develop recommendations for this area.

### A.2.7. Existing rail corridor Pepel to Lunsar

**Key habitats:** grassland vegetation, farmbush, plantations, settlements, vegetable gardens, wild oil palm.
**Conservation importance:** low.
**Species of conservation concern:** *Terminalia ivorensis.*
**Recommendations:** no further botanical survey work is required in this area.
**Notes:** The project had instigated a programme of intense ‘slash and burn’ for a corridor of vegetation c. 30 m wide along the length of the existing railroad. This process was already well-advanced during this fieldwork.

### A.2.8. Port Loko area including proposed railway bridge and Port Loko freshwater ecosystems

**Key habitats:** mangroves and associated species, freshwater ecosystems, inland valley swamps, farmbush, settlements, vegetable gardens, wild oil palm, grassland vegetation.
**Conservation importance: HIGH** (freshwater ecosystems), **medium** (mangroves/inland valley swamps, and presence of potential species of conservation concern); other habitats ( low).
**Species of conservation concern:** an undescribed new species of *Macropodiella* (Podostemaceae) has been identified from Port Loko freshwater Creek; *Hallea stipulosa* (in the inland valley swamps).

**Recommendations:** The freshwater river areas and saline/freshwater transition zone of Port Loko Creek should be surveyed in more detail for plant taxa of potential conservation concern, particularly rheophytes; further survey work of inland valley swamps.

## A.2.9. Port Loko Strict Nature Reserve

**Key habitats:** agroforestry plantations, grassland vegetation.
This is a production forest of plantation species, with a dedicated nursery raising seedlings, especially of *Tectona grandis*, *Acacia mangium* and *Gmelina arborea*.
**Conservation importance:** low (potentially **HIGH**).
**Species of conservation concern:** none identified in the reserve, but an undescribed species of *Macropodiella* (Podostemaceae) has been identified just downstream from the reserve.
**Recommendations:** The river running by the reserve to be surveyed for rheophytes, especially *Macropodiella* sp. nov. The Ministry of Forests should be encouraged to undertake seed collection using local people and specialists and subsequently introduce species of conservation concern into their propagation programme at the Port Loko Strict Nature Reserve plant nursery facility for inclusion in planting mixes. Raise awareness of threatened species and opportunity for reintroductions.

## A.2.10. Haul road Lunsar to River Rokel western bank

**Key habitats:** grassland vegetation, inland valley swamps, farmbush, plantations, settlements, wild oil palm, bamboo patches, inselbergs.
**Conservation importance: medium**.
**Species of conservation concern:** *Hallea stipulosa*, *Nauclea diderrichii*.
**Recommendations:** conduct further survey work in inland valley swamps; visit inselbergs to assess remnant forest patches, e.g. 'Takobli'.
**Notes:** most of the haul road crosses species-poor grassland vegetation, but areas of potential interest were noted, especially inland valley swamps.

## A.2.11. River Toka rail and road crossing points

**Key habitats:** riverine/gallery forest, swampy patches, grassland vegetation.
**Conservation importance:** low/potentially **medium**.
**Species of conservation concern:** none identified.
**Notes:** some species identified from this swampy gallery/riverine forest, e.g. *Cynometra vogelii* and *Uapaca guineensis*, were also recorded from the Rokel River strip of forest which suggests some affinities between these two areas. Time did not allow additional specimen sampling along the River Toka forest, but it is possible that species of conservation concern found at River Rokel also occur along this strip. This type of forest is very rare across the surveyed area and, as such, merits further investigation.
**Recommendations:** maintain these crossing points, ensuring water flow is uninterrupted. Extend survey work of this riverine vegetation beyond crossing points for approximately 1 km in either direction to determine presence or absence of conservation species. This could enable better understanding of the distribution of rare forest plants across this similar, but rarely occurring, habitat type in different locations.

## A.2.12. Selected tailings option

**Key habitats:** a few forest patches, farmbush, plantations, inland valley swamps, grassland vegetation.
**Conservation importance:** low.
**Species of conservation concern:** *Aeschynomene deightonii*, *Hallea stipulosa*.

**Recommendations:** a detailed survey could be considered here, especially on the few forest patches and the inland valley swamps, but such work is unlikely to reveal many species of conservation concern.

# APPENDIX 9

**Tonkolili Vegetation Survey and Inventory Report - Final - Prepared by Herbarium, Royal Botanic Gardens, Kew**

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## Tonkolili Iron Ore Project

# Tonkolili Vegetation Survey and Inventory Report - Final - Prepared by Herbarium, Royal Botanic Gardens, Kew

305000-00006 – 305000-00006-0000-EN-REP-0003

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

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**TONKOLILI VEGETATION SURVEY AND INVENTORY REPORT - FINAL - PREPARED BY HERBARIUM, ROYAL BOTANIC GARDENS, KEW**

**TONKOLILI IRON ORE PROJECT**

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**PROJECT 305000-00006 - TONKOLILI VEGETATION SURVEY AND INVENTORY REPORT - FINAL - PREPARED BY HERBARIUM, ROYAL BOTANIC GARDENS, KEW**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
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# REPORT ON THE VEGETATION SURVEY & BOTANICAL INVENTORY OF THE TONKOLILI PROJECT AREA, SIERRA LEONE

Iain Darbyshire & Xander van der Burgt
Royal Botanic Gardens, Kew
8 February 2010

**CONFIDENTIAL**

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**REPORT ON THE VEGETATION SURVEY & BOTANICAL INVENTORY OF THE TONKOLILI PROJECT AREA, SIERRA LEONE**

**8 February 2010**

**PREPARED FOR:**
African Minerals Ltd

**PREPARED BY:**
Herbarium, Royal Botanic Gardens, Kew

**AUTHORS AND CONTRIBUTORS:**

I. Darbyshire, X. van der Burgt, M. Cheek, R. Clark, G. Marchant & J. Moat. *RBG, Kew*

A.M.B. Feika & M.S. James. *National Herbarium of Sierra Leone, Njala University*

K.M.T. Kanu & J.A. Sesay. *Fourah Bay College Herbarium, Freetown*

Emily Robinson. *SRK Consulting (UK) Ltd*

# EXECUTIVE SUMMARY

A vegetation and plant species survey was conducted in the Tonkolili Project area from 24th November to 11th December 2009, building on the 3.5 day reconnaissance survey carried out in September. A combination of plot-based sampling and walk-over survey was used to characterise the different vegetation types and to record the plant species found within each habitat. A reconnaissance-scale survey of the three potential tailings or mine-related infrastructure locations was also conducted.

Whilst the dominant vegetation cover (c. 90%) of the three iron-ore deposits and immediate surroundings is a mosaic of farmland and fallow bushland of low conservation value, the remaining areas are found to contain a range of natural or semi-natural vegetation types. Five of these vegetation types are of conservation significance: hillslope forest, riverine forest, river channel plant communities, hill summit (wooded) grassland and seasonally wet grassland.

34 plant species of conservation concern (IUCN Red list species or candidate species) have so far been recorded on the deposits and in the potential tailings or infrastructure locations, of which nine are considered of high conservation priority. Included within these nine are two newly discovered species, apparently unique or nearly unique to the Project area based upon current knowledge: *Pseudovigna* sp. nov., restricted to the hill summit grasslands, and *Eriocaulon* sp. nov., found only in the river channel east of Farangbeya village.

The highest number of species of conservation concern is found in the riverine strip of forest east of Farangbeya village and the nearby hillslope forest southwest of Kegbema village, both falling within potential tailings or infrastructure option 4. These areas are considered to be of highest conservation importance within the Project area based upon the botanical surveys conducted to date. It is recommended that efforts are made to protect this river system and adjacent forests from any disturbance by future mine-related activity. Although degraded, the riverine forest in potential tailings or infrastructure option 1 has been found to contain three conservation priority species so far, with more likely to be uncovered by more intensive survey. The reconnaissance survey of option 5 revealed no species or habitats of high conservation concern.

On the deposits themselves, the seasonally wet (seepage) grassland on the southern slopes of Marampon contains a concentration of high conservation priority species, and the hill summit grassland on Numbara is considered to be of importance due to its large colony of *Pseudovigna* sp. nov.

Measures should be put in place to mitigate or offset the impact of these losses through a combination of ex situ conservation measures (seed storage and plant nursery schemes), translocation to secure sites and identification of comparable sites for protection and/or management. A range of recommendations are provided for future plant-related survey and conservation work to meet these requirements.

Plot data analyses indicates that our survey work to date has not been exhaustive and it is quite possible that further survey work, particularly at different seasons, will uncover more species of conservation concern within the Project area.

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# 1. INTRODUCTION

This report summarises the findings of the vegetation survey and plant inventory of the Tonkolili iron ore mining project (henceforth the Project) in Sierra Leone, under license to African Minerals Ltd. The survey was conducted over a two week period from 24th November to 11th December and builds upon the 3.5 day reconnaissance vegetation survey conducted at the Project site in September 2009. The field team for the Nov-Dec visit were: Xander van der Burgt, Ruth Clark & Iain Darbyshire (RBG Kew); Emily Robinson (SRK Consulting UK); Abdulai Feika & Matthew James (Njala University); Kabie Kanu & Julius Sesay (Fourah Bay College), splitting into two field teams over a 10-day survey period, one team remaining on site for an extra three days.

This report will feed into the wider Environmental & Social Impact Assessment (ESIA) and Feasibility Study for the Project, being conducted by Worley Parsons Ltd and SRK Consulting (UK) Ltd. The scope of the current phase of this work was set out by SRK Consulting (UK) Ltd, the principal points being to:

- undertake an intensive two-week botanical survey of the three deposits on Numbara, Marampon and Simbili Hills (figure 1) and immediate vicinity likely to be impacted by mining activity
- identify and characterise the vegetation types and inventory the plant species present on the deposits with emphasis upon those habitats and species of key conservation concern that will need to be taken into consideration by the Project Feasibility Study
- identify potential impacts on the vegetation in the study area and provide recommendations for mitigation of these impacts including protection of species of conservation concern and initial identification of potential offset areas
- undertake a reconnaissance-level survey of the vegetation of the areas potentially affected by tailings deposits and/or mine-related infrastructure, including the identification of any sensitive or “no go” areas.

The **Project area** is here defined as the area covered by the mining exploration license plus the areas identified as potential tailings or infrastructure locations. However, the focus of the study within this wider area is the three deposits (Numbara, Marampon and Simbili) plus the three options (1, 4 & 5) identified to be the most likely locations for tailings and infrastructure.

Due to delays in obtaining the SPOT satellite imagery required for adequate delimitation of the vegetation types in the Project area, the vegetation map which accompanies this document is currently in preparation and will be delivered separately in a supplementary report.

### Background information on the vegetation and environment of the Project area

The Project lies within Tonkolili District of Northern Province, Sierra Leone, in the southern portion of the Sula mountain chain. The Sula Mts are one of a series of isolated highland regions in northern and eastern Sierra Leone which together form the westernmost extent of the Guinea (or Loma-Man) Highlands which extend to western Côte d’Ivoire. This is one of the richest regions in West Africa for plant diversity, with significant numbers of endemic (unique) and rare species.

The Sula Mts coincide with a belt of higher annual rainfall than other regions of Sierra Leone with the exception of the coastal strip. Rainfall here is highly seasonal, the wet season beginning slowly in March–April and peaking in July–September. The dry season typically begins in mid-October with very little rain falling from mid-November through to March.

The altitude at the Project area ranges from 120 m in the Tonkolili River valley, to 830 m on the peak of Simbili Hill. Submontane elements of the Guinea highlands vegetation extend down to altitudes well below 1000 m in this part of Sierra Leone, hence the vegetation of the Project area is likely to contain some submontane elements in addition to lowland elements. Lowland and submontane forest have suffered extensive losses throughout West Africa, resulting in large and potentially threatening declines in the range of many species unique to this region. The Tonkolili region is no exception, where forest, the natural climax vegetation of most of the region, is now largely restricted to narrow strips along river valleys and on the steepest slopes, and sacred groves and community forests.

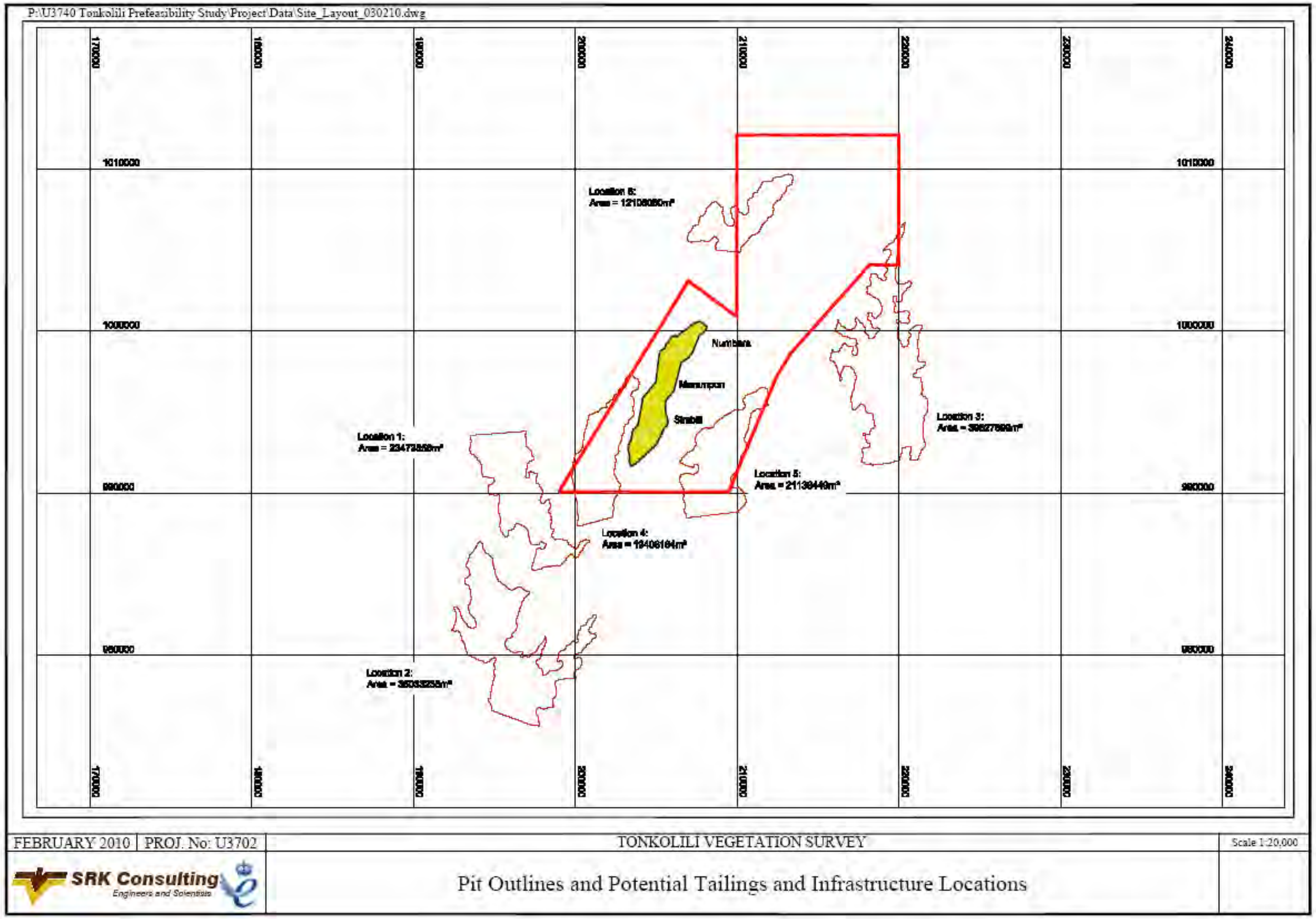


*Figure 1: location of the three deposits and proposed tailings options at the Tonkolili mine site, reproduced with permission from SRK Consulting UK Ltd. (bold Red Line = total area covered by the mining exploration license).*

There has been a long history of botanical exploration in Sierra Leone, especially during the British colonial period, with extensive historic collections held in herbaria, particularly at RBG Kew. Whilst the larger Loma Mts and Tingi Hills close to the Guinea border have been visited by many botanists, few previous botanical expeditions appear to have been made in the southern Sula Mts and the vegetation of this region is not well documented.

# 2. METHODOLOGY

## 2.1 DEPOSITS AND ADJACENT TONKOLILI RIVER VALLEY

The three deposits, Simbili, Marampon and Numbara, and adjacent areas likely to be directly impacted by the mine were surveyed in detail using a combination of walk-over survey (botanical patrol) and plot sampling. Priority was given to the habitats identified as of potential conservation concern from the reconnaissance survey. A total of 12 plots were surveyed (table 1, fig. 2). Different vegetation types were sampled using different plot sizes:

- *Forest* - 25 m × 25 m Hall & Swaine (1981) plots, used widely in West African vegetation survey, in which every vascular plant species is recorded and, unless identified on the spot with certainty, vouchered; additionally every tree ≥ 10 cm dbh (diameter at breast height, c. 130 cm) is recorded, together with basic plot data. As the strip of riverine forest is too narrow to permit a 25 × 25 m square, plot T4 in this habitat was modified to 12.5 m × 50 m.
- *Grassland & wooded grassland* - 10 m × 10 m plots. Data recorded as above but all trees ≥ 5 cm dbh are recorded together with estimates of % ground cover for each herb species. Plot T7 is a composite transect of eight 10 m × 10 m plots aimed primarily at providing more data on the tree species within this habitat.
- *Secondary thicket / woodland* - 10 m × 10 m plots. Data recorded as for wooded grassland plots. The three plots taken are intended to provide an overview of this vegetation type which is considered to be of low conservation concern.

| Plot | Size (m) | Vegetation type | Locality | Geo-reference and altitude |
|---|---|---|---|---|
| T1 | 10 × 10 | Grassland | Numbara summit ridge | 09°01'39.0" N 11°40'07.1" W 800 m |
| T2 | 10 × 10 | Wooded grassland | Numbara Numbara S facing slope of summit ridge | 09°01'48.4" N 11°39'54.5" W 770 m |
| T3 | 10 × 10 | Wooded grassland | Numbara S facing slope of summit ridge | 09°01'48.2" N 11°39'54.1" W 760 m |
| T4 | 12.5 × 50 | Riverine forest | Tonkolili River E of Farangbeya | 08°59'09.6" N 11°42'09.8" W 340 m |
| T5 | 10 × 10 | Wooded grassland | Marampon, ridge NW of summit | 08°59'46.1" N 11°40'55.3" W 670 m |
| T6 | 10 × 10 | Wooded grassland (disturbed) | Marampon summit ridge | 08°59'47.1" N 11°40'49.9" W 690 m |
| T7 | 10 × 80 | Grassland / wooded grassland | Numbara, N section of summit ridge | 09°01'56.4" N 11°39'51.9" W 760 m |
| T8 | 10 × 10 | Bushland (secondary) | W slopes of saddle between Numbara and Marampon | 08°59'05.6" N 11°41'21.6" W 570 m |
| T9 | 25 × 25 | Hillslope forest | Simbili W slopes | 08°58'36.2" N 11°41'21.7" W 770 m |
| T10 | 10 × 10 | Bushland (secondary) | W slopes of saddle between Numbara and Marampon | 08°59'15.3" N 11°41'26.3" W 470 m |
| T11 | 10 × 10 | Bushland (secondary) | W slopes of saddle between Numbara and Marampon | 08°59'10.9" N 11°41'42.5" W 430 m |
| T12 | 25 × 25 | Hillslope forest | SW of Kegbema village | 09°00'25.7" N 11°42'05.6" W 430 m |

*Table 1: summary of vegetation survey plots, Nov-Dec 2009 (see figure 2).*

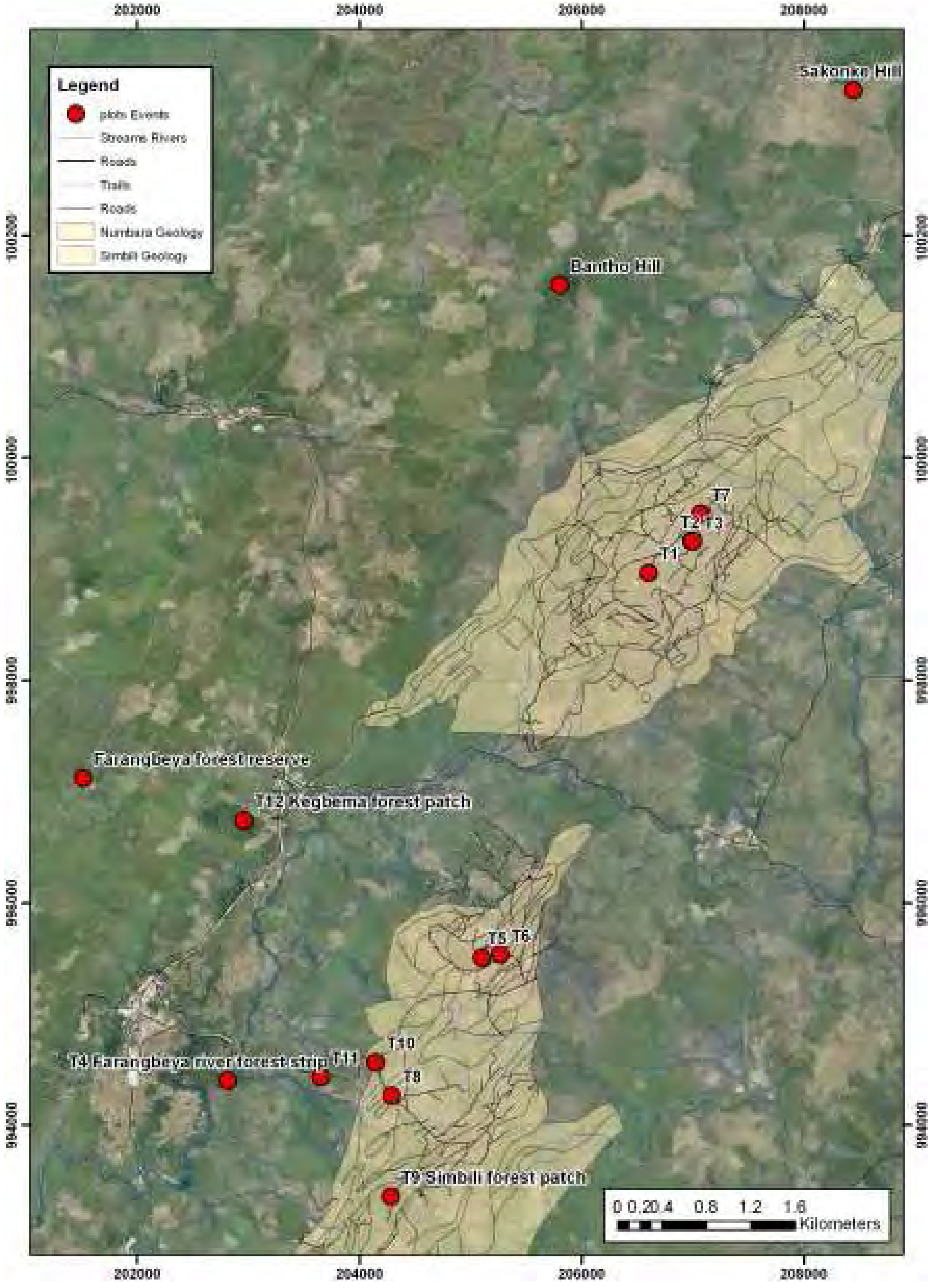


*Figure 2: location of vegetation survey plots, important collecting localities in the Project area and potential offset sites surveyed.*

Primarily for reasons of time-constraint and logistics, rather than using pre-selected random sampling within each vegetation type, the plots were selected on the ground, choosing typical representative areas of each habitat type.

Standard field data forms were used to collect data in each plot, the information collected including georeference, altitude, aspect, soil type, evidence of disturbance (human influence, fire), overview notes on the vegetation including dominant species, and photographs of the plot to record the vegetation structure together with close-ups of species of interest. Plot forms and plot species lists are not presented in this report but are available on request.

The survey teams did not enter any sacred forest groves (society bush) and the AML Public Relations Officer, Atkins Koroma, was consulted prior to entering any forest areas / selecting forest plot localities to ensure that we were not entering restricted-access areas. Sacred forests within the vicinity of the deposits, such as that on the west side of the road between Farangbeya and Kegbema, were briefly surveyed by use of binoculars from the roadside.

Seasonally inundated grasslands were not sampled using formal plots; instead a full species survey was conducted within these small areas (typically less than 50 × 50 m), recording dominant species and vouchering all flowering and fruiting species not identified with certainty in the field.

All additional herbarium voucher specimens collected and sight records made during the walk-over surveys were georeferenced and accompanied by notes on habitat, species abundance etc. Voucher specimens were pressed and dried using electric fan heaters. Oversized material such as large fruits were dried separately and cross-referenced to the associated pressed specimen.

## 2.2 RECONNAISANCE SURVEY OF POTENTIAL TAILINGS OR INFRASTRUCTURE LOCALITIES

Of the six potential localities identified by SRK Consulting, the botanical team were asked to provide an overview survey of the three most likely options: 1, 4 & 5 (see fig. 1). These options were mapped onto composite aerial photograph images and locations with vegetation of potential conservation concern were identified. Where possible within the timeframe, these areas were subsequently visited. The degree of surveying varied depending on the site:

*OPTION 1: Tonkolili River system W of the Kunsulma ridge, S of Bumbuna town*
This tailings option was covered by a full day walk-over survey by one of the teams, starting at the bridge over the Tonkolili River on the road south of Bumbuna, and following the river upstream. For the majority of the time a village path was used; several visits were made to the river to study the vegetation. In addition to the riverine forest, many observations were made in the farmbush adjacent to the river.

*OPTION 4: Tonkolili River system E of the Kunsulma ridge and W of the mine deposits*
The northern sector of this tailings option was surveyed in detail as part of the vegetation survey of the deposits, including plot T4, as this river system will be directly impacted by the mining activity (see 2.1). The southern sector was covered by a full day walk-over survey by one of the teams, concentrating on the riverine strips south of Wandugu and west of Foraia, with additional observations made of the surrounding valley floor and slopes.

*OPTION 5: River system E of the mine deposits*
A combination of observation from the vehicle and walk-over survey, with brief sampling of the habitats deemed of most interest (low altitude wooded grassland and inland valley swamps) was carried out by one of the teams during a full day. The area covered was within the triangle of villages Numkekoro 1, Sangbaia and Fenkembaia.

## 2.3 VOUCHER SPECIMEN IDENTIFICATIONS

Over the combined Sept and Nov-Dec trips, a total of 1059 herbarium voucher specimens were collected and databased, together with a further 373 species observation records (table 2).

| Collector | Number range | Total specimens |
|---|---|---|
| Burgt, X.M. van der | 1346–1394 | 49 |
| Clark, R. | 165–204 | 40 |
| Darbyshire, I. | 581–645 | 65 |
| Feika, A.M.B. | 1–75 | 75 |
| James, M.S. | 1–22 | 22 |
| Kanu, K.M.T. | 1–64 | 64 |
| Robinson, E. | 1–8 | 8 |
| Sesay, J.A. | 1–29 | 29 |
| Tonkolili Plants | 1–257 & 501–950 | 707 |

*Table 2: herbarium voucher specimens collected during the Sept and Nov-Dec botanical surveys*.

The top set of each specimen was deposited at the National Herbarium of Sierra Leone, Njala University; duplicates, if collected, being distributed to Fourah Bay College and RBG Kew. All specimens collected in unicate (a single sheet) were loaned to RBG Kew from Njala for identification. Specimens were identified by the Kew contributors and a range of specialists (see acknowledgements) through reference to relevant botanical literature and comparison to the extensive herbarium collections from West Africa housed at RBG Kew.

### 2.4 ASSESSMENT OF SPECIES CONSERVATION STATUS

The Categories & Criteria of the IUCN (2001) provide the international standard for species conservation assessment, through which species considered to be globally threatened can be added to the IUCN Red list (2009). The Red list was consulted to check for species identified from Tonkolili which are already assessed from Sierra Leone. All other species identified from the Tonkolili survey were then rapidly assessed against the IUCN categories and criteria using current and historic distribution records obtained from the available literature and existing herbarium collections. Species considered to be globally threatened were given a provisional threat assessment.

## 3. LIMITATIONS & ASSUMPTIONS

- The vegetation has only been studied in two seasons to date: briefly during the wet season (September) and more extensively at the on-set of the dry season (late November–early December). It is certain that a more complete coverage over the year, including the dry season (December–March) and onset of the wet season (April–May), would reveal a range of additional species which may well include further species of conservation concern.

- Some plant groups remain under-represented in the species inventory. Of particular note are the orchids for which CITES permits are required for specimen export; as we were unable to arrange these permits within the short timeframe, only photographs were taken and non-flowering plants (frequently encountered) could not be identified. The survey of large forest trees has not been exhaustive to date and the species accumulation curve derived from the forest plot data (see section 4.2) indicates that our coverage of the forest plant species in general is still some way from complete. In addition, weed species are under-represented in the checklist as we did not survey weedy habitats in detail, as it was assumed that these species are very unlikely to be of conservation value and priority was given to “natural” habitat types.

- Sacred forest patches were not surveyed in detail due to strict restrictions on access. These may well contain additional populations of the species of conservation concern found elsewhere in the Project area.

- As many of the herbarium voucher specimens collected were sterile (lacking flowers and fruits), complete and confident identifications could not be made for all the material. It is quite possible that some of the preliminary identifications will be changed if fertile material is collected in future visits.

- The IUCN conservation assessments listed in this report for the rare species found must be considered provisional at present in view of the incomplete information we have on the current distributions of the majority of the species.

- The survey of the three potential tailings or infrastructure locations must be considered highly provisional in view of the very limited time available and the incomplete coverage.

# 4. VEGETATION CLASSIFICATION & DESCRIPTIONS

This section details the structure and composition of the eight vegetation types recognised within the Project area. This classification is based upon the combination of general overview survey and analyses of the plot data collected to date.

## 4.1 FOREST ON HILLSLOPES

As has been remarked in the reconnaissance survey report, the natural climax vegetation of the majority of the study area is likely to be lowland rainforest. Presently, only a few small patches of forest remain, with most of the area now being used for the cultivation of rice by slash-and-burn agriculture (see 4.7 & 4.8). The two largest forest patches found on aerial photographs were studied in detail: the forest patch on the western slopes of Simbili (fig. 3), and the forest patch on the slopes to the southwest of Kegbema village (fig. 4). A 25 m × 25 m plot was made in each of these two patches (plots T9 and T12), and the forest surrounding these plots was studied by way of a walk-over survey. Several other small forest patches in the study area were also visited, but more briefly.

*Figure 3: the forest patch on the western slopes of Simbili, Nov. 2009 (X. van der Burgt).*

Plot T9 in the forest patch on the western slopes of Simbili is situated in a small grove of *Cryptosepalum tetraphyllum* (IUCN: VU) trees. All medium sized trees were coppiced several decades ago by farmers, but there are no signs of any damage by fire. Lower on the slopes on Simbili a large single tree of *Entandrophragma cylindricum* (in the centre of Fig. 3; IUCN: VU) is surrounded by a diverse and little-disturbed patch of forest. Other parts of this forest patch are more degraded, with tree species such as *Piptadeniastrum africanum* and *Pycnanthus angolensis*, characteristic of secondary forest.

*Figure 4: the forest patch on the slopes to the southwest of Kegbema village, Nov. 2009 (X. van der Burgt).*

The forest patch surrounding Plot T12 on the slopes to the southwest of Kegbema village is of good quality. The canopy is unbroken and consists of a diverse range of tree species characteristic of West African forests, for example *Daniellia thurifera* (the large tree in the centre of Fig. 4), *Guibourtia leonensis* and *Newtonia aubrevillei*. The understory is in good condition and consists of a variety of forest herbs, shrubs and small trees as well as seedlings and saplings of the large trees. The structure in this patch is characteristic of primary forest, and there are no signs of any damage by fire in the central portion. The only signs of damage by humans inside the plot are four stumps of medium sized trees logged several decades ago. Three of these are of the species *Baphia nitida*, of which the wood is used for carving, turning and making red dye (Burkill 1985–2004). A single medium sized tree of the species *Afzelia bella* was also logged several decades ago, probably for construction wood. Mature specimens of both species are still present within the forest patch. The absence of grove-forming tree species from the Legume subfamily Caesalpinioideae, in contrast to their presence in the strip of forest along the river near Farangbeya village (see below), does not necessarily indicate a higher degree of disturbance. Primary forests in Africa can have a high percentage of grove-forming Caesalpinioideae trees, as well as an absence of these.

The Kegbema forest is probably inside the Farangbeya Forest Reserve (demarcation of eastern boundary is uncertain), which would give it a national protected status. This forest must also have some kind of protected status given by the local villagers, or it would be much more degraded or lost.

### 4.2 RIVERINE FOREST

Maps of the study area indicate that the rivers in the Project area are usually bordered by a strip of forest. The forest strip along the river near Farangbeya village, which is the largest and most intact area identified from aerial photographs, was studied in detail. A 12.5 m x 50 m plot (T4) was made, and the forest surrounding the plot was studied by way of a walk-over survey. Several other riverine forest strips in the study area were also visited, but more briefly.

The strip of forest along the river near Farangbeya village (Fig. 5) is approximately 10 m to 50 m (occasionally more) wide on both sides of the river and bordered by almost treeless farmland. The forest here is of good quality, both in terms of species composition and structure, despite its proximity to the village. The canopy of this forest also consists of a diverse sample of tree species characteristic of West African forests. In addition, there are species characteristic of riverine forest, e.g. *Heisteria parvifolia* and *Strephonema pseudocola*. Four grove-forming tree species from the Legume subfamily Caesalpinioideae were found: *Aphanocalyx pteridophyllus, Brachystegia leonensis, Gilbertiodendron aylmeri* and *Copaifera salikounda*. These four species are all of conservation concern (see tables 7 & 8). The presence of these grove-forming species indicates that this forest strip is a remnant of species-rich primary rainforest. The understory is in good condition and contains a variety of forest species of herbs, shrubs and small trees as well as seedlings and saplings of the large trees. There are no signs of fire in most parts of the forest strip, though fire damage was observed in some areas especially along the forest edges bordering farmland.

*Figure 5: the strip of forest along the river near Farangbeya village, Nov. 2009 (X. van der Burgt).*

**Discussion on hillslope and riverine forests**

The edges of the forest patches in the study area are more degraded compared to their interior; fires have penetrated during the dry season, destroying the shrub layer and damaging the large trees. This process slowly decreases the size of the forest patches in the study area. These forest patches are and have been used for the collection of construction wood and firewood, for hunting, fruit gathering and medicinal plant gathering.

Of the three forest patches studied in detail, the strip of riverine forest near Farangbeya and the patch to the southwest of Kegbema village have the highest conservation value. This is indicated by the structure of these forest patches, their species richness, their general species composition and the presence of species of conservation concern. Both patches are equally rich in species, and richer than the forest patch on the western slopes of Simbili (Table 3). Plot T4 in the strip of riverine forest near Farangbeya has four conservation species compared to six such species in plot T12 in the forest patch to the southwest of Kegbema village (Table 3). Eight conservation species were found in the whole forest patch to the southwest of Kegbema village compared to 14 such species in the strip of forest near Farangbeya. The reason for the higher number in the latter site is probably that several days were spent here on the walk-over survey, while only one day was spent on the walk-over survey in the Kegbema forest patch. Although the three forest plots do not show large differences in their species composition, the separation of natural forest vegetation in the study area into forests on hill slopes and riverine forest is still maintained on the basis of their structural differences.

| Forest patch locality | Plot | Number of species | | |
|---|---|---|---|---|
| | | Total | Of conservation concern | |
| | | In plot | In plot | In forest patch |
| Along river near Farangbeya | T4 | 128 | 4 | 13 |
| Western slopes of Simbili | T9 | 86 | 2 | 7 |
| Southwest of Kegbema village | T12 | 127 | 7 | 9 |

*Table 3: number of species in the three forest plots.*

A species accumulation curve was made for the three plots (Fig. 6). Although three plots is too low a number for a good analysis of a species accumulation curve, some conclusions can be drawn from the figure. The total number of species in all three plots is 257. At the third plot the species accumulation curve still climbs, indicating that not all forest species were found by the present survey. A fourth plot in forest would on average have an estimated number of 46 species new to the forest plot survey, bringing the total to an estimated number of 303 species (some of these species may, of course, already have been found by the walk-over survey). The total number of forest species in the study area can only be estimated very roughly from this curve, but is expected to have been between 500 and 800 species prior to the loss and disturbance of much of the forest cover. Since much of the forest between and around the three plots has now been converted to farmland, a proportion of these species will have disappeared from the study area and a species count towards the lower end of this estimate is most likely.

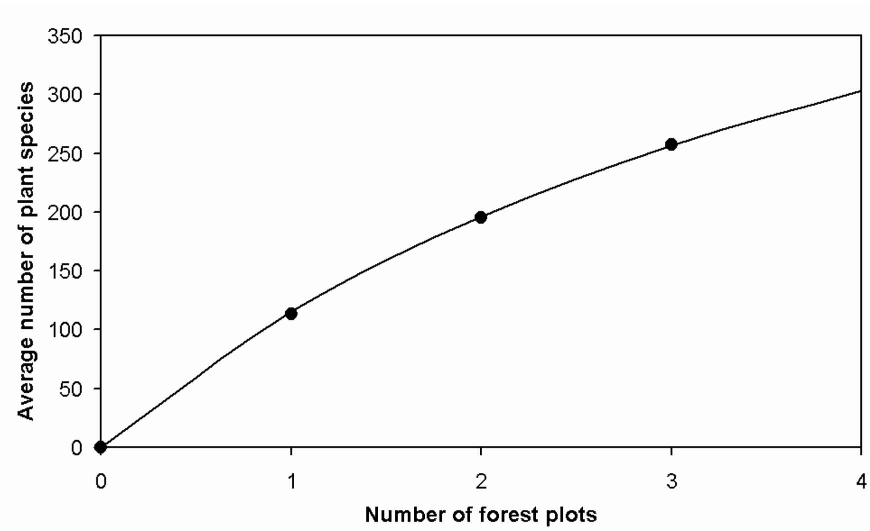


*Figure 6: species accumulation curve for the three forest plots. If a fourth plot is made it can be expected to have an average of 46 species new to the forest plot survey.*

**4.3. RIVER CHANNEL COMMUNITIES**

Stretches of the Tonkolili River between Farangbeya and Foraia (potential tailings or infrastructure option 4) are fast-flowing with a series of rapids and small falls over a rocky bed (fig. 7). These potentially support a rheophytic plant community (plants adapted to fast flowing, clear, well-oxygenated water, usually with narrow leaves and strong anchoring rootstocks). Two rheophytic species have been uncovered to date: the widespread *Marsdenia oblanceolata* and a probable new species to science, *Eriocaulon* sp. nov. nr. *E. varians*. This latter species is known only from one other collection, having been collected over 50 years ago from the same locality at Farangbeya. We are currently awaiting confirmation of its status from the specialist in this plant group.

A more complete survey of the Tonkolili River channel when water levels are lower (late Dec-March) will almost certainly reveal further rheophytes. Amongst these, we are likely to find species of the Podostemaceae family, a group of tiny herbs highly specialised to this environment and easily overlooked, particularly when water levels are high as in the Nov-Dec visit. Many species in this family are highly localised and scarce; it is therefore anticipated that further species of conservation concern will be revealed from this habitat.

Rheophytes can be sensitive to environmental change such as changing water levels and increased sedimentation, processes which may be exacerbated by mining activities. On the other hand, the population of the *Eriocaulon* at Farangbeya has clearly survived the large-scale deforestation of the surrounding hillslopes which will have had a significant impact upon water run-off volumes and particularly sedimentation rates; the extent to which this species can cope with further environmental change is unknown and requires further consideration.

*Figure 7: potential rheophyte habitat on the Tonkolili River W of Foraia village, proposed tailings option 4, Dec. 2009 (I. Darbyshire).*

The shallow rocky bed along the river margin becomes exposed as the water level falls in the dry season. These areas support a community of water-loving herbs which are less specialised than rheophytes. The common species are *Anubias afzelii* / *barteri* (no flowers or fruits seen to date, these being required to separate these two species) and the highly pungent *Hygrophila odora* which can form carpets amongst the exposed rock beds. Also recorded in this habitat W of Farangbeya was the rare *Anubias gracilis*.

### 4.4. GRASSLAND AND WOODED GRASSLAND ON WELL-DRAINED SOILS

Grassland (characterised by a tree canopy cover of less than 10%) and wooded grassland (canopy cover 10–40%), often together referred to as “savanna”, are widespread habitats in Sierra Leone. Although sometimes treated as two distinct vegetation types, the natural grasslands and wooded grasslands in the Project area form a mosaic, variable over a matter of a few tens of metres dependent upon subtle changes in slope and soil depth. They are therefore treated as a single entity here, but are subdivided into two distinct types (secondary grassland is treated separately in section 4.7.1):

#### 4.4.1 Hill summit (wooded) grassland

The summit ridges (over c. 650 m alt.) of the higher peaks in the southern Sula Mts hold extensive areas of a natural fire-prone grassland / lightly wooded grassland, with the canopy cover varying from 0% to c. 30%, this figure typically increasing on the steeper ridge slopes. This grassland develops over thin soils, with regular outcrops of iron-rich bedrock. This vegetation type has been surveyed in plots T1, 2, 3, 5, 6 & 7.

The most intact and extensive examples of this habitat type on the mine site are to be found on Numbara (fig. 8). Whilst the numerous exporation tracks and drill pads have impacted upon this habitat to some extent, the effects are localised and the majority of the habitat remains undisturbed. Whilst these grasslands are also extensive on Marampon, some areas show evidence of recent rice farming and some invasion of secondary grassland species (see 4.7.1). The summit of Simbili holds degraded forest, but the subridge to the north of the summit is largely covered by grass with scattered tree species typical of the natural wooded grassland habitat. However, all the grasslands on Simbili are much disturbed with secondary grassland species dominant and with evidence of recent farming. Beyond the mine site, we found a good further example of this hill summit grassland on Sakonke Hill to the NW of Numbara and outside the mine concession. Viewed through binoculars from the summit of Numbara, many of the larger hills in the northern sector of the licensed mining exploration area appear to hold similar habitat, although these have not yet been surveyed on the ground.

*Figure 8: hill summit Loudetia grassland and lightly wooded grassland on Numbara, Nov 2009; the burnt summmit grasslands of Sakonke Hill can be seen in the top left (I. Darbyshire).*

Woody species diversity is low in this habitat, with only 13 tree species recorded (table 4), all being common species typical of the West African (Guinean) "savannas". By far the most common is *Pterocarpus erinaceus*, with *Bridelia micrantha*, *Lophira lanceolata* and *Parkia biglobosa* also frequently encountered. The mature trees typically reach a height of 3–7 m. Many tree saplings were recorded in the plots, including forest/woodland pioneer species such as *Allophylus africanus*, *Anisophyllea laurina* and *Albizia zygia* but many of these are likely to be lost during dry season burning (see Fire Regime below) – certainly, very few mature trees of these species were recorded during our surveys of this habitat.

| **Tree species** | **Number of mature individuals recorded in the 13 plots** | | **Number of plots in which species was recorded, including immature individuals** |
|---|---|---|---|
| | **5 - 10 cm dbh** | **> 10 cm dbh** | |
| *Pterocarpus erinaceus* | 2 | 11 | 12 |
| *Bridelia micrantha* | 3 | 4 | 8 |
| *Parkia biglobosa* | 1 | 1 | 2 |
| *Lophira lanceolata* | 0 | 1 | 3 |
| *Anisophyllea laurina* | 0 | 0 | 4 |
| *Albizia zygia* | 0 | 0 | 3 |
| *Cussonia arborea* | 0 | 0 | 2 |
| *Allophyllus africanus* fa. *africanus* | 0 | 0 | 1 |
| *Ochna afzelii* | 0 | 0 | 1 |
| *Erythrina senegalensis* | 0 | 0 | 0 |
| *Hymenocardia acida* | 0 | 0 | 0 |
| *Psorospermum febrifugum* | 0 | 0 | 0 |
| *Syzygium guineense* subsp. *macrocarpum* | 0 | 0 | 0 |

*Table 4: tree species recorded in the hill summit Loudetia grassland / wooded grassland, with summary plot data (for the purpose of this table, the composite plot T7 is subdivided into eight 10 × 10 m plots).*

The ground cover is usually 100% except in areas of bare rock exposure. In the majority of this habitat, the grass cover is dominated (70–95%) by 2–2.5 m tall *Loudetia arundinacea*. This is a widespread species, typical of dry thin soils over rock outcrops. Other common grasses (usually at ≤ 5% cover) are *Hyparrhenia diplandra*, *Chasmopodium afzelii*, *Andropogon gayanus* and/or *A. tectorum*, typically at 2–3.5 m height. In areas of deeper soils and/or some disturbance, *Andropogon tectorum* can dominate (e.g. 75% ground cover in plot T6). Areas of recent and regular disturbance, most notably along the fringes of the mining exploration tracks and drill pads, are dominated by the 1–1.5 m grasses *Pennisetum hordeioides* and/or *P. polystachion*.

The herb flora is more varied. Robust perennial herbs and subshrubs are scattered amongst the grass, common species including *Aedesia glabra*, *Dolichos dinklagei*, *Droogmansia scaettaiana*, *Melastomastrum theifolium*, *Psorospermum alternifolium* and *Vernonia guineensis.* In areas of loose rock, the fleshy *Cissus caesia* can form large sprawling tangles. Common annual herbs, flowering early in the dry season, include *Alectra sessiliflora*, *Hypoestes cancellata*, *Polygala multiflora*, *P. rarifolia*, *Sopubia parviflora* and the twining *Vigna venulosa*. A community of small ephemeral herbs develop on the exposed rocky areas, flowering towards the end of the wet season when surface moisture is available before setting seed and quickly dying off as the grassland dries; common species include the widespread *Bulbostylis congensis*, *Cyanotis longifolia*, *Mesanthemum prescottianum*, *Neurotheca loeselioides*, *Scleria hirtella* and *Spermacoce pusilla*, together with the more localised and uncommon *Osbeckia decandra* and *Spermacoce bambusicola*. The fern *Nephrolepis undulata* is very common on exposed rock between the grass tussocks.

Of particular note amongst the herb flora is the discovery of a new species to science: *Pseudovigna* sp. nov., a perennial of the pea family. This species has an underground, fire-resistant rootstock. During the rainy season it develops a series of large trailing stems over exposed rocks where the grass cover is more sparse. It is particularly numerous on the summit of Numbara but has also been found on Marampon (a single plant) and was successfully located beyond the Project area on the summit of Sakonke Hill to the NW of Numbara.

Two rather scarce species restricted to submontane grassland have been recorded from Numbara: *Cyperus (tenuiculmis* var.) *guineensis* and *Crassocephalum guineense*. It therefore seems that the Numbara summit is sufficiently high to capture some submontane grassland elements, an important habitat for rare species in the wider Guinea (Loma-Man) Highlands. Indeed, it is possible that *Pseudovigna* sp. nov. is a submontane species which just extends onto these peaks; it is certainly absent from the lower altitude wooded grasslands.

**Fire regime**

The presence of several range-restricted species, in particular the apparent endemic *Pseudovigna* sp. nov., clearly indicates that the ridge-top wooded grasslands are a natural habitat and have been in place for some time. Whilst the thin soils with frequent outcrops of bedrock may limit the encroachment of woodland or forest, it is certain that annual burning plays an important role in maintaining these grasslands. All the mature tree species found in this habitat have fire resistant bark and physiology and evidence for regular burning is clear from the blackened trunks.

The grasses grow quickly during the wet season and flower at the end of the rains in November. As conditions dry, burning (through lightning strikes or often deliberate setting by man) typically commences in Nov–Dec. Indeed, during our visit the *Loudetia* grassland on Sakonke Hill had already been deliberately burnt (fig. 9). It is at this point that many of the woody saplings will be killed off. On both Marampon and Numbara several deep channels have been cut along the ridge and slopes, presumably geological sample trenches. Saplings growing in these ditches are protected from fire and we found several maturing plants or colonies of woodland / forest pioneers such as *Alchornea cordifolia*, *Margaritaria discoidea* and *Anthocleista nobilis*.

Within a few weeks of burning, fire-resistant herbs with perennial underground rootstocks (pyrophytes) are likely to emerge to flower and fruit – as we have not visited these sites at the appropriate season, this set of species remains little-surveyed in the Project area.

**Conservation value**

Of the hill summit grasslands on the deposits, those on Numbara are considered to be of highest conservation value in terms of quantity and quality of habitat, species richness and the presence of a sizable population of the conservation priority species *Pseudovigna* sp. nov.

*Figure 9: recently burnt Loudetia grassland on the summit of Sakonke Hill, Dec. 2009 (I. Darbyshire).*

**4.4.2 Low Altitude Wooded Grassland**

Some areas of the valley floors beyond the riverine fringe and the adjacent lower hillslopes are occupied by wooded grassland which looks superficially similar to that on the ridge summits. As this habitat is not recorded on the three mine deposits, it has not been surveyed in detail. However, it is frequently encountered in the potential tailings or infrastructure locations (particularly option 5) and an initial assessment has therefore been made on several representative patches of this habitat.

The ground cover is again ± 100% and is dominated by *Hyparrhenia-Loudetia* grassland. Conspicuous amongst the grasses are stands of the ginger *Aframomum* sp. 1 of Tonkolili (unidentifiable to species at this time of year as not in flower). The woody component in these areas is often more dense than on the hill summits and, although many of the species encountered are the same (e.g. *Pterocarpus erinaceus*, *Parkia biglobosa*) the dominant species differ, often being *Lophira lanceolata*, *Crossopteryx febrifuga* and/or *Hymenocardia acida*, the *Crossopteryx* being apparently absent from hill summit sites. In several areas within option 5, the native woody species are supplemented by planting of *Gmelina arborea* Roxb., a fast growing Asian tree planted here in rows perhaps as a boundary marker; it is also used locally as a shade tree.

These wooded grasslands are used for cattle grazing by local communities and it is likely that browsing of tree and shrub saplings by the domestic livestock plays an important role in halting the succession to thicket and closed woodland. Regular burning is, however, also likely to be significant in this process as on the ridge summits.

The examples of this habitat found between Numkekoro and Sangbaia (e.g. 8° 58' 54.1" N, 11° 38' 37.1" W) and between Numkekoro and Fenkembaia (e.g. 8° 58' 03.3" N, 11° 38' 30.5" W) in tailings option 5 have a more diverse woody flora than on the hill summits (fig. 10) and should be surveyed in more detail if this option is selected for development. However, this is a common habitat type in Sierra Leone and, from the brief survey, appears to be typical of the widespread "Guinean" wooded grasslands which extend all the way from West Africa to Sudan and NW Uganda, which is not known to contain a large number of rare or localised species. The conservation value of this habitat type is therefore provisionally assessed as low.

*Figure 10: low altitude wooded grassland between Numkekoro and Sangbaia, proposed tailings option 5, Dec. 2009 (I. Darbyshire).*

## 4.5. SEASONALLY WET GRASSLAND

Areas of seasonally wet grassland can develop in shallow depressions over flat bedrock (fig. 11) and in areas of seepage over bedrock on hillslopes (figs. 12 & 13). These sites support an ephemeral wetland community quite distinct from that supported by the surrounding free-drained soils. They are usually wet only during the latter part of the wet season and into the earliest part of the dry season. Many of the herbs have a short life-cycle, dying off quickly after setting seed as the seasonal wetland dries out. This habitat is widespread in the Guinea Highlands and often contains highly localised and rare species.

Four such areas were located during the reconnaissance visit in Sept 2009; the Nov-Dec visit resurveyed these sites and also found two further significant sites for this habitat, one within the Project area and one beyond the mine concession area (table 5). Unfortunately, the delay in timing of the Nov-Dec visit meant that several of these sites had dried out and many of the species had therefore died off. The combined survey from the two visits will not therefore have provided an exhaustive inventory of this habitat. However, our findings to date confirm that this is a habitat of high conservation value.

| Location | Georeference | Description |
|---|---|---|
| *Numbara summit, drill platform NURC005* | 09° 01' 48.5" N<br>11° 40' 00.3" W | a small (c. 30 × 15 m) shallow depression on the summit ridge with stagnant water over flat bedrock; most of the water had evaporated by the Nov-Dec visit but still with wet mud and small pools of water remaining. |
| *Marampon summit crossroads* | 08° 59' 47.1" N<br>11° 40' 49.8" W | a small shallow depression (c. 10 × 5 m) clearly derived from the creation of the crossroads and completely dry by the Nov-Dec visit |
| *Marampon southern slopes* | 08° 59' 33.5" N<br>11° 41' 03.9" W | an area of downslope seepage (c. 100 × 50 m), bisected by the main route up to Marampon summit. Much of this area had dried out by the Nov-Dec visit but a small area of surface run-off remained with a diverse herb community found |
| *Depression ESE of Marampon* | 08° 59' 40.5" N<br>11° 40' 34.9" W | a large area of seepage on the slopes of Marampon and adjacent hill to the southeast with a central depression. This area was found in the Nov-Dec visit by which time it had dried completely |
| *NE slopes of Sakonke Hill (outside the mine concession area)* | 09° 03' 45.3" N<br>11° 38' 45.6" W &<br>09° 04' 09.2" N<br>11° 38' 51.7" W | A series a small (typically less than 30 $m^2$) seepage areas formed at the decline in slope gradient; these sites are all close to farmbush and may be subject to disturbance. They were mainly dry at the time of our visit. |

*Table 5: seasonally inundated and seepage grassland sites in the Tonkolili region.*

Although the range of species varies considerably from site to site in response to differences in water depth and whether stagnant or seeping, several species are common and characteristic of this habitat. The margins of these wetlands are typically dominated by the c. 1 m tall grass *Schizachyrium* sp. 1 (identity unconfirmed as it had finished flowering by the Nov-Dec visit) and the sedge *Nemum spadiceum* which often forms dense carpets 10–20 cm tall (fig. 12). Areas of bare mud hold a community of diminutive herbs, common species including *Adelostigma senegalense*, *Cyanotis lanata, Cyclocarpa stellaris*, *Eriocaulon* spp., *Polygala lecardii*, *Rotala stagnina* and *Utricularia* spp. Woody species are absent.

*Figure 11: seasonally inundated shallow depression on summit ridge of Numbara, drill platform NURC005; above: Sept 2009 (X. van der Burgt), below: late Nov 2009; the green tussocks in the latter photo are of the rare Schoenoplectiella oxyjulos (I. Darbyshire).*

The shallow depression on Numbara (drilling platform NURC005) contains a set of species not recorded in the seepage areas. Dominant in the areas of wet mud are *Panicum humile*, *Cyperus pustulatus*, *Pycreus capillifolius* and the rare *Schoenoplectiella oxyjulos* (fig. 11), with *Aponogeton vallisnerioides*, *Dopatrium senegalense* and *Xyris barteri* all common here. The drill platform is situated within this site and it was at first thought that the wetland was created by scraping away of the topsoil in preparation for the drilling. However, there is no evidence of surface scraping (we would expect to see mounds of earth around the edge of the site) and the range of species recorded suggests that the site is a natural depression; in other areas on the ridge summit disturbed by mine exploration activity there are many weedy species present but these are absent at NURC005.

The most important seasonally wet grassland for conservation identified to date is that on the S slopes of Marampon at the north end of the Simbili-Marampon saddle (figs. 12 and 13). The small area of seepage here holds three species of conservation concern including two potentially Endangered species: *Bryaspis humularioides* subsp. *falcistipulata* and *Schizachyrium lomaense* (the third, *Panicum glaucocladum*, is considered Vulnerable). The survey of this site during Nov-Dec visit was not exhaustive - a second day visit was planned to conduct a full survey of the grasses at this site but the area was burnt before this could be conducted (see below).

*Figure 12: seepage grassland on the S slopes of Marampon, with abundant Nemum spadiceum in the foreground, Nov 2009 (I. Darbyshire).*

*Figure 13: the same site, viewed looking S towards Simbili peak, showing open wet mud with surface seepage; the rare Bryaspis humularioides subsp. falcistipulata can be seen in the foreground, Nov. 2009 (I. Darbyshire).*

### ***Afrotrilepis* tussocks**

The seasonally wet grasslands on the slopes of Marampon are surrounded by patches of the tussock-forming sedge *Afrotrilepis pilosa*. Regular burning appears to be an important element of this species' ecology, the plants developing a tough raised and blackened fire-resistant perennial base. Indeed, the *Afrotrilepis* tussocks and adjacent *Schizachyrium* grassland around the seepage site on the S slopes of Marampon was burnt (apparently deliberately) during the Nov-Dec visit. This species is commonly found growing on exposed rock faces and is often associated with granite inselbergs (indeed, it is much in evidence on granite hills to the west and south of the mine concession area) but on Marampon it grows on slopes over thin soils which are seasonally wet. It therefore forms a transition between the freely drained grasslands and the seasonally wet grasslands. On the summit of Marampon, *Afrotrilepis* dominates in shallow drainage ditches dug along the ridge-top tracks.

### 4.6. INLAND VALLEY SWAMP

Where river valleys and cut-off former river meanders (ox-bows) are flooded during and following the wet season, freshwater swamps develop. Some of these swamps are maintained artificially for rice cultivation. Only small areas of this habitat are to be found in the vicinity of the mine deposits, along the Tonkolili River east of Farangbeya and at the southern foot of Numbara. This habitat is, however, common in proposed tailings option 5, with several large examples observed between Numkekoro, Sangbaia and Fenkembaia (fig. 14).

*Figure 14: inland valley swamp with rice cultivation S of Numkekoro in tailings option 5; Raphia palma-pinus and Hallea stipulosa are frequent in the swamp (I. Darbyshire)*

Many of these swamps are intensively cultivated for rice. However, more natural vegetation is to be found at some sites, though perhaps this develops during fallow periods. A typical shallow-water valley swamp was surveyed in some detail at the foot of Numbara. It supports a dense sedge community, most commonly *Fuirena stricta* var. *stricta* together with *Cyperus haspan*, *Fuirena umbellata*, *Rhynchospora corymbosa* and *Scleria melanomphala*. Wetland herbs interspersed within the sedge communities include *Ludwigia abyssinica*, *Mesanthemum radicans* and the rare *Aeschynomene deightonii*.

Some of the swamps in tailings option 5 contain deeper water (to c. 1.5 m or more) and can contain a range of aquatic species. A reconnaissance survey of one of the less disturbed sites recorded *Eichhornia natans*, *Limnophila dasyantha*, *Limnophyton angolense*, *Nymphaea maculata*, *Ottelia ulvifolia* and *Utricularia gibba*. All are widespread species at least in West Africa, only the *Limnophila* being at all uncommon, and with none being considered threatened.

Woody species are very few in this habitat. The small palm *Raphia palma-pinus* is frequent and all the valley swamps seen contained groves of *Hallea stipulosa*, a timber species considered Vulnerable on the IUCN Red list due to over-exploitation. This species is locally very common, acting as a pioneer tree, and in view of the large extent of valley swamps in this region of Sierra Leone, the *Hallea* is not considered a conservation priority.

Whilst the conservation importance of this habitat is provisionally assessed as low, the presence of *Aeschynomene deightonii*, a species considered to be globally threatened based on current evidence, suggests that further rare species may be uncovered if this habitat is surveyed further.

## 4.7 SECONDARY HABITATS

The slash-and-burn farming practiced by local communities, with long periods of fallow, result in a mosaic of farmbush and degraded secondary habitats over the majority of the Project area. Increased recent migration into the area may have exacerbated the rate of slash and burn farming here.

### 4.7.1 Secondary grassland

Extensive areas of the hillslopes on the three mine deposits are covered by dense stands of *Andropogon tectorum* grassland 3–3.5 m tall (fig. 15). Very few other herbaceous species are able to compete for light and nutrients, with the exceptions of the twining *Vigna venulosa* and the root parasite *Striga macrantha* which presumably parasitises the *Andropogon* here. In some areas on Simbili, the *Andropogon* is accompanied by *Setaria megaphylla* (again to 3 m tall), whilst particularly along recently disturbed forest margins the shorter (c. 1.5–2 m) *Melinis minutiflora* can dominate.

*Figure 15: extensive Andropogon tectorum secondary grassland on Numbara, Nov 2009. The transition to the hill summit lightly wooded grassland can be seen in the top right (E. Robinson).*

The large stands of *Andropogon* almost certainly indicate recent human slash and burn activity and are quite likely the initial stage of a secondary succession. This habitat is of minimal conservation concern.

The transition from *Andropogon* grassland to hill summit natural *Loudetia* grassland is usually gradual and partially dependent upon the degree of disturbance. However, soil depth may also play an important role in this transition and it is possible that *Andropogon* would also dominate on deeper soils in this region even in the absence of human disturbance.

From a vegetation mapping perspective, it is very difficult to separate areas of secondary grassland from the “natural” grassland habitats.

### 4.7.2 Secondary herbaceous *Chromolaena* scrub

Extensive stands 2–2.5 m tall of the invasive introduced weed *Chromolaena odorata* are recorded on some hillslopes on the deposits (fig. 16). This is a native of South and Central America and has spread rapidly in tropical Africa within the last few decades. Here, it represents an early stage in the succession following abandonment of agricultural land. Other species commonly associated with this habitat type are *Aspilia africana* and the fern *Pteridium aquilinum* (bracken). It is unclear as to why some areas are dominated by this species as opposed to *Andropogon* grassland (see 4.4.3) which seems to occupy a similar stage in the post-disturbance succession. This habitat is of no conservation value.

*Figure 16: extensive stands of Chromolaena odorata on the saddle between Simbili and Marampon, Dec 2009 (I. Darbyshire).*

### 4.7.3 Secondary thicket and woodland

The term "thicket" is precisely defined as a closed stand of bushes and climbers usually between 3–7 m tall, whilst "woodland" is defined as an open stand of trees at least 8 m tall with a canopy cover ≥ 40%. The woody secondary growth widespread in the Tonkolili region is intermediate in character.

Within a short period of fallow (estimated at 1–3 years), the hillslopes revert to a dense secondary thicket of bushes, small trees and lianas with a broken canopy cover, later (estimated at within 5 years) developing into a tree/bush thicket with a canopy cover of over 80%. Good examples of this habitat type were surveyed on the slopes of the saddle between Marampon and Simbili and the three plots T8, T10 and T11 provide a snapshot of this vegetation type (fig. 17). Of these, plot T10 contained the most mature thicket whilst T8 contained the least mature. Table 6 provides a list of the trees with dbh 5–10 cm and ≥10 cm and gives a good overview of the most commonly encountered species. The dominant species vary somewhat from site to site, but particularly abundant are *Dichrostachys cinerea*, *Anisophyllea laurina*, *Sterculia tragacantha* and *Alchornea cordifolia* (the latter often dominant along roadsides and margins of disturbed habitat). Immature treelets or shrubs of these species are also common in the understorey of this habitat. All these species are widespread and common species and typical fast-growing pioneers of secondary regrowth. Other pioneer species commonly encountered, though only as immature treelets (or absent) in the three plots surveyed, are *Bersama abyssinica*, *Napoleonaea* cf. *heudelotii*, *Newbouldia laevis* and *Trema orientalis*, the lattermost abundant along forest margins.

Particularly at the early stages of succession, a shrub layer is also present, with characteristic species including *Chassalia kolly*, *Diospyros heudelotii*, *Mareya micrantha*, *Microdesmis keayana*, *Solanum erianthum* and *S. torvum* (both abundant along disturbed forest margins) and *Tetracera alnifolia* (later climbing).

Both herbaceous and woody climbers are abundant in this habitat, often forming dense tangles. Common species include *Cardiospermum grandiflorum*, *Clerodendron splendens*, *Combretum* spp. including the vivid scarlet *C. grandiflora*, *Entada rheedei*, *Ipomoea involucrata*, *Leptoderris fasciculata*, *Merremia pterygocaulos*, *Smilax anceps* and *Tiliacora louisii*.

*Figure 17: mature secondary thicket / woodland on the saddle between Simbili and Marampon, plot T10, Dec. 2009 (I. Darbyshire).*

| **Species** | **Plot 8** | | **Plot 10** | | **Plot 11** | |
|---|---|---|---|---|---|---|
| | **Number*** | **Max. height** | **Number*** | **Max. height** | **Number*** | **Max. height** |
| *Dichrostachys cinerea* | 2 / 1 | 9 m | 5 / 5 | 11 (15) m | 0 / 0 | - |
| *Sterculia tragacantha* | 0 / 0 | - | 1 / 0 | 6 m | 5 / 1 | 12 m |
| *Anisophyllea laurina* | 3 / 0 | 7 m | 1 / 1 | 9 m | 0 / 0 | - |
| *Margaritaria discoidea* | 1 / 1 | 8 m | 0 / 0 | - | 2 / 1 | 10 m |
| *Baphia nitida vel. aff.* | 2 / 0 | 6 m | 0 / 0 | - | 0 / 0 | - |
| *Rauvolfia mannii* | 0 / 0 | - | 1 / 0 | 7 m | 1 / 0 | 6 m |
| *Harungana madagascariensis* | 0 / 0 | - | 0 / 1 | 10 m | 0 / 0 | - |
| *Alchornea cordifolia* | 0 / 0 | - | 1 / 0 | 7 m | 0 / 0 | - |
| *Mareya micrantha* | 0 / 0 | - | 1 / 0 | 7 m | 0 / 0 | - |
| *Myrianthus libericus* | 0 / 0 | - | 1 / 0 | 7 m | 0 / 0 | - |
| *Nauclea latifolia* | 0 / 0 | - | 1 / 0 | 6 m | 0 / 0 | - |
| *Pancovia pedicellaris* | 0 / 0 | - | 1 / 0 | 6 m | 0 / 0 | - |
| *Blighia cf. welwitschii* | 0 / 0 | - | 0 / 0 | - | 1 / 0 | 5 m |
| *Milicia regia* | 0 / 0 | - | 0 / 0 | - | 1 / 0 | 5 m |

*Table 6: mature tree species recorded in the 10 × 10 m secondary thicket plots; *number = number of trees with dbh 5–10 cm / > 10 cm. Max. height is only recorded for trees with dbh 5 cm or more (saplings and treelets are discounted).*

Nearly all the mature trees and shrubs in these thickets display evidence of past cutting to the base and dead trees through excessive cutting and burning are a frequent site. However, in the areas of thicket surveyed, there was no evidence of recent felling of larger trees. Therefore, whilst it is almost certain that these hillslopes were once forested, it is likely that the majority of forest loss is not recent (but see discussion on forest margin disturbance in section 4.2).

In the early stages of thicket development, as in plot T8, a rather dense herb layer persists, typically with the species recorded in the *Chromolaena* scrub together with *Ageratum conyzoides*, *Desmodium velutinum*, *Triumfetta* spp. and several Acanthaceous herbs including *Justicia ladanoides* and abundant *Hypoestes forskaolii.* However, as the bushland matures, light availability decreases and the ground cover becomes sparse, with secondary forest species such as *Psychotria subglabra* and the grass *Olyra latifolia* being most common.

### 4.8 AGRICULTURAL LAND

Agriculture within the Project area is varied. Farming in the valley bottoms and particularly the swampy areas consists of monocultures of rice (see fig. 14) or occasionally peanuts. Hill slopes and free-drained valley bottoms are usually farmed at a low intensity subsistence level, the principal crops being rice and cassava, with maize, okra, pepper, pigeon pea and sorghum also commonly grown. A variety of fruits as well as oil palms are commonly grown around villages. Hillslope farms are established following slash and burn, with the crop plants often scattered amongst the regenerating secondary growth. Cattle are also reared, with grazing on the natural wooded grassland (savanna); this was only observed in the low-altitude wooded grasslands, with no evidence of grazing on the hill summit grasslands at least during our visit.

Many weedy plant species are associated with these agricultural lands. Whilst a full weed survey has not been conducted, we can be confident that there are no species of high conservation concern in this habitat.

## 5. SPECIES OF CONSERVATION CONCERN

The IUCN Red list (2009) currently lists 46 globally threatened plant species occurring in Sierra Leone, of which 42 are assessed as Vulnerable (VU), three as Endangered (EN) and one as Critically Endangered (CR). Nearly all these species are timber trees, assessed on the basis of over-exploitation for commercial use coupled with habitat loss and so qualifying as threatened under criterion A of IUCN (2001); many are widespread in the forests of wet tropical Africa. Of these 46 species, **15** have been recorded in the Tonkolili region through the current survey work, with a further Red listed species (*Placodiscus oblongifolius*) recorded in Sierra Leone for the first time (table 7).

| Species | Family | Habit | IUCN | Habitat at Tonkolili |
|---|---|---|---|---|
| *Afzelia africana* | Leguminosae-Caesalpinioideae | T | VU A1d | HF, ST |
| *Amanoa bracteosa* | Phyllanthaceae (Euphorbiaceae) | T | VU A1c, B1+2c | RF |
| *Anopyxis klaineana* | Rhizophoraceae | T | VU A1cd | RF |
| *Copaifera salikounda* | Leguminosae-Caesalpinioideae | T | VU A1d | RF |
| *Cryptosepalum tetraphyllum* | Leguminosae-Caesalpinioideae | T | VU A1c, B1+2c | HF, RF |
| *Drypetes afzelii* | Putranjivaceae (Euphorbiaceae) | S/T | VU A1c, B1+2c | HF |
| *Entandrophragma cylindricum* | Meliaceae | T | VU A1cd | HF |
| *Garcinia kola* | Clusiaceae | T | VU A2cd | HF |
| *Guarea cedrata* | Meliaceae | T | VU A1c | HF |
| *Hallea stipulosa* | Rubiaceae | T | VU A1cd | VS |
| *Heritiera utilis* | Sterculiaceae | T | VU A1cd | HF, RF |
| *Nauclea diderrichii* | Rubiaceae | T | VU A1cd | HF |
| *Placodiscus oblongifolius* | Sapindaceae | T | VU A1c, B1+2c | HF |
| *Placodiscus pseudostipularis* | Sapindaceae | T | EN B1+2c (but see Annex 2) | HF |
| *Terminalia ivorensis* | Combretaceae | T | VU A1cd | RF |
| *Turraeanthus africanus* | Meliaceae | T | VU A1cd | HF |

*Table 7: IUCN Red listed species recorded at Tonkolili. Habit abbreviations: T = tree; S = shrub; L – liana/climber; H = herb. Habitat abbreviations: HF = hillslope forest; RF = riverine forest; VS = valley swamp; ST = secondary thicket and woodland. High priority species for conservation are highlighted in bold.*

However, only 3–5% of the world's plant species have been assessed using the IUCN (2001) protocol to date and therefore this list of 46 species represents only a very small proportion of the true number of Sierra Leonean plant species threatened with extinction. Most species of no commercial value have never been evaluated, even if they are extremely rare and/or localised in distribution. Following the current botanical survey work, a further **18** species recorded within the Tonkolili area (mine deposits and wider mining concession) are here recognised for the first time as Red list candidate species (table 8). These include two species completely new to science and currently known only from the Project area and/or immediate surroundings: *Pseudovigna sp. nov.* and *Eriocaulon sp. nov*.

| Species | Family | Habit | No. of previously known localities | Potential IUCN status based upon current knowledge | Habitat at Tonkolili |
|---|---|---|---|---|---|
| *Aeschynomene deightonii* | Leguminosae-Papilionoideae | H | 9 | VU under criterion B | VS |
| *Anthonotha explicans vel. sp. aff.* | Leguminosae-Caesalpinioideae | T | c. 8 | VU under criterion B | ST |
| *Anubias gracilis* | Araceae | H | c. 7 | VU under criterion B | RC |
| *Aphanocalyx pteridophyllus* | Leguminosae-Caesalpinioideae | T | 9 | VU under criteria A & B | RF |
| *Brachystegia leonensis* | Leguminosae-Caesalpinioideae | T | c. 15 | VU under criterion A | RF |
| ***Bryaspis humularioides* subsp. *falcistipulata*** | **Leguminosae-Papilionoideae** | **H** | **1** | **EN under criterion B** | **IG** |
| ***Dactyladenia smeathmannii*** | **Chrysobalanaceae** | **T** | **3** | **EN under criterion B** | **RF** |
| ***Dialium pobeguinii*** | **Leguminosae-Caesalpinioideae** | **T** | **5** | **VU under criterion B (potentially EN under criterion A)** | **RF** |
| ***Eriocaulon sp. nov.**** | **Eriocaulaceae** | **H** | **1 (same as this survey)** | **CR under criterion B** | **RC** |
| ***Gilbertiodendron aylmeri*** | **Leguminosae-Caesalpinioideae** | **T** | **6** | **VU under criterion B (potentially EN under criterion A)** | **RF** |
| ***Guibourtia leonensis*** | **Leguminosae-Caesalpinioideae** | **T** | **5** | **VU under criterion B (potentially EN under criterion A)** | **HF, RF** |
| ***Leptoderris micrantha*** | **Leguminosae-Papilionoideae** | **L** | **3** | **EN under criterion B** | **RF** |
| *Nemum bulbostyloides* | Cyperaceae | H | 9 | VU under criterion B | IG |
| *Panicum glaucocladum* | Gramineae | H | c. 7(–9) | VU under criterion B | IG |
| *Pavetta platycalyx* | Rubiaceae | S | c. 7 | VU under criterion B | HF |
| ***Pseudovigna sp. nov.*** | **Leguminosae-Papilionoideae** | **H** | **-** | **EN under criterion B** | **HG** |
| ***Schizachyrium lomaense*** | **Gramineae** | **H** | **2** | **EN under criterion B** | **IG** |
| *Schoenoplectiella oxyjulos* | Cyperaceae | H | c. 8 | VU under criterion B (or possibly NT) | IG |

*Table 8: IUCN Red list candidate species recorded at Tonkolili, with the provisional IUCN category and criteria based upon current knowledge. Habit abbreviations: T = tree; S = shrub; L – liana/climber; H = herb. Habitat abbreviations: HF = hillslope forest; RF = riverine forest; RC = rheophytic community; HG = hill summit grassland / woody grassland; IG = seasonally inundated grassland; VS = inland valley swamp; ST = secondary thicket and woodland. Highest priority species for conservation are highlighted in bold.*
**note: identification of Eriocaulon sp. nov. is subject to confirmation as it is closely allied to the E African species E. varians.*

Of the three threat categories recognised by IUCN, EN and CR species are of particular importance since these currently trigger the requirement for critical habitat assessment under IFC Performance Standard 6. However, following the current modification of this standard, it is likely that species assessed as VU under criterion B (number of localities / populations) will also fall under the critical habitat definition in the near future. As the species of conservation concern listed in table 8 are, in the main, assessed under criterion B, these should therefore be considered of the highest priority with regard to the IFC standards. The nine species considered of highest priority are highlighted in bold in the table.

A further potential new species to science, ***Dilophotriche* sp. ?nov.**, has been collected from the nearby Sakonke Hill (9° 04' 09.2" N 11° 38' 51.7" W, fig. 2) but not yet found within the mine concession. However, this species may well occur in suitable habitat on the mine site and should be sought for in the seepage grasslands on Marampon.

Whilst we can be confident that all the species listed in table 8 are genuinely scarce, the conservation status applied to each must be considered provisional in view of our incomplete knowledge of the current distribution of most of these species. It is quite probable that further survey work in the montane regions of northern Sierra Leone will reveal additional sites for many of these species and that their IUCN threat category may then be downgraded. On the other hand, in view of the surprisingly high number of species of conservation concern already identified, it is quite likely that some further threatened species will be uncovered by more detailed survey work within the Project area.

The maps in figs. 18 & 19 pinpoint the distribution of the species of conservation concern in the Tonkolili region. As anticipated, the four most "natural" habitats identified in the reconnaissance study, together with the rheophytic community, contain the highest number of conservation species (table 9).

Based upon our current sampling, the highest concentrations of these species can be found:

a) in the riverine forest E of the village of Farangbeya in proposed tailings option 4
b) in the hillslope forest W of the village of Kegbema on the edge of proposed tailings option 4
c) in the small seepage grassland area on the S slopes of Marampon

| Habitat | No. of IUCN Red listed spp. | No. of IUCN Red list candidate spp. | No. of potential EN or CR spp. |
|---|---|---|---|
| Hillslope forest | 11 | 2 | 1 |
| Riverine forest | 6 | 7 | 2 |
| Rheophytic (river channel) communities | - | 2 | 1 |
| Hill summit (wooded) grassland | - | 1 | 1 |
| Low altitude wooded grassland | - | - | - |
| Seasonally inundated grassland | - | 6 | 3 |
| Inland valley swamp | 1 | 1 | - |
| Secondary habitats | 1 | 1 | - |
| Agricultural land | - | - | - |

*Table 9: Number of listed and candidate Red-data (threatened) species per habitat at Tonkolili.*

More detailed information on each of the conservation species, together with photographs to aid identification, are given in Annex 2.

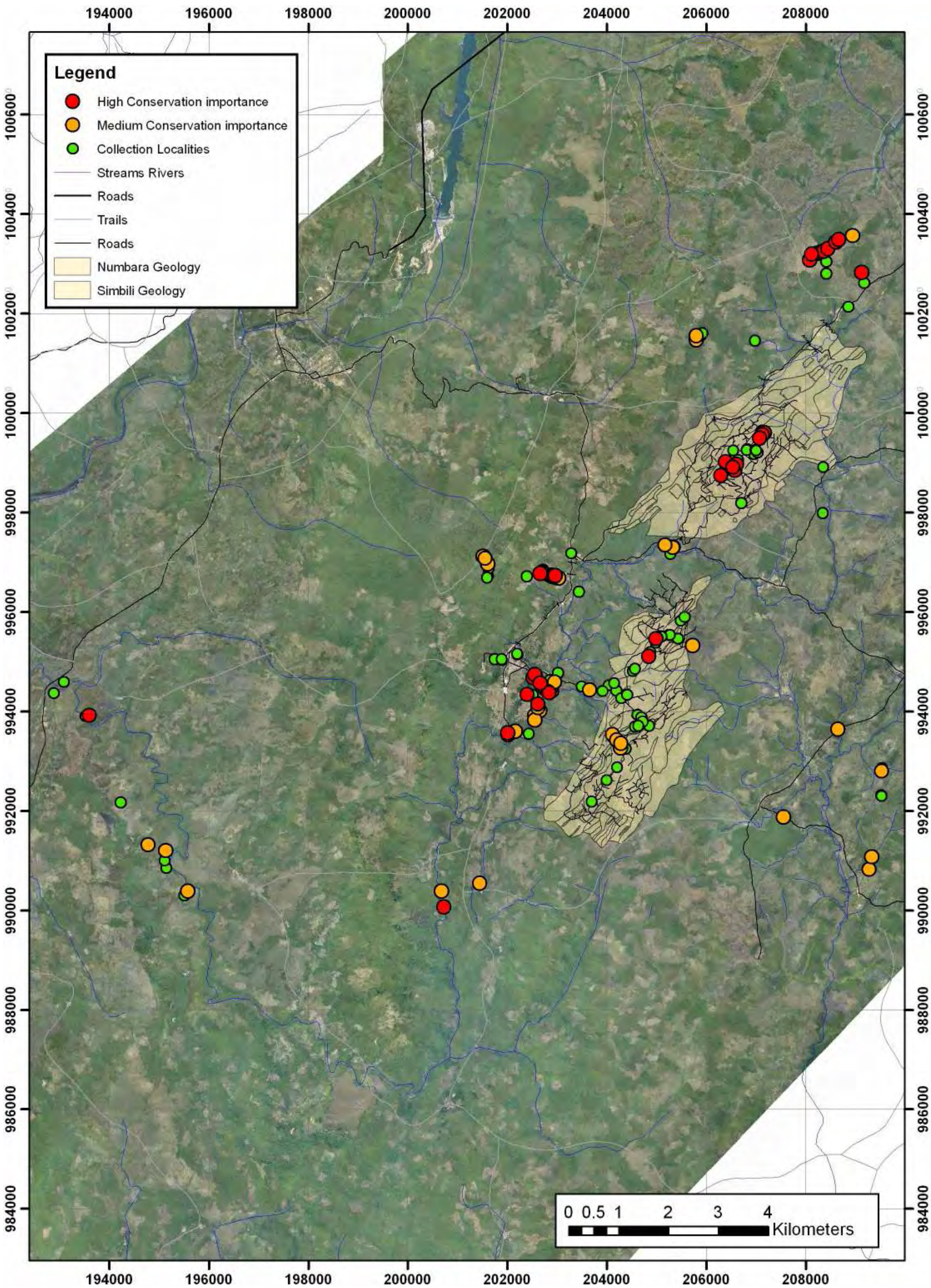


*Figure 18: map of the study area showing all plant collecting localities (green dots). Localities where one or more plant species of conservation concern were found, are shown in red (high conservation importance) and orange (medium conservation importance). The many red dots on Numbara and on the summit of Sakonke Hill to the NW of Numbara all represent a single species, Pseudovigna sp. nov.*

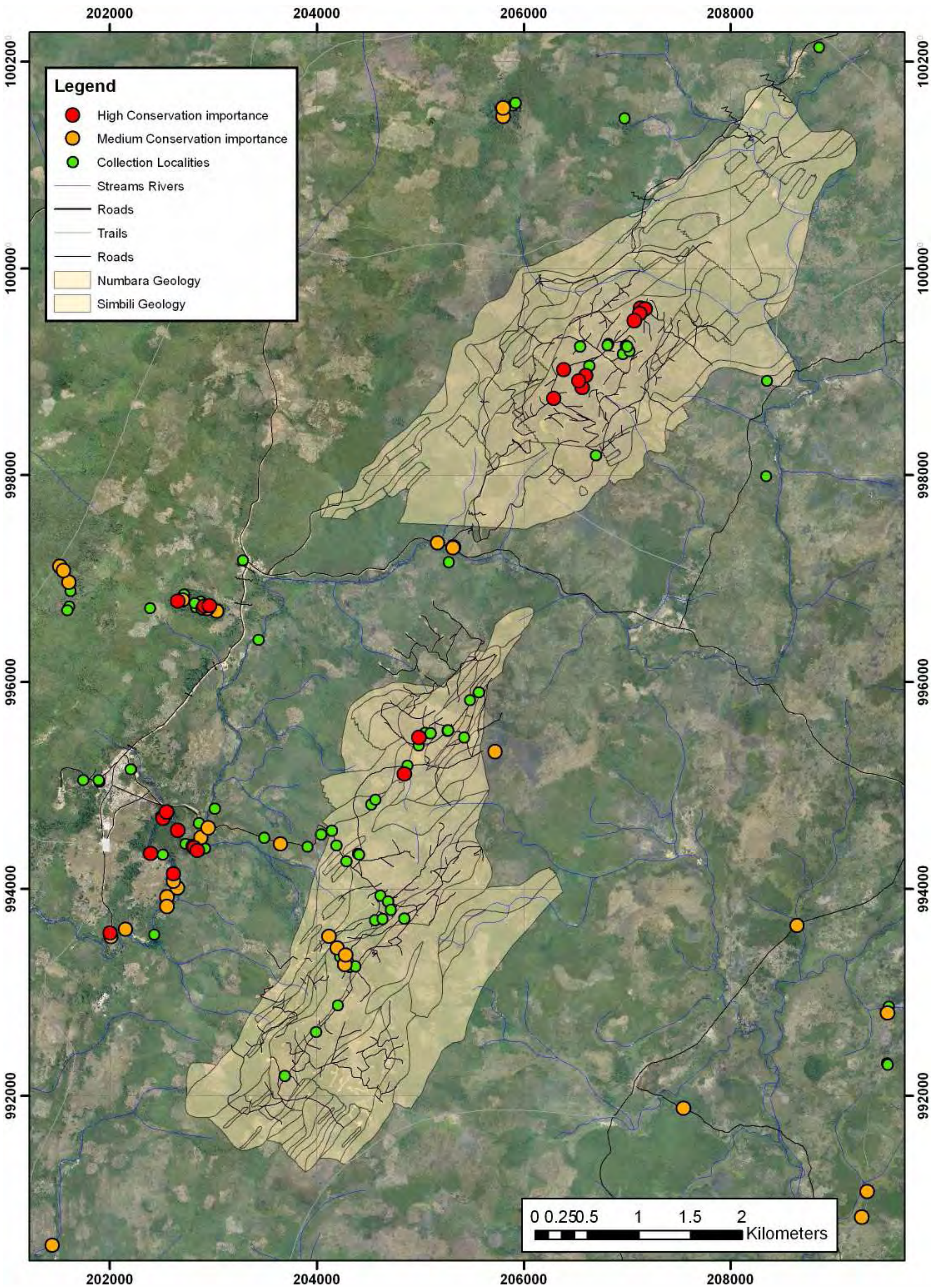


*Figure 19: enlargement of a portion of the map of Fig. 18, showing detail of the distribution of conservation species on the three deposits Simbili, Marampon and Numbara, the strip of riverine forest near Farangbeya and the forest patch to the southwest of Kegbema village.*

## 6. RECONNAISSANCE SURVEY OF POTENTIAL TAILINGS OR INFRASTRUCTURE PLACEMENT

The vegetation and species of conservation concern identified by the reconnaissance survey of the three potential tailings or infrastructure sites have been covered in sections 4 & 5 of this report; the current section aims to provide recommendations based upon the relative conservation importance of the three options; these must, however, be viewed as provisional in view of the limited survey work carried out at these sites to date:

***OPTION 4: Tonkolili River system E of the Kunsulma ridge and W of the deposits***
In view of the intact areas of species-rich riverine forest and the high number of conservation priority species recorded both in the forest and in the river channel along this section of the Tonkolili River (see sections 4.2 & 4.3), this area is viewed as the most important site for conservation in the Project area. This area would not, therefore, be recommended for development. Concerns over the potentially high impact of the mining activity itself upon this river system must also be considered in view of the presence of several species of high conservation significance here.

***OPTION 1: Tonkolili River system W of the Kunsulma ridge, S of Bumbuna town***
Whilst much of the riverine forest of the Tonkolili River is degraded in the northern section of option 1, three species of conservation importance have already been found within the forest remnants and adjacent degraded habitats (*Anthonotha explicans vel sp. aff.*, *Brachystegia leonensis*, *Dialium pobeguinii*) and it is likely that others will be uncovered if the area is surveyed in more detail. Furthermore, it appears from aerial photographs that the more remote stretches of the river in the southern portion of this tailings area may hold more intact riverine forest. Due to difficulties of access, this portion has not yet been surveyed on foot and it is recommended that this is carried out prior to any further decision on the development of this site.

***OPTION 5: River system E of the deposits***
Our preliminary survey work has so far not revealed any sizable areas of conservation importance within this option, and no species of conservation concern with the exception of the low priority *Hallea stipulosa*. Patches of forest within this valley system are largely restricted to small community forests adjacent to villages, with the riverine fringe being heavily degraded at least in the areas visited. Further survey work is, however, required in the patches of “natural” wooded grassland and valley swamp.

## 7. INITIAL SURVEY OF POTENTIAL OFFSET SITES

The identification of sites suitable for offsetting the losses of biodiversity on the proposed mine site must be informed by the vegetation survey and the identification of conservation priority species / habitats. It would therefore have been premature to carry out extensive searches for such sites during the Nov-Dec 2009 visit. However, some initial work on potential offset / species translocation sites was conducted in the immeditate vicinity of the Project area (see fig. 2):

***Farangbeya Forest Reserve*** (c. 9°01’ N 11°43’ W)
This reserve lies along the ridge and steep slopes of the Kunsulma Range to the W of the mine deposits down to the point at which the Tonkolili River bissects this range. Whilst nominally “protected” as a Reserve, no practical protection is in place and the vast majority of the forest has been replaced by farmland and regenerating secondary thicket of low conservation value. Several forest remnants were visited towards the ridge summit and found to contain groves of *Cryptosepalum tetraphyllum*, a conservation priority species (IUCN: VU). These sites were, however, degraded and had little additional conservation value. The notable exception is the forest patch SW of Kegbema which apparently falls just within the boundary of the Farangbeya F.R. – this site is discussed in detail in sections 4.1 and 4.2 and should be considered a good candidate for protection as an offset against the loss of the Simbili forest patches. The Kegbema forest clearly has significance to the local community and so involvement of the local community in its protection would be vital.
The Farangbeya Forest Reserve may be a good candidate for a habitat restoration project, with translocation of forest species from the deposit sites. This could provide a high profile positive

conservation project for the client in collaboration with both national government and local communities.

***Bantho Hill Forest*** (9°03' N 11°41' W)
This small patch of forest is located on the ridge summit of the Kunsulma Range to the north of the Farangbeya Forest Reserve and is accessed from Bongbongba village to the north on Numbara Hill. A day visit was made to this site by one of the botanical teams in an attempt to find some of the rare hillslope forest species recorded at Simbili. The slopes of the ridge here are again almost completely converted to farmbush and secondary thicket. The forest contains many large trees of *Piptadeniastrum africanum*, an indicator of secondary forest, and the open canopy and dense shrub-dominated understorey would support this. No *Cryptosepalum tetraphyllum* was found. Two species of conservation concern were recorded here: the timber tree *Heritiera utilis* and the rare shrub *Pavetta platycalyx*; this latter species was fairly common at this but has strangely not yet been recorded from the forests on or adjacent to the deposits. The Bantho Forest appears to be preserved by the local community, perhaps as a hunting area (hunting trails are certainly in evidence here).

***Sakonke Hill*** (9°04' N 11°39' W)
This large hill (summit c. 860 m alt.) is situated to the N of Numbara Hill and is accessed from the village of Sasakala. It was chosen for survey as it is the most accessible hill outside the mining exploration license with extensive areas of hill summit grassland and so potentially holding *Pseudovigna* sp. nov. A full day site visit was made by one of the botanical teams. The summit had been recently burnt but we were still able to locate the *Pseudovigna* here, recording 99 plants over a wide area. Whilst the population is not as large as on Numbara, this is still an important site for this species and could be suitable for translocation of plants from the deposit sites.
Also found on the descent on the NE and E sides of the hill was a series of small seepage grasslands. Whilst these had largely dried out by the time of our visit, two species of high conservation concern were found: *Dilophotriche* sp. ?nov. and *Bryaspis humularioides* subsp. *falcistipulata*. These wet grasslands should be surveyed further at the optimum time (late Oct–early Nov) and may prove to contain a similar range of species to the seepage grasslands on Marampon.
The majority of the lower slopes of this hill are covered in a mosaic of farmland and secondary bushland of low conservation concern.

Further work on identification of suitable offset / translocation sites will need to involve wider searches well beyond the Project area, aided by available maps and satellite imagery. Potential sites for such work are listed in section 9.

## 8. PRELIMINARY CONCLUSIONS

Based upon the vegetation survey and plant inventory work carried out to date, we have identified five habitats of conservation concern within the Tonkolili Project area, here listed together with the key sites of importance:

- Riverine forest (riverine strip near Farangbeya village)
- Hillslope forest (forest patch SW of Kegbema village)
- Seasonally wet grassland (seepage area on S slopes of Marampon)
- Hill summit grassland and wooded grassland (Numbara summit)
- River channel plant communities (riverine strip near Farangbeya village)

Whilst these habitats together only constitute a small percentage of the total land cover in the Project area (the large majority being taken up by farmland and secondary vegetation communities of low conservation concern), they together contain over 30 rare and potentially threatened plant species and a rich plant diversity.

Wherever possible, efforts should be made to prevent the loss of these habitats and the populations of these key species during future mining activity. Where this is unavoidable, measures should be put in place to mitigate or offset the impact of these losses through a combination of ex situ conservation measures and identification of comparable sites for protection and/or management as offsets.

The work conducted to date provides a strong baseline for recommendations on conservation priorities and proposed conservation actions; however, a series of additional surveys are required to supplement this work; a full list of recommendations is provided in section 9.

## 9. RECOMMENDATIONS FOR FURTHER BOTANICAL WORK

1) ***Further survey work on the deposits***
Whilst the survey work conducted to date has covered the vegetation on the deposits in some detail, it cannot be considered exhaustive. In particular, it would be desirable to cover a greater range of the seasonal variation to capture:

- dry season flowering species, including short-lived post-burning herbs in the wooded grasslands (Jan–March)
- species triggered by the onset of the early rains (March-May)
- optimal flowering and fruiting time for the seasonally inundated grasslands (mid Oct–early Nov)
- low water levels in the rivers for optimal study of the rheophytic communities (Jan–March)
- flowering and fruiting material for those species with currently uncertain identity
- a full survey of the weedy species, with emphasis upon potentially invasive species for which some control measures may have to be put in place.

The species accumulation curve for the forest plots surveyed to date (fig. 6) demonstrates that our species coverage in the forests is incomplete (see section 4.2); we would recommend further walk-over survey and particularly plot work within the remaining forest patches.

2) ***Ethnobotanical survey***
To engage with local communities, aided by the PROs employed by AML at Farangbeya, to catalogue the plants used locally for food, medicines etc. This will provide important information on the types and locations of natural vegetation which have social and cultural significance. It would feed into the wider social aspects of the ESIA.

3) ***Further survey work in the proposed tailings options***
With the exception of the northern section of option 4, only a rapid reconnaissance survey of the proposed tailings options has been carried out to date. Further survey is therefore essential within the chosen option.
A botanical survey of the rail corridor and site of the new port will also need to be conducted as part of the wider EISA. Initially, a desktop study using baseline data held at RBG Kew could be used to pinpoint any sites along the proposed route(s) that might have species of high conservation concern.

4) ***Follow-up surveys of the species of high conservation concern***
The 34 species of conservation concern, and in particular the nine species highlighted as of highest priority (table 8), must be addressed in detail. The first stage must be to investigate more fully their current distribution. Maps and available satellite imagery (e.g. Google Earth, Landsat), together with historic plant specimen data, can be used to identify potentially suitable sites for each of the species. Subsequent site visits should be made to co-incide with peak flowering/fruiting times for each species (forest species can be surveyed at any time of year, wooded grassland and inundated grassland species to be targeted at the wet/dry season transition).

Potential sites to concentrate these efforts would be:

- Northern section of the Sula Mts, including Lake Sonfon National Park (c. 9°15’N 11°35’W)
- Tonkolilini Hill and Gbengbe Hills N of Bumbuna (c. 9°15’N 11°45’W)
- Kangari Hills SE of Magburaka (c. 8°30’N 11°40’W)
- Loma Mts National Park (c. 9°10’N 11°5’W)
- Tingi Mts NE of Kono (c. 8°55’N 10°47’W)
- Kekekonko and Gori Hills Se of Kono (c. 8°35’N 10°45’W)
- Nimini Hills SW of Kono (c. 8°30’N 11°10’W)
- Wara Wara Mts N of Fadugu (c. 9°35’N 11°40’W)

Past experience has shown that it is highly likely that we will be able to uncover additional secure sites for many of the conservation species. This is likely to lead to a downgrading of their conservation status. More importantly, it will help us to identify sites suitable for safe-guarding of these species and potential areas for population translocation as future offset / mitigation for the proposed mine.
Of the two ‘unique’ species at Tonkolili, we have already had some success with *Pseudovigna* sp. nov., having located a population of c. 100 plants on Sakonke Hill, beyond the mining concession. It is anticipated that further investigation along the Sula Mts chain will reveal additional sites for this species. Of greater concern is the (potentially) new species of *Eriocaulon*. Whilst our initial suggestion is to search for other river sites suitable for this species, it is quite likely that this species will remain at least Endangered. If so, all efforts must be made to protect the Tonkolili River against significant environmental changes during the mining operations.

5) ***Identification of suitable offset localities***
Where appropriate, the losses of natural vegetation on the mine site can be offset by formal protection of equivalent (or more diverse and/or larger) site(s) within Sierra Leone. The bulk of this work would be carried out in tandem with recommendation 4.
However, it should be noted that under the current published IFC Performance Standard 6, habitats containing species assessed as EN or CR are not offsettable and alternative solutions would be required. Whilst PS6 is being modified to be more flexible regarding such species, they may well still trigger strict regulations.

6) ***Establishment of in-situ and ex-situ conservation measures for the species of high conservation concern***

- Collection and banking of seeds provides an ex situ conservation measure; these seeds could be stored in country and, as a back up, at the Millennium Seedbank (MSB) at RBG Kew. Initial training in seed collection and storage could be provided through the MSB. A portion of the seed collections can subsequently be used for translocation of species to secure sites, post-mining habitat restoration, growing on in botanic gardens to establish germination protocols etc.
- Establishment of an on-site tree nursery; this is particularly useful for species not suitable for long-term seed storage (usually wet forest species). These trees can again be used for translocation, restoration etc. Following initial horticultural training, the tree nursery can subsequently be run through the local community, providing a source of employment.
- One possibility worth exploring would be for African Minerals to work with local government on the restoration of parts of the Farangbeya Forest Reserve as an offset against the loss of forest on the mine deposits. This would be a high profile conservation effort which could be run in collaboration with the local community.

7) ***Continued institutional capacity building in Sierra Leone***
Building in-country capacity, through training and donation of essential equipment, will permit our local institutional partners to take a more central role in the follow-up survey and conservation work. This process was begun successfully during the Sept and Nov-Dec visits. To build upon this, it is recommended that one staff member from each of the two partner institutions are seconded to RBG Kew for a short intern period (c. 1 month) to train in plant identification, vegetation analysis, seed collection and storage methods etc.
In addition, it would be highly desirable to have employed an on-site full-time Environmental Scientist who could be trained through RBG Kew and partner institutions in Sierra Leone in plant survey and monitoring techniques, specimen and seed collection and basic horticultural skills. This person would be ideally placed to oversee or assist in the above recommendations, with RBG Kew playing an advisary and supporting role.

8) ***Immediate / short-term conservation recommendations***
In view of the continuing exploratory work at the mine site, there is a significant risk that some of the priority habitats and species will be lost or damaged prior to any conservation measures being implemented. It is therefore recommended that some protection measures are put in-place immediately, for example through cordoning off the key sites and briefing the ground staff. The key sites to be protected at present are:

- Strip of riverine forest near Farangbeya
- Forest patch to the southwest of Kegbema on the edge of the Farangbeya Forest Reserve
- Seepage grassland on S slopes of Marampon

- Hill summit grassland on Numbara
- Seasonally inundated depression on summit of Numbara, drill platform NURC005
- Valley swamp at foot of Numbara (to protect the colony of *Aeschynomene deightonii*)

## ACKNOWLEDGEMENTS

From African Minerals Sierra Leone, we particularly thank Musa Alie Bangura for his assistance with all logistical matters, and Terry Cheek, Barry Young and others for their assistance and hospitality at the Farangbeya camp. Atkins Koroma, Public Relations Officer at the Farangbeya camp, was very helpful in negotiating with local communities over access to several sites away from the mine deposits. We thank Craig Watt at SRK for undertaking the initial negotiations with regard to this survey and for establishing the collaborative links in-country. Mr Sheku Ahmed Mansaray and Mrs Kate Garnett at the Ministry of Agriculture, Forestry & Food Security provided the necessary research permits and specimen export permits within the short timeframe available.
Helen Fortune-Hopkins, Laura Pearce, Jonathan Ashworth and Reka Komaromi assisted greatly with the specimen identification and databasing at RBG Kew. The following botanists named or assisted in the naming of their specialist groups: William Baker (*Palmae*), Henk Beentje (*Compositae*), Gill Challen (*Euphorbiaceae* and allies), Tom Cope (*Gramineae*), Sally Dawson (herbaceous *Rubiaceae*), Peter Edwards (ferns and fern allies), David Goyder (*Apocynaceae*), Gwil Lewis (*Leguminosae*), Mike Lock (*Xyridaceae*), Barbara Mackinder (*Leguminosae*), Sylvia Phillips (*Eriocaulaceae*), Dave Roberts (*Orchidaceae*), Dave Simpson (*Cyperaceae*), Paul Wilkin (*Dioscoreaceae*), Yvette Harvey (*Sapotaceae*), Doug Stone (*Melastomataceae - Memecylon*) Maria Vorontsova (*Solanaceae*), Lesley Walsingham (*Lamiaceae*), Odile Weber (*Dracaenaceae*) and Elizabeth Woodgyer (*Melastomataceae*).

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# ANNEX 1: PLANT SPECIES CHECKLIST

The following checklist records all the flowering plants, ferns and fern allies recorded to date from the Tonkolili Project area during the two botanical survey periods, September and November-December 2009: 658 species. The species are listed alphabetically within each plant family.

Angiospermae: Dicotyledonae

| Taxon | Collector | Number |
|---|---|---|
| **Acanthaceae** | | |
| *Asystasia buettneri* Lindau | James, M.S. | 1 |
| *Barleria oenotheroides* Dum. Cours. | Darbyshire I. | 592 |
| *Brillantaisia lamium* (Nees) Benth. | Tonkolili Plants | 130 |
| *Eremomastax speciosa* (Hochst.) Cufod. | Kanu, K.M.T. | 30 |
| *Hygrophila odora* (Nees) T.Anderson | Tonkolili Plants | 244 |
| *Hypoestes cancellata* Nees | Clark, R. | 177 |
| *Hypoestes forskaolii* (Vahl) R.Br. | Tonkolili Plants | 99 |
| *Justicia extensa* T.Anderson | Sesay, J.A. | 20 |
| *Justicia flava* (Vahl) Vahl | Tonkolili Plants | 112 |
| *Justicia heineana* Vollesen | James, M.S. | 3 |
| *Justicia ladanoides* Lam. | James, M.S. | 20 |
| *Justicia tenella* (Nees) T.Anderson | Tonkolili Plants | 133 |
| *Lepidagathis alopecuroides* (Vahl) Griseb. | Tonkolili Plants | 507 |
| *Phaulopsis cf. talbotii* S.Moore | Tonkolili Plants | 240 |
| *Phaulopsis ciliata* (Willd.) Hepper | James, M.S. | 10 |
| *Phaulopsis imbricata* (Forssk.) Sweet subsp. *poggei* (Lindau) Mankt. | Darbyshire I. | 589 |
| *Pseuderanthemum tunicatum* (Afzel.) Milne-Redh. | Tonkolili Plants | 730 |
| *Rhinacanthus virens* (Nees) Milne-Redh. | Darbyshire I. | 604 |
| *Thunbergia chrysops* Hook. | Tonkolili Observations | 234 |
| *Whitfieldia lateritia* Hook. | James, M.S. | 11 |
| | | |
| **Amaranthaceae** | | |
| *Celosia argenta* L. | Tonkolili Observations | 10 |
| *Celosia trigyna* L. | Feika, A.M.B. | 55 |
| *Cyathula prostrata*(L.) Blume | Tonkolili Plants | 646 |
| *Pandiaka angustifolia*(Vahl) Hepper | Tonkolili Plants | 122 |
| | | |
| **Anacardiaceae** | | |
| *Lannea acida* A.Rich. | Tonkolili Plants | 186 |
| *Sorindeia juglandifolia* Planchon ex Oliver | Clark, R. | 199 |
| *Trichoscypha arborea* (A.Chev.) A.Chev. | Burgt, X.M. van der | 1379 |
| *Trichoscypha smythei* Hutch. & Dalziel | Tonkolili Plants | 553 |
| | | |
| **Ancistrocladaceae** | | |
| *Ancistrocladus abbreviatus* Airy Shaw | Kanu, K.M.T. | 61 |
| *Ancistrocladus cf. barteri* Scott-Elliot | Tonkolili Plants | 245 |
| *Ancistrocladus* sp. 1 of Tonkolili | Tonkolili Plants | 709 |
| | | |
| **Anisophylleaceae** | | |
| *Anisophyllea laurina* R. Br. ex Sabine | Tonkolili Plants | 13 |
| *Anisophyllea* sp. 1 of Tonkolili | Tonkolili Plants | 638 |
| *Anisophyllea* sp. 2 of Tonkolili | Tonkolili Plants | 620 |
| | | |
| **Annonaceae** | | |
| *Annickia polycarpa* (DC.) Setten & P.J.Maas | Tonkolili Plants | 614 |
| *Artabotrys insignis* Engl. & Diels | Feika, A.M.B. | 29 |

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| *Friesodielsia enghiana* (Diels) Verdc. | Tonkolili Plants | 19 |
| *Friesodielsia gracilis* (Hook.f.) Steenis | Darbyshire I. | 596 |
| *Monanthotaxis barteri* (Baill.) Verdc. | Darbyshire I. | 597 |
| *Monanthotaxis whytei* (Stapf) Verdc. | Sesay, J.A. | 29 |
| *Piptostigma fasciculatum* (De Wild.) Boutique | Tonkolili Plants | 728 |
| *Uvaria afzelii* Scott-Elliot | Tonkolili Plants | 569 |
| *Uvaria anonoides* Baker f. | Darbyshire I. | 603 |
| *Uvariodendron* cf. *angustifolium* Engl. & Diels | Tonkolili Plants | 208 |
| *Xylopia acutiflora* (Dunal) A.Rich. | Darbyshire I. | 608 |
| *Xylopia aethiopica* (Dunal) A.Rich. | Tonkolili Plants | 624 |
| *Xylopia quintasii* Engl. & Diels | Tonkolili Plants | 741 |
| *Xylopia villosa* Chipp | Tonkolili Plants | 824 |
| | | |
| **Apocynaceae** | | |
| *Alafia barteri* Oliv. | Tonkolili Plants | 688 |
| *Alafia landolphioides* (A.DC.) Benth. & Hook.f. ex K.Schum. | Tonkolili Plants | 645 |
| *Baissea baillonii* Hua | Tonkolili Plants | 593 |
| *Funtumia africana* (Benth.) Stapf | Tonkolili Plants | 881 |
| *Holarrhena floribunda* (G.Don.) T. Durand & Schinz | Tonkolili Plants | 166 |
| *Landolphia hirsuta* (Hua) Pichon | Tonkolili Plants | 538 |
| *Landolphia incerta* (K.Schum.) Persoon | Tonkolili Plants | 606 |
| *Landolphia* sp. 1 of Tonkolili | Burgt, X.M. van der | 1371 |
| *Landolphia* sp. 2 of Tonkolili | Tonkolili Plants | 532 |
| *Marsdenia oblanceolata* (Turrill) R.Omlor | Tonkolili Plants | 502 |
| *Oncinotis gracilis* Stapf | Sesay, J.A. | 26 |
| *Periploca nigrescens* Afzel. | Tonkolili Plants | 172 |
| *Rauvolfia mannii* Stapf | Tonkolili Plants | 209 |
| *Rauvolfia vomitoria* Afzel. | Tonkolili Plants | 7 |
| *Tabernaemontana africana* Hook. | Sesay, J.A. | 9 |
| *Tabernaemontana* sp. | Tonkolili Plants | 662 |
| | | |
| **Araliaceae** | | |
| *Cussonia arborea* A.Rich. | Tonkolili Plants | 138 |
| | | |
| **Aristolochiaceae** | | |
| *Pararistolochia flos-avis* (A.Chev.) Hutch. & Dalziel | Tonkolili Plants | 582 |
| | | |
| **Begoniaceae** | | |
| *Begonia cavallyensis* A.Chev. | Tonkolili Plants | 726 |
| *Begonia quadrialata* (Warb.) Sosef subsp. *quadrialata* var. *quadrialata* | Tonkolili Plants | 719 |
| *Begonia rostrata* Welw. ex Hook.f. | Feika, A.M.B. | 19 |
| | | |
| **Bignoniaceae** | | |
| *Markhamia tomentosa* (Benth.) K. Schum. ex Engl. | Tonkolili Observations | 451 |
| *Newbouldia laevis* (P.Beauv.) Seeman ex Bureau | Tonkolili Plants | 126 |
| *Spathodea campanulata* P.Beauv. | Tonkolili Observations | 347 |
| | | |
| **Bombacaceae** | | |
| *Ceiba pentandra* (L.) Gaertn. | Tonkolili Observations | 6 |
| | | |
| **Burseraceae** | | |
| *Canarium schweinfurthii* Engl. | Tonkolili Plants | 9 |
| *Dacryodes klaineana* (Pierre) H.J.Lam | Kanu, K.M.T. | 57 |
| *Santiria trimera* (Oliv.) Aubrév. | Tonkolili Plants | 877 |
| | | |

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|---|---|---|
| **Campanulaceae** | | |
| *Wahlenbergia perrottetii* (A.DC.) Thulin | Tonkolili Plants | 131 |
| | | |
| **Capparaceae** | | |
| *Euadenia eminens* Hook.f. | Tonkolili Plants | 211 |
| | | |
| **Cecropiaceae** | | |
| *Musanga cecropioides* R.Br. ex Tedlie | Tonkolili Observations | 1 |
| *Myrianthus libericus* Rendle | Tonkolili Plants | 561 |
| | | |
| **Celastraceae** | | |
| *Loeseneriella africana* (Willd.) Wilczek ex N.Hallé | Robinson, E. | 2 |
| *Loeseneriella iotricha* (Loes.) N.Hallé | Tonkolili Plants | 736 |
| *Salacia erecta* (G. Don) Walp. | Kanu, K.M.T. | 42 |
| *Salacia lehmbachii* Loes. var. *leonensis* (Hutch. & M.B.Moss) N.Hallé | Tonkolili Plants | 573 |
| *Salacia senegalensis* (Lam.) DC. | Tonkolili Plants | 207 |
| *Salacia* sp. | Tonkolili Plants | 509 |
| *Salacia staudtiana* Loes. | Darbyshire I. | 622 |
| *Salacia zenkeri* Loes. | Kanu, K.M.T. | 53 |
| *Tristemonanthus nigrisilvae* (N.Hallé) N.Hallé | Sesay, J.A. | 23 |
| | | |
| **Chrysobalanaceae** | | |
| *Dactyladenia smeathmannii* (Baill.) Prance & F.White | Burgt, X.M. van der | 1386 |
| *Dactyladenia whytei* (Stapf) Prance & F.White | Burgt, X.M. van der | 1375 |
| *Maranthes aubrevillei* (Pellegr.) Prance ex F.White | Tonkolili Plants | 594 |
| *Maranthes* cf. *glabra* (Oliv.) Prance | Tonkolili Plants | 597 |
| *Parinari excelsa* Sabine | Tonkolili Plants | 12 |
| | | |
| **Combretaceae** | | |
| *Combretum comosum* G. Don | Tonkolili Plants | 695 |
| *Combretum cuspidatum* Planch. ex Benth. | Tonkolili Plants | 542 |
| *Combretum grandiflorum* G. Don | Darbyshire I. | 626 |
| *Combretum mucronatum* Schumach. & Thonn. | Tonkolili Plants | 225 |
| *Combretum paniculatum* Vent. | Tonkolili Plants | 128 |
| *Combretum platypterum* (Welw.) Hutch. & Dalziel | Tonkolili Plants | 844 |
| *Combretum rhodanthum* Engl. & Diels | James, M.S. | 5 |
| *Strephonema pseudocola* A.Chev. | Burgt, X.M. van der | 1377 |
| *Terminalia ivorensis* A.Chev. | Tonkolili Plants | 23 |
| | | |
| **Compositae** | | |
| *Adelostigma senegalense* Benth. | Kanu, K.M.T. | 17 |
| *Aedesia glabra* O.Hoffm. | Tonkolili Plants | 32 |
| *Ageratum conyzoides* L. | Tonkolili Observations | 138 |
| *Anisopappus chinensis* Hook. & Arn. subsp. *buchwaldii* (O. Hoffm.) S. Ortiz, Paiva & Rodr. Oubiña var. *buchwaldii* | Tonkolili Plants | 89 |
| *Aspilia africana* (Pers.) C.D.Adams | Tonkolili Plants | 40 |
| *Chromolaena odorata* (L.) R.M.King & H.Robinson | Tonkolili Observations | 335 |
| *Conyza bonariensis* (L.) Cronquist | Robinson, E. | 3 |
| *Crassocephalum guineense* C.D.Adams | Clark, R. | 178 |
| *Kinghamia angustifolia* (Benth.) C.Jeffrey | Tonkolili Plants | 82 |
| *Mikania cordata* (Burm.f.) B.L.Robinson | Tonkolili Observations | 50 |
| *Vernonia guineensis* Benth. | Tonkolili Plants | 88 |
| | | |
| **Connaraceae** | | |
| *Agelaea pentagyna* (Lam.) Baill. | Tonkolili Plants | 838 |

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|---|---|---|
| *Agelaea rubiginosa* Gilg | Tonkolili Plants | 644 |
| *Cnestis corniculata* Lam. | Tonkolili Plants | 676 |
| *Cnestis ferruginea* Vahl ex DC. | Tonkolili Plants | 873 |
| *Cnestis racemosa* G.Don | Tonkolili Plants | 882 |
| *Connarus africanus* Lam. | Darbyshire I. | 642 |
| *Manotes expansa* Sol. ex Planch. | Tonkolili Plants | 248 |
| *Rourea* cf. *solanderi* Baker | Tonkolili Plants | 790 |
| *Rourea thomsonii* (Baker) Jongkind | Tonkolili Plants | 819 |
| | | |
| **Convolvulaceae** | | |
| *Calycobolus africanus* (G.Don) Heine | Tonkolili Plants | 671 |
| *Ipomoea involucrata* P.Beauv. | Tonkolili Observations | 268 |
| *Ipomoea ochracea* G. Don | Darbyshire I. | 621 |
| *Merremia pterygocaulos* (Steud. ex Choisy) Hallier f. | Darbyshire I. | 620 |
| *Merremia umbellata* (L.) Hallier f. | Tonkolili Plants | 152 |
| | | |
| **Cucurbitaceae** | | |
| *Coccinia barteri* (Hook.f.) Keay | Feika, A.M.B. | 16 |
| *Raphidiocystis chrysocoma* (Schumach.) C.Jeffrey | Darbyshire I. | 600 |
| *Ruthalicia eglandulosa* (Hook.f.) C.Jeffrey | Tonkolili Plants | 154 |
| | | |
| **Dichapetalaceae** | | |
| *Dichapetalum* aff. *heudelotii* (Planch. ex Oliv.) Baill. | Tonkolili Plants | 791 |
| *Dichapetalum albidum* A.Chev. ex Pellegr. | Feika, A.M.B. | 26 |
| *Dichapetalum* cf. *toxicaria* Baill. | Tonkolili Plants | 815 |
| *Dichapetalum heudelotii* (Planch. ex Oliv.) Baill. | Tonkolili Plants | 16 |
| *Dichapetalum pallidum* (Oliv.) Engl. | Burgt, X.M. van der | 1362 |
| | | |
| **Dilleniaceae** | | |
| *Tetracera alnifolia* Willd. | Sesay, J.A. | 10 |
| | | |
| **Dioncophyllaceae** | | |
| *Triphyophyllum peltatum* (Hutch. & Dalziel) Airy Shaw | Burgt, X.M. van der | 1394 |
| | | |
| **Droseraceae** | | |
| *Drosera indica* L. | Tonkolili Plants | 46 |
| | | |
| **Ebenaceae** | | |
| *Diospyros cooperi* (Hutch. & Dalziel) F.White | Kanu, K.M.T. | 40 |
| *Diospyros heudelotii* Hiern | Tonkolili Plants | 180 |
| *Diospyros mannii* Hiern | Tonkolili Plants | 894 |
| *Diospyros piscatoria* Gürke | Feika, A.M.B. | 25 |
| *Diospyros thomasii* Hutch. & Dalz. | Tonkolili Plants | 592 |
| | | |
| **Euphorbiaceae** | | |
| *Alchornea cordifolia* (Schum. & Thonn.) Müll.Arg. | Tonkolili Plants | 950 |
| *Alchornea hirtella* Benth. | Darbyshire I. | 623 |
| *Croton hirtus* L'Hér. | Tonkolili Observations | 348 |
| *Discoglypremna caloneura* (Pax) Prain | Tonkolili Plants | 603 |
| *Erythrococca anomala* (Juss. ex Poir.) Prain | Tonkolili Plants | 505 |
| *Erythrococca* sp. aff. *anomala* (Juss. ex Poir.) Prain | Tonkolili Plants | 691 |
| *Euphorbia hyssopifolia* L. | Tonkolili Plants | 30 |
| *Macaranga barteri* Müll.Arg. | Tonkolili Plants | 905 |
| *Manniophyton fulvum* Müll.Arg. | Tonkolili Plants | 219 |
| *Mareya micrantha* (Benth.) Mull.Arg. | Darbyshire I. | 625 |

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|---|---|---|
| *Ricinodendron heudelotii* (Baill.) Pierre ex Heckel | Tonkolili Plants | 951 |
| *Tetrorchidium didymostemon* (Baill.) Pax & K.Hoffm. | Feika, A.M.B. | 15 |
| *Tragia* sp. A of FWTA | Tonkolili Plants | 162 |
| *Tragia tenuifolia* Benth. | Sesay, J.A. | 24 |
| | | |
| **Flacourtiaceae** | | |
| *Homalium africanum* (Hook.f.) Benth. | Feika, A.M.B. | 30 |
| *Homalium angustifolium* Sm. | Darbyshire I. | 628 |
| *Homalium cf. dewevrei* De Wild. & T.Durand | Tonkolili Plants | 512 |
| *Scottellia klaineana* Pierre var. *klaineana* | Tonkolili Plants | 576 |
| | | |
| **Gentianaceae** | | |
| *Neurotheca loeselioides* (Spruce ex Prog.) Baill. | Tonkolili Plants | 51 |
| | | |
| **Guttiferae** | | |
| *Garcinia cf. ovalifolia* Oliv. | Tonkolili Plants | 621 |
| *Garcinia kola* Heckel | Clark, R. | 195 |
| *Garcinia smeathmannii* (Planch. & Triana) Oliv. | Tonkolili Plants | 936 |
| *Harungana madagascariensis* Lam. ex Poir. | Tonkolili Plants | 17 |
| *Psorospermum alternifolium* Hook. f. | Feika, A.M.B. | 58 |
| *Psorospermum febrifugum* Spach | Tonkolili Plants | 147 |
| *Vismia guineensis* (L.) Choisy | Feika, A.M.B. | 3 |
| | | |
| **Icacinaceae** | | |
| *Iodes liberica* Stapf | Sesay, J.A. | 25 |
| *Leptaulus daphnoides* Benth. | Tonkolili Plants | 604 |
| *Polycephalium capitatum* (Baill.) Keay | Tonkolili Plants | 182 |
| *Pyrenacantha acuminata* Engl. | Tonkolili Plants | 103 |
| *Pyrenacantha glabrescens* (Engl.) Engl. | Tonkolili Plants | 543 |
| *Rhaphiostylis beninensis* (Hook.f. ex Planch.) Planch. ex Benth. | Tonkolili Plants | 704 |
| *Rhaphiostylis preussii* Engl. | Kanu, K.M.T. | 41 |
| | | |
| **Irvingiaceae** | | |
| *Irvingia robur* Mildbr. | Clark, R. | 198 |
| *Klainedoxa gabonensis* Pierre ex Engl. | Tonkolili Plants | 243 |
| | | |
| **Ixonanthaceae** | | |
| *Phyllocosmus africanus* (Hook.f.) Klotzsch | Burgt, X.M. van der | 1346 |
| | | |
| **Labiatae** | | |
| *Clerodendrum silvanum* Henriq. var. *buchholzii* (Gürke) Verdc. | James, M.S. | 15 |
| *Clerodendrum silvanum* Henriq. var. *silvanum* | Tonkolili Plants | 206 |
| *Clerodendrum splendens* G.Don | Tonkolili Plants | 917 |
| *Clerodendrum umbellatum* Poir. | Feika, A.M.B. | 70 |
| *Gmelina arborea* L. | Tonkolili Plants | 949 |
| *Hyptis lanceolata* Poir. | Tonkolili Plants | 135 |
| *Platostoma africanum* P.Beauv. | Tonkolili Plants | 136 |
| *Plectranthus africanus* (Scott-Elliot) A.J.Paton | Darbyshire I. | 591 |
| *Plectranthus betonicifolius* Bak. | Kanu, K.M.T. | 8 |
| *Plectranthus occidentalis* B.J.Pollard | Tonkolili Plants | 28 |
| *Premna hispida* Benth. | Tonkolili Plants | 832 |
| *Vitex ferruginea* Schum. & Thonn. | Darbyshire I. | 641 |
| *Vitex grandifolia* Gürke | Burgt, X.M. van der | 1376 |
| *Vitex micrantha* Gurke | Clark, R. | 186 |
| *Vitex oxycuspis* Baker | Tonkolili Plants | 706 |

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| *Vitex rivularis* Gürke | Tonkolili Plants | 581 |
| *Vitex thyrsiflora* Baker | Tonkolili Plants | 95 |
| | | |
| **Lecythidaceae** | | |
| *Napoleonaea heudelotii* A.Juss. | Kanu, K.M.T. | 34 |
| *Napoleonaea vogelii* Hook. & Planch. | Kanu, K.M.T. | 44 |
| | | |
| **Leeaceae** | | |
| *Leea guineensis* G.Don | Tonkolili Plants | 4 |
| | | |
| **Leguminosae-Caesalpinioideae** | | |
| *Afzelia africana* Sm. | Tonkolili Plants | 232 |
| *Afzelia bella* Harms | Tonkolili Plants | 755 |
| *Anthonotha explicans vel. sp. aff.* (Baill.) J.Léonard | Tonkolili Plants | 932 |
| *Anthonotha macrophylla* P.Beauv. | Kanu, K.M.T. | 25 |
| *Aphanocalyx pteridophyllus* (Harms) Wieringa | Burgt, X.M. van der | 1359 |
| *Brachystegia leonensis* Burtt Davy & Hutch. | Kanu, K.M.T. | 63 |
| *Bussea occidentalis* Hutch. | Tonkolili Plants | 947 |
| *Cassia aubrevillei* Pellegr. | Tonkolili Plants | 231 |
| *Chamaecrista mimosoides* (L.) Greene | Tonkolili Observations | 8 |
| *Chidlowia sanguinea* Hoyle | Tonkolili Plants | 63 |
| *Copaifera salikounda* Heckel | Burgt, X.M. van der | 1391 |
| *Cryptosepalum tetraphyllum* (Hook.f.) Benth. | Burgt, X.M. van der | 1382 |
| *Daniellia ogea* (Harms) Rolfe ex Holl. | Tonkolili Plants | 64 |
| *Daniellia thurifera* Bennett | Clark, R. | 183 |
| *Detarium senegalense* J.Gmelin | Tonkolili Plants | 752 |
| *Dialium aubrevillei* Pellegr. | Tonkolili Plants | 62 |
| *Dialium dinklagei* Harms | Tonkolili Plants | 928 |
| *Dialium guineense* Willd. | Clark, R. | 196 |
| *Dialium pobeguinii* Pellegr. | Kanu, K.M.T. | 62 |
| *Distemonanthus benthamianus* Baill. | Tonkolili Plants | 526 |
| *Gilbertiodendron aylmeri* (Hutch. & Dalziel) J.Léonard | Burgt, X.M. van der | 1384 |
| *Guibourtia leonensis* J.Léonard | Burgt, X.M. van der | 1393 |
| *Mezoneuron benthamianum* Baill. | Clark, R. | 188 |
| *Paramacrolobium coeruleum* (Taub.) J.Léonard | Clark, R. | 203 |
| | | |
| **Leguminosae-Mimosoideae** | | |
| *Acacia ataxacantha* DC. | James, M.S. | 19 |
| *Acacia pentagona* (Schum.) Hook.f. | Feika, A.M.B. | 22 |
| *Albizia adianthifolia* (Schum.) W.F.Wight | Tonkolili Plants | 127 |
| *Albizia altissima* Hook. | Tonkolili Observations | 439 |
| *Albizia zygia* (DC.) J.F.Macbr. | Tonkolili Plants | 117 |
| *Aubrevillea kerstingii* Pellegr. | Tonkolili Plants | 808 |
| *Aubrevillea platycarpa* Pellegr. | Tonkolili Plants | 855 |
| *Calpocalyx brevibracteatus* Harms | Burgt, X.M. van der | 1368 |
| *Dichrostachys cinerea* (L.) Wight & Arn. | Tonkolili Plants | 165 |
| *Entada rheedei* Spreng. | Darbyshire I. | 587 |
| *Newtonia aubrevillei* (Pellegr.) Keay | Tonkolili Plants | 754 |
| *Newtonia duparquetiana* (Baill.) Keay | Tonkolili Plants | 796 |
| *Parkia bicolor* A.Chev. | Tonkolili Plants | 853 |
| *Parkia biglobosa* (Jacq.) R.Br. ex G. Don | Tonkolili Plants | 72 |
| *Pentaclethra macrophylla* Benth. | Tonkolili Plants | 575 |
| *Piptadeniastrum africanum* (Hook.f.) Brenan | Feika, A.M.B. | 8 |
| *Samanea dinklagei* (Harms) Keay | Tonkolili Plants | 3 |
| *Xylia evansii* Hutch. | Tonkolili Plants | 733 |

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| **Leguminosae-Papilionoideae** | | |
| *Abrus canescens* Welw. ex Baker | Feika, A.M.B. | 56 |
| *Abrus precatorius* L. | Tonkolili Plants | 528 |
| *Abrus pulchellus* Wall. ex Thwait. subsp. *suffruticosus* (Boutique) Verdc. | Tonkolili Plants | 749 |
| *Aeschynomene deightonii* Hepper | Feika, A.M.B. | 60 |
| *Aganope leucobotrya* (Dunn) Polhill | Feika, A.M.B. | 59 |
| *Amphimas cf. Latilo* FHI 28909 | Tonkolili Plants | 235 |
| *Amphimas pterocarpoides* Harms | Tonkolili Plants | 53 |
| *Baphia nitida* Lodd. | James, M.S. | 21 |
| *Baphia spathacea* Hook.f. subsp. *spathacea* | Burgt, X.M. van der | 1378 |
| *Bryaspis humularioides* Gledhill subsp. *falcistipulata* Gledhill | Feika, A.M.B. | 38 |
| *Cajanus cajan* (L.) Millsp. | Tonkolili Observations | 70 |
| *Calopogonium mucunoides* Desv. | Tonkolili Observations | 438 |
| *Crotalaria doniana* Baker | Tonkolili Plants | 134 |
| *Crotalaria lathyoides* Guill. & Perr. | Clark, R. | 174 |
| *Crotalaria polygaloides* Welw. ex. Baker | Feika, A.M.B. | 49 |
| *Cyclocarpa stellaris* Afzel. ex Baker | Tonkolili Plants | 33 |
| *Dalbergia adamii* J.Berhaut | Tonkolili Plants | 239 |
| *Dalbergia afzeliana* G. Don | Burgt, X.M. van der | 1392 |
| *Dalbergia hepperi* Jongkind | Tonkolili Plants | 613 |
| *Dalbergia oblongifolia* G.Don | Clark, R. | 202 |
| *Dalbergia rufa* G.Don | Tonkolili Plants | 740 |
| *Dalbergia saxatilis* Hook.f. | Tonkolili Plants | 184 |
| *Desmodium linearifolium* G.Don | Kanu, K.M.T. | 1 |
| *Desmodium velutinum* (Willd.) DC. | Tonkolili Plants | 176 |
| *Dolichos dinklagei* Harms | Feika, A.M.B. | 39 |
| *Droogmansia scaettaiana* Chev. & Sillans | Clark, R. | 180 |
| *Eriosema glomeratum* (Guill. & Perr.) Hook.f. | Clark, R. | 185 |
| *Eriosema laurentii* De Wild. | Clark, R. | 191 |
| *Erythrina senegalensis* DC. | Robinson, E. | 7 |
| *Indigofera dendroides* Jacq. | Burgt, X.M. van der | 1356 |
| *Indigofera macrocalyx* Guill. & Perr. | Clark, R. | 181 |
| *Indigofera simplicifolia* Dennst. | Feika, A.M.B. | 57 |
| *Kotschya ochreata* (Taub.) Dewit & Duvign. var. *ochreata* | Clark, R. | 166 |
| *Leptoderris fasciculata* (Benth.) Dunn | Tonkolili Plants | 168 |
| *Leptoderris micrantha* Dunn | Burgt, X.M. van der | 1374 |
| *Leptoderris sp. aff. fasciculata* (Benth.) Dunn | Tonkolili Plants | 215 |
| *Millettia chrysophylla* Dunn | Tonkolili Plants | 727 |
| *Millettia pallens* Stapf | Tonkolili Plants | 167 |
| *Millettia rhodantha* Baill. | Burgt, X.M. van der | 1365 |
| *Millettia sanagana* Harms | Tonkolili Plants | 205 |
| *Mucuna poggei* Taub. var. *occidentalis* Hepper | Feika, A.M.B. | 45 |
| *Mucuna pruriens* (L.) DC. var. *utilis* (Wall. ex Wight) Baker ex Burck | Tonkolili Plants | 221 |
| *Pseudovigna sp. nov.* Lewis | Kanu, K.M.T. | 9 |
| *Pterocarpus erinaceus* Poir. | Darbyshire I. | 581 |
| *Pterocarpus santalinoides* L'Hér. ex DC. | Burgt, X.M. van der | 1388 |
| *Pterocarpus sp. aff. santalinoides* L'Hér. ex DC. | Tonkolili Plants | 610 |
| *Rhynchosia pycnostachya* (DC.) Meikle | Clark, R. | 204 |
| *Vigna venulosa* Baker | Tonkolili Plants | 41 |
| | | |
| **Lentibulariaceae** | | |
| *Utricularia gibba* L. | Darbyshire I. | 616 |
| *Utricularia pubescens* Sm. | Burgt, X.M. van der | 1351 |
| *Utricularia subulata* L. | Burgt, X.M. van der | 1352 |

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| **Linaceae** | | |
| *Hugonia planchonii* Hook.f. | Feika, A.M.B. | 11 |
| | | |
| **Linderniaceae** | | |
| *Lindernia schweinfurthii* (Engl.) Dandy | Kanu, K.M.T. | 16 |
| *Torenia thouarsii* (Cham. & Schltdl.) Kuntze | Tonkolili Plants | 113 |
| | | |
| **Loganiaceae** | | |
| *Anthocleista nobilis* G.Don | Tonkolili Plants | 943 |
| *Anthocleista procera* Lepr. ex Bureau | Tonkolili Plants | 934 |
| *Spigelia anthelmia* L. | Tonkolili Observations | 72 |
| *Strychnos afzelii* Gilg | Sesay, J.A. | 7 |
| *Strychnos soubrensis* Hutch. & Dalz. | Burgt, X.M. van der | 1380 |
| *Strychnos* sp. 1 of Tonkolili | Tonkolili Plants | 619 |
| *Strychnos usambarensis* Gilg | Tonkolili Plants | 871 |
| *Usteria guineensis* Willd. | Darbyshire I. | 645 |
| | | |
| **Loranthaceae** | | |
| *Phragmanthera leonensis* (Sprague) Balle | Darbyshire I. | 619 |
| *Tapinanthus bangwensis* (Engl. & K.Krause) Danser | Feika, A.M.B. | 2 |
| | | |
| **Lythraceae** | | |
| *Rotala stagnina* Hiern | Kanu, K.M.T. | 22 |
| | | |
| **Malpighiaceae** | | |
| *Acridocarpus plagiopterus* Guill. & Perr. | Kanu, K.M.T. | 24 |
| *Acridocarpus* sp. | Tonkolili Plants | 708 |
| | | |
| **Malvaceae** | | |
| *Hibiscus asper* Hook.f. | Clark, R. | 173 |
| *Hibiscus sterculiifolius* (Guill. & Perr.) Steud. | Robinson, E. | 6 |
| *Sida linifolia* Juss. ex Cav. | Feika, A.M.B. | 66 |
| *Urena lobata* L. | Tonkolili Observations | 458 |
| | | |
| **Melastomataceae** | | |
| *Amphiblemma cymosum* Naudin | Feika, A.M.B. | 13 |
| *Dissotis brazzae* Cogn. | Tonkolili Plants | 751 |
| *Dissotis grandiflora* (Sm.) Benth. | Tonkolili Plants | 52 |
| *Dissotis rotundifolia* (Sm.) Triana | Darbyshire I. | 609 |
| *Dissotis tubulosa* (Sm.) Triana | Tonkolili Plants | 720 |
| *Melastomastrum capitatum* (Vahl) A. & R.Fern. | Tonkolili Plants | 194 |
| *Melastomastrum theifolium* (G.Don) A. & R.Fern. | Clark, R. | 182 |
| *Memecylon aylmeri* Hutch. & Dalziel | Kanu, K.M.T. | 39 |
| *Memecylon lateriflorum* (G.Don) Brem. | Burgt, X.M. van der | 1370 |
| *Memecylon normandii* Jacq.-Fél. | Sesay, J.A. | 12 |
| *Osbeckia decandra* (Sm.) DC. | Tonkolili Plants | 80 |
| *Spathandra blakeoides* (G.Don) Jacq.-Fél. | Darbyshire I. | 635 |
| | | |
| **Meliaceae** | | |
| *Carapa procera* DC. | Sesay, J.A. | 8 |
| *Entandrophragma cylindricum* (Sprague) Sprague | Tonkolili Plants | 725 |
| *Guarea cedrata* (A.Chev.) Pellegr. | Tonkolili Plants | 678 |
| *Guarea thompsonii* Sprague & Hutch. | Tonkolili Plants | 60 |
| *Trichilia prieureana* A.Juss. | Tonkolili Plants | 686 |

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| *Trichilia tessmannii* Harms | Tonkolili Plants | 827 |
| *Turraeanthus africanus* (Welw. ex C.DC.) Pellegr. | Tonkolili Plants | 851 |
| | | |
| **Melianthaceae** | | |
| *Bersama abyssinica* Fresen. | Tonkolili Plants | 8 |
| | | |
| **Menispermaceae** | | |
| *Rhigiocarya racemifera* Miers | Tonkolili Plants | 591 |
| *Tiliacora leonensis* Diels | Tonkolili Plants | 607 |
| *Tiliacora louisii* Troupin | Tonkolili Plants | 102 |
| *Triclisia patens* Oliv. | Tonkolili Plants | 549 |
| | | |
| **Moraceae** | | |
| *Antiaris toxicaria* Lesch. subsp. *welwitschii* (Engl.) C.C. Berg var. *africana* | Tonkolili Plants | 233 |
| *Dorstenia turbinata* Engl. | Kanu, K.M.T. | 58 |
| *Ficus exasperata* Vahl | Tonkolili Plants | 11 |
| *Ficus ovata* Vahl | Tonkolili Plants | 711 |
| *Ficus sagittifolia* Mildbr. & Burret | Tonkolili Plants | 770 |
| *Ficus sur* Forssk. | Tonkolili Plants | 510 |
| *Ficus umbellata* Vahl | Kanu, K.M.T. | 54 |
| *Milicia regia* A.Chev. | Tonkolili Plants | 701 |
| *Streblus usambarensis* (Engl.) C.C.Berg | Kanu, K.M.T. | 56 |
| *Trilepisium madagascariense* DC. | Tonkolili Plants | 937 |
| | | |
| **Myristicaceae** | | |
| *Pycnanthus angolensis* (Welw.) Warb. | Tonkolili Plants | 618 |
| | | |
| **Myrtaceae** | | |
| *Eugenia kalbreyeri* Engl. & Brehmer | Tonkolili Plants | 778 |
| *Eugenia leonensis* Engl. & Brehmer | Burgt, X.M. van der | 1349 |
| *Syzygium guineense* (Willd.) DC. subsp. *macrocarpum* (Engl.) F.White | Kanu, K.M.T. | 59 |
| *Syzygium staudtii* (Engl.) Mildbr. | Tonkolili Plants | 680 |
| | | |
| **Ochnaceae** | | |
| *Campylospermum congestum* (Oliv.) Farron | Tonkolili Plants | 765 |
| *Campylospermum reticulatum* (P.Beauv.) Farron var. *reticulatum* | Feika, A.M.B. | 33 |
| *Campylospermum schoenleinianum* (Klotzsch) Farron | Tonkolili Plants | 503 |
| *Campylospermum squamosum* (DC.) Farron | Darbyshire I. | 605 |
| *Lophira lanceolata* Tiegh. ex Keay | Tonkolili Observations | 5 |
| *Ochna afzelii* R.Br. ex Oliv. | Tonkolili Plants | 142 |
| *Ochna membranacea* Oliv. | Tonkolili Plants | 712 |
| | | |
| **Olacaceae** | | |
| *Heisteria parvifolia* Sm. | Sesay, J.A. | 4 |
| *Octoknema borealis* Hutch. & Dalziel | Kanu, K.M.T. | 29 |
| *Olax gambecola* Baill. | Tonkolili Plants | 149 |
| *Ptychopetalum anceps* Oliv. | Tonkolili Plants | 628 |
| *Strombosia pustulata* Oliv. | Clark, R. | 201 |
| | | |
| **Oleaceae** | | |
| *Chionanthus mannii* (Soler.) | Kanu, K.M.T. | 55 |
| *Jasminum pauciflorum* Benth. | Tonkolili Plants | 108 |
| | | |
| **Onagraceae** | | |
| *Ludwigia abyssinica* A.Rich. | Feika, A.M.B. | 65 |

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|---|---|---|
| **Opiliaceae** | | |
| *Urobotrya congolana* (Baill.) Hiepko subsp. *afzelii* (Engl.) Hiepko | Clark, R. | 192 |
| | | |
| **Orobanchaceae** | | |
| *Alectra sessiliflora* (Vahl) Kuntze | Tonkolili Plants | 71 |
| *Buchnera leptostachya* Benth. | Feika, A.M.B. | 37 |
| *Sopubia parviflora* Engl. | Kanu, K.M.T. | 5 |
| *Striga aequinoctialis* A.Chev. | Burgt, X.M. van der | 1347 |
| *Striga asiatica* (L.) Kuntze | Kanu, K.M.T. | 13 |
| *Striga macrantha* (Benth.) Benth. | Feika, A.M.B. | 51 |
| | | |
| **Pandaceae** | | |
| *Microdesmis keayana* J. Leon. | Kanu, K.M.T. | 46 |
| | | |
| **Passifloraceae** | | |
| *Adenia guineensis* De Wilde | Tonkolili Plants | 222 |
| *Smeathmannia laevigata* Sol. ex R.Br. var. *laevigata* | Tonkolili Plants | 748 |
| *Smeathmannia pubescens* Soland. ex R.Br. | Darbyshire I. | 637 |
| | | |
| **Phyllanthaceae** | | |
| *Amanoa bracteosa* Planch. | Darbyshire I. | 634 |
| *Bridelia micrantha* (Hochst.) Baill. | Clark, R. | 179 |
| *Hymenocardia acida* Tul. | Feika, A.M.B. | 72 |
| *Hymenocardia lyrata* Tul. | Darbyshire I. | 631 |
| *Maesobotrya barteri* (Baill.) Hutch. var. *sparsiflora* (Scott-Elliot) Keay | Burgt, X.M. van der | 1361 |
| *Margaritaria discoidea* (Baill.) Webster | Feika, A.M.B. | 9 |
| *Thecacoris stenopetala* (Müll.Arg.) Müll.Arg. | Sesay, J.A. | 27 |
| *Uapaca corbisieri* De Wild. | Tonkolili Plants | 66 |
| *Uapaca guineensis* Müll.Arg. | Tonkolili Plants | 527 |
| *Uapaca heudelotii* Baill. | Tonkolili Plants | 923 |
| | | |
| **Piperaceae** | | |
| *Peperomia fernandopoiana* C.DC. | Tonkolili Plants | 681 |
| *Piper guineense* Schum. & Thonn. | Tonkolili Plants | 731 |
| *Piper umbellatum* L. | Tonkolili Plants | 15 |
| | | |
| **Plantaginaceae** | | |
| *Dopatrium senegalense* Benth. | Burgt, X.M. van der | 1358 |
| *Limnophila dasyantha* (Engl. & Gilg) Skan | Darbyshire I. | 618 |
| *Scoparia dulcis* L. | Tonkolili Observations | 71 |
| | | |
| **Polygalaceae** | | |
| *Polygala lecardii* Chod. | Kanu, K.M.T. | 11 |
| *Polygala multiflora* Poir. | Tonkolili Plants | 69 |
| *Polygala rarifolia* DC. | Clark, R. | 175 |
| | | |
| **Putranjivaceae** | | |
| *Drypetes afzelii* (Pax) Hutch. | Clark, R. | 193 |
| *Drypetes cf. gilgiana* (Pax) Pax & K.Hoffm. | Tonkolili Plants | 818 |
| *Drypetes inaequalis* Hutch. | Clark, R. | 200 |
| *Drypetes* sp. 1 of Tonkolili | Tonkolili Plants | 529 |
| | | |
| **Rhamnaceae** | | |
| *Gouania longipetala* Hemsl. | Burgt, X.M. van der | 1383 |

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| *Ventilago africana* Exell | Tonkolili Plants | 715 |
| | | |
| **Rhizophoraceae** | | |
| *Anopyxis klaineana* (Pierre) Engl. | Tonkolili Plants | 622 |
| | | |
| **Rubiaceae** | | |
| *Aidia genipiflora* (DC.) Dandy | Feika, A.M.B. | 6 |
| *Argostemma pumilum* Benn. | Tonkolili Observations | 13 |
| *Aulacocalyx jasminiflora* (Hook.f.) Hook.f. subsp. *jasminiflora* | Tonkolili Plants | 568 |
| *Bertiera bracteolata* Hiern | Tonkolili Plants | 504 |
| *Bertiera racemosa* (G.Don) K.Schum. var. *racemosa* | Sesay, J.A. | 21 |
| *Bertiera spicata* (Gaertner) Wernh. | Darbyshire I. | 636 |
| *Chassalia corallifera* (A.Chev. ex De Wild.) Hepper | Clark, R. | 194 |
| *Chassalia kolly* (Schumach.) Hepper | Tonkolili Plants | 187 |
| *Chassalia subherbacea* (Hiern) Hepper | Kanu, K.M.T. | 45 |
| *Chazaliella cf. sciadephora* (Hiern) E.M.A.Petit & Verdc. | Tonkolili Plants | 635 |
| *Chazaliella lophoclada* (Hiern) E.M.A.Petit & Verdc. | Tonkolili Plants | 717 |
| *Chazaliella sciadephora* (Hiern) E.M.A.Petit & Verdc. | Feika, A.M.B. | 28 |
| *Coffea liberica* Bull. ex Hiern | Kanu, K.M.T. | 52 |
| *Corynanthe pachyceras* K.Schum. | Tonkolili Plants | 557 |
| *Craterispermum laurinum* Benth. | Tonkolili Plants | 935 |
| *Crossopteryx febrifuga* (G.Don) Benth. | Darbyshire I. | 612 |
| *Cuviera macroura* K.Schum. | Tonkolili Plants | 188 |
| *Dictyandra arborescens* Welw. ex Hook.f. | Feika, A.M.B. | 32 |
| *Didymosalpinx abbeokutae* Hiern | Tonkolili Plants | 574 |
| *Gaertnera paniculata* Benth. | Clark, R. | 184 |
| *Geophila afzelii* Hiern | Tonkolili Plants | 598 |
| *Geophila obvallata* (Schumach.) Didr. | Tonkolili Plants | 599 |
| *Hallea stipulosa* (DC.) Leroy | Tonkolili Plants | 24 |
| *Heinsia crinita* (Afzel.) G.Taylor | Burgt, X.M. van der | 1387 |
| *Hutchinsonia barbata* Robyns | Darbyshire I. | 638 |
| *Hymenocoleus hirsutus* (Benth.) Robbr. | Tonkolili Plants | 564 |
| *Hymenocoleus neurodictyon* (K.Schum.) Robbr. var. *neurodictyon* | Tonkolili Plants | 563 |
| *Ixora nimbana* Schnell | Sesay, J.A. | 1 |
| *Keetia cf. mannii (Hiern) Bridson* | Tonkolili Plants | 555 |
| *Keetia sp. nov. aff tenuiflora* (Hiern) Bridson | Robinson, E. | 5 |
| *Massularia acuminata* (G.Don) Bullock ex Hoyle | Tonkolili Plants | 746 |
| *Morinda geminata* DC. | Tonkolili Plants | 836 |
| *Morinda longiflora* G.Don | Tonkolili Plants | 195 |
| *Mussaenda afzelii* G.Don | Tonkolili Plants | 515 |
| *Mussaenda elegans* Schum. & Thonn. | Feika, A.M.B. | 23 |
| *Mussaenda erythrophylla* Schum. & Thonn. | Feika, A.M.B. | 12 |
| *Nauclea diderrichii* (De Wild. & T.Durand) Merrill | Tonkolili Plants | 929 |
| *Nauclea latifolia* Sm. | Tonkolili Observations | 295 |
| *Nichallea soyauxii* (Hiern) Bridson | Kanu, K.M.T. | 35 |
| *Oldenlandia goreensis* (DC.) Summerh. | Tonkolili Plants | 137 |
| *Oldenlandia herbacea* (L.) Roxb. | Tonkolili Plants | 50 |
| *Oxyanthus formosus* Hook.f. ex Planch. | Tonkolili Plants | 249 |
| *Oxyanthus speciosus* DC. | Feika, A.M.B. | 31 |
| *Pavetta platycalyx* Bremek. | Darbyshire I. | 601 |
| *Pentodon pentandrus* (Schum. & Thonn.) Vatke var. *pentandrus* | Feika, A.M.B. | 63 |
| *Psilanthus ebracteolatus* Hiern | James, M.S. | 17 |
| *Psychotria brachyanthoides* De Wild. | Tonkolili Plants | 546 |
| *Psychotria calva* Hiern | Kanu, K.M.T. | 37 |
| *Psychotria gabonica* Hiern | Sesay, J.A. | 13 |

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| *Psychotria limba* Scott-Elliot | Kanu, K.M.T. | 33 |
| *Psychotria peduncularis* (Sal.) Steyer. var. *guineensis* (Schnell) Verdc. | Feika, A.M.B. | 27 |
| *Psychotria subglabra* De Wild. | Kanu, K.M.T. | 38 |
| *Psydrax horizontalis* (K.Schum. & Thonn.) Bridson | Darbyshire I. | 630 |
| *Rothmannia urcelliformis* (Hiern) Bullock ex Robyns | Kanu, K.M.T. | 28 |
| *Rothmannia whitfieldii* (Lindl.) Dandy | Tonkolili Plants | 109 |
| *Rutidea parviflora* DC. | Kanu, K.M.T. | 50 |
| *Sabicea calycina* Benth. | Tonkolili Plants | 516 |
| *Sabicea venosa* Benth. | Feika, A.M.B. | 35 |
| *Sacosperma paniculatum* (Benth.) G.Taylor | Darbyshire I. | 588 |
| *Schizocolea linderi* (Hutch. & Dalz.) Bremek. | Burgt, X.M. van der | 1389 |
| *Sherbournia calycina* (G.Don) Hua | Sesay, J.A. | 14 |
| *Spermacoce bambusicola* (Berhaut) Lebrun & Stork | Feika, A.M.B. | 53 |
| *Spermacoce exilis* (Williams) C.D.Adams ex W.C.Burger & C.M.Taylor | Tonkolili Plants | 129 |
| *Spermacoce ivorensis* Govaerts | Tonkolili Plants | 48 |
| *Spermacoce pusilla* Wall. | Tonkolili Plants | 79 |
| *Spermacoce ruelliae* DC. | Burgt, X.M. van der | 1348 |
| *Spermacoce verticillata* L. | Tonkolili Observations | 69 |
| *Trichostachys aurea* Hiern | Burgt, X.M. van der | 1366 |
| *Uncaria africana* G.Don subsp. *africana* | Robinson, E. | 1 |
| *Virectaria multiflora* (Sm.) Bremek | Tonkolili Plants | 132 |
| *Virectaria procumbens* (Sm.) Bremek | Tonkolili Plants | 241 |
| | | |
| **Rutaceae** | | |
| *Zanthoxylum gilletii* (De Wild.) P.G.Waterman | Tonkolili Plants | 753 |
| | | |
| **Sapindaceae** | | |
| *Allophylus africanus* P. Beauv. forma *africanus* | Tonkolili Plants | 118 |
| *Blighia welwitschii* (Hiern) Radlk. | Tonkolili Plants | 2 |
| *Cardiospermum grandiflorum* Sw. | James, M.S. | 18 |
| *Deinbollia cuneifolia* Baker | Tonkolili Plants | 924 |
| *Deinbollia grandifolia* Hook. f. | Tonkolili Plants | 14 |
| *Lecaniodiscus cupanioides* Planch. ex Benth. | Tonkolili Plants | 164 |
| *Pancovia pedicellaris* Radlk. & Gilg | James, M.S. | 13 |
| *Placodiscus oblongifolius* J.B.Hall | Tonkolili Plants | 829 |
| *Placodiscus pseudostipularis* Radlk. | Tonkolili Plants | 776 |
| | | |
| **Sapotaceae** | | |
| *Chrysophyllum africanum* A.DC. | Tonkolili Plants | 817 |
| *Chrysophyllum perpulchrum* Mildbr. ex Hutch. & Dalziel | Kanu, K.M.T. | 27 |
| *Chrysophyllum pruniforme* Pierre ex Engl. | Tonkolili Plants | 830 |
| *Chrysophyllum subnudum* Baker | Tonkolili Plants | 590 |
| *Chrysophyllum welwitschii* Engl. | Darbyshire I. | 640 |
| *Englerophytum oblanceolatum* (S.Moore) T.D.Pennington | Kanu, K.M.T. | 51 |
| *Ituridendron bequaertii* De Wild. | Burgt, X.M. van der | 1390 |
| *Synsepalum brevipes* (Baker) T.D.Penn. | Kanu, K.M.T. | 60 |
| | | |
| **Simaroubaceae** | | |
| *Hannoa klaineana* Pierre & Engl. | Tonkolili Plants | 920 |
| | | |
| **Solanaceae** | | |
| *Physalis angulata* L. | Tonkolili Plants | 256 |
| *Physalis micrantha* Link | Tonkolili Plants | 254 |
| *Solanum erianthum* D.Don | Tonkolili Plants | 252 |
| *Solanum torvum* Sw. | Tonkolili Observations | 49 |

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| **Sterculiaceae** | | |
| *Cola chlamydantha* K.Schum. | Tonkolili Plants | 544 |
| *Cola lateritia* K.Schum. var. *maclaudi* (A. Chev.) Brenan & Keay | Tonkolili Plants | 67 |
| *Dombeya buettneri* K. Schum. | Darbyshire I. | 590 |
| *Heritiera utilis* (Sprague) Sprague | Tonkolili Plants | 944 |
| *Sterculia tragacantha* Lindl. | Tonkolili Plants | 729 |
| | | |
| **Thymelaeaceae** | | |
| *Craterosiphon scandens* Engl. & Gilg | Tonkolili Plants | 707 |
| *Dicranolepis disticha* Planch. | Sesay, J.A. | 16 |
| | | |
| **Tiliaceae** | | |
| *Clappertonia ficifolia* (Willd.) Decne. | Tonkolili Observations | 80 |
| *Glyphaea brevis* (Spreng.) Monach. | Burgt, X.M. van der | 1373 |
| *Grewia pubescens* P.Beauv. | Darbyshire I. | 624 |
| *Triumfetta cordifolia* A.Rich. | Tonkolili Plants | 185 |
| *Triumfetta pentandra* A.Rich. | Tonkolili Plants | 220 |
| | | |
| **Ulmaceae** | | |
| *Trema orientalis* (L.) Blume | Feika, A.M.B. | 1 |
| | | |
| **Urticaceae** | | |
| *Boehmeria macrophylla* Hornem. | Feika, A.M.B. | 7 |
| *Pouzolzia guineensis* Benth. | Tonkolili Plants | 125 |
| *Urera oblongifolia* Benth. | Tonkolili Plants | 10 |
| | | |
| **Verbenaceae** | | |
| *Stachytarpheta indica* (L.) Vahl | Tonkolili Observations | 454 |
| | | |
| **Violaceae** | | |
| *Rinorea afzelii* Engl. | James, M.S. | 12 |
| *Rinorea aylmeri* Chipp | Feika, A.M.B. | 74 |
| *Rinorea* sp. 1 of Tonkolili | Tonkolili Plants | 214 |
| *Rinorea subintegrifolia* (P.Beauv.) Kuntze | Tonkolili Plants | 658 |
| *Rinorea welwitschii* (Oliv.) Kuntze | Kanu, K.M.T. | 47 |
| | | |
| **Vitaceae** | | |
| *Cayratia gracilis* (Guill. & Perr.) Suesseng. | Feika, A.M.B. | 17 |
| *Cissus aralioides* (Welw. ex Baker) Planch. | Tonkolili Plants | 632 |
| *Cissus caesia* Afzel. | Tonkolili Plants | 86 |
| *Cissus diffusiflora* (Baker) Planch. | Feika, A.M.B. | 21 |
| *Cissus polyantha* Gilg & Brandt | Tonkolili Plants | 106 |
| *Cissus producta* Afzel. | Feika, A.M.B. | 18 |

Angiospermae: Monocotyledonae

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| **Alismataceae** | | |
| *Limnophyton angolense* Buchenau | Tonkolili Plants | 163 |
| | | |
| **Anthericaceae** | | |
| *Chlorophytum orchidastrum* Lindl. | Sesay, J.A. | 18 |
| | | |
| **Aponogetonaceae** | | |
| *Aponogeton vallisnerioides* Baker | Kanu, K.M.T. | 20 |

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| **Araceae** | | |
| *Amorphophallus* cf. *aphyllus* (Hook.) Hutch. | Tonkolili Plants | 931 |
| *Anchomanes difformis* (Blume) Engl. | Tonkolili Plants | 107 |
| *Anubias afzelii* vel barteri | Tonkolili Plants | 524 |
| *Anubias gracilis* A.Chev. ex Hutch. | Tonkolili Plants | 521 |
| *Cercestis afzelii* Schott | Tonkolili Plants | 761 |
| *Culcasia angolensis* Welw. ex Schott | Tonkolili Plants | 745 |
| *Culcasia* cf. *striolata* Engl. | Tonkolili Plants | 679 |
| *Culcasia liberica* N.E.Br. | Tonkolili Plants | 539 |
| *Culcasia parviflora* N.E.Br. | Tonkolili Plants | 648 |
| | | |
| **Burmanniaceae** | | |
| *Burmannia madagascariensis* Mart. & Zucc. | Burgt, X.M. van der | 1353 |
| | | |
| **Colchicaceae** | | |
| *Gloriosa superba* L. | Tonkolili Observations | 9 |
| | | |
| **Commelinaceae** | | |
| *Aneilema beniniense* (P.Beauv.) Kunth | James, M.S. | 2 |
| *Commelina capitata* Benth. | Tonkolili Plants | 96 |
| *Commelina* cf. *africana* L. | Tonkolili Plants | 119 |
| *Cyanotis lanata* Benth. | Kanu, K.M.T. | 3 |
| *Cyanotis longifolia* Benth. var. *longifolia* | Kanu, K.M.T. | 2 |
| *Floscopa glomerata* (Willd. ex J.A. & J.H.Schult.) Hassk. subsp. *pauciflora* (C.B.Cl.) J.K.Morton | Feika, A.M.B. | 68 |
| *Palisota bracteosa* C.B.Clarke | Tonkolili Plants | 821 |
| *Palisota hirsuta* (Thunb.) K.Schum. | Tonkolili Plants | 615 |
| *Polyspatha paniculata* Benth. | Tonkolili Plants | 665 |
| | | |
| **Cyperaceae** | | |
| Cyperaceae indet. 1 of Tonkolili | Tonkolili Observations | 110 |
| Cyperaceae indet. 1 of Tonkolili | Tonkolili Plants | 84 |
| Cyperaceae indet. 2 of Tonkolili | Tonkolili Observations | 104 |
| *Afrotrilepis pilosa* (Boeck.) J.Raynal | Tonkolili Observations | 21 |
| *Bulbostylis congolensis* De Wild. | Kanu, K.M.T. | 4 |
| *Cyperus guineensis* Nelmes | Tonkolili Plants | 26 |
| *Cyperus haspan* L. | Feika, A.M.B. | 48 |
| *Cyperus pustulatus* Vahl | Kanu, K.M.T. | 23 |
| *Fuirena stricta* Steud. var. *stricta* | Feika, A.M.B. | 42 |
| *Fuirena umbellata* Rottb. | Feika, A.M.B. | 64 |
| *Hypolytrum poecilolepis* Nelmes | Tonkolili Plants | 767 |
| *Kyllinga tenuifolia* Steud. | Tonkolili Plants | 257 |
| *Nemum bulbostyloides* (Hooper) J. Raynal | Robinson, E. | 8 |
| *Nemum spadiceum* (Lam.) Desv. ex Ham. subsp. *spadiceum* | Clark, R. | 171 |
| *Pycreus capillifolius* (A.Rich.) C.B.Clarke | Feika, A.M.B. | 44 |
| *Rhynchospora corymbosa* (L.) Britt. | Feika, A.M.B. | 62 |
| *Schoenoplectiella oxyjulos* (S.S.Hooper) Lye | Clark, R. | 172 |
| *Scleria boivinii* Steud. | Tonkolili Plants | 201 |
| *Scleria* cf. *hirtella* Sw. | Feika, A.M.B. | 41 |
| *Scleria hirtella* Sw. | Kanu, K.M.T. | 12 |
| *Scleria melanomphala* Kunth | Feika, A.M.B. | 71 |
| *Scleria naumanniana* Boeck. | Tonkolili Plants | 201 |
| | | |
| **Dioscoreaceae** | | |
| *Dioscorea praehensilis* Benth. | Feika, A.M.B. | 4 |

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|---|---|---|
| *Dioscorea togoensis* Knuth | Tonkolili Plants | 124 |
| | | |
| **Dracaenaceae** | | |
| *Dracaena cristula* W.Bull | Burgt, X.M. van der | 1367 |
| | | |
| **Eriocaulaceae** | | |
| *Eriocaulon cinereum* R.Br. | Burgt, X.M. van der | 1357 |
| *Eriocaulon latifolium* Sm. | Clark, R. | 189 |
| *Eriocaulon pulchellum* Koern. | Burgt, X.M. van der | 1354 |
| *Eriocaulon remotum* Lecomte | Tonkolili Plants | 153 |
| *Eriocaulon setaceum* L. | Kanu, K.M.T. | 18 |
| *Eriocaulon* sp. | Tonkolili Plants | 44 |
| *Eriocaulon* sp. nov. cf. *varium* Kimpouni | Burgt, X.M. van der | 1372 |
| *Mesanthemum prescottianum* (Bong.) Koern. | Kanu, K.M.T. | 6 |
| *Mesanthemum radicans* (Benth.) Koern. | Feika, A.M.B. | 61 |
| | | |
| **Gramineae** | | |
| *Acroceras gabunense* (Hack.) W.D.Clayton | Tonkolili Plants | 652 |
| *aff. Monocymbium ceresiiforme* (Nees) Stapf | Tonkolili Plants | 123 |
| *Andropogon gayanus* Kunth | Tonkolili Plants | 90 |
| *Andropogon tectorum* Schum. & Thonn. | Tonkolili Plants | 111 |
| *Chasmopodium afzelii* (Hack) Stapf | Tonkolili Plants | 76 |
| *Dilophotriche sp. nov?* | Darbyshire I. | 583 |
| *Eragrostis unioloides* (Retz.) Nees ex Steud. | Tonkolili Plants | 45 |
| *Guaduella oblonga* Hutch. ex W.D.Clayton | Tonkolili Plants | 559 |
| *Hyparrhenia diplandra* (Hack.) Stapf | Tonkolili Plants | 75 |
| *Hyparrhenia mutica* W.D.Clayton | Tonkolili Plants | 34 |
| *Loudetia arundinacea* (Hochst. ex A.Rich.) Steud. | Tonkolili Plants | 74 |
| *Loudetia simplex* (Nees) C.E.Hubb. | Kanu, K.M.T. | 15 |
| *Melinis minutiflora* P.Beauv. | James, M.S. | 9 |
| *Olyra latifolia* L. | James, M.S. | 6 |
| *Oplismenus hirtellus* (L.) P.Beauv. | James, M.S. | 7 |
| *Panicum congoense* Franch. | Burgt, X.M. van der | 1355 |
| *Panicum glaucocladum* C.E.Hubb. | Feika, A.M.B. | 47 |
| *Panicum humile* Steud. | Clark, R. | 170 |
| *Panicum pilgeri* Mez | Darbyshire I. | 586 |
| *Paspalum scrobiculatum* L. | Darbyshire I. | 584 |
| *Pennisetum hordeoides* (Lam.) Steud. | Tonkolili Plants | 92 |
| *Pennisetum polystachion* (L.) Schult. | Feika, A.M.B. | 50 |
| *Rhytachne rottboellioides* Desv. | Kanu, K.M.T. | 10 |
| *Schizachyrium lomaense* A.Camus | Feika, A.M.B. | 46 |
| *Schizachyrium* sp. 1 of Tonkolili | Clark, R. | 176 |
| *Setaria megaphylla* (Steud.) T.Durand & Schinz | Tonkolili Plants | 255 |
| *Sporobolus pectinellus* Mez | Kanu, K.M.T. | 7 |
| *Streptogyna crinita* P. Beauv. | Tonkolili Plants | 840 |
| | | |
| **Hydrocharitaceae** | | |
| *Ottelia ulvifolia* (Planch.) Walp. | Darbyshire I. | 615 |
| | | |
| **Marantaceae** | | |
| *Hypselodelphys sp.* | Tonkolili Plants | 831 |
| *Megaphrynium distans* Hepper | Tonkolili Plants | 584 |
| *Sarcophrynium brachystachys* K. Schum. | Tonkolili Plants | 722 |
| | | |
| **Nymphaeaceae** | | |

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|---|---|---|
| *Nymphaea maculata* Schum. & Thonn. | Darbyshire I. | 614 |
| | | |
| **Orchidaceae** | | |
| *Angraecum distichum* Lindl. | Tonkolili Observations | 450 |
| *Brachycorythis macrantha* (Lindl.) Summerh. | Tonkolili Observations | 15 |
| *Bulbophyllum falcatum* (Lindl.) Rchb. f. | Tonkolili Observations | 447 |
| *Bulbophyllum recurvum* Lindl. | Tonkolili Observations | 448 |
| *Disperis thomensis* Summerh. | Tonkolili Observations | 14 |
| *Eulophia horsfallii* (Batem.) Summerh. | Tonkolili Observations | 18 |
| *Habenaria macrandra* Lindl. | Tonkolili Observations | 449 |
| *Habenaria* sp. | Tonkolili Observations | 151 |
| *Habenaria zambesina* Rchb.f. | Tonkolili Observations | 3 |
| *Liparis rufina* (Ridl.) Rchb. f. ex Rolfe | Tonkolili Observations | 16 |
| *Nervilia subintegra* Summerh. | Tonkolili Observations | 17 |
| *Platycoryne paludosa* Rolfe | Tonkolili Observations | 19 |
| | | |
| **Palmae** | | |
| *Calamus deerratus* Mann & Wendland | Tonkolili Plants | 933 |
| *Elaeis guineensis* Jacq. | Tonkolili Observations | 334 |
| *Raphia palma-pinus* (Gaertn.) Hutch. | Tonkolili Observations | 77 |
| | | |
| **Pandanaceae** | | |
| *Pandanus* sp. | Tonkolili Observations | 457 |
| | | |
| **Pontederiaceae** | | |
| *Eichhornia natans* (P.Beauv.) Solms | Darbyshire I. | 617 |
| | | |
| **Smilacaceae** | | |
| *Smilax anceps* Willd. | Feika, A.M.B. | 52 |
| | | |
| **Xyridaceae** | | |
| *Xyris barteri* N.E.Br. | Clark, R. | 168 |
| *Xyris decipiens* N.E.Br. | Feika, A.M.B. | 40 |
| *Xyris straminea* L. A. Nilsson | Clark, R. | 167 |
| | | |
| **Zingiberaceae** | | |
| *Aframomum cf. sceptrum K. Schum.* | Kanu, K.M.T. | 26 |
| *Aframomum* sp. 1 of Tonkolili | Tonkolili Observations | 452 |

Pteridophyta: Filicopsida

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|---|---|---|
| **Adiantaceae** | | |
| *Adiantum philippense* L. | Tonkolili Plants | 197 |
| *Pityrogramma calomelanos* (L.) Link var. *calomelanos* | Tonkolili Plants | 523 |
| | | |
| **Aspleniaceae** | | |
| *Asplenium dregeanum* Kunze | Tonkolili Plants | 640 |
| | | |
| **Dennstaedtiaceae** | | |
| *Pteridium aquilinum* (L.) Kuhn subsp. *capense* (Thunb.) C.Chr. | Tonkolili Plants | 43 |
| | | |
| **Dryopteridaceae** | | |
| *Tectaria fernandensis* (Baker) C.Chr. | Tonkolili Plants | 721 |
| *Triplophyllum fraternum* (Mett.) Holttum var. *fraternum* | Tonkolili Plants | 797 |
| | | |

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|---|---|---|
| **Lomariopsidaceae** | | |
| *Bolbitis acrostichoides* (Afzel. ex Sw.) Ching | Tonkolili Plants | 216 |
| | | |
| **Oleandraceae** | | |
| *Nephrolepis undulata* (Afzel. ex Sw.) J.Sm. | Tonkolili Observations | 95 |
| | | |
| **Osmundaceae** | | |
| *Osmunda regalis* L. | Sesay, J.A. | 2 |
| | | |
| **Polypodiaceae** | | |
| *Platycerium stemaria* (P.Beauv.) Desv. | Tonkolili Plants | 710 |
| | | |
| **Pteridaceae** | | |
| *Pteris burtoni* Baker | Tonkolili Plants | 769 |
| *Pteris catoptera* Kunze var. *catoptera* | Tonkolili Plants | 196 |
| | | |
| **Schizaeaceae** | | |
| *Lygodium smithianum* C.Presl. ex Kuhn | Tonkolili Plants | 898 |

Pteridophyta: Lycopsida

| | | |
|---|---|---|
| **Selaginellaceae** | | |
| *Selaginella* sp. 1 of Tonkolili | Tonkolili Plants | 85 |
| *Selaginella* sp. 2 of Tonkolili | Tonkolili Plants | 237 |
| *Selaginella* sp. 3 of Tonkolili | Tonkolili Plants | 508 |
| *Selaginella* sp. 4 of Tonkolili | Tonkolili Plants | 664 |

## ANNEX 2: DETAILED ANALYSIS OF SPECIES OF CONSERVATION CONCERN


***Aeschynomene deightonii*** Hepper (Leguminosae-Papilionoideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this species would qualify as **Vulnerable** VU B2ab(iii). A rare herb of wetlands, it is likely to have suffered declines due to conversion of its favoured habitats to rice cultivation; the Tonkolili site is threatened by disturbance and pollution/sedimentation from future mining activity on the adjacent Numbara Hill.
**Distribution**: Guinea (2 sites); Sierra Leone (5 sites); Côte d'Ivoire; (1 site); Ghana (1 site).
**Habitat:** Wet grassland, ditches, marshes and shallow valley swamps.
**Tonkolili:** *Inland valley swamp* – common in shallow sedge-dominated swamp at foot of Numbara (9°0'44.7N 11°40'48.4"W).
**Note:** this species is also likely to occur in the valley swamps within tailings option 5.


***Afzelia africana*** Sm. (Leguminosae-Caesalpinioideae)
**IUCN: Vulnerable** VU A1d (African Regional Workshop (Conservation & Sustainable Management of Trees, Zimbabwe) 1998). A widespread species, considered threatened by exploitation of the timber for commercial trade.
**Distribution**: Senegal; Guinea-Bissau; Guinea; Sierra Leone; Côte d'Ivoire; Mali; Burkina Faso; Ghana; Togo; Benin; Nigeria; Cameroon; Chad; Niger; Central African Republic; Congo-Brazzaville; D.R. Congo; Sudan; Uganda.
**Habitat:** Tree, typically in drier types of forest and forest-wooded grassland transition; rocky areas in moist forest.
**Tonkolili:** *Secondary Thicket* – a single tree sapling 0.5 m tall found in plot T11 on the Marampon-Simbili saddle. *Hillslope forest* – a tree sapling 1.5 m tall in plot 12, Kegbema forest.
**Note:** this very widespread species is considered of low conservation priority for the Project, particularly as it has been found regenariting (albeit 1 plant so far) in secondary habitat.

***Amanoa bracteosa*** Planch. (Euphorbiaceae)
**IUCN: Vulnerable** VU A1c, B1+2c (Hawthorne 1998). A local species threatened principally by habitat loss.
**Distribution**: Sierra Leone (8 sites); Liberia (5 sites); Côte d'Ivoire (4 sites); Ghana (1 site); Cameroon (1 site – Korup NP).
**Habitat:** Tree in a range of wet evergreen forest types, particularly in swampy areas and along riverbanks.
**Tonkolili:** *Riverine Forest* - recorded from riverine forest strip between Wandugu and Foraia and W of Foraia in proposed tailings option 4.
**Note:** the current IUCN assessment of this species is outdated and if re-assessed it would no longer be considered VU under criterion B, although it is still reasonably treated as VU under criterion A.



***Anopyxis klaineana*** (Pierre) Engl. (Rhizophoraceae)
**IUCN: Vulnerable** VU A1cd (Hawthorne 1998). A locally common timber species, threatened by a combination of habitat loss, over-exploitation of its timber and poor seed viability / regeneration.
**Distribution**: Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Nigeria; Cameroon; Congo-Brazzaville; Sudan; Ethiopia.
**Habitat:** Canopy tree in a range of forest types but particularly in wet evergreen forest.
**Tonkolili:** *Riverine Forest* – one 30 m tree recorded in Farangbeya riverine forest.
**Note:** as this species is so widespread and still reasonably common, it is considered of lesser conservation concern to those species assessed here as VU based on criterion B.


***Anthonotha explicans*** (Baill.) J.Léonard **vel sp. aff.** (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, *A. explicans* would qualify as **Vulnerable** VU B2ab(iii). This is a rare tree threatened by habitat loss throughout its range.
**Distribution**: for *A. explicans* - Senegal (unknown number of sites); Guinea (3 sites); Sierra Leone (1 site); Liberia (3 sites); Côte d'Ivoire (1 site).
**Habitat:** Wet evergreen forest and wooded grassland.
**Tonkolili:** *Secondary thicket* – a colony of several small trees found in farmbush near the Tonkolili River in proposed tailings option 1.
**Note:** the first priority is to confirm the identity of the population at the Project area (fertile material is desirable). As it was found growing in farmbush, this may not be a species of high conservation priority.


***Anubias gracilis*** A.Chev. ex Hutch. (Araceae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Vulnerable** VU B2ab(iii). A rare herb restricted to river channels in the Guinea (Loma-Man) Highlands. The current site and one site in Guinea are directly threatened by proposed mining activity which would alter the river volume and sedimentation rates significantly.
**Distribution**: Guinea (4 sites); Sierra Leone (3 sites); Liberia (?1 site).
**Habitat:** Herb of rocky streambeds, typically in sluggish and shallow water.
**Tonkolili:** *River channel community* – a single plant collected from the margins of the Tonkolili River E of Farangbeya village.


***Aphanocalyx pteridophyllus*** (Harms) Wieringa (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Vulnerable** under IUCN criteria A2c and B2ab(iii). This is a localised species and has suffered from extensive habitat loss throughout its range; a comparison of forest cover loss maps in Chatelain *et al.* (2004, p.16) with the distribution map of this species (Poorter *et al.* 2004) indicates that most of its former potential habitat has been lost.
**Distribution**: Sierra Leone (5 sites); Liberia (5 sites).
**Habitat:** Tree of evergreen forest including riverine fringes.
**Tonkolili:** *Riverine forest* – a common component of the riverine fringe from E of Farangbeya to W of Foraia and probably beyond, but not recorded in the disturbed riverine forest of proposed tailings option 1. Many fruiting trees seen and many young saplings recorded.
**Note:** The upper Tonkolili River must be considered a site of global significance for this species.


***Brachystegia leonensis*** Burtt Davy & Hutch. (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Vulnerable** under IUCN criterion A2c. This is a highly localised species and has suffered from extensive habitat loss throughout its range which is comparable with that of *Aphanocalyx pteridophyllus*.
**Distribution**: Sierra Leone (4 sites); Liberia (4 sites); W Côte d'Ivoire (c. 7 sites).
**Habitat:** Tree of wet evergreen forest.
**Tonkolili:** *Riverine forest* – several trees recorded along river E of Farangbeya; 15 large trees and regenerating seedlings recorded in degraded riverine forest along Tonkolili River in proposed tailings option 1.

***Bryaspis humularioides*** Gledhill subsp. ***falcistipulata*** Gledhill (Leguminosae–Papilionoideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Endangered** (EN B2ab(iii)), being known from only three sites with the Marampon site being directly threatened by the proposed mining activity. Subsp. *humularioides* is similarly rare, being known from a single Liberian collection, hence the species as a whole must also be considered Endangered.
**Distribution**: Sierra Leone (3 sites – type locality is Gbengbe Hill, Bumban, to the NW of Bumbuna).
**Habitat:** Seepage grassland over bedrock.
**Tonkolili:** *Seasonally wet grassland* – one population of c. 10 plants on south slopes of Marampon peak; a second similarly small population on NE slopes of Sakonke Hill.
**Note:** the wet grassland at the latter site had dried by the time of our visit (1/12/09) with only dried old stems of the *Bryaspis* remaining; no herbarium voucher was therefore made and the identification is provisional, as the similar *B. lupulina* also occurs in SL. This population should be revisited to confirm the identification.

***Copaifera salikounda*** Heckel (Leguminosae-Caesalpinioideae)
**IUCN: Vulnerable** VU A1d (African Regional Workshop (Conservation & Sustainable Management of Trees, Zimbabwe) 1998). Considered threatened on the basis of exploitation of its timber and habitat loss throughout its range causing population declines.
**Distribution:** Guinea; Sierra Leone; Liberia; Côte d'Ivoire; Ghana. Over 20 sites known.
**Tonkolili:** *Riverine forest* – one tree in fruit found in Farangbeya river forest.

***Cryptosepalum tetraphyllum*** (Hook.f.) Benth. (Leguminosae-Caesalpinioideae)
**IUCN: Vulnerable** VU A1c, B1+2c (Hawthorne 1998). A rare forest species, threatened by habitat decline throughout its range.
**Distribution**: Guinea; Sierra Leone; Liberia; Côte d'Ivoire; Ghana. Over 20 sites known, the majority in Sierra Leone.
**Habitat:** Tree of wet forest and along riverine fringes in drier forest types.
**Tonkolili:** *Hillslope forest* – Simbili Forest, 14 trees over 10cm dbh and many saplings present in plot 9; several trees in Kegbema Forest; several small groves of this species in the degraded forest of Farngbeya Forest Reserve. *Riverine forest* – single tree recorded in riverine fringe between Wandugu and Foraia in proposed tailings option 4.
**Note:** although clearly rare, the assessment of VU under criterion B would no longer stand if reassessed; however, the assessment of VU under criterion A appears correct. This is an important component of the remnant forests in the Project area and must be considered a key species for any proposed forest restoration schemes.

***Dactyladenia smeathmannii*** (Baill.) Prance & F.White (Chrysobalanaceae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Endangered** under criterion B2ab(iii). A very rare species, with only 5 previous collections known, the 4 Sierra Leone specimens being historic, two without precise locality. The current site is threatened by alteration of the Tonkolili River system due to the proposed mining activity.
**Distribution**: Sierra Leone (3 known sites); Liberia (1 site).
**Habitat:** Tree of forest; in Liberia recorded from secondary growth and on almost bare rock but at Tonkolili restricted to undisturbed riverine forest.
**Tonkolili:** *Riverine forest* – 3 flowering trees E of Farangbeya; a single flowering tree W of Foraia in proposed tailings option 4.
**Note:** this species may prove to be more common along the Tonkolili River than currently documented as it was not targetted as of high conservation concern during the Nov-Dec survey. A full survey of its status in the Project area is therefore recommended as a first step. Care should be taken to separate this species from other closely related *Dactyladenia* spp.

 

***Dialium pobeguinii*** Pellegr. (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would certainly qualify as **Vulnerable** under criterion B2ab(iii) but may well qualify as **Endangered** under criterion A. This is a rare species restricted to a very few localities. The current site is threatened by alteration of the Tonkolili River system due to the proposed mining activity.
**Distribution**: Guinea (2 sites); Sierra Leone (4 sites).
**Habitat:** Tree restricted to riverine forest.
**Tonkolili:** *Riverine forest* – disturbed forest along the Tonkolili River in proposed tailings option 1, a single c. 12 m high tree recorded to date.
**Note:** Most of the historic collections are from the Njala area; this area should be revisited to check if it is still extant there. A survey of this species' abundance along the Tonkolili River should be conducted.

 

***Dilophotriche sp. ?nov.*** (Gramineae)
**IUCN:** Not currently assessed, with confirmation of the status of this species needed prior to further assessment;.
**Distribution:** Sierra Leone, apparently restricted to the Southern Sula Mts.
**Habitat:** A perennial grass of seasonal wet flushes on hillslope grassland.
**Tonkolili:** *Seasonally wet grassland* – a single sizable population in an area c. 20 × 20 m on the slopes of Sakonke Hill.
**Note:** the single known site is not on the mine deposits and is actually outside the wider concession area. However, it is quite possible that this species also occurs on the mine site - the wet flushes were drying out at the time of the visit and flowering can end abruptly at the onset of the dry season; grasses are largely impossible to identify when lacking flowers and fruits hence it may have been missed if not flowering e.g. on the flushes S and SE of Marampon; this area should be thoroughly checked for this species.

 

***Drypetes afzelii*** (Pax) Hutch. (Euphorbiaceae / Putranjavaceae)
**IUCN: Vulnerable** VU A1c, B1+2c (Hawthorne 1998). An uncommon species that has suffered from general declines in its habitat because of mining, logging and commercial forestry activities.
**Distribution**: Sierra Leone (12 sites); Liberia (2 sites); Côte d'Ivoire (4 sites); Ghana (no. of sites unknown).
**Habitat:** Shrub or small (to medium) tree of wet evergreen forest, generally along rivers.
**Tonkolili:** *Hillslope forest* - several records from Kegbema Forest including disturbed areas; four small trees in plot 12.
**Note:** the assessment of VU under criterion B would no longer stand if reassessed; however, the assessment of VU under criterion A may be correct; it is certainly a local species with Sierra Leone being the most important country.

 

***Entandrophragma cylindricum*** (Sprague) Sprague (Meliaceae)
**IUCN: Vulnerable** VU A1cd (Hawthorne 1998). A prime timber species, exploited heavily throughout its range. Large-scale depletion of mature individuals from populations has taken place in some countries.
**Distribution**: Sierra Leone; Côte d'Ivoire; Ghana; Togo; Nigeria; Cameroon; Gabon; Congo-Brazzaville; D.R. Congo; Uganda; Angola. Known from many collections.
**Habitat:** A canopy tree of forest, often in drier, semi-deciduous forest types.
**Tonkolili:** *Hillslope forest* – one tree to 40 m tall in Simbili Forest.
**Note:** as this is such a widespread species, it is considered by us to be of lower conservation priority to those species assessed as VU under criterion B.

 

***Eriocaulon sp. nov.*** (Eriocaulaceae)
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Critically Endangered** CR B1ab(iii)+B2ab(iii) if it is confirmed as a distinct species. The single locality is threatened by changes in run-off quantity and reduced water clarity and oxygen-content if/when the mining operations go ahead. It would be completely lost if proposed tailings option 4 were adopted.
**Distribution:** Sierra Leone, apparently restricted to the Southern Sula Mts.
**Habitat:** A rheophyte growing within river rapids, the foliage often submerged with only the inflorescence exposed above the water surface.
**Tonkolili:** *River channel community* – a single population found in the river E of Farangbeya. The collection made by Crisp c. 50 years ago is believed to be from the same locality.
**Note:** it is essential that the status of this species is confirmed as soon as possible; if as expected it proves to be a new species, all efforts must be made to protect the Tonkolili River from increased disturbance. It should also be sought for in the southern section of proposed tailings option 4.

 

***Garcinia kola*** Heckel (Clusiaceae)
**IUCN: Vulnerable** VU A2cd (Cheek 2004). A widespread but local species, threatened by over-exploitation for use as chewsticks (dental hygiene) and over-harvesting of the medicinal seeds (bitter cola).
**Distribution**: Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Benin; Cameroon; Gabon; D.R. Congo.
**Habitat:** Tree of evergreen forest.
**Tonkolili:** *Hillslope forest* – one record from Simbili Forest; frequent in Kegbema Forest, where the fruits are harvested by the local community.
**Note:** This species could be used within a forest restoration programme in view of its value to local communities.

***Gilbertiodendron aylmeri*** (Hutch. & Dalz.) J.Léonard (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Vulnerable** under criterion B2ab(iii) but may well qualify as **Endangered** under criterion A2c. It is a rare and very localised species and is likely to have experienced a serious range decline due to habitat loss.
**Distribution**: Sierra Leone (5 sites); Liberia (1 site).
**Habitat:** A grove-forming canopy tree of wet forest.
**Tonkolili:** *Riverine forest* – at least 44 trees found in 3 groups in Farangbeya riverine forest; many in fruit.
**Note:** This is an important species of the Tonkolili riverine forest and in view of its rarity this should be a high conservation priority in the Project area.

***Guarea cedrata*** (A.Chev.) Pellegrin (Meliaceae)
**IUCN: Vulnerable** VU Alc (World Conservation Monitoring Centre 1998). A timber species with moderate exploitation; it has also suffered declines due to its similarity to the prime timber tree *Entandrophragma angolense*.
**Distribution**: Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Nigeria; Cameroon; Congo-Brazzaville; D.R. Congo; Uganda.
**Habitat:** A canopy tree of moist semi-deciduous forest and in drier areas of evergreen forest; it can be locally abundant.
**Tonkolili:** *Hillslope forest* – 3 trees in plot 12 in Kegbema Forest, 1 tree in plot 9 in Simbili Forest.
**Note:** as this is such a widespread and locally common species, it is considered by us to be of lower conservation priority to those species assessed as VU under criterion B.


***Guibourtia leonensis*** J.Léonard (Leguminosae-Caesalpinioideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Vulnerable** under criterion B2ab(iii) but may well qualify as **Endangered** under criterion A2c. It is a very rare species and is likely to have experienced a serious range decline due to habitat loss. Part of the population on the Project area will be lost if/when the SImbili-Marampon deposits are mined.
**Distribution**: Guinea Bissau (1 site); Guinea (1 site); Sierra Leone (3 sites); Liberia (1 site); Côte d'Ivoire; Ghana; Nigeria; Cameroon; Congo-Brazzaville; D.R. Congo; Uganda.
**Habitat:** A canopy tree of moist semi-deciduous forest and in drier areas of evergreen forest; it can be locally abundant.
**Tonkolili:** *Hillslope forest* – saddle between Simbili and Marampon (1 tree seen); Kegbema forest (2 trees seen). *Riverine forest* – Tonkolili river at Farangbeya (2 trees seen). All fruiting.
**Note:** As for the *Gilbertiodendron*, this should be considerd a high conservation priority species at the Project area and it is essential to look for additional secure populations.


***Hallea stipulosa*** (DC.) Leroy (Rubiaceae)
**IUCN: Vulnerable** VU A1cd (World Conservation Monitoring Centre 1998). An important timber species, over-exploited in many areas.
**Distribution**: Gambia; Senegal; Guinea; Sierra Leone; Ghana; Nigeria;Cameroon; Gabon; Central African Republic; Congo-Brazzaville; D.R. Congo; Sudan; Uganda; Zambia; Angola.
**Habitat:** Tree of swamp forest, also growing as a pioneer in open valley swamps including areas cultivated for rice.
**Tonkolili:** *Inland valley swamp* – foot of Numbara peak, numerous in small swamp; common as a pioneer tree in valley swamps in proposed tailings option 5
**Note:** this species grows as a common pioneer in all valley swamps in this area of Sierra Leone and in view of this fact, together with its broad distribution, its threatened status must be questioned. It is not considered to be a high conservation priority here.



***Heritiera utilis*** (Sprague) Sprague (Sterculiaceae)
**IUCN: Vulnerable** VU A1cd (Hawthorne 1998). A timber species, threatened by unsustainably high extraction rates.
**Distribution**: Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Gabon.
**Habitat:** Canopy tree usually in evergreen forest where it can be common.
**Tonkolili:** *Hillslope forest* – Bantho Hill (1 tree seen). *Riverine forest* - Farangbeya river forest (1 tree seen).


***Leptoderris micrantha*** Dunn (Leguminosae–Papilionoideae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Endangered** EN B2ab(iii). Despite its wide distribution, it appears to be extremely rare and is threatened by habitat loss.
**Distribution:** Sierra Leone (1 site); Ghana (1 site); Nigeria (2 sites).
**Habitat:** A liana of forest and thicket including riverine forest.
**Tonkolili:** *Riverine forest* – several lianas seen east of Farangbeya in strip of forest along river bank, collected in flower.
**Note:** This is the first record for Sierra Leone, representing a major range expansion for this rarity.


***Nauclea didderrichii*** (De Wild. & T.Durand) Merrill **(**Rubiaceae)
**IUCN:** VU A1cd (African Regional Workshop (Conservation & Sustainable Management of Trees, Zimbabwe)1998). It is heavily exploited for its timber, which is used in general construction work.
**Distribution:** Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Nigeria; Cameroon; Central African Republic; Gabon; Congo-Brazzaville; D.R. Congo; Angola; Uganda; Mozambique.
**Habitat:** An evergreen forest tree.
**Tonkolili:** *Hillslope forest* – one large tree seen in Kegbema forest.


***Nemum bulbostyloides*** (S.S.Hooper) J.Raynal (Cyperaceae)
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Vulnerable** VU B2ab(i, ii, iii, iv, v). It is a rare submontane species, restricted to the Guinea (Loma-Man) Highlands. The current site and two sites in the Simandou area of Guinea are directly threatened by planned mining activity.
**Distribution**: Guinea (6 sites); Sierra Leone (1 site); Liberia (1 site); Côte d'Ivoire (2 sites).
**Habitat:** Perennial herb of seasonal wet flushes over rock outcrops or laterite.
**Tonkolili:** *Seasonally wet grassland* – locally common in an area of seasonal wet grassland SE of Marampon Hill but entirely absent from the well-surveyed seepage area on the S slope of that hill.
**Note:** This is the first record of this species from Sierra Leone.


***Panicum glaucocladum*** C.E.Hubb. (Gramineae)
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Vulnerable** VU B2ab(i, ii, iii, iv, v), being known from fewer than 10 sites and with direct threat to the Tonkolili site.
**Distribution:** Guinea (1 site); Sierra Leone (4 sites); Liberia (1 site); Côte d'Ivoire (2 sites).
**Habitat:** An annual grass of seasonal wet flushes, growing on shallow bare mud over bedrock.
**Tonkolili:** *Seasonally wet grassland* – one large population in a small seepage area on S slopes of Marampon.
**Note:** Several collections have been made from the Loma Mts where it is unlikely to be threatened.


***Pavetta platycalyx*** Bremek.
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Vulnerable** VU B2ab(iii), the principal threat being destruction of its forest habitat.
**Distribution:** Guinea-Bissau (1 site); Guinea (2 sites); Sierra Leone (2 known sites); Côte d'Ivoire (2 sites).
**Habitat:** An understorey shrub of wet forest.
**Tonkolili:** *Hillslope forest* – common in the remnant forest patch on Bantho Hill N of the Farangbeya Forest Reserve.
**Note:** This species has not so far been found on the potential mine footprint area, being apparently absent from the Simbili and Kegbema forests which is curious in view of the proximity of these sites to Bantho hill.


***Placodiscus oblongifolius*** J.B.Hall (Sapindaceae)
**IUCN: Vulnerable** VU A1c, B1+2c (Hawthorne 1998). A local species (though apparently fairly common in Ghana), much of this species' habitat has been lost to mining, logging and commercial forestry.
**Distribution:** Sierra Leone (1 site); Liberia (3 sites); Côte d'Ivoire (5 sites); Ghana (3 sites at Kew).
**Habitat:** Tree of wet evergreen forest.
**Tonkolili:** *Hillslope forest* – a single tree 12 m tall in plot 12, Kegbema forest.
**Note:** This is the first record of this species for Sierra Leone and as it is based on a sterile collection, it requires confirmation. However, the range extension to SL is not unexpected. This species can no longer be considered VU under criterion B but its assessment of VU based on criterion A is reasonable.


***Placodiscus pseudostipularis*** Radlk. (Sapindaceae)
**IUCN: Endangered** EN B1+2c (Hawthorne 1998) – but see note. Losses of its favoured habitats of lowland coastal and riverine forest have been severe. Hawthorne & Jongkind (2006) however record it as a "common small tree…across the region".
**Distribution:** Sierra Leone (6 sites); Liberia (1 site); Côte d'Ivoire (4 sites); Ghana (1 site).
**Habitat:** A small tree of wet forest, typically in coastal forest remnants and in riverine forest.
**Tonkolili:** *Hillslope forest* – a single tree 6 m tall in plot 12, Kegbema forest.
**Note:** Although currently listed as Endangered, this species no longer qualifies as such under criterion B and in fact would not be considered threatened if reassessed under that criterion; however, it can reasonably considered as **Vulnerable** under criterion A.

***Pseudovigna* sp. nov.** (Leguminoae–Papilionoideae)
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Endangered** EN B1ab(i, ii, iii, iv, v)+B2ab(i, ii, iii, iv, v). It appears to be restricted to the Sula Mts, with two of the three sites found to date being directly on the potential mine deposits.
**Distribution:** Sierra Leone, apparently restricted to the Southern Sula Mts.
**Habitat:** A perennial herb of hill-summit lightly wooded fire-prone grassland with exposed iron-rich bedrock.
**Tonkolili:** *Natural (wooded) grassland* – 3 populations currently known: Numbara peak, estimated population of several hundred plants; Marampon peak, only one plant found; Sakonke Hill, population survey recorded 99 plants (but almost certainly not exhaustive).
**Note:** The successful location of this species on Sakonke Hill bodes well for its discovery on other similar sites along the Sula Mts chain.

***Schizachyrium lomaense*** A.Camus (Gramineae)
**IUCN:** Not currently assessed. On the basis of current evidence, this subspecies would qualify as **Endangered** under criterion B2ab(iii). Previously known only from Mt Bintumane and a single site in the Tingi Mts, Sierra Leone. The site on the Project area would be destroyed by the proposed mining.
**Distribution**: Sierra Leone (3 sites).
**Habitat:** Perennial grass of wet flushes in montane and submontane grassland.
**Tonkolili:** *Seasonally wet grassland* – a small population in the seepage area on the S slopes of Marampon.
**Note:** This species has previously been recorded from higher altitude sites – it is likely to be a submontane species that just extends into the highest parts of the Sula Mts. This must be considered a high priority conservation species.


***Schoenoplectiella oxyjulos*** (S.S.Hooper) Lye (Cyperaceae)
**IUCN:** Not currently assessed. Based upon current knowledge, this species would qualify as **Vulnerable** VU B2ab(iii). Although very widespread, it is very rare, being known from less than 10 sites globally. The Tonkolili site would be destroyed by the proposed mining activity.
**Distribution**: Guinea (2 sites); Sierra Leone (2 sites); Nigeria (2 sites); Cameroon (1 site); Central African Republic (?1 site); Sudan (1 site).
**Habitat:** Annual herb of seasonal wet flushes over rock outcrops or laterite.
**Tonkolili:** *Seasonally wet grassland* – common in a small (c. 10 × 15 m) seasonal wetland on summit of Numbara Hill.
**Note:** it is possible that further sites for this species will be uncovered following a visit to the Paris herbarium, which may result in a down-grading to Near Threatened (NT). It is an inconspicuous species which could be easily overlooked in the field, perhaps contributing to its apparent scarcity.

***Terminalia ivorensis*** A.Chev. (Combretaceae)
**IUCN: Vulnerable** VU A1cd (Hawthorne 1998). A timber species, with moderate exploitation in some areas.
**Distribution**: Guinea; Sierra Leone; Liberia; Côte d'Ivoire; Ghana; Nigeria; Cameroon.
**Habitat:** Tree of wet forest, often in secondary forest and forest remnants.
**Tonkolili:** *Riverine forest* – recorded from degraded swampy forest at foot of Numbara peak where this species is rather frequent with evidence of regeneration.
**Note:** this species is assessed as VU purely down to its commercial interest; at Tonkolili it has only been found in degraded habitat, growing as a pioneer and is not considered of high conservation priority.
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***Turraeanthus africanus*** (Welw.) Pellegr. (Meliaceae)
**IUCN: Vulnerable** VU A1cd (African Regional Workshop (Conservation & Sustainable Management of Trees, Zimbabwe)1998). A widespread timber species, with exploitation resulting in declining populations in some areas.
**Distribution**: Sierra Leone; Côte d'Ivoire; Ghana; Benin; Nigeria; Cameroon; Equatorial Guinea; D.R. Congo; Uganda; Angola.
**Habitat:** Canopy tree of forest, often in semi-deciduous forests on poorly drained soils.
**Tonkolili:** *Hillslope forest* – a single 20 m tree recorded in Kegbema forest plot 12.
**Note:** as this is such a widespread species, it is considered by us to be of lower conservation priority to those species assessed as VU under criterion B.

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## APPENDIX 10

## Report on the Vegetation Map of the Tonkolili Project Area

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## Tonkolili Iron Ore Project

# Report on the Vegetation Map of the Tonkolili Project Area

305000-00006 – 305000-00006-0000-EN-REP-0016

21-Apr-2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

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**PROJECT 305000-00006 - REPORT ON THE VEGETATION MAP OF THE TONKOLILI PROJECT AREA**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | P Burris | P Burris | N/A | 21-Apr-2010 | N/A | |
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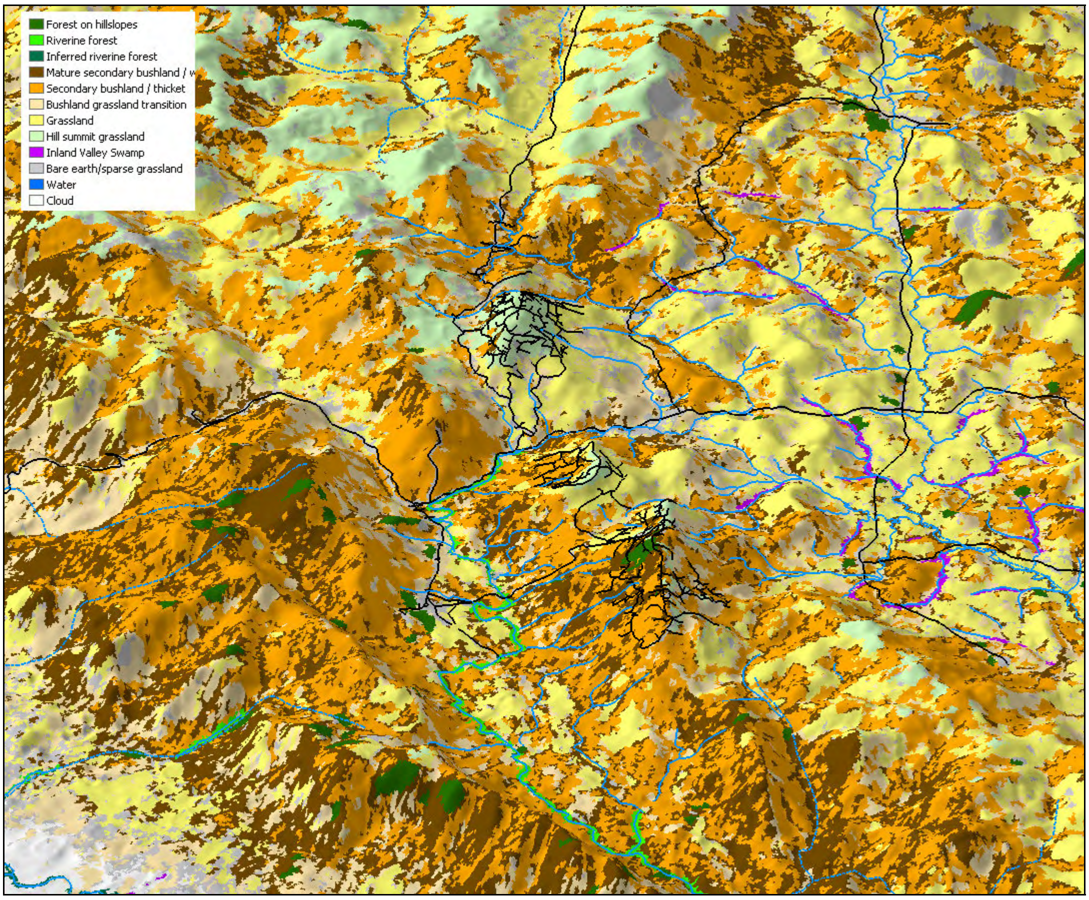
# REPORT ON THE VEGETATION MAP OF THE TONKOLILI PROJECT AREA, SIERRA LEONE

Justin Moat, Iain Darbyshire & Xander van der Burgt
Royal Botanic Gardens, Kew

**CONFIDENTIAL**




March 2010

# REPORT ON THE VEGETATION MAP OF THE TONKOLILI PROJECT AREA, SIERRA LEONE

**March 2010**

## PREPARED FOR:

SRK Consulting (UK) Limited / African Minerals Limited

## PREPARED BY:

Royal Botanic Gardens, Kew

## AUTHORS AND CONTRIBUTORS:

Justin Moat, Iain Darbyshire and Xander van der Burgt. *RBG, Kew*

## EXECUTIVE SUMMARY:

This report presents the vegetation map for the Tonkolili project area and the wider Tonkolili region, together with summary information on each of the vegetation classes and their conservation importance, and an assessment of the confidence limits of the classification. It supplements the earlier “Report on the Vegetation Survey & Botanical Inventory of the Tonkolili Project Area, Sierra Leone” (Darbyshire & van der Burgt 2009).

Within the main study area (the deposits Numbara, Marampon and Simbili and the adjacent potential tailings and infrastructure localities), less than 2% of the total vegetation is classified as forest despite this being the putative climax vegetation of the region. Less than 7% of the area is covered by vegetation of high conservation value, with a further 0.6% covered by habitat of moderate conservation value; these figures are comparable for the wider Tonkolili region. Over 90% of the vegetation is considered to be of low conservation value, the majority being a mosaic of secondary grassland, bushland and woodland derived from cyclical slash-and-burn agriculture.

This report is presented as a pdf document with the associated GIS data.

## ACKNOWLEDGEMENTS:

The authors would like to thank the following people for their input during the preparation of this report and accompanying maps: Susana Baena, Martin Cheek, Tracy Irvine and Gemma Marchant (RBG Kew); Abdulai Feika and Matthew James (Njala University); Kabbie Kanu and Julius Sesay (Fourah Bay College); Paul Mitchell, Emily Robinson and Craig Watt (SRK Consulting (UK) Ltd.).

## 1. INTRODUCTION

This report provides a written accompaniment to the vegetation maps of the Tonkolili project area. It concludes the botanical aspects of Phase 2b of the Tonkolili project biodiversity studies, commissioned by SRK Consulting (UK) Limited on behalf of African Minerals Limited. This report supplements “Report on the Vegetation Survey & Botanical Inventory of the Tonkolili Project Area, Sierra Leone” by Darbyshire & van der Burgt (2010) and should be read in conjunction with that work, although key points from the earlier report are summarised here where appropriate.

The vegetation classification and associated maps fulfil the following deliverables of the Phase 2b work:

- To provide a detailed characterisation of vegetation types at the project site.
- To provide description and mapping of the habitats of conservation concern.

## 2. METHODOLOGY

### 2.1 DATA DESCRIPTION

The main source of data for mapping the vegetation in the Tonkolili project area is a satellite image from the SPOT family of satellites, tailored to meet the mapping demands. A single multispectral satellite image (three bands in the visible and near infra red) from HRG – SPOT 5 was acquired from the SPOT Archive (January 2008, http://www.spotimage.com/) to cover the main area at 5 m resolution (see Map 1). The image was pre-processed for radiometric corrections and rectified to UTM WGS 84 (Zone 29 north). This should provide location accuracy to 50 m or better.

A further SPOT image was also purchased from the archive for March 2006, at 20 m resolution (see Figure 1). This image was to be used to fill in any gaps in the data due to cloud cover on the 2008 image. Ultimately, it was not used for two reasons: first, the cloud cover on the 2008 image did not impact greatly on the main project area and second, the change in vegetation cover was significant over the 2 year period.

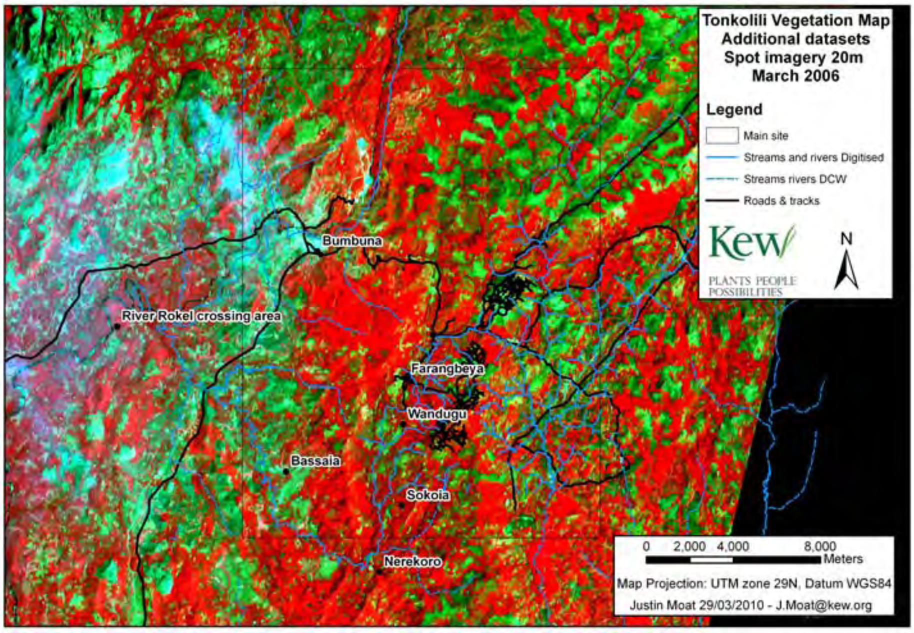



*Figure 1: 2006 SPOT image of the Tonkolili region, 20 m resolution.*

In addition to field survey work, the aerial photograph mosaic from March 2009 at 20 cm resolution was used to provide some ground control and for locational accuracy.

An ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) derived Digital Elevation Model (DEM) was additionally used in the classification.

### 2.2 VEGETATION CLASSIFICATION SCHEME

The vegetation classification system adopted is a combined physiognomic-floristic approach which describes both the vegetation structure and floristic composition (modified from White 1983). The physiognomic method, looking at the dominant vegetation formation, makes the system easily recognisable in the field and relates to spectral response from satellite images, which makes the mapping phase feasible. The physiognomic types are then related to the floristic composition and key environmental variables to fully describe and characterise the vegetation of the area.

The aim was to produce a repeatable classification process, using standard terminology and discriminating classification units which are ecologically meaningful and easily discernible in the field. This vegetation classification scheme intends to discriminate the following vegetation types:

- Forest
  - Forest on hillslopes
  - Riverine forest
- Grassland
  - Hill summit (wooded) grassland
  - Grassland
- Bushland
  - Mature secondary bushland / woodland
  - Secondary bushland / thicket
  - Bushland / grassland transition
- Bare earth / sparse grassland
- Inland Valley Swamp

Of the vegetation types described in the project area by Darbyshire & van der Burgt (2010), the River Channel Communities and the Seasonally Wet Grasslands are not mapped here. This is due in part to their very small areal extent, these sites always being below the minimum mapping unit area following the map accuracy assessment (see Section 3.3). In addition, it proved impossible to separate Seasonally Wet Grassland from other grassland communities using GIS and remote sensing techniques, and we would therefore have had low confidence in any extrapolated areas of this vegetation class beyond the surveyed sites. Both these vegetation types are of high conservation concern but together represent only a small fraction of a percentage of the total area covered. The known Seasonally Wet Grasslands are included as point data on the map of conservation importance.

### 2.3 FIELD METHODS

The field survey methods have been outlined in full by Darbyshire & van der Burgt (2010).

The favoured approach to vegetation mapping is to provide an initial GIS-based vegetation classification using satellite imagery, followed by ground-truthing using pre-selected sampling localities to cover as wide a range of potential vegetation types and environmental variables as possible. However, due to both the short timeframe and the unavailability of the SPOT imagery prior to the field survey period in November-December 2009, this approach could not be adopted. Instead, the field surveys were conducted using the aerial photograph composite as guidance, with plots and Ground Control Points (GCPs) being recorded for all the different vegetation types observed. These were then used to inform the vegetation classification map. No time has been available at the time of preparing this report for further ground-truthing of this classification.

It should be noted that accessibility to many areas was limited by the physical terrain, availability of time and logistics of travel. In addition, sampling effort was different depending on the vegetation type, giving greater importance to those types considered to have higher conservation value or that would be most affected by project activities.

Table 1 lists the plots taken in each of the vegetation types considered in this report (also see Maps 1 and 5):

| Plot | Size (m) | Vegetation type | Locality | Geo-reference and altitude |
|---|---|---|---|---|
| T1 | 10 × 10 | Hill summit grassland | Numbara summit ridge | 09°01'39.0" N 11°40'07.1" W 800 m |
| T2 | 10 × 10 | Hill summit (wooded) grassland | Numbara south facing slope of summit ridge | 09°01'48.4" N 11°39'54.5" W 770 m |
| T3 | 10 × 10 | Hill summit (wooded) grassland | Numbara south facing slope of summit ridge | 09°01'48.2" N 11°39'54.1" W 760 m |
| T4 | 12.5 × 50 | Riverine forest | Tonkolili River east of Farangbeya | 08°59'09.6" N 11°42'09.8" W 340 m |
| T5 | 10 × 10 | Hill summit (wooded) grassland | Marampon, ridge northwest of summit | 08°59'46.1" N 11°40'55.3" W 670 m |
| T6 | 10 × 10 | Hill summit (wooded) grassland (disturbed) | Marampon summit ridge | 08°59'47.1" N 11°40'49.9" W 690 m |
| T7 | 10 × 80 | Hill summit (wooded) grassland | Numbara, north section of summit ridge | 09°01'56.4" N 11°39'51.9" W 760 m |
| T8 | 10 × 10 | Secondary bushland / thicket | West slopes of saddle between Numbara and Marampon | 08°59'05.6" N 11°41'21.6" W 570 m |
| T9 | 25 × 25 | Forest on hillslopes | Simbili west slopes | 08°58'36.2" N 11°41'21.7" W 770 m |
| T10 | 10 × 10 | Mature secondary bushland / woodland | West slopes of saddle between Numbara and Marampon | 08°59'15.3" N 11°41'26.3" W 470 m |
| T11 | 10 × 10 | Secondary bushland / thicket | West slopes of saddle between Numbara and Marampon | 08°59'10.9" N 11°41'42.5" W 430 m |
| T12 | 25 × 25 | Forest on hillslopes | Southwest of Kegbema village | 09°00'25.7" N 11°42'05.6" W 430 m |
| T13 | 25 x 25 | Riverine forest | Tonkolili River southwest of Bassaia village | 08°56'54.5'' N 11°46'07.0'' W 125 m |

*Table 1: summary of vegetation survey plots (adapted from Darbyshire & van der Burgt 2009).*

## 2.4 DATA ANALYSIS

### 2.4.1 REMOTE SENSING ANALYSIS

No additional geometric corrections have been applied to the satellite images (supplied at Level 2A); they have been provided in UTM WGS 84 zone 29N and image analysis was carried out using this projection to avoid losing data integrity by resampling.

After an initial supervised classification using the SPOT5 image to explore the separability, it became obvious that some vegetation types could not be easily distinguished spectrally. The main problems were with the separation of forest from mature bushland / woodland (which grade into one another). To aid classification, two further bands were added to the SPOT image; these were two texture images derived from the SPOT infra red and red bands (Variability for a 7x7 pixel area) which showed the variability in the pixels of the surrounding area (i.e. the higher the number, the more textured/bumpy the image). This allowed some of the forest areas to be distinguished (as these areas are more textured) and also emphasised the more homogenous area (e.g. roads and areas of bushland).

A supervised classification procedure was applied to a subset of the image (the main study area: the 3 deposits Numbara, Marampon and Simbili and the adjacent potential tailings and infrastructure localities) using a maximum likelihood algorithm and training data collected in the first phase of field work.

The scheme used for this classification tried to separate the 8 broad classes defined in the vegetation classification scheme.

- Hill summit grassland did not present a significantly distinctive spectral signature (from other grassland types), therefore the threshold for this vegetation type was set at 630 metres and above (defined from fieldwork observations) and the classification refined using a digital elevation model.
- Riverine forest also did not present a distinctive spectral signature (from hillslope forest; this was as expected), but was delimited as forests within 60–90 metres of rivers and streams (digitised separately). Note: on the maps we have a category called inferred riverine forest; this is inferred from a combination of river position and fieldwork observations, as the cloud cover in this region is too high for use of the SPOT imagery.
- Inland valley swamps were very difficult to distinguish from secondary bushland and from the grassland / bushland transition. As there was very little of this vegetation class in the study area, these were digitised separately and manually.

Areas with cloud cover in the south western part of the image and their associated shadows provide incorrect reflectance values and disrupted the classification. The main cloud areas were therefore classified out for the region. There are still areas of haze in the valleys; this again results in incorrect reflectance values and will disrupt the classification in this area (we note an over classification of mature bushland in this area; it is more likely to be secondary bushland). These areas have been left as the algorithm classified, but it should be understood that results here should be treated as less certain (see Figure 3).

To avoid the "salt-and-pepper" appearance of the pixel-based classified image and to give a more readable final vegetation map, the original satellite image was run through a segmentation algorithm, grouping original pixels into segments according to their spectral similarity. The original pixel-based supervised classification was then used to assign classes to the segmented image. (see: http://www.idrisi.com/applications/upload/Segmentation-IDRISI-Focus-Paper.pdf).

To test the accuracy of the finalised map, 232 random points were generated for the area. These were then classified by one of the authors (I.D.) based upon field knowledge and use of the March 2009 aerial photograph composite and SPOT images for the region. Results are given in Section 3.3.

The same analysis was applied to the wider region to give an indication of the vegetation in the surrounding areas, including the northern sector of the mining exploration license area. It should be noted that there are no Ground Control Points (GCPs) in these areas, so results are conjectural at present.

# 3. RESULTS

## 3.1 OVERVIEW OF THE VEGETATION

The vegetation of the Tonkolili region is mapped in Maps 2 and 3. The area is dominated by a mosaic of grassland and bushland / woodland habitats which are predominantly secondary in nature and which grade into one another, thus classification into discrete vegetation units can be difficult.

Comparison of the 2008 SPOT image with the 2009 aerial photo composite shows that a remarkable amount of vegetation change has occurred in the Tonkolili region within one year; this is also true based on a comparison of the 2006 and 2008 SPOT images. In particular, large areas of woody vegetation (chiefly secondary bushland and woodland) has been converted to grassland, almost certainly through slash-and-burn agricultural practices. This may well be typical of the natural cycling of land from subsistence agricultural land to fallow bushland and back, though it may also in part reflect the increased migration into the region following the commencement of mining interest.

In view of this rapid change it should be noted that the precise boundaries of vegetation types represented on the maps may, in some instances, no longer be the same on the ground, but the overall picture (that of highly restricted natural vegetation types within a mosaic of secondary vegetation) remains the same.

Table 2 provides a summary of the areal extent of each vegetation type, with Figure 2 showing the proportional breakdown for the whole region. Areas and proportional breakdowns are also given for cloud cover and water (see figure 3 for boundaries of main study are and whole region).

| **NAME** | **Whole Region (ha)** | **Whole Region (%)** | **Main study area (ha)** | **Main study area (%)** |
|---|---|---|---|---|
| Forest on hillslopes | 591 | 0.65 | 313 | 0.88 |
| Riverine forest | 303 | 0.33 | 201 | 0.56 |
| Inferred riverine forest | 372 | 0.41 | 102 | 0.29 |
| Grassland | 17,881 | 19.63 | 6,398 | 17.96 |
| Hill summit grassland | 4,870 | 5.35 | 1,789 | 5.02 |
| Secondary bushland / thicket | 20,206 | 22.18 | 9,199 | 25.82 |
| Mature secondary bushland / woodland | 14,104 | 15.48 | 6,989 | 19.62 |
| Bushland / grassland transition | 12,056 | 13.24 | 6,321 | 17.74 |
| Bare earth/sparse grassland | 8,053 | 8.84 | 2,522 | 7.08 |
| Inland Valley Swamp | 1,220 | 1.34 | 221 | 0.62 |
| Water | 175 | 0.19 | 110 | 0.31 |
| Cloud cover | 11,259 | 12.36 | 1,463 | 4.11 |

*Table 2: Summary of the area and percentage cover for each class on the vegetation map, both for the main study area and the wider Tonkolili region* (note: values may not add to 100% due to rounding).

Map 4 presents the potential conservation importance of habitats in the region, each vegetation class being assigned High, Medium or Low importance based upon field survey work (see Darbyshire & van der Burgt 2010). In all areas beyond those visited on the ground, the maximum conservation importance for that vegetation class is assumed, for example all forest on hillslopes and all hill summit grassland is recorded as of High importance. In reality, this will of course vary depending on presence / absence of key species of conservation concern, degree of disturbance etc. For the sites visited, the conservation importance has been adjusted to reflect knowledge of the sites. For example, the summit grasslands on Simbili have been downgraded to low importance as they are disturbed and *Pseudovigna sp. nov.* (the key conservation priority in this habitat) has not been found there.

### 3.2 DESCRIPTION OF THE VEGETATION TYPES

The vegetation types and the species of conservation concern for each have been described in full by Darbyshire & van der Burgt (2010) with accompanying photographs and details of their conservation significance; here, we provide summary information on each type, with:

- Areal coverage for the main study area and for the whole SPOT scene (ha & %).
- Locality and physical geography i.e. elevation range, aspect, slope.
- Remote Sensing classification.

- Vegetation physiognomy / structure.
- Dominant and important species.
- Influential factors and threats.
- Conservation importance.

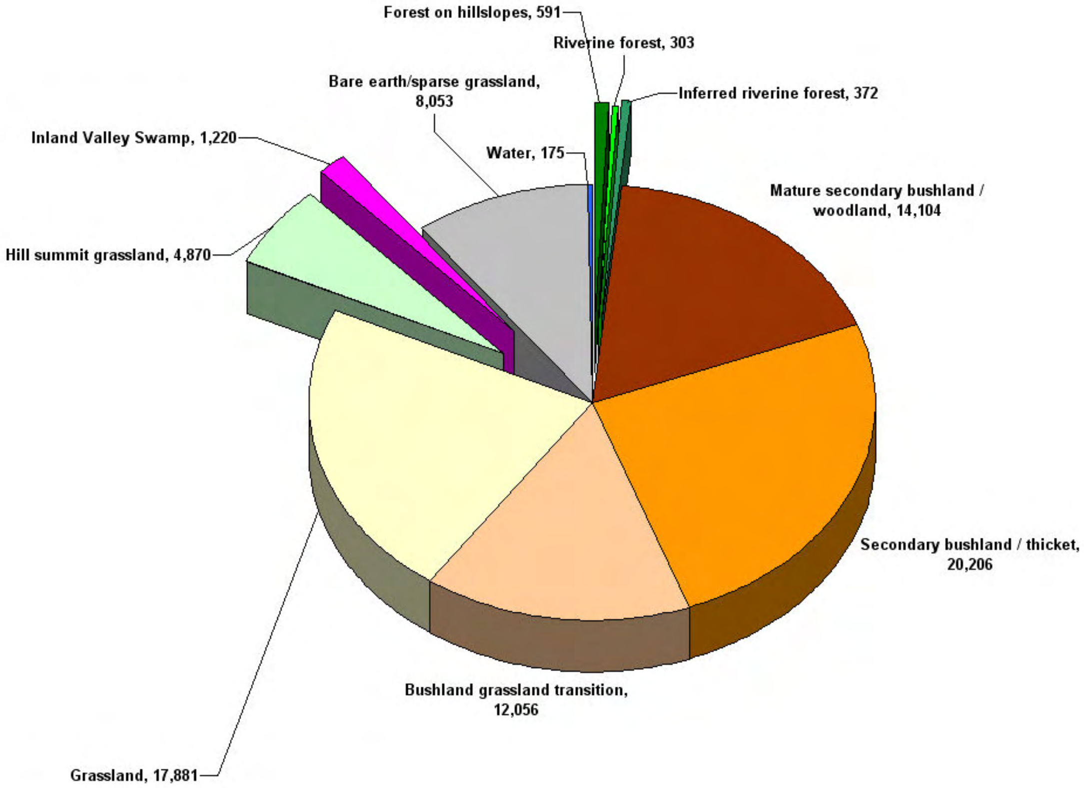



*Figure 2: pie chart of vegetation types for the wider Tonkolili region, excluding area of cloud cover*

### 3.2.1 FOREST ON HILLSLOPES

**Statistics**

Very small area: c. 590 ha for the wider region and 310 ha (less than 1%) for the main study area.

**Locality and physical geography**

Often either (1) in the vicinity of villages, these being community forests / sacred groves, or (2) on hillslopes and ridge summits, in areas rather inaccessible to humans or unfavourable to agriculture.

**Remote Sensing classification**

This vegetation type can often be confused with the bushland classes, especially mature secondary bushland / woodland. Some of the vegetation classified as mature bushland may therefore possibly be forest or have some remnant forest elements. Within the images, forest has a rough texture.

**Vegetation physiognomy/structure**

Forest with (partially) closed canopy c. 30 m tall, understory of small trees, shrubs and forest floor herbs.

**Dominant and important species**

The canopy layer comprises a diverse range of species with no dominant species, though in some areas *Cryptosepalum tetraphyllum* can be locally grove-forming.

**Influential factors and threats**

Only very small remnants of this vegetation type, believed to be the climax vegetation of the free-draining areas of the Tonkolili region (with the probable exception of shallow soils on hill summits), are extant. The remaining sites are usually of cultural significance or used as hunting grounds and many of the remnants are under continued threat, with evidence of recent fire damage, felling etc., particularly along the margins where degradation is clearly evident.

**Conservation importance**

HIGH or MEDIUM (some of the community forests may be of low conservation importance)

### 3.2.2 RIVERINE FOREST

**Statistics**

Very small area: 675 ha (c. 300 classified, 375 inferred) for the wider region and c. 300 (100 classified, 200 inferred) for the main study area (less than 1%).

**Locality and physical geography**

Within 60–90 m of rivers, often a very narrow strip backing onto agricultural land in the valley floor, sometimes discontinuous.

**Remote Sensing classification**

Spatially the same as forest on hillslopes (see Section 3.2.1)., but distinguished by its proximity to rivers. Whilst this differentiation is perhaps artificial, some minor differences in species composition justify the separation of the two forest types. Riverine forest can also be confused with the bushland classes.

**Vegetation physiognomy/structure**

As for forest on hillslopes.

**Dominant and important species**

The canopy layer comprises a diverse range of species, including species typical of riverine forest in West Africa and in some areas grove-forming Caesalpinioid legume species. The understory has a diverse assemblage of shrubs, small trees and herbs; no species were notably dominant.

**Influential factors and threats**

Largely as for forest on hillslopes (see above), though these forests would never have occupied a large total area within the study region.

**Conservation importance**

HIGH

### 3.2.3 GRASSLAND

**Statistics**

Grassland (excluding hill summit grassland – see below) is extensive in the project area, covering c. 17,900 ha of the wider region and 6,400 ha (approx. 18%) of the main study area.

**Locality and physical geography**

Recorded from a wide variety of geographical locations, from valley floors to steep hillslopes.

**Remote Sensing classification**

Spatially very different to all other vegetation types. There is, however, some variability within the spatial characteristics of this vegetation type which could be mapped, but much of this is probably down to seasonal changes, most notably burning. Grassland and bare earth / sparse grassland form a continuum, hence there is potential for mis-classification of this vegetation type.

**Vegetation physiognomy/structure**

"Grassland", as covered here, includes several inter-related vegetation types which are spatially indistinguishable (see above): (1) "natural" low altitude (wooded) grassland dominated by tall perennial grasses with scattered woody species; this habitat is usually associated with cattle-grazing areas; (2) secondary grassland, abundant in the early stages of post-agricultural fallow and again dominated by tall perennial grasses, and (3) subsistence agricultural land – the low intensity cropping with irregular field boundaries is not readily separable from "natural" grassland through the satellite imagery.

**Dominant and important species**

The "natural" low altitude grasslands are dominated by *Loudetia* and *Hyparrhenia* spp. widespread and common in West Africa. Secondary grasslands are typically dominated by *Andropogon tectorum*. The agricultural land will hold cereal species such as rice, often inter-mixed with the same wild grass species as above.

**Influential factors and threats**

These grasslands are fire-maintained and reliant on human intervention, through slash-and-burn, domestic livestock grazing etc. Left fallow and unburnt, pioneer woody species will quickly encroach.

**Conservation importance**

LOW

### 3.2.4 HILL SUMMIT (WOODED) GRASSLAND

**Statistics**

Hill Summit Grassland covers 4,870 ha for the wider region and just under 1,800 ha for the main study area, approx. 5% in both cases.

**Locality and physical geography**

Hill summits, ridges and upper slopes over c. 630 m altitude, dominating on thin soils over iron-rich bedrock which is regularly exposed.

**Remote Sensing classification**

Spatially the same as grassland but is classified as areas over 630 m altitude.

It should be noted that outside the main study area it is not known if the area mapped as hill summit grassland is compositionally different from "grassland", although the Sula Mountains ridge running north was studied through binoculars from the summit of Numbara and did appear to hold extensive areas of this vegetation type.

There is some variability within the spatial characteristics of this vegetation type which are again probably due to seasonal changes, principally burning.

**Vegetation physiognomy/structure**

Tall (2–3 m) grassland with scattered small trees and with areas of bare ground where the bedrock is exposed, these with a small annual herbaceous community.

**Dominant and important species**

This grassland is dominated (70–95%) by *Loudetia arundinacea*, with few associated grass species. Only 13 tree species have been recorded, the most common being *Pterocarpus erinaceus*.

**Influential factors and threats**

This habitat is fire-maintained. The most obvious threat (beyond the proposed mining activity) is encroachment of farming which has occurred on Marampon and particularly Simbili. However, the very thin soils on Numbara have probably prevented encroachment there.

**Conservation importance**

HIGH, but only where (a) *Pseudovigna sp. nov.* is present and (b) in areas which have not been degraded by human activity.

### 3.2.5 SECONDARY BUSHLAND / THICKET

**Statistics**
Secondary bushland / thicket covers c. 20,200 ha of the wider region and c. 9,200 ha (c. 26%) of the main study area, this being the most extensive vegetation class.

**Locality and physical geography**

Recorded from a wide variety of geographical locations, from valley floors to steep hillslopes.

**Remote Sensing classification**

Secondary bushland / thicket is transitional between the bushland / grassland transition and mature bushland / woodland (i.e. cut and/or burnt forest) and therefore can be spatially mistaken for these two classes, but it does have a much more uniform texture than the mature bushland / woodland.

**Vegetation physiognomy/structure**

A dense thicket of bushes, small trees and lianas, typically 5–10 m tall, with or without a dense herb layer (depending upon light availability).

**Dominant and important species**

Pioneer tree species are dominant, notably *Dichrostachys cinerea*, *Anisophyllea laurina*, *Sterculia tragacantha* and *Alchornea cordifolia*.

**Influential factors and threats**

This vegetation class appears to be a phase in the post-fallow vegetation succession. In many cases it will be temporary, the bushland / thicket being cleared by slash-and-burn. Many of the woody species show signs of past cutting.

**Conservation importance**

LOW

### 3.2.6 MATURE SECONDARY BUSHLAND / WOODLAND

**Statistics**
Mature secondary bushland / woodland covers c. 14,100 ha for the wider region and 7,000 ha (c. 20%) for the main study area.

**Locality and physical geography**

Recorded from a variety of geographical locations, though often adjacent to remnant forest patches.

**Remote Sensing classification**

Mature secondary bushland / woodland is often as a secondary transition from forest (i.e. cut and/or burnt forest) or a more mature phase of secondary bushland/thicket and can therefore can be spatially mistaken for these classes, but it does have a more uniform texture than forest and a coarser texture than secondary bushland / thicket.

**Vegetation physiognomy/structure**

As for secondary bushland / thicket, but often taller (to 15 m or more) and often with some forest elements (remnant trees or fast growing forest pioneers). Undergrowth usually has few herbs due to dense woody component.

**Dominant and important species**

As for secondary bushland / thicket.

**Influential factors and threats**

As for secondary bushland / thicket.

**Conservation importance**

LOW

### 3.2.7 BUSHLAND / GRASSLAND TRANSITION

**Statistics**
Bushland/grassland transition covers c. 12,000 ha for the wider region and c. 6,300 ha (c. 18%) for the main study area.

**Locality and physical geography**

Recorded from a wide variety of geographical locations, from valley floors to steep hillslopes.

**Remote Sensing classification**

This appears to be a transition vegetation type of low lying bushland mixed within grassland. It can occasionally be mixed with Inland Valley Swamp.

**Vegetation physiognomy/structure**

A transitional phase between open grassland / arable land and closed bushland. Some of the "natural" wooded grassland (almost certainly maintained by cattle grazing) will fall within this category.

**Conservation importance**

LOW

### 3.2.8 INLAND VALLEY SWAMP

**Statistics**
Inland Valley Swamp covers only 1,220 ha of the wider region and c. 220 ha (less than 1%) of the main study area.

**Locality and physical geography**

Located within river / stream valleys, this habitat is frequently encountered only in the south east portion of the study area, though it is widespread in Sierra Leone.

**Remote Sensing classification**

Inland Valley Swamp is often confused with bushland/grassland transition. It was therefore digitised separately and manually. In view of this confusion, it is possible that this habitat type is somewhat over-represented in the southeastern portion of the region.

**Vegetation physiognomy/structure**

Typically dominated by herbaceous species, either native wetland species such as sedges, or with intensive rice cultivation. Woody species are sparse, though it is possible that, left undisturbed, these sites would eventually revert to woodland or forest.

**Dominant and important species**

In the areas not given over to rice cultivation (? fallow), a mixed herb community including a variety of sedge species dominates. The small palm *Raphia palma-pinus* and the tree *Hallea stipulosa* are also common.

**Influential factors and threats**

Rice farming is common in this habitat; some of these swamps are probably artificially maintained for this purpose. Drainage or infilling are the main threats.

**Conservation importance**

MEDIUM

### 3.2.9 OTHER CLASSES

#### 3.2.9.1 BARE EARTH / SPARSE GRASSLAND

This class includes a variety of land uses (most notably towns and villages, recently cleared land for agriculture etc.). Areas of rock outcrops will be of more interest botanically but there are no significant areas of this on the mine deposits or likely to be impacted by the associated infrastructure, tailings etc.

This class can be spatially over-represented in areas where there is haze on the imagery.

### 3.2.10 OTHER CLASSES: NON-VEGETATION

#### 3.2.10.1 CLOUD

Cloud cover distorts the south west section of the 2008 SPOT image.

#### 3.2.10.2 WATER

Very distinct. Represented here by the rivers and by the (then only partially filled) Bumbuna reservoir.

## 3.3 MAP ACCURACY ASSESSMENT

Vegetation maps derived from remotely sensed data inevitably contain errors of various types and degrees. These errors may arise for a number of reasons:

- Limited positional accuracy: more likely when the observations are made close to a class boundary or in a transition zone.
- Inability to sample randomly due to accessibility restrictions.
- Misinterpretation of classes.
- Distortions introduced by data processing and classification techniques.

Therefore, accuracy assessment is an important step in vegetation mapping because estimates of these errors allows for the assessment of data suitability for a particular application.

### 3.3.1 POSITIONAL ACCURACY

Positional accuracy is an assessment of the closeness of the location of spatial objects in relation to their true positions on the earth's surface. When working with satellite images, positional accuracy is dependent on the geometric corrections applied to the original imagery. The SPOT image used for the development of this vegetation map was provided at level of processing 2A (the information about the orbit and altitude of the satellite has been used to geolocate each pixel to the UTM map projection and referenced to WGS84 ellipsoid). The absolute location accuracy for these corrected products is usually better than 50 m.

The accuracy of the SPOT imagery was checked against the aerial photographs from 2009; Unfortunately the accuracy of this imagery is unknown, but the discrepancies between the images was on average 26 m, with a maximum of 73 m in areas of high elevation change (steep hills or valleys).

Locations in the vegetation map must also be positioned with respect to the mapped vegetation classes. Therefore, apart from the point location accuracy, it is also necessary to know the accuracy of the map vegetation boundaries. Working at a resolution of 5 m, and after applying the segmentation analysis, we have a confidence of 30 m. Consequently the minimum mapping unit (the smallest vegetation area reported in the map) is approximately 900 metres square (30 × 30 m).

### 3.3.2 THEMATIC ACCURACY

The thematic accuracy of a vegetation map refers to the extent to which it agrees with a set of reference data. One of the most common means of expressing this is to produce an error matrix, a comparison on a category by category basis of the relationship between known reference data and the corresponding map results.

Reference data has to be independent from the mapping process. It would be usual to do this assessment with further field work, but as this was impossible within the short timeframe, accuracy was access using 232 random points generated for the area. These were then classified by one of the authors (I.D.) from his field knowledge and using the aerial photos and SPOT images for the region as a reference (see Table 3 below).

| **Vegetation type** | **1** | **2** | **3** | **4** | **5** | **6** | **8** | **9** | **11** | **12** | | **%** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Mature secondary bushland / woodland (1)** | 30 | | 3 | | | | | | | | 33 | 90% |
| **Bare earth / sparse grassland (2)** | | 13 | | 3 | | | | | | | 16 | 81% |
| **Secondary bushland / thicket (3)** | | | 48 | | | | | | | | 48 | 100% |
| **Grassland (4)** | | | 1 | 40 | 2 | | | | | | 43 | 93% |
| **Bushland / grassland transition (5)** | | | 7 | | 21 | | | | | | 28 | 75% |
| **Water (6)** | | | | | | 7 | | | | | 7 | 100% |
| **Forest on hillslopes (8)** | 2 | | | | | | 8 | | | | 10 | 80% |
| **Riverine forest (9)** | | | | | | | | 8 | | | 8 | 100% |
| **Inland Valley Swamp (11)** | | | | | | | | | 10 | | 10 | 100% |
| **Hill Summit Grassland (12)** | | | | | | | | | | 8 | 8 | 100% |
| **Totals** | 32 | 13 | 59 | 43 | 23 | 7 | 8 | 8 | 10 | 8 | 211 | |

*Table 3: thematic accuracy test matrix. Note numbers of vegetation types and in bracket are not consecutive but refer to pixel values in finalisedGIS image.*

Note: 21 points within the area dominated by cloud cover were omitted from the accuracy assessment.

The overall accuracy (number of correctly classified samples divided by the total number of reference data) yields a result of 91.5 %, which is very high against generally assumed standards of higher than 80%. However, it should be remembered that this is using the aerial photos and not on-the-ground observation, so there is the possibility that this accuracy measure is artificially high. Further, it should be noted that there was much change observed between the 2008 SPOT imagery and the 2009 aerial photos (most notably the widespread removal of woody vegetation).

Finally, a confidence map was produced which shows the areas where we have high to lower confidence in the classification (this is only for the main vegetations types and not those derived from digitising). Confidence is lower outside the main study areas (i.e. those areas for which field knowledge and GCPs are available) and particularly in the area affected by cloud cover and haze in the south west portion (see Map 5).

### 3.3.3 OTHER DATASETS

*Digital Elevation Model* - this was downloaded from the ASTER DEM website at 30 m resolution.

*Streams and rivers* - the available streams and rivers dataset (Tonkolili_Streams_polyline.shp) was used on the vegetation map. Whilst this was accurate for the mining deposit sites, it was very crude (up to 640 m out) for areas outside. Therefore rivers and streams that were needed for the riverine forests were digitised directly from the SPOT imagery (see Figure 3).

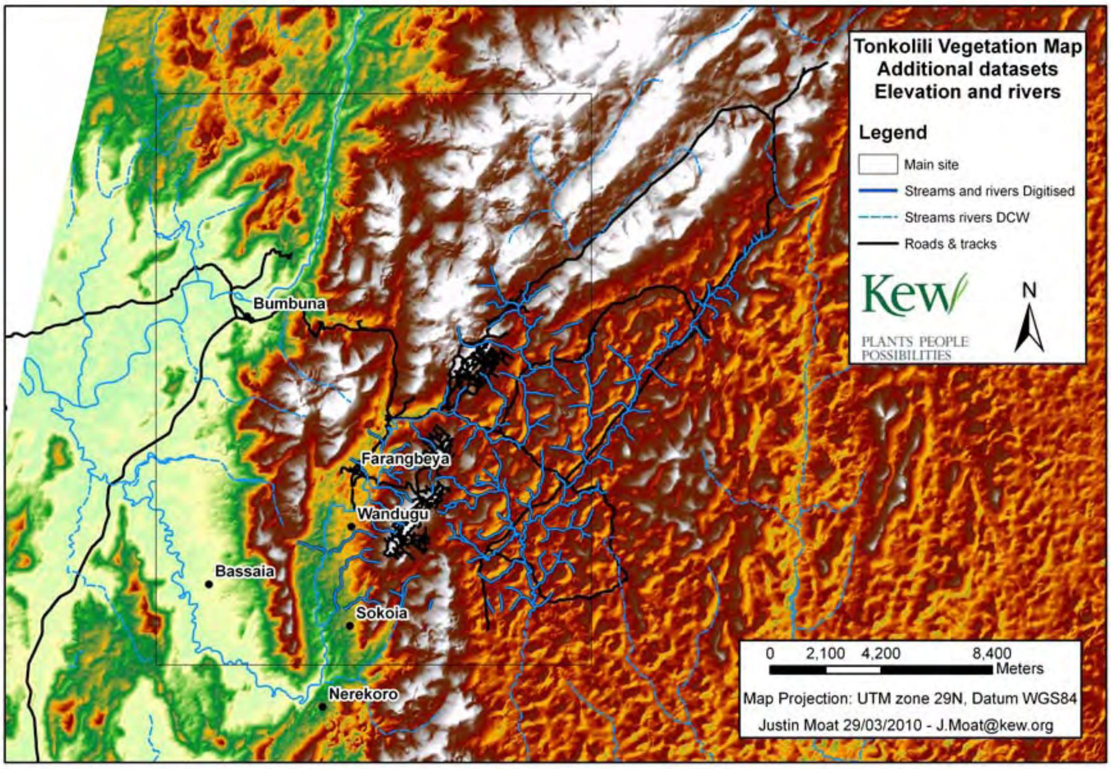



*Figure 3: additional datasets used for the Tonkolili vegetation map.*

## 4. RECOMMENDATIONS FOR FINE-TUNING THE VEGETATION MAP

**1. Further dataset requirements**

- Good quality rivers dataset is needed, especially for accurate delimitation of the riverine forests.
- High resolution elevation model.
- Meta-data, including positional error, of the 2009 aerial photographs.

**2. Further survey work**

The current ground survey is limited both in extent and seasonal coverage (see Darbyshire & van der Burgt 2010). In particular, ground-truthing is required for:

- The northern sector of the mining license area, particularly the extent of hill summit grassland.

- The southwest sector which is under cloud cover on the SPOT image.

### 3. Vegetation change

Recent vegetation change in the region has been both rapid and widespread as is evident through comparison of the SPOT imagery for 2008 with the aerial photos for 2009. Monitoring of this situation is important, particularly for the areas of high conservation importance.

### 4. Incorporation of the mine plan into the vegetation map

Including the finalised infrastructure and tailings locations and transport routes.

## REFERENCES

Darbyshire, I. & Burgt, X.M. van der (2010). Report on the vegetation survey and botanical inventory of the Tonkolili Project area, Sierra Leone. Herbarium, Royal Botanic Gardens, Kew, 8 February 2010.

White F. (1983). The Vegetation of Africa. Natural resource research No. 20 A descriptive memoir to accompany UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Paris

## MAPS TO ACCOMPANY THIS REPORT

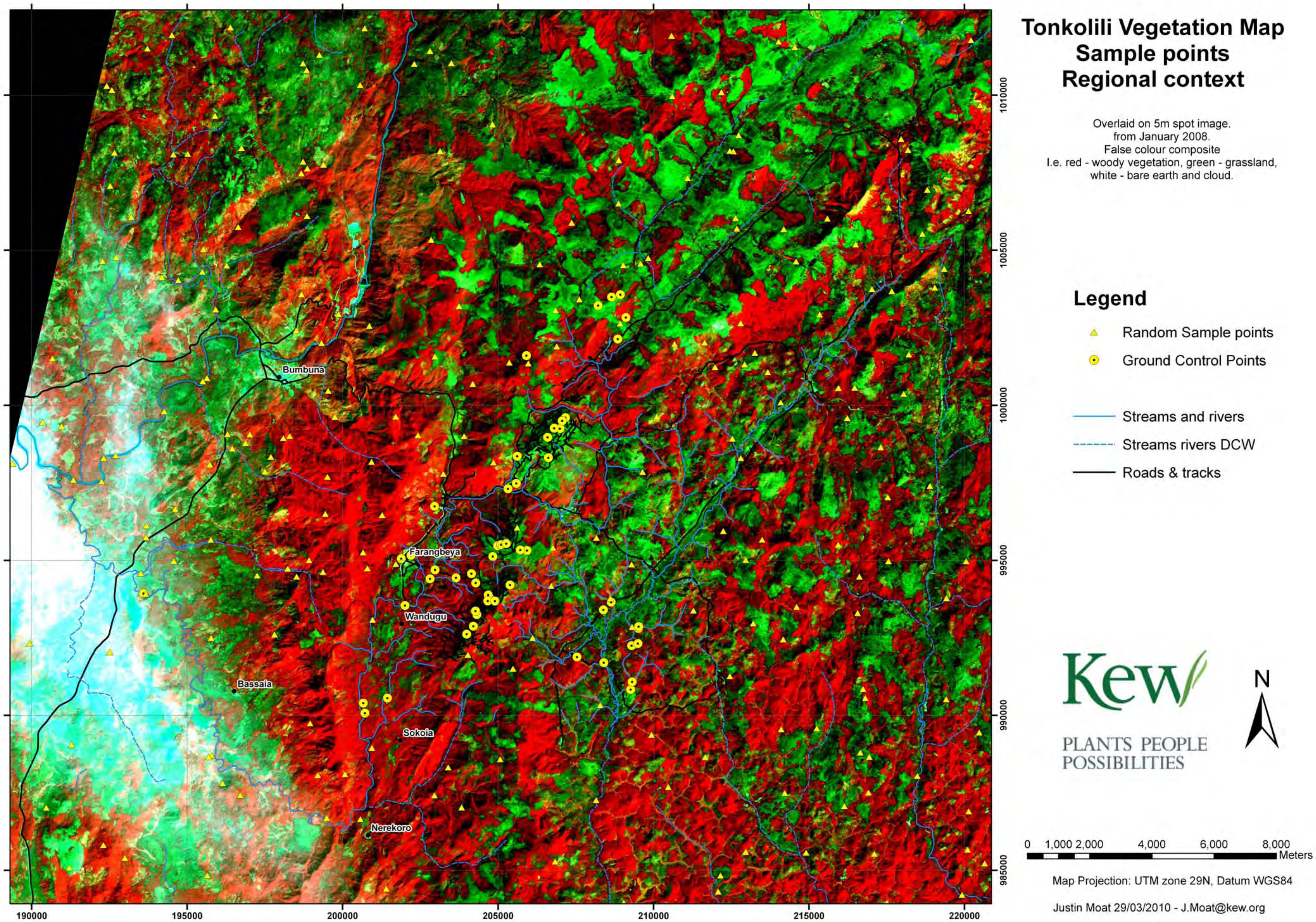
Map 1: SPOT imagery 2008 with sample points and ground control points.

Map 2: Regional Vegetation map

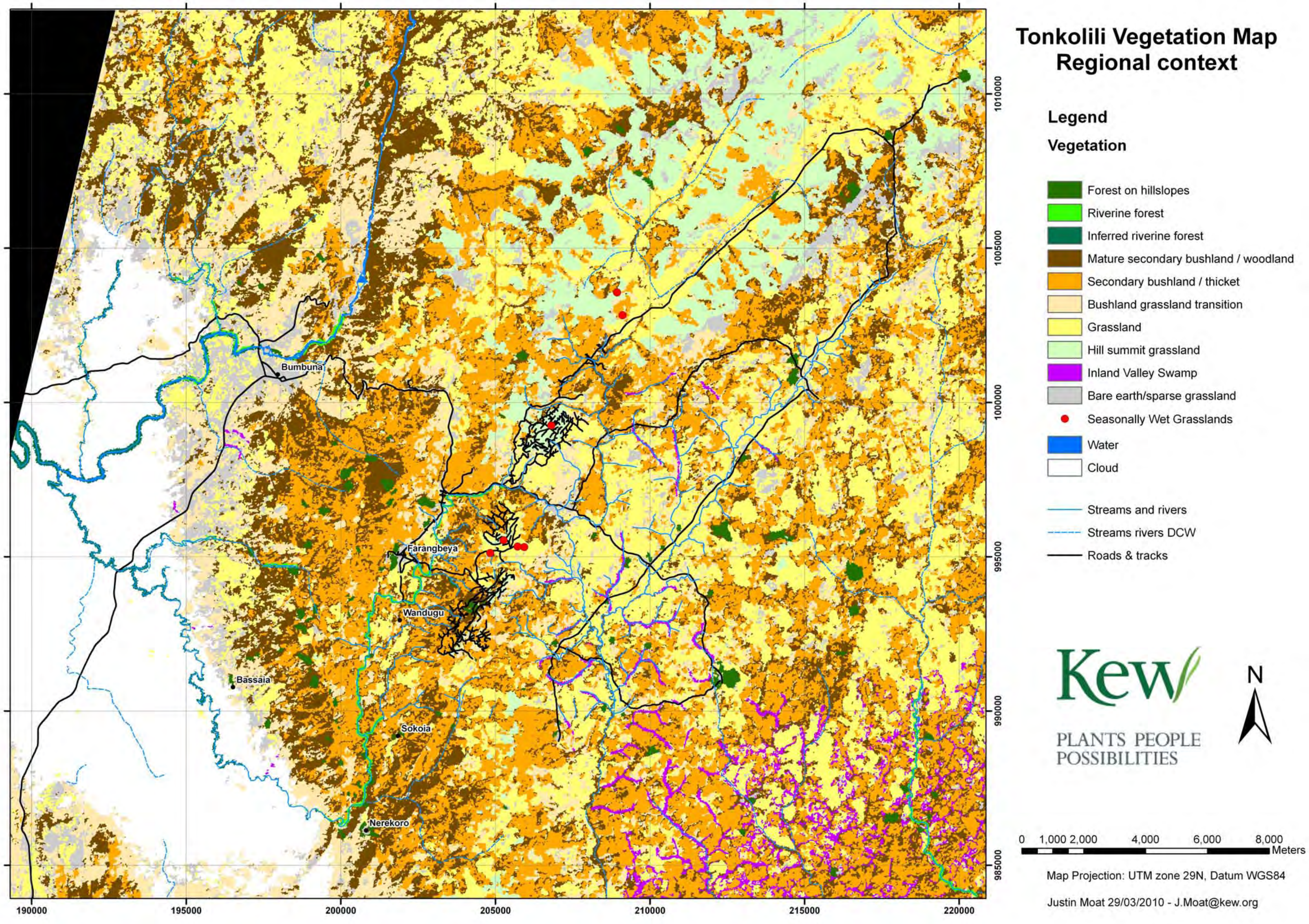
Map 3: Main site Vegetation map

Map 4: Potential conservation importance map

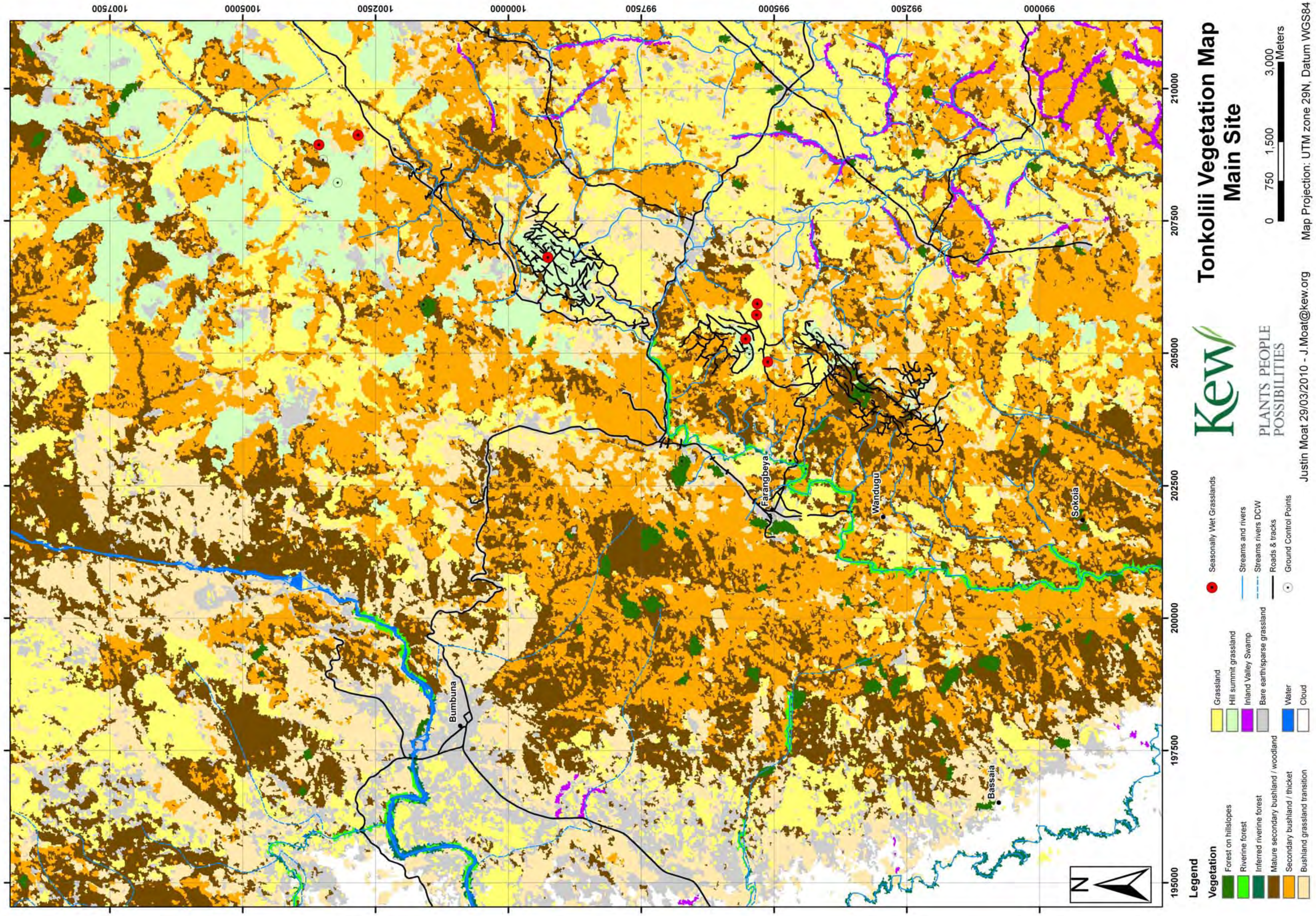
Map 5: Classification confidence map with ground control points




Map 1: SPOT imagery 2008 with sample points and ground control points.

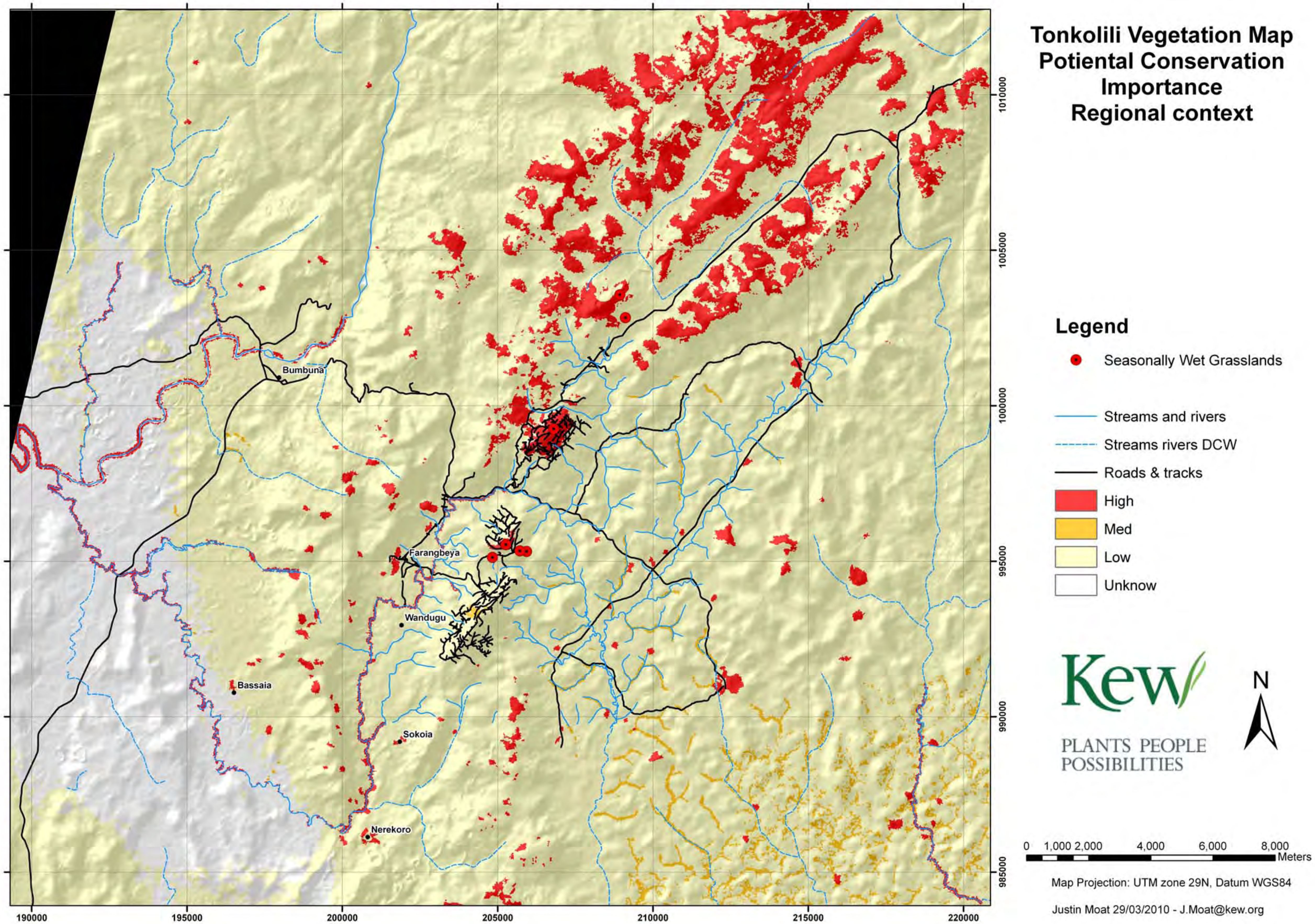



Map 2: Regional Vegetation map

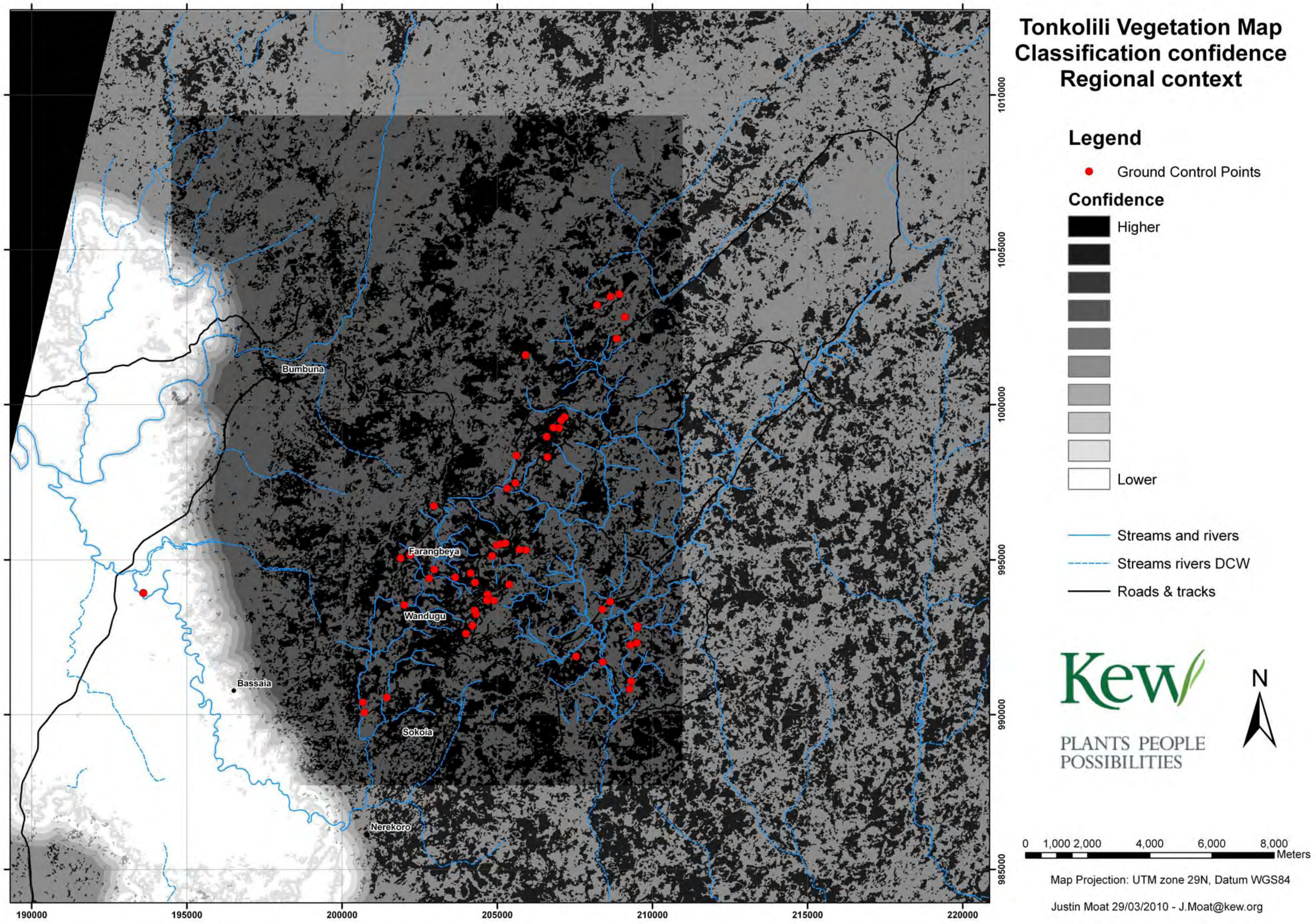





Map 3: Main site Vegetation map




Map 4: Potential conservation importance map




Map 5: Classification confidence map with ground control points

# APPENDIX 11

## Summary of Report, Phase 1 Study of Terrestrial Fauna at Tonkolili Mine Site, Sierra Leone prepared by the Wildlife Conservation Society

WorleyParsons

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## Tonkolili Iron Ore Project

# Preliminary Report on Phase 1 - Fauna Fieldwork - Prepared by SRK

305000-00006 – 305000-00006-0000-EN-REP-0011

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

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**PRELIMINARY REPORT ON PHASE 1 - FAUNA FIELDWORK - PREPARED BY SRK**

**TONKOLILI IRON ORE PROJECT**

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| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
| | | | | | | | |
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| | | | | | | | |

SRK Consulting (UK) Ltd
5th Floor Churchill House
17 Churchill Way
Cardiff
United Kingdom
CF10 2HH
e-mail: cardiff@srk.co.uk
URL: www.srk.co.uk
Tel: + 44 (0)29 20 34 81 50
Fax: + 44 (0)29 20 34 81 99

# EXTERNAL MEMORANDUM

| | | | |
|---|---|---|---|
| **TO:** | Phil Burris | | |
| **COPY TO:** | Oscar Zarzo | **FROM:** | Paul Mitchell on behalf of Craig Watt |
| **SUBJECT:** | SRK Memo to Worley Parsons - Preliminary Report on Phase 1 Fauna Fieldwork | **DATE:** | 30 March 2010 |

Dear Phil / Oscar

Please find attached the preliminary report on the Phase 1 fauna fieldwork, as prepared by Joe Walston and colleagues of the Wildlife Conservation Society.

Yours sincerely,

**Craig Watt**
**Principal Environmental Engineer**

SRK Consulting (UK) Ltd
Tel: +440292348180
Mob: +447841800102
Email: cwatt@srk.co.uk

# SUMMARY OF REPORT, PHASE 1 STUDY OF TERRESTRIAL FAUNA AT TONKOLILI MINE SITE, SIERRA LEONE

**Joe Walston**
**Wildlife Conservation Society**

Graceful Chameleon *Chamaeleo gracilis,* found near the Nerekoro Sacred Forest



**March 2010**

**THIS REPORT IS PRELIMINARY AND CONFIDENTIAL**

**Executive Summary**

From the literature review and the ground surveys it is clear that populations of most wildlife species, historically occurring throughout this area of Sierra Leone, are already in an extremely precarious position. Very few large mammals were encountered, or even reported. The central plains of Sierra Leone have been heavily modified by man over a large number of years and while some species of conservation significance do persist, they do so in small numbers and are fragmented and isolated. The situation is more encouraging for birds, though they are also under severe pressure.

Although the overall project site is highly degraded and has lost key components of biodiversity, the area retains certain faunal values that are important to conserve and that could be lost without appropriate planning. Non-location specific recommendations are presented with respect to protecting and enhancing the remaining habitats of conservation concern, with additional specific recommendations for the mine area, the transport corridor and the port areas. Means of addressing indirect impacts and using biodiversity offsets to balance unavoidable impacts are also discussed. Finally, suggestions for follow-on fauna surveys are presented.

## 1. Introduction

This is a summary of the Phase 1 (rapid assessment) fauna studies for Tonkolili mine, Sierra Leone. For more information the reader is referred to the full fieldwork report (in preparation).

A ten day survey of fauna and habitat at the Tonkolili Mine Project was undertaken in March 2010 by WCS staff, assisted by local specialists. A total of thirty sites were surveyed in the mine area, along the transport corridor and in the port areas. Collectively the sites surveyed comprised key areas for the Early Cash Flow (ECF) project and the Tonkolili project.

The purpose of the survey was to rapidly assess and evaluate the importance of the area for indigenous fauna, focusing mainly on mammals and birds, but also including herpetofauna, and to identify opportunities for nature conservation within the full scope of the Tonkolili project, including provision of a set of recommendations for the avoidance and mitigation of extraction and transportation-related impacts and possible offsetting opportunities. The findings of the assessment will also help determine future faunal studies that will be required to characterize the ecological baseline of the Project area.

## 2. Methods

Prior to fieldwork a review of published literature, books and (most importantly) 'grey' literature from relevant Environmental Impact Assessments and faunal surveys in Sierra Leone was completed. The literature review informed the planning and implementation of the fieldwork, which included visual observations by the WCS team and local specialists, supplemented by information gathered from ad-hoc village interviews.

## 3. Limitations and assumptions

Due to the rapid nature of the surveys and the wide geographic coverage, investigations in some areas were cursory, particularly along the transport corridor. In this context, original plans to use camera-traps, bat nets and spot-lighting techniques were deferred until subsequent (more detailed) study phases. Survey planning was also hindered by a lack of high resolution satellite or aerial images for much of the project area.

## 4. Preliminary results

Preliminary results for the Phase 1 studies are summarised in Table 1 below. Further information for each location is available in Annex A.

**Table 1: Preliminary results**

| Project area | Areas of conservation concern | Fauna / habitats of conservation concern |
|---|---|---|
| *Mine site and environs* | Numbara | The globally threatened Sierra Leone Prinia (a grassland specialist bird species). |
| | Farangbaia Forest Reserve. | Western Chimpanzees are likely to persist in scattered forest patches at the southern end of the Reserve. |
| | Small patches of village owned evergreen forest surrounding mine area. | Smaller wildlife, especially birds (some Guinea forests). |
| | East of Anbelo Hills in the lower Tonkolili valley. | Very low numbers of large ungulates (e.g. African Buffalo) may still persist. |
| | Riparian woodland along the Tonkolili, Rokel and Toka rivers and their tributaries | Birds |
| | Residual pockets of evergreen forest along watercourse or in community 'sacred forests'. | |
| *Haulage road and corridor* | Traditionally managed agricultural areas near the Rokel River in the vicinity of Bumbuna and along the Toka River west of Makeni and more generally along the transport corridor. | Birds and amphibians. |
| | Small pockets of forest northeast of Lunsar (junction of existing railway and proposed haul road) | Confirmed populations of Western Chimpanzee. |
| *Coastal areas* | Tagrin and the Sierra Leone Estuary | Small freshwater wetland areas in the peninsula, the fully intertidal areas of the estuary: the island mangroves, the 'on-shore' mangroves, the sand flats, mud flats and sheltered beaches, together with the open waters of the natural harbour beyond. |



## 5. Recommendations

Headline recommendations are noted below. Many of these recommendations relate to the protection and enhancement of habitat that supports fauna of conservation concern, rather than the fauna species themselves. Further details are available in Annex B.

### 5.1 General (applicable to all locations)

- Project related activities should be undertaken to a high standard, reflecting international good practice.
- Avoid project development work in remaining patches of forest wherever possible.
- Opportunities to control and minimize uncontrolled in-migration of people should be explored with relevant stakeholders, including the Government of Sierra Leone.
- Revegetation should be based on indigenous species to enhance long-term sustainability.

### 5.2 Mine area and environs

- Consider offset opportunities to address unavoidable habitat loss as a result of mining and related activities at Numbara, Marampon and Simbili.

### 5.3 Roads

- Avoid the Farangbaia Forest Reserve.
- Avoid sacred forests / bushes by at least 200 m.
- Minimise river crossings and avoid locating crossings in patches of existing forest.
- Apart from river crossings, the haul road should not encroach within 500 m of the Tonkolili River.
- Right-of-way clearance should be minimized, commensurate with relevant design and safety standards.

### 5.4 Addressing indirect impacts

*5.4.1 Timber*

- Source timber required for the project from certified plantations.
- Support the development of local certified plantations.

*5.4.2 Water*

- Remaining riparian vegetation should be strictly protected.
- AML should explore opportunities to contribute to the reforestation of the Farangbaia Forest Reserve.

*5.4.3 Bushmeat*

- Enforce a total ban on hunting and capture of wildlife by AML employees and contractors.
- AML should explore opportunities to support the development of local animal husbandry techniques and capacity (as an alternative to bushmeat).

### 5.5 Coastal conservation and offsets

- Ensure project activities do not contribute to significant existing pollution around the shoreline of Tagrin.
- Establish 'no-take' areas in the mangroves and native bush land at Tagrin and avoid damage to mangroves and any fresh or brackish waterways and their wetland communities in all areas.
- Consider offset opportunities at Tagrin and Pepel to conserve and improve the area's natural heritage throughout the project's lifecycle.
- Explore tourism and public education opportunities at Tagrin.
- Undertake measures to protect the integrity of Bunce Island, a *de facto* nature reserve.

### 5.6 Further fauna surveys

- Assessment of the potential impacts of the major coastal operations on the intertidal mudflats, sand-flats, mangroves and their associated avifauna.
- Assessment of how and where conservation efforts for Western Chimpanzees can best be directed.

- Assessment of other marine-based values of the coastal fauna and the impact of the project on these.
- Assessment of the conservation values of seasonal wetlands and scattered forest patches along the Toka river valley and along Rokel River upstream from Makeni to its confluence with the Tonkolili River.

## 6. Conclusions

*Preliminary figure / map showing areas of possible conservation concern and opportunities for improvement to be inserted here.*

## ANNEX A: Preliminary results (further details)

The project area, for the purposes of this report, is divided into three main blocks: the mine site and environs, the haulage road and corridor, and the coastal areas.

### A.1 The mine site and environs

Farangbaia itself (the mine project headquarters) lies in the eastern flank of the Kunsulma range, location of the Farangbaia Forest Reserve, which while still extant on the statute books has been almost entirely logged-out. The mine administrative complex is almost circled by extremely small patches of village-owned evergreen forest in which some smaller wildlife, especially birds, persists. Some of these are species restricted to the West Guinea forests - an endemic bird area.

With respect to the mountains, despite being already largely deforested, the three peaks (Numbara, Marampon and Simbili) support rare and interesting wildlife some of which is of international conservation concern. The 'semi-natural' grassland communities of Numbara are host to rare flora and also support a grassland specialist bird species, the globally threatened Sierra Leone Prinia.

Western Chimpanzees persist in the scattered forest patches at the southern end of the Farangbaia Forest Reserve in small numbers. Reports of recent direct observations of chimps, both by locals and by mine employees visiting the area suggest that the chimps are still moving between forest fragments and utilising what available forest habitat remains. The patchwork of forest fragments in the area exist both inside and outside the Farangbaia Forest Reserve and include the woodland of the Tonkolili river valley. Interviews with local communities suggest that the chimps are coming into ever more frequent contact with the rapidly expanding human population there

Similarly the last large ungulates, e.g. African Buffalo, were reported as being extirpated from the tiny pockets of suitable evergreen forest/bush. These larger species might persist only in these southern and western areas near to the proposed route of the haulage road east of the Anbelo Hills in the lower Tonkolili valley, though inevitably in very low numbers.

Birds fare slightly better. Inland, even in the hills, larger birds were concentrated in those areas that are least accessible to villagers. Fortunately it seems that firearms are rare and consequently smaller bird species persist in some areas in relative abundance; as do the larger unpalatable or inedible species. It was evident that even in areas that are nominally reserves there are no protection measures in force and that in many cases the tall woody growth of such places has been largely removed and replaced by a shifting mosaic of scrub, often grassy, and swidden agriculture typically on a rotation of five years or less.

Concentrations of birds in particular were found in riparian woodland along the Tonkolili, Rokel and Toka rivers and their tributaries or in residual pockets of evergreen forest either along other watercourses or in the widespread community "sacred forests" where villagers, to a varying degree, restrict access and activity. The value of these forest patches should not be underestimated especially where they exist in a matrix of less intensively modified anthropogenic habitats whether agricultural or residential.

**A.2 Haulage road and corridor**

As with the mine site, much of the haulage road and its corridor had been heavily modified well before mine activities began. However, although each 'priority' site designated for surveys was visited, there was insufficient time and a lack of high resolution maps to effectively evaluate all areas. Traditionally managed agricultural areas (e.g. extensive cattle pastures, rice fields and other seasonally inundated land) are common along the transport corridorand were remarkably rich in birds and amphibians especially near the Rokel in the vicinity of Bumbuna and along the Toka west of Makeni. There are additional sites that warrant further investigation. For instance, north east of Lunsar where the proposed haul road meets the existing railway, small pockets of forest that still maintain Western Chimpanzee populations were recently confirmed. Recommendations are provided, though clearly the on-going road-building process is moving faster than possible detailed evaluations of optimal routes from a biodiversity perspective.

**A.3 Coastal areas**

The coastal areas of the project around Tagrin and the Sierra Leone Estuary provided some of the most interesting and productive sites; namely Pepel and its associated islands, the eastern coastline of the Tagrin peninsula itself, some small freshwater wetland areas in the peninsula and the fully intertidal areas of the estuary: the island mangroves, the 'on-shore' mangroves, the sand flats, mud flats and sheltered beaches, together with the open waters of the great natural harbour beyond. Almost the entire Tonkolili iron ore project area at the coast lies within a designated Ramsar site and the wider estuary has been classified internationally as a globally significant Important Bird Area. There is considerable opportunity for integrating important conservation activities within the project's plans for port development.

## ANNEX B: Recommendations (further details)

Recommendations presented here should not be considered definitive given the brief nature of the study. Where further work is necessary, this has been suggested.

Although the overall project site is highly degraded and has lost key components of biodiversity, the area retains certain faunal values that are important to conserve and that could be lost without appropriate planning. Consequently, to minimize additional impacts, project related activities should be undertaken to a high standard, reflecting international good practice.

### B.1 General (applicable to all locations)

- AML should work with government to explore opportunities to control and minimise the uncontrolled in-migration of people into areas newly opened-up by road construction, especially along the roads themselves. Uncontrolled in-migration will lead to further forest and wildlife losses and compound pressures on existing human communities.
- Any infrastructure and mine developments should avoid remaining patches of forest. All remaining forest, regardless of size, social function or location, is of elevated conservation value given the small amount of mature forest habitat that remains. A patch of forest, no matter how small or isolated is an important part of the habitat mosaic. While contiguous forest habitat would be preferable, it is important to understand that a network of small forest fragments can still retain important values.
- Replanting of vegetation for any purpose should use indigenous species and should be based on silvicultural systems that promote natural ecosystem functions and that increase the probability that native species and ecological processes will be maintained.
- Crossings of any drainage lines or water bodies should have appropriate culverts built to international environmental standards.

### B.2 Mine area and environs

- Loss of habitat at the Numbara, Marampon and Simbili peaks, some of which supports rare and interesting wildlife, will be unavoidable due to the nature of the mining operations at the three peaks. In this context, it would be sensible for AML to focus on offsets rather than mitigation measures for habitat loss associated with Numbara, Marampon and Simbili.

### B.3 Roads

- The **main haulage road** crosses the Tonkolili River at the existing cleared crossings. From there the road should head south past the villages of Furia and Sokoia onward to the village of Nerekoro and from here it should loop around the outside of the southern end of the forest reserve to cross the Tonkolili river once again at Balaya village. After this the road can head north-west towards the proposed rail loop area.
- The haulage road should not run through any of the Farangbaia Forest Reserve. Although this site is highly degraded, it remains a legal forest reserve and would legally require formal government degazettement. Furthermore, the reserve can recover many of its watershed maintenance values if well protected, as well as providing refugia for indigenous wildlife.
- All roads should avoid sacred forests/bushes by at least 200m.
- The number of points where roads cross waterbodies should be kept to a minimum. Crossings should avoid existing forest patches and their immediate surroundings, as identified using satellite and aerial images.

- Apart from crossing points the road should not encroach to within approximately 500m of the Tonkolili River.
- AML should quickly identify opportunities to integrate environmental considerations with its plans for the design, location, construction, maintenance, control and decommissioning of all roads in order to avoid or minimize environmental impacts. Excessive right-of-way clearance has a major environmental impact in tropical forests, particularly areas such as that which hosts the Tonkolili project, where remaining forests are vulnerable and already in decline. Roads should be kept to the minimum width possible, consistent with safety and other pertinent international standards.

### B.4 Addressing indirect impacts

It is possible that the project's indirect impacts may be as significant as the direct impacts. As with many major industrial projects in the developing world, people have flocked to the area in search of employment. With this in-migration has come inevitable added pressure on land and the limited natural resources that remain. AML should explore opportunities to work with the Government of Sierra Leone (GoSL) limit uncontrolled or uncoordinated migration to rural areas, including the mine site. In doing this, AML will also benefit by reducing the pressures that could impact negatively on the project (e.g. increased conflicts motivated by complications of land tenure, compensation demands and employment issues). Specific recommendations relate to timber, water and bushmeat.

*B.4.1 Timber*

The last remaining stands of forests in the area are still being logged for a number of purposes, legally and illegally. The project's presence is indirectly driving some of this logging and there are two mitigation measures that could have positive outcomes:

- The project should source all timber from certified plantations (i.e. not local sources of timber, which come only from the last remaining natural forests, which now require the highest level of protection).
- The project should investigate the potential for supporting local plantations, which would be beneficial to the project, local livelihoods and the remaining natural forests (and therefore, also for fauna).

*B.4.2 Water*

Given the nature of the project's activities, the extreme variation in conditions across the seasons, the likely increase in local human populations, and the massive scale of deforestation that has occurred prior to inception of the project, the availability and quality of fresh water will undoubtedly become more important. Two approaches to addressing this issue will deliver complementary benefits for fauna:

- The strict protection of water bodies and of the riparian vegetation must be a priority for local government, traditional governance systems and the project itself.
- Reforestation, involving indigenous trees, aimed at significant ecological and watershed restoration of the Farangbaia Reserve should be a high priority. AML may wish to explore opportunities to contribute to such work, perhaps as an offset for unavoidable habitat loss at Numbara, Marampon and Simbili.

*B.4.3 Bushmeat*

This is one of the most important issues for both fauna conservation and local nutrition and livelihoods for those living away from the coast. Traditionally, communities have relied on bushmeat (that is, any wild fauna hunted for consumption) and freshwater fish for their protein intake. Over the last few decades, the removal of natural forests and the over-hunting of large mammals has lead to the local extirpation of many species, a shift in the focus of hunting to small mammals (cane rats being the most common now) and genuine shortages of available protein. Systems of animal husbandry are almost absent or very basicand limited. . In this context there is considerable scope for positive intervention:

- The company should establish and enforce a total ban on undertaking or financing the hunting and capture of wildlife by its employees and contractors.
- Any form of hunting within the project areas around Tagrin and in the mangroves around Pepel should be prohibited; this ban should be total and vigorously enforced, especially with respect to bird congregation locations, in order to avoid the emergence of 'loop-hole opportunities' for those seeking to profit from bushmeat and bird-killing.
- The government, supported by AML, should strictly control human in-migration to the area (see above).
- Communities should be supported in the development of improved animal husbandry techniques and provided with starter stocks. This would be a positive contribution to the livelihoods of people and also reduce demand for bushmeat and limit the impact of hunting restrictions on local communities.

**B.5 Coastal conservation and offsets**

- No waste material from the project operations should be added to the already substantial amount of solid and liquid pollutants (i.e. every kind of effluent and garbage) present around the shoreline of Tagrin and, at present, issuing largely from Freetown.
- Project related wastes should be removed for proper disposal or managed on-site in an appropriate facility, to avoid adding to existing significant pollution along the coastline near Freetown. AML could investigate opportunities to use any waste disposal facility it creates to take waste from other clean-up efforts.
- All infrastructure developments should avoid unnecessary damage to mangroves and any fresh or brackish waterways and their wetland communities, whether via physical or chemical impacts.
- Crossings of creeks, drainage lines or other water bodies should have appropriate culverts built to international standards.
- There is considerable opportunity for AML to not only mitigate impacts, but to make genuine positive contributions to global conservation efforts, and for these efforts to be visible and tangible. There is high potential to deliver an outcome of lasting value from this investment both to the people of Tagrin/Pepel and to those of Sierra Leone in general. Especially in the port area this project could deliver real benefits not only to the village communities but to many residents of Freetown through the provision of small protected areas around the estuary, in effect analogous to the national historical monument that is Bunce Island, where environmental education and ecological precepts might be best explained to the public. There are also numerous and excellent opportunities for ecotourism, as the area is so close to Freetown, and immediately adjacent to the international airport. This work could be undertaken to offset impacts in the coastal areas that cannot be avoided even with the implementation of international good practice.
- There are significant "offset" opportunities at both Tagrin and Pepel to conserve and restore some small wetland areas and mangrove habitats, which are of notable livelihood and biological conservation value. These reserves could help to protect and enhance the faunal value of the area, while raising awareness within Sierra Leone of the country's importance to (for example) migratory shorebirds travelling from the far north of Europe to the southern tip of Africa.

- The opportunity exists to put in place measures to conserve and improve the area’s natural heritage throughout the project’s lifecycle. A further assessment is needed to accurately map and articulate a strategy for this work. .

*B.5.1 Tagrin*

- Creation of a shorebird and waterfowl observation point and explanatory visitor centre close to the service wharf ideally overlooking the tidal flats approximately 0.5 – 1 km northeast of Tagrin point.
- Creation of a local nature reserve and interpretation centre around the freshwater pools at Rosint village.
- Training of at least two local village people to be guides at each of the above mentioned sites.
- Establishment of discrete, easily identifiable 'no-take' areas in the mangroves; perhaps adjacent to the coal stockpile area 3 km northeast of Tagrin point and a buffer zone of no-take native bush land (from which woody growth may not be extracted) which once established might provide a partial screen around the adjacent coal-fired power station; similarly a buffer zone could be established along the Tagrin haul road.
- The haul road which is planned to connect the ore stockyard to the service wharf should be sited carefully in order to minimize impact on any patches of indigenous woody vegetation.

*B.5.2 Pepel*

- Dredging operations in the approach to Pepel, and especially in the vicinity of Bunce Island should be conducted with the utmost care. The integrity of Bunce Island must be maintained. It has been long recognized as an historical monument of international significance and has thereby become a *de facto* nature reserve, itself of great value.
- The engineering of all transport approaches to Pepel Island by channel dredging, road construction and rail refurbishment should be closely monitored to avoid any excessive right-of-way clearance and damage to mangroves.
- Sanbilma island (opposite Pepel) should not be developed further unless absolutely necessary. In-migration should be prohibited. While this is the responsibility of the GoSL, if the investment agreement for AML establishes private tenure (even on a lease basis) then AML should enforce controls on in-migration.



**B.6 Further surveys**

Additional, focused faunal surveys are required to:

- Assess with greater accuracy the potential impacts of the major coastal operations on the intertidal mudflats, sand-flats, mangroves and their associated avifauna; a large part of which is highly migratory, and thus increasingly threatened by intensifying human activity throughout the flyway network and consequently subject to mounting international concern and monitoring. It would be best if this were undertaken in two periods: May 2010, during the afrotropical breeding season at the start of the rains and November-December 2010 at the height of the shorebird influx from northern Eurasia.
- Assess how and where conservation efforts for Western Chimpanzee populations is best directed.
- Assess the other marine-based values of the coastal fauna, including a more thorough review of the areas relevant to cetaceans, sea turtles and certain key fish species (e.g. Tarpon) and

define the project impacts on, and conservation options for, African Manatee (*Trichechus senegalensis*) in the Sierra Leone estuary.

- Assess the conservation value of extensive semi-natural seasonal wetlands and scattered forest patches along the Toka river valley, essentially those between Makeni and Lunsar, and the gallery evergreen forest along the Rokel upstream from Makeni to its confluence with the Tonkolili River. These investigations would be most productive if undertaken in May 2010 and November-December 2010 in conjunction with the monitoring of coastal areas noted above.

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# APPENDIX 12

## Rapid Assessment of Aquatic Environments for the Tonkolili Project prepared by SRK

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## Tonkolili Iron Ore Project

# Rapid Assessment of Aquatic Environments for the Tonkolili Project - Prepared by SRK

305000-00006 – 305000-00006-0000-EN-REP-0012

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

WorleyParsons
resources & energy

African MINERALS

**AFRICAN MINERALS LIMITED**

**RAPID ASSESSMENT OF AQUATIC ENVIRONMENTS FOR THE TONKOLILI PROJECT - PREPARED BY SRK**

**TONKOLILI IRON ORE PROJECT**

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**PROJECT 305000-00006 - RAPID ASSESSMENT OF AQUATIC ENVIRONMENTS FOR THE TONKOLILI PROJECT - PREPARED BY SRK**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
| | | | | | | | |
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Hydrobiology

# Rapid Assessment of Aquatic Environments for the Tonkolili Project

SRK Consulting (UK) Ltd

April 2010

| | |
|---|---|
| **ABN** | 26 096 574 659 |
| **GST** | The company is registered for GST |
| **Head Office** | 27 / 43 Lang Parade<br>Auchenflower QLD 4066 |
| **Registered Office** | Suite 309 Coolangatta Place<br>87 Griffith Street<br>Coolangatta, QLD 4225 |
| **Postal Address** | PO Box 2050<br>Milton QLD 4064 |
| **Phone** | 61 (07) 3368 2133 |
| **Fax** | 61 (07) 3367 3629 |
| **Email Contact** | info@hydrobiology.biz |
| **Website** | http://www.hydrobiology.biz |



Cover Photo: Tonkolili River (Site TKR3)

# Rapid Assessment of Aquatic Environments for the Tonkolili Project

## SRK Consulting (UK) Ltd

**April 2010**

| Document Control Information | | | | | |
|---|---|---|---|---|---|
| **Date Printed** | 29 March, 2010 | | | | |
| **Project Title** | Rapid Assessment of Aquatic Environments for the Tonkolili Project | | | | |
| **Project Manager** | Shirley Connelly | | | | |
| **Job Number** | 10-061-SRK01 | | | | |
| **Report Number** | DRAFT | | | | |
| **Document Title** | Rapid Assessment of Aquatic Environments for the Tonkolili Project | | | | |
| **Document File Name** | **Document Status** | **Originator(s)** | **Reviewed By** | **Authorised By** | **Date** |
| 10-061-SRK01-Tonkolili_RA_V0.2SV.docx | DRAFT | S. Vardy L. Bland (SRK) | | | |
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Distribution

| Document File Name | Description | Issued To | Issued By |
|---|---|---|---|
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# EXECUTIVE SUMMARY

This report details the results from a Rapid Aquatic Ecosystem Assessment undertaken by Hydrobiology on behalf of SRK Consulting (UK) LTD for the Tonkolili Iron Ore Project. The main purpose of this work was to assess the health of the aquatic ecosystems covered by the project (particularly the work to be carried out at haul road crossings in the near future) and to make recommendations on the ecological value of areas potentially impacted by the work.

Overall, the rivers and streams surveyed are in good condition (particularly in regards to in-stream habitat), despite the potential for anthropogenic impacts.

The impacts at crossings should be minor if the following points are taken into consideration:

1. That best practice sediment control measures are used during construction of the crossings. Although it is likely that there is some natural tolerance to sediment loads of the aquatic ecosystems within and downstream of the mining lease, very few data are available to assess the natural temporal extent and the magnitude of these fluctuations;

2. Where bridges are built, that they are designed in a manner that does not confine the river;

3. Minor in-stream infrastructure can constitute barriers to fish migration. Where possible, these should be designed to be compatible with the passage of migratory stream organisms, such as the use of bridges rather than culverts where possible, or where culverts are built that open box culverts with natural substrata are used in preference to enclosed culverts, and the avoidance of vertical barriers such as downstream culvert ends suspended above the natural substrata.

The Mawuru River will be dammed to allow for the construction of a tailings storage facility (TSF). At the proposed TSF site there are no mitigation measures that can be put in place to prevent impacts – the river, streams, and swamps in the area will be submerged. There is no indication that any aquatic surveys have been undertaken in the proposed TSF area. As this area contains many small streams that may host endemic species, it is strongly suggested that an aquatic fauna survey is undertaken to fully describe the aquatic biota in this area.

From the information Hydrobiology currently has, it is not possible to assess potential impacts to the aquatic ecosystems downstream (to the south) of the TSF.

Hydrobiology strongly suggests that an adequate baseline water quality monitoring program be established for the area. This will enable the assessment of changes (if any) to the downstream rivers due to the mine’s activities and will supply a baseline dataset for management action in the future if negative changes to the water quality do occur. It should be noted that the natural acidity and low conductivity of the water bodies indicates that if acid rock drainage (ARD) does occur, there is little natural buffering (neutralisation) capacity available.

Hydrobiology also suggests that a baseline tissue metal survey of aquatic fauna be undertaken to assess the existing (pre-Tonkolili) concentrations, which are likely to be influenced by the activities of artisanal miners in the area and natural mineralisation (for example, elevated levels of arsenic, chromium and nickel have been detected in the Simbili ore deposit). Hydrobiology's experience is that adequate baseline data is an important defense against pollution-related litigation, particularly concerning human health, which may be impacted by the accumulation of toxic elements in the food chain.

Freshwater fish are vitally important to the local population as a protein source and therefore maintaining the fishing resource is critical for food security for local villages. In general, fishing is at a subsistence level. It is therefore important that African Minerals Limited acquires a detailed understanding of fisheries in the area, in order to mitigate and manage any future mining-related impacts that may occur.

# Rapid Assessment of Aquatic Environments for the Tonkolili Project

## SRK Consulting (UK) Ltd

**April 2010**



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## FIGURES

# 1 INTRODUCTION

This report details the results from a Rapid Aquatic Ecosystem Assessment undertaken by Hydrobiology between the 10th and 16th March 2010 on behalf of SRK Consulting (UK) LTD for the Tonkolili Iron Ore Project situated in the Sula Mountain Range in Sierra Leone.

The Tonkolili Iron Ore project is expected to commence in two phases:

1. The Early Cash Flow phase (ECF) which involves mining the topmost layer of hematite ore (mostly found in the Simbili deposit). A haul road will be built for transfer of ore between the mine site and Lunsar whereupon the ore will be transferred to rail and transported using the existing rail line to Pepel Port. From there, it will be shipped out of the country;

2. The Full Project involves mining the whole ore body (consisting of magnetite) and will involve the construction of a new rail line from the mine site to Tagrin Point for shipment of the ore out of the country. A large tailings storage facility (TSF) will be built on the Mawuru River within the project area, for beneficiation tails. As far as Hydrobiology is aware, there are no other plans for processing on site...

The Rapid Assessment was undertaken with both project phases in mind. At the current time, a detailed aquatic ecological study has not been undertaken. The main purpose of this work was to assess the health of the aquatic ecosystems covered by the project and to make recommendations on the ecological value of areas potentially impacted by the proposed project development.

# 2 METHODOLOGY

The study was carried out in the dry season (March 2010) when water levels were sufficiently low to allow assessment of in-stream and riparian aquatic habitats.

The basic method of assessment included:

- Habitat assessment using suitable guidelines and expert knowledge;
- Observations on water quality i.e. clarity, pH, temperature, conductivity;
- Observations on existing stressors and significant aspects of the ecology;
- Observations on potential sampling techniques and requirements at each of the sites;
- Observations on any species visible;
- Discussions with locals on species caught in different areas and trends in catches;
- Observations at local markets;
- Observations on hydrology of the river systems
- Inter-comparison between sites.

A subjective assessment of in-stream habitat at the selected sites was carried out based on in-stream debris cover (logs, branches, leaves and twigs, algae); presence or absence of macrophytes, rock faces and overhangs, boulders, tree roots, vegetation overhang and canopy cover. Riparian vegetation was assessed in terms of canopy cover, continuity and width, a general assessment of weeds and grass infiltration of the riparian vegetation. Specialists from the Herbarium, Royal Botanic Gardens, Kew have undertaken a more detailed assessment of plant species of conservation concern (Burgt, 2009; Burgt & Pollard, 2010; Darbyshire & Burgt, 2010).

Fish observations were planned for at local markets. Hydrobiology visited two local markets and the fish were dried and salted, making identification of the fish difficult and due to time constraints, this approach was not pursued.

# 3 SITES

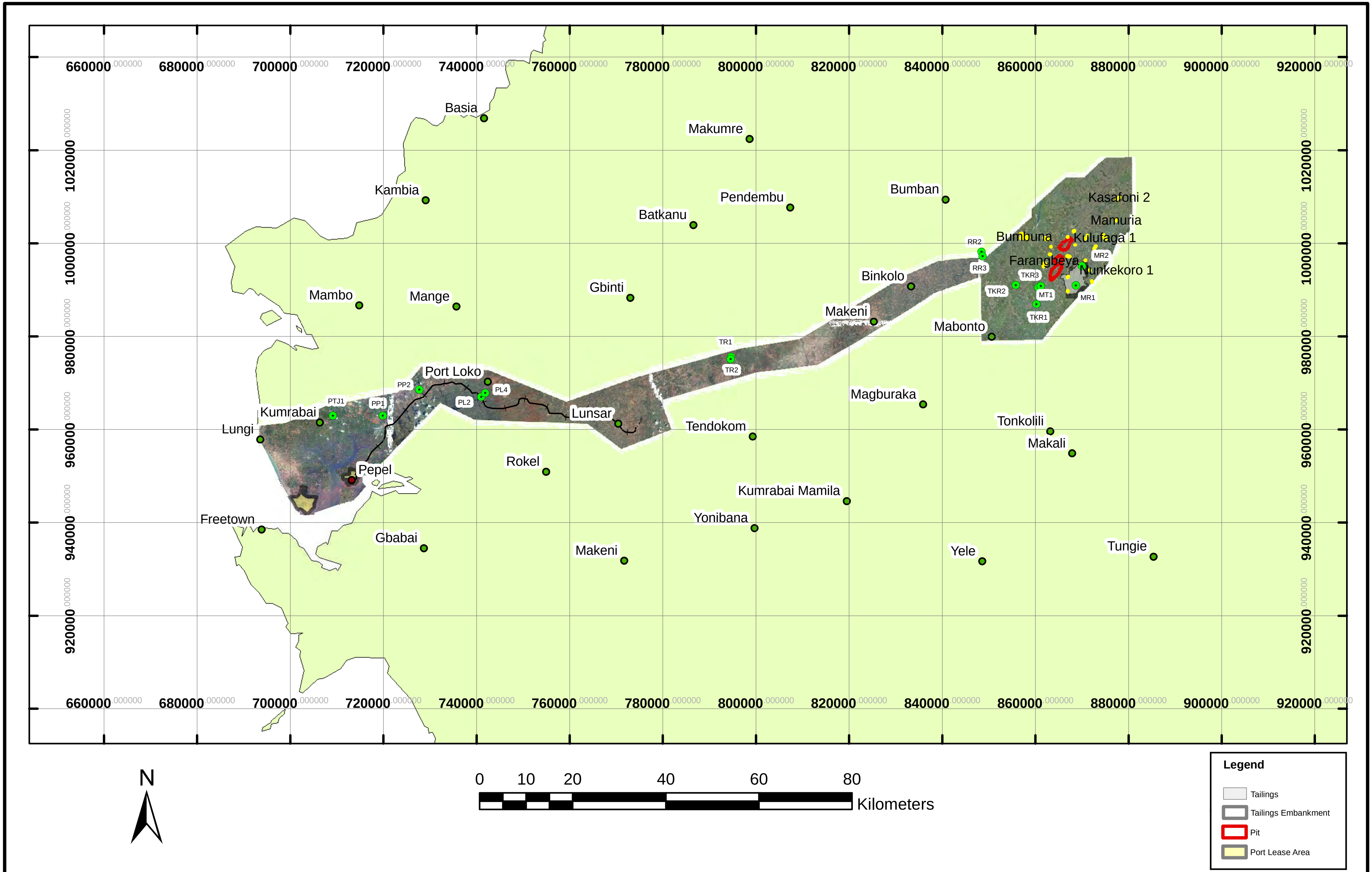
The overall project map is shown in Figure 3-1. Hydrobiology was asked to visit the following general areas to undertake the Rapid Assessment (from west to east):

1) The Petifu Junction Assessment Area (Figure 3-1);
2) The general Pepel Port area (Figure 3-2);
3) The Port Loko River mainline crossing (Figure 3-3);
4) The Toka River mainline and haul road crossings (Figure 3-4);
5) The Rokel River mainline and haul road crossing areas (Figure 3-5);
6) The Mine Site Area (Figure 3-5) which included:
    a. Rail Loop 5 Infrastructure Assessment area;
    b. Haul Road Pinch point & Nerekoro Society Bush Assessment area;
    c. Matoine Stream and Tonkolili River, Furia & Sokia Villages Assessment areas;
    d. The proposed TSF which will include the damming of the Mawuru River.

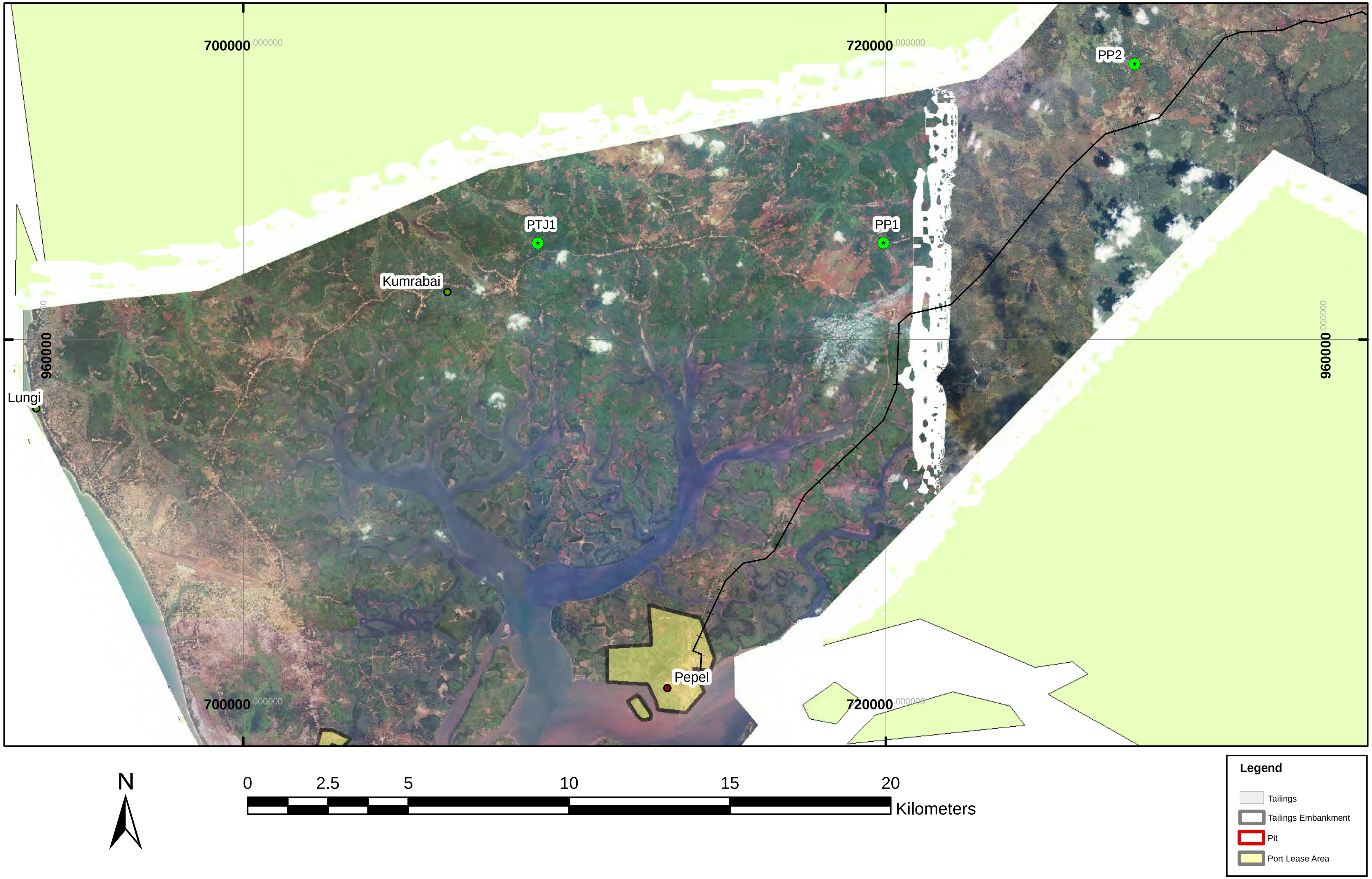
Waypoints for the sites are summarised in Table 3-1.

Due to time constraints, Hydrobiology was unable to survey two of the requested sites:

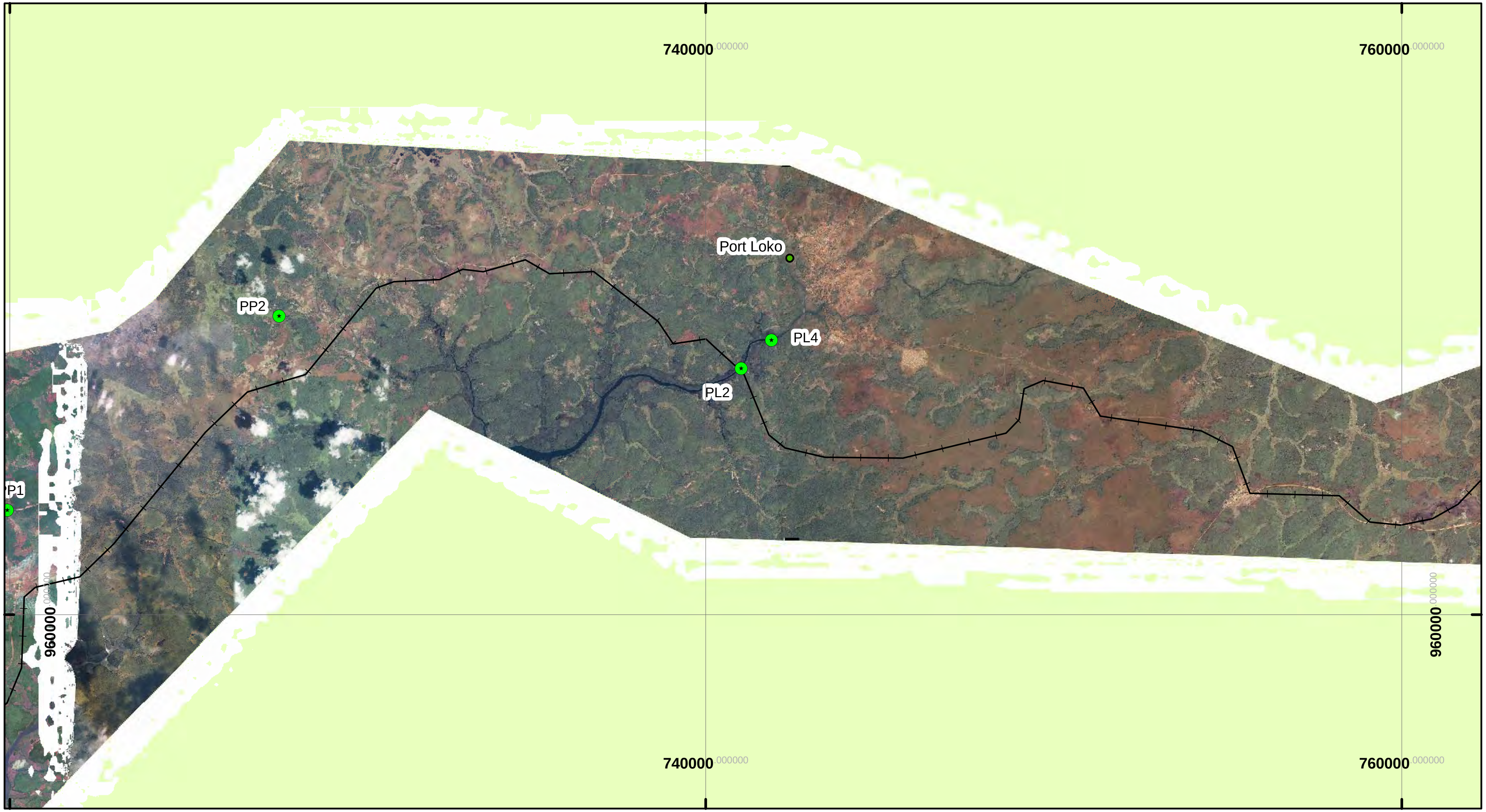
- The Strict Nature Reserve; and
- The area south of the TSF.




| APRIL 2010 | PROJ. No: 4041 | TONKOLILI FRESHWATER MAPS | |
|---|---|---|---|
| SRK Consulting Engineers and Scientists | | Overall Project Area Map | Fig 3.1 |




| APRIL 2010 | PROJ. No: 4041 | TONKOLILI FRESHWATER MAPS | |
|---|---|---|---|
| SRK Consulting Engineers and Scientists | | Petifu Junction and Port Pepel Rapid Assessment Areas | Fig 3.2 |




N

0 1.25 2.5 5 7.5 10
Kilometers

**Legend**

- Tailings
- Tailings Embankment
- Pit
- Port Lease Area

| APRIL 2010 | PROJ. No: 4041 | TONKOLILI FRESHWATER MAPS | |
|---|---|---|---|
| SRK Consulting<br>Engineers and Scientists | | The Port Loko Rapid Assessment Areas | Fig 3.3 |

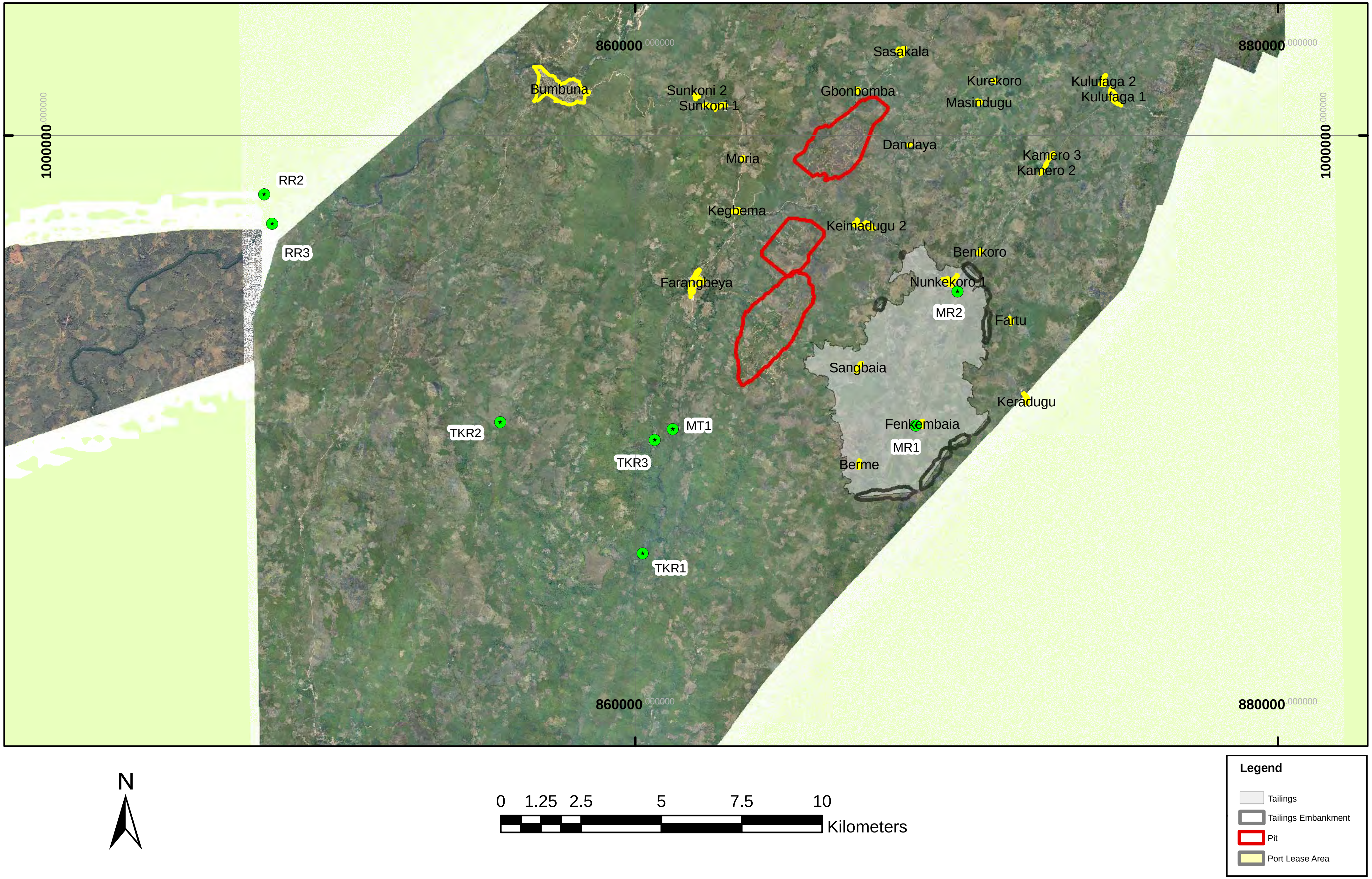

APRIL 2010 | PROJ. No: 4041

TONKOLILI FRESHWATER MAPS

SRK Consulting
Engineers and Scientists

Toka River Rapid Assessment Areas

Fig 3.4




| APRIL 2010 | PROJ. No: 4041 | TONKOLILI FRESHWATER MAPS | |
|---|---|---|---|
| SRK Consulting Engineers and Scientists | | Rokel River and Mine Area Rapid Assessment Areas | Fig 3.5 |

### Table 3-1 Site waypoints (Coordinate System: WGS 84)

| 3.1 Site | 3.2 Latitude | 3.3 Longitude |
|---|---|---|
| PTJ1 | 8° 42.432'N | 13° 5.929'W |
| PP1 | 8° 42.407'N | 13° 0.062'W |
| PP2 | 8° 45.408'N | 12° 55.787'W |
| PL2 | 8° 44.550'N | 12° 48.554'W |
| PL4 | 8° 44.988'N | 12° 48.075'W |
| TR1 | 8° 49.025'N | 12° 19.280'W |
| TR2 | 8° 48.748'N | 12° 19.333'W |
| RR2 | 9° 0.982'N | 11° 49.870'W |
| RR3 | 9° 0.484'N | 11° 49.738'W |
| TKR1 | 8° 54.865'N | 11° 43.504'W |
| TKR2 | 8° 57.104'N | 11° 45.901'W |
| TKR3 | 8° 56.781'N | 11° 43.283'W |
| MTR1 | 8° 56.959'N | 11° 42.977'W |
| MR1 | 8° 56.985'N | 11° 38.852'W |
| MR2 | 8° 59.239'N | 11° 38.124'W |

# 4 RESULTS

An extensive area was assessed over the five days of the study, with a focus on crossing areas. The survey areas covered lowland swamp areas (Pepel Port), small streams (Petifu Junction), small rivers (the Toka River) and more substantial rivers (the Tonkolili River and the Rokel River).

## 4.1 Water quality

Generally, the water in the areas surveyed was clear, with the exception being Tonkolili River, the water quality of which appeared to be impacted by upstream artisanal mining. Waters generally had low conductivity and were slightly acidic, meaning little or no buffering capacity of acid inputs if acid rock drainage occurs from the mining activities (Table 4-1). It should be noted that the Bumbuna Dam EIA Fish Baseline Study found the waters in area to be neutral to alkaline (Nippon Koei UK, 2007). However, data collected by Worley Parsons and supplied to Hydrobiology by SRK (P. Mitchell, Pers. Comm.), also found the waters to be acidic, casting some doubt on the water quality results from the Bumbuna Dam EIA Fish Baseline Report. From the anecdotal accounts of various local guides, the turbidity of the waters increases during the wet season (one guide said that the Rokel River 'ran red'). However, the current absence of a cohesive water quality monitoring program means that a quantitative assessment of the fluctuations in the various rivers and streams potentially impacted by the mine is not possible at present.

**Table 4-1 Water quality data from March 2009 Rapid Aassessment survey**

| Area | Site | pH | Conductivity (µS/cm) | Temperature (°C) | Turbidity (notes only) |
|---|---|---|---|---|---|
| Petifu Junction | PTJ1 | 5.55 | 6* | 28.6 | Clear water, slightly turbid in pool where people had been washing clothes |
| Pepel Port | PP1 | 5.24 | 9* | 31.5 | Clear water |
| | PP2 | 5.55 | 1* | 32.4 | Clear water |
| Port Loko | PL2 | 5.89 | 2186 (tide going out) | 30.2 | Clear water, with some turbid plumes on ebb tide |
| | PL4 | 6.0 | 1463 (tide going out) | 31.4 | Clear water. |
| Toka River | TR1 | 5.63 | 37 | 28.4 | Clear, tannin stained water |
| | TR2 | 5.61 | 35 | 28.1 | Clear, tannin stained water |
| Rokel River | RR2 | 6.4 | 30 | 28.0 | Clear water |

| Area | Site | pH | Conductivity (µS/cm) | Temperature (°C) | Turbidity (notes only) |
|---|---|---|---|---|---|
| and Mine Area | RR3 | 6.4 | 30 | 28.0 | Clear water |
| | TKR1 | 6.26 | 12 | 27.8 | Slight turbidity. |
| | TKR2 | 6.21 | 14 | 28.0 | Slight turbidity |
| | TKR3 | 6.250 | 12 | 29.3 | Water clear |
| | MTR1 | 6.23 | 7* | 27.9 | Water cloudy – artisanal mining occurring here and substantial riparian clearing |
| | MR1 | 6.07 | 13 | 26.3 | Clear |
| | MR2 | Not Taken | Not Taken | Not taken | Clear |

*** The conductivity probe used in this survey was a Hanna probe (HI7031) that can only be calibrated at 1413 µS/cm. It is likely the low conductivity measurements are not strictly linear and that the true conductivity is slightly higher than readings indicate.**

## 4.2 Aquatic Habitat

The sites surveyed have been qualitatively assessed with respect to the quality of associated in-stream and riparian vegetation based on expert knowledge. The rating scheme is summarized in Table 4.2.

**Table 4-2 Qualitative assessment coding for in-stream and riparian vegetation**

| Rating 1 Very High / Pristine | Rating 1.5 | Rating 2 High | Rating 2.5 | Rating 3 Good | Rating 3.5 | Rating 4 Poor | Rating 4.5 | Rating 5 Very poor |
|---|---|---|---|---|---|---|---|---|

Overall, the springs and streams of the area around Pepel Port and Petifu Junction have highly disturbed riparian vegetation. In-stream aquatic habitat consists mainly of submerged macrophyte and sedge communities. The Toka River also has only a thin edge of thick riparian vegetation (about 5 m width) but in-stream condition (particularly in the general area of the haul road crossing) is good. The bed of the Toka River at both the haul road and rail line crossing has about a 90% coverage of terrestrial leaves (typical in tropical streams), indicating that ecological functioning of the river is probably terrestrially driven (allochthonous). Therefore, it is possible to conclude that even though the riparian vegetation is not extensive, it has an important role in the ecosystem functioning of the stream.

The Port Loko River is a tidally driven river, with mangrove communities occurring almost continuously along the river (until the more populous Port Loko town is reached). It was not possible to assess the in-stream habitat from the edge of the river. However, the intact mangrove communities are a good indicator that the river is ecologically healthy (some turbidity is natural in tidally driven rivers).

The Rokel River has a high rating for aquatic habitat (Table 3-1), with good continuous riparian vegetation that only appears to be cleared for river access in small sections. In-stream habitats include tree roots, rock faces, boulders and cobbles, vegetation overhang, riffles, runs, glides and pools.

The rivers in the general mine area are slightly more disturbed than Rokel River and Port Loko River. Two Tonkolili River sites (TKR3 and TKR2) have good in-stream habitat. TKR2 has very thick riparian vegetation and adjacent forest on the right bank[1], but the left bank has been cleared for farming (apart from the almost continuous riparian vegetation about 10 m thick). TKR1, upstream of TKR2 (in the Haul Road Pinch point & Nerekoro Society Bush assessment area) is the most disturbed, with discontinuous riparian vegetation. The site has slightly elevated turbidity. This made it difficult to assess the in-stream habitat, but the area appears to be slightly degraded with a little variation in potential aquatic habitat. The Matoine Stream (MT1) has good in-stream habitat (typical of small mountain streams), but the riparian vegetation has been recently burnt and almost completely cleared for farming (at least on the right bank).

Two sites in the Mawuru River (within the TSF) were assessed, and appear to have good in-stream habitat. The riparian vegetation has been highly disturbed at both sites, but this appears to have allowed the formation of submerged macrophyte beds (extra habitat) due to the extra light penetration to the stream resulting from the removal of riparian canopy cover. Many swampy areas were noted between MR1 and MR2, but these were not assessed due to lack of time.

Overall ratings for the areas surveyed are summarised in Table 4-3.

Fish were seen at all sites apart from TKR2, but it was not possible to identify them with any certainty.

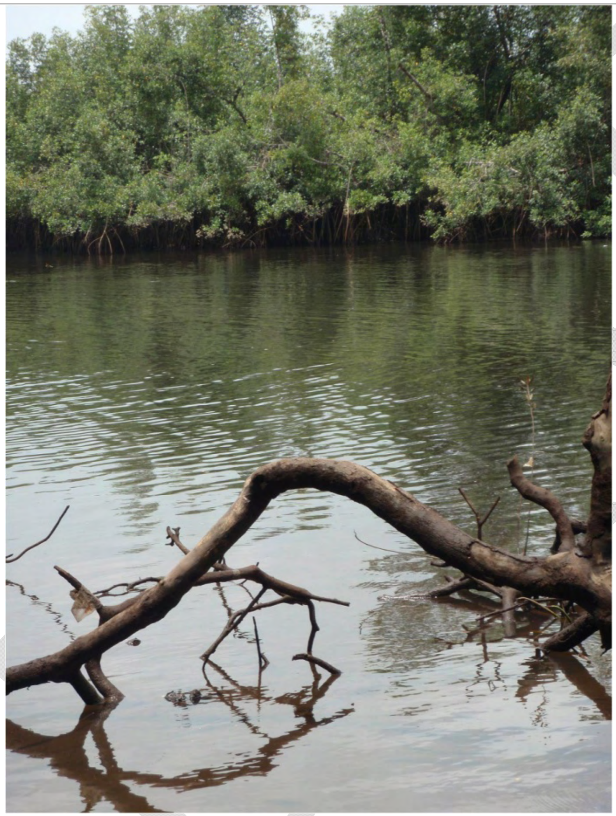
[1] It is convention to describe the left hand and right hand sides of a stream from facing downstream.

**Table 4-3 Summary of rapid assessment f sites**

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| PTJ1 | Petifu Junction |  | 4.0 | 4.0 | Water turbid as the area was being used to wash clothes in prior to photographs being taken.<br><br>Two different fish species were spotted but not identified (one Cichlidae).<br><br>Water appeared to come from groundwater source upstream about 100 m.<br><br>Most riparian vegetation removed. Some palms that provide shading to the stream bed. Patches of macrophytes in the pool.<br><br>Locals report good fishing downstream, use seine nets and hooks. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| PP1 | Pepel Port area (outside of assessment zone).<br><br>No freshwater areas in assessment zone. |  | 3.5 | 5.0 | Drinking water source for local village. Villages report fishing in area banned by the chief as the water was becoming too turbid. Very few freshwater sources in Pepel Port area according to locals.<br><br>Swampy area with some floating macrophyte habitat. Few sedges. Locals report some very deep pools downstream in the 'devils area' where locals do not go.<br><br>The local guide is hoping this water source will be used for Pepel Port Infrastructure as a source of freshwater so local villagers will get some payment.<br><br>Locals use seine nets for fishing. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| PP2 | Pepel Port |  | 3.5 | 5.0 | Freshwater reservoir used previously for port infrastructure at Pepel Port.<br><br>Swampy area with some floating macrophyte habitat and emergent sedges.<br><br>Fire had recently passed through the edges of the swamp.<br><br>Locals use seine nets for fishing. |
| PL2 | Port Loko |  | 2.0 | 2.0 | Existing rail crossing – photo from bridge.<br><br>Tidal area, mangrove lined.<br><br>Riparian vegetation appeared to be intact all the way up the river (until Port Loko town).<br><br>Some turbid plumes in water, otherwise water very clear. Tide going out.<br><br>Could hear chain saws – some clearing of trees by logging occurring (told only one or two mature trees). |

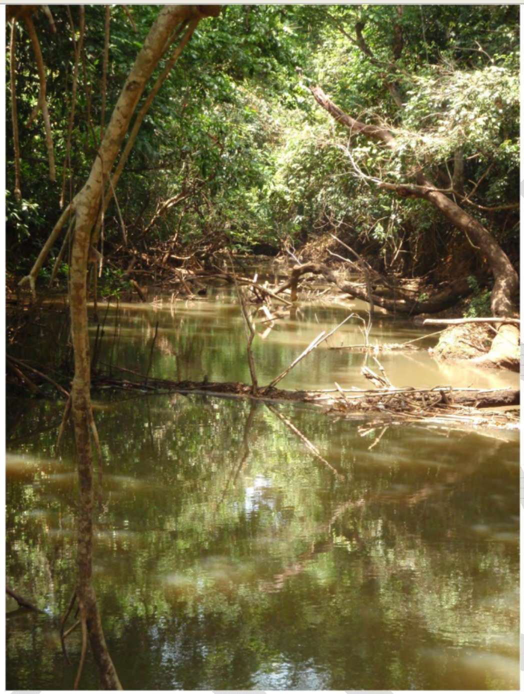
| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| | | | | | Some erosion under bridge. |
| PL4 | Port Loko |  | 2.0 | 2.0 | Close to mainline crossing. Riparian vegetation on left bank was cleared for river access for adjacent village (boat launch, swimming, washing). However, rest of riparian vegetation looked intact up and down river.<br><br>Farming abutted riparian strip.<br><br>Water was clear. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| TR1 | Toko River |  | **2.5** | **3** | Mainline crossing area. Water very clear, leaf litter, good canopy cover.<br><br>Riparian vegetation on access side (south side) only about 5 m wide – land completely cleared up to this point. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| TR2 | Toko River |  | **4.0** | **4.0** | Pandanus thicket. May have some habitat value for small fish. May be used by local villagers.<br><br>Thicket so thick we were not able to access stream.<br><br>Not sure if it is possible to fish here – pandnus impenetrable. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| RR2 | Rokel River |  | 2.0 | 2.0 | Suggested to be a preferred crossing point for the haul road by Kew specialists.<br><br>Rocky substrate, good riparian vegetation tree roots, rock faces, boulders and cobbles, vegetation overhang, riffles, glides and pools. |
| RR3 | Rokel River |  | 2.0 | 2.0 | Mainline crossing.<br><br>Rocky substrate, good riparian vegetation tree roots, rock faces, boulders and cobbles, vegetation overhang, riffles, glides and pools. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| TKR1 | Haul Road Pinch point & Nerekoro Society Bush |  | 3.5 | 3.5 | Water more turbid than at other sites.<br><br>Fewer habitats than other sites on the Tonkolili River, but still some logs and branch piles.<br><br>Appears to be impacted slightly by upstream artisanal mining. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| TKR2 | Rail Loop 5 Infrastructure |  | 2.0 | 2.5 | Good habitat. Logs, branches, algae on rocks, rock overhangs, vegetation overhang. Good canopy cover. Good forest on RHS.<br><br>Water cloudy – could not see bottom.<br><br>River rises about 8 m in wet season and floods left bank to about 100 m.<br><br>Local people fish using seine on flooded edge during wet season, and big hooks baited with frogs. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| TKR3 | Matoine Stream and Tonkolili River, Furia & Sokia Villages |  | 2.5 | 3.0 | Good habitat. Water clear. Organic floc in backwaters and algae. Rock edges, tree roots, vegetation overhang. Terrestrial leaves in backwaters. Substrate rock.<br><br>Large snake swam by – guide told us it was a cobra that hunts fish and the locals like to catch the snakes for food.<br><br>. |
| MT1 | Matoine Stream and Tonkolili River, Furia & Sokia Villages |  | 3.5 | 3.5 | Matoine stream, small rocky stream but riparian vegetation almost completely cleared recently for farming by burning on RHS of stream. Riparian vegetation on LHS of stream in moderate condition. Evidence of artisanal mining in-stream. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| MR1 | TSF |  | 3.0 | 3.5 | Fairly disturbed riparian vegetation and some evidence of erosion. Sandy substrate. Macrophytes (*Crinum nathans*) in channel, with weed grasses also growing in channel where riparian vegetation removed. |

| Site | Assessment Area | Picture | In-stream Aquatic Habitat Rating | Riparian Vegetation Rating | Notes |
|---|---|---|---|---|---|
| MR2 | TSF |  | 3.0 | 3.5 | Very disturbed riparian vegetation. Macrophytes (*Crinum nathans*) in channel, with weed grasses also growing in channel where riparian vegetation removed.<br><br>Water clear. |

# 5 RARE AND THREATENED AND ENDEMIC FISH

An IUCN red list search of threatened freshwater fish species was undertaken. The species *Pristis microdon* (Largetooth sawfish) was listed as present in Sierra Leone and critically endangered. Although this species is usually found in turbid channels, it is known to be found in freshwater (www.fishbase.org).

A search of http://www.fishbase.org/ indicated three endemic species to Sierra Leone found in the Rokel River and will potentially be impacted by mining activities. They are:

1. *Leptocypris taiaensis* (Cyprinidae) (also reported from the Taia River, Little Scarcies River, Waanje River and Jong rivers);

2. *Marcusenius meronai* (Mormyridae) (also reported the Sewa River); and

3. *Prolabeo batesi* (Cyprinidae) (also reported from the Sewa, Pampana, Little Scarcies and Jong rivers).

None of these species have been assessed under the IUCN red list system, and so their status is not assigned. However, endemism inherently means that there is a limited geographical distribution of a species. Of the one critically endangered and three endemic species listed above, only *Marcusenius meronai* was recorded, at three sites, in the baseline study for the Bumbuna Dam (Nippon Koei UK, 2007).

The limited literature review undertaken in conjunction with fieldwork planning indicated that the fish of Sierra Leone have not been well studied, particularly the smaller fish in streams and brooks. An example of fish that may have a locally endemic distribution are the killifish (Cyprinodontiformes) – brightly coloured fish that are found in small streams throughout the Americas, Eurasia and Africa, but which appear to have a high level of endemism in west Africa. It is therefore suggested that aquatic fauna surveys be undertaken in the small streams and swamps likely to be impacted by the Tonkolili Project.

To facilitate future identification of fish it is recommended that local fishermen accompany the survey team to facilitate cross-referencing collected data with local knowledge and species names.

# 6 DISCUSSION

The majority of sites covered in this initial Rapid Assessment could potentially be impacted by road and rail crossings associated with the transport infrastructure of the project. Although many of the streams are in good condition (particularly with respect to in-stream habitat), impacts at crossing points should be minor if the following mitigation measures are taken into consideration:

1. That best practice sediment control measures are used during construction of the crossings. It is likely that there is some natural tolerance to sediment loads in the aquatic ecosystems within and downstream of the mining lease and in the streams where the crossings will occur, due to the natural fluctuations in turbidity in the wet seasons as noted by local guides. However, very few data are available to assess the temporal extent and magnitude of changes in turbidity or to support the assessment and management of potential impacts should they arise;

2. Where bridges are built, that they are designed in a manner that does not confine the river. If the river is confined it will cause localised faster flow and scouring and may impede migratory species;

3. Minor in-stream infrastructure can constitute barriers to fish migration. Where possible, in-stream infrastructure should be designed to be compatible with the passage of migratory stream organisms, for example the use of bridges rather than culverts, or selection of open box culverts with natural substrata rather than enclosed culverts. Additionally vertical barriers such as downstream culvert ends suspended above the natural substrata should be avoided. Suitable stream passage construction designs can be found, for example, in Cotterell (1998) or the Washington Department of Fish and Wildlife (2003);

4. As the haul road is typically to be 13 m in width, the absence of upstream light (which can deter fish from entering a passage) is unlikely to be a substantial problem provided the culvert diameter is kept large enough to keep wet season flows to below 0.3 m/s, but it would also be preferable to add at least a central skylight to the culvert design.

The Mawuru River will be dammed to allow the construction of the TSF. At the proposed TSF site, there are no mitigation measures that can be put in place to prevent impacts – the small streams and the river and swamps in the area will be submerged. There is no evidence that any aquatic surveys have been undertaken in the proposed TSF area. As this area contains many small streams that may house endemic species, it is strongly suggested that an aquatic fauna survey is undertaken to fully describe the aquatic biota in the area. This will enable AML to illustrate that no endemic species are present in the area, or conversely, if some do exist in the TSF area, action can be taken.

From the information Hydrobiology currently has, it is not possible to adequately assess impacts downstream of the TSF. From available information it appears that the water will not be of suitable quality for release into the downstream reaches without treatment, particularly with respect to alkalinity (a pH of 10-11 is predicted) and potentially with respect to suspended solids. Background water quality data and information on the geochemical aspects of the deposit are limited. While the presence of pyrite (a potential source of acid rock drainage) has been noted in overburden materials and potentially toxic elements such as arsenic, chromium and nickel are also present at elevated concentrations in the Simbili deposit, the potential for related impacts on water quality and aquatic habitats downstream of the TSF are presently unknown, and will depend on the mineralogy and geochemistry of the tailings stored there.

Detailed hydrological data is not available and therefore it is not possible to assess the potential impacts of a reduced flow from the Mawuru River into downstream reaches, nor is detailed mapping of the rivers and streams in the area currently available on which to base an assessment of the hydrological connectivity between the rivers.

Hydrobiology strongly suggests that an adequate baseline water quality monitoring program be established for the area. This will enable the assessment of changes (if any) to the downstream rivers due to the mine's activities and will supply a baseline dataset for management action in the future if negative changes to water quality do occur. It should be noted that the natural acidity and low conductivity of the water bodies indicate that if ARD does occur, there would be little or no natural buffering (neutralization) capacity.

Hydrobiology also suggests that a baseline tissue metal survey of aquatic fauna be undertaken to assess the existing (pre-Tonkolili) concentrations, which are likely to be influenced by the activities of artisanal miners in the area, and natural mineralisation associated with iron ore deposits and gold deposits in the general area.

The assessment of metal concentrations in biological tissues can give an indication of the overall exposure of biota to toxicants and are particularly useful for those that biomagnify (increase in concentration as they pass up the food chain), such as mercury. Hydrobiology made initial enquiries as to whether mercury is being used in the area by artisanal gold miners, but was unable to acquire reliable data. Although most gold mining activity appears to be use gravity methods (panning) the likelihood exists that some miners use mercury for gold extraction.

Hydrobiology's experience is that adequate baseline data for contaminant concentrations in biological tissues is an important defense against pollution-related litigation, particularly concerning human health, which may be impacted by the accumulation of toxic elements in the food chain, particularly when the local population are reliant on fish as a food source.

Of final note is the importance of fish to the local communities. SRK found that food shortages wase an issue raised in the social surveys (Kumar & Van Vlaenderen, 2010), and that it is evident that many villages in the vicinity of the rivers and streams rely on fishing to supplement their diets. Maintaining the fishing resource is therefore critical in terms of food security for these villagers. It is therefore important that African Minerals Limited acquires a detailed understanding of fisheries in the areas that may potentially be impacted by project-related activities, in order to design, plan and implement appropriate mitigation and management measures.

# 7 REFERENCES

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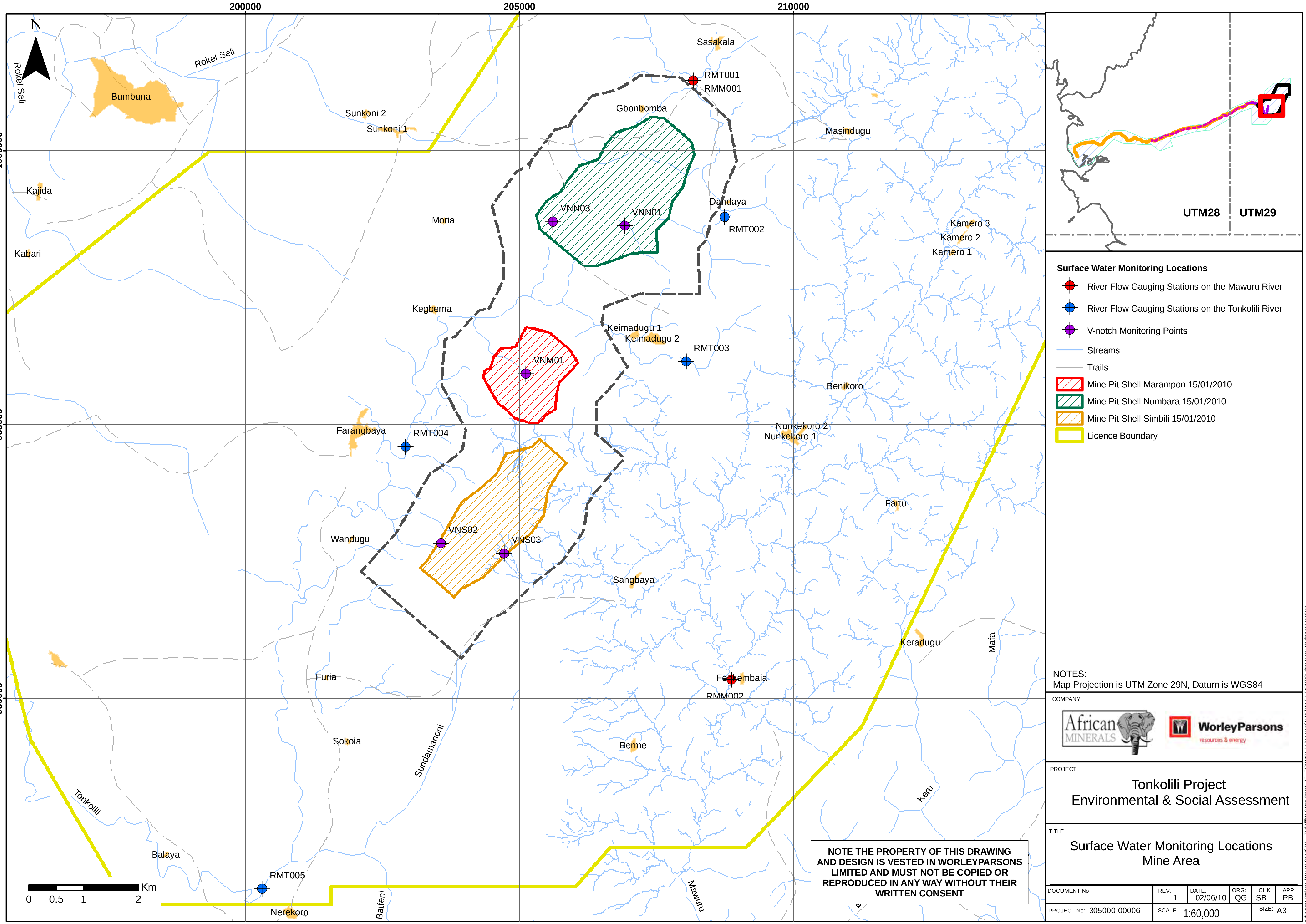
# APPENDIX 13

## Surface Water Monitoring Locations for the Mine Area


200000
205000
210000
1000000
995000
990000
N
Rokel Seli
Rokel Seli
Bumbuna
Sunkoni 2
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Sasakala
RMT001
RMM001
Gbonbomba
Masindugu
Kajida
Moria
VNN03
VNN01
Dandaya
RMT002
Kamero 3
Kamero 2
Kamero 1
Kabari
Kegbema
Keimadugu 1
Keimadugu 2
RMT003
VNM01
Benikoro
Farangbaya
RMT004
Nunkekoro 2
Nunkekoro 1
Fartu
VNS02
VNS03
Wandugu
Sangbaya
Keradugu
Mafa
Furia
Fenkembaia
RMM002
Sokoia
Sundamanoni
Berme
Keru
Tonkolili
Balaya
RMT005
Nerekoro
Batfeni
Mawuru
0 0.5 1 2 Km
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UTM28
UTM29
Surface Water Monitoring Locations
River Flow Gauging Stations on the Mawuru River
River Flow Gauging Stations on the Tonkolili River
V-notch Monitoring Points
Streams
Trails
Mine Pit Shell Marampon 15/01/2010
Mine Pit Shell Numbara 15/01/2010
Mine Pit Shell Simbili 15/01/2010
Licence Boundary
NOTES:
Map Projection is UTM Zone 29N, Datum is WGS84
COMPANY
African MINERALS
WorleyParsons
resources & energy
PROJECT
Tonkolili Project
Environmental & Social Assessment
TITLE
Surface Water Monitoring Locations
Mine Area
DOCUMENT No:
REV: 1
DATE: 02/06/10
ORG: QG
CHK SB
APP PB
PROJECT No: 305000-00006
SCALE: 1:60,000
SIZE: A3

resources & energy



# APPENDIX 14

## Tonkolili Soils and Laterite Profile – Prepared by SRK

WorleyParsons
resources & energy

African MINERALS

**AFRICAN MINERALS LIMITED**

## Tonkolili Iron Ore Project

# Tonkolili Soils and Laterite Profile - Prepared by SRK

305000-00006 – 305000-00006-0000-EN-REP-0008

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

AFRICAN MINERALS LIMITED
TONKOLILI SOILS AND LATERITE PROFILE - PREPARED BY SRK

TONKOLILI IRON ORE PROJECT

## Disclaimer



**PROJECT 305000-00006 - TONKOLILI SOILS AND LATERITE PROFILE - PREPARED BY SRK**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
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| A | Issued for Internal Review | O Fuertes | P Burris | N/A | 08 Apr 2010 | N/A | |
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SRK Consulting (UK) Ltd
5th Floor Churchill House
17 Churchill Way
Cardiff
United Kingdom
CF10 2HH
e-mail: cardiff@srk.co.uk
URL: www.srk.co.uk
Tel: + 44 (0)29 20 34 81 50
Fax: + 44 (0)29 20 34 81 99

# EXTERNAL MEMORANDUM

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| **TO:** | Phil Burris | **FROM:** | Paul Mitchell (on behalf of Craig Watt) |
| **FILE REF:** | *Soil_laterite_v4.docx* | **DATE:** | 31 March 2010 |
| **SUBJECT:** | **U4041 - Tonkolili Soils and Laterite Profile** | | |



## INTRODUCTION

The purpose of this Memorandum is to provide information in respect of the soils present in the area surrounding the Simbili and Numbara deposits at the Tonkolili iron ore project, Republic of Sierra Leone. This information has been derived from both diamond and reverse circulation drilling and includes an interpretation of the superficial material. However, it is to be noted that, for most drill sites the first two (2) metres of material was removed during preparation of the drill pad (i.e. clearing and levelling via bulldozer).

## OVERVIEW

The upper most surficial material at the Tonkolili iron ore deposits is dependent on the underlying geology. Where the underlying geology is the iron-ore protolith (quartz and silicate itabirites) then a ferruginous hardcap or canga profile has developed. Where the underlying geology is either the footwall or hangingwall acid to intermediate rocks a simple laterite profile has developed.

The canga at the Tonkolili iron-ore project consists of predominantly angular to subrounded fragments of hematite and pisoliths partially replaced by goethite and cemented by clays, reprecipitated silica and iron oxide. At the hangingwall/footwall contacts and slope failures, goethite-rich pisoliths, gibbsite and clays are more common. Simple laterites are typically red in colour, comprising of massive and colloform goethite-hematite, with common iron-oxide fragments cemented by clays, reprecipitated silica and iron oxides.

## GEOMORPHOLOGY AND LATERITE DEVELOPMENT

The Tonkolili iron-ore project comprises a portion of the north-south trending Archean Sula Mountain range which extends for over 20 km and has elevations between 200 and 880m. Superficial laterites, including iron-ore enrichment, are considered to be the result of laterisation, whereby the previously uplifted land surface has undergone erosion during an extended period of tectonic stability, under the influence of a tropical to subtropical climate. Laterite development is likely to have occurred in the Pleistocene or Upper Tertiary, a common age worldwide for the development of laterite deposits. Importantly, the moderately- to steeply-dipping structure of the rocks at the Tonkolili iron-ore project assisted groundwater circulation and development of the laterite profile. Younger east-west trending tectonic movements produced deep trenches and gorges in the Tonkolili laterites and iron-ores and led to erosion and redeposition of lateritic materials.

## SOILS

The laterite soil profile (Figure 1-1) at the Tonkolili iron-ore project has developed to depths of between 40 and 105 m, with a goethite-rich surficial crust up of to 10m thick. Due to the acid to intermediate character of the footwall and hangingwall rocks, the laterite profile at Tonkolili may be generalised into two types: canga and simple laterite. Canga is a laterite soil developed over iron-ores which presents Fe-enrichments which exceed 58% Fe. Simple laterite comprises a ferruginous crust which has developed over any and all host rocks having produced a compositional and textural variation related to the protolith.

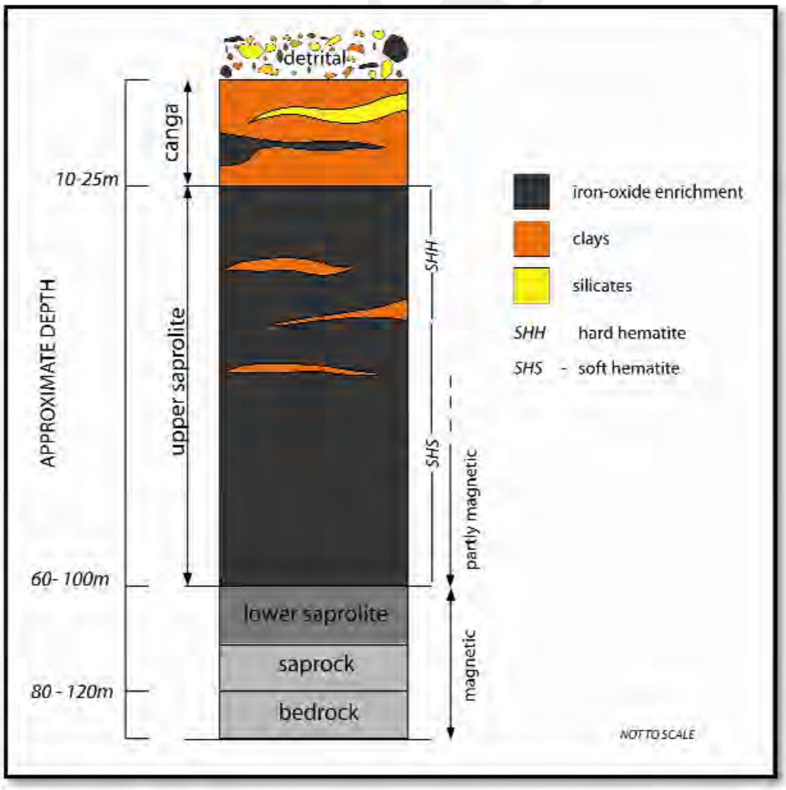


**Figure 1-1. Typical laterite profile at the Simbili deposit**

## Canga

The Canga profile as seen at Tonkolili is presented as a well-developed laterite profile which progresses from texturally-preserved lower saprolite (at depth) rocks with low to moderate permeability, through a highly permeable fine grained friable hematite horizon (SHS - main supergene iron-ore at the redox front; Figure 1-2). The friable hematite horizon, which contains minor clays and granular silica, underlies a hard hematite zone (SHH; Figure 1-2) which typically comprises banded hematite and minor permeable clays (due to protolith silicate content). Towards the surface, there is an increase in hematite-goethite infilled fractures and colloform precipitates, which give way to moderately permeable canga, consisting of angular to subrounded fragments of hematite and pisoliths, which form the top 2-3m. These surficial sediments are partially replaced by goethite and cemented by clays, reprecipitated silica and iron oxides. At the hangingwall and footwall contacts and slope failures goethite-rich pisoliths, gibbsite and clays are more common.


**Figure 1-2: examples of hematite mineralisation from the laterite profile. SHS-typical soft hematite; SHH typical hard hematite**

### Simple Laterites

The simple laterites profiles observed at a the Tonkolili project consist of two distinct types, based on proto-lithological associations; clastic-chemical sequences with tuffaceous contribution and acid to intermediate pyroclastic rocks.

The Clastic-chemical sequence consists of, clays, including kaolin, with minor silica, which is predominantly white to beige in colour with minor variation to pink-red and browns due to the variable content of mafic minerals in the protolith. The sequence is typically massive with low permeability. The uppermost surficial metres (Figure 1-3) are typically red and brown and comprises massive and colloform goethite-hematite, with common iron-oxide fragments cemented by clays, reprecipitated silica and iron oxides.

**Figure 1-3. Clay rich goethite laterite**

The acid, acid to intermediate and acid-intermediate pyroclastic rock related laterites consist of clays, excluding kaolin, and are predominantly pink to red in colour with minor variation to yellow-ochre and brown. Typically, this sequence is massive with low permeability (Figure 1-4). The uppermost surficial metres are typically red and comprises massive and colloform goethite-hematite, with common iron-oxide fragments cemented by clays, reprecipitated silica and iron oxides, and the development of pisoliths (accretionary mass of iron oxides).


**Figure 1-4: Thick intersection of clays from the laterite profile**

## APPENDIX 15

## Geological and Geomorphologic Baseline Study - Prepared by SRK

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## Tonkolili Iron Ore Project

# Geological and Geomorphologic Baseline Study - Prepared by SRK

305000-00006 – 305000-00006-0000-EN-REP-0007

08 Apr 2010

Parkview, Great West Road
Brentford Middlesex TW8 9AZ London
United Kingdom
Telephone: +44 (0) 20 8326 5000
Facsimile: +44 (0) 20 8710 0220
www.worleyparsons.com

WorleyParsons
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GEOLOGICAL AND GEMORPHOLOGICAL BASELINE STUDY - PREPARED BY SRK

TONKOLILI IRON ORE PROJECT

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# TONKOLILI IRON ORE PROJECT GEOLOGICAL AND GEMORPHOLOGICAL BASELINE STUDY

**Report Prepared for:**

## AFRICAN MINERALS LTD

**Victoria Place**
**31 Victoria Street,**
**Hamilton,**
**HM10,**
**Bermuda**



SRK Consulting
Engineers and Scientists

**FILE REF:** **P:\U4041 Tonkolili WP Framework\Task 5 ECF ESHIA Programme\Reps\Baseline_Geology_Geomorphology\Version 6\Tonkolili_Geology_Geomorphology_v6.docx**

**MARCH 2010**

# TONKOLILI IRON ORE PROJECT GEOLOGICAL AND GEMORPHOLOGICAL BASELINE STUDY

**Report Prepared for**

**AFRICAN MINERALS LTD**
**VICTORIA PLACE**
**31 VICTORIA STREET,**
**HAMILTON,**
**HM10,**
**BERMUDA**

**U4041**

**SRK Consulting (UK) Ltd**
**5th Floor Churchill House**
**17 Churchill Way**
**Cardiff, UK**
**CF10 2HH**

**Tel : +44 29 20 34 81 50**
**Fax : +44 29 20 34 81 99**
**cardiff@srk.co.uk**
**www.srk.co.uk**

**FILE REF:** **P:\U4041 Tonkolili WP Framework\Task 5 ECF ESHIA Programme\Reps\Baseline_Geology_Geomorphology\Version 6\Tonkolili_Geology_Geomorphology_v6.docx**

**MARCH 2010**

Report Authors
James Dendle

Reviewed by:
Dr. Tim Lucks
Paul Mitchell

:

# Executive Summary

SRK Consulting (UK) Ltd (SRK) has been engaged by African Mineral Ltd (AML) to undertake a Geological and Geomorphological Baseline Study to assess the impact of the proposed Tonkolili Iron Ore Mine. SRK has conducted a thorough desktop review of available literature from a number of sources.

The Tonkolili Iron Ore project is located in the margins of the Sula Mountains in northern-central Sierra Leone, approximately 180-200km ENE of the capital, Freetown. This study focuses on the study area covered by the May 2009 Mineral Resource Estimate reported by SRK which includes the Simbili, Marampon and Numbara deposits  and totals 5.1 Bt of ore, at a grade of 30% Fe.

The Tonkolili region is made up of high rugged mountain ranges, eroded plateaus and smooth hill tops that rise from 200 to 880 m in elevation. The lowest points which form narrow valleys and gorges have elevations of between 200 to 350 m. Within the larger area, hills have a dominant NE-SW to NNE-SWW trend and are intersected by approximately orthogonal valleys, which expand out towards the south of Numbara.

The primary BIF mineralisation occurs in the form of mixed silicate and quartz itabirite (magnetite), hosted by metamorphosed successions of acid-volcanics, tuffs, pelitic sediments, clastic sediments and metacarbonate rocks, all of which are cross cut by pegmatites and porphyritic dykes and sills, Structurally, the Tonkolili iron deposits are arranged in a left-stepping array, at a very low angle to the overall trend (NE-SW),displaced, by a series of ESE-WNW trending faults.

The bedrock geology is overlain by laterally and vertically variable laterite and duricrust, which contribute to the three distinct geomorphological domains that can be observed:

- Accumulative valley deposits (domain 1)
- Denuded weather slopes (domain 2)
- Deeply weathered Peneplains (domain 3)

The Tonkolili area is host to a network of rivers and seasonal streams that feed the perennial Tonkolili River.  The drainage network is variable in pattern ranging from dendritic to parallel (sub-parallel) to trellis, to rectangular and annualar.

The Tonkolili Iron Project will significantly alter the geology and geomorphology of the area, with additional implications of the hydrogeological/hydrological regime. In order to mitigate these affects a number of steps can be taken. For example, watercourses can be diverted to protect excavation areas and prevent contamination. Land used during construction should be reclaimed and rehabilitated.

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SRK Consulting (UK) Ltd
5th Floor Churchill House
17 Churchill Way
Cardiff
United Kingdom
CF10 2HH

e-mail: cardiff@srk.co.uk
URL: www.srk.co.uk

Tel: + 44 (0)29 20 34 81 50
Fax: + 44 (0)29 20 34 81 99

March 2010

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# TONKOLILI IRON ORE PROJECT GEOLOGICAL AND GEOMORPHOLOGICAL BASELINE STUDY



## 1 INTRODUCTION

### 1.1 Qualification of Consultants

The SRK Group comprises over 900 staff, offering expertise in a wide range of resource engineering disciplines. The SRK Group's independence is ensured by the fact that it holds no equity in any project. This permits the SRK Group to provide its clients with conflict-free and objective recommendations on crucial judgment issues. The SRK Group has a demonstrated track record in undertaking independent assessments of resources and reserves, project evaluations and audits, JORC Code compliance audits, independent engineers' reports and independent feasibility evaluations to bankable standards on behalf of exploration and mining companies and financial institutions worldwide. The SRK Group has also worked with a large number of major international mining companies and their projects, providing mining industry consultancy service inputs. SRK also has specific experience in commissions of this nature.

This technical report has been prepared based on a technical review by consultants sourced from the SRK Group's United Kingdom office. These consultants are specialists in the fields of geology and Mineral Resource estimation.

SRK's independence is ensured by the fact that it holds no equity in any project and that its ownership rests solely with its staff. SRK has a demonstrated track record in providing independent estimates of Mineral Resources and Ore Reserve Estimates, project evaluations and audits, competent person's reports and independent feasibility evaluations to bankable standards on behalf of exploration and mining companies and financial institutions worldwide. SRK also has specific expertise in relation to iron ore projects.

Neither SRK nor any of its employees employed in the preparation of this report has any beneficial interest in the assets of AML. SRK will charge a fee for this work in accordance with normal professional consulting practice.

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## 1.2 Project Location

The Tonkolili License area lies largely within the rugged greenstone belt of the southern Sula Mountain Range approximately 10 km east-southeast of the town of Bumbuna. The project area is best accessed by road, using 4-wheel drive vehicles. The journey typically comprises travel along a series of poorly constructed gravel tracks for approximately two hours from Lungi to Port Loko, followed by one and half hours on a tarmac highway between Lunsar and Magburaka, passing through Makeni, and finally a further one and a half hours on gravel tracks from Magburaka to the exploration camp, passing through Bumbuna (Figure 1-1).

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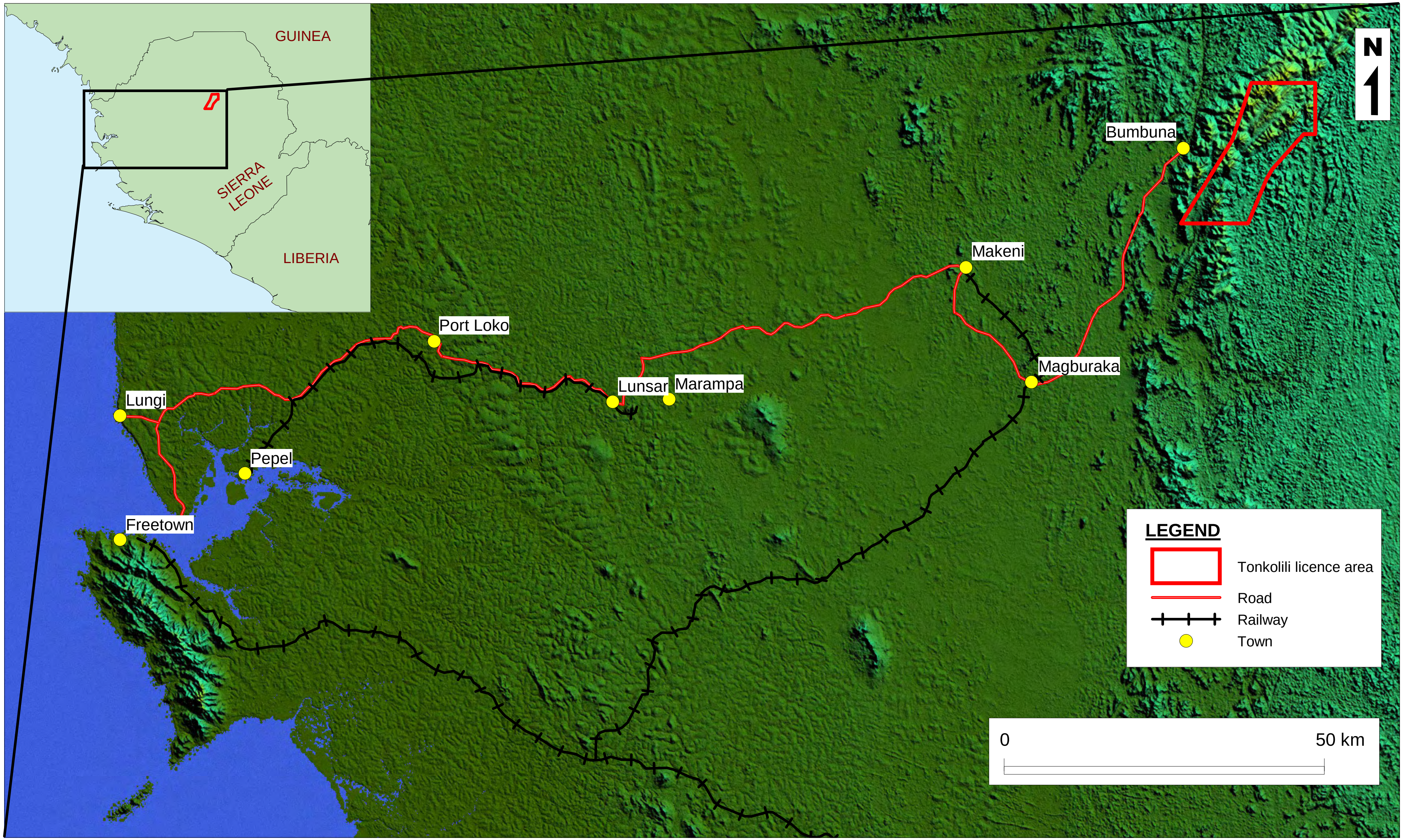


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| SRK Consulting Engineers and Scientists | | Tonkolili Location Map | Fig 1-1 |

# 2 PROJECT SCOPE

The scope of work required for the baseline study is as follows:

- Desktop review of the available literature on the geology and geomorphology of the area around the proposed Tonkolili mine.
- Identification of potential impacts on the integrity of geological structures as well as on the geomorphology of the area as a result of contamination and/or activities relating to the proposed mine development.
- Suggestion of appropriate mitigation measures to minimise/reduce the impacts on the geology and geomorphology of the area.

SRK does not consider any further fieldwork required to establish the geological and geomorphological baseline conditions for the site.

# 3 METHODOLOGY

In order to accurately assess the baseline geological and geomorphological conditions for the Tonkolili Project and surrounding area, a number of sources have been reviewed:

- SRK Mineral Resource Report, May, 2009.
- SRK Mineral Resource Update Report, March, 2010.
- SRK Open pit hydrogeological investigation: Phase 2 Interim Report, January, 2010.
- SRK Structural Geological Review, January, 2010.
- SRK Exploration: Geological Mapping, logging and field notes.
- Peer reviewed scientific papers.
- Geological Survey of Sierra Leone reports.
- Geological models created by SRK for Mineral Resource Estimation purposes.
- Assay database, drillholes, trenching and lithological, geotechnical and structural logging information, supplied to SRK by AML.

# 4 GEOLOGY

## 4.1 Regional Geology

The Tonkolili Exploration License is situated within, and marginal to, the Sula Mountains greenstone belt in the older Achaean granitic basement region of Sierra Leone. Two major orogenic episodes are reported that resulted in the development of a major intracrustal basin that was subsequently metamorphosed during a second (Liberian) episode of deformation to form the Kambui Group greenstones, which has subsequently been uplifted to form the Sula Mountains.

The License is underlain by various schists of the intracrustal Sula Mountains greenstone belt, adjacent to basement syn-kinematic granites intruded by late-kinematic granites.

The Sula Mountains greenstones (Kambui Group) are metamorphosed intracratonic basinal sediments in which lithologies grade upwards and inwards from basal metamorphosed ultramafic volcanics (chlorite and talc schists), through metamorphosed basic volcanics (amphibolites) to central quartzites and metasediments with interbedded banded ironstones. Deep weathering during landform modification and uplift gave rise to the formation of the duricrust zone on the original Cretaceous peneplanized surfaces

## 4.2 Local Geology and Mineralisation

The predominantly Archean granite-greenstone belt terranes that comprise approximately 75% of Sierra Leone represent the remnants of continental nuclei at the edge of the West African Craton. The Archean bedrock geology of Sierra Leone can be broadly subdivided into; intracrustal gneisses and granitoids; supracrustal greenstone belts and basic-ultra basic igneous complexes.

The basement of the license area is formed of granitoids of the Leonean and Pre-Liberian Granites. These basement rocks are believed to have been emplaced during both the syn- and late-kinematic events related to the Leonean Orogeny. The Leonean Granites are the precursors to the Liberian Granites and both were formed as intracrustal rock formations. The various igneous differentiates of these granitic rocks were classified based on the preservation of the major deformation fabrics (Macfarlane et al, 1981). Late acid gneissic rocks and pegmatites are common with the granitic rocks.

The syn-kinematic granites (Leonean) were emplaced between 3.2 and 2.9 Ga, and are exposed as coarse grained, equigranular, grey to light grey coloured with biotite, plagioclase feldspars and quartz as major mineral components. The late-kinematic (Liberian) granites were emplaced during the late stages of the Leonean orogensis and are composed of quartz, microcline, plagioclase feldspar, and ± muscovite and ± hornblende (Frikken, 2006). These later granites are lighter coloured due to their lack of ferromagnesian minerals.

Within the license area the Liberian Granites occupy mostly the eastern part of the prospect area, while the Leonean Granites occur to the south eastern end. Cross cutting relationships are rare, however approximately 300 m north of Kemadugu village, the Leonean Granites are intruded by the Liberian Granites.

The granitic basement rocks are unconformably overlain by a regionally metamorphosed thick sequence of meta-sedimentary, meta-volcanics, volcano-sedimentary and ultramafic rock units of the Kambui Super group. The metamorphic grade is characterised by mineral assemblages of the low grade greenschist facies (chlorite-actinolite–hornblende–muscovite-± epidote-albite). The Kambui Super group forms the north-east trending Sula Mountain Greenstone Belt sequence.

The license area is dominated by rock units of the Sula Group which is part of the Kambui Super group. The Sula Group is comprised of the Sonfon Formation and Tonkolili Formation, of which the latter is the younger rock unit and is largely constituted of meta-sedimentary and meta-volcanics, particularly tuffaceous layers.

The Sonfon Formation is documented as being composed of amphibolites with basalt pillow lavas and ultramafic rocks (MacFarlane et al, 1981). The Sonfon Formation in the most part occupies the western side of the project area, and form possible thrust-bounded bodies within the project, an example of which can be seen east of Farengbaya.

To the south of Numbara, the Simbili and Marampon prospects are characterised by the amphibolites and amphibolite schists of the Sonfon formation. These are associated with mica-quartz-schists interbedded with some pelitic sediments and quartz-mica-schists. Where the amphibolites are observed to have a gradational contact with the various mica-schist beds (MacFarlane et al, 1981).

The Sonfon Formation is conformably overlain by the Tonkolili Formation which is composed of well-stratified interbedded thin beds of quartz-mica-schists, mica-quartz-schists, metamorphosed semi-pelitic to pelitic sediments and thin interbeds of meta-tuffaceous materials. The stratigraphic relationship between the quartz-mica-schist and the pelitic sediments is not clear, but appears to have an interfingering relationship.

The Tonkolili Formation occupies the majority of the project area and it is within the upper part of the sequence that the BIF is hosted. The geology of the Tonkolili formation is split into two, the upper part is mainly comprised of finer, well-stratified and alternating thin beds of mica-quartz-schist, semi-pelitic to pelitic sediments and possibly tuffites. The lower part of the sequence is composed of mostly coarser grained quartz-mica-schist which grade into quartzites further south of the area.

### *4.2.1 Stratigraphy*

Work undertaken to date includes the revised stratigraphy of the Simbili deposit which is summarised below (Figure 4-1). From hangingwall to footwall, the interpreted upper greenschist to amphibolite facies grade sequence comprises:

- Acid, acid to intermediate and intermediate to basic volcanic rock: green, fine grained, porphyritic aspect, hydrothermally-altered (silicification-potassification). The Mineralogy consists of quartz phenocrysts set in a fine grained matrix of biotite+amphibole+quartz. In drill intersections this rock presents variable compositional facies, probably due to magmatic differentiation (evolution). Gradational upper contact with overlying sequence.

- Acid-intermediate volcanoclastic rock: grey-green banded rock, fine to very fine grained. Grey bands comprise quartz+biotite+amphibole+chlorite+/-chalcopyrite and pyrite; green bands predominantly comprise amphibole and rare magnetite.

- Silicate itabirite: grey-green banded rock, low to moderate magnetite content comprising: amphibole+biotite+quartz+chlorite+magnetite+garnet;

- Quartz itabirite: characteristic compositional banding on a millimetre scale comprising alternate bands of microcrystalline quartz and magnetite with typical magnetite content >35-40%. The entire sequence has been metamorphosed to upper greenschist /amphibolite facies grade.

- Clastic-chemical sequence with tuffaceous contribution, metamorphosed to upper greenshcist /amphibolite facies grade. This sequence has a sharp contact with underlying rocks and presents facies variations within which contacts are gradational.
  - Metacarbonate-metapelite: shows compositional banding of mafic metamorphic minerals (amphibole-biotite-chlorite) alternating with bands richer in quartz+biotite and with common carbonate, and chalcopyrite+pyrite.
  - Acid pyroclastic rock: variable texture and grainsize from <2mm to >10cm diameter (breccia and bombs/ blocks) with reaction borders. Strong hydrothermal alteration (silicification-potassification); disseminations and veinlets of chalcopyrite+pyrite+pyrrhotite;
  - Marble-metacarbonate: recrystallised coarse grained calcite containing veins and boudins of amphibole, and disseminations and veinlets of chalcopyrite+pyrite+pyrrhotite;
  - Quartzo feldspathic rock: white, fine to very fine grained, silicified, comprising quartz and K-feldspar in roughly equal proportions. May have acid tuff/ fine quartzite/ volcanogenic origin. Weathering reduces it to clay.
  - Metapelite: banded, magnetic, and comprising amphibole +quartz+biotite+magnetite+garnet.

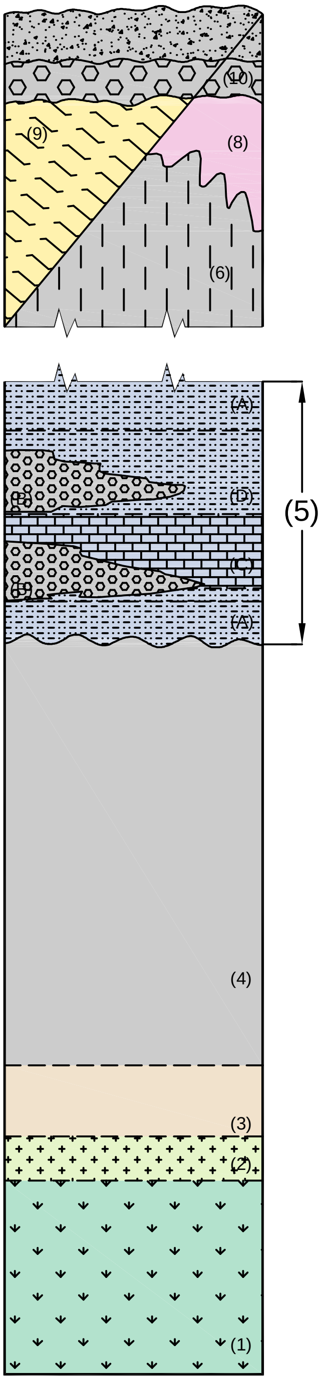
- Porphyritic acid dykes or sills containing phenocrysts of quartz: typically occur within the itabirite.

- Pegmatite dykes.

- Supergene enrichment of itabirite.
- Saprolite of quartz-K-feldspar rock.
- Hardcap comprising goethite containing voids.

Whilst this stratigraphic sequence has been devised specifically for Simbili, the various lithologies can be observed, to a greater or lesser extent, throughout Numbara and Marampon.

STRATIGRAPHY - SIMBILI PROJECT




(10) **Hardcap comprising goethite containing voids**

(9) **Saprolite of quartz-kfeldspar rock fragments and kaolin**

(8) **Supergene enrichment of itabirite**

(5) **Clastic-chemical sequence with tuffaceous contribution:** metamorphosed to upper greenschist/amphibolite facies grade. This sequence has a sharp contact with underlying rocks and presents facies variations within which contacts are gradational

(A) **Calc-silicate rocks:** show compositional banding of mafic metamorphic minerals (amphibole+biotite+chlorite) alternating with bands rich in quartz+biotite and with common carbonate,calcopyrite+pyrite

(B) **Acid pyroclastic rock:** variable texture and grain size from <2mm to 10cm diameter (breccia and bombs/blocks) with reaction borders. Strong hydrothermal alteration (calcification-potassification) disseminations and veinletts of chalcopyrite+pyrite+pyrrhotite

(C) **Impure marble:** recrystalised coarse grained calcite containing veins and boudins of amphibole and disseminations and veinlets of chalcopyrite+pyrite+pyrrhotite

(D) **Qurtzofoldspathic rock:** white, fine to very fine grained silicified, comprising quartz and kieldspar in roughly equal portions.May have acid tuff fine quartzite volcanogenic origin. Weathering reduces it to clay.

(E) **Metapelite:** banded,magnetic and comprising amphibole+quartz+biolite+magnetite+garnet. Not observed in all drill sections

(4) **(BIF) Quartz itabrite:** characteristic compositional banding on a millimeter scale, comprising alternate bands of microcrystalline quartz and magnetite with typical magnetite content >35-40%. The entire sequence has been metamorphosed to upper greenschist/ amphibolite facies grade

(3) **(BIF) Silicate Itabrite:** grey-green banded rock, low to moderate magnetite content comprising: magnetite+biotite+quartz+chlorite+magnetite+garnet

(2) **Acid-intermediate volcanoclastic rock:** grey-green banded rock, fine to very fine grained. Grey bands comprise quartz+biotite+amphibole+chalcopyrite and pyrite: green bands predominantlly comprise amphobole and rare magnetite

(1) **Acid, acid to intermediate and intermediate to basic volcanic rock:** green, fine grained, porphyritic aspect, hydrothermally-altered (sillicification-potassification). Minerology quartz phenocrysts set in a fine grained matrix of biotote+amphibole+quartz. In drill intersections this rock presents variable compositional facies, probably due to magmatic differentiation (evolution). Gradational upper contact with overlying sequence.

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| SRK Consulting Engineers and Scientists | | Schematic Simbili Stratigraphy | Fig 4-1 |

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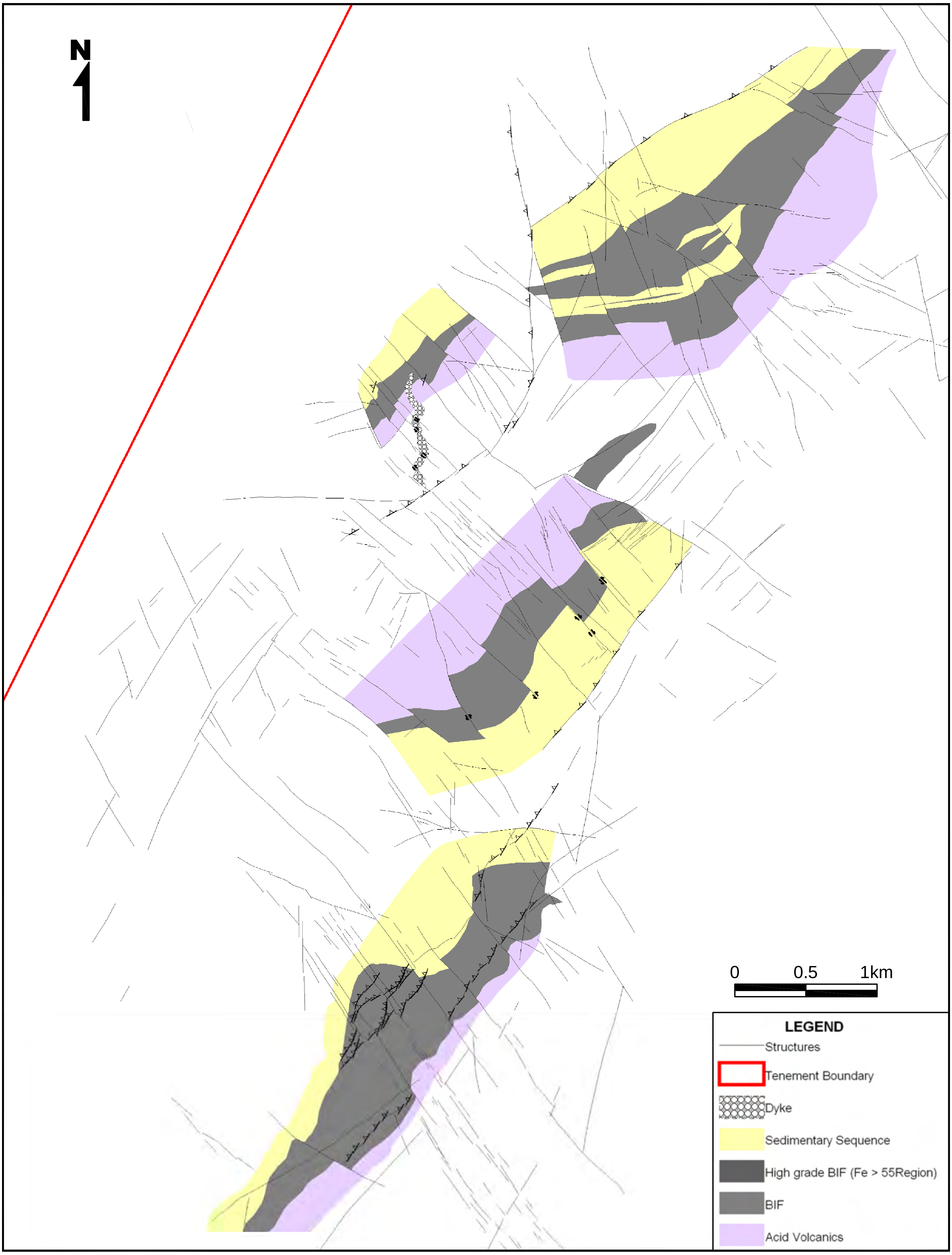


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|---|---|---|---|
| SRK Consulting Engineers and Scientists | | Schematic Simbili Stratigraphy | Fig 4-2 |

### *4.2.2 Structure*

The Tonkolili iron deposits are arranged in a left-stepping array, at a very low angle to the overall trend. Major lineaments along the margins of several of the deposits shown on magnetic survey data are interpreted as significant shear zones which have tectonically interleaved and juxtaposed the deposits.

The rock units of the Kambui Super Group which includes the Sonfon and Tonkolili Formations have been subjected to at least two sets of deformation which have developed a broad south plunging synform with northeast trending open folds. These folds are documented (Frikken, 2006) to have been formed during a major northwest-southeast compressional event related to the Leonean Orogeny. These folded metamorphosed volcano-sedimentary sequences have been further disturbed by an array of northeast to north northeast and northwest to north northwest trending lineaments or faults.

The main BIF units comprising the Tonkolili resource constitute a relatively simple package of moderately to strongly sheared ironstones, dipping steeply towards the NW. Original depositional banding within the ironstones is almost entirely lost due to metamorphism and deformation. However, a strong tectonic fabric manifested as compositional banding defines the structure of the rocks and dips moderately to steeply towards the Northwest. This relatively planar fabric has resulted from top-to-the-southeast shear along the NE-striking belt and locally grade into lower strain zones where folds with axial planes dipping parallel to the banding is evident.

The down-dip extension of the Simbili deposit is affected by a series of subvertical, SE-side-down shear zones which tectonically interleave BIF and country rocks. This shear zone and several others like it are believed to flank the main deposit areas and are responsible for juxtaposing the main ironstone units. Tectonic contacts between the units are characterised by change in foliation orientation and strain intensity, strong chlorite-actinolite alteration and, occasionally, narrow slivers of country rock. The setting of the Tonkolili project is provisionally interpreted as an over-steepened thrust zone or pure-shear dominated zone of sinistral transpression.

The main Tonkolili range is affected by a set of steep to subvertical northwest-striking fault zones, which accommodate decimetre-scale apparent displacements of the magnetite resource. These appear to be zones of preferred fluid ingress and weathering of the ironstones.

The geometry of the fabrics and the belt as a whole is closest to either an over-steepened thrust belt (i.e., back-tilted), or a positive flower structure in a zone of pure shear dominated transpression (contraction with a subordinate component of transcurrent movement).

### 4.2.3 *Deposit Geometry*

The deposits generally strike NE-SW, dipping 60-70° towards the NW, with the exception of Marampon, which dips at angle of approximately 24° (also towards the NW). Simbili extends over a strike length of approximately 3600m, Numbara 3000m, Marampon 1600m and Kasafoni 7600m. Simbili and Numbara range in thickness from 80 to 550m. Marampon and Kasafoni are generally narrower at 60-220m. The Kasafoni and Numbara South areas of the deposit are not covered within the remit of this baseline study and as such will not be further mentioned (Figure 4-3).

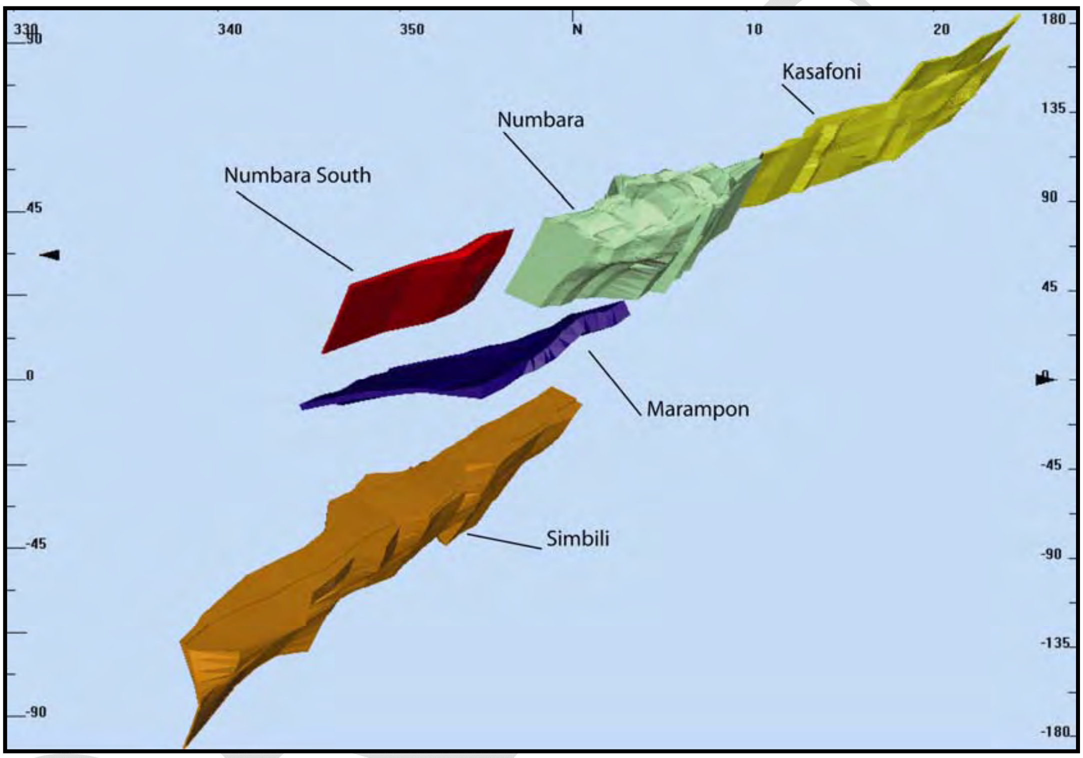


**Figure 4-3. Orebodies; geometries and sizes**

### 4.2.4 *Seismicity*

Earthquakes are a negligible risk at Tonkolili, the USGS National Earthquake Information Centre has recorded no earthquakes where the epicentre was within a 180km of the Tonkolili deposit. In fact there have only been five recorded earthquakes where the epicentre was within a 500 km radius of the Tonkolili deposit which occurred in 1983, 1987, 1995, 2001 and 2004, all of which occurred within the neighbouring countries of Guinea and Liberia.

## 4.3 Surficial Geology

Ten regolith zones have been defined and exist in varying proportions depending on the underlying geology (Table 4-1). The zones predominantly define hillside and hilltop domains.

### Table 4-1. Regolith zones

| REGOLITH ZONE | | |
|---|---|---|
| **Code** | **Name** | **Description** |
| DET | Detrital | soil, alluvium, colluvium, duricrust, fragments of canga |
| SHC | Hardcap | canga, ferricrete, calcrete, silcrete |
| SUP | Upper Saprolite | no primary texture >10% goethite-hematite |
| SLO | Lower Saprolite | primary texture >10% goethite-hematite |
| SSR | Saprock | primary texture <10% goethite-hematite |
| SBR | Bedrock | primary texture no goethite-hematite |
| SUH | Hydrated | goethite > hematite - colloform, vitreous |
| SUD | Dehydrated | hematite > goethite - colloform, vitreous |
| SUM | Main | hematite > goethite - platy, granular, porous, friable, powdery |
| SUL | Leached | goethite ochre-yellow > hematite - earthy, powdery |

The regolith zone at Numbara has a depth ranging from 14 to 120m, with an average depth of 73m, compared with 64m at Simbili, which exhibits a depth range of 2-158m (Figure 4-4). The area immediately above and down slope of the magnetite BIF is dominated by hematite and goethite rich duricrust, which ranges from soft hematite sand to hard, silica and alumina rich duricrust.

As the orebody extends down dip the overlying surficial lithologies tend towards iron poor, silica and alumina rich saprock typified by earthy, powdery lithologies.

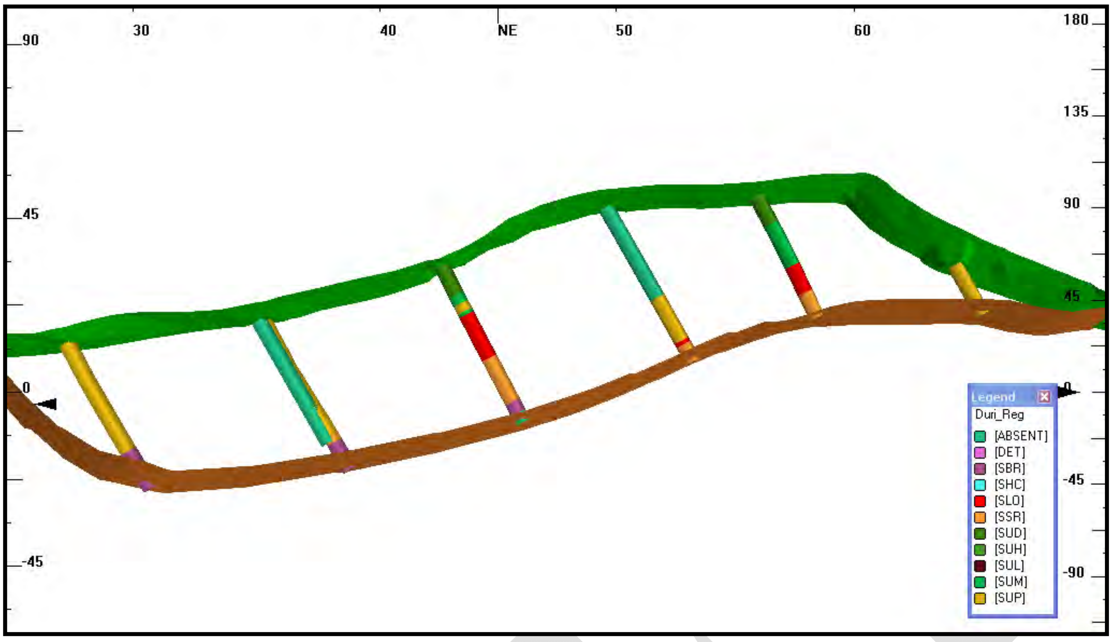


**Figure 4-4. Oxidised regolith zones on Simbili. The green surface represents topography and the brown, base of the oxidised zone. The drillholes are coloured by logged lithology**

## 4.4 Geological Exploration

### *4.4.1 Drilling*

AML has undertaken surface trenching, RC and diamond drilling and across both Numbara and Simbili, surface trenching and diamond drilling across Marampon. The diamond drilling makes up the majority of the database that intersects the primary BIF mineralisation and laterite duricrust while the RC drilling and surface trenching is limited to the laterite duricrust.

Numbara has been drilled on a dominant 300 m Y by 100 m X grid with partial infill drilling on a 100 m Y by 100 m X grid. Simbili has been drilled on a dominant 200 m Y by 100 m X grid, Marampon has been drilled on a 200 m Y by 200 m X grid (Table 4-2).

**Table 4-2. Drill spacings for each deposit.**

| Project | Dominant Drill Spacing (m) | Number of Drillholes | Total Metres | Total Metres (May 2009 Update) |
|---|---|---|---|---|
| **Numbara** | 300 x 100 | 97 | 40,355 | 37,018 |
| **Marampon** | 200 x 200 | 19 | 6,339 | 3,858 |
| **Simbili** | 200 x 100 | 140 | 31,678 | 29,676 |
| | **Total** | **293** | **90,893** | **70,552** |

The majority of holes have been drilled dipping to the southeast, on an azimuth of 130° and a dip of -60°, to intersect perpendicular to the BIF units that dip to the northwest. Shallow vertical holes have been completed in the laterite duricrust at the Simbili deposit.

### *4.4.2 Geophysical Surveying*

Magnetic surveys were flown over the license area in mid 2005 by Firefly Aviation Inc of Calgary, Canada, to aid in the evaluation of the iron ore potential. The data presented for this license represents the merging of several separate datasets including the original Tonkolili survey totalling 404 line km at 200 m line spacing, a historical survey flown at 200 m spacing and an infill survey flown to close the historic data at 100 m line spacing. In addition AML have also performed a series of ground magnetic surveys at an infill 200 m line spacing.

## 4.5 Mineral Resource Estimation

The Mineral Resource Statement (Table 4-3) released by SRK in May 2009 was restricted to that BIF material falling within the Whittle Shell derived using a metal price of 80 USc/dmtu. This represents the material which SRK considers has reasonable prospect for eventual economic extraction potential based on the above Whittle optimisation analysis.

In total, Numbara, Marampon and Simbili have a combined resource of 5.1 Bt grading 30.0% Fe Total, 26.5% Fe Mag, 45.3% $SiO_2$ and 4.7% $Al_2O_3$. Davis Tube testwork results in a mass recovery of 29.0% for 1.5 Bt of concentrate grading at 67.7% Fe, 4.92% $SiO_2$, 0.48% $Al_2O_3$ and 0.01% P. Numbara contains an Indicated Resource of 1.6 Bt, Marampon an Indicated Resource of 0.4 Bt and Simbili an Indicated Resource of 1.1 Bt. Approximately 60% of the resource has been classified as an Indicated Resource (Figure 4-5; Figure 4-6).

**Table 4-3. May 2009 Mineral Resources for Simbili, Numbara, Marampon and Combined**

| Deposit | Resource Category | Billion Tonnes (Bt) | FE_TOT % | SIO2 % | AL2O3 % | P % | MN % | CAO % | MGO % | TIO2 % | FE_MAG % | MREC % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Numbara | INDICATED | 1.6 | 30.2 | 44.6 | 5.1 | 0.05 | 0.41 | 2.3 | 1.8 | 0.2 | 25.7 | 28.3 |
| | INFERRED | 0.5 | 28.6 | 45.7 | 5.7 | 0.05 | 0.38 | 2.5 | 1.9 | 0.2 | 23.9 | 26.5 |
| | **TOTAL** | **2.1** | **29.8** | **44.9** | **5.2** | **0.05** | **0.40** | **2.4** | **1.8** | **0.2** | **25.3** | **27.8** |
| Marampon | INDICATED | 0.4 | 28.8 | 46.6 | 4.7 | 0.06 | 0.29 | 2.8 | 2.9 | 0.1 | 27.4 | 29.2 |
| | INFERRED | 0.1 | 30.1 | 45.8 | 4.0 | 0.05 | 0.30 | 2.8 | 2.9 | 0.1 | 27.6 | 29.9 |
| | **TOTAL** | **0.5** | **29.0** | **46.5** | **4.6** | **0.06** | **0.29** | **2.8** | **2.9** | **0.1** | **27.4** | **29.3** |
| Simbili | INDICATED | 1.1 | 32.1 | 44.1 | 3.5 | 0.05 | 0.33 | 2.7 | 2.3 | 0.1 | 28.7 | 32.2 |
| | INFERRED | 1.4 | 29.0 | 46.5 | 4.8 | 0.05 | 0.33 | 2.7 | 2.3 | 0.2 | 26.1 | 28.1 |
| | **TOTAL** | **2.5** | **30.4** | **45.4** | **4.2** | **0.05** | **0.33** | **2.7** | **2.3** | **0.2** | **27.3** | **30.0** |
| Combined | INDICATED | 3.1 | 30.7 | 44.7 | 4.5 | 0.05 | 0.4 | 2.5 | 2.1 | 0.2 | 27.0 | 29.8 |
| | INFERRED | 1.9 | 28.9 | 46.3 | 5.0 | 0.05 | 0.3 | 2.6 | 2.2 | 0.2 | 25.6 | 27.8 |
| | **TOTAL** | **5.1** | **30.0** | **45.3** | **4.7** | **0.05** | **0.4** | **2.6** | **2.2** | **0.2** | **26.5** | **29.0** |
| **Magnetic Concentrate** | | **1.5** | **67.7** | **4.92** | **0.48** | **0.01** | | | | | | |

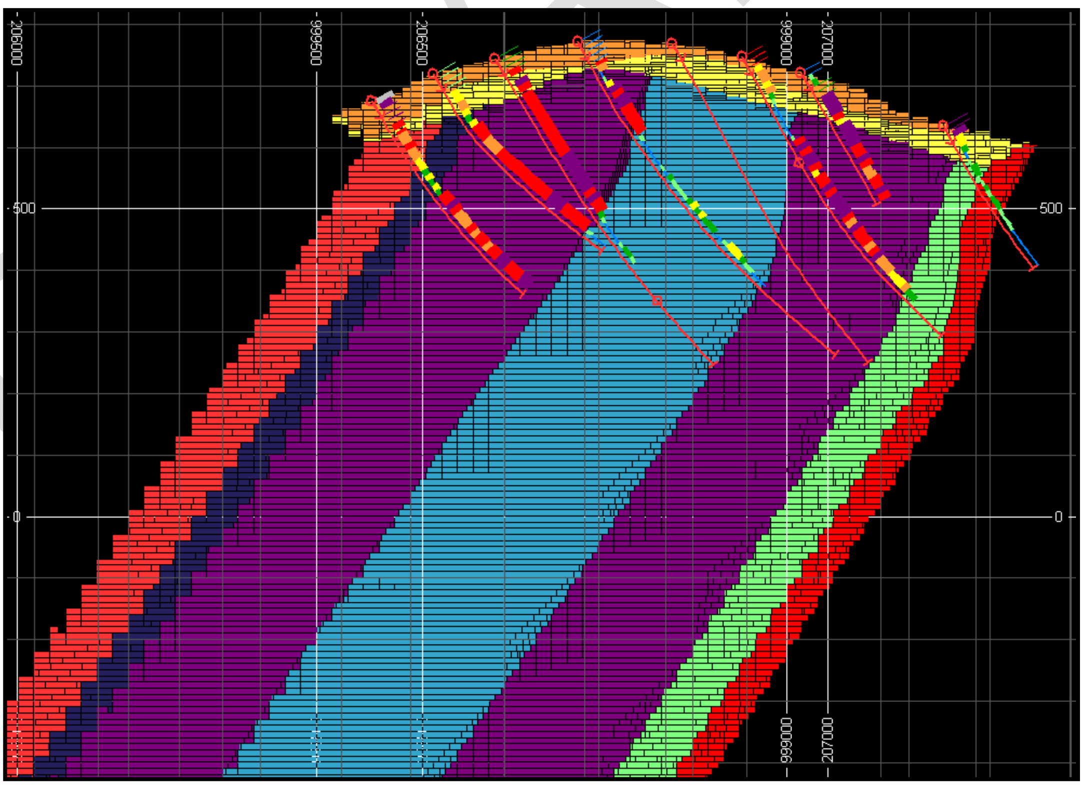


**Figure 4-5. Section through the Numbara Block model. High grade BIF domain – purple; low grade BIF domain – red; transitional – yellow; amphibolites – blue, green; duricrust – orange**

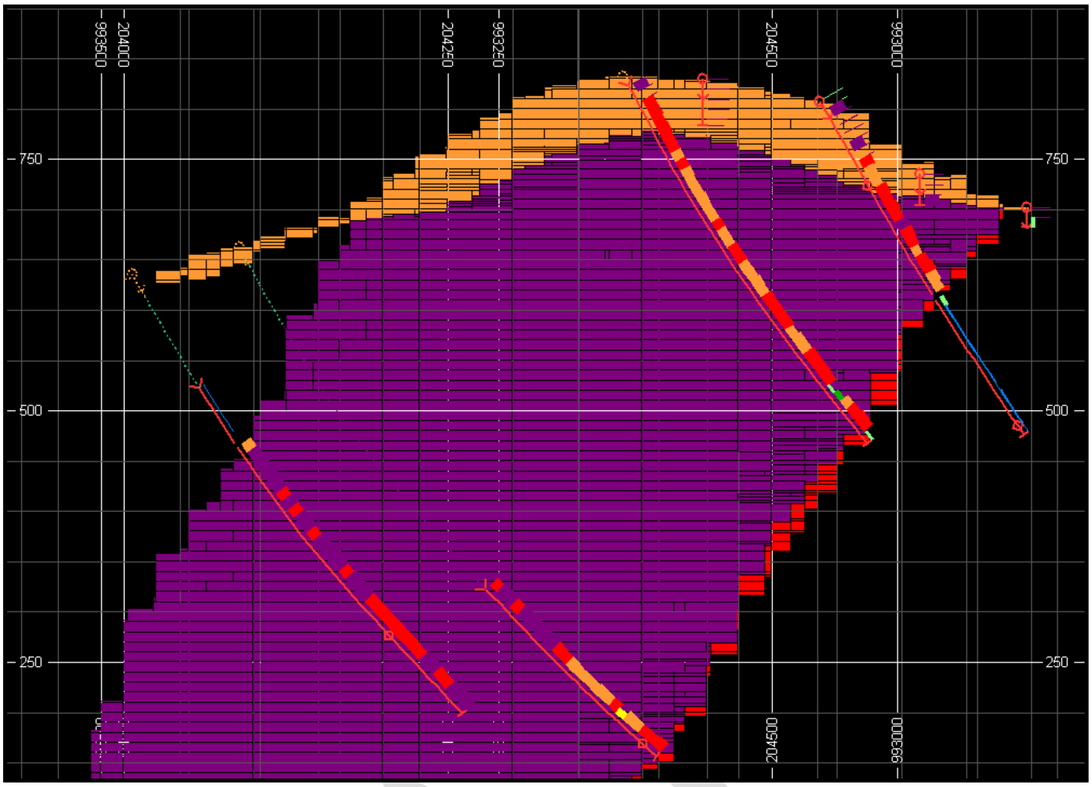


**Figure 4-6. Section through the Simbili Block model. High grade BIF domain – purple; low grade – red; transitional – yellow; duricrust – orange**

## 4.6 Open Pit Optimisation

The Mineral Resources have been reported within a Whittle optimised open pit shell to define that material which has the potential for economic extraction, giving an indication of the potential pit area of the proposed mine. This exercise includes consideration of slope angles, mining costs, mining dilution and losses, ore treatment and recovery, transport costs, royalties and metal prices. The resultant shells represent a possible outline of the potential open pit mine, and do not represent the final pit design (Figure 4-7).

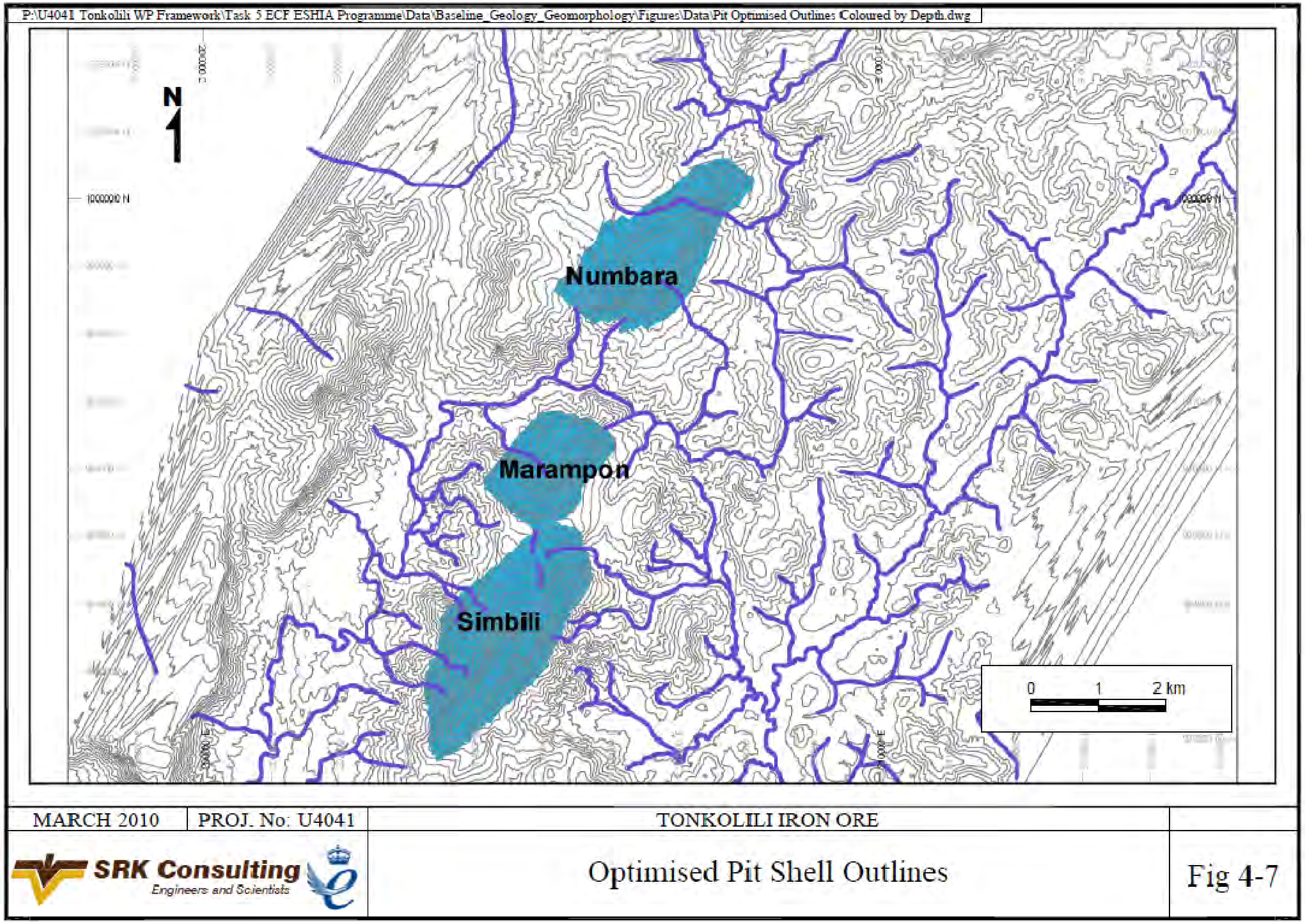


**Figure 4-7. Whittle optimised pit outlines for Simbili, Numbara and Marampon.**

# 5 GEOMORPHOLOGY

## 5.1 General description

The Tonkolili region is made up of high rugged mountain ranges, eroded plateaus and smooth hill tops that rise from 200 to 880 m in elevation. The lowest points which form narrow valleys and gorges have elevations of between 200 to 350 m. Within the license area, the smooth hill tops and plateaus trend in a north-easterly direction and are deeply incised by the Tonkolili River drainage system which flows to the south east. Most of the steeply inclined drainages are filled with laterite duricrust and boulders, whereas, the downstream valley-floor areas are typically swampy and flat-lying. Within the larger area hills have a dominant NE-SW to NNE-SWW trend and are intersected by approximately orthogonal valleys, which expand out towards the south of Numbara.

The Tonkolili area consists can be subdivided into three distinct geomorphological domains that directly reflect topography. The topographically lowest domain exists at the base of the valleys and extends approximately 20 m up slope. This domain yields to the steeply inclined hill sides (second domain), which in turn lead to the peneplainised hill tops, constituting the third geomorphological domain:

- Accumulative valley deposits (domain 1)
- Denuded weather slopes (domain 2)
- Deeply weathered Peneplains (domain 3)

The local topography is reasonably steeply inclined (see Figure 5-1) with hill sides that typically range from 15° to 45°. Small cliff sections are common, particularly at the crest of the numerous landslides, which possess elevated slope angles in excess of 45°. The east facing slopes of Simbili and west facing slopes of Numbara South represent the steepest parts of the deposits The undulating bases of valleys dip from 0° to 15° over short ranges.. In general, the peneplainised hill tops appear as small areas of near horizontal terrain (0-5°~) surrounded by progressively steeper ground (moving downslope).

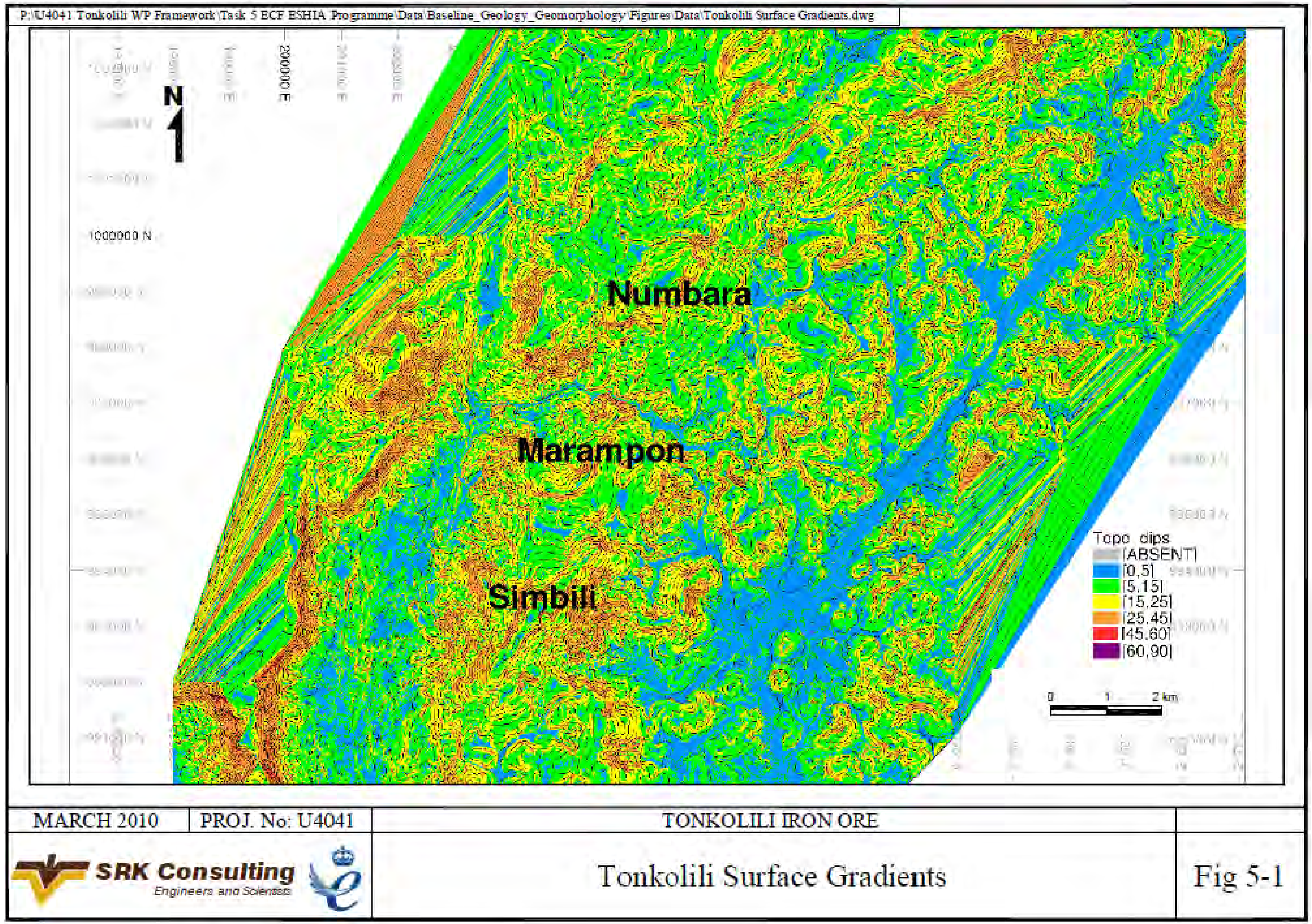


**Figure 5-1. Topographical gradients (in degrees) of the proposed Tonkolili Mine and surrounding area**

### *5.1.1 Geomorphological Domains*

**Accumulative valley deposits**

The accumulative domain consists of deposits of Quaternary alluvial sands, silts, clays and conglomerates forming as thick, river cut successions at the base of wide "U" shaped valleys. Alluvial material is overlain by thin deposits of soil. Sedimentation and development of this domain is particularly active in the wet season via the transport of suspended sediment, and eroded in the dry season, by the frequent heavy rains. This domain typically expands in width towards the south of the project area, where valleys expand from 100-200m in the north to 1.5-2km south of Simbili.

The valley domain varies from flat lying sediment accumulations to gently undulating mounds and depressions, vegetated by grasses, small trees and localised dense tropical bush (progressing respectively from the middle of valleys to edges).

**Denuded, deeply weathered slopes**

The deeply incised (by the Tonkolili River drainage system) slopes that extend from the valley bottoms to the peneplainised hill tops consist of a mixture of autochthonous weathered BIF and allochthonous boulders and Fe-rich soils. Slopes are cut by runnels which range in morphology from shallow seasonal channels to densely vegetated, deeply weathered perennial runnels associated with aquifer discharge and wet season runoff.

**Peneplains**

The hill tops are typically gently inclined plateaus, split by steeper horseback-crest style relief and short, steep ramps. These areas range in gradient from 0° to a maximum of 10° (Figure 5-2).

The southern half of Simbili, which is geomorphologically distinct from the northern end, is typically more undulating along its length than Marampon and Numbara. This area consists of narrower interlinked peneplains, connected by 10-25° ramps either side of the hill top.

This domain is deeply weathered, up to approximately 100m resulting in a variable soil profile, which is dependent on the positions of the BIF subcrop. Typically this domain is vegetated by grassy scrubland to green bush with small trees and shrubs.

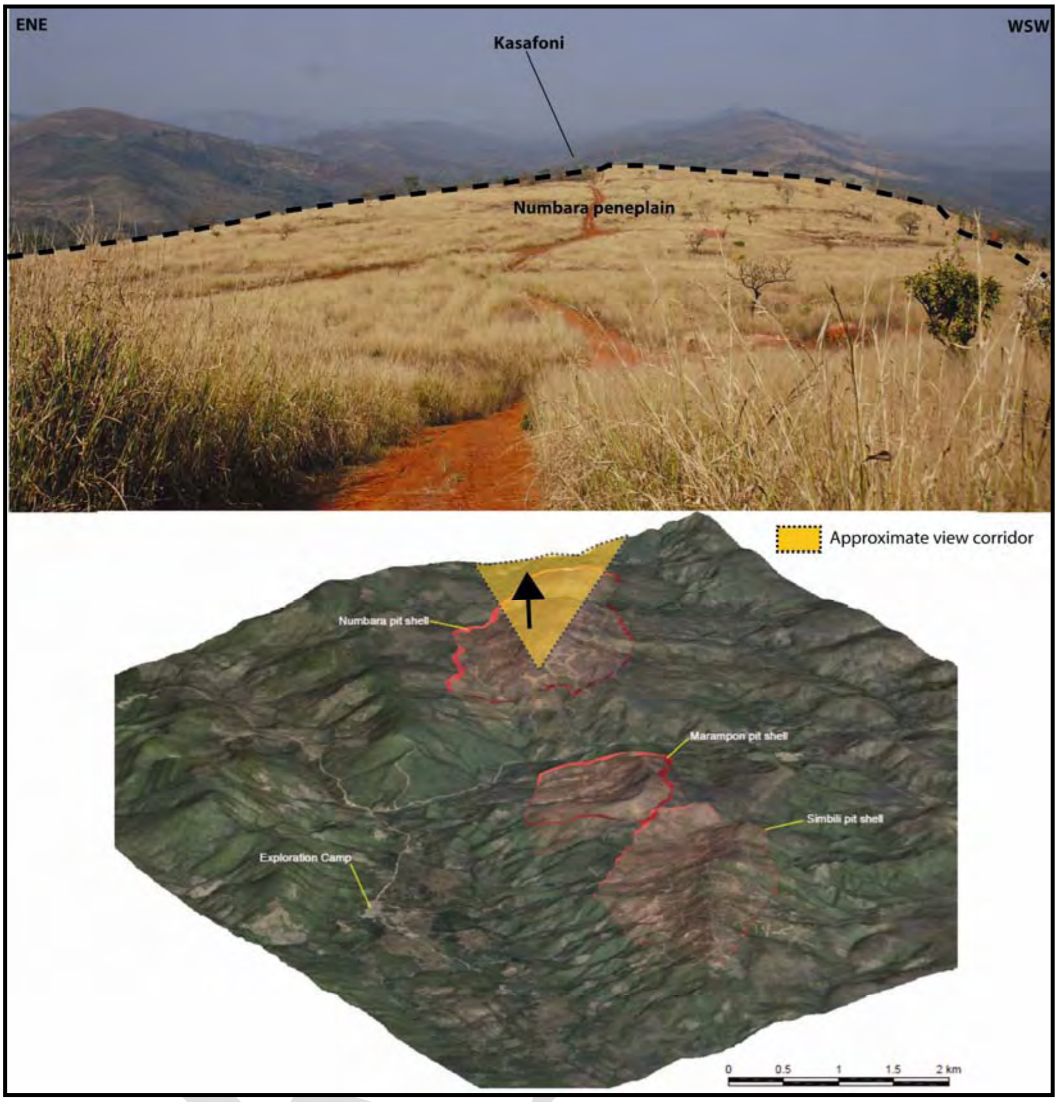


**Figure 5-2. Numbara peneplain, looking towards Kasafoni**

### 5.1.2 Landslips

A number of significant landslips exist around the deposits with perhaps the most sizeable located on the upper SW slope of Simbili (Figure 5-3).The landslips are characterised by steep (>70°) main scarps beneath the landslide crown, and progressively shallower minor scarps (60° down to 25°) towards the toe/toes of surface rupture area of the slide. Further downslopes, landslides are expressed by convex, radial structures with prominent transverse ridges at a reduced gradient (15-30).

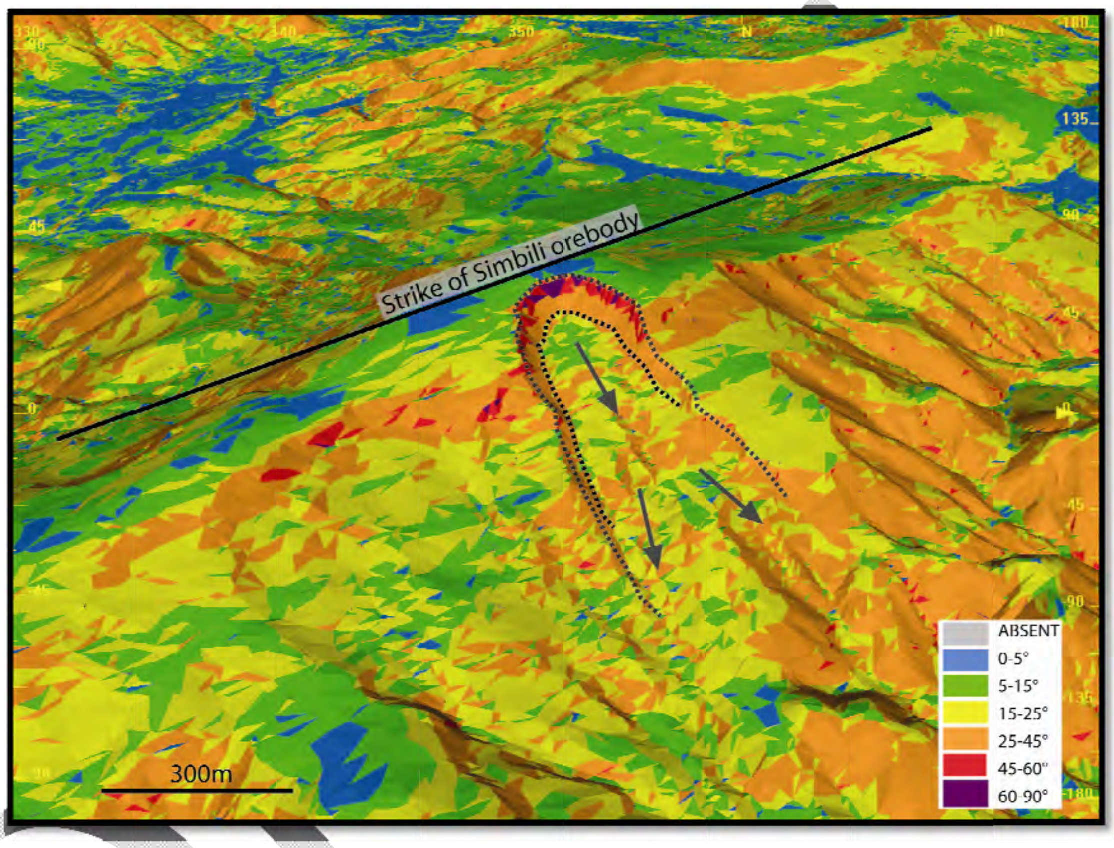


**Figure 5-3. Prominent landslide of the east facing slope of Simbili**

# 6 HYDROGEOLOGY

### 6.1.1 Regional Hydrogeology

The Tonkolili River (Figure 6-1) lies within the catchment of the Seli River basin. The Seli River (also referred to as the Rokel) is the largest river in Sierra Leone, draining a basin of 10,620km$^2$ on its 400km south westerly course toward the Atlantic. The river rises in the interior plateaux and hill ranges of Sierra Leone and empties into the Sierra Leone Estuary.

The maximum average monthly flow in the Seli River at Bumbuna occurs during September, and the minimum during March. Peak flows are greatest between July and October (600 to

1200m$^3$/s). The mean annual discharge of 113m$^3$/s is equivalent to around 890 mm of annual rainfall.

Within the area immediately surrounding the Tonkolili Project, rectangular, trellis, dendritic, parallel and annular drainage patterns can be observed (Table 6-1). Rectangular patterns prevail in the northern parts of the Sula Mountains, extending as far south as the town of Bumbuna. Between the deposit areas there is a strong structural control, with broadly parallel to dendritic (almost trellis) drainage patterns trending NE-SW to NNE-SSW. Annular patterns are common over areas of granitic intrusion and other dome like structures (Wilson & Marmo, 1958).

**Table 6-1. Length weighted percentage of river azimuth in the Tonkolili-Sula Mountains region**

| Dominant Azimuth | Percentage - by length |
|---|---|
| 125-135 | 18 |
| 45-60 | 17 |
| 25-35 | 14 |
| 150-165 | 14 |
| 85-100 | 13 |
| 170-5 | 11 |
| 70-80 | 6 |
| 105-115 | 6 |

Lower valley areas (geomorphological domain 1) typically exhibit parallel or dendritic drainage patterns, whereas slope areas (domain 2), are more commonly characterised by dendritic, parallel and sub-parallel drainage patterns.

The Tonkolili River is likely to follow the lithological contacts between more resistant quartz schist and another (unknown), softer lithology. It is suggested that NW-SE trending sections of the river are likely to parallel the strike of a regional set of faults that exist in that orientation.

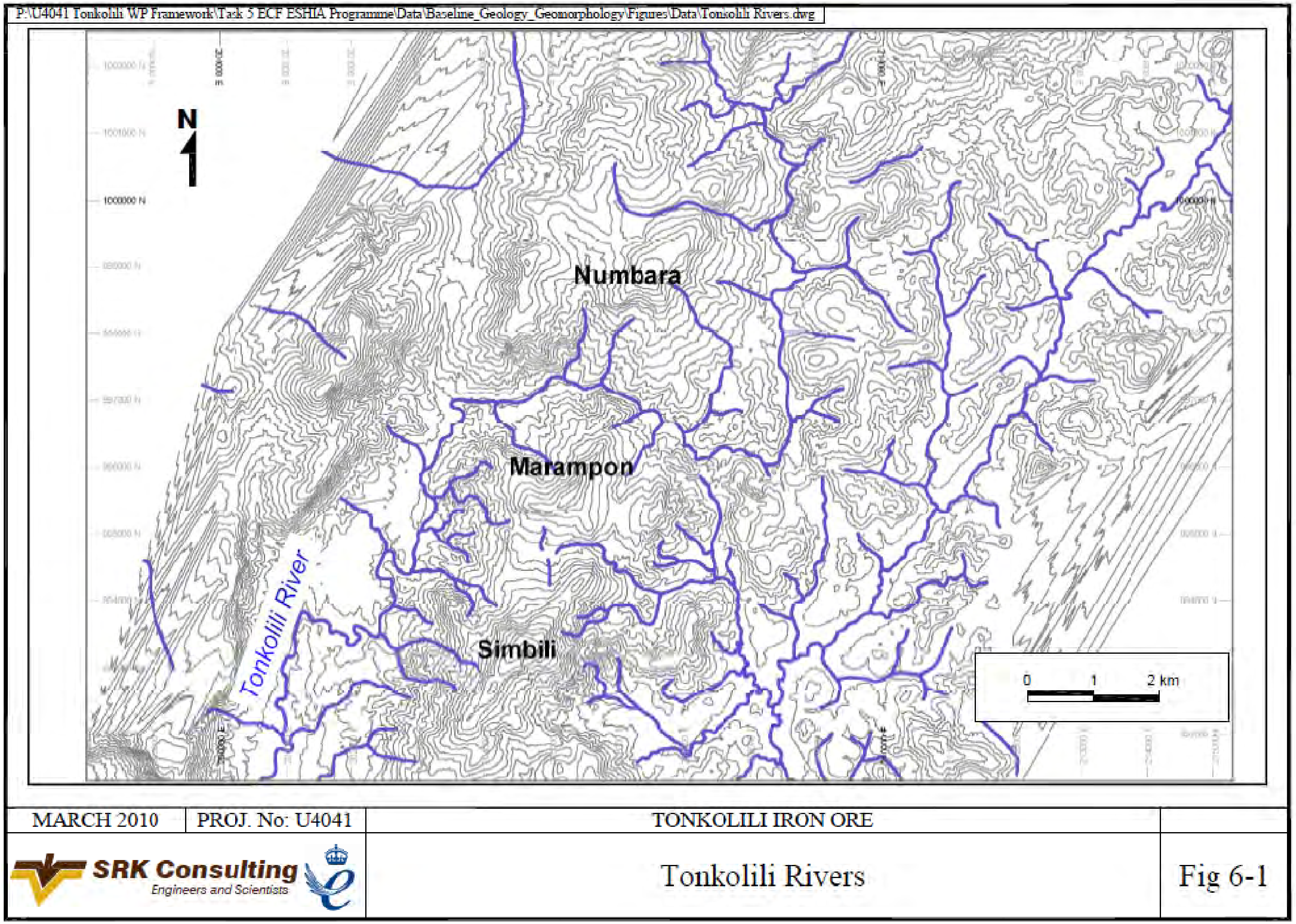


**Figure 6-1. Digitised rivers showing the Tonkolili River and associated drainage catchment**

### *6.1.2 Local Drainage and Flow Characteristics*

The sites of Numbara, Marampon and Simbili are drained by three main catchment areas. All three sites drain in a westerly direction towards the Rokel River catchment (south of the Bumbuna Dam). Whilst the Numbara site drains exclusively to this catchment, the Marampon and Simbili sites also drain easterly into the Mawura catchment. The westerly draining water contributes to the Tonkolili River.

The majority of groundwater flow at the Simbili, Numbara and Marampon deposits occurs through the weathered cap, which comprises partially weathered amphibolite and BIF. Within this zone, most groundwater flow occurs through open fractures. The weathered cap exhibits a permeability that is approximately one order of magnitude higher in the fractures than in the matrix. Connectivity of fractures varied between test sites and between observation wells at the same test site, which demonstrates the heterogeneous nature of the weathered cap aquifer (SRK Open pit hydrogeological investigation, 2010).

Although differences in permeability between the weathered BIF on Simbili and the weathered amphibolite on Numbara may be lithological, it is likely that the principal control on the connectivity and alignment of fractures in the weathered cap is structural. However, little data exists on the distribution and orientation of fracturing in the weathered cap. A structural interpretation of the geotechnical logging data from the weathered cap (and other geological units) is clearly required.

Whatever the control on fracture extent, it is clear from the testwork that the weathered cap is significantly more permeable (hydraulic conductivity (K)=E-1 to E-3m/d) than the more completely weathered and transported material present on the hill flanks (K=E-4 to E-5m/d). From examination of the existing core, it is also likely that the underlying fresh BIF and amphibolite are significantly less permeable than the weathered cap, a hypothesis that is supported by the very dominant spring line which surrounds all three deposits. However, this may again depend heavily on structural features and the permeability of the underlying fresh rock has not been directly investigated in this study.

The completely weathered rock that makes up the overlying laterite and, locally, the duricrust mainly comprises silt-grade material.

Although the laterite/duricrust is unlikely to play an important role in terms of groundwater flow, it may play a significant role in groundwater recharge. It is possible that the laterite/duricrust may act as a buffer to rapid recharge the groundwater flow to springs as well as to direct through flow to springs, which in turn would control the hydrograph response in the rivers. Removal of the laterite/duricrust could see a more flashy hydrograph response in the Tonkolili and Mawura rivers.

The conceptual hydrogeological model (Figure 6-2) can be summarised as follows. Recharge percolates through the laterite or duricrust into the weathered cap from where the majority of groundwater flows laterally, at the contact with fresh rock, towards the ridge flanks and discharges through springs to the surface water network. The component of groundwater flow from the weathered cap to the colluvium is unknown but is considered to be low given the generally low permeability of the colluvium. Similarly, it is thought that groundwater flow from the weather cap to the underlying fresh BIF and amphibolite, which appears to be generally competent, is also low.

Mining operations are likely to encounter potentially moderate to high initial inflows from groundwater as the pit progresses below the water table, but these inflows are likely to be short lived as groundwater flow from fracture storage is depleted. As the cone of depression from the open pit extends to beyond the limit of the weathered cap and into the colluvium, inflows with reduce again.

The impact of mining on groundwater-fed springs discharging from the flanks of the deposits will most likely be significant as the source of groundwater to springs is dewatered from the pit. This will affect river baseflow, which will be most noticeable during the dry season. However, the extent of the impact on baseflow is not known and should be investigated further in the coming stages of the investigations.

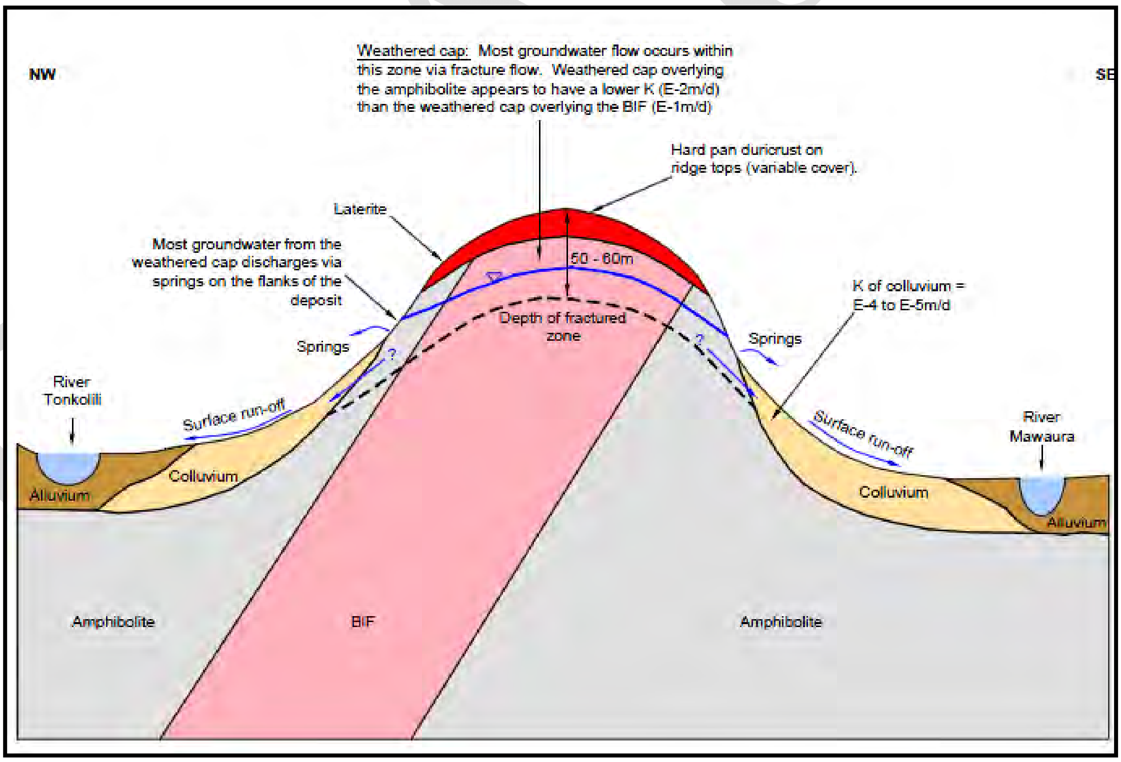


**Figure 6-2. Conceptual hydrogeological model for Tonkolili**

# 7 IMPACTS AND MITIGATION MEASURES

## 7.1 Impacts

During the mining operations, mine site infrastructure and mine waste disposal will sterilise the potential for undertaking further exploration in parts of the project area, and hence sterilise the use of existing resources. However, work is being undertaken to ensure that there is no sterilisation of resources in key areas of proposed infrastructure/construction.

The ore will be extracted by open-pit methods, which will be optimised to suit the orebody geometry and ground conditions. Mining of the ore amounts to the use of a non-renewable resource; such that once the reserves are depleted this natural resource cannot be used again. The optimised pit shells suggest the designed pits will occupy a significant area. For example, the Simbili open pit may be up to 4 km in length and over 2 km wide (Figure 7-1).

Potential impacts on the geology and geomorphology of the Project Area include:

- changes to the topography and geological unit geometry as a result of exploratory drilling and trenching, infrastructure construction, open pit extraction, waste rock storage, stockpiling and an extensive tailings facility;
- human-induced landslides and other slope processes due to man-made ground vibrations;
- changes in rock stress regimes;
- potential changes in flow regime, and water quality, of rivers, along with other ephemeral watercourses, and groundwater, due to extraction and new infrastructure, and stockpiling potentially harmful material;
- loss of land capability indefinitely in the pit area and in areas of new infrastructure;
- alteration of overland flow and gully pathways due to extraction, infrastructure and waste and stockpile dumps;
- alteration of local topography surrounding incline ramp, pit, tailings storage dam, waste rock dumps, processing plant and associated infrastructure (roads etc); and
- creation of man-made soils.

Current exploration work, in the form of trenching, pitting and drill pad construction has already altered the topography of the area, resulting in changes to local watercourses, overland flow rates and sedimentation, by weathering and erosion. These changes compound the existing geological and geomorpholoigcal impacts resulting from extensive artisanal gold mining that is centred on most local watercourses.

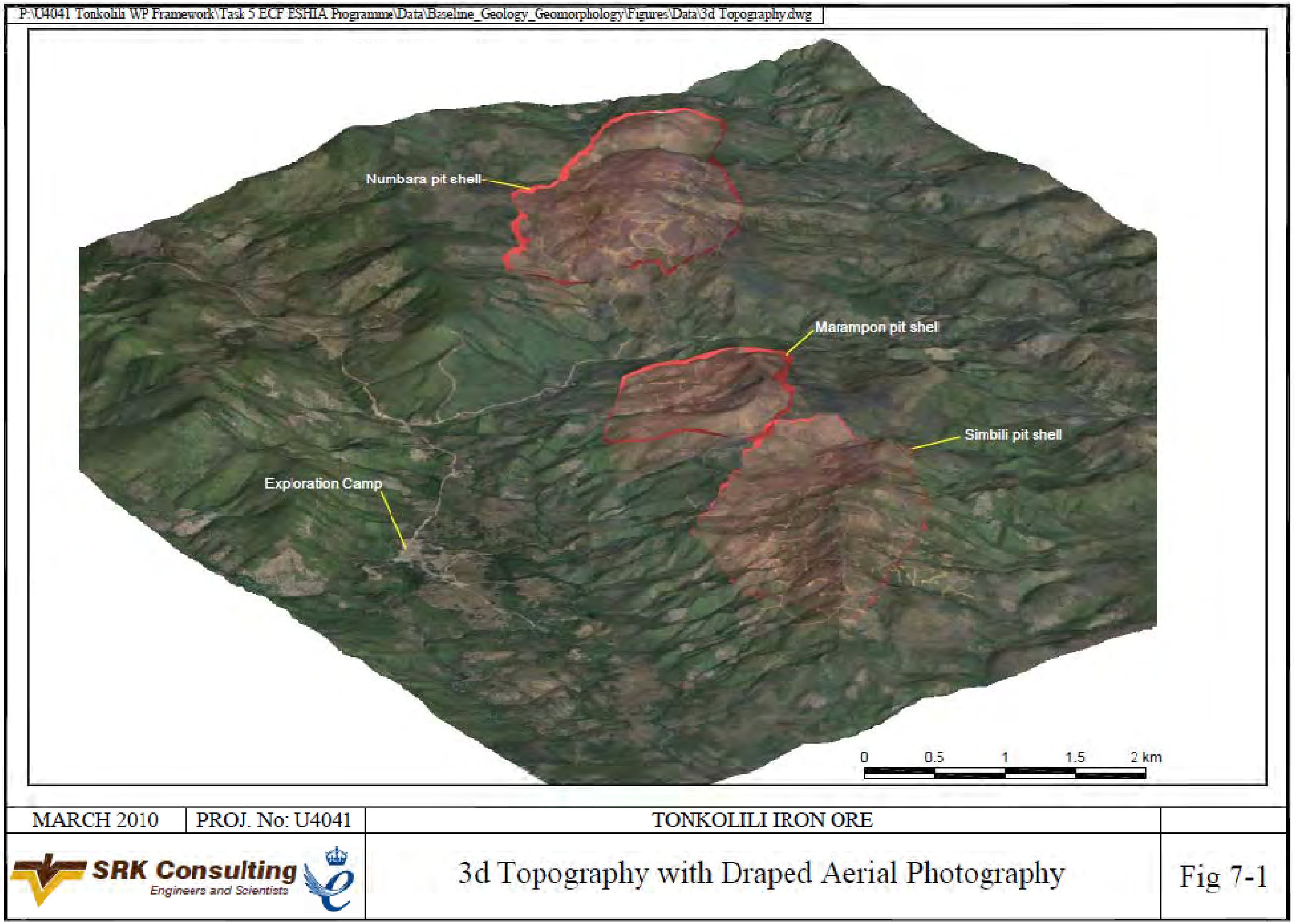


**Figure 7-1. 3D topography with draped aerial photography, showing the surface outlines on the Whittle pits**

## 7.2 Mitigation

To reduce the effect the mine will have on the geology and geomorphology of the Project Area, the following recommendations should be adhered to:

- Preserve watercourses where possible, and divert others to protect excavations and containment areas (that is, infrastructure stability).

- Reclaim and rehabilitate land disturbed during construction by re-grading, re-contouring and replacing topsoil following closure and decommissioning.

- Rehabilitate and landscape areas disturbed during construction of permanent/semi-permanent structures.

- Reuse excavated material, where possible, for further construction and earth works, in order to minimise the necessity for construction associated quarrying in the area.

- Reduce harmful effects on the shape of the landscape by using well-designed blasting programmes and mining techniques to minimise vibrations.

# 8 CONCLUSIONS

Following studies by SRK a number of key conclusions have been reached that outline the geological and geomorphological impacts of the Tonkolili Iron Ore Project. This Baseline study represents a contribution towards the Scoping Report and eventual Environmental and Social Impact Assessment (ESIA) report by WorleyParsons.

The most significant potential impacts to the geology and geomorphology by the development Tonkolili Iron Ore Project include:

- Loss of a non-renewable Resources;
- Loss/change in existing land use within the area during the life of the project;
- Irreversible loss of land capability in the proposed open pit area;
- Likely changes in water flow regime and drainage patterns and associated impacts on rivers and landforms; and
- Potential change in river water quality

The main mitigation measures for reducing the impact on geology and geomorphology at Tonkolili include:

- Preserve watercourses where possible, and divert others to protect excavations and containment areas (that is, infrastructure stability), and minimise contamination;
- Reclaim and rehabilitate land disturbed during construction by re-grading, re-contouring and replacing topsoil following closure and decommissioning; and
- Reduce harmful effects on the shape of the landscape by using well-designed blasting programmes and mining techniques to minimise vibrations.

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**For and on behalf of SRK Consulting (UK) Ltd**

**James Dendle**
**Consultant Resource Geologist**

**Craig Watt**
**Principal Environmental Engineer**

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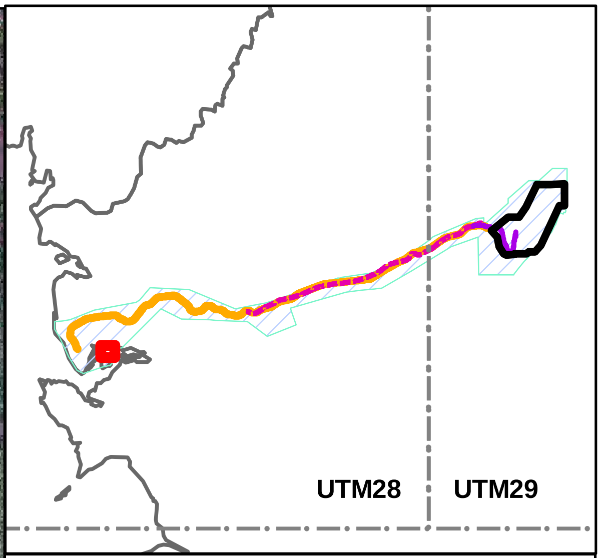
# APPENDIX 16

## Pepel Port Soil and Water Samples Locations


## Railway old alignment

- Old Main Alignment
- Secondary Track
- Pepel Layout
- Pepel Lease Area Approx

## Monitoring Points

- Groundwater
- Pure product/free phase/NAPL
- Soil Sampling
- Surface Water

NOTES:
Map Projection is UTM Zone 28N, Datum is WGS84

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PROJECT

Tonkolili Project
Environmental & Social Assessment

TITLE

PEPEL PORT
SOIL AND WATER
SAMPLE LOCATIONS

| DOCUMENT No: | REV: 1 | DATE: 24/03/10 | ORG: QG | CHK AH | APP PB |
|---|---|---|---|---|---|
| PROJECT No: 305000-00006 | SCALE: 1:16,000 | | SIZE: A3 | | |

## APPENDIX 17

## Environmental Note on Malaria Control

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# Environmental Note on Malaria Control Options

## Tonkolili Iron Ore Project

DRAFT

**305000-00006 / WP0205000**

2 June 2010

**WorleyParsons Canada Ltd.**
**Infrastructure & Environment Division**
4500 16th Avenue NW
Calgary, AB  T3B 0M6  CANADA
Phone: +1 403 247 0200
Toll-Free: 1  800  668 6772
Facsimile: +1 403 247 4811
www.worleyparsons.com

DRAFT

**PROJECT 305000-00006 / WP0205000 - ENVIRONMENTAL NOTE ON MALARIA CONTROL OPTIONS**

**FILE LOC.: CALGARY**

| REV | DESCRIPTION | ORIG | REVIEW | WORLEY-PARSONS APPROVAL | DATE | CLIENT APPROVAL | DATE |
|---|---|---|---|---|---|---|---|
| A | Issued for review | E.Baulk | G.Ramesh | G.Ramesh | dd-mmm-yy | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## Disclaimer

# CONTENTS

# 1. INTRODUCTION

Malaria is by far the most important insect transmitted disease (Gilles and Warrell, 1993). Latest WHO estimates are that there are 300-500 million cases of clinical malaria per year, with 1.4 to 2.6 million deaths, mainly among African children. Malaria is therefore a major cause of infant mortality and is the only insect borne parasitic disease comparable in impact to the world's major killer transmissible diseases: diarrhea, acute respiratory infections, tuberculosis and AIDS.

Malaria is a life-threatening disease caused by parasites called plasmodium. Plasmodium are transmitted by the bites of infected *anopheles* mosquitoes who require a blood meal for egg production (PAN 2009). Once inside the body, the plasmodium parasites are carried in the blood stream to the liver, where they multiply before infecting the red blood cells. Malarial attacks are characterized by fever, severe chills, headache and vomiting and are triggered when the parasitic load within the red blood cells peaks; the red blood cells rupture releasing a large number of parasites into the bloodstream, infecting the red blood cells around them. If not treated, malaria can become life-threatening by disrupting the blood supply to the vital organs.

There are four main types of plasmodium that cause malaria (*P. falciparum, P. vivax, P. malariae* and *P. ovale*); in sub-Saharan Africa, the predominant one is *P. falciparum*. Approximately 40 anopheline mosquito species are capable of transmitting malaria, all of which require water for larvae development. Outside of this universal requirement, preferred breeding habitats can vary from species to species e.g. sun or shade, temperature range, flowing or stagnant water, vegetation, floatability, salt content etc. Once juvenile aquatic stages are completed, most adult mosquitoes have a range of 1-3 km by air. Flying and feeding times vary by species, with some active at dawn and dusk and others during the daytime. The dominant mosquito species in sub-Saharan Africa are *A. gambiae* and *A. funestus*, species characterised by high longevity, density and anthropophily i.e. they prefer to feed on human rather than animal blood (PAN 2009). It is estimated that on average, a person receives c.121 infected bites per year in Africa (PAN 2009).

**Table A Predominant Anopheles Species in Africa**

| | ***A. funestus*** | ***A. gambiae arabiensis*** | ***A. gambiae melas*** |
|---|---|---|---|
| **Preferred habitat / breeding ground**<br><br>**(WHO 1984)** | Permanent vegetated water including swamps, ponds, lake margins, streams, ditches and rice fields | Semi permanent rain pools or overflow water, roadside ditches, clogged drainage ditches, small borrow pits, wheel ruts, hoof prints, natural depressions in the ground and puddles at the margins of rice fields | Brackish or saltwater marshes and lagoons including saltwater fish ponds, in partial or full sunlight |

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## 2. POTENTIAL IMPACT OF RESOURCE DEVELOPMENT PROJECTS ON MALARIA

Development projects have the capacity to influence the transmission of malaria. It can be expected that if not anticipated and corrected for in the initial plan, most development projects will result in an increase in malaria transmission because of one or more of the following factors:

- Irrigation;
- water provision;
- building sites;
- road construction;
- deforestation;
- population shifts (resulting from economic, seasonal, or permanent migration, refugee situations).

In countries with a high malarial burden such as Africa, the health impacts associated with development-related increase in malaria should therefore be given due consideration. Ideally, this is done during initial planning in order that mitigation might be put in place to reduce the severity of this impact. Since malaria is a vector-borne disease - meaning that it is transmitted through the bite of another organism (i.e. the mosquito) - control of malaria transmission can be affected by means designed either to reduce mosquito populations, or reduce human contact with those populations. The impacts of the development projects on malaria through increased vector breeding sites should be considered for both inland as well as shoreline activities.



## 3. OPPORTUNITIES FOR CONTROL OF MALARIA ASSOCIATED WITH DEVELOPMENT EFFORTS

### 3.1 Planning for and Monitoring of Malaria Control Associated with Development Efforts

It is recommended that all development projects take into account the potential for an adverse impact on malaria disease transmission. Project plans must thus include provisions for reducing the potential for transmission. Development of such plans and mechanisms for monitoring impact can best be achieved by cross-sectoral teams.

Prevention of malaria associated with development can best be established at the pre-planning stage. Early prevention of malaria is generally simpler and cheaper than instituting corrective measures later. Specified recommended components, to be carried out by the team members, must be included in the planning and implementation phases, respectively, to prevent an adverse impact on malaria. It is critical that the implementation phase must continue and reinforce the interventions initiated in the planning phase. These efforts should include:

**In the planning phase:**

- **In-country epidemiologic assessment for malaria.** Projects must include a baseline epidemiologic characterization of the region selected for development. This characterization will include the current malaria situation, the biology of the malaria parasite and its various vector control strategies, and the roles of the health system, the community, and the other sectors in any existing malaria program;
- **Community involvement**. A commitment to involve the community and develop a plan in conjunction with the affected community. The input, consultation, and education of the affected human population;
- **Design and establishment of safeguards**. Preventive and corrective policies and practices must be instituted to control malaria associated with development efforts; and
- **A real time plan**. Opportunity for later modifications to the development plan. The planning phase must also include a consideration of changes that the development projects may generate and, most importantly, allow for modifications to the plan to reduce the transmission of malaria in the future.



**In the implementation phase:**

- Regular and ongoing monitoring (at least yearly) of malaria epidemiology;
- Continual involvement of the community in program implementation; and
- Monitoring and enforcement of safeguards.

The WHO recommends an Integrated Vector Management (IVM) approach, a systematic control approach based on evidence and knowledge of the local situation (WHO website 2010). Integrated vector management (IVM) is defined as "a rational decision-making process for the optimal use of resources for vector control" and includes five key elements: 1) evidence-based decision-making, 2) integrated approaches 3), collaboration within the health sector and with other sectors, 4) advocacy, social mobilization, and legislation, and 5) capacity-building (Beier et al 2008). In 2004, the WHO adopted IVM globally for the control of all vector-borne diseases. Important recent progress has been made in developing and promoting IVM for national malaria control programmes in Africa at a time when successful malaria control programmes are scaling-up with insecticide-treated nets (ITN) and/or indoor residual spraying (IRS) coverage.

## Available Control Measures

Since malaria involves three living beings: man (the host), plasmodia (the agent), and anopheles mosquito (the vector), control of this menace is a formidable task. The measures most widely employed to control malaria currently include insecticide-treated nets, preventative / curative medicines (chemoprophylaxis and chemotherapy), and application of pesticides to control the vectors (mosquitoes). Other control measures involve the use of environmental control strategies which can be used in addition to, or in some cases in place of more conventional techniques in order to provide a more sustainable approach. An effective malaria control programme will often incorporate a number of measures that will work in unison. The type or combination of control measures used for a given development project will depend on a number of local factors and should be determined during the planning phase.

IRS is one of the primary vector control and transmission disruption measures used to control malaria (WHO 2006). IRS involves the application of long-acting chemical insecticides to the inside walls and ceilings of buildings to kill the adult vectors that land on them. This serves two functions, firstly to reduce the lifespan of infected adult vectors, and secondly to reduce vector density (WHO 2006). The insecticide used for IRS must be chosen according to local conditions (vector species – susceptibility and behaviour), safety for humans and environment, and cost effectiveness balanced with efficacy. The WHO recommend 12 different insecticides (WHO 2006). Since many of these chemicals have known health effects (e.g. DDT), care should be exercised when developing mitigation strategies that involve use of these potentially toxic insecticides. It is important that IRS is carried out properly and safely and that unwanted exposure or release does not occur (consider aspects such as training of personnel, subcontracting, prevention of unauthorized use etc). Also of note is the fact that strategies with a high dependence on chemical pesticides can be undermined by development of vector resistance, and vector behaviour adaptation (avoidance) (WHO 2006, PAN 2009). Insecticide resistance is of particular concern in Africa; WHO recommend a comprehensive assessment of resistance at a local level before planning an IRS programme (WHO 2006). If such an assessment has been carried out locally, the findings may be of use. These factors should be taken into consideration when planning a malaria mitigation programme.



Non-insecticide based environmental control techniques are also available. Environmental control strategies can be regarded in three categories (WHO 1982):

- manipulation or modification of human habitation or behaviour – e.g. the use of non-pesticidal personal protection, proofing houses or citing settlements away from major breeding sites;
- environmental modification – permanent or long-lasting measures to prevent, eliminate or reduce vector habitats; and
- environmental manipulation – planned, recurrent activities that reduce the favourability of a habitat for breeding.

When planning development projects, these categories can also be viewed from a 'potential' rather than 'existing' standpoint, i.e. construction can be planned to avoid unnecessary creation of larval habitat. Care should be taken that mitigation measures are planned and carried out such that there are not excessive adverse effects on surrounding ecosystems (for example drainage of natural wetlands etc).

## 3.2 Options for Practical Application of Malaria Control Measures during Resettlement, Construction and Operation Phases

### 3.2.1 Community Resettlement

Where resettlement of communities is necessary, the following mitigation measures should be taken into consideration (IFC 2009, WHO 2006):

#### Education

Planning sessions for community resettlement should include educational segments for leaders of the community (including women) on the importance of design and construction of housing with regard to malaria-protective measures (screened windows and doors) and their proper use.

#### Construction

When resettlement housing is constructed, malaria-protective measures should be incorporated (if acceptable to the local community). Boreholes should be designed such that country design requirements are met, with drainage sufficient to prevent formation of mosquito breeding sites. Insecticidal treatments, i.e. IRS, for new housing should be considered if appropriate.



#### Location

Resettlement housing should located at least 500m from significant anopheles breeding sites. In addition, communities with low malarial transmission rates should not be placed in or near communities with high transmission rates.

#### Community Support

Support of local / regional malarial control programmes e.g. through the provision of insecticide treated nets at reduced cost to impacted communities. Educate community members on the use of such nets and other controls e.g. environmental management programmes and community clean-up days.

### 3.2.2 Project Construction Phase

Construction creates many opportunities for increased mosquito breeding sites, including creation of pits, berms and waste piles in which water can pool, or which may affect existing drainage, the rutting of surfaces by heavy plant and alteration of vegetation patterns. Possible environmental management techniques for malaria control during construction include (IFC 2009, PAN 2009, WHO 1982, WHO 1984, WHO 2006):

- Creating adequate drainage;
- Filling depressions to prevent pooling of water;

- Covering water tanks and stagnant water;
- Due care and planning when re-routing water features (streams, wetlands, rivers, rice plantations etc);
- Vegetation management in construction area to reduce the favourability of breeding habitat for dominant mosquito species;
- Education of workers on the use of personal protection (long sleeve shirts and pants / repellent / nets for sleeping), provision of suitable clothing where appropriate;
- Placement of any worker camps away from mosquito breeding sites (1.5 - 2 km from major breeding sites);
- Good construction of housing and buildings in worker camps (repairing of cracks and holes, covering eaves where appropriate) installation of screens on windows and doors, and provision of treated nets for sleeping;
- Periodic IRS where appropriate and as per WHO guidance (WHO 2006);
- Vegetation clearing around worker camps to reduce favourable breeding or resting sites; and
- Good housekeeping (e.g. removal of debris that may collect water, vigilance and awareness of issues, keeping drains clear of refuse and free-flowing, maintenance of all vector control measures already in place etc).

### 3.2.3 Operation Phase

A number of the malaria control techniques were used during construction can be used ‘as is’ or modified for use during the operation phase of a project; this is especially true in a mine area since there will be constant remodelling of the landscape. The techniques employed during operation should be sustainable over the lifetime of the project; some will require maintenance in order to achieve this, and others will be more permanent. They include (IFC 2009, PAN 2009, WHO 1982, WHO 1984, WHO 2006):

- Creating adequate drainage systems;
- Land levelling;
- Filling depressions to prevent pooling of water;
- Covering water tanks and stagnant water;
- Vegetation management in construction area to reduce the favourability of breeding habitat for dominant mosquito species;
- Planting of indigenous water-intensive plants/trees to help dry problem areas (with due care to avoid biodiversity issues);
- Education of workers on the use of personal protection (long sleeve shirts and pants / repellent / nets for sleeping) to prevent sickness;

- Placement of any worker camps away from mosquito breeding sites (1.5 - 2 km from major breeding sites);
- Good construction of housing and buildings in worker camps (repairing of cracks and holes, covering eaves where appropriate) installation of screens on windows and doors, and provision of treated nets for sleeping;
- Periodic IRS where appropriate and as per WHO guidance;
- Vegetation clearing around worker camps to reduce favourable breeding or resting sites; and
- Good housekeeping (e.g. removal of debris that may collect water, vigilance and awareness of issues, keeping drains clear of refuse and free-flowing, maintenance of all vector control measures already in place etc).

## 4. REFERENCES

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# APPENDIX 18

## Environmental Management Plan

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## APPENDIX 19

## Minutes of Early Works Chiefdom Committee (EWCC) Meetings

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Introduction

| **PARTICIPANT NAME & ORGANISATION** | | **DATE** | 1 March 2010 |
|---|---|---|---|
| **CLIENT** | Paramount Chief Kalansogoia | **TIME START** | 2:45 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 3:30 |
| | | **LOCATION** | PC's Office Bumbuna |
| **AML** | Alie Bangura (PRO) | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0013 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | **PROJ REF** | |
| **SIGNATURE ORIGINATOR** | | **DATE SIGNED** | |
| **SIGNATURE OTHER PARTY** | | **DATE SIGNED** | |
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## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>Start safety moment here | |
| 2. | **EWCC** Introduction of ToR for committee | |
| 3. | Attendance discussed with the PC and agreed that he would notify his section chiefs, councillors, NGO's, women's and youth groups. AML were asked to coordinate with the District Council Chairman to bring the GoSL district heads of department on board and to contact the area MP. | |
| 4. | The Paramount Chief contacted the Chairman and made an appointment for WP/AML to meet on 3rd March 2010 at 10am in Magburaka (district headquarters) | |
| 5. | The inaugural meeting was scheduled for Wednesday, 10th March 2010 at the PC office in Bumbuna. | |
| 6. | The EWCC will be responsible for high level issues and it was noted that community sensitisation should be carried out on the ground. The PC recommended that suitable locations could be identified so that villagers could attend a central location reducing the number of meetings required. | |

**MEETING RECORD**

**END OF RECORDS**

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Introduction

| PARTICIPANT NAME & ORGANISATION | | DATE | 2 March 2010 |
|---|---|---|---|
| **CLIENT** | Paramount Chief Kafe Simira | **TIME START** | 10:00 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 10:30 |
| | | **LOCATION** | PC's Office Mabonto |
| **AML** | Alie Bangura (PRO) | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0014 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
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## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>Start safety moment here | |
| 2. | **EWCC** Introduction of ToR for committee | |
| 3. | Attendance discussed with the PC and agreed that he would notify his section chiefs, councillors, NGO's, women's and youth groups. AML were asked to coordinate with the GoSL district heads of department and to contact the area MP. | |
| 4. | The inaugural meeting was scheduled for Wednesday, 10th March 2010 at the PC office in Bumbuna. | |
| 5. | The EWCC will be responsible for high level issues and it was noted that community sensitisation should be carried out on the ground. Colin Forbes indicated that suitable locations could be identified so that villagers could attend a central location reducing the number of meetings required. | |
| 6. | The PC requested that maps be made available to accurately disseminate information to the villagers. | |

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**MEETING RECORD**

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 7. | The PC also asked for guidance on whether farmers should continue farming. Colin Forbes responded that it was important to continue providing for their own needs until such time that the route was clearly identified on the ground. | |

**END OF RECORDS**

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Introduction

| PARTICIPANT NAME & ORGANISATION | | DATE | 3 March 2010 |
|---|---|---|---|
| TONKOLILI DISTRICT COUNCIL | Augustine Koroma - District Counci Chairman<br>Michael Touray - Chief Administrator<br>District | TIME START | 10:00 |
| WORLEYPARSONS: | Colin Forbes | TIME FINISH | 12:00 |
| | | LOCATION | District Council Headquarters - Magburaka, Tonkolili District |
| AML | Tim Fofana (Lead PRO)<br>Alie Bangura (PRO) | RECORDER | Author |
| | | DOC NO | 305000-00006-0000-O-MOM-0015 |
| | | FILE LOC | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | PROJ REF | |
| SIGNATURE ORIGINATOR | | DATE SIGNED | |
| SIGNATURE OTHER PARTY | | DATE SIGNED | |
| COPIES | | | |

**RECORD OF DISCUSSIONS**

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>Start safety moment here | |
| 2. | The District Council Chairman introduced himself and the Chief Administrator and clarified that his role was equivalent to a 'governor' in the US system of administration. | |
| 3. | The District Chairman thanked AML for coming. He noted, however, that this visit was the first time AML have been to his office since they arrived. He indicated that the District Council have not even opened a file for AML as yet.<br>He noted that he has tried to visit the site and was turned back at the gate without being given the chance to meet with the General Manager.<br>He noted that the Paramount Chiefs reported to him. | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | He advised that ADDAX had been to visit him as they were aware of his role in Tonkolili District. As such, he was in a position to advise people when they asked for advice on the ethanol project. He emphasized that this was not possible in the case of AML as he knew nothing of the project.<br>He recommended more involvement with the District Council and improved communications between AML and them.<br>He made a point of stating that his reports went to 'State House' and that the minutes from District Council meetings were not very complimentary stating that there was significant 'disturbance' amongst local in relation to AML. | |
| 4. | On a positive note the Chief Administrator thanked AML for contributing to the well being of people in his district noting the educational bursaries that were provided by AML.<br>He also commended AML for improving roads in the area.<br>He stated that the council was meant to provide support to AML and as much as the district needs AML, AML needs the council as many sectors have been devolved from central government.<br>He noted that AML could look at the Tonkolili District website and see in what areas there could be collaboration. | |
| 5. | On the subject of employment particular emphasis was placed on preferential treatment for locals indigenous to the area by the Chief Administrator. He advised AML to 'strategise' carefully on the employment issue as it had the potential to derail company activities.<br>He claims that complaints are coming in over AML's employment of people from Freetown. Local jobs should be for locals and not for people from outside the area, he reiterated. Furthermore, he stated that it was in AML's best interest to employ locals as they were motivated to keep the project going and improve the area unlike outsiders. | |
| 6. | The Chairman recommended that AML be given a slot in the next Council meeting to officially present the Tonkolili Iron Ore Project. These meetings are held on the last Wednesday of every month. | |
| 7. | Tim Fofana addressed the meeting and stated that it was not AML's intention to cause such distress to the Council and its Chairman and would follow up with his superiors to find out what had happened. | |
| 8. | Colin Forbes reiterated what Mr Fofana had said and recommended that future consultation would be more cognisant of the administrative structure to which the Chairman referred. asked that the EWCC be discussed | |
| 9. | On the subject of the EWCC, the Chairman welcomed the formation of the committees and provided some input as follows:<br>• The head of the Council's Mineral Resources Committee should be involved. He is also the District Ministry of Mines representative (Sylvester Koroma).<br>• The Council currently has staff undergoing training in crop valuation but for the time being it should be handled by the District Ministry of Agriculture representative.<br>• Environmental issue facing Tonkolili District are currently handled by the | |

## MEETING RECORD

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
| --- | --- | --- |
| | Ministry of Health Officer as EPA do not have representation as yet.<br>• Tree valuation is determined by the District Director of Forestry.<br>• For structures, the Chairman recommended that we include the Ministry of Works representative and/or the Sierra Leone Roads Authority. | |

**END OF RECORDS**

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Inaugural Meeting

| PARTICIPANT NAME & ORGANISATION | | | |
|---|---|---|---|
| | | **DATE** | 10 March 2010 |
| **CLIENT** | See Kalansongoia Attendance List (attached) | **TIME START** | 11:00 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 12:30 |
| | | **LOCATION** | Court Barrie Bumbuna |
| **AML** | Mustapha Kamara<br>Tim Fofana<br>Abdul Sesay | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0018 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
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**RECORD OF DISCUSSIONS**

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC Conducted as per Kalansongoia Agenda** (attached) | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | It was agreed that the meeting would be conducted in Krio with translation into English when required. | |
| 5. | The Paramount Chief opened the meeting by welcoming all those present and stressing that the Early Works Chiefdom Committee (EWCC) has an important role to play in making sure that the construction of the haul road goes on well and benefits for the local communities can be realised. | |
| 6. | EWCC members present introduced themselves (see Attendance Register). | |
| 7. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Peel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train). | |

<table>
<tr><th>ITEM</th><th>ITEM DETAILS</th><th>ACTION BY AND DATE</th></tr>
<tr><td>8.</td><td>A review of the villages that would be affected by the works was undertaken listing the following:<br>1. Farangbaya<br>2. Wandugu<br>3. Furia<br>4. Balaya<br>5. Kanigba<br>6. Basaiya<br>7. Kasikoro<br>8. Kapete</td><td></td></tr>
<tr><td>9.</td><td>Committee structures were reviewed and emphasis was placed on roles being relevant to the subject matter. It was also stated that there should be room to induct further members in the future if necessary. The notion that village heads should also be included was rejected as it was felt that there was adequate representation through the Section Chiefs and that the Community Sensitisation Program would allow for their participation.<br><br>Membership was agreed (with reference to the EWCC Terms of Reference (ToR) guide) as follows:<br>1. Paramount Chief<br>2. 3 Section Chiefs<br>3. 1 women’s leader<br>4. 1 youth leader<br>5. 1 MP<br>6. 2 councillors<br>7. Representatives from these lead agencies:<br>a. EPA (not present but indicated they would try to make themselves available from Freetown)<br>b. Ministry of Agriculture, Forestry and Food Security<br>c. Ministry of Lands and Housing<br>d. Ministry of Mines represented here by the Chairman of the Tonkolili District Council Committee on mineral Resources.<br>e. 1 District Council Internal Affaires Department<br>8. 3 AML personnel<br>9. 1 NGO to be selected by SLANGO ensuring that a suitable locally active NGO is chosen.<br><br>A monthly meeting schedule was agreed.<br><br>This EWCC would operate through consensus.</td><td></td></tr>
<tr><td>10.</td><td>The ToR were adopted as per the attached guide. The grievance mechanism is to be defined at the next meeting and other items may be presented after time is given to review and absorb the document.</td><td></td></tr>
</table>

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 11. | Social Impacts were discussed as a way of gearing members up to participate actively in ensuring that issues affecting local communities as a result of the early works were addressed. These included:<br>• Loss of agricultural land<br>• Loss of economic trees<br>• Loss of sacred bush<br>• Relocation of structures<br>• Loss of social amenities although it was stressed that this would be dealt with by the larger committee handling the next phase of mining (magnetite) through a Community Development Plan and the Resettlement Action Plan.<br>• It was felt that loss of social cohesion would not be an issue as settlements would not be moving.<br>• Villages may migrate closer to road once built (safety issue).<br>• Youth felt that employment would be a very positive impactas long as locals were given jobs.<br>• Women would be affected by loss of land reducing their ability to farm and produce food for their families.<br>• The District Forest Officer stated that measures should be put in place to address protection of forests. | |
| 12. | Part of the EWCC's role is to ensure that decisions made by the committee are communicated to people on the ground. This is to be carried out through the Section Chiefs and the Community Sensitisation Program (CSP).<br>The CSP would begin with relaying the Project Description to the affected villages and then carry out regular information sessions through designated EWCC members to allow for local communities to receive and respond to issues raised.<br>Villages will be grouped together to simplify the exercise as follows:<br>1. Farnagbaya, Wandugu and Furia<br>2. Basaiya, Kanigba and Balaya<br>3. Kasikoro and Kapete<br>The first CSP meeting is to be held on 13th March 2010 in Wandugu. | |
| 13. | Other points of discussion included:<br>1. Members enquired whether food and transport would be made available to them during their participation in EWCC meetings – AML are to review this request and further deliberations on allowances will be needed.<br>2. Will the same meeting format be used for CSP meetings – no, these meetings should be brief enough to get information to the communities in a non-technical way and may not require the presence of all EWCC members.<br>a. The Paramount Chief suggested that a bag of rice be made available for the villages at the meeting and Mustapha Kamara | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | concurred stating that from his experience it would be important to support the community in this way. | |
| | b. A Section Chief asked if AML would build access roads for the villagers to connect to the haul road – Mustapha Kamara reiterated that the haul road will be a private road and for safety reasons it cannot be used by the general public. | |
| 14. | The next meeting was set for 10th April 2010 at St. Mathews Secondary School in Bumbuna. | |
| 15. | Meeting ended with Muslim and Christian prayers followed by lunch. | |

**END OF RECORDS**

**EARLY WORKS CHIEFDOM COMMITTEE MEETING**
**ATTENDANCE REGISTER**

Chiefdom: KALANSOGOIA                                        Date: 10th MARCH 2010.

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | SYLVESTER H. KOROMA | Chairman Mineral Resources Committee | [illegible] | 076 85 8830 |
| 2 | KOLI KERA | COUNCILLOR WARD 228 SAMBAIA & KALANSOGOIA | [illegible] | 033 833 409<br>076 58 65 76 |
| 3 | LESLIE J. GREYWOODE | DISTRICT CROPS OFFICER | Greywoode | 076 370151<br>088 509788 |
| 4 | MOHAMED D. MANSARAY | DISTRICT FOREST OFFICER | [illegible] | 076-988233 |
| 5 | Lawrence D. Gbaya | Valuation officer and Quantity Surveyor | [illegible] | 077818837 |
| 6 | Alimamy B.Y. Koroma III | Paramount Chief | [illegible] | 076851634/033256800 |
| 7 | Michael Y. Kallon | Resident NGO | [illegible] | 076-924163<br>033-255666 |
| 8 | Solomon T. Forneeh | Section Chief Bumbuna | S Forneeh | 088-743510<br>076-213846 |
| 9 | Pa Ferenkeh Koroma | Section Chief Lower, Bumbuna | F. Koroma | — |
| 10 | Ibraham Koroma | Section Chief Songonie. | | |

| | | | | |
|---|---|---|---|---|
| 11 | Sheku Koroma | Section Chief Kemendugu | S. Koroma | — |
| 12 | Atkins Y. Koroma | PRO Kalansogoia | Koroma | 033-256760 |
| 13 | Gibrilla B. Kamara | Youth leader | Kamara | 033779648 |
| 14 | Isatu Sesay | Women leader | Sesay | 076635946 |
| 15 | Brima Conteh | Town Chief Bumbuna | B. Conteh | — |
| 16 | Alie K. Turay | FOREST OFFICER BUMBUNA | [illegible] | 078-459511 |
| 17 | Musa M. Conteh | D.F.O Driver | M.M. Conteh | 077-304651 |
| 18 | Danny Ramunno | Project Manager African Minerals | [illegible] | 033100250. |
| 19 | Tim Fofana | Manager P.R. | M Fofana | 033256702 |
| 20 | COLIN FORBES | WorleyParsons | [illegible] | 033379018 |

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**MEETING RECORD**

**Project No:** 305000-00006
**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Inaugural Meeting Kafe Simira

| PARTICIPANT NAME & ORGANISATION | | DATE | 11 March 2010 |
|---|---|---|---|
| **CLIENT** | See Kafe Simira Attendance List (attached) | **TIME START** | 11:00 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 12:30 |
| | | **LOCATION** | Court Barrie Mabonto |
| **AML** | Mustapha Kamara<br>Tim Fofana<br>Abdul Sesay | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0016 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | **PROJ REF** | |
| **SIGNATURE ORIGINATOR** | | **DATE SIGNED** | |
| **SIGNATURE OTHER PARTY** | | **DATE SIGNED** | |
| **COPIES** | | | |

## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC Conducted as per Kafe Simira Agenda** (attached) | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | It was agreed that the meeting would be conducted in Krio with translation into English when required. | |
| 5. | The Paramount Chief could not attend and was represented by his brother Dr. Bangura. The area MP was chosen to chair the meeting and opened the meeting by welcoming all those present and stressing that the Early Works Chiefdom Committee (EWCC) has an important role to play in making sure that the construction of the haul road goes on well and benefits for the local communities can be realised.<br>Dr Bangura was asked to speak on behalf of the Paramount Chief and advised that Kafe Simira Chiefdom was willing to give support to the project in return for | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | tangible benefits and development for Kafe Simira.He recommended that AML be allowed to proceed but recommended that AML write to the PC officially to formalise the EWCC's work. | |
| 6. | EWCC members present were introduced (see Attendance Register). | |
| 7. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Peel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train). | |
| 8. | Committee structures were reviewed and emphasis was placed on roles being relevant to the subject matter. It was also stated that there should be room to induct further members in the future if necessary.<br>Membership was agreed (with reference to the EWCC Terms of Reference (ToR) guide) as follows but is subject to the Paramount Chief blessing at a later date:<br>1. Paramount Chief<br>2. 2 Section Chiefs<br>3. 1 women's leader<br>4. 1 youth leader<br>5. 2 MP's<br>6. 2 councillors<br>7. Representatives from these lead agencies (Dr Bangura suggested that it is important to identify heads of department who will articulate GoSL policy and law accurately):<br>a. EPA (not present but indicated they would try to make themselves available from Freetown)<br>b. Ministry of Agriculture, Forestry and Food Security<br>c. Ministry of Lands and Housing<br>d. Ministry of Mines represented here by the Chairman of the Tonkolili District Council Committee on mineral Resources.<br>e. 1 District Council Internal Affaires Department<br>8. 1 NGO to be selected by SLANGO ensuring that a suitable locally active NGO is chosen.<br>9. 3 AML personnel<br>A monthly meeting schedule was agreed.<br>This EWCC would operate through consensus. Dr Bangura commented that this approach would be in line with traditional norms. | |
| 9. | The ToR were adopted as per the attached guide following the comments presented by Dr Bangura including:<br>• Noting that if this approach had been adopted in Kono they would not be experiencing the problems that they currently face.<br>• On behalf of the community he appreciated AML delivering comprehensive ToR such as these. | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | The Chairman asked that the meeting accept the ToRs through him and there were no objections. | |
| 10. | Social Impacts were discussed as a way of gearing members up to participate actively in ensuring that issues affecting local communities as a result of the early works were addressed.<br>• Dr Bangura commented that people should take this seriously as they do not want what happened in Kono to happen in Kafe Simira and the messages and the results of EWCC deliberations should be communicated directly to those affected. Mustapha Kamara noted that this was contained in the Community Sensitisation Program which was later on in the agenda. | |
| 11. | Part of the EWCC's role is to ensure that decisions made by the committee are communicated to people on the ground. This is to be carried out through the Section Chiefs and the Community Sensitisation Program (CSP).<br>The CSP would begin with relaying the Project Description to the affected villages and then carry out regular information sessions through designated EWCC members to allow for local communities to receive and respond to issues raised.<br>Villages will be grouped together to simplify the exercise. | |
| 12. | Other points of discussion included:<br>1. Work carried out by EWCC will be important introduction into modalities of the larger committee that would be established for the main magnetite mining phase.<br>2. Mr Kanu asked whether the work will be carried out mechanically or manually. Mustapha Kamara replied emphasising that AML first priority was to employ locals but modern techniques would be used during construction including heavy machinery. He reassured members that the contractors in place have been advised that they should maximise local labour content.<br>3. The Chairman noted that Mabonto, the Chiefdom headquarters had problems with communication as there was no phone signal nearby. Mustapha Kamara noted that as the project is implemented this will change as a communications tower will be erected nearby.<br>4. Asked about training for local people Mustapha Kamara explained that a training program will commence soon.<br>5. Responding to queries about the number of PRO for Kafe Simira compared to Kalansongoia, he noted that more PRO's are being mobilised.<br>6. The Chairman noted that the District Council should be given a familiarisation tour of the project.<br>7. Dr Bangura noted that AML should increase their presence in the area and the chiefdom should be given equal representation on the current community consultation committee as the letter that was sent to them stating that had fewer places that their neighbours was unacceptable. Mustapha Kamara responded saying that there was no malice intended and that the numbers were based on current drilling activities which at the moment do not affect Kafe Simira. Dr Bangura acknowledged the | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | apology but stated that he did not agree with the reasoning stating the committee should have full and equal representation regardless of the current project activity. As this was not an issue for the EWCC it would be resolved directly between the parties. | |
| 13. | The next meeting was set for 17th April 2010 at the court barrie in Mabonto. | |
| 14. | Meeting ended with Muslim and Christian prayers followed by lunch. | |

**END OF RECORDS**

# EARLY WORKS CHIEFDOM COMMITTEE MEETING
## ATTENDANCE REGISTER

Chiefdom: Kafe Simiraia  Date: 11/3/10

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | ALIMAMY PALLO BANGURA | FOR P.C. ALIMAMY BANGURA II | ABangura | 030 111 127<br>033 309 465<br>076 636 684 |
| 2 | Hon. Mohamed A. Tarawalli | MP | [signature] | 076 633769<br>matharr@yahoo.fr |
| 3 | Con. Sylvester H. Koroma | Mineral Resources Committee Chairman | [signature] | 076 858830 |
| 4 | LESLIE J. GREYWOODE | DISTRICT CROPS OFFICER | Greywoode | 076370151 |
| 5 | MOHAMED D. MANSARAY | DISTRICT FOREST OFFICER | [signature] | 076 988233 |
| 6 | Lawrence D. Gbaya | Valuation officer Quantity surveyor Works | [signature] | 077 818837 |
| 7 | Tamba T. Bangura | Youth chair | [signature] | |
| 8 | John M Sesay | Councellor | [signature] | 076589824. |
| 9 | UNISA BANGURA | S/Chief | [signature] | |
| 10 | COLIN FORBES | Worley Parsons | [signature] | 033 379018 |

| | | | | |
|---|---|---|---|---|
| 11 | Regina S. Bangura | Chairlady | [illegible] | 076777477 |
| 12 | HENRY S. KAMARA | SECTION CHIEF OF MAKENTHADA | [illegible] | 078 477569<br>076 649 208 |
| 13 | Modu Sesay | EX-High Commissioner<br>ex-Finan Director, NSL | [illegible] | 076-305761<br>033-137661 |
| 14 | Tim FOFANA | Manager PR. Affairs AMI | TMFofana | 033-256702 |
| 15 | E.O.K. Tholley | Management | EOKTholley | 076-619950 |
| 16 | Thomas S. Kargbo | Councillor | [illegible] | 077-568795 |
| 17 | Francis S.F. Lakkoh | Elder | Lakkoh | 076 645500 |
| 18 | | | | |
| 19 | | | | |
| 20 | | | | |

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Inaugural Meeting Safroko Limba

| PARTICIPANT NAME & ORGANISATION | | DATE | 12 March 2010 |
|---|---|---|---|
| **CLIENT** | See Safroko Limba Attendance List (attached) | **TIME START** | 11:00 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 12:30 |
| | | **LOCATION** | Court Barrie Binkolo |
| **AML** | Tim Fofana<br>Abdul Sesay | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0021 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | **PROJ REF** | |
| **SIGNATURE ORIGINATOR** | | **DATE SIGNED** | |
| **SIGNATURE OTHER PARTY** | | **DATE SIGNED** | |
| **COPIES** | | | |

## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC Conducted as per Safroko Limba Agenda** (attached) | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | It was agreed that the meeting would be conducted in the local language Limba with translation into Krio and English when required. | |
| 5. | The Paramount Chief opened the meeting by welcoming all those present and stressing that the Early Works Chiefdom Committee (EWCC) has an important role to play in making sure that the construction of the haul road goes on well and benefits for the local communities can be realised. He emphasised that this road will pass through swamp and agricultural land and may affect some structures along the way.<br>A comment was raised at this juncture by a participant noting that they never received compensation promised during the Bumbuna Transmission Line | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
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| | resettlement program and hoped that this project would be different. The Paramount Chief responded saying that he would ensure that everything would be done so that AML will pay the compensation that is due and that it is important for this project to benefit citizens of Sierra Leone.<br>Further to that the member representing the Ministry of Mines stated that his ministry had built an office in Makeni to serve Northern Province. He was happy that AML has taken such a positive step towards consultation with communities affected by it's project and wished that the company will continue to support them through the development of schools and other social infrastructure. | |
| 6. | EWCC members present introduced themselves (see Attendance Register). | |
| 7. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Peel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train). | |
| 8. | A review of the villages that would be affected by the works was undertaken and will be reviewed in meetings to follow. | |
| 9. | Committee structures were reviewed and emphasis was placed on roles being relevant to the subject matter. It was also stated that there should be room to induct further members in the future if necessary.<br>Membership was agreed (with reference to the EWCC Terms of Reference (ToR) guide) as follows:<br>1. Paramount Chief<br>2. 3 Section Chiefs (Kayasi, Binkolo, Mabamba)<br>3. 1 women's leader – Chiefdom women's leader.<br>4. 1 youth leader – Chiefdom youth leader.<br>5. 1 MP<br>6. 2 councillors<br>7. Representatives from these lead agencies:<br>a. EPA (not present but indicated they would try to make themselves available from Freetown)<br>b. Ministry of Agriculture, Forestry and Food Security<br>c. Ministry of Lands and Housing<br>d. Ministry of Mines represented here by the Chairman of the Tonkolili District Council Committee on mineral Resources.<br>8. 3 AML personnel<br>9. 1 NGO selected – Cartholic Mission.<br>A monthly meeting schedule was agreed although more frequent meeting were initially sought. Colin Forbes pointed out that time was needed to conduct community sensitisation in between EWCC meetings.<br>This EWCC would operate through consensus initially but voting may be incorporated after further discussion. | |
| 10. | The ToR were adopted as per the attached guide. Other questions arising during this discussion included: | |

**MEETING RECORD**

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | • What social infrastructure will AML put in place – Colin Forbes noted that this would be discussed during the main magnetite mining project consultation process as part of a broader Community Development Plan.<br>• Will AML also elp with improvements to existing roads as they will increase traffic volumes as a result of construction and operation – Abdul Sesay stated that this would be looked into. | |
| 11. | Social Impacts were discussed as a way of gearing members up to participate actively in ensuring that issues affecting local communities as a result of the early works were addressed. These included:<br>• Loss of agricultural land and therefore livelihoods<br>• Loss of land<br>• Health impacts such as dust from road traffic<br>Other issues raised at this time were as follows:<br>• Will AML provide allowances for committee members – Tim Fofana responded that it would be looked into.<br>• Colin Forbes suggested that the most efficient committee practice would be adopted as the model for the larger committees that are to follow.<br>• Those who attended were keen to hear how long it would take to replace housing – Colin Forbes stated that relocation of structures would be undertaken as a last resort. The structure in question must be assessed in terms of its use, size and construction to determine how to proceed. Nevertheless house must be replaced prior to removal. | |
| 12. | Part of the EWCC's role is to ensure that decisions made by the committee are communicated to people on the ground. This is to be carried out through the Section Chiefs and the Community Sensitisation Program (CSP).<br>The CSP would begin with relaying the Project Description to the affected villages and then carry out regular information sessions through designated EWCC members to allow for local communities to receive and respond to issues raised.<br>Villages will be grouped together to simplify the exercise. | |
| 13. | Other points of discussion included:<br>1. If the contractor uses a borrow pit or quarry on someone's land will the owner be compensated – The representative from the Ministry of Mines stated that there are regulations for such activities and these need to be followed.<br>2. How would road accidents be dealt with – Tim Fofana noted that this would be handled in accordance with law. He noted that the road will be private and is not intended for public vehicles. | |
| 14. | The next meeting was set for $9^{th}$ April 2010 at court barrie in Binkolo. | |
| 15. | Meeting ended with Muslim and Christian prayers followed by lunch. | |

**END OF RECORDS**

**EARLY WORKS CHIEFDOM COMMITTEE MEETING**
**ATTENDANCE REGISTER**

Chiefdom: Safroko Limba                                        Date: 12/3/10

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | P.C. ALIMAMY DURA III | PARAMOUNT CHIEF | P.C. [signature] III | 076-444-671 |
| 2 | MOMOH T KOROMA | BINKOLO SECTION | Chief M Koroma | 076 906 465 |
| 3 | PA. KOLIA MANSARAY | EX " | | |
| 4 | PA. THAMBA BANGURA | KABETMGBEH " | | |
| 5 | PA. BOBOH CONTEH | T/H. BUMBAN | | |
| 6 | SORIE BANGURA | T/H. MAFARAY | | |
| 7 | SORIE KAYBAY | BINKOLO | | |
| 8 | MASSAQUIR MANSARAY | MAKAITA | | |
| 9 | BONGO SESAY | KABETMGBEH | | |
| 10 | ROBERT SESAY | ACT. KABONK | | |

| | | | | |
|---|---|---|---|---|
| 11 | THAMBA SESAY | T/H - MAFORYOH | | |
| 12 | PA SAMBA SELLAH | " KABOMBEH | | |
| 13 | PA - KADURU FOFANAH | SECTION CHIEF | | |
| 14 | PA. MOMODU SESAY | T/H. KABOLI | | |
| 15 | PA: THAMBA KOINDU SESAY | AG. SECTIONS CHIEF | | |
| 16 | PA MUSTAPHA KOROMA | SECTION CHIEF | | |
| 17 | Mr. FRANCIS B. SESAY | COURT CLERK | [signature] | 076-457431 |
| 18 | SORIE SESAY | T/H. Mabonta | | |
| 19 | Sullaiman Conteh | T/H. Rep - madiff | | |
| 20 | Nameh Conteh | mamy Queen | | |
| 21 | Tim Fofanah | AML | | |
| 22 | Abdul Deen Sesay | Corporate Assistant | [signature] | 033-353-334 |

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**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# EWCC Community Sensitisation Meeting

| **PARTICIPANT NAME & ORGANISATION** | | **DATE** | 13 March 2010 |
|---|---|---|---|
| **CLIENT** | Farangbaya, Wandugu, Furia villages | **TIME START** | 11:30 |
| **WORLEYPARSONS:** | Colin Forbes | **TIME FINISH** | 13:30 |
| | | **LOCATION** | Wandugu |
| **AML** | Tim Fofana | **RECORDER** | Author |
| | | **DOC NO** | 305000-00006-0000-O-MOM-0017 |
| | | **FILE LOC** | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | **PROJ REF** | |
| **SIGNATURE ORIGINATOR** | | **DATE SIGNED** | |
| **SIGNATURE OTHER PARTY** | | **DATE SIGNED** | |
| **COPIES** | | | |

## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC meeting to sensitise communities on haul road construction activities.** | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | It was agreed that the meeting would be conducted in Kranko with translation into Krio and English when required. | |
| 5. | The Paramount Chief opened the meeting by welcoming all those present and stressing that the Early Works Chiefdom Committee (EWCC) has an important role to play in making sure that the construction of the haul road goes on well and benefits for the local communities can be realised. | |
| 6. | EWCC members present introduced themselves.<br>Paramount Chief<br>Kalansongoia women's leader | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | 2 Section Chiefs<br><br>Present on behalf of the villagers were:<br>Farangbaya –<br>Fatuma Sisay (women's leader)<br>Karfa Sisay (Youth leader)<br>Town chief<br>Wandugu –<br>Kali Konteh (Town chief)<br>Saye Koroma (women's leader)<br>Youth leader<br>Furia –<br>Anson Dawo (Town chief)<br>Sara Tole (women's leader)<br>Usman Kargbo (youth leader)<br>Others not named numbered approximately 70 people. | |
| 7. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Pepel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train).<br>It was explained that the villages are situated close to the intended haul road alignment which is why this meeting was taking place. | |
| 8. | The function and structure of the EWCC was explained to those present so that they were aware of efforts being undertaken to address issues of concern resulting from construction activities and subsequent operations. | |
| 9. | The Paramount Chief opened the meeting to question from the villagers.<br>1. Sembu Kamara – Wandugu<br>Is AML going to build access roads directly to villages from the haul road?<br>Tim Fofana – A community service road will be built alongside the haul road but the haul road itself will be private. For safety reasons no public traffic, pedestrians or animals will be allowed.<br>Paramount Chief – Safety is a very important issue and the haul road will be out of bounds to the public including those residing in nearby villages.<br>2. Aminata Konteh – Wandugu<br>Are our people going to get jobs?<br>Colin Forbes – SL legislation is very strong in terms of local employment and every effort will be made to ensure that where suitable skills are available locals are prioritised in the selection process. Contracts signed with the road construction companies include provisions for the | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | maximisation of local labour. Important to note that this committee is established to handle issues relating to the haul road and another committee will be set up in the near future to address issues related to the main mining project.<br>3. Singare Konteh – Wandugu<br>Will the company provide a water supply to us?<br>Paramount Chief – The larger committee will address this issue later so this question should be raised then.<br>4. Mohamed Dao – Furia<br>The access road has already been cleared very close to our village. Will the haul road also be so close?<br>Tim Fofana – This is an access track only and the proper alignment will be identified later.<br>The Paramount Chief encouraged those present to continue asking questions as it was an effective way of understanding their concerns.<br>5. Lanson(?) Dao – Furia<br>We have trees in two locations as we were advised to move previously . How will the committee deal with this?<br>Tim Fofana – We are aware of the issue and the committee will deliberate on how to address them in the future. It is hoped that boundary issues can be solved as soon as possible.<br>6. Alimamy Konteh – Wandugu<br>Want to notify the committee that some sacred bush areas have already been cleared by recent work.<br>Tim Fofana – This is very unfortunate since efforts had been made to identify all sacred bush. AML will investigate how this happened and resolve the issue as soon as possible. AML has recruited more PRO's to provide better co-ordination between community and the company in an effort to eliminate these sorts of occurrences. | |
| 10. | In closing the meeting the Paramount Chief thanked everyone present for taking the time to attend and participate in such an important forum. Tim Fofana thanked the residents for their efforts in organising the venue and preparing food for the occasion. | |
| 11. | The meeting ended with Muslim and Christian prayers followed by some lunch. | |

**END OF RECORDS**

WorleyParsons

resources & energy

African MINERALS

**MEETING RECORD**

**Project No:** 305000-00006

**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Inaugural Meeting Maforki

| PARTICIPANT NAME & ORGANISATION | | DATE | 15 March 2010 |
|---|---|---|---|
| CLIENT | See Port Loko Attendance List (attached) | TIME START | 11:00 |
| WORLEYPARSONS: | Colin Forbes | TIME FINISH | 13:30 |
| | | LOCATION | Court Barrie Port Loko |
| AML | Dezlyne Decole<br>Tim Fofana | RECORDER | Author |
| | | DOC NO | 305000-00006-0000-O-MOM-0019 |
| | | FILE LOC | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | PROJ REF | |
| SIGNATURE ORIGINATOR | | DATE SIGNED | |
| SIGNATURE OTHER PARTY | | DATE SIGNED | |
| COPIES | | | |

## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC Conducted as per Maforki Agenda** (attached) | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | It was agreed that the meeting would be conducted in Temneh with translation into Krio and English when required. | |
| 5. | The Regent Chief (the Paramount Chief's position has not been filled) discussed the appointment of the District women's leader as Chairperson of the EWCC meeting. Although another location was chosen for this meeting, the Regent Chief preferred that it be held at the court barrie. After welcoming all participants to the meeting the Regent Chief stated that he prayed that accidents would be averted and benefits will flow from development of the Project. He continued by saying that this was necessary as Maforki was one of the lowest in the country in terms of development. He also stated that he was | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | happy to welcome AML to Maforki and assured the company that all chiefs under him in the area had been informed of the upcoming work. | |
| 6. | EWCC members present introduced themselves (see Attendance Register). | |
| 7. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Peel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train). | |
| 8. | Committee structures were reviewed and emphasis was placed on roles being relevant to the subject matter. It was also stated that there should be room to induct further members in the future if necessary<br>Membership was agreed (with reference to the EWCC Terms of Reference (ToR) guide) as follows:<br>1. Paramount Chief<br>2. 12 Section Chiefs (to be reviewed in upcoming EWCC meetings)<br>I. Palmamy Kanu – Maranko Section<br>II. Selu Konteh (acting) – Magbanta Section<br>III. Almamy Kargbo – Rogberay Section<br>IV. Idrissa Touray – Rofenka Section<br>V. Palmamy Kennedy Kamara – Moria Section<br>VI. Almamy Sonkoi Kamara – Kamrabai/Waterloo Section<br>VII. Palmamy Sorie Kamara – Mathera Section<br>VIII. Palmamy Thonkara – Thonkara Section<br>IX. Pabu Fouray Kanu (acting) Maforay Section<br>X. Palmamy Kanu – Magberi Section<br>XI. Palmamy Konteh – Gberaymorie Section<br>XII. Palmamy Kamara – Mamanso Section<br>3. 1 women's leader<br>4. 1 youth leader<br>5. 3 MP<br>I. Hasan Sheriff<br>II. A.O. Darani<br>III. Isa Tuji<br>6. 4 councillors<br>7. Representatives from these lead agencies:<br>I. EPA (not present but indicated they would try to make themselves available from Freetown)<br>II. Ministry of Agriculture, Forestry and Food Security<br>III. Ministry of Lands and Housing<br>IV. Ministry of Mines represented here by the Chairman of the | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | Tonkolili District Council Committee on mineral Resources.<br>V. 1 District Council Internal Affaires Department<br>8. 3 AML personnel<br>9. 1 NGO to be selected by Isa Tuji (area MP) ensuring that a suitable locally active NGO is chosen.<br>Additional membership would be required to assist the EWCC:<br>• On valuation of structures. It was determined that the Port Loko District Council has suitable resources to fill this role and that they should be approached to participate accordingly.<br>• The District Forest Officer in Port Loko represents the EPA in the Port Loko and should also be invited to attend.<br>A monthly meeting schedule was agreed.<br>This EWCC would operate through consensus. A Section Chief was concerned that educated people would dominate the committee and he would not be given a chance to participate. | |
| 9. | The ToR will be reviewed in more detail at the next meeting to make sure that all participants have an opportunity to comment. | |
| 10. | Social Impacts were discussed as a way of gearing members up to participate actively in ensuring that issues affecting local communities as a result of the early works were addressed. | |
| 11. | Part of the EWCC's role is to ensure that decisions made by the committee are communicated to people on the ground. This is to be carried out through the Section Chiefs and the Community Sensitisation Program (CSP).<br>The CSP would begin with relaying the Project Description to the affected villages after the next meeting and then carry out regular information sessions through designated EWCC members to allow for local communities to receive and respond to issues raised.<br>Members suggested that political leaders could assist AML with CSP and the EWCC could design a program that would provide entertainment so that the messages would be well received by the affected communities. AML was advised to budget appropriately for this.<br>The Chairperson had conducted these sorts of committee meetings in the past with London Mining and she advised that lower Maforki was conversant with the program but warned that the EWCC would have to act quickly to inform those in upper Maforki. She noted that there were important ritual areas in upper Maforki.<br>Members were reminded that only the Chief can allay villagers fears.<br>Suggested EWCC should go to villagers to advise them on compensation issue through the CSP. They could be scheduled two per day. | |
| 12. | Other points of discussion included:<br>1. Councillor Kamara was glad to attend and has been waiting for some time for the opportunity to discuss the AML project. AML's public image is good and it is hoped that this will continue through the EWCC process. Maforki is hungry for development and as a councillor must push wherever possible to serve the people of the chiefdom. Maforki needs: | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
| --- | --- | --- |
| | a. Clean water (not available in many areas)<br>b. Broken bridges replaced.<br>c. Not enough schools in the area.<br>It is hoped that AML will assist with all of these issues.<br>Thanks was given to the Chairperson and the Regent Chief .<br>2. Section Chief Palmamy Thonkari also expressed his gratitude to the Regent Chief and reiterated that his area had been through this with London Mining and if AML were also going to pass through his area he would be very happy as well. He would like to see AML assist with the following in his area:<br>a. Health<br>b. Education (secondary school for lower Maforki)<br>c. Water<br>He also advised the EWCC that safety should be discussed as a priority during the meetings.<br>3. The area youth leader noted that he was elected by the youth leadership to represent them at this meeting and future EWCC meetings. He stated that he was happy to participate noting that this was the first time that the youth had been consulted in such a project within the chiefdom.<br>Youth are looking forward to the employment opportunities that the project will generate. He cautioned AML to keep to the promises made with respect to jobs for affected people.<br>Scholarships are also needed to uplift the youth of the area and the youth stand to lose the most if these benefits are not delivered as they usually do not benefit from compensation payments made to their elders.<br>4. Mrs Kamara noted the primary importance of employing locals to reduce the impact from loss of crops, land and plantations. The EWCC should look at alternatives in the case of loss of land.<br>5. The Regent Chief wanted to encourage full participation of all members and asked that they take the earliest opportunity to go to the ground and deliver the message to the communities and that they would also be happy about the project.<br>He will need to pay respect to the village chiefs to get their respect in return.<br>He advised AML that the Chairperson had many years experience in the area and that’s why she was asked to attend.<br>6. The Chairperson, in closing, thanked all participants for attending and assisting AML. She stated that AML should call on those who are available to work with them to provide meaningful input.<br>She advised that with the Regent Chiefs blessing another venue should be identified for the next meeting. | |
| 13. | The next meeting will be determined once the following has been undertaken: | |

**MEETING RECORD**

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | 1. Everyone chosen should be informed by the District Council Chairman.<br>2. Area MP to be invited to Chair the meeting. | |
| 14. | This meeting was interrupted a person who turned out to be the area MP (Isa Tuji) who was very upset that we were meeting in her constituency without her knowledge. She initially insisted that the meeting stop immediately and everyone vacate. After interjection of the Chairperson and other participants it was explained that AML were tasked with informing the area MP and they apologised for not carrying that task through. | |
| 15. | Meeting ended with Muslim and Christian prayers followed by lunch. | |

**END OF RECORDS**

## EARLY WORKS CHIEFDOM COMMITTEE MEETING
## ATTENDANCE REGISTER

Chiefdom: Maforki

Date: 15th March 2010

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | COLIN FORBES | Worleyparsons | [signature] | 033 379018 |
| 2 | Douglas A. Kamara | District Crops officer MAFFS | [signature] | 033-688854 |
| 3 | Pa Alimamy Kekoor Kamara | Regent Chief elder | | |
| 4 | Pa Alimamy Sorikoi Kamara | Section chief | | 076 932970 |
| 5 | Pa Alimamy Sorie Kamara | Section " | | |
| 6 | Pa Alimamy Kangbo Kamara | Section " | | |
| 7 | Pa Idrissa Turay | Section " | | |
| 8 | Pa Alimamy N Kennedy | Section " | | 088 86-86-75 |
| 9 | Anthony K Kamara | Secretary | | 077-50-52-37 |
| 10 | Ya Bom Kapri Kamara BaBah | Se | | 076 893222 |

| | | | | |
|---|---|---|---|---|
| 11 | Pa Kemoko ~~Section~~ Sesay | Section Chief. | | |
| 12 | Pa Alimamy Kanu | Section " | | |
| 13 | Pa Alimamy Kamara | Section " | | |
| 14 | Pa Alamamy Koretel | Section " | | |
| 15 | Abdulrahman Kamara | Youth | | |
| 16 | Mariama M Sesay | " | | 088 509980 |
| 17 | Abdul K. Kamara | Councillor ~~17~~ | ward 170 | 076788758 |
| 18 | Pa Alimamy Fofanah | Section " | | |
| 19 | Zainab Mansaray | Councillor | ward 169 | 07632323 0 |
| 20 | Patricia Foki Sowkri | NGO/CBO Rep. | | 076-866660. |

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African MINERALS

**MEETING RECORD**

**Project No:** 305000-00006
**Project**: Tonkolili Iron Ore Project

# Early Works Chiefdom Committee Inaugural Meeting Makari Gbanti

| PARTICIPANT NAME & ORGANISATION | | DATE | 16 March 2010 |
|---|---|---|---|
| CLIENT | See Makari Gbanti Attendance List (attached) | TIME START | 11:00 |
| WORLEYPARSONS: | Colin Forbes | TIME FINISH | 13:30 |
| | | LOCATION | Court Barrie Panlap |
| AML | Tim Fofana<br>Abdul Sesay | RECORDER | Author |
| | | DOC NO | 305000-00006-0000-O-MOM-0020 |
| | | FILE LOC | SharePoint\AML Tonkolili Page\Minutes of Meeting |
| | | PROJ REF | |
| SIGNATURE ORIGINATOR | | DATE SIGNED | |
| SIGNATURE OTHER PARTY | | DATE SIGNED | |
| COPIES | | | |

## RECORD OF DISCUSSIONS

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 1. | **Safety Moment**<br>None | |
| 2. | **EWCC Conducted as per Makari Gbanti Agenda** (attached) | |
| 3. | Prayers were conducted for Muslim and Christian members. | |
| 4. | The Paramount Chief delegated the chairmanship for this meeting to the area councillor. | |
| 5. | It was agreed that the meeting would be conducted in Timneh with translation into English when required. | |
| 6. | The Paramount Chief opened the meeting by welcoming all those present and stressing that the Early Works Chiefdom Committee (EWCC) has an important role to play in making sure that the construction of the haul road goes on well and benefits for the local communities can be realised.<br>He welcomed all participants and thanked AML for the participatory approach to | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| | development. He indicated that this was essential to building the foundations of sustainable development. | |
| 7. | EWCC members present introduced themselves (see Attendance Register).<br>The Chairman commented that Makari Gbanti was lucky to lead all other chiefdoms. He advised AML to quarry stone in Makari Gbanti as it was known for it's strength. He also advised the company to pay attention to swamp areas as that is where locals earn their living and feed themselves. | |
| 8. | A description of the Early Works Program was provided (see attached sheet – Early Works Project Description) which included hematite mining, construction of the haul road and refurbishment of the Peel railway and port. There was also a brief discussion on haul road operations (see attached sheet – Road train). | |
| 9. | After reviewing the map provided by Colin Forbes, the EWCC was asked to produce a list of affected villages in the chiefdom at the next meeting. | |
| 10. | Committee structures were reviewed and emphasis was placed on roles being relevant to the subject matter. It was also stated that there should be room to induct further members in the future if necessary. The Paramount Chief asked that the Section Chiefs pick able people to attend.<br>Membership was agreed (with reference to the EWCC Terms of Reference (ToR) guide) as follows:<br>1. Paramount Chief<br>2. 7 Section Chiefs<br>3. 1 women's leader<br>4. 1 youth leader<br>5. 1 MP<br>6. 3 councillors<br>7. Representatives from these lead agencies:<br>a. EPA (not present but indicated they would try to make themselves available from Freetown)<br>b. Ministry of Agriculture, Forestry and Food Security<br>c. Ministry of Lands and Housing<br>d. Ministry of Mines represented here by the Chairman of the Tonkolili District Council Committee on mineral Resources.<br>8. 3 AML personnel<br>9. 1 NGO to be selected by SLANGO ensuring that a suitable locally active NGO is chosen.<br>A monthly meeting schedule was agreed.<br>This EWCC would operate through consensus. | |
| 11. | It was decided that the ToR would be reviewed at the next meeting when all participants will be present. | |
| 12. | • Social Impacts were discussed as a way of gearing members up to participate actively in ensuring that issues affecting local communities as a result of the early works were addressed | |

| ITEM | ITEM DETAILS | ACTION BY AND DATE |
|---|---|---|
| 13. | Part of the EWCC's role is to ensure that decisions made by the committee are communicated to people on the ground. This is to be carried out through the Section Chiefs and the Community Sensitisation Program (CSP).<br>The CSP would begin with relaying the Project Description to the affected villages and then carry out regular information sessions through designated EWCC members to allow for local communities to receive and respond to issues raised.<br>Villages will be grouped together to simplify the exercise.<br>It was suggested that the CSP could be delivered through existing information dissemination structures. Tim Fofana responded saying that AML want to participate directly with message delivery. | |
| 14. | No other issues were discussed. | |
| 15. | The next meeting was set for 30th March 2010 at Panlap. | |
| 16. | Meeting ended with Muslim and Christian prayers followed by lunch. | |

**END OF RECORDS**

# EARLY WORKS CHIEFDOM COMMITTEE MEETING
## ATTENDANCE REGISTER

Chiefdom: Makari-Gbanti C/Dom

Date: 16-3-2010

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | P.C. Massa Yeli Tham II | Paramount Chief | P.C. Massa Yeli | 078-705313 |
| 2 | Pa Alimamy Kamara | C/Dom SPK | Pa Alimamy Kamara | |
| 3 | Madam Yeli Tham | Women Leader | M Thom | 076-834671 |
| 4 | Pa Alimamy Tarawallie II | Section Chief | [illegible] | |
| 5 | " Santigie Lima | Mankneh chief " " | for AB | |
| 6 | MR Alfred A. Sesay | Mabanta section chief | A Sesay | 077 434331 |
| 7 | MR Sallie G.O. Kamara | member | [illegible] | 076888196 |
| 8 | MR James Mansaray | Rosint section chief | for AB | 088-885028 |
| 9 | MR. Alfred K. Tarawallie | Treasury Clerk | [illegible] | 076-709983 |
| 10 | MR Mattine Bangura | Honourable | | |

| | | | | |
|---|---|---|---|---|
| 11 | MR. Osman K. Tarawalie | Rep Town Headman | [signature] | 076-894755 077-154251 |
| 12 | Pa Umaru Kabia | Section chief Masuba | [signature] | 077-260816 |
| 13 | MR. Desmond Bangura | Councilor | Bang. | 077-832444 033-716572 |
| 14 | Pa Alimamy Conteh | Section Chief Mena-Gbanti | [signature] | |
| 15 | MR. Peter K. Bangura | Gbosana section | PBangura | 078-556655 |
| 16 | MR. Matin Turay | Okdom Youth Leader | GMartin | 076-505781 |
| 17 | MRS Matha Karim | Councilor | MKarim | 076-532029 |
| 18 | Pa Alimamy I Tarawallie | Magbentah section chief | RTP | |
| 19 | MR Mohamed S. Kamara | mines | HKamara | 076-650350 |
| 20 | MR Boyntine | Agriculture | [signature] | 076-588368 |

***Minutes of inaugural meeting-Buya Romende***

Minutes of the inaugural meeting held for the formation of an Early Works Chiefdom Committee for Buya Romende.

Location: Kamasundu N.A. Court Barrie
Date: 19th March 2010.
Present: Please see the attached.

The chairing role for the occasion was carried out by Hon.Alhaji Buya Kamara MP

Prayers were recited in both the Muslim and Christian faiths.

The Paramount Chief and Hon.Alhaji Buya Kamara welcomed all the attendees especially the AML personnel.

Brief introduction of each person on the high table was individually done.

Mustapha Kamara told the attendees that the main purpose of the meeting was to have a committee formed that represents the interest of all stakeholders to be affected by the construction of a major haul road being undertaken by AML.

He talked about the following:

- AML's previous activities at the Tonkolili Project Site which yielded the discovery of some huge amount of iron ore deposit of magnetite that is covered by oxidized haematite.

- The company's intentions to mine,treat and haul the haematite for export on a road that will pass through Buya Romende chiefdom to end up at the old Delco rail line at Rolethe.

- Due to the scale of the engineering works to be undertaken in the construction of this haul road across the chiefdom, many side effects are sure to emerge. He cited the inevitable loss of some agricultural land e.g. swamps etc. He said every effort is being made to eliminate or minimize inconveniences to the communities affected. Bridges, underpasses etc will be built so as to maintain continuity of road links and services between villages/towns.

- Many other issues affecting the communities may come up during and after the construction of the haul road. The physical dimensions of the road's width and the length of the Land Train that will ply the route were indicated outside the court barrie. (diagrammatic pics. of the Land Train and map showing the road thro' the chiefdom were distributed.)

- The need to inform people about the haul road and to address adequately and promptly any and all problems facing the communities could best be done by a committee comprising of the Paramount Chief, Section Chiefs of the affected sections, Political leaders, representation from the Youths, Women and some actively-based non-Governmental organization or Community-based Organization plus the line Ministries e.g. Agriculture, Mineral Resources, EPA etc.

- The sheets containing the Terms of Reference for the committee were handed out and discussed. It was unanimously agreed that the composition of the committee and its terms of reference are adequate and satisfactory.

Meetings are scheduled to be held once a month. The Councillors and Section Chiefs are to immediately start sensitizing communities in their respective wards. Mustapha Kamara apologized to the chiefdom authorities for a complaint that some road contractor started his work even before AML informed the chiefdom about the project.

The date for the next meeting is to be advised.

The meeting ended with prayers.

## EARLY WORKS CHIEFDOM COMMITTEE MEETING
## ATTENDANCE REGISTER

Chiefdom: Buya Romende        Date: 19th March 2010

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | Issa B. Maral | MAFFAS | [signature] | 077 491 393 |
| 2 | Pa Kapr Wander | Ceremonial chief | | 088 597365 |
| 3 | Pa Roke Sesay | " | [signature] | |
| 4 | Pa Kuma Bangura | " | PA KUMA | 076-935646 |
| 5 | Alpha Ibrahim Kargbo | Imam | | |
| 6 | Santigie Kamara | Farmer | | |
| 7 | Alhaji Unisa Kargbo | chief Imam | [signature] | |
| 8 | Abo Kargbo | | ABU KB | 076-716973 |
| 9 | Baba Kargbo | | | |
| 10 | Tim Fofana | Amh | [signature] | 033-256-702 |

19-3-2010

| | | | | |
|---|---|---|---|---|
| 11 | ANDREW HUCKBODY | EIA Manager Worley Parsons | [signature] | +76318515 |
| 12 | Murtyda Kamara | African Minerals | [signature] | +23221605829 |
| 13 | Hon Alhaji Buya Kamara | M.P. | [signature] | 076731170 |
| 14 | Pc Bai Banta N'Kemp | P.C | [signature] | 076 ~~373~~ 440 |
| 15 | mohamed Turay | councilor-176 | [signature] | 076-208-903 |
| 16 | Ishmail Fouti Kamp | Councillor-177 | [signature] | 076-690-374 |
| 17 | Pa Morlai Kamp | S.P.K. B/Rande | MOR | 076 332716 |
| 18 | PATRICK A. TURAY | C.C.A.C. | [signature] | 076-220926 |
| 19 | Pa. Alimamy Kama | Section chief | Pa Almamy Kama | 088-598665 |
| 20 | Alfred B. Kargbo | Treasury clerk | [signature] | 088-785251 |
| 21 | Abdul Deen Sesay | AML | [signature] | 033-353-334 |

# ***Excerpts of a Post Meeting held at Loko - Masama***

**Location:** Petifu Junction
**Date:** 20th March 2010.
**Present:** Signatories to the attached and many other listeners.

Apologies were offered reservedly to the Paramount Chief for my inability to attend the main meeting which ended some half hour before my arrival.

The chief and all present were told that although the direct and indirect consequences of the construction of the haul road do not affect them, I explained about AML's activities.

***Lectures were given on the following;***

- ✓ Iron ore deposit at Tonkolili

- ✓ The plans to Mine, Treat and Haul the hematite for export which the country stands to benefit from.

- ✓ The construction of a haul road that runs through many chiefdoms before finishing at Rolethe in the Maforki Chiefdom.

- ✓ The much needed exporting of the mined ore at Ferengbaia can only be achieved by the refurbishing of the old Delco rail line that goes through Loko - Masama to Marampa.

- ✓ They were informed about the 99yr. lease agreement between AML and the Government of Sierra Leone. The 30 years of inactivity of the rail line may have resulted to the putting up of houses close to the rail line and the growing of trees of economic importance to the communities. International standards prohibit all of these and communicating this to the communities and seeking solutions to them is best done by a competent committee.

- ✓ It is particularly crucial for the formation of this committee comprising of the Paramount Chief, Section Chiefs, Political Leaders, representation from the line Ministries, Youths, Women NGO etc. The committee is to seek the interest of the Stakeholders, address in time all issues affecting the project etc.

- ✓ Copies of the Early Works Project Description, Terms of Reference for the committee and the map showing the rail line to Pepel were distributed.

- ✓ The date for the next meeting will be communicated to the committee later.

**EARLY WORKS CHIEFDOM COMMITTEE MEETING**
**ATTENDANCE REGISTER**

Chiefdom: Loko Masama

Date: 20-3-2016

| No. | Name | Designation | Sign | Contacts |
|---|---|---|---|---|
| 1 | P.C, Bai Mano Kombo IV | Paramount Chief | [signature] | 076-655890 |
| 2 | Hon. Kombo Kamara | | | |
| 3 | Hon. Binneh Bangura | | | |
| 4 | Umaro Bai Kallay | Councillor ward 193 | [signature] | 076-784140 |
| 5 | D'Bai Feth Kamara | Section chief | [signature] | 076-750508 |
| 6 | Mamoh C, Bangura | Revenue Collector | [signature] | 076-689024 |
| 7 | Pa. Alimany Conteh | Section chief | [signature] | 076-574397 |
| 8 | Basiru Kamara | Chiefdom organizer | [signature] | 088-253548 |
| 9 | Thaimu Conteh | Photographer | [signature] | 076990614 |
| 10 | Margai Bangura | Health Inspector | [signature] | 078 487564 |

| | | | | |
|---|---|---|---|---|
| 11 | Samuel Kamara | Regent Sect. chief | [signature] | 078 40 73 90 |
| 12 | chernor Mansaray | Driver | [signature] | 078-668051 |
| 13 | Thaimu Kamara | | | |
| 14 | Alpha Yayah Kamara | Farmer | K TP. | |
| 15 | Joseph B. Bangura | Retired Civil Servant | | |
| 16 | Pa. Santigie Yalla Boy | Farmer | | |
| 17 | Isatu Bangura | House wife | | |
| 18 | Hadja Memuna Gassama | House wife | H.M. Gassama | 076-672646 |
| 19 | Pa. santigie Kolen Kamara | | | |
| 20 | Hawanatu Kamara | House wife | | |

# APPENDIX 20

## The Resettlement Policy Framework

# 1 THE RESETTLEMENT POLICY FRAMEWORK

The Resettlement Policy Framework (RPF) outlined in this report provides guidelines for the compensation of those who will be affected by physical and/or economic displacement. In line with IFC Performance Standard 5, it aims to:

- Clarify the legal requirements and principles for compensation for loss of property, livelihood and relocation or resettlement (of directly affected people) in order to ensure that project affected people (PAP) will not be negatively affected by resettlement or economic displacement.
- Describe the social context in which the resettlement will take place.
- Identify affected parties.
- Define the actions and tasks that need to be undertaken to plan the resettlement programme.
- Define the roles and responsibilities necessary to develop a full RAP.
- Describe the arrangements for funding resettlement and compensation as well as a timeline for activities.

These objectives are addressed in the following sections.

# 2 LEGISLATIVE OVERVIEW

In the sections below both Sierra Leone legislation and international best practice for resettlement and compensation are discussed.

## 2.1 Sierra Leone Legislation

### *2.1.1 The Mines and Minerals Bill*

**Occupation of Land, Resettlement and Compensation**

The Mines and Minerals Bill, August 2009 outlines the legislation in terms of occupation of land, resettlement and compensation. The relevant sections are outlined below:

**Section 32**

**(1)** The holder of a mineral right shall not exercise any of his rights, under the mineral right- except with the written consent of the owner or lawful occupier or his duly authorised agent, in respect of:

(i) any land dedicated as a place of burial or which is a place of religious or other cultural significance;

(ii) any land which is the site of, or which is within two hundred metres or such greater distance as may be prescribed, of any inhabited, occupied or temporarily unoccupied house or building;

(iii) any land which is within fifty metres or such greater distance as may be prescribed, of land which has been cleared or ploughed or otherwise bona fide prepared for the growing of, or upon which there are growing agricultural crops;

(iv) any land which is the site of, or within one hundred metres or such greater distance as may be prescribed, of any cattle dip, tank, dam, or other body of water,

(v) in respect of any land within any township, or within two hundred metres or such greater distance as may be prescribed, of the boundaries of any township, except with the written consent of the local authority having control over the township.

### Section 33

**(1)** The owner or lawful occupier of any land which within an area that is the subject of a mineral right shall retain the right to graze stock upon or to cultivate the surface of such land in so far as such grazing or cultivation does not interfere with the proper use of such area for reconnaissance, exploration, or mining operations.

**(3)** The rights conferred by a mineral right shall be exercised reasonably and so as to affect as little as possible the interests of any owner or lawful occupier of the land on which such rights are exercised consistent with the reasonable and proper conduct of the operations concerned.

### Section 34

Subject to the provisions of any law relating to the acquisition of land titles[1] and Section 38, the holder of a large-scale mining license shall obtain a land lease or other rights to use the land upon such terms as to the rents to be paid for the license, the duration or the extent or area of the land to which such license shall relate, as may be agreed between such holder and such owner or lawful user of the land or failing that, such agreement as may be determined by the Minister on the advice of the Minerals Advisory Board.

### Section 35

**(1)** The holder of a mineral right shall on demand being made by the owner or lawful occupier of any land subject to such rights pay such owner or lawful occupier fair and reasonable compensation for any disturbance of the rights of such owner or occupier and for any damage done to the surface of the land by his operations and shall on demand being made by the owner of any crops, trees, buildings or works damaged during the course of such operations pay compensation for such damage subject to the following-

[1] *See below: Provinces Land Act, Chapter 122 of the Laws of Sierra Leone, 1960. Section 4.*

(a) subject to section 38, payment of rent under the provisions of section 34 shall be deemed to be adequate compensation for deprivation of the use of land to which such rent relates;

(b) in assessing compensation payable under this section, account shall be taken of any improvement effected by the holder of the mineral right or by his predecessor in title the benefit of which has or will inure to the owner or lawful occupier;

(c) the basis upon which compensation shall be payable for damage to the surface of any land shall be the extent to which the market value of the land (for which purpose it shall be deemed saleable) upon which the damage has occurred has been reduced by reason of such damage, but without taking into account any enhanced value due to the presence of minerals;

(d) no compensation shall be payable to the occupier of a state grant of land in respect of any operations under a mineral right existing at the date of such grant; and

(e) no demand made in terms of this subsection shall entitle the owner or lawful occupier to prevent or hinder the exercise by the holder of a mineral right of his rights there under pending the determination of compensation to be paid.

**(2)** If the holder of a mineral right fails to pay compensation when so demanded under the provisions of this section, or if the owner or lawful occupier of any land is dissatisfied with any compensation offered, such compensation may be determined by the Minister on the advice of the Mineral Advisory Board.

**(3)** A claim for compensation under the provisions of subsection (1) shall be made within a period of two years from the date when the compensation became due failing which, notwithstanding the provisions of any other enactment, such claim shall not be enforceable.

### Section 36

**(1)** The Government may, by order published in the Gazette, compulsorily acquire in the name of the Republic private land or rights over or under private land for use by the holder of a large scale mining licence.

**(2)** Before making an order under subsection (1) the Government shall be satisfied that;

(a) the holder of a large-scale mining licence has taken all reasonable steps to acquire on reasonable terms by agreement with the owner, the land which he wishes to use or the right which he wishes to exercise and has been unable to do so; and

(b) the acquisition of such land or right is necessary for mining purposes or for purposes ancillary to mining.

### Section 37

**(1)** Subject to Section 38, when land is acquired compulsorily pursuant to Section 36, those persons having an interest in or rights over the land concerned shall be paid adequate compensation by the holder of the mineral right determined on the same basis as compensation for disturbance of rights pursuant to Section 35.

**(2)** The holder of a large-scale mining licence shall, before entering into possession for enjoyment of any land or before exercising any right over the land, make payment of compensation as determined in accordance with subsection (1) to the person or persons concerned or if the whereabouts of the person or persons concerned or any of them are unknown, give such undertakings concerning the payment of compensation as the Government may require.

### Section 38

**(1)** The Minister shall ensure that all owners or lawful occupiers of land who prefer to be compensated by way of resettlement as a result of being displaced by a proposed mining operation are resettled on suitable alternate land, with due regard to their economic well-being and social and cultural value so that their circumstances are similar to or improved when compared to their circumstances before resettlement, and the resettlement is carried out in accordance with the relevant planning laws.

**(2)** The cost of resettlement shall be borne by the holder of the mineral right,

(a) as agreed by the holder and the owner or lawful occupier of land or by separate agreement with the Minister, or

(b) in accordance with a determination by the Minister, except that where the holder elects to delay or abandon the proposed mining operation which will necessitate resettlement, the obligation to bear the cost of resettlement shall only arise upon the holder actually proceeding with the mining operation.

**(3)** Subject to this section, the Minister and a person authorised by the Minister may take the necessary action to give effect to a resettlement agreement or determination.

### *2.1.2 Artisanal Mining*

**Section 30**

- Where the Minister considers that it is in the public interest to encourage exploration and mining of minerals in any area by methods not involving substantial expenditure or the use of specialised technology, he may by notice in the *Gazette*, declare that area for licensing of artisanal or small-scale mining operations and the provisions of Part X and Part XI shall apply.

**PART X: Artisanal mining licences**

**Section 84**

**(1)** Any person/partnership (Sierra Leone citizen) who wishes to carry out artisanal mining operations shall apply for an artisanal mining licence.

**(3)** All such partnerships shall register with the Director and shall provide such documentation as the Director may require.

**Section 87**

**(1)** No person other than the holder of an exploration licence shall be granted an artisanal mining licence in respect of land which constitutes the exploration licence area or part of the exploration licence area, except with the consent of the exploration licence holder.

**(2)** No artisanal mining licence shall be granted to an applicant in an area designated under Section 30 for small-scale mining operations.

**Section 88**

**(1)** An artisanal mining licence in the prescribed form shall

(a) state the period for which it is granted;

(b) include a description and plan of the area of land over which it is granted; and

(c) state the conditions on which it is granted.

**(2)** There shall be appended to an artisanal mining licence a certified copy of the agreement between the applicant and the Chiefdom Mining Allocation Committee or the rightful occupiers or owners of the land over which the artisanal mining licence is granted which shall form part of the terms and conditions of the artisanal mining licence.

**Section 89**

An artisanal mining licence area shall not be more than one half hectare.

**Section 90**

**(1)** Subject to subsection (2), an artisanal mining licence shall be valid for a period of one year and may be renewed for up to three further periods not exceeding one year at a time.

**(2)** An artisanal mining licence shall not be renewed pursuant to subsection (1)-

(a) if the artisanal mining licence area has ceased to be an area declared for artisanal mining operations;

**Section 91**

**(1)** Subject to the provisions of this Act or any other law and any condition of an artisanal mining licence, the holder of an artisanal licence shall have the exclusive right to carry on exploration and mining operations in the licensed area.

### *2.1.3 Land Acquisition Law*

The leasing of land is dealt with in the Provinces Land Act, Chapter 122 of the Laws of Sierra Leone, 1960. Section 4 of the Act states: a non-native cannot acquire a greater interest in land in the provinces than a lease for a period of fifty years. A clause can however be inserted in a lease, which provides for renewals of such a lease for terms each not exceeding twenty-one years.

A lease is defined in the Act as "*a grant of the possession of land by the tribal authority (now known as the 'Chiefdom Council'), as lessor, to a non-native, as lessee, for a term of years or other fixed period with a reservation of a rent*". The initial lease cannot be for a period exceeding 50 years; it can then subsequently be renewed for periods of up to 21 years. The lease agreement is required to state (a) the rent (b) the term of years (c) the purpose for which the land is to be used (d) whether the interest is assignable, (e) whether buildings of permanent structures are to be erected and the rights of the parties on the expiration/determination of the lease (f) that the rent is subject to review every seven years by the District Officer/Chief Administration office when the term of years exceeds seven years.

The Act makes no express reference to land owners; therefore a lease under the Act must be made between the chiefdom council and the non-native The Lease requires the rent to be split in accordance with the traditional approach of one-third being retained by the Chief Administrative Officer, one-third being paid to the Chiefdom Council and one-third being paid and to be shared between the traditional landowners on the Leased Area. Land lease agreements between AML and the affected chiefdoms are currently being put place in accordance with the land acquisition law.

## 2.2 International Guidelines

World Bank Operational Policy 4.122 (World Bank, 2004) is regarded internationally as the standard resettlement guidance. The objective of resettlement planning is to avoid resettlement whenever feasible, and when resettlement is unavoidable, to minimise its extent and to explore all viable alternatives. IFC Performance Standard 3: Land Acquisition and Involuntary Resettlement (IFC, 2006) was developed by the IFC (as part of the World Bank group) from OP 4.12 and provides internationally accepted policies and guidelines for resettlement. Performance Standard 5 states:

"*Where involuntary resettlement is unavoidable, the client will carry out a census with appropriate socio-economic baseline data to identify the persons who will be displaced by the project, to determine who will be eligible for compensation and assistance, to make an inventory of landholdings and immovable/non-retrievable improvements and to discourage inflow of people who are ineligible for these benefits. In the absence of host government procedures, the client will establish a cut-off date for eligibility. Information regarding the cut-off date will be well documented and disseminated throughout the project area*."

The standard states the following basic principles in terms of resettlement:

- Avoid or at least minimise involuntary resettlement wherever feasible by exploring alternative project designs;
- Mitigate adverse social and economic impacts from land acquisition or restrictions on affected persons' use of land by:
  - Providing compensation for loss of assets at replacement cost; and ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected.
  - Improving or at least restoring the livelihoods and standards of living of displaced persons.
  - Improving living conditions among displaced persons through provision of adequate housing with security of tenure at resettlement sites.
- Prepare a RAP and have it accepted by the relevant authorities prior to implementing resettlement activities. The RPF is a stepping stone towards the RAP once the project impacts are more clearly defined.

[2] (www.worldbank.org) and in the *World Bank's Resettlement and Rehabilitation Guidebook.*
[3] The IFC (www.ifc.org) Handbook for Preparing a Resettlement Action Plan.

- Ensure provision of compensation and the restoration of livelihoods of those affected prior to any actual resettlement. In particular, the policy requires that possession of land for project activities may take place only after compensation has been paid, or alternatively, if adequate guarantees of compensation have been made to the PAP's satisfaction. If the latter is chosen, compensation payments must not be delayed once resettlement has taken place. Resettlement sites, new homes and related infrastructure, public services and moving allowances must be provided to the affected persons in accordance with the provisions of the RAP.
- Pay particular attention to the needs of vulnerable groups. These are generally defined as those below the poverty line, the landless, the elderly, women and children, indigenous groups, ethnic minorities, orphans, disabled people and other disadvantaged persons.

## 2.3 Comparison of Sierra Leone Legislation and International Standards

This RPF is based on both Sierra Leone law and international guidelines, following the most stringent requirements of each. The comparison between both sets of guidelines is presented in Table 2-1 below.

**Table 2-1: Comparison Between Sierra Leone and International Standards**

| Topic | Sierra Leone legislation | IFC Performance Standard 5 | Preferred approach |
|---|---|---|---|
| Resettlement decision | Negotiated between Project and affected parties. If negotiation is not successful forced removal is possible | Negotiated between Project and affected parties | Negotiated between Project and affected parties |
| Resettlement | Optional depending on choice of affected | Recommended if affected parties' livelihoods are land based | Recommended if affected parties' livelihoods are land based |
| Eligibility for compensation criteria | Those who have legal rights to the land and those who do not have formal legal rights but have claim to such land or assets provided that such claims are recognised under the law | All those who are physically and/or economically-displaced, including those without legal status to occupy land | All those who are physically and/or economically-displaced, including those without legal status to occupy land |
| Cut-off date | No moratorium provided by the Government | If no moratorium is provided by the Government, the Project should establish and disseminate a cut off date. No compensation after the cut off date | A cut-off date needs to be established and disseminated. No compensation after cut off date |
| Compensation | Compensation can be in any form | Strongly recommends in-kind compensation, (replacement housing and replacement land especially for those with land based | Recommend in-kind compensation, but is negotiable |
| Calculation of compensation | Negotiated | Replacement costs or more | Replacement costs or more |
| Consultation with PAP and host | Provides for participation of local authorities insofar as negotiation for compensation arises | All affected parties should be involved in planning and implementing resettlement programmes. Displaced persons and host areas are provided | All affected parties and stakeholders need to be consulted |
| Payment of compensation for land | Land lease is paid to local authorities / not directly to the landowners | Payment should involve directly affected parties | Paid to local authorities but with mechanism to safeguard compensation of directly affected |
| Resettlement assistance | No specific legislation | Compulsory | Compulsory |
| Monitoring | No specific legislation | The project is responsible for monitoring of the resettlement activities | The project is responsible for monitoring of the resettlement activities |
| Vulnerable groups | No specific provisions for vulnerable groups | Require special attention and monitoring of vulnerable groups. | Special attention for vulnerable groups required |

From Table 2-1 it can be seen that in many respects Sierra Leone and international guidelines coincide. There are no contradictions between the two sets of guidelines. IFC standards supersede Sierra Leone standards in terms of resettlement assistance, monitoring, consultation with directly affected parties and special provision for vulnerable groups. IFC standards also make provision for a cut-off date for compensation eligibility.

# 3 SOCIO-ECONOMIC PROFILE OF THE AFFECTED AREAS

To effectively execute the resettlement process, the social context in which the resettlement will need to take place needs to be understood. This is described below.

## 3.1 National context

### *3.1.1 Introduction*

The Republic of Sierra Leone, which covers an area of 71,740 $km^2$, is located in West Africa, bordered by Guinea in the northeast, Liberia in the east, and the Atlantic Ocean in the southwest. Freetown, the capital of Sierra Leone, is located on the coast[4].

### *3.1.2 History[5]*

Early inhabitants of Sierra Leone include the Sherbro, Temne, Limba, and Tyra peoples. Later, the Mende and the Kono arrived and settled in the east of the country. In 1462, the Portuguese explorer Pedro da Cintra gave the country its name Serra de Leão, meaning Lion Mountains.

Sierra Leone became an important centre of the transatlantic slave trade until 1792, when Freetown was founded by the Sierra Leone Company as a home for formerly enslaved African Americans who had been promised their freedom for joining the British Army during the American Revolution. Thousands of formerly enslaved Africans, mainly from the West coast of the USA, were returned to or liberated in Freetown.

In 1808, Freetown became a British Crown Colony, and in 1896, the interior of the country became a British Protectorate. During colonisation indigenous people mounted several unsuccessful revolts against British rule. The most notable was the Hut Tax war of 1898. Its first leader was Bai Bureh, a Temne chief who refused to recognise the British-imposed tax on huts (dwellings).

In 1961, Sierra Leone gained independence and the Sierra Leone People's Party (SLPP) won by large margins in the nation's first general election under universal adult suffrage in May 1962. Turbulent political years followed with several uprisings and coups, culminating in the development of a one party state. Government corruption, neglect of the interior, mismanagement of diamond resources and the spilling over of the Liberian conflict into its borders eventually led to the Sierra Leone civil war, which began in 1991 and was resolved in 2001 after

[4] *Information acquired from Wikipedia on 2 April 2010.*
[5] *Information acquired from Wikipedia on 2 April 2010.*

the United Nations led by Nigeria defeated the rebel forces. The war claimed an estimated 20,000 lives and over 2 million people were displaced from their homes. In December 2005, UN peacekeeping forces pulled out of Sierra Leone and in August 2007, presidential and parliamentary elections were held. Ernest Bai Koroma was elected president.

### *3.1.3 Demographics*[6]

Sierra Leone's population is 6,440,053 with a population growth rate of 2.3%. Forty four percent of the population is under the age of 14. There are 16 ethnic groups, each with their own language and culture. The two largest groups are the Mende and the Temne, each comprises 30% of the population. The Mende predominate in the South-Eastern Provinces; the Temne in the Northern Province. Other groups include the Limba, the Kono, the Mandingo and the Krio (descendants of freed West Indians slaves from the West Indies and freed African American slaves from the United States). Three religions prevail in Sierra Leone. The majority (60%) are Muslim, 30% are Christian and the remaining 10% consist of indigenous religions.

### *3.1.4 Living Standards*[7]

The UNDP Global Human Development Report (2007) ranked Sierra Leone at the bottom of 177 countries in terms of general development. About 70% of the population lives below the national poverty line. Poverty is most prevalent in the rural areas and amongst the youth (males and females between 15 and 35). Youth are increasingly leaving agriculture to find economically more rewarding occupations, often failing to find secure employment or gainful economic activities. During the war 57% of the population lived on less than US$1 a day.

Sierra Leone’s Poverty Reduction Strategy paper of 2005 outlined its commitment to poverty alleviation. However, youth unemployment / underemployed remains high at 70% and food security constitutes a major challenge constrained by lack of access to markets and poor rural infrastructure. The country is heavily dependent on Official Development Assistance (ODA), with about 50% of public investment programmes financed by external resources.

The poor national infrastructure and the small size of the private sector are significant impediments to the achievement of the higher and more equitable growth required to effectively address poverty and unemployment.

[6] *CIA World book.*
[7] *Poverty Reduction Strategy Paper.*

### 3.1.5 Economy[8]

The economy of Sierra Leone has suffered greatly as a result of the civil war. During the war, economic growth plunged to -4.5% per annum. However Sierra Leone experienced a robust post-war recovery. In the aftermath of the civil war (1992-2001) it sustained one of the highest GDP growth rates (an average of 7%) in Africa. Reconstruction, a substantial increase in aid flows and improved structural and macroeconomic policies contributed to this rapid growth. Large mineral deposits enabled strong export growth. Sierra Leone‘s strong recovery continued into 2008 when real Gross Domestic Product (GDP) grew by an estimated 5.5% despite rising food and fuel prices.

However, economic recovery has slowed down along with the global economic downturn. In 2009, the IMF forecasts that real GDP growth is expected to drop to 4.5% as global recession reduces the demand for Sierra Leone‘s mineral exports and the rate of post-war recovery declines. Given the breadth of the current economic crisis, and the potentially damaging effect of falling commodity prices, identifying and remedying investment climate problems is essential. Investment climate reforms would increase the ability of the economy to adapt to economic shocks more easily.

The goal of sustaining rapid and inclusive growth is made more challenging because so much of Sierra Leone’s growth has been dependent on the exploitation of natural resources, such as diamonds, rutile and bauxite. Yet most mining is capital intensive, and although it contributes more than 19% of GDP, it employs less than 3% of the formal sector population (although closer to 7% of the total population). In contrast, the agriculture sector (including fisheries) employs more than 60% of the population while providing 44% of GDP, with both the share of employment and GDP declining every year. The manufacturing sector has been weak, due to supply side constraints and competition from cheaper imports.

Economic diversification and more inclusive growth patterns will be critical to sustain high growth. A recently completed private sector development diagnostic report noted the critical need to develop a culture of entrepreneurship, as Sierra Leone is weaker than many of its West African peers in the rate of new business entry. It also identified fisheries, segments of agriculture and tourism as potentially strong sources of private sector growth.

### 3.1.6 Health

The state of health of Sierra Leone’s population is generally poor. The infant mortality rate is 165 deaths per 1,000 live births[9] and life expectancy is 42.1 years[10].

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[8] *Based on World Bank. (2009). Sierra Leone Country Brief. March.2009, Economist Intelligence Unit (2009). ―Country Report, Sierra Leone June 2009; IMF. ―Sierra Leone: Selected Issues and Statistical Appendix. January 2009. IMF Country Report No. 09/12 17 IMF. ―Sierra Leone: Selected Issues and Statistical Appendix. January 2009. IMF Country Report No. 09/12.*

[9] *Poverty Reduction Strategy Paper.*

Approximately 47% of the population do not have access to clean water and 50% is undernourished.

Malaria and waterborne diseases are the main health threats. An MSF[11] study in 2005 showed that 63% of deaths in children were caused by malaria. The estimate of HIV/ AIDS prevalence in 2007 was 1.7%[12].There are, however great disparities in the prevalence among different segments of the population. In particularly the uniformed service personnel and commercial sex workers have higher prevalence rates, estimated at 10%[13].

The social costs of the protracted civil war in Sierra Leone have been extremely high[14]. About 75% of the country's health care facilities, including 15 hospitals and 150 primary health care centres, were not functional during that period. Due to insufficient financial resources, health care facilities have not been adequately restored. Faced with the shortfall of subsidies from government and international sources, most public health structures apply a *de facto* system of cost recovery, requiring patients to pay for most services[15]. Since a large section of the population cannot afford health services the use of the non-official health sector[16] is very high.

### *3.1.7 Education*

In Sierra Leone primary (6 years) and junior secondary (3 years) school level education is compulsory and free for all children. However a shortage of schools and teachers has made implementation of this legal requirement impossible. The civil war resulted in the destruction of 1,270 primary schools and in 2001, 67% of all school-age children were out of school.

The situation has improved considerably since then with primary school enrolment doubling between 2001 and 2005, and the reconstruction of many schools since the end of the war. However, the educational system is still grappling with myriad problems. Many rural primary schools do not have trained and qualified teachers. The Government's recent drive to encourage children to go to school has also created the unintended effect of overcrowding, even in urban areas.

The country has two universities, whilst teacher training colleges and religious seminaries are found in many parts of the country. These higher learning institutions also face considerable resource constraints, leading to shortages of essential personnel for science and technology teaching, applied agricultural research and extension and health care.

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[10] *UNDP stats 2006.*
[11] *Medecins Sans Frontieres.*
[12] *http://www.unicef.org/infobycountry/sierraleone_statistics.html. Figures for population between 15 and 49.*
[13] *Poverty Reduction Strategy Paper.*
[14] *Poverty Reduction Strategy Paper.*
[15] *Poverty Reduction Strategy Paper.*
[16] *Non-official sector refers here to traditional healers and informal sector. Informal sector includes ambulatory pharmacists ("pepper doctor"), home visit by a nurse etc.*

The literacy rate in Sierra Leone is low (35.1%, 2004 est.) with a large discrepancy between men (46.9 %) and women (24.4 %).

**Photo Plate 1: School building and a health centre in the project area**

### 3.1.8 *Gender*

As in many sub-Saharan countries, women are marginalised in terms of economic and political power. Although women in Sierra Leone carry out the majority of agricultural work, they have limited control over the economic resources they generate. Women are dependent on male family members, or the discretion of community leaders for access to land.

Discrimination against women in Sierra Leone has been exacerbated by the civil war, when women were submitted to displacement, insecurity and the breakdown of social services and support. Women and girls fulfilled a variety of functions during the war, including sex slaves and combatants. Many women were sole breadwinners, lacking the traditional family networks. Many women were subjected to extensive sexual violence throughout the period of war.

## 3.2 Regional Context

The Republic of Sierra Leone is composed of three provinces: the Northern Province, Southern province and the Eastern province and one other region called the Western Area. The provinces are further subdivided into 12 districts. District councils were established in 2000 and local government elections held for the first time in May 2004. The elected councils constitute representative bodies with delegated powers and funds to execute local governance. The district administration is made up of a senior district officer and officers representing various line ministries. The Ministry of Local Government and Rural Development coordinates the district officers. The district administration is responsible for the overall management of the districts, including provision of critical social services to the population.

The proposed development site and its transport infrastructure are situated in the Northern Province and cover the Districts of Tonkolili, Bombali and Port Loko (see Figure 3-1). The sections below provide a short description of these districts.

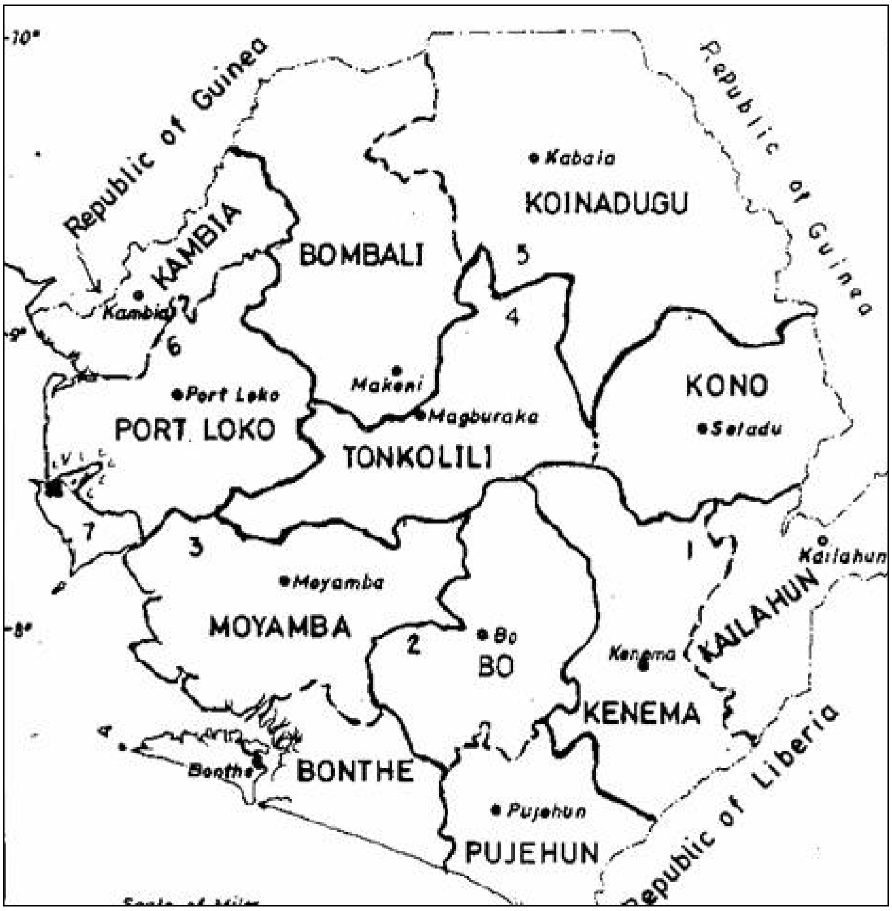


**Figure 3-1: Sierra Leone Districts**

### 3.2.1 *Tonkolili District*

Tonkolili District covers 7,003 km$^2$ and comprises 11 chiefdoms. It has a population of 345,884 (2004 census). The District capital is Magburaka town, with Mile 91 being the commercial centre. The main ethnic groups are the Temne, Limba and Kuranko. Islam is the dominant religion.

Agriculture remains the largest sector of the economy, providing a livelihood for up to 75% of the population. However, yields are typically low for the overall food production (maize, cassava and sweet potatoes). Gold mining is another important activity in the District. The livestock sector remains relatively small and underdeveloped.

Tonkolili District has several industries:

- The Magbass sugar complex, which produces sugar and ethanol and provides substantial employment in the area.
- The Gari factory at Robinke, which provides a market for cassava and employment for people, especially women.
- A large scale sugar cane plantation (Addax Biofuel Project), which is in the process of development.
- Other small-scale industries such as tailoring, carpentry, weaving, blacksmithing, gara tie-dye and soap making.

There was a market structure in each chiefdom's main town, but most of these were destroyed during the civil war. The growing need for locally produced and manufactured goods has resulted in the emergence of weekly markets commonly called 'Loumas'.

Infrastructure and standards of living are low in the District. Life expectancy at birth is 47.9 years, and infant mortality rates are 118 per 1,000 at birth (although low, both figures are better than the national standard). The percentage of people without safe water is 71.1%, (higher than the national average) with 60% using the river as their water source and only 8.5% having access to running water. The main source of fuel for cooking is wood (96.2% of the population) and the energy source for lighting is almost exclusively kerosene and torches. The literacy rate is lower than the national average at 30.5%.

### *3.2.2 Bombali District*

Bombali District[17] covers an area of 8,279 $km^2$ and comprises 14 chiefdoms. It has a population of 494,048 and the main ethnic groups are the Temne, the Loko and the Limba. The majority of the population are Muslim, with a small percentage adhering to Christianity and animism[18]. The main economic activities include small scale production of food crops (rice, cassava and sweet potatoes), production of charcoal, small scale mining, and small ruminants. The potential for large scale farming is significant, but is hampered by several limitations such lack of mechanisation, inputs and access to markets and poor infrastructure. The Addax Biofuel Project, involving a large scale sugar cane plantation, is currently under development.

Makeni, with a population of 82,840 (2004 estimate, probably an underestimate) is the administrative and commercial centre of the District and the Northern Province as a whole. It also provides educational and health facilities for the area. It grew as a

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[17] *Ministries, Departments and Agencies (MDAs) in Bombali District.*
[18] *The attribution of a living soul to plants, inanimate objects and natural phenomena. The belief in a supernatural power that organises and animates the material universe.*

trade and collecting centre among the Temne people. Palm oil, kernels and rice collected in Makeni were and still are transported by road to Freetown. The town is known for Gara tie-dyeing, which is an important industrial activity for Makeni women. The town is lacking in basic facilities such as water, sewerage system, electricity and a good road network

Bombali District was principally a rebel stronghold during the recent ten year civil war and experienced considerable destruction, displacement and trauma. Atrocities including forceful conscription of children, sexual abuse and prostitution were rife, which had an important effect on the youth, in particular girls. This situation exacerbated the incidence and prevalence of HIV/AIDS, which has added to the growing public health burden in the district.

During the war, socio-economic activities and social service delivery was seriously disrupted, and the enforcement of law and recognition of the authority of traditional leaders strongly compromised. Since the end of the war, security has largely been restored, but the local economy, social infrastructure and services have not adequately recovered. During the period of the study, however, several signs of development were witnessed in Makeni town: banks were established, several small businesses opened and a new hospital was built.

Standards of living are low in the District. However, a life expectancy of 52.5 and infant mortality rates of 96 per 1,000 live births are both better than the national standard[19]. The percentage of people without safe water is 57 (which is higher than the national average), with 40% using the river as their water source and only 25% having access to running water. The main source for cooking is wood (95% of the population) and the energy source for lighting is almost exclusively kerosene or torch.

The District has 437 primary school and 31 junior secondary schools. The majority of teachers in the primary schools are unqualified and the teacher pupil ratio is 54 to 1. The conscription of children as freedom fighters also led to a drastic reduction in school-going children, hence a high illiteracy rate of 65%. Nevertheless, post-war sensitisation and motivation has begun to increase enrolment.

### 3.2.3 *Port Loko District*

Port Loko District covers an area of 5,943 km$^2$ and is, with a population of 477,978, the most populous district in the Northern Province. The main ethnic group are the Temne (80%). The second largest group are the Fula and the Susu. The district is largely Muslim (75%).

The main economic activities are small scale diamond mining, subsistence farming (rice, cassava, millet, groundnut, maize and sweet potato in particular, small commerce) and small scale fishing. The production of charcoal has become a

[19] *Sierra Leone encyclopedia*http://www.daco-sl.org/encyclopedia/3_dist/3_1j_pl.htm

relatively important economic activity since the civil war, when farming activities were disrupted.

Its capital is Port Loko and the largest city is Lunsar (16,567, 2004 estimate). Other major towns in the district include the coastal town of Lungi (host to the Lungi International Airport) and Kupr[20].

Life expectancy is 49 and infant mortality 112 per 1000 live births. Only 1.6% of the population uses pit latrines[21].

The District has 469 primary schools (mainly in a bad state of repair) and 24 junior secondary schools. Less than half of the teachers are qualified.

## 3.3 Administrative and Authority Structures

Districts in Sierra Leone are subdivided into chiefdoms, which are headed by paramount chiefs, who are elected for life by chiefdom councillors, who in turn are elected by the residents of the chiefdom. The paramount chief is responsible for general administration, the distribution of land, collection of land taxes, the maintenance of law and order (settlement of disputes) and the development of his chiefdom. He also inherits custodian rights over land within his chiefdom. The paramount chief works with a chiefdom committee, council of elders and the Native Administration.

The chiefdom is subdivided into sections comprising a number of villages. Sections are headed by a section chief and villages by a town chief. The chiefdoms and the major towns in the Project area are presented in Table 3-1 and shown in Figures 1, 2 and 3 above.

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[20] *Wikipedia, April 2010.*
[21] *Sierra Leone encyclopaedia 2008*

**Table 3-1: Administrative Entities in the Project Area**

| Project aspect | Districts | Chiefdoms | Town |
|---|---|---|---|
| Mine area | Tonkolili | Kalansogia | Bumbuna |
| | | Sambaya | Bendugu |
| Transport corridor | Tonkolili | Kalansogia | Bumbuna |
| | | Sambaya | Bendugu |
| | | Kafe Simiria | Mabonto |
| | Bombali | Safroko Limba | Binkolo |
| | | Makari Gbanti | Makeni |
| | Port Loko | Buya Romende | Foredugu |
| | | Marampa | Lunsar |
| | | Maforki | Port Loko |
| | | Loko Massama | Lokomasama |
| | | Kaffu Bullom | Lungi |

## 3.4 Social Baseline

The socio-economic baseline in the Project area is outlined below. A more detailed description is presented in the Preliminary Social Baseline and Impact Assessment report prepared by SRK (April 2010).

### *3.4.1 Demography*

The Project impacted area includes small and medium villages as well as some larger towns. In terms of gender distribution, 49% are males and 51% are females. The average household size is approximately 9 people, with the smallest household counting 3 members and the largest 15. Four percent of the households count 10 or more members. Polygamy is practised in the project area and 35% of the households have more than one wife per household head, whilst 43% are monogamous and 22% of the households are single-parented.

### *3.4.2 Livelihood Strategies*

In the mine area the majority of the population is involved in agriculture (including economic trees) and animal husbandry, whilst some villages are heavily involved in artisanal mining. There are few artisans and mechanics.

Along the transport corridor agriculture (including plantations) and animal husbandry are the main activities, with charcoal production in some villages. There is also some hunting activity. The transport corridor villages are host to more artisans, government employees and mechanics than villages in the mine area.

In the Pepel port area the main activity is agriculture (including plantations), sea fishing and some animal husbandry.

Overall, the most important livelihood strategy across the project area is agriculture and plantations and to a lesser extent animal husbandry. Hunting is rare and confined to a small number of villages.

**Photo Plate 2: Agriculture fields, artisanal mining site and fishing location within the proposed project areas**

### 3.4.3 Access to Land[22]

Land tenure in the Republic of Sierra Leone (except the Western Area), is held in communal ownership under customary tenure and is controlled by traditional chiefs who administer it on behalf of their communities in accordance with customary principles.

The rule of customary law in the provinces is established by section 76 (1) of the Courts Act 1965. However, the validity of customary law is contingent on it being compatible with statutory law. Three statutes are directly relevant to customary landholding practices in Sierra Leone:

- The Provinces Lands Act – (Cap 122).
- The Chiefdom Councils Act – (Cap 61).
- The Local Government Act –1994.

Through customary law, ownership of land is vested in the chiefdoms and communities. Land cannot be owned freehold; land always belongs to the communities under the different forms of tenure under customary law. This principle is established by the Chiefdom Councils Act as well as by Section 28 (d) of the Local Government Act 1994. It provides for the establishment of a local court authorised to administer customary law in every chiefdom. The most common forms of customary land tenure are:

- Family tenure.
- Communal tenure.
- Individual tenure.

**Family tenure** is the most common form of tenure found in the provinces. Family tenure is a system under which entitlements to land within a particular chiefdom are claimed by various descent groups each with a common ancestor and that constitute a family unit. Such family units are a corporate entity and have capacity to claim and hold land as a body. The paramount title to family land is vested in the family as a group. However, underneath the umbrella of this title, varying degrees of lesser interests held in specific or particular portions of family land may be held by some family groups or individuals. Responsibility for the management of family land is vested in the head of the family assisted by principal members. The head of the family has the right to allocate unoccupied portions of family land to members of the family. They also may bring claims on land against outsiders on behalf of the family for trespassing on family land.

**Communal tenure** is the case where title to land in a given area in the chiefdom is claimed by or on behalf of the community as a whole and not by or on behalf of

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[22] *The section on land tenure is based on the report: Van Vlaenderen, H. (2010). Addax Biofuel Project: Social Impact Assessment. Coastal and Environmental Services, Grahamstown, South Africa and Huggins , G (2010) Addax Biofuel Project: Resettlement Policy Framework . Coastal and Environmental Services, Grahamstown, South Africa*

families or individuals. The community is also a corporate entity, endowed with legal capacity to enforce and defend its claims and rights to communal lands vis-a-vis other communities. Unlike the family, a community is not a kinship, but a socio-political entity and its members are not necessarily related to each other. Another feature of communal tenure is that title to communal lands is not vested directly in the community as an entity as in the case of the family. Rather, it is vested in the socio-political head of a particular community. It is so vested in a representative capacity. Another feature of communal tenure similar to family tenure is that it is only the unapportioned portions of communal lands and those lands which are strictly public lands, such as sacred bushes, common grazing lands and communal farms that are subject to direct management, control and supervision by the socio-political heads.

It has been argued that in customary land tenure there is no individual land ownership. But it is found to exist among some communities. For example, there are practices whereby families owning large pieces of land allocate portions of land to individual members of the family to enable them to set up their individual households. Even though the paramount title remains vested in the family, each individual member holds interest in his holdings. When the individual dies, the land is inherited by his immediate or nuclear family or nearest next of kin. It is also common to find practices where a man may give each of his wives land for her use and that of her own children. When the man dies the land is inherited by the wife, who was given the land when the man was living, and her children. Whether the land would continue to be held as individual holdings would depend on a number of factors, such as the number of children.

There are generally three ways in which individual acquisition of title is accomplished:

- By clearing of virgin forest – any land not appropriated by the community as a whole can be claimed individually.
- By straight forward purchase – individuals who are not otherwise entitled to land in a given area can purchase land outright from the recognised owner.
- By gift – individual owners may acquire land as a gift. For example, where a stranger marries into a land-owning family, land may be given for his use.

### 3.4.4 *Standard of Living*

Poverty is pervasive in the area, as in the whole of Sierra Leone, and people need to pursue a mixed livelihood, to obtain sufficient income for survival. The household survey conducted for the social impact report shows that only 15% of the adult population in Project area (age 15-60) had a stable and regular income. The sale of agricultural produce is an important source of income. Remittances are also significant.

**Photo Plate 3: House structures in the proposed project areas**




A major cost item for the household is food, which indicates that people do not grow sufficient food to feed themselves or need to sell food at certain times of the year to purchase other goods, leaving them with insufficient supplies for the entire year. Clothing, agricultural and livestock expenses are also significant cost items. People generally do not have many savings.

Lack of food security is common. In the household survey conducted for the preliminary social baseline and impact assessment (April 2010), 85% of the households indicated that they had experienced food shortages at some stage during the year, predominantly during the period July to September.

The energy source for lighting is predominantly candles, followed by torches and paraffin. The energy source used for cooking consists almost exclusively of wood, with a few households using some charcoal.

Although the majority of the rural population is poor, some stratification exists. There are traditional elite families who can trace descent (usually through the father's line) to a warrior or hunter who first settled in an area. These families then control and administer land, which puts them in an advantageous relationship to non-landholders.

### *3.4.5 Socio-Cultural Situation*

The dominant ethnic group in the mine area are the Kuranko. Along the transport corridor there is a variety of ethnic groups, with large concentrations of Kuranko, Temne and Susu. In the area of Tagrin Point there are predominantly Susu and Temne.

The most important cultural phenomena are the secret societies, which are popular throughout the Project area. Their primary purpose is to regulate sexual identity and social conduct, and to produce fully socialised human beings with clear gender identities. Secret societies induct members by means of initiation.

Religion plays an important role. Nominally the majority of the residents are Muslim. However, most communities have both a mosque and a church. Mainstream religions are however intertwined with traditional beliefs.

The household is the primary residential unit. There are various types of households, but most have a family (husband, wife or wives, and their children) as the core. Some are complex (two or more married men, either father and son or two brothers), often with other, more-distant kin or even strangers in residence. The household head (the eldest male/female) is the legal custodian of the household property (including land), responsible for protection and security and resolves disputes by mediation and represents the household in village affairs. Land-use rights and most portable forms of wealth are inherited patrilinealy.

Decision making in the village is done by the chief and the elders of the landowning families. Youth and women organisations are regularly consulted in decision making. Youth are consulted in particular with respect to development projects for the village. In general village issues are discussed and final decisions presented by the elders to the community during a village assembly. The Imam also plays an important role in terms of looking after the spiritual well-being of the villagers and the settling of family and community disputes.

### 3.4.6 Gender

As in most traditional African communities, gender roles are relatively clearly defined in the area. However, due to the many socio-economic disruptions, wars and family break-ups, gender roles may have become less rigid. Data collection shows however that men make most of the decisions in terms of the household and at the broader community level, whereas women conduct most of the daily chores. The secret societies for women reinforce their role as home makers in service of their husbands.

### 3.4.7 Health

Health and hygiene conditions in the Project area are generally poor. The household survey showed that 83% of the households deposit their household waste in the areas around their homesteads. Many households use the bush for toilet and the main water sources are rivers, rainwater tanks and unprotected wells. The water quality is often of inferior standard and wells dry out during the dry season. Villagers often need to walk long distances to fetch water.

The most prevalent diseases are malaria and diarrhoea related ailments. There is also malnutrition in the area.

Health facilities in the project area are generally poor, with many villages lacking a health centre, forcing people to travel long distances to receive medical care. The existing health posts often lack equipment, trained staff and medication. Often, villagers call upon traditional healers and local pharmacists for medical treatment.

### 3.4.8 Education

The levels of education and literacy are generally low in Sierra Leone and in the Project area. The study revealed a 70% of illiteracy in the Project area. The education sector encounters several problems including:

- Lack of schools (not all settlements have primary schools and in the rural areas there is a lack secondary schools). Children often have to walk long distances to reach school, resulting in low attendance and large numbers of drop outs.
- Shortage of trained and qualified teachers.
- Late or no payment of teachers leading to de-motivation.
- Dilapidated school buildings and shortage of classrooms; overcrowded classes.

# 4 RESETTLEMENT PLANNING ACTIONS

This section of the RPF sets out the main tasks and procedures required to develop a RAP for the Project. It outlines the procedures for identification of affected people, assessment of eligibility for compensation, identification of host areas for resettlement, procedures for resettling and compensation, budget categories, procedures for monitoring and evaluating the resettlement process and the necessary institutional arrangements for execution of the resettlement and compensation process.

It is important to note that this conceptual document differs from a RAP, which sets out in detail the strategies for resettling people affected by land acquisition. In order to develop a full scale RAP there are several additional requirements:

- Detailed final information about the mining process and the location of the different project components.
- A detailed social baseline.
- The RPF needs to be debated and approved by the various stakeholders.

## 4.1 Minimising Resettlement

The IFC standards require that resettlement be minimised as far as possible. The primary reason for resettlement in the mine area is the location of the mineral resource and technologies for its exploitation, in this case open pit mining. The location of the pits is fixed by the location of the mineral resource; and will invoke involuntary resettlement. As such, resettlement cannot be minimised in this area.

More broadly resettlement will be influenced by the development and location of project infrastructure in the mine area, the transport corridor and at the port facility. Such infrastructure includes rock dumps, processing plant, tailings storage facility, stockpiles, offices, workshops, stores, power generation, housing, the railway line and port facilities. Resettlement is also influenced by health and safety considerations (e.g. human settlements should be an appropriate distance from hazards).

AML’s engineering and environmental and social consultants should be working in tandem to ensure that infrastructure across the Project area is developed and located in a way that minimises resettlement.

The following has been done in this respect:

- The rail loop, which requires a large area, has been positioned at the mine site where population density is lower than at Tagrin, the other option.
- The rail and haul road alignment has been designed to avoid villages using Quantm optimisation software.
- Construction and operations camps are planned in areas with low population densities.
- Waste rock dumps have been optimised to minimise additional area required beyond the fly rock zone.
- Refurbishment of the Pepel rail and port is to be undertaken on the exisiting footprint to minimise the need to acquire more land for project operations.

At this stage, nonetheless, it is certain that there will be a requirement to relocate villages either partially or entirely.

## 4.2 Identifying Eligibility for Compensation

The definition of eligibility requires an assessment of the type and number of people residing or using the affected area and the types of loss they incur. This is outlined below.

### *4.2.1 Project Affected People*

Project affected people (PAP) can be divided into two categories:

- **Affected household:** households[23] are affected if one or more of its members suffer loss of assets, land and property, and/or access to natural and/or economic resources as a result of the project activities.
- **Host area households:** households in any of the host resettlement sites (sites where people may be resettled), whose infrastructures and/or resources will be impacted.

### *4.2.2 Types of Loss*

PAP may incur a loss or disruption of access to the following assets and resources:

- Buildings, homesteads and related structures (such as storage facilities, graves).
- Land.
- Permanent or temporary use of agricultural land.
- Sacred sites.
- Mining deposits (artisanal mining).
- Natural plant and animal (including fish) resources.
- Small enterprises.
- Communal infrastructure (wells, boreholes, irrigation works, schools, clinics).
- Access routes (between villages, to towns and other resources i.e. fishing beaches).

A detailed description of the number and type of beneficiaries in terms of the various eligibility criteria will need to be provided once the exact location of the Project infrastructure is known and a census has been conducted. At this stage, however, the following information is available:

#### Homesteads

It is envisaged that 47 villages will have to be partially or entirely resettled. It is estimated that 2,441 houses and related structures will be affected.

[23] *For the purposes of this RPF a household consists of people who are economically dependent on each other and who typically live in the same compound and eat from the same pot.*

### Land

It is envisaged that 12 674 ha will be affected by the Project; 11,507 ha at the mine site, 288 ha along the rail corridor and 880 ha at the Port. These belong to various villages/towns. A land survey will need to be conducted to assess which land belongs to which villages and to which landowning families.

### Agricultural Crops

Approximately 215.30 ha of currently cultivated land will be affected by the Project; 95 ha at the mine site, 56 ha along the rail corridor and 64 ha at the Port. A survey will have to be conducted to assess the number and size of fields of affected households, as well as the crops cultivated.

### Tree Plantations

Approximately 21 ha of current plantation will be affected by the Project; 8 ha along the rail corridor and 12 ha at the Port. A survey will have to be conducted to assess the number and size of plantations of affected households, as well as the trees/plants cultivated. The main plantations are palm, mango, banana and pineapple.

### Forests

Some forested areas may be affected. These serve several needs. For instance sacred bushes are an important cultural heritage of the local people in the Project area and significant for their spiritual well being. It is likely that several sacred bushes will be affected. Sacred bushes will need to be identified along with other potential uses of the forest.

### Sacred Sites

Sacred sites include such sites or places/features that are important for customary practices, tradition and culture, and thus considered sacred. Sacred sites include tombs, graves and cemeteries and ritual sites.

In general people bury their deceased in tombs near their homestead. Resettlement of villages may involve the relocation of graves.

### Artisanal Mining

The social description of the affected villages in the mine lease area shows that households maintain a mixed livelihood consisting of mining as well as farming.

There are a significant number of artisanal miners (exact figures be established during RAP preparation) working in and around the concession area, including in the areas which will be required for the mining infrastructure. Consequently these miners may lose their livelihoods.

### Natural Plant and Animal Life

Some areas used by local residents for collection of natural resources (fire wood, wild foods, timber, medicinal plants, game) may be affected by the mining and transport infrastructure. Generally, however, natural resources used by the local population are plentiful in the larger area and the loss of the area needed for the project may not require compensation. This will however need to be verified by the census conducted as part of the RAP.

The port lease area may impact on the access of fishermen to the beach (i.e. homesteads of fishermen may need to be moved or access to the landing and fishing beach may be constrained or removed).

### Small Enterprises

The villages and towns affected by resettlement are host to several small businesses. These businesses are generally run from small structures near the homestead or from the homestead itself. The exact number of small businesses affected will need to be identified.

### Social Infrastructure

The villages affected by physical resettlement are host to schools, clinics, community halls, drying areas and potentially other communal infrastructure. The RAP census will need to identify all communal infrastructure which may be affected

### Access Routes

The mining and transport infrastructure may have impact on communications between villages and towns and villages and agricultural fields, cutting some residents off from their resources. Loss of livelihoods as a result of this communication severance will need to be assessed and compensated for.

## *4.2.3 Eligibility: Cut-Off Date*

The determination of eligibility for various types of compensation is defined in terms of the PAP categories described above, as well as whether the PAP's affected properties were present in the project area prior to the resettlement cut-off date on land development. A resettlement cut-off date is the date which signifies a moratorium on settling, building or making improvements on affected land. This cut-off date needs to be made public to all those affected through a public consultation process. Sierra Leone law does not make provision for the declaration of a moratorium. It will be the task of AML to identify and publicise (in collaboration with local government) the cut-off date, which should coincide with the completion of the RAP census and asset survey and obtaining a lease agreement. It should be noted that the cut-off date for building new structures and planting trees may be different from growing annual crops (the latter may be later if no resettlement will take place within the next season). An agreement will need to be reached with the local authorities on the procedures to be used in the event of claims being submitted after the cut-off date, as well as in the event of counter-claims and disputes.

## 4.3 Census and Assets Inventory

To develop the resettlement programme a thorough knowledge is required of the existing socio-economic context of the affected households and communities. The process for achieving this is set out in the following sections.

### *4.3.1 Mapping*

The resettlement process should be supported by a Geographic Information Systems (GIS) interface and field maps with socio-economic infrastructure and land use patterns and natural features (of the resettlement site and host site(s)).

### *4.3.2 Census*

A census must be undertaken of all directly affected households (either physically displaced – losing a homestead) or economically displaced (losing a livelihood). The census will include:

- Demographics, family structure (household position, age, residence status, occupation, educational level).
- The incidences of disease or illness amongst household members in the past year and receipt of health services.
- Deaths and births within the household in the past year.
- Usage of social infrastructure – e.g. church/clinic/school.
- Access to land on a cyclical / rotational basis and access to resources on communal land.
- Possession of livestock.
- Household economic activities and their relative importance.
- Household income (details of average annual income, monthly sources of income, annual agricultural sales and other sales sources).
- Details of loans / savings.
- Expenditure on major items (i.e. food, transport, agricultural inputs, health, education).
- Availability of food throughout the year.
  Ownership of a predetermined collection of possessions to be used as indicators in ascertaining the socio-economic status of the households.

A survey will also need to be conducted on a sample of people using communal land resources, for example hunting, honey production, wood collection for charcoal production and artisanal mining or seeing the land used as part of their fallow cycle, or grazing by nomadic people). As the number of such people may be high and difficult to demarcate, only a representative sample is surveyed.

### 4.3.3 Assets Inventory

Inventories will need to be made of both household and communal assets. Aspects for inclusion are outlined below.

**Household Assets**

An assets inventory needs to be conducted for each of the affected households[24] included in the census, recording all permanent and temporary losses of physical structures and natural resources incurred. These include:

- Homesteads and homestead structures (such as outside kitchens, latrines, chicken pens etc). This includes the number, size and condition of structures and a field drawing of the homestead buildings as well as photographic records.
- Family business-related structures.
- Graves associated with each household.
- Agricultural fields owned by each homestead or rented, leased, or given for use.
- Planted trees, within the homestead areas and plantations.

The census and assets inventory serves as:

- A register of the legitimate beneficiaries as per their residency or locality.
- Social data, which can serve as a reference point for compensation and monitoring.

**Communal Infrastructure**

An audit will be required of all communal assets affected by relocation. These include:

- Market areas.
- Drying areas (for food produce).
- Administrative buildings.
- Recreational buildings, community halls.
- Churches.
- Schools.
- Clinics.
- Sites of cultural importance (e.g. sacred bushes) or historical importance.

### 4.3.4 Census and Inventory Asset Methodology

The following steps should be followed in conducting the census and household assets survey:

[24] *This assets inventory can be conducted at the same time as the census.*

- Recruitment and training of local fieldworkers in the survey methodology.
- Design, piloting and (where necessary) refining of a census and assets questionnaire.
- A meeting with the affected communities to explain the purpose of the surveys and the procedures to be used.
- Provision of an ID number to all households/individuals involved in the census. They should be photographed with the ID number in front of their homestead /affected structures.
- Photographing of all structures, with GPS coordinates taken for the main building.
- Ensuring that the household head of the affected asset is present during the survey interview and that he/she countersigns the inventory sheets as proof that he/she agrees to the assets that have been recorded (Note: the signature of the household head does not signify acceptance of a compensation package only recognition that the data were correct when collected).
- Ensuring that a community representative, delegated to this particular task, also signs the inventory sheets as a witness to the recording exercise.
- Entry of data from the census and photographs in a Microsoft Access (or other electronic) database for record keeping and analysis.

## 4.4 Valuation

This section provides a framework for detailed valuation procedures to be developed in the RAP. Valuation is based both on Sierra Leone and international policies. Valuation rates and the process should be ratified by a Resettlement Working Group (see description below), any relevant authority and the affected parties.

### *4.4.1 Compensation for Loss of Homesteads and Fixed Structures*

Two options are available for compensation for physical structures lost due to the Project.

**Option 1:**

Compensation for all homestead structures is provided in cash. This includes replacement costs, cost for transportation and cost for building labour.

**Option 2:**

Compensation is provided by replacement (to an agreed standard) of the primary structures of the homestead plot in an identified host area, with structures of similar or better quality. It is recommended that a local contractor is hired to build the houses and that local labour is employed, whilst AML ensures quality control. Professional surveyors should provide cost estimates of replacement housing. (Note: AML’s estimated cost for construction of a substantial traditional rural house in the mine area was about US$13,500, though it is likely to be different in other areas and for other house types).

Option 2 is the recommended option. In accordance with IFC guidelines cash compensation for structures is discouraged. This is to avoid the risk that cash is not spent on housing (which would leave households without shelter).

A variation on this option is to provide cash compensation for the smaller additional structures (e.g. outside kitchen, fences, latrines, chicken pens). Justification for this is that these structures may be dismantled and taken by the owners to the new abode, avoiding the need for AML to build myriad small structures.

In case of partially built structures AML will compensate for lost materials. Abandoned structures are not compensated.

#### Taking Occupation of the New Homestead

The following rules are recommended:

- A reasonable time period should be allowed prior to moving people in order to give them the opportunity to salvage building materials from their old homes.
- AML should provide transport for each homestead sufficient to move the family and belongings (including building materials such as doors and windows (but not bricks or masonry), livestock, food, and personal effects from the old homestead) to their new residence.
- Households should sign a document to forego all rights to the old homestead (including trees and materials). AML will demolish the old homestead (otherwise squatters may take over the abandoned houses).
- An AML representative should visits households a month after they have moved into their new abode to assess the new structure and note potential defects and arrange for repairs.
- AML should provide structural warrantee on the dwelling structures to cover against defects arising from poor design, workmanship and material for a period of 5 years.

### *4.4.2 Compensation for Land*

The project will require the lease of land, which will be guided by Sierra Leone's Provinces Land Act, Chapter 122 of the Laws of Sierra Leone, 1960[25]. A land lease contract will then be required for the affected land in the three Districts, identifying the exact settlements and chiefdoms involved. Lease rent will need to be paid. Government guidelines are US$3.60 per acre, with one third paid to the Chiefdom council, one third to the District Council and one third to the respective traditional

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[25] *See Section 4.1.2 above.*

landowners. It is the task of the District Council to pay out the fees to the respective parties.

The section above indicates that land tenure and land use are governed by customary law and subject to local social and traditional cultural norms. These may make the process of paying out compensation for loss of land more complex for the following reasons:

- Land belongs to family clans and or villages, not individuals.
- Land has generally not been surveyed and no records of (customary or other) ownership of areas of land exist. Land disputes are common.
- People using the land belong to either landowning families in the area or tenants (with no tenure claims, so tenants will be a vulnerable group since they will not receive lease rent).
- Land lease infers that land will most likely be returned to the lessor on completion or termination of the lease agreement. In some instances land taken for the Project will not be returned.

In order not to disadvantage people, and to enhance the productivity of remaining land, the mechanism for acquisition of replacement land needs to be examined in detail in the RAP as well as livelihood restitution programmes which enhance agricultural productivity.

### *4.4.3 Compensation for Crops and Trees*

#### Crops

Standing crops will be compensated for. The main crops are rice, cassava, groundnuts, maize and sweet potatoes.

#### Trees

Only exotic planted trees belonging to households or communities qualify for compensation. The most common trees used for food and as a source of income are palm trees, mangoes, bananas, oranges and pineapple.

#### Valuation Process

The affected area of crops need to be measured and number of trees counted by a team including the affected person, a representative of AML, a representative of the Ministry of Agriculture and a representative of the local chiefdom. The numbers of trees and areas of crops needs to be included in the assets inventory and signed off by the team doing the assessment.

According to IFC standards, crops and trees need to be compensated in line with the market rates for the different crops/trees. The Government of Sierra Leone provides compensation rates, but these were determined in 2006 and are generally regarded as outdated (see Table 4-1). It is suggested that the compensation rates are guided by the recent rates identified for the Addax Biofuel Project (neighbouring the Tonkolili Project) which is currently developing a RAP. See Table 4-1 for rates which were identified and ratified by Director of Agriculture in both Bombali and Tonkolili districts in collaboration with the Addax resettlement team.

**Table 4-1: Proposed Compensation Rates**

| Item | Government Value 2006-2007 (SL Leonies) | Value 2010 (SL Leonies) |
|---|---|---|
| Banana | 20,000 | 26,620 |
| Bread fruit | 40,000 | 53,240 |
| Cabbage ½acre | 35,000 | 46,585 |
| Cashew | 50,000 | 148,000 |
| Cassava ½ acre | 150,000 | 350,000 |
| Cassava ½ acre immature | 50,000 | 175,000 |
| Cassava not dense - grown in heaps ½ acre mature | | 200,000 |
| Cassava not dense - grown in heaps ½ acre immature | | 100,000 |
| Citrus | 50,000 | 72,500 |
| Cocoa | 45,000 | 73,500 |
| Coconut | 40,000 | 73,500 |
| Coffee 1 acre | 35,000 | 46,585 |
| Cucumber ½ acre | 30,000 | 39,930 |
| Economic tree (Timber individually owned) | 20,000 | 54,400 |
| Groundnut ½ acre | 150,000 | 199,650 |
| Guava ½ acre | 15,000 | 19,965 |
| Hot pepper ½ acre | 30,000 | 39,930 |
| Kola nut | 40,000 | 76,400 |
| Krain krain ½ acre | 50,000 | 66,550 |
| Lettuce ½ acre | 35,000 | 46,585 |
| Maize ½ acre | 100,000 | 133,100 |
| Mango improved | 50,000 | 66,550 |
| Millet ½ acre | 100,000 | 133,100 |
| Oil palm | 25,000 | 33,275 |
| Oil palm improved | 40,000 | 57,000 |
| Okra ½ acre | 40,000 | 53,240 |
| Paw paw | 10,000 | 13,310 |
| Pear / avocado | 60,000 | 79,860 |
| Pineapple | 1,000 | 1,331 |
| Plantain | 20,000 | 26,620 |
| Plum tree | 50,000 | 66,550 |
| Pumpkin ½ acre | 30,000 | 39,930 |
| Rice (inland valley swamp) ½ acre | 200,000 | 266,200 |
| Rice (upland) ½ acre | 200,000 | 266,200 |
| Sweet pepper ½ acre | 36,000 | 47,916 |
| Tomatoes ½ acre | 35,000 | 46,585 |
| Water melon ½ acre | 40,000 | 53,240 |

**Note:** At the time of the writing of the report US$1 = 3,890 SLL

The crop/tree owner will be paid the rate multiplied by the acres of crops/number of trees lost. This compensation fee is a one off payment. However the loss of fruits over a period of time, until new seedlings are becoming of fruit bearing age need to be taken into account for the calculation of the compensation fees. If the farmer does not own the land, the crops compensation should still be paid to the farmer while any land compensation goes to the owner of the land. AML should also consider providing seedlings to replace lost trees. Any standing crop can be harvested by the owner, even if the family may have physically moved to their new location.

### 4.4.4 *Compensation for Disturbance of Graves and Sites of Cultural, Historical or Religious Importance*

Valuation for graves and sacred sites will be as noted below.

#### Graves

There are 3 options:

- Homesteads may choose to re-bury people on or near their resettlement plot. Providing this does not contradict any by-laws or customary restrictions, this should be permitted.
- Communal re-burial may be arranged with local entities (municipality, and traditional leaders, as well as religious leaders). In such cases an appropriate piece of land needs to be identified in consultation with the local authorities.
- In cases where grave relocation is not necessary and agreement is reached, the HH may hold a ceremony in accordance with local customs.

In both cases appropriate timing and arrangements for the relocation and re-burial of the deceased will need to be agreed upon with all stakeholders. AML will meet the costs of:

- Exhumation including permit (if required), transport and re-burial (re-interment) of the deceased.
- Provision of a coffin. An approved supplier will provide the coffin.
- Provision of a flat rate per grave to satisfy any customary cost.
- All works associated with the burial.
- All costs associated with a ceremony if not relocating grave.

The affected households/religious leaders are responsible for organising the appropriate ceremonies in accordance with their religious beliefs and/or customs.

#### Sacred Sites

In terms of communal sacred sites or cultural heritage, a process for appeasement of disturbance of the site and potentially the establishment/inauguration of a new site will need to be negotiated with the affected communities. AML will cover the cost of obtaining the new site and the appropriate ceremonies required for this process (to be negotiated with stakeholders). AML will not be responsible for organising these ceremonies.

### 4.4.5 Compensation for Loss of Access to Mining Areas (Artisanal Mining)

There are significant numbers of artisanal miners working in and around the Project area (exact figures to be established in the RAP).

In keeping with IFC standards it is proposed that compensation for income from artisanal mining is dealt with differently from compensation for other livelihood strategies such as agriculture, small business etc since artisanal mining is generally transient. Whereas the former is addressed at the level of individual households, compensation for loss of livelihood based on artisanal mining will be dealt with on a collective basis (i.e. collective, alternative livelihood projects may be developed such as agricultural projects, skills development project, agro-small business projects).

### 4.4.6 Compensation for Loss of Natural Plant and Animal Resources

The extent and nature of different types of loss of access to natural resources will be assessed in the RAP and compensation strategies for each type of loss negotiated. These may include:

- Development of wood lots in case of loss of timber and firewood.
- Development of nurseries for lost plants.
- Development of alternative livelihoods for those relying on natural resource production (i.e. charcoal production and fishermen).
- Identification and arrangement of alternative grazing areas.
- Providing access to alternative beaching/mooring areas for fishermen.

### 4.4.7 Compensation for Businesses and Enterprises

For the valuation of the loss of an enterprise its function, intensity of use (average monthly income), location importance and its market catchments will need to be determined.

Valuation should be based on the cost of re-establishing the commercial activity at a new location. This may include costs for:

- Acquisition of new land.
- Material and construction costs of replacement structures (this may involve rebuilding the structure or providing cash compensation).
- Compensation of lost income during resettlement (based on audited monthly income).
- Compensation for loss of wages of staff.

### 4.4.8 Compensation for Loss of Social Infrastructure

It is necessary to ensure that resettlers are not worse off after the resettlement process in terms of access to socio-economic services. This may require the upgrading of existing social infrastructure in the host areas to accommodate the enlarged population or it may require the building of new infrastructure. According to IFC guidelines the infrastructure should be equal to or better than that being replaced. Community structures or resources may include:

- Clinics and dispensaries.
- Community halls.
- Markets.
- Schools.
- Village rice drying floors or structures.
- Wells/boreholes.

The valuation of community structure and resources will require consultation with community leaders, committees or individuals that have responsibility over community structures of both the resettled community and the host community.

The valuation should be based on replacement costs of materials, buildings costs and the acquisition of additional land.

## 4.5 Identification and Evaluation of Resettlement Sites

Resettlement for the Project will require the identification of multiple residential areas (for those physically displaced) and identification of multiple areas of agricultural land for those economically displaced. Ideally for each affected area several options need to be explored for those to be resettled. In order to assess the feasibility of different options the following is required:

- Assessment of land ownership and tenure rights.
- Assessment of the need for improvement of infrastructure (water resources, educational, health facilities, road infrastructure) to accommodate additional inhabitants.
- Assessment of the impact of resettlement on small businesses in both resettled communities and host community.
- Assessment of available agricultural land in the vicinity of the resettled communities adequate for all of the people eligible for allocation of agricultural land.
- Assessment of access to natural resources (i.e. timber and firewood).
- Access to livelihoods (fishing/artisanal mining).
- Assessment of disturbance of community and family support networks.

The assessment needs to be conducted:

- In consultation with the affected villages (those to be resettled and in the host area(s)) in terms of their needs, compatibility, their perceived advantages and disadvantages.

- In consultation with the Resettlement Working Group[26] in terms of legal aspects, perceived advantages and disadvantages of the option.

The process will involve:

- Pre-selection of best candidate sites.
- Visits to pre-selected resettlement sites with representatives of affected populations.
- Selection of preferred sites in collaboration with relevant traditional and local authorities.
- Conducting an ESIA of selected sites.
- Validation of the choice in general community meetings.

Once the feasibility of the host areas have been established  a detailed plan of the host areas will need to be developed indicating existing dwellings and infrastructure as well as the areas allocated to new dwellings, additional infrastructure, agricultural land available for resettlers and transport network.

## 4.6 Transitional Support

IFC guidelines state clearly that additional support may be required for PAP during the resettlement period. Depending on the timing of the resettlement, it is possible that households will not be able to farm during a particular period (dry and or wet season) because they arrive in their new home after the sowing/planting time. Others may need time to develop new livelihood strategies (i.e. fishermen, artisanal miners). In such cases households will require transitional support. Individual support packages will need to be developed with affected families. It is recommended that this is done in cooperation with competent organisations and in consultation with the Resettlement Working Group.

## 4.7 Income Restoration and Sustainable Development Initiatives

Besides the loss of assets, resettlement may lead to permanent disruptions of income-earning or subsistence capacity. The IFC resettlement guidelines require that if project-related impacts to livelihoods are significant (with a 10% or greater loss), livelihood restoration needs to be included in the RAP.

A core aspect of the RAP census will be to understand, at a household level, the exact nature of household economic and livelihood strategies, so as to assess the changes in these as a result of economic and or physical resettlement. Livelihood restoration is addressed in the following sections.

[26] *See section below.*

### 4.7.1 Agricultural Support Programme

In order to restore livelihoods for farmers, there may be a need to assist with the preparation of new land and the provision of agricultural support and extension programme. This may include:

- Provision of training on improved agricultural techniques.
- Support for the purchase of agricultural equipment, fertilisers and improved seeds.

An example of a farmers support programme is the Farmer Field School Programme currently implemented by the Addax Biofuel Project in collaboration with FAO Sierra Leone in Bombali District. The programme combines training and demonstration in agricultural practices with representatives of affected communities.

### 4.7.2 Skills Training

It is recommended that skills replacement training be provided for households for which the continuation of an agrarian or artisanal mining lifestyle is not possible or desired. The primary objective of the skills replacement training will be to teach skills that could be of value to the local economy but not necessarily related to agriculture. Potential skills to be taught include block making and building; carpentry; plumbing; welding and tinsmith services; retailing; secondary processing of agricultural product. In terms of skills training programmes, partnerships should be established with NGO and other agencies in the area to maximise benefits.

### 4.7.3 Artisanal Mining

Agreement between AML and the artisanal mining organisation(s) may be developed to allow continued artisanal mining on the periphery of the concession area, with support from AML. This would require legal approval.

### 4.7.4 Community Development Initiatives

A key requirement of World Bank OP 4.12 is that '*all involuntary resettlement will be conceived and executed as development programmes*.' Key objectives of community development are:

- To stimulate long-term community, economic and social development programmes among those to be resettled and host communities that will lead to sustainable local communities.
- To seek ways of building mutually beneficial linkages between AML support of community development and other development initiatives in the district and region so as to obtain maximum leverage for the affected people from all initiatives.

The results of the social impact assessment and the RAP census should provide information on development priorities in the area, which can become the focus of a Community Development Plan (CDP). This may include health, education, water infrastructure, electrification, agricultural processing, micro-credit, fisheries, aquaculture, poultry etc. The actual CDP will however result from a participatory process between AML and local, regional stakeholders and potentially international partners.

Community development benefits will apply in order of priority to:

- The affected households within the mining area as well as those affected by the additional infrastructure required for the Project operation.
- The host resettlement area.
- The households residing outside of the Project area but who have land within the Project area.
- Artisanal miners and fishermen affected.

### 4.7.5 Vulnerable Individuals and Households

Vulnerable people are those who through any characteristic may be more adversely affected by resettlement than others, and who may be limited in their ability to claim or take advantage of resettlement assistance and related development benefits. Specifically, as defined by the IFC, vulnerable people include the following:

- Households headed by women or children, particularly those headed by aged widows.
- People with disabilities.
- The extremely poor (those with no visible means of income and the landless are often the poorest).
- The elderly, specifically households where no members are below the age of 60.
- The internally displaced and orphaned children.
- Groups that suffer social or economic discrimination.

IFC guidelines state that vulnerable groups need to be identified and given specific attention. Identification of the vulnerable groups will be done through the RAP census and additional interviews with community members and leadership. This step is critical because often vulnerable people do not participate in community meetings, and their disability/vulnerability may remain unknown. The process of providing assistance to vulnerable people will include:

- Identification of required assistance at the various stages of the process, including negotiation, compensation and moving.
- Implementation of the measures necessary to assist the vulnerable person with the resettlement process.

- Monitoring and continuation of assistance after resettlement and/or compensation, if required, and/or identification of those entities.

Assistance may take the following forms, depending upon vulnerable persons:

- Provision for separate and confidential consultation.
- Priority in site selection in the host area.
- Assistance with the compensation payment procedure.
- Relocation near to kin and former neighbours.
- Assistance with the post-payment period to secure the compensation money and reduce risks of misuse/robbery.
- Assistance with dismantling materials from their original home.
- Assistance with moving: providing a vehicle, driver and assistance at the moving stage.
- Assistance with identifying his/her resettlement plot.
- Assistance with building: providing materials, workforce, or building houses.
- Counselling in matters such as family and health, and budgeting matters.
- Priority access to all other mitigation and development assistance during the post-resettlement period, particularly if the support networks that the vulnerable person was relying on have been affected, such as food support, health monitoring, etc.
- Health care if required during the moving and transition periods.

# 5 CONSULTATION

WB OP 4.12 specifically states that ‘displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs.’

Consultation has two aspects. The first is the timely dissemination of information regarding the project and its resettlement component, which is essentially a one-way flow of information to the public. The second aspect is the two-way exchange of information that gives stakeholders a chance to express their concerns and contribute to the actual planning of resettlement. In order to facilitate consultation several mechanisms need to be established which will be described in the Stakeholder Engagement Plan.

## 5.1 The Resettlement Working Group (RWG)

Resettlement Working Groups (RWGs) will need to be set up in each of the three affected Districts. The RWG should comprise:

- Representatives of directly affected land owners.
- Representatives of directly affected tenants.
- A representative of women’s organisations.
- A representative of youth organisations.

- A representative of AML.
- Representatives from relevant provincial government departments (the Ministry of
- Agriculture and Food Security, Ministry of Land, Ministry of Health).
- Representatives from the traditional and community leadership.
- Relevant local NGOs.
- A representative of the District Council.
- A representative of the chiefdom council.
- Local MPs.

The RWG has the following functions:

- Acting as the primary channel of communication between the various interest groups/organisations involved in the resettlement process. In particular, it will serve to facilitate communication between AML and the PAP.
- Acting as a forum at which AML can consult on various resettlement aspects, i.e. debate the Entitlement Framework (EF) that is generated for the RAP. The EF is the core of the RAP and spells out who is protected under the auspices of the RAP, how they are protected and what they can expect in terms of compensation and livelihood protection or restitution.
- Approving suitable host area(s) for people to be resettled.
- Serving as the court of first appeal to solve any grievance that arises relating to the resettlement process. If it is unable to resolve any such problems, it channels them through the appropriate grievance procedures.
- Assuming primary responsibility for assisting AML in overseeing the resettlement processes in all its phases.
- Monitoring the stakeholder engagement process related to resettlement and compensation.

## 5.2 Community Resettlement Committees

Community Resettlement Committees (CRCs) will need to be established in all of the affected villages (clusters of several villages may be appropriate in certain areas). These will consist of:

- The village chief.
- A representative of the landowners of the village.
- A representative of the tenants of the village.
- A representative of the women organisations of the village.
- A representative of the youth organisation of the village.

These committees will meet regularly to ensure timely and clear communication between AML and the local communities in terms of resettlement. These committees will also assist with the census and assets inventory and negotiations in terms of identifying host areas.

## 5.3 Public Consultation

Besides the meetings of the RWG and the CRC there will be a need for public meetings with all PAP. A first meeting will need to be held before the RAP is prepared, to inform affected people about the process which will unfold, i.e. the census and assets inventory, identification and ratification of host areas, and development of entitlement contracts per affected household.

Once the RAP has been developed, a second round of public meetings with PAP will need to be conducted to present the RAP. At these meetings, the RAP report and popularised pamphlets explaining the RAP should be made available. The RAP should be subject to scrutiny by all relevant stakeholders including affected households, local communities, and relevant authorities.

## 5.4 Grievance Redress

Even when the project can ultimately claim successful resettlement, there may still be individuals and groups with grievances. A credible and accessible grievance mechanism will be required and implemented in consultation with the RWG in line with local cultural norms.

Individuals or groups who wish to lodge a complaint or grievance, should be able to do so in various ways: during community meetings, through an AML Community Liaison Officer (CLO) based at local offices throughout the project area or with the relevant RWG. The process of receiving formal grievances at the offices will be as follows:

### Step 1: Receipt of Grievance

Grievances will be received by the CLO either verbally or by written notification and will be entered in a complaints register. Registers will be available in all CLO offices. Languages used will be English or Krio. The person submitting the grievance will be given a receipt of their submission. People will also have the option of making their initial complaint either through the Section Chief/Paramount Chief, or the District Council. A receipt will be provided to the person lodging the complaint.

### Step 2: Assessment

The CLO will assess the grievance in terms of his/her capacity to resolve it locally. If this is not possible, the grievance will be communicated to the AML Social Affairs Manager for further action.

### Step 3: Acknowledgement of Complaint/Grievance

Written information (accompanied with verbal explanation) as to the steps that will be undertaken to resolve the grievance and the expected time for its resolution will be provided to the complainant within two weeks. This exchange will be recorded in the register.

### Step 4: Investigation and Resolution of Grievance

AML will conduct an internal investigation to determine the underlying cause of the grievance and make any changes required to internal systems to prevent reoccurrence of a similar grievance.  As appropriate, AML will also hold meetings with the person/group expressing the grievances to discuss, clarify and solve the issue, and prevent it from reoccurring.

### Step 5: Closure

Once the investigation has been completed and necessary measures been taken, the results will be communicated to the complainant and entered in the register.

### Step 6: Outcome of the corrective action

Outcome of the corrective action is verified with the complainant. Following completion of the corrective action, the appropriate CLO will verify the outcome with the complainant. The complainant will be asked to sign off on his/her acceptance of the ’solution' (or nominate someone to do so on his/her behalf). In the event that the complainant remains dissatisfied with the outcome, additional corrective action may be agreed and carried out by AML or the complainant can be advised of further avenues for recourse. The grievance log will be entered in a dedicated data base.

Situations may arise where complainants will choose to pursue legal recourse. AML should not impede access to this recourse.

# 6 IMPLEMENTATION RESPONSIBILITIES

To develop and execute the RAP the following entities are required.

## 6.1 AML

AML will provide the financial resources and the managerial and technical expertise for the resettlement and compensation process (the latter may be handled by a consultant engaged by AML).

The resettlement activities of AML will be handled by a Resettlement Unit, headed by a Social and Community Manager (possibly assisted by a consultant), who coordinates the work of several teams of resettlement officers. It is suggested that there are three teams, one for the mine area, one for the transport corridor and one for the port area.  The size of the team will need to be established. The Social and Community Manager will report to the General Manager.

During pre-implementation (development of the RAP), AML will:

- Collect all data required to effect resettlement including the census.
- Draw up Terms of Reference and contract all major planning services needed to effect resettlement.
- Project manage and financially support the development of the land-use plan for any host resettlement areas.
- Coordinate selection of alternative resettlement sites.
- Present, discuss and obtain approval for any developed land-use plans.
- Identify vulnerable groups.
- Ensure that, as necessary, the RWG remains functional in the period following the finalisation of the RAP and leading up to Project implementation.
- Attend RWG meetings, and provide administrative support and ad hoc managerial and technical support as required.

In the implementation phase, AML will:

- Draw up offer documents for each individual household affected.
- Discuss terms and conditions of resettlement with each household.
- Plan and supervise compensation activities, including for lost crops, land, buildings and livestock, and to restore lost livelihoods.
- Establish a socio-economic monitoring programme for the affected households.
- Monitor and report on the construction of replacement village structures.
- Address compensation and resettlement grievances.
- Assist and monitor vulnerable groups.
- Plan and coordinate the move into replacement housing for affected parties.
- Define and implementing community development and monitoring programmes to ensure that affected households are not worse off in the post-implementation phase through post-implementation monitoring.

# 7 MONITORING

Monitoring is required by IFC standards in order to assess whether the goals of the resettlement and compensation plan are being met. Monitoring will be undertaken at two levels:

### Internal Monitoring

Internal monitoring is an internal management function allowing the project management (or consultant) to measure physical progress against milestones set out in the RAP. Internal monitoring will:

- Ensure that due process has been followed in the notification of stakeholders with adequate public meetings being held.
- Verify that there are no outstanding or unresolved land acquisition issues regarding the Project or any of its sub-projects.
- Ensure that the census of all PAP has been carried out.
- Ensure that property valuation and resettlement has been carried out properly.
- Maintain records of any grievances that require resolution.
- Oversee that all resettlement measures are implemented as approved by the project.
- Verify that funds for implementing resettlement activities are provided in a timely manner, are sufficient for their purposes, and are spent in accordance with the provisions of the RAP.
- Ensure that monitoring and evaluation reports are submitted.

This type of monitoring should be ongoing with monthly reports.

### External Independent Monitoring

This type of monitoring focuses on the impact of resettlement. This refers to the effectiveness of the resettlement in terms of meeting the needs of the resettled people. Such monitoring should be conducted by an independent consultant twice a year for at least three years following resettlement.

Impact monitoring and evaluation will include an assessment of social indicators against baseline data from the census. These will include:

- Children in school by age and sex.
- Distance to primary school.
- Access to safe water.
- Distance to water source.
- Access to sanitation.
- Incidence of disease.
- Distance to health centre.
- Incidence of HIV/AIDS and of other STDs by gender and age.
- Housing, quality of roof, walls, floor.
- Access to public transport.
- Patterns of employment and income generation activities.
- Income/expenditure/debts per household.
- Improvement in production/income for women/youths.
- Assets owned (e.g. radios, bicycles, iron bedstead, television, etc).
- Capacity building, skills / vocational training.
- Community infrastructure.
- Land lease rent.
- Agricultural yields, possession of cattle.

This evaluation will employ the following methods:

- Analysis of questionnaires with a random sample of affected people (the same sample should be used each time). A sample will be drawn based on statically defensible principles.
- Interpretation of public consultations with affected people at the village level.
- Use of secondary statistical data.
- Reviewing the grievance register.
- Interviews with the local authorities.

The RWG and AML should meet after each monitoring exercise to discuss the outcomes and to plan steps to rectify issues, if necessary.