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ArcelorMittal

Nimba Western Area Iron Ore Concentrator Mining Project, Liberia

Environmental and Social Impact Assessment

Volume 1:
Main Report

March 2013

Prepared for:
ArcelorMittal Liberia Limited

REVISION SCHEDULE

Rev	Date	Details	Prepared by	Reviewed by	Approved by
1	08/01/2012	Draft	Melanie Porschmann Lead EIA/ EMP specialist Tanya Romanenko ESIA Coordinator	Gareth Hearn Technical Director	Gareth Hearn Technical Director
2	July 2012	Draft	Gareth Hearn Project Technical Director	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa
3	19 February 2013	Final Draft	Gareth Hearn Project Technical Director	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa
4	25 & 28 February 2013	Final Draft	Gareth Hearn Project Technical Director	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa
5	4 March 2013	Final Draft	Gareth Hearn Project Technical Director	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa
6	8 March 2013	Final Draft	Gareth Hearn Project Technical Director	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa
7	13 March 2013	Final Draft	Tanya Romanenko ESIA Co-ordinator	Tanya Romanenko Project Manager	Martin Edge Director, Europe and Africa
8	15 March March 2013	Final	Gareth Hearn Project Technical Director Tanya Romanenko ESIA Co-ordinator/ Project Manager	Tanya Romanenko ESIA Co-ordinator/ Project Manager	Martin Edge Director, Europe and Africa

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LIST OF ABBREVIATIONS

Abbreviation	Term
ABA	Acid Base Accounting
ACCNNR	African Convention on the Conservation of Nature and Natural Resources
AML	ArcelorMittal Liberia Limited
AOD	Above Ordnance Datum
AP	Acid Production
ARD	Acid Rock Drainage
ASL	Above Sea Level
BBOP	Business and Biodiversity Offset Program
BFI	Baseflow Index
BioPA	Biological Preliminary Assessment
BOD	Biological Oxygen Demand
BS	British Standard
BSI	British Standards Institution
CBD	Convention on Biological Diversity
CDIAC	Carbon Dioxide Information Analysis Centre
CEPF	Critical Ecosystem Partnership Fund
CF	Community Forest
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora)
CI	Conservation International
CMS	Convention on the Conservation of Migratory Species
CO2	Carbon dioxide
COPAN	Consolidation of Liberia Protected Areas Network
CR	Corporate Responsibility
dB	Decibel
dBLAeq	Equivalent continuous sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified period
DDT	Dichloro-Diphenyl-Trichloroethane
DEFRA	Department for Environment, Food and Rural Affairs
DSO	Direct Shipping Ore
EBA	Endemic Bird Area
ECEC	Effective Cation-Exchange Capacity
EDG	Environmental Design Guidance
EHS	Environment Health and Safety
EEC	European Economic Community
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EITI	Extractive Industries Transparency Initiative
EMP	Environmental Management Plan
ENNR	East Nimba Nature Reserve
EPA	Environmental Protection Agency
EPCM	Engineering Procurement Construction Management
EPML	Environmental Protection and Management Law of the Republic of Liberia
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management (Mitigation) Plan
FAO	Food and Agriculture Organisation

Abbreviation	Term
FDA	Forestry Development Authority
FFI	Fauna and Flora International
FONSI	Finding of No Significant Impact
FS	Feasilitiy Study
GFWA	Guinean Forests of West Africa
GIS	Geographical Information System
GLVIA	Guidelines for Landscape and Visual Impact Assessment
GoL	Government of Liberia
GPS	Global Positioning Systems
ha	Hectare
IBA	Important Bird Area
IAIA	International Association for Impact Assessment
ICCPR	International Covenant on Civil and Political Rights
ICESCR	International Covenant of Economic, Social and Cultural Rights
ICMM	International Council on Mining and Metals
IDF	Intensity-Duration-Frequency
IEEM	Institute of Ecology and Environmental Management
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
ILO	International Labour Organisation
IUCN	International Union for the Conservation of Nature
KIA	Kilometric Indices of Abundance
km	Kilometre(s)
kVA	Kilovoltampere(s)
LAMCO	Liberian American Mining Company
LCC	Land Capability Class(ification)
LEITI	Liberian Extractive Industries Transparency Initiative
LiDAR	Light Detecting and Ranging
LIMINCO	Liberian Mining Company
M	Metre(s)
mg/m3	Milligrams per cubic metre
MAFF	Ministry of Agriculture Fisheries and Food
MCA	Minerals Council of Australia
MCP	Mine Closure Plan
MDA	Minerals Development Agreement
MLME	Ministry of Lands, Mines and Energy
MML	Minerals and Mining Law
MPEA	Ministry of Planning and Economic Affairs
MT	Million tonnes
mtpa	Million tonne(s) per annum
NBSAP	National Biodiversity Strategy and Action Plan
NCA	Nimba Landscape Character Area
ng/m^3	Nanogram(s) per cubic metre
NGO	Non-Governmental Organisation
NP	Neutralisation Potential
NTU	Nephelometric Turbidity Units
OAU	Organization of African Unity
ODPM	Office of the Deputy Prime Minister

Abbreviation	Term
ORP	Oxidation/Reduction Potential
OHSES	Occupational Health, Safety, Environment and Security
PA	Protected Area(s)
PAH	Polycyclic Aromatic Hydrocarbons
PMx	Particulate Matter less than x micrometers
pPA	Proposed Protected Area
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
PSD	Particle Size Distribution
RAP	Rapid Appraisal Programme
RGA	Rapid Geomorphic Assessment
RO	Reverse Osmosis
ROM	Run of Mine
RTC	Royal Timber Company
RUSLE	Revised Universal Soil Loss Equation
SASS	South African Scoring System
SCS	Soil Conservation Service
SGV	Soil Guideline Value(s)
SIA	Social Impact Assessment
SMFG	Société des Mines de Fer de Guinée
SPOT	Système Probatoire pour l'Observation de la Terre
SS	Suspended Solids Concentration
TBR	Tipping Bucket Rain (gauge)
TMF	Tailings Management Facility
TOR	Terms of Reference
TSS	Total Suspended Solids
UDHR	Universal Declaration of Human Rights
UN	United Nations
UNEP	United Nations Environment Programme
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USDI	United States Department of the Interior
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VE	Visual Envelope
WBG	World Bank Group
WHO	World Health Organisation
WRD	Water Retention Dam
WWF	Worldwide Fund for Nature
$\mu g/m^3$	Micrograms per cubic metre

1 EXECUTIVE SUMMARY

Background

Mining at Mount Tokadeh, in Nimba County, Liberia took place between 1973 and the early 1990s, linked to iron ore mining in the East Nimba Range carried out by LAMCO and then LIMINCO. Mining at Tokadeh is currently undertaken as part of ArcelorMittal's (the Company's) Phase 1 Direct Shipping Ore (DSO) activities and will be expanded under the proposed Phase 2 Concentrator ore extraction and processing project. Gangra and Yuelliton are still green field sites as far as mining activity is concerned; although permitted for Phase 1 DSO mining, these areas are now expected to be mined only under Phase 2 Concentrator activities. At the time of the preparation of this report environmental degradation was observed in these areas due to past road construction and mine exploration work. Legacy pollution effects remain from the earlier mining period at Tokadeh, especially with regard to sedimentation in water courses.

The proposed mine sites are close to Mount Nimba, and can be considered topographically as being part of the wider Nimba Range. From a global conservation perspective, the Nimba Range with its forests and grasslands is among the most important areas in Africa, with a number of endemic species, many of them considered to be globally threatened. There are multiple threats to the biological integrity of the area. In addition to the current plans for iron ore mining, there are also pressures from land clearance for agriculture, uncontrolled fires, unsustainable hunting and logging, and the legacy of past mining operations

Project Outline

The Concentrator mining involves the excavation, crushing, screening and concentration (magnetic and flotation separation) of an estimated 15 million tonnes per year over a period of 20 years between 2015 and 2034. This ore will be mined to a maximum depth of 200m, 175m and 100m at Yuelliton, Gangra and Tokadeh respectively, over a combined area of approximately 1,200 hectares, including stockpiles and waste dumps. A Tailings Management Facility occupying approximately 303 hectares of land will be established at Tokadeh and treatment ponds across the site will extend over approximately 146 hectares. The total area of the mine exclusion zone (which includes safety zones that will be not be accessible to the community for the life of the mine, but which will not otherwise be disturbed) is considered likely to be 2,146 hectares. Ore will be concentrated at Tokadeh and transported via an existing 255km long railway to an existing port at Buchanan for export.

Additional township development will take place at Yekepa and Buchanan, requiring housing refurbishment and the provision of services, including drinking water, power, sewage treatment and waste management. A temporary construction camp will be required for a maximum of 1,250 workers and a railway maintenance camp will continue to operate at Greenhill in Bong County, part way along the railway.

This Environmental and Social Impact Assessment (ESIA)

This report (Volume 1) contains a summary of the findings of the Phase 2 ESIA and recommendations for mitigation. Other volumes contain the legal and administrative framework relevant to the project, additional baseline surveys, impact assessments and environmental management proposals for the physical, biological and socio-economic environments. Relevant environmental standards, guidelines and management plans developed by the Company are also contained in other volumes. The baseline data for the ESIA relies considerably on information collected for the Phase 1 ESIA (2010) and an Addendum to it (2011), but also includes important gap-filling studies and other physical, biological and social surveys to accommodate the Phase 2 proposals.

This ESIA has been conducted based on feasibility study and, in some cases, pre-feasibility study level information. Some elements of the scheme are currently more advanced than others in terms of their development proposals, and it has not been possible to undertake a complete impact assessment for those elements that do not yet have the required levels of design detail. This relates, for example, to some of the drainage management provisions, and borrow area locations, and the details of the Township Development Plan for Yekepa.

Nevertheless, in most cases, it has been possible to carry out indicative impact assessment based on judgement, as well as observations made concerning actual Phase 1 impacts. Remaining gaps in this assessment will therefore be filled by subsequent addenda to this ESIA.

Project Benefits

The economic impact of the project is on a national rather than a local scale. The Nimba Western Range Iron Ore Project was the first mining concession to be awarded following the cessation of the civil war in 2003, and in 2011 became the first mine to produce and export ore in a period of twenty years. The Government of Liberia is relying heavily on mineral exploitation to underpin its recovering economy and support national development. According to the Company, the resumption of iron ore exports with its Phase 1 DSO Project has been the largest contributor to Liberia's GDP growth of 9 percent in 2012. The International Monetary Fund (2012) states that the present value of the future stream of revenues from this planned Company project alone is estimated to be $ 2.4 billion to the Government of Liberia, with a permanent revenue of around 1.3 percent of 2011 GDP, which would help support the Liberia Rising 2030 plan. At the same time, the project will generate direct employment, skills development and infrastructure benefits to the operational areas and, through the proposed offsetting arrangements, the opportunity exists to contribute significantly to sustained rural development and forest conservation.

Other opportunities are in environmental, agricultural and social improvement. These include the provision of employment, the improved facilities to be installed at Yekepa and Buchanan, and the opportunities for training and skills development among the workforce, and provision of improved schooling and scholarships for further education. The project will generate the need for service provision and this will encourage local service sector enterprises to develop. The Company can encourage this and provide business training in the process. It will be important to ensure economic diversification away from iron ore, particularly in Yekepa, to strengthen the economy and sustain social provision once iron ore mining ceases. Other opportunities for improvement include the development of protected sites within West Nimba and the strengthening of the East Nimba Nature Reserve. Although not a requirement of the Mineral Development Agreement (MDA), the Company also has the opportunity to further mitigate some of the legacy issues surrounding earlier mine workings.

Project Effects

Physical Environment

The physical environmental impacts associated with the project relate primarily to the removal of the mountain tops at Tokadeh, Gangra and Yuelliton and the landtake required to construct and operate the works. The maximum extent of ridge lowering, from a visual perspective, is approximately 75 to 100m at Gangra and Yuelliton. The Gangra-Yuelliton ridge is a high value landscape that is irreplaceable and it will be noticeably diminished by Phase 2 activity. Drainage is another significant physical impact receptor. The potential to pollute watercourses downstream of the mine is high, and this could have significant secondary effects associated with water usage by local communities and riverine biological habitats. Potential sources of mine sediment include landslides and erosion from mine surfaces, erosion of stream channels and material eroded from stockpiles, waste dumps and other areas. The effects of unmitigated Phase 1 activity in 2011 and 2012 at Tokadeh demonstrate how materials from unprotected surfaces can quickly enter and pollute stream water. The intense and often prolonged rainfall in the Nimba area is able to entrain, transport and deposit downstream considerable volumes of sediment. To avoid and mitigate this, a comprehensive plan of protection and retention is required with regular maintenance and effluent monitoring. It is a current priority of the Company to implement appropriate measures for the control of erosion of materials at source and to design, construct and maintain runoff retention structures in order to reduce effects to acceptable levels. However, the observed outcome from Phase 1 activity at Tokadeh is not a positive precedent for such mitigation works. Therefore, the Company's proposals for its sedimentation ponds and effluent control systems at Tokadah, Gangra and Yuelliton will require design and review before Phase 2 mining can be implemented. Temporary, though robust, erosion and sediment control will need to be put in place before any forest clearance operations commence to construct these permanent drainage works. The 2011-2012 situation at Tokadeh, whereby runoff and sediments were discharged largely uncontrolled into downstream water courses, should be significantly mitigated by the implementation of the proposed water retention schemes.

There is also the potential for the failure of slopes (natural and excavated), waste dumps, stockpiles and the Tailings Management Facility. This issue is being investigated by the Company and will require robust design and preparedness plans to be put in place.

Groundwater, watercourses and habitats can all be polluted significantly from spills and leakages of toxic or hazardous substances. Assuming that international industry standards are used to manage, protect and contain these materials, the potential effects can be avoided or minimised to acceptable levels. Groundwater resources in the project area are believed to comprise a shallow aquifer in the underlying basement rocks. There is very little information on the yield and quality of this aquifer. In the mine area, and downstream of it, special consideration will need to be given to the quality of groundwater being used by local communities. The intention is to provide additional abstraction facilities for these communities where required and therefore quality checks and monitoring will be needed. The aquifer in the Buchanan area was exploited during the LAMCO-LIMINCO mining period. On the whole, there is insufficient information concerning the nature of project water use and abstraction requirements to be able to make any confident predictions of how the project might affect the groundwater regime, both in terms of quantity and quality. Further investigations will therefore be required at Yekepa and Buchanan to establish yield and quality, and to ensure that water supply to other users is not adversely affected by project drawdown.

Other aspects concerning the physical environment relate to air quality and noise. Dust is a significant issue at certain times of year, and mining operations, quarries, borrow pits and access road construction and operation will contribute more locally. Standard measures for dust suppression will need to be deployed. Dispersion modelling of emissions from the Tokadeh concentrator and Buchanan power plants has demonstrated that a stack height of 32 m would be sufficient to ensure there would not be a breach of ambient air quality standards at sensitive receptor locations, if the plants are operated within emissions limits specified by IFC guidance (IFC, 2007).

There will be noise generated at the Tokadeh rail head that will require mitigation in terms of hoarding and local bunding for example, and noise barriers will be required to reduce noise from railway operation to acceptable levels close to Sanniquellie Hospital. Predicted vibration levels for the operating theatre at Sanniquellie are considered to be significant and these will need to be mitigated, either by use of a floating floor or relocation. A noise barrier will also be required at the edge of the port area to reduce received noise levels at the adjacent Buchanan city.

Biological Environment

The Gangra-Yuelliton and Tokadeh ridges lie on the eastern margin of a large forest area remaining mostly intact that contains rich biodiversity and many examples of rare and globally threatened animals and plants (henceforth referred to as “West Nimba”). Some groves of forest within mine footprints also contain tall, closed canopy trees, and several examples of Black Star (very narrow global range with high priority for conservation) and Gold Star (globally fairly restricted) species have been found. Black Star species are top ranking in terms of global rarity. Environmental constraints maps have been produced for all three mine areas that indicate important habitats and the Company has attempted to avoid many of these areas in the design of its layouts. Nevertheless, significant residual biodiversity losses will occur. It is anticipated that 227 hectares of moist evergreen forest, 6 hectares of montane forest and 1,242 hectares of other forest will be removed by the actual mine and its infrastructure. 250 hectares of Level 1 biological constraint area (high biodiversity habitat) will be removed as part of this forest clearance, including sites where 38 Black Star botanical species encounters have been recorded.

Downstream effects on riverine habitats, including swamps, could be more critical than the removal of habitat in the mine areas themselves, with endangered species, such as the Lugbe River Crab and the Nimba Otter Shrew considered likely to inhabit such areas. This reinforces the absolute necessity to exercise total control over runoff, sediments and toxic materials, so that downstream habitats are protected.

Bushmeat hunting is placing rare and endangered animals at risk, and an increased workforce, plus migrants seeking employment (see below), will increase the pressure on local wildlife. There should be a zero tolerance policy on bushmeat hunting among Company employees, contractors and suppliers within the Concession Area. A public awareness campaign will also need to be put in place to educate the public as to the biodiversity value of the wildlife and to find alternative sources of livelihood (see below). This was one of the recommendations in the Phase 1 ESIA that was included by the Company in the scope of its current Biodiversity Conservation Programme.

Elsewhere in the project area, ecological considerations include the potential for a railway wagon spillage of iron ore into the St John River or its tributaries and the potential to pollute sea water and marine life in the Buchanan port area should a spillage take place of iron ore, fuel or any other toxic substance. These potential sources of risk can be minimised and managed through adherence to appropriate international operating standards and the implementation of an emergency preparedness plan. Further along the coast from the port, there are known turtle nesting sites, and the opportunity may exist to protect them from hunting as part of the offset programme.

Noise and vibration will lead to a reduction in habitat quality adjacent to the mine periphery, and some birds and mammals are likely to move away from the area.

At this stage the details of the Phase 2 mine layout design and operation are still being developed and so it is not possible fully to evaluate the potential environmental effects of the project. For the same reason it is not yet possible to propose and develop the full details of mitigation strategies and site-specific management plans. It is, nevertheless, strongly recommended that the Company continues to take full consideration of the findings of the environmental baseline surveys in all of its future activities.

So far this summary has focused on the land directly affected by the project proposals. Some patches of good (and some high bio-quality “hot”) forest remain outside of the mine areas and these should be protected wherever possible. It is the stated intention of the Company to remain at the forefront as an active stakeholder and supporter of the development and implementation of biodiversity conservation programmes within the wider Nimba area. This is of utmost ecological priority and will require the strict control of bushmeat hunting, slash and burn agriculture, logging, road construction and mineral exploration. The designation of the West Nimba Forest as the Gba Community Forest may alter the forest use dynamics but not necessarily in favour of conservation. Improved agro-forestry activities in existing farms around the project area should be promoted by the Company as a compensatory measure. As an important part of this protection it is considered imperative to prevent any runoff or material spill, clearance or other disturbance on the slopes to the south and west of Tokadeh, and to the west of Gangra-Yuelliton. Even very small, isolated patches of forest (e.g. on small hills in the lowlands west of Mount Gangra and riparian strips throughout the landscape) have considerable biodiversity and local use-value, and should be protected. Support for the improvement of agro-forestry practices and for forest restoration requires an early start, and the plant nursery already established by the Company to propagate indigenous, especially rare, useful and vigorous pioneer plants will require continued support. This in turn will involve collecting a wide range of local genetic material and development of the land and human capital that such a plant nursery will require in coming years. Continuation and expansion of the Company’s Phase 1 Biodiversity Conservation Programme will allow some compensation to be made for Phase 2 impacts on the biological and social environments.

Social Environment

The project is likely to result in a significant increase in human population in the area (workforce, service providers, job-seekers and other migrants) and this will place increased pressure on local resources. Approximately 385 hectares of agricultural land will be removed from community use by the implementation of the exclusion zone and the combined Phase 1 & Phase 2 layouts, and this will impact on the livelihoods of project-affected people, including women and women-headed households especially. Impacts to the socio-economic environment relate principally to the involuntary resettlement and economic displacement of people from farmland in the mine area and from some areas of Yekepa to house company employees. It has not been possible to confirm the final numbers of directly affected population in the township of Yekepa as the Township Development Plan has yet to be confirmed and the populations themselves are highly transient. The most significant outcome would be physical and economic displacement, and the loss of livelihoods, increased vulnerability to disadvantaged groups and increased pressure on limited land and resources elsewhere in the vicinity.

The Company is in the process of undertaking a Resettlement Action Plan and Livelihood Restoration Programme for Phase 1, and has developed a Framework Resettlement Plan for Phase 2. It is implicit that this programme be fully inclusive of all social groups and be based on a case-by-case assessment, leading to the provision of equal or improved and sustainable livelihoods. This ESIA reiterates the importance of a robust Community Development Programme including the current agriculture intensification initiatives and the support of local handicrafts and other small scale economic development initiatives to assist in the creation of alternative sustainable livelihoods. It will also be necessary to expand on the agricultural intensification programme whereby investments are made in the provision of land and resources to increase agricultural activity in other areas in order to enable displaced farmers to be accommodated. The Company has now engaged three Liberian NGOs to promote better land husbandry to compensate for Phase 1 effects, and the opportunity should be taken to develop this initiative further.

Other issues relate to the removal of sites of cultural importance to the local communities as a result of mining and related activities. It is important to avoid disturbing these sites to the greatest extent possible, or to provide culturally acceptable alternatives if avoidance is not an option. It is paramount that managed access is arranged to sites outside of the mine area but within the exclusion zone. Controlled access should also be provided for harvesting non-timber forest products including medicinal plants, in balance with conservation requirements. Furthermore, alternative provision should be given for the propagation of these and other plants of ecological importance in nurseries and other forest areas for use by the affected communities.

Other socio-economic considerations relate to the townships of Yekepa and Buchanan and the need to provide safe and suitable living conditions in terms of human health, human rights, social vulnerability, control on alcohol, drugs and violence, provision of potable water supplies, and safe and adequate sewerage systems and waste disposal. Food security could be an issue following the anticipated influx of workers and job-seekers into the Yekepa area especially, and this will need to be assessed and managed. Safety to the workforce and the public is critical across the entire project. This can relate to accidents at the workplace, road traffic accidents and railway accidents, and all measures should be taken to prevent them and contain their effects when they do occur. These should include training in the use and handling of hazardous materials, containment and clean-up measures in the event of a spillage, the use of personal protective equipment, hazard warning signs, prevention of theft, safety awareness campaigns and measures to reduce traffic accidents, including speed control, access control, audible and visible warnings, and public awareness campaigns. Once the Company has a Township Development Plan in place for Yekepa it will be necessary to carry out further environmental impact assessment to safeguard social livelihoods and welfare.

The environmental planning system developed by the Company identifies precautionary, mitigation and improvement measures required to be included in its Environmental Management Plans to achieve the above. The Company should demonstrate to the EPA that it has properly designed and put in place the required mitigation, and has developed procedures that will minimise environmental and social impact prior to any works being undertaken. The progress of this mitigation should then be monitored independently as provided for in the Mineral Development Agreement. The environmental and social development staff of the Company will be required to oversee the implementation of these Plans and a number of additional studies will be required to design the required mitigation. It is important that social development staff include representatives of the local societies that are native or fluent speakers of the main local languages at all the Company work locations.

2 INTRODUCTION

This document has been prepared by URS Infrastructure & Environment UK Limited (henceforth referred to as 'URS') as the Phase 2 Iron Ore Concentrator ESIA Consultant (henceforth referred to as 'the Consultant') for its client ArcelorMittal Liberia Ltd (henceforth referred to as 'the Company'). The report presents the Environmental and Social Impact Assessment (ESIA[1]) relating to the Phase 2 proposals of the Company. Phase 2 includes the expansion of existing Phase 1 (Direct Shipping Ore - DSO) mining sites at Tokadeh, development of mining activities at Gangra and Yuelliton Mountains in Nimba County, iron ore concentration operations and its transportation via an existing railway for export from the port at Buchanan (Figures 2.1 and 2.2). The ESIA undertaken for Phase 1 was prepared by the Consultant for the Company in September 2010.

This report summarises the findings of baseline studies and presents an assessment of potential environmental impacts associated with the Phase 2 scheme along with a proposed strategy for mitigation. The baseline studies themselves are found in supporting volumes, as follows:

Volume 2	Legal and Administrative Framework
Volume 3	Physical Environment: Baseline Conditions and Impact Assessment and Mitigation
Volume 4	Biological Environment: Baseline Conditions and Impact Assessment and Mitigation
Volume 5	Socio-Economic Environment: Baseline Conditions and Impact Assessment and Mitigation.

The Phase 2 ESIA uses the pre-DSO baseline as presented in the Phase 1 ESIA report and supporting documents, supplemented with additional baseline survey in order to fill any information gaps and to develop baseline data specific to Phase 2. These additional surveys took place between 2011 and November 2012 mainly in the subject areas of botany, zoology, hydrology, climate change, air quality and noise, socio-economics, cultural heritage and human rights.

Furthermore, the following documents have been developed by the Company and form part of this ESIA submission:

Volume 6, Part 1	Framework Resettlement Action Plan for Phase 2
Volume 6, Part 2	ArcelorMittal Liberia Environmental Standards Manual
Volume 6, Part 3.1	Overall Environmental Management Plan for Phase 2
Volume 6, Part 3.2	Environmental Management Plan: Construction Works near Mount Tokadeh
Volume 6, Part 3.3	Environmental Management Plan: Operation of Quarries
Volume 6, Part 3.4	Environmental Management Plan: Rehabilitation of Facilities at the Port of Buchanan
Volume 6, Part 3.5	Environmental Management Plan: Operation of the Buchanan-Tokadeh Railway
Volume 6, Part 3.6	Environmental Management Plan: Operation of the Port of Buchanan
Volume 6, Part 3.7	Hazardous Materials and Waste Management Plan
Volume 6, Part 3.8	Township Management Plan
Volume 7	Framework for a Mine Closure Plan for Phase 2
Volume 8	Framework of the Proposed Environmental Offset Programme for Phase 2
Volume 9	Statement of Legacy Environmental Impacts from the LAMCO-LIMINCO Mines and Industrial Areas.

[1] An Environmental Impact Assessment is defined in the Environmental Protection and Management Law (EPML) as "the systematic examination of a project or activity that may have adverse impact on the environment" (GoL, 2003b).

Combined, these volumes address the requirements as specified in Sections 14(1) and (2) of the Government of Liberia Environmental Protection and Management Law (EPML) and Section 2.4 of the Liberia Environmental Protection Agency's (EPA's) EIA Procedural Guidelines (EPA, 2006). Table 2.1 lists those EPA Procedural Guidelines to which each part of the report relates.

This ESIA is based largely on the Company's feasibility study and, in some cases, pre-feasibility study level information for Phase 2. Design details have, as yet, not been developed with respect to a number of issues and the impact assessment is, therefore, incomplete in this regard. Where required, impact assessments have been made based on the general details provided and the Consultant's judgement based on the outcome of Phase 1 activities. Although note has been taken of updated information as it has been released, it will require to be finalised once final details and designs emerge. Table 2.2 summarises the project design information gaps in relation to this ESIA.

Figure 2.1: Location of the Project Area in Liberia

Figure 2.2: Overview of the Mine Area

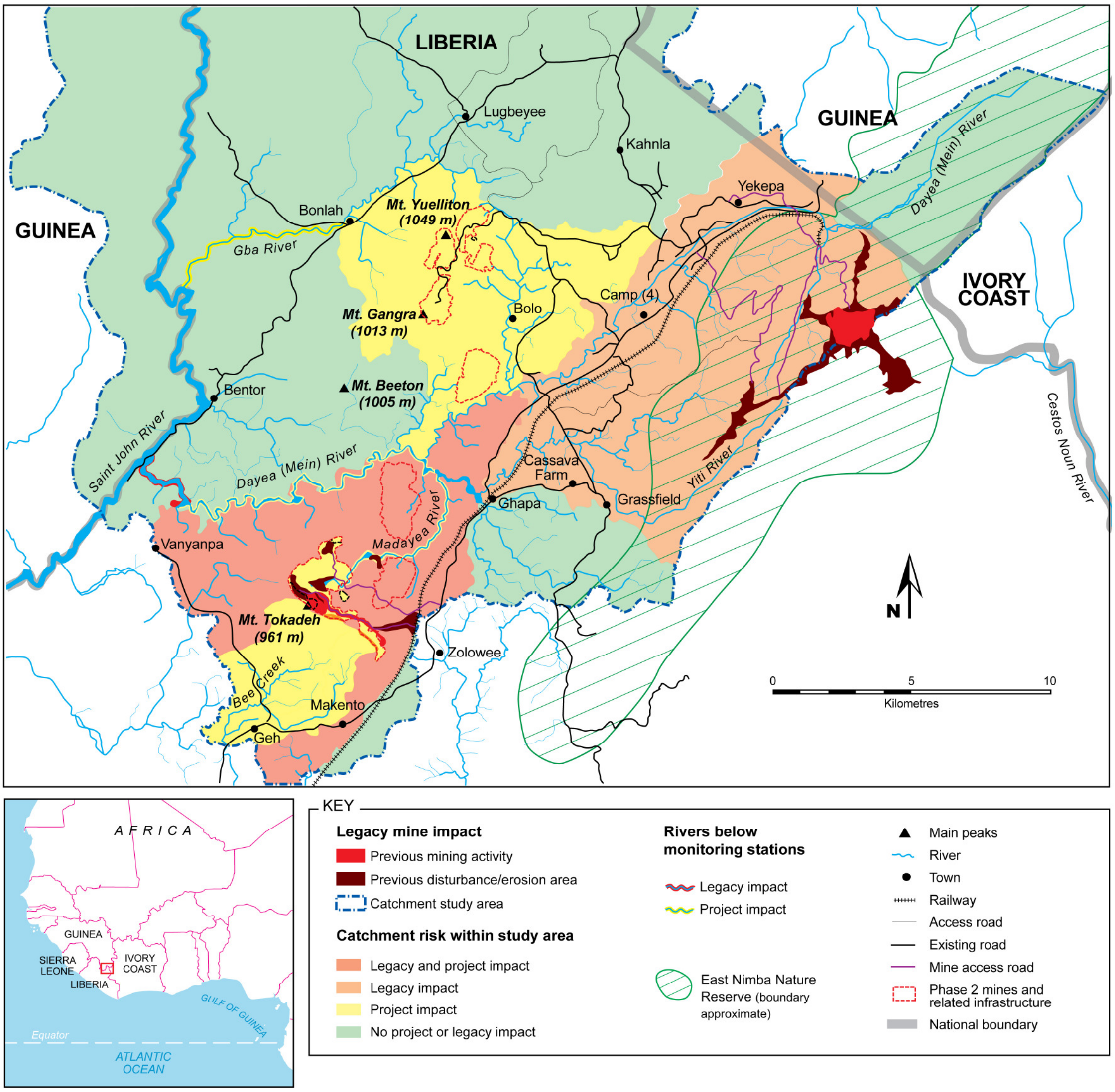


TABLE 2.1 REPORT STRUCTURE AND EPA PROCEDURAL GUIDELINES

Volume 1 Section & Supporting Volumes	Subject	EPA Procedural Guidelines Section
	Abbreviations	**3.2.1**
Section 1	**Executive Summary**	**3.2.2**
Section 2	**Introduction**	
Section 3	**Project Description**	
Section 4	**Project Alternatives**	
Section 5	**ESIA Scope and Methodology**	**3.2.2 3.2.12**
Section 6 and Volume 2	**Policy, Legal and Administrative Framework**	
Section 7 & Volumes 3 to 5	**Description of the Environment**	
Sections 7.1 – 7.4 & Volume 3	**Physical Environment** Climate, Topography, Geology, Soils, Slope Stability, Hydrology, Hydrogeology, Air Quality, Noise, Vibration, Landscape, Visual Amenity	3.2.5.2 and 3.2.6
Sections 7.5 – 7.6 & Volume 4	**Biological Environment** Terrestrial and Aquatic Biodiversity (Flora and Fauna)	**3.2.5.1 and 3.2.6**
Section 7.7 & Volume 5	**Socio-Economic Environment** Assessment of the Socio-Economic Environment Livelihood (Agricultural, Trading, Employment) aspects, Cultural Heritage Social, Economic and Community Issues	3.2.5.3, 3.2.7 and 3.2.8
Sections 8 – 9 & releveant Volumes	Assessment of Impacts and Proposed Mitigation	8 3.2.6 and 3.2.9
Section 10	Cumulative and Transboundary Impacts	
Section 11	Expected Residual Adverse and Beneficial Impacts	**3.2.11**
Volume 6 (prepared by the Company)	Environmental And Social Management Plan	3.2.9 (requires description of detailed design and operating procedures), 3.2.11 (monitoring plan) and 3..2.13 (use of best available technology)
Volumes 7-9 (prepared by the Company)	Framework for Proposed Mine and Infrastructure Closure Plan, Framework for Proposed Offsetting Programme Assessment of Legacy Issues	3.2.9, 3.2.11 and 3.2.13

A list of references is given in Appendix 1. Appendix 2 contains a schedule of the project permitting documents to date. A list of project team members involved in the preparation of this ESIA and / or the ESIA field studies is provided in Appendix 3. The URS Quality Assurance Certificates are in Appendix 4.

3 PROJECT DESCRIPTION

The following description was provided by the Company in February and March 2013.

3.1 Summary of overall project

ArcelorMittal (formerly Mittal Steel) has been undertaking a series of studies since 2005, to investigate the feasibility of reinstating and expanding former iron ore mining infrastructure and activities in Nimba County and associated infrastructure (primarily rail, port, quarries and community infrastructure).

The package of proposals comprises the following four key elements:

- production, handling and processing of iron ore at Tokadeh, Gangra and Yuelliton Mountains in Nimba County;
- reinstatement and operation of the railway line and associated facilities between Yekepa and Buchanan to transport supplies to, and ore from, the mine sites through Nimba, Bong and Grand Bassa Counties to the port at Buchanan;
- reinstatement and operation of the port at Buchanan for outward transport of ore;
- rehabilitation of community infrastructure at Yekepa and Buchanan.

The intention is to implement the proposal in three phases**,** over a period of 20 to 30 years, which in outline involves the following.

Phase 0: Enabling works: exploratory drilling and mine design at Mounts Tokadeh, Gangra and Yuelliton; and refurbishment of the railway line and associated service and access roads. This work started in 2008 and was completed in late 2012.

Phase 1: Production of up to 20 million tonnes of high grade, direct shipping ore (DSO) at Mount Tokadeh, and possibly also Mounts Gangra and Yuelliton, between mid 2011 and 2015. This initial mining is supported by operation of the railway line and further rehabilitation of the port and community infrastructure.

Phase 2: Production of up to 250 million tonnes of lower grade, beneficiated ore at Mounts Tokadeh, Gangra and Yuelliton from 2015 to approximately 2034. This will involve the construction between 2013 and 2015 of an ore concentration plant, storage reservoirs, a tailings management facility, a power plant and other associated infrastructure. It will be supported by additional enhancements to rail, port and community facilities.

The subject of this Environmental and Social Impact Assessment is the proposed Phase 2. This document describes what is proposed, using non-technical terminology wherever possible.

Phase 2 of the Project builds on previous investment. Rehabilitation of severely damaged relict infrastructure from the LAMCO period, plus the installation of new facilities to allow the commencement of Phase 1 DSO operations in 2011, was undertaken over two main construction cycles between 2008 and 2011. This represented an initial investment of around US$ 800 million, financed directly by the Company. Most of this infrastructure will be used in Phase 2, although some of the smaller DSO mine equipment will be retired early in the Phase 2 period as it reaches the end of its working life. Further capital investment is expected to be of the order of US$ 1.4 billion up to the start of Phase 2 operations (i.e. excluding operational expenditure for both phases). This mainly incorporates new facilities for train unloading and ore handling at the port, including a power plant, and fuel handling and storage; and at the mine involves the concentrator and its ancillary infrastructure, as well as roads, sediment control dams and the starter dam of the tailings management facility. This will be raised by the Company either from equity or through a mixed portfolio of internal corporate and external investment funds.

3.2 Location of the project

Overview

The iron ore mines at Tokadeh, Gangra and Yuelliton Mountains are part of the Western Area Deposits in the north of Nimba County, near the border with Guinea. These are the richest and most extensive such deposits in Liberia, and their exploitation has major implications for national revenue and development. There is nowhere else that can be mined on this scale. The close proximity of the Gangra and Yuelliton ore bodies means that they are most economically mined as one project.

The main elements of the project are as summarised below, and further details are given in Section 3.3. The general aim is to ship around 15 million tonnes of iron ore per year over a twenty-year period. Iron ore is a bulk commodity and its exploitation is largely a matter of logistics. The project aims to work close to the design capacity of the former LAMCO rail and port, which could handle a maximum of 16.5 million tonnes per year. This approach avoids major investments to upgrade the infrastructure and thereby makes the project economically viable.

Mining

There will be opencast mining of around 450 million tonnes of low grade iron ore (oxides and transition ores with Fe contents of 40 to 60 percent) from the ore bodies at Mounts Tokadeh, Gangra and Yuelliton in Nimba County. In this second operational phase, the concentrating plant is designed to produce 15 million tonnes per year of concentrate, which requires treating up to 18 million tonnes per year (2015-2017) of oxide and up to 30 million tonnes per year (2015-2034) of transition crude ores from the three deposits. Remaining deposits of DSO will be used up between 2015 and 2017 at the rate of around 4 million tonnes per year.

Ore processing

The beneficiation operation requires a major processing plant, with a primary tip and crushers installed adjacent to the Tokadeh mine. Crushed material will be stored in an homogenising blending pile prior to feeding the concentrator. Concentrator product will be sent either directly to the rail load-out silos or to an intermediate stockpile for later reclaim.

Waste product from the concentrator will be fed as a slurry to a tailings management facility. This requires an earthen tailings dam, and a water supply and circulation system. The tailings dam will be located to the north-east of Mount Tokadeh, in the catchment of the Madayea Creek which flows off the mountain towards the north. Water for the system will be drawn from two large sediment and silt treatment ponds and re-circulated within a loop between ponds, concentrator and tailings dam. Losses in the extracted material, and through seepage and evaporation, will be replenished through natural inflow to the sediment ponds, and surplus water will be released from the silt treatment pond into the environment, and specifically into the Dayea River catchment. The processing facilities, comprising the crushers, screens, concentration equipment, conveyors and pumps, require a considerable amount of power. This is to be provided by a dedicated power plant, which will be located close to the plant at the Tokadeh site.

It is proposed that the processing operation will be located near to the Tokadeh mine and the railway, since there is a suitable location that minimises material movements and therefore maximises energy efficiency. However, this facility will occupy around 5 km^2, and the tailings dam and sediment ponds will be on green field sites in secondary forest and heavily degraded bush. The stockpiles, concentrator, power plant and other infrastructure will be on brown field land in the former LAMCO ore processing area between the foot of Mount Tokadeh and the railway.

Transportation by railway

The concentrated ore will be transported along the existing railway to the Port of Buchanan, a distance of 255 km. This will use the full design capacity of the railway, and apart from regular maintenance there will be no further development of the railway.

The railway runs right across the middle of Liberia, from almost the furthest inland corner of Liberia in the Nimba mountains, to the coast. It passes across the north-western edge of Nimba passing close to the Guinea border, across the south-eastern side of Bong and across the centre of Grand Bassa County to reach the Port of Buchanan. Of its length, nearly 100 km is in Nimba, 60 km in Bong and 90 km in Grand Bassa. The reason for the project using this route is that, rather than build a new extraction route for the ore, it aims to limit its impacts by restoring and operating the existing but dilapidated railway.

Export by sea

At Buchanan Port the ore will be transferred from the trains into ships for export from Liberia. The operation of the port will essentially be at its original LAMCO design capacity, and no further expansion of the port is envisaged.

Like the railway, the port at Buchanan is also well suited for the proposed activities, and is the terminus of the railway. It is well protected by breakwaters and can accommodate ships of sufficient size to export the ore at the rates currently anticipated in this phase of the project.

3.3 Project Design and Activities

3.3.1 Mining of iron ore at Mounts Tokadeh, Gangra and Yuelliton

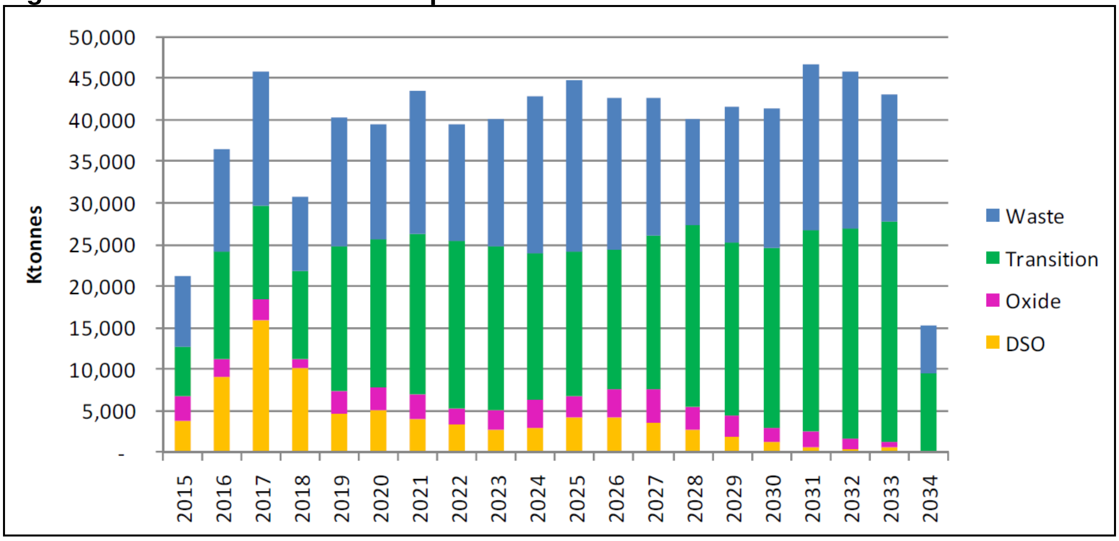
Overview

The purpose of the project is to mine and export 180 million tonnes of iron ore over the 20 years from 2015 to 2034. This will occur at the rate of about 15 million tonnes per year. It will be derived from the ore bodies at the three mountains, mining deeper than is the case for the Phase 1 (DSO) mining from 2011 to 2015. Once beneficiated, it will be shipped to ArcelorMittal steel foundries as well as to other buyers in other countries.

During Phase 1 of mining, material recovery is 95% which requires approximately 4.2 million tonnes of run of mine (ROM) material from the mine to meet the 4 million tonnes per year delivery schedule. However, Phase 2 will commence with ore that is referred to as oxide. The concentrator recovery of this is 65%, which requires the mine to produce larger volumes of ROM material to deliver 15 million tonnes of concentrated ore for export. As mining progresses, the ore body changes into harder materials (“transition” ore), and the oxide concentrator will be modified to process harder, lower grade material via the addition of grinding, flotation, and classification capacity. It is more difficult to liberate Fe from this material. As a result, the transition concentrator’s recovery is 50% which will require the mine to deliver 30 million tonnes per year of ROM material to achieve the 15 million tonnes of ore for export.

In practice the process is not quite as straightforward as the previous paragraph suggests, since the layout of different ore grades does not lend itself to simple sequential mining, and from the beginning a mixture has to be mined for practical access reasons, and blended before concentration. Modelling of the resource and the practicalities of mining therefore leads to the chart in Figure 3.1, which summarises the various materials encountered as mining progresses, leading to fluctuating quantities of the total materials mined.

Figure 3.1: Variations in the anticipated materials to be mined



It is also important to appreciate that DSO is high grade iron oxide ore, and Figure 3.1 distinguishes between these two types of oxide although the descriptive text here treats all oxides as one in terms of concentrator feed. Once the concentrator is commissioned, DSO will be fed to the concentrator along with lower grade oxide. During the concentrator ramp up, some DSO is to be direct shipped to supplement production from the concentrator: in 2015 it will be all of the DSO shown in Figure 3.1; in 2016 it will be about half of the mined DSO; and in the first quarter of 2017 the last 1 million tonnes of DSO will be direct shipped, and from then on all DSO material mined will be fed to the concentrator as part of the oxide ore volumes.

Mine design

Smoothed pits, including ramp access and minimum mining width, have been designed for Tokadeh, Gangra, and Yuelliton utilising the pit optimisation work as a guide. Likewise, intermediate phases were designed within the ultimate pits to segregate oxide material from transition material. For all pits, the following design criteria were used:

- Based on geotechnical studies of existing Tokadeh mine benches, mapping of geological structures and evaluation of kinematic slope failure possibilities, slope parameters were divided into different geotechnical sectors and assigned to one of seven slope codes with angles between 20 and 52 degrees;
- 32 m internal ramp widths;
- 8% ramp gradients; and
- 40 m minimum mining widths.

Based on these criteria and the modelled distribution of the different grades of iron ore, six mining phases have been designed at Tokadeh, and two were designed at both Gangra and Yuelliton. Following are the phase names which include a descriptor of the ore type for which the phase was designed:

- Tokadeh Oxide North;
- Tokadeh Oxide Main;
- Tokadeh Transition Main;
- Tokadeh Transition Area B;
- Tokadeh Transition Area F;
- Tokadeh Transition Final;
- Gangra Oxide;

- Gangra Transition;
- Yuelliton Oxide; and
- Yuelliton Transition.

The resulting pit models and phasing scenario have led to a series of proposed mine development layouts which are shown for each of the three mountains in the Mine Plan. These are accompanied by summaries to show how the required ROM material will be mined as each pit progresses, in order to meet the projected volumes shown in Figure 3.1.

Run of mine feed to the concentrator is based on producing 15 million tonnes per annum of concentrate following the ramp-up period. The initial feed will be a blend of 90% oxide ores and 10% transition ores. The mine schedule has been developed to maintain the 90% oxide to 10% transition feed as long as possible. Once this blend is no longer possible, a fourth line will be added to the concentrator, allowing it to process higher blends of transition ore, up to 100% transition. Following the addition of the fourth line, there are no specific blending requirements; consequently, instead of targeting a specific material blend, the mine schedule will aim to maintain constant truck requirements. By balancing mining with stockpile re-handling on a period by period basis, truck requirements will be maintained at relatively constant levels.

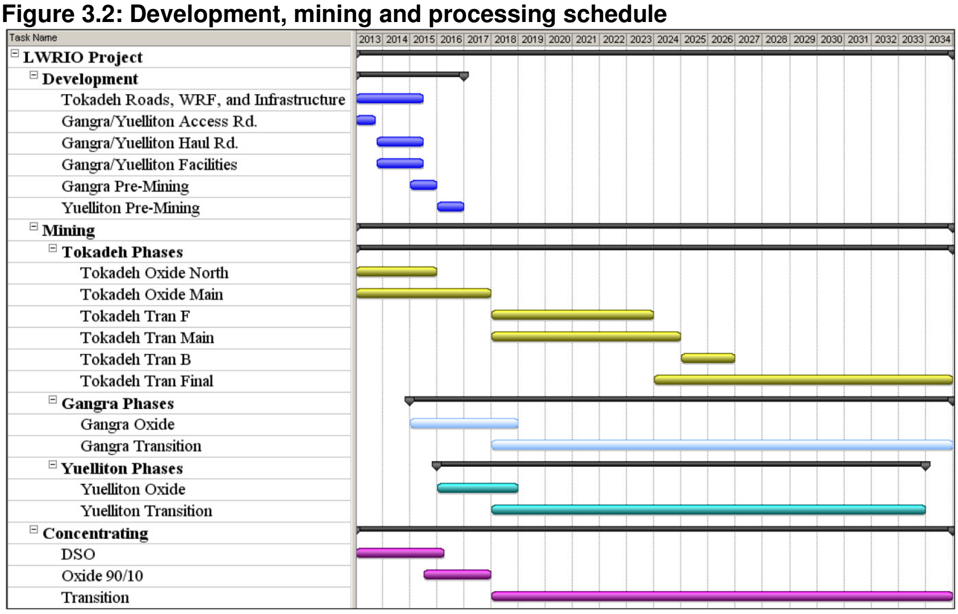
Process Fe recovery for material in the 90/10 feed is to be 76.2% and 68.0% for oxide and transition ores, respectively. Once the fourth line is brought on and the concentrator is configured to process transition ores, recovery for both oxide and transition ores will be 72.1%. Although mass recovery is grade based, it will generally be in the range of 65% for oxide ores and 50% for transition ores to produce a 65% Fe grade concentrate.

Mining is to be undertaken by standard opencast methods. Benches are excavated into the ore, and worked down through it. As in normal practice elsewhere, mine design has included modelling of the ore resources, a feasible means of extracting it, and the areas needed for stockpiles and dumps of spoil and overburden, and for other infrastructure. In addition to the process targets noted, mining will be limited to an 80 m sink rate in each phase, or eight benches mined per year.

Mine schedules

The overall mine schedule has been developed quarterly for the first three years and annually thereafter. The summary schedule for the project is shown in Figure 3.2. The intention is to follow a concentrator commissioning and ramp-up schedule that brings the concentrator to full capacity after approximately two and a half years

Figure 3.2: Development, mining and processing schedule



To supplement concentrate feed during the ramp up period, DSO will continue to be produced at the rates of 4 million tonnes per year in each of 2015 and 2016, and ending with 1 million tonnes in 2017. From 2017, the concentrator will be producing 15 million tonnes per year of concentrate which equals the capacity of the rail line; consequently, DSO operations are terminated during 2017 after supplying the targeted 1 million tonnes.

Mining in each phase is limited to an 80 m vertical sink rate, or eight benches mined per year. With the exception of initial pioneering work in the oxide phases, this constraint is met (see Figure 3.3). While feeding the concentrator oxide material in years 2015 to 2017, the number of phases mined is limited to three. During the transition phase, four active mining areas are targeted per year, with the exception of years 2018 and 2024 when mining is transitioning between active phases.

At Tokadeh, Phase 2 mining expands greatly from Phase 1 operations, and consequently limited mine infrastructure is available to support the start of Phase 2 mining. Initial Tokadeh development involves clearing the pit and waste rock facility area and base, and building initial access roads between the mine areas and the waste dump.

Following initial mine development, the Phase 1 mine fleet is supplanted by the larger Phase 2 mine fleet, starting in the third quarter of 2015. Initial Phase 2 mining starts in the two Tokadeh oxide phases, Tokadeh Oxide North and Tokadeh Oxide Main. Following the concentrator fourth line addition in 2018, mining commences in both the Tokadeh Transition F and the Tokadeh Transition Main phases. The final phases mined at Tokadeh are the Transition B phase between 2025 and 2026, and the Tokadeh Final phase from 2024 to project completion in 2034. During Tokadeh oxide mining, one to two active mining areas are scheduled. With the exception of the Tokadeh Final phase, mining is scheduled in two active transition phases over the project life. Tokadeh period plans in one year increments for the first five years and then every five years thereafter are included in the Mine Plan

Figure 3.3: Phase development and bench schedule: exceptions to the normal targets are highlighted in pink.

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Tokadeh Oxide North	9																			
Gangra Oxide	4	10	9	6																
Tokadeh Oxide Main		2	7	7																
Yuelliton Oxide		6	9	3																
Tokadeh Transition Area F				5	5	3	3	3	4											
Tokadeh Transition Main				5	6	2	4	2	3	7										
Yuelliton Transition				6	3	2	2	1	2	2	2	2	2	1	1	1	2	3	3	
Gangra Transition				5	2	2	1	3	2	2	2	2	2	2	2	2	2	2	3	6
Tokadeh Transition Area B										6	5									
Tokadeh Transition Final										3	3	2	3	2	2	2	3	3	5	5
Total Bench Advance	13	18	25	37	16	9	10	9	11	20	12	6	7	5	5	5	7	8	11	11
Total Active Phases	2	3	3	7	4	4	4	4	4	5	4	3	3	3	3	3	3	3	3	2

Gangra mine development is due to commence in 2013. Because the Gangra and Yuelliton mines are green field sites with no established infrastructure, developing the Gangra-Yuelliton Haul Road is critical to the schedule. Initially, the existing exploration access road will be improved in 2013 to allow for the passage of 40 t articulated trucks, excavators, and supporting mining equipment. In 2014, initial access roads into the mine and waste rock facility will be constructed, and tree clearing undertaken to accommodate early works in Gangra and Yuelliton. In 2015, the small development mining fleet consisting of four 40 t articulated trucks and one CAT 390 excavator will mine 1.75 million tonnes over four benches. Mined waste material is to be used for road building and ore placed in a temporary stockpile area located outside of the Gangra Oxide phase, but within the ultimate Gangra pit limit. Also in 2014 to 2015, the permanent Gangra-Yuelliton haul road will be constructed, the Gangra waste rock facility base prepared, and supporting infrastructure constructed.

In 2016, mining with the 140 t trucks will start in the Gangra Oxide phase, while the small development mining fleet is deployed to open up Yuelliton. After establishing initial mining access, this small fleet will mine 1.65 million tonnes from the Yuelliton Oxide phase in 2016. Also in 2016, the bases of the Yuelliton waste rock facilities will be prepared ahead of mining with the 140 t trucks in 2017.

After initial mine development, both the Gangra and Yuelliton oxide phases are to be mined until depletion in 2018. Like Tokadeh, mining transition ore at Gangra and Yuelliton will commence in 2018 with the addition of the fourth concentrator line. The Gangra transition phase is to be mined from 2018 to 2034, while the Yuelliton transition phase will be mined from 2018 to 2033. Period plans for both Gangra and Yuelliton are included in the Mine Plan; both are shown in one year increments for the first five years and then every five years thereafter.

Waste rock facilities and stockpiles

Environmental criteria for dump and stockpile design were provided in advance, and have therefore been incorporated into the outline mine design. In general, dumps and stockpiles should be constructed so that they are stable at any time during mining activities to ensure that if mining activities are abruptly suspended, they will remain physically and chemically stable without creating an environmental hazard. This will require bottom up dump construction, benching, drainage, and concurrent reclamation. The following specific design recommendations were also incorporated.

- Western slopes of Tokadeh, Gangra and Yuelliton, and the southern slopes of Tokadeh, are excluded from all mining operations and infrastructure siting.
- All Priority 1 environmental constraints areas (as mapped by the ESIA consultant's flora and fauna specialists) must be avoided. Priority 2 and 3 areas must be avoided to the greatest extent possible.
- No tree clearing, building construction, or waste disposal is to be done within 15 m on either side of a watercourse. For the design basis, ArcelorMittal provided that waste dumps are offset a minimum of 100 m from streams. This allows for construction of sediment basins between the dumps and the riparian zones while maintaining the required offset of the sediment basin from the streams. Where this is not achievable, sediment control ponds will be provided downstream of the disturbed channel.
- Waste dumps and stockpiles must not be placed across drainage lines, even with provision for creeks to flow underneath. If necessary, they can be created such that they infill small valleys from the crest downwards, as long as provision for spring flow is installed before starting to build the dump.
- Dumps are therefore to be built on higher ground between water courses and swamps to ensure that the mountains are fully drained and that riparian areas are not disturbed.
- A delineation feature for the waste dump toes must be constructed to contain rock spillage.
- The haul road from Gangra-Yuelliton must use the eastern flanks and avoid the western slopes even if the engineering is more difficult. This restricts the extent of areas where it can be used as an access route to waste dumps.
- The geometry of mining at Tokadeh must be to ensure drainage towards the north-east (into the Dayea) to the maximum extent possible. Drainage to the south-west would cause more environmental damage. For the same reasons, the geometry of mining at Gangra and Yuelliton must be to ensure drainage towards the east. Waste dumps and other infrastructure are to follow the same rules.
- Topsoil is to be removed and stockpiled in shallow layers following strict guidelines.
- All spoil generated must be placed in designated waste dumps on stable terrain, in carefully constructed layers, and benched in levels not exceeding 20 metres thickness and with the steps at no more than 35 degrees (1v:1.5h) and an overall slope of 1:3.
- A 30% swell factor was used for designing dump volumes.

To honour an ArcelorMittal requirement that dumps do not sterilise potential resources, the waste dumps are placed 100 metres outside the resource pits. The stockpiles, including the low grade fresh material, are preferentially placed within the resource pit to reduce hauls. Some temporary stockpiles will also be within the footprints of the waste dumps.

Due to the steep topography and high frequency of drainage lines near the mine areas, any waste rock dumps close to the pits would have large footprints relative to storage capacity. As a result of the multiple constraints, one waste dump located on relatively flat ground has been designed for the Tokadeh waste rock. Adjacent to this is sited an ore stockpile for oxide and transition material. The Tokadeh waste rock facility is designed to store approximately 203.2 million tonnes and will have an ultimate design height of 160 metres. This will accommodate the planned waste tonnage of 131.7 million tonnes and provide a location for temporary topsoil and subsoil storage within the footprint. The nearby ore stockpile is designed to store approximately 23 million tonnes and to have a maximum height of 80 m.

Likewise, a single waste rock facility has been designed for Gangra, also located in relatively flat ground. This is designed to store approximately 241.1 million tonnes and has an ultimate design height of 160 metres. The design capacity accommodates the planned waste tonnage of both Gangra (77.2 Mt) and the surplus waste from Yuelliton (10.9 Mt). Close to it, the Gangra ore stockpile is designed to store approximately 7.1 million tonnes and to have a maximum design height of 60 metres.

For Yuelliton, more problematic because only steeper terrain was available and despite the large footprints relative to storage capacity, two small waste rock facilities have been retained in the design, in order to limit the truck haulage requirements. The North-east Yuelliton dump has a design capacity of 58.3 million tonnes and an ultimate height of 270 metres (from lowest point to crest); the East Yuelliton dump has a design capacity of 25.4 million tonnes and an ultimate height of 220 metres. The two Yuelliton waste dumps do not have adequate capacity for all of the Yuelliton waste or for interim stockpile storage, but surplus Gangra dump capacity is used to supplement the Yuelliton facilities.

Waste dump base preparation is required ahead of dumping activities. Preparation includes tree felling, vegetation grubbing, and topsoil and subsoil stripping. The trees will be felled by hand utilising chainsaws and timber reclaimed according to the provisions of the MDA. Grubbed material will be piled adjacent to the site and allowed to decompose. The topsoil and subsoil will be stripped from the base of the dump area and stored in nearby topsoil stockpiles according to AML's Environmental Standards Manual. Following base preparation and prior to waste rock dumping, rock spillage containment berms, surface run-off ditches, and attenuation ponds are to be constructed around the perimeter of each waste rock facility, utilising borrow material from within the footprints. Base preparation will be an annual event with one year of dump capacity prepared in advance during the dry season.

During operations, the large mine trucks will end-dump the waste material into 20 m terraced lifts constructed from the bottom up. A D9 class dozer is to be used both to maintain a safe dump berm and to grade the dumped material so that positive drainage is achieved from the surface. The targeted gradient across the waste rock facility surface is 2%.

After the first year of active dumping, concurrent reclamation will be initiated during the dry season. Reclamation activities will include establishing permanent drainage, placing subsoil and topsoil on the berms and, in the ensuing wet season, re-vegetating. Only those portions of the waste dumps that are at their final limits are reclaimed at any operational year: permanent drainage is established on those portions of the WRFs that are at their final limits to accommodate the upstream watershed. Drainage channels will typically include the use of concrete or rip-rap channels. Both subsoil and topsoil will then be placed on completed berms between the slopes and fringed a little way up the slopes. The slopes will then be revegetated as soon as the wet season allows growth to occur, using appropriate pioneer species on the bare slopes and more demanding species where soil has been replaced. Maintenance of the reclaimed waste dump sections is ongoing during mining operations to repair any erosion and to replant areas with low plant density.

During the course of mining operations, AML will mine three material types that will require stockpiling: soil, canga, and ore.

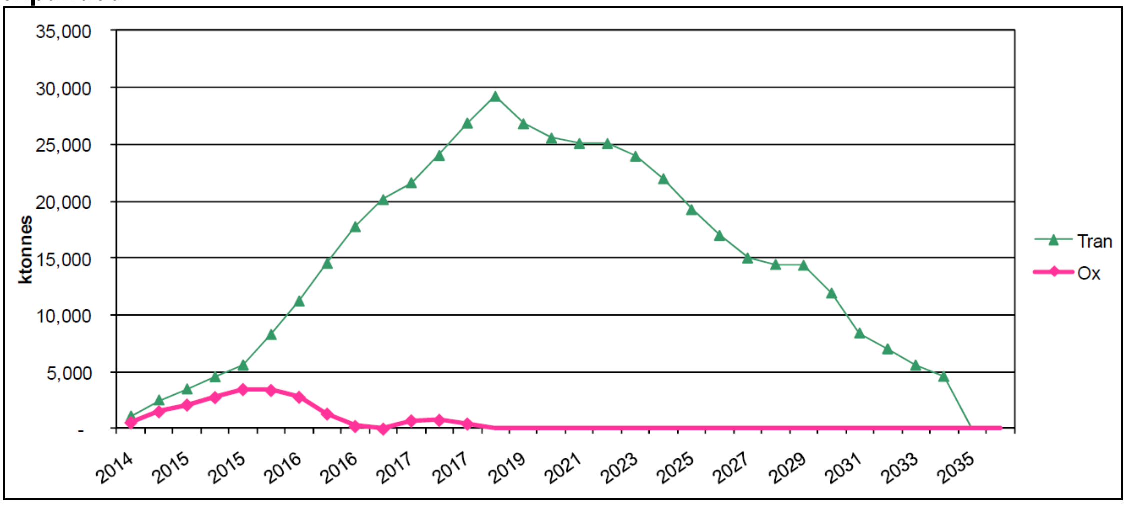
Ahead of developing the open pits, waste rock facilities and stockpiles, the areas will be prepared by felling trees, grubbing vegetation, and stripping soils. The topsoil and subsoil stripped at Tokadeh is to be placed within the footprint of the Tokadeh waste dump and used for concurrent reclamation as the final dump slopes are developed. Soils stripped at Gangra and Yuelliton will be placed within the footprint of the Gangra waste rock facility and will also be used for concurrent dump reclamation as the final slopes are developed at the one Gangra and two Yuelliton waste dumps.

Canga, an iron silicate rich material overlying the deposit areas, is a valuable source of road maintenance material. Prior to developing a mining phase, the canga will be stripped by mine dozers and then stockpiled within the footprint of the Tokadeh and Gangra waste rock facilities. From these locations it will be used for road maintenance as required. Additionally, following suspension of Phase 1 processing at the DSO material handling facilities, canga will be stockpiled at the DSO facility for screening and crushing to produce a more consistent road sheeting product. The canga quantities estimated within the mining area are 52.3 million tonnes, of which approximately 50% is likely to be recoverable.

Preferentially, ore is direct fed to the sizer and concentrated into a final product; however, due to material handling and processing constraints there is a need to develop multiple short-term ore stockpiles. This is firstly because there are times when the sizer is not available to accept ore from the mine, and so a 100,000 tonne ROM stockpile area must be developed on the sizer pad for later re-handling to the sizer. The second constraint is that, during the first three to five years of mining, the concentrator is configured to accept a blend of 90% oxide material and 10% transition material. The excess transition material mined during this period must be stockpiled in designated portions of either the Tokadeh or the Gangra waste rock facility and re-handled to the concentrator once it is configured for concentrating predominately transition material. The anticipated accumulation and subsequent utilisation of these stockpiles is shown in Figure 3.4.

Low grade ores (between 30% and 40% Fe) generated during mining will be placed within either the Tokadeh or Gangra waste rock facilities. These materials will be placed strategically within the dumps to facilitate future recovery if this should be warranted.

Figure 3.4: Cumulative run of mine stockpiles, showing how predominantly transition ore will accumulate and then be run down. Note that the early part of the time scale is expanded.

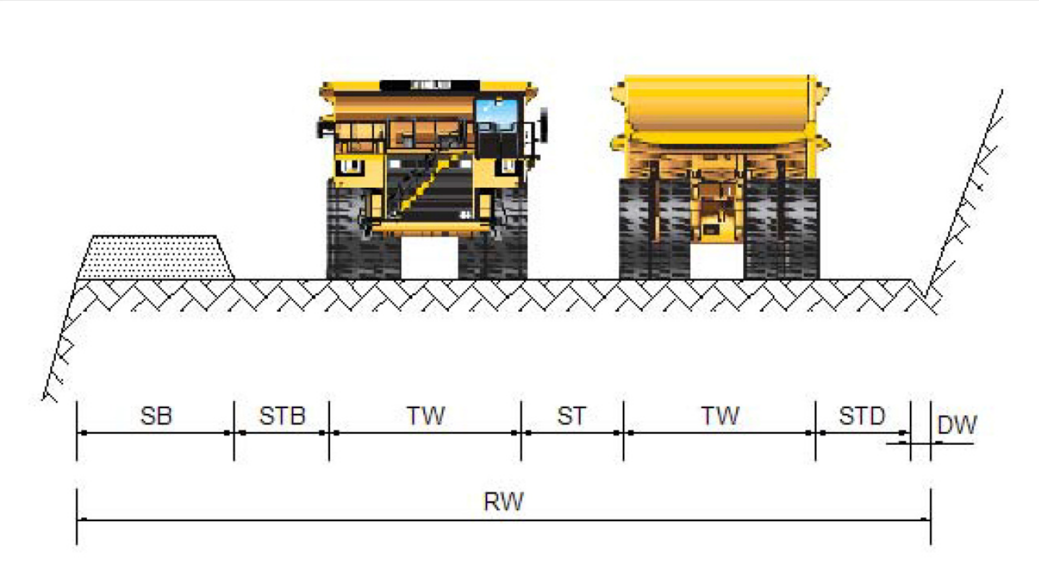


Road and ramp designs

The standard haul truck selected is the 133 tonne capacity Caterpillar CAT 785. However, to allow flexibility, the mine ramp widths are designed to accommodate the larger 180 tonne CAT 789 trucks so that a fleet of larger trucks could be used in the future without having to redesign the mine. Figure 3.5 provides a cross-section of an interior pit ramp design. The design is based on providing an operational width equal to 3.5 times the truck width. With an outside body width for a CAT 789, dual slope bed truck at approximately 7 m, the operating design width is 24.5 m. To the operational width, a 3.2 m drainage ditch and a 4.3 m berm are added. The berm width is estimated at three times the height of the CAT 789 tyre radius of 1.45 m. The overall design width for the interior pit ramp design is therefore 32 m. In-pit single lane ramps, generally located in pit bottoms or drop cuts, are designed at 17 m and allow for one way haul truck traffic. For overland roads, which are amenable to future widening, the designs are based on the CAT 785 truck's dimensions. The overland haul roads include a safety berm on both sides of the road and no ditch, with a design width of 28 m.

Although most ramps are designed at an 8% gradient to accommodate the prevalence of downhill loaded hauling, there are some portions designed at 10%. For example, the top portions of the initial Gangra and Yuelliton haul roads are designed at 10%; and, the ramp designed to access the bottom of the East Yuelliton waste dump includes 10% sections.

Figure 3.5: Cross-section of the proposed standard mine road.



SB:	Safety Berm	4.3 m
STB:	Space Between Truck and Safety Berm	3.5 m
TW:	Truck Width	7.0 m
ST:	Space Between Trucks	3.5 m
TW:	Truck Width	7.0 m
STD:	Space Between Truck and Ditch	3.5 m
DW:	Ditch Width	3.2 m
RW:	Ramp Width	32.0 m

The main haul road from Mounts Gangra and Yuelliton to the ore processing site near Mount Tokadeh crosses difficult terrain. Alignment studies are still continuing, and its route and construction will be the subject of an addendum to this ESIA.

Mine operating schedules

The mines will operate 24 hours a day, 7 days a week. A 24/7 schedule was selected to minimise capital requirements by fully utilising the mine fleet. Mine operations will have four rotating crews to cover a 24/7 schedule with three crews on and one crew off on any given day. During a day, there are to be three 8-hour shifts scheduled, comprised of a day shift, a swing shift, and a night shift. The crews will “hot change” or overlap between shifts to allow for continuous mine operations.

In a day, approximately 5.5 hours are lost to standby time, typically made up of 3 hours for breaks, half an hour for fuelling, half an hour for pre-shift inspections, and 1.5 hours for shift changes. The three hours for breaks is for a 1 hour lunch for each crew. The crews will travel to a central cafeteria for a hot, catered lunch. Because the CAT 785 trucks will have extended capacity fuel tanks, they will require once-a-day fuelling, which takes approximately half an hour each time. Despite a “hot change,” approximately half an hour will be lost between shifts during the operator exchange, not counting the 10 minutes required for the operator to complete a pre-shift equipment inspection.

Over a year, approximately 15 days or 360 hours are likely to be lost to poor weather conditions, including heavy rains and fog. It is assumed that the equipment is manned but delayed during these weather events.

Accounting for standby time and weather delays, equipment will accumulate approximately 5,242 hours per year of use according to standard operational use. For productivity calculations, it is assumed that trucks and shovels will be in a productive cycle approximately 50 minutes out of an hour or 83% of the time. For drills and support equipment, the utilisation is usually lower. Additionally, productive utilisation for all equipment is lower during the initial two years as the Liberian local work force develops operating skills. The Mine Plan projects productive utilisation for all equipment to be 50% in the first operational quarter-year, with increases by year 4 to ceilings of 83% for the shovels and trucks, 70% for the drills and 75% for support equipment.

Like mine operations, mine maintenance is scheduled to work a 24/7 schedule to allow for continuous maintenance coverage. Nonetheless, the majority of the planned maintenance work is to be done during the day, with a skeleton crew scheduled for the nights.

Blasting is only scheduled during the day shift. There will be two blast crews that work a Monday to Friday schedule. Blasting at weekends is done on an as-needed basis, with Sunday blasting avoided under company rules.

Mine engineering and geology support, such as survey, ore control and short range planning, will provide 7-day coverage during daylight hours, employing two crews. These crews will each work a four-day by 10-hour shift and overlap one day a week. All other engineering and geology personnel will work one day shift with coverage from Monday to Friday.

Mine equipment

The mobile equipment fleet is sized to mine approximately 40 million tonnes per annum from three to four mining areas concurrently. Because there are three unique mining areas – Gangra, Yuelliton and Tokadeh – the proposed equipment fleet is sized for both coverage and productivity. Equipment requirement estimates on a period by period basis were made for each equipment fleet using first principles.

Throughout the project, drilling is required for both ore control and blasting. Initially, drilling requirements are driven by soft oxide ore mining from project inception to Year 4. In Year 4 and beyond, drilling requirements are driven by a mix of mining moderately hard transition and soft oxide materials. Investigations described in the mine plan show that the optimal machine for production drilling is the Caterpillar CAT 6240 drill, with two needed at start-up and an increase to a maximum of four in year 7. In addition to the production drills, one CAT MD5075 top head hammer (THH) drill will be required for road construction drilling. The THH drill can also be used for definition drilling to depths of 50 m, angle drilling for wall control, and horizontal drain drilling for slope depressurisation on an as-needed basis.

Blasting operations will be performed as part of mine operations with explosive product delivered by rail to storage facilities on site. A 100% emulsion product is to be used, which is inserted into drilled holes by an emulsion truck owned and operated by the company. An expatriate drill and blast supervisor will manage drill and blast operations throughout the duration of the project. In addition to supervising the four drill crews, this supervisor will oversee two blast crews comprised of four blasters each. The blast crews will include one lead blaster, a blaster helper, and two labourers whose primary responsibility is to stem blast holes. The blast crews will work an eight-hour shift from Monday to Friday. Generally one crew will support the Tokadeh mine while the other will support the Gangra and Yuelliton mines.

The calculations used in predicting blast densities and charge sizes are summarised in the Mine Plan. These are determined by the changing materials that will be mined, and in particular the need to loosen the harder transition ores. It is anticipated that emulsion use will fluctuate between about 5,000 and 9,000 tonnes per year. Detonator and booster use is related to the numbers of blasts and size of charges, but as a general rule four or five of each will be required per tonne of emulsion used.

The primary Phase 2 loading unit will be the Caterpillar CAT 6040 hydraulic shovel. It can load a CAT 785 truck in four passes, in approximately 2 minutes and 20 seconds. Annual production after year 4, when the shovels reach 83% productive utilisation is expected to be approximately 9.8 million tonnes of ore per year per shovel. Four of these large machines will be required throughout most of the mine life.

To assist the CAT 6040 shovel fleet with peak production requirements and to provide additional flexibility, three 13.0 m^3 high-lift front-end loaders (CAT 993) will be required. Each of these loaders is capable of mining 5.2 million tonnes of ore per year at 83% productive utilisation. In addition to supporting primary production, the loaders are scheduled to mine the ore stockpiles and to provide support at the concentrator ROM stockpile as needed.

All loading will be done at bench grade (i.e. no loading ramps or platforms will be required).

The primary haul truck will be the Caterpillar CAT 785. It is matched with both the CAT 6040 hydraulic shovel and the CAT 993 high lift loader. Because the terrain is steep, footing conditions are soft, and mining width is limited, the mines will initially be opened up using a fleet of four 40 tonne articulated trucks. Once initial pit development is done, the larger 140 t CAT 785 trucks are to be used.

The Mine Plan describes the estimated truck requirements on a period by period basis using travel distances measured for each material type from their location on a mining bench to their final destination. Assuming a 3% rolling resistance for haul roads and a 5% rolling resistance for in-pit and on-dump roads, travel speeds were estimated from the manufacture's performance curves and applied to each haul segment to estimate travel time. To reflect actual speeds better in an operating environment, the truck speeds were limited according to the numbers given in Figure 3.6. Fixed times by material type were also added to the travel times to estimate the total times required.

Figure 3.6: Fixed times and speed limits for the CAT 985 main haul trucks.

		CAT 785 Ore Haul	CAT 785 Waste Haul
Payload	t	133	133
Cycle, Queue	min	1.17	1.17
Cycle, Spot	min	0.50	0.50
Cycle, Load	min	2.33	2.33
Cycle, Spot Dump at Crusher/Dump	min	3.00	1.00
Total Cycle	min	7.00	5.00
Speed limit, downhill loaded >= -8%	km/hr	20.00	20.00
Speed limit, downhill unloaded >= -8%	km/hr	20.00	20.00
Speed limit, Overall	km/hr	40.00	40.00
Speed limit, Inpit	km/hr	20.00	20.00

Annual truck requirements by period and productivity were calculated to estimate the fleet size. Truck requirements start at 23 in the third quarter of year 1 and increase to a peak of 65 by the end of year 3. The steep ramp-up in truck requirements is the result of supplying oxide ore from Gangra and Yuelliton to meet the 90/10 oxide to transition ore blend. After the fourth concentrator line is added, truck requirements drop to 57 and then slowly reduce to an average of 50 trucks in year 13 and beyond.

Support equipment includes tracked bulldozers, front-end loaders, graders, water trucks, haul trucks and excavators. The major tasks for the support equipment will include:

- Bench and road maintenance;
- Shovel support and clean-up;
- Waste dump maintenance;
- Stockpile construction and maintenance;
- Road building and maintenance;
- Pioneering and clearing work; and
- Concurrent dump reclamation.

A description of each support equipment fleet follows:

- 330 kW tracked dozers (CAT D9) are matched with the primary production fleet and are estimated to be required at one dozer per every hydraulic shovel and production blasthole drill. Their primary function is to maintain dumps and stockpiles, build pit roads, clean final pit walls, and perform concurrent dump reclamation. Due to limited mobility and an abundance of working areas, the 49 t dozers are to be transported between working areas using a 90 t capacity transport. Note that the transport is also used to move the 62.5 t drills and 86 t excavators. Up to eight dozers will be required at any one time.
- 414 kW loaders (CAT 988) are matched with the primary mining areas with one support loader required per active mining area plus one backup loader. Their primary function will be to maintain shovel floors, provide drill pattern clean-up, clear rock spillages and provide backup dump and stockpile maintenance. The CAT 988 loader also provides backup to the CAT 390 excavator for loading the 40 t articulated trucks. Four of these will be required for most of the mine life.
- 221 kW motor graders (CAT 16M) are estimated at approximately one grader per eight trucks. Their primary function is to maintain roads, dump areas, and pit areas. At peak, the grader fleet will support a fleet of 65 haul trucks, but it is planned to run seven graders for most of the mining period.
- 45,000 litre water trucks (CAT 773G) are matched with the truck fleet at a ratio of one water truck per twelve haul trucks. During the rainy season from June to October, water trucks will be scheduled primarily for watering the drills and for fire patrol; nonetheless, even during the rainy season roads can sometimes become dusty. During the two moderate seasons – November and March to May – water trucks will be scheduled more frequently to provide dust control. In the driest season – December to February – the water trucks will be scheduled fully for dust control during the day and swing shifts, and partially during the night shift. Average annual utilisation for the water trucks is 73%. Figure 3.7 provides an estimate of the annual mine water consumption to support the peak mining fleet in Year 3. For most of the mine life, five water trucks will be operated.
- A single 86 t excavator (CAT 390D) is matched with a fleet of 40 t articulated trucks to mine approximately 1.5 million tonnes per year during two eight-hour shifts per day for initial pioneering work. Following pioneering work to open up Gangra and Yuelliton, the excavator in combination with the articulated trucks will be utilised for construction projects including road maintenance, stripping and clearing, and reclamation.
- 40 t articulated haul trucks (CAT 740B) are matched with the 86 t excavator above for the same operations. These trucks are suited to initial pioneering work in steep and space-limited areas with poor underfoot conditions. Based on calculated travel distances and speeds, four 40 t trucks are required.

Ancillary equipment will include miscellaneous machines to support maintenance and mining activities. Although maintenance will be performed under a maintenance and repair contract (MARC), the company will purchase the maintenance ancillary equipment to be used by the MARC contractor. For mine operations, the types and numbers of ancillary equipment (which are listed in the Mine Plan) are based on:

- Blasting by ArcelorMittal;
- Field drill support;
- Breaking oversized material;
- Transport of support equipment and drills;
- Road and dump maintenance;
- Equipment dispatching;
- Site engineering and geology support; and
- Local pit dewatering.

Figure 3.7: Mine water requirements at the peak haulage period.

	Jun - Oct	Nov	Dec - Feb	Mar - May	Annual
	Rainy Season	Moderate	Dry Season	Moderate	
Days/Period	153	30	90	92	365
Peak Haul Trucks	65	65	65	65	65
Haul Trucks/Water Trucks	12	12	12	12	12
Water Trucks	5.0	5.0	5.0	5.0	5
Capacity per truck (l)	45,000	45,000	45,000	45,000	45,000
Loads/per shift	2	4	5	4	3.75
Water Trucks Day shift	2	3	4	3	3.00
Water Trucks Swing shift	2	2	4	2	2.50
Water Trucks Night shift	2	2	2	2	2.00
Truck shifts/day	6	7	10	7	7.50
Liters/day	540,000	1,260,000	2,250,000	1,260,000	1,327,500
Liters/period	82,620,000	37,800,000	202,500,000	115,920,000	438,840,000

Mine infrastructure

Fuel storage and distribution is described later.

Other infrastructure will be as follows.

- A steel clad structure will be provided for the plant workshop. The building shall include a common equipment receiving area (serviced by a 10 tonne overhead crane) with separate enclosed areas for a mechanical shop, plate shop, welding shop, electrical shop and tool room. An office will be supplied each shop.
- A steel clad structure will house 5 vehicle service bays, welding shop and an enclosed vehicle wash bay with wash water treatment equipment. Each vehicle bay will be serviced by an independent overhead crane.
- A small steel-clad workshop will be provided at the Gangra-Yuelliton saddle for minor daily maintenance of the operations fleet on those mountains.
- A steel and brick structure (40m x 80m x 2 floor levels) will be provided for the administration building. The building will house the office requirements for administration, operations, safety, medical facility, dry change rooms and a cafeteria.
- A laboratory facility will be supplied as a complete module within the administration facility.

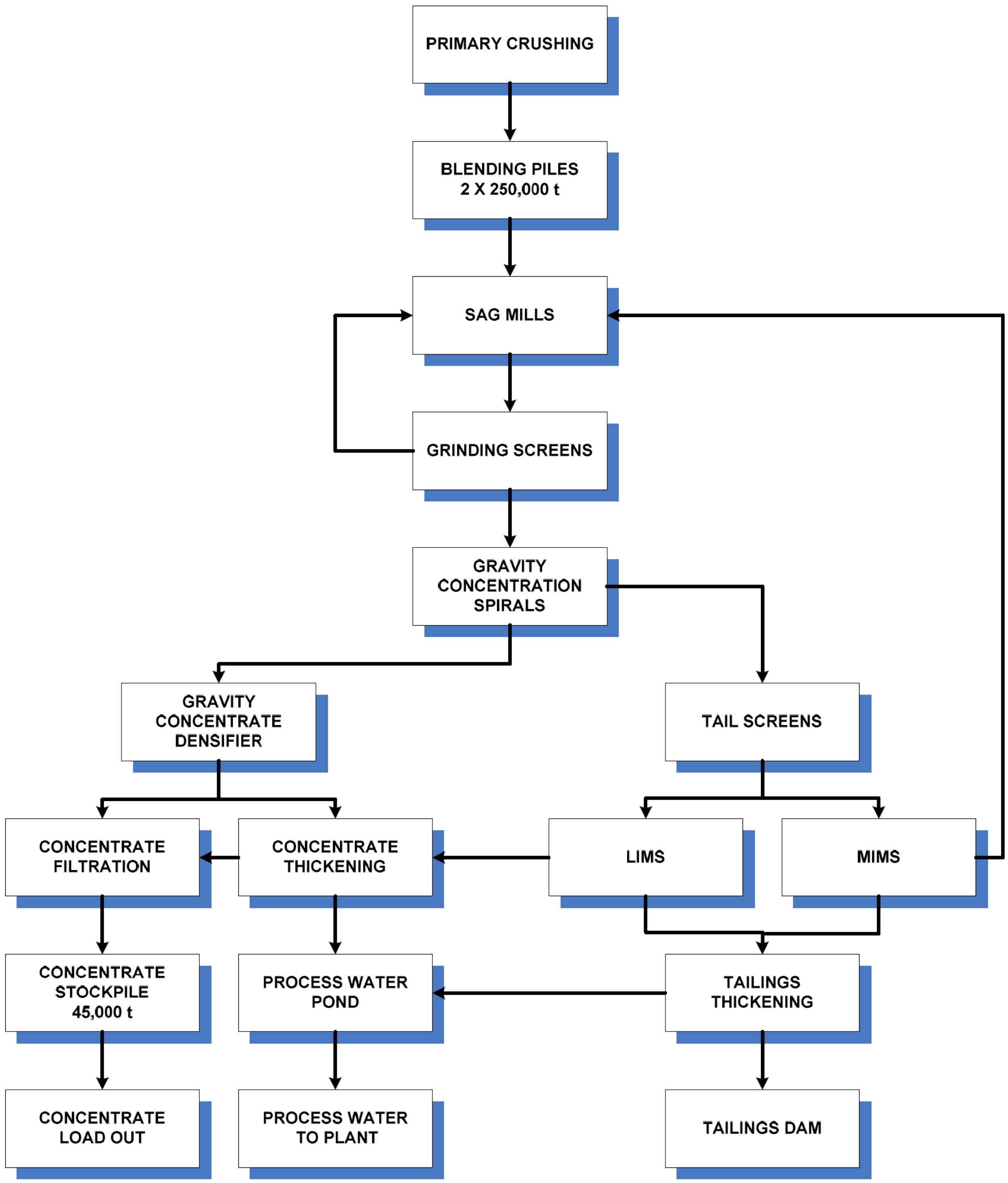
- A steel-clad warehouse structure (40m x 100m x 10m high) will be provided. Two offices, storage racking, floor storage, flammable material storage area, material receipt and dispatch areas are included. A fenced area (40m x 40m) for outside storage is located on the south side of the warehouse.
- A modularised sewage treatment facility will treat all sewage produced by the facility before discharging the treated effluent to the environment.
- Security will be an extension to the existing security contract in place for Phase 1 of the project.

3.3.2 Ore processing and the concentration plant

This part of the project is to convert the raw material from low grade iron ore (40 to 60% Fe content) into a concentrate of enriched fines at 65% Fe. It is a physical process involving grinding, blending and separation of the ore, to form a consistent material that is saleable to steel mills overseas. To produce 15 million tonnes of concentrate per year requires a major industrial installation, which is described in outline below.

The design of the ore processing and concentration plant is complex, but is described here in some detail, both to demonstrate the large number of elements and to explain how the process is entirely physical, requiring only energy and water (i.e. involving no other chemicals). Figure 3.8 gives a simplified flowchart of the process.

Figure 3.8: Simplified flowchart of the ore processing and concentration facility.



The ore will be delivered to the primary crusher station dump hoppers by 140 tonne mine trucks. For oxide (at 23 million tonnes per year run of mine material) and transition (30 mtpa-ROM) ore, three and four crushing stations will be required respectively, each with a capacity of about 1500 tonnes per hour. These will be located together in an area adjacent to the crushed ore blending beds. In each crushing station, apron feeders will withdraw the ore from a 300 tonne (or 2 truck loads) ore dump pocket to a scalping grizzly (a vibrating screen that separates undersize material), and then to a primary crusher, which will be either a jaw or a gyratory type. Each crusher will have a closed side setting of 175 mm and will be able to crush at a rate of about 750 tonnes per hour. A hydraulic rock breaker will also be installed above each crusher to break oversize rocks. Crushed product and scalping grizzly undersize material will be collected on discharge conveyors that will feed to a common crusher transfer collection conveyor. The transfer conveyor will deliver 4,500 tonnes per hour of crushed oxide ore (6,000 tonnes per hour of transition ore), either to an overland feed conveyor, or to an emergency crushed ore stockpile. The overland conveyor discharges to a blending bed feed conveyor. A fresh water tank, filled by a water truck, will supply water for dust suppression systems installed on each of the crushing circuits.

The iron deposits are variable in quality and hardness, and therefore a blending system is required to deliver ore to the processing plant that is as consistent as possible. Some blending will be done with mine trucks and with the selection of run of mine material from the stockpiles, but the majority will be done by a crushed ore blending bed system. The crushed ore from the overland conveyor will be conveyed by a blending bed feed conveyor to two 250,000-tonne blending stockpiles, with four days capacity during oxide ore processing (and three days for transition ore).

A bridge type bucket-wheel reclaimer will blend and homogenise material that has been piled up to the stacker of the blending bed yard. Each pile will be about 40 metres wide by about 18 metres high and 250 metres long. Two bucket-wheels are fixed on a trolley which travels along a fixed girder at variable heights. The trolley travel speed will be adjustable so that, in connection with the variable cutting depth, optimum operating conditions can be chosen for reclaiming different ore types. Each bucket wheel will be equipped with two rakes, and will move parallel to the front of the trolley to take up the material that has been stripped off by the rakes. Each cross-travel of the trolley will be followed by a forward step of the complete machine. As the two buckets are transposable, the machines can operate in two directions, an advantage for stacking one stockpile while reclaiming another. The bucket wheel excavator will discharge to a plant reclaim conveyor that delivers ore to a tripper conveyor discharging into the plant feed bins.

During oxide processing the concentrating plant is designed with two identical semi-autogenous grinding (SAG) lines, each fed from separate crude ore bins by a tripper belt conveyor installed above the bins. Each SAG mill line ore bin will have a live capacity of 6,000 tonnes, which is sufficient to operate the grinding circuit at design capacity for 4 hours. The SAG mills will be fed from the bins at a rate of 1,500 tonnes per hour by an apron feeder. A variable speed drive is to be provided to allow controlled adjustment of the SAG mill throughput as the ore hardness gradually increases from initial very soft oxide ore, as well as providing operational flexibility to deal with feed stockpiles of different hardness.

During modifications to the plant to process transition ore, an additional two identical SAG grinding lines must be installed to handle an increase in total throughput to about 4,000 tonnes per hour, as well as harder ore and a finer primary grind size requirement.

Each mill is equipped with a discharge return trommel screen installed on the mill to control oversize from the mill: this is a rotating cylindrical screen to sift out oversized material. The trommel screen will have an aperture of 3 mm. The undersize from the trommel screen is collected in a pumpbox and is diluted for pumping to the primary distributor. Each SAG mill will be equipped with sixteen multi-deck stack sizer screens which have an aperture of about 0.8 mm (0.5 mm during transition ore). The screen oversize discharges onto the SAG mill feed conveyor for recycle to the mill, and the undersize is collected in the pumpbox for pumping to the distributor.

The feed to the SAG mills will be controlled either with the set point of a belt scale that will control the speed of the apron feeders, or for finer tuning with the load in the mill by measuring the back-pressure on the mill bearings that will re-set the belt scale controller set-point. Steel balls will be added to the mill to facilitate grinding breakage and to decrease fines generation. A steel consumption of about 0.8 kg per tonne of ore fed is assumed. An automatic SAG ball loading system is provided to deliver up to 60 tonnes per day of steel balls from a ball bin.

The underflow of the sizing screens of each SAG mill will be collected in a spiral concentration plant feed pumpbox and pumped to a distributor feeding two spiral rougher lines arranged one below the other (four lines in total). The recovered rougher spiral concentrate is collected in launders and pumpboxes, and pumped to one of the two adjacent cleaner spiral line feed distributors. The rougher spiral concentrate is pumped to the cleaner spirals in order to control the feed density to the cleaner stage and obtain good separation efficiency. The spiral banks of each cleaner line are installed on the same operating floor level as the upper rougher spirals. The concentrate from the cleaner bank lines flows by gravity to recleaner spiral lines installed immediately below them. The recleaner banks are positioned on the same operating platform as the lower rougher spiral banks. The recleaner concentrates are collected in launders and pumpboxes and pumped to separate concentrate densifying and horizontal belt filters for dewatering.

Middlings from the cleaners and recleaners are gathered by collection launders immediately beneath the recleaner bank platform and directed to middlings pumpboxes. Both the middlings pumpboxes pump to densifying cyclones. The densifying cyclones overflow gravitates to a launder feeding the plant tailings thickener. The densified underflows are combined in a dense middlings pumpbox and pumped to a mill area feed box splitter for regrind in the SAG mills.

Each of the four rougher spiral lines will consist of 20 banks of 16 double start 7-turn washwater spirals in a 2 × 8 module configuration. Initially 60 of the 80 rougher spiral banks will be installed for oxide processing and the other 20 will be installed with the expansion required to process transition ore. However the required spiral plant structure and floor mounts will be completed during initial construction ready to install these. Each of the two cleaner and recleaner spiral lines will consist of 20 banks of 16 double start 5-turn washwater spirals also arranged in a 2 × 8 module configuration. Each spiral set is supplied in a pre-assembled framed module with a 32-way slurry distributor, necessary launder systems, washwater manifold and distribution systems in order to facilitate site erection.

Rougher spirals tailings are collected by launders and pumpboxes below the lower level rougher spiral banks and pumped to a set of multi-deck stack sizer screens via 8-way and 5-way distributors. The screen decks are equipped with 0.25 mm screens. The screen oversize is collected in a coarse middlings pumpbox and sent to the feed distributor of MIMS (Medium Intensity Magnetic Separation) magnetic concentrators. These wet drum separators will have a counter-rotation tank, which is designed for high magnetic recovery with minimum losses. The MIMS concentrate will be a low grade middlings product that is re-slurried and pumped to the SAG mill feed via a splitter box for regrinding and eventual recycle to the spiral plant. Transition ore MIMS concentrate must be reground finer for recycling to the spiral plant than can be achieved by the SAG mill. Therefore during the required transition ore expansion a vertical mill will be installed to regrind this material.

The spiral tails screen undersize (<0.2 mm) will be collected in a pumpbox and sent to the feed distributor of LIMS (Low Intensity Magnetic Separation) magnetic concentrators. These wet drum separators will be arranged in four lines of three stages of rougher, cleaner and recleaner LIMS. The final recleaner upgrades and partially dewaters the LIMS concentrate, which is collected in a pumpbox to go to a fine concentrate filter feed tank. The LIMS and MIMS magnetic concentrators are arranged on an elevated platform adjacent to the spiral plant. The tailings from these are collected in a raised launder below them, and flow by gravity assisted with process push water to an adjacent tailings thickener feed distributor.

The concentrates emerging from the spiral recleaners are collected in launders, and pumped to two separate concentrate densifying cyclones and 80 m^2 horizontal vacuum belt filters for dewatering. The densifying cyclones initially thicken the slurry to a proper density for direct filtration. The cyclone overflow will contain finer iron particles and will flow to a concentrate thickener for thickening and process water recovery. The recleaner concentrates can also be directed to the concentrate thickener for emergency storage in the event of a filter stoppage. The underflow of the concentrate thickener at 55% solids is pumped to an agitated filter feed tank. LIMS concentrate product can be pumped either to the concentrate thickener for further densification or storage, but it is normally directed to the filter feed tank.

The amount of fine concentrate produced for dewatering is largely determined by the magnetite content of the ore recovered via the LIMS separators. Pilot plant work has indicated that during oxide processing the weight recovery of LIMS concentrate will be about 3.8% and increase to about 4.5% during transition processing. Given the low production of fine material relative to coarse spiral product, it is assumed that the thickened flocculated fine concentrate will also pumped to the belt filter for dewatering. This will be pumped to a separate filter feed distributor in the initial cake form zone of the filter so that the coarse material will act as a natural filter medium for it. A cost and space allowance has also been provided in the open layout for the assumed future installation of another belt filter (or discs) during the transition ore phase should feasibility study pilot plant testwork planned on new samples indicate either that the production of LIMS concentrate is higher than that shown by current work, or filtration rates are lower than those currently assumed, and therefore it may be preferred to filter this product separately, or add more filtration area.

Each belt filter will have a dedicated vacuum pump which will be cooled by fresh water. The filtrate collected from the belt filters by filtrate receivers is pumped to the concentrate thickener for process water recovery. The belt filter concentrate will discharge with a moisture of about 8% to a concentrate transfer conveyor at a rate of about 2,000 tonnes per hour and will be conveyed to the concentrate storage and loadout yard.

During oxide ore processing, 15 million tonnes per year of washed sinter fines concentrate will be produced with weight recovery of about 65%, a 65% Fe grade, and SiO_2 and Al_2O_3 contents of about 5% and 0.8 % respectively. During transition ore processing, this 15 million tonnes per year of washed sinter fines concentrate will be produced with weight recovery of about 50%, a 66.5% Fe grade, and SiO_2 and Al_2O_3 contents of about 5% and 0.7% respectively. The moisture content will be about 8% for both ores.

The final concentrate product will be conveyed at a rate of about 2,000 tonnes per hour to either a one-day capacity, 45,000 tonne concentrate surge stockpile for later reclaim, or directly to a train rapid load-out silo system for loading to trains and transport to the port of Buchanan. The load-out bin will hold about 10,800 tonnes, sufficient for a block train of 120 wagons of 90 tonnes each. An average of four trains will be loaded daily in about three hours each. A truck top sampling station will be provided for product railing quality control. By the time the train reaches Buchanan the product quality will have been determined for input into a port and ship loading stockpile quality management system.

All the plant rejects will be collected in the tailings thickener. Flocculent will be added to achieve overflow clarity of about 50 ppm. The thickener underflow pumps will be located in a tunnel underneath the thickener tank. The underflow, at about 50% solids, will be pumped into a tailings pump-box for sending to the tailings pond about 5 km away via an HDPE pipeline running above ground, alongside the road to the tailings pond. The elevation of the initial tailings starter dam is about the same as the plant at about 460 metres, and it will be developed to a height of about 500 metres over the mine life. During transition processing, the quantity of tailings will double from 8 to 16 million tonnes per year and it is assumed an identical tailings thickener, set of pumps and disposal pipeline are installed.

The overflows of both the concentrate and the tailings thickeners will flow by gravity to a below grade concrete basin process water reservoir for re-use in the plant. This will provide enough capacity to retain all the process water required in the plant. When the plant is operating, the water in the reservoir will barely cover the intakes of the water pumps. When the plant stops, all the water that has been held up in the plant flows back to the reservoir and the plant is ready for restart. Process water pumps and floor washdown pumps will be located in a covered pump house located over the reservoir intakes. These will all be vertical turbine pumps and the length of the column determines the depth of the reservoir. Fresh make-up water will be added either directly to the reservoir, or reclaimed from an adjacent identical fresh water reservoir to maintain level. Fresh water will also enter the plant from the freshwater reservoir and a distribution tank as part of the pump gland seal (high and low pressure) water system.

Processed ore will be transferred from the concentrator building to the rail wagon loading silos by a series of belt conveyors. An emergency dump pile site is provided, to which ore can be re-routed via a diverter chute and reclaimed via vibratory feeders. Three rail wagon loading silos will be provided straddling the railway loading spur line. Dust generated at transfer points will be suppressed by a dust suppression system.

3.3.3 Mine and processing areas water management

At Mount Tokadeh the general approach is to ensure that all surface water is drained from the mine and processing areas into the Madayea River catchment, which flows northwards. The mountain has a long, curved ridge that dips north-eastwards into a broad bowl that forms the headwaters of the Madayea. The steep scarp slopes to the south and west drain into the Bee River catchment. Following abandonment by LAMCO and LIMINCO, the Madayea River remained polluted due to failures on the old mine benches and disturbance at the ore processing area near the railway. During and after the war, this was exacerbated by considerable amounts of shifting cultivation in the lower parts of the Tokadeh bowl. Although the Bee River was affected by LAMCO mining and the rapid abandonment by LIMINCO in 1992 of Mining Area F (a deposit of DSO at the lower, south-eastern end of the ridge), there was less agriculture on the steep mountain slopes and so it remained relatively pristine. Part of the water supply for Sanniquellie comes from the Bee River. A small amount of the drainage from the Phase 1 DSO loading area still flows into the Bee headwaters via the drains alongside the stretch of railway immediately south of the loading area.

A double attenuation pond system is proposed on the upper Madayea River. An initial large sediment pond is to be sited by constructing a dam just below the main confluence on the Madayea where the tributary streams from Tokadeh meet: this is referred to as the South Pond. It will discharge into another large settling pond, the North Pond, which is required to settle out the finer suspended particles in the water in order to achieve to adopted high standard of 50 ppm of total suspended solids. A constant minimum dry season compensation flow of 0.25 m^3/s will be provided from the North Pond to ensure that the Madayea River always carries water. In fact, the dam of the North Pond is not far upstream of the confluence with the Yeti River, which itself is close to the confluence of the Yeti with the much larger Dayea River. These two attenuation ponds will also act as the water storage part of the water balance for the ore processing and tailings management facility. The description of these ponds given below therefore takes this additional element into account.

The design for the dams of the two ponds will include the following components.

- A homogeneous lateritic low permeability earth fill embankment using borrow material won from the basin area.
- A cut-off trench along the alignment of the valley invert.
- An upstream slope rip-rap layer to protect the structural earth fill from erosion due to wave action and storm water run-off.
- A longitudinal blanket filter drain.
- A series of transverse sand finger drains for embankment seepage recovery reporting to a 2-metre wide open channel drain aligned adjacent to the toe.
- A 6-metre wide crest access track to the spillway.
- A rock gabion-reinforced spillway inlet, stone-pitched channel and gabion energy dissipaters.

The South Pond is designed to intercept and attenuate runoff from the mining areas and release it to a water treatment facility. In order to do this, a dam has been designed with a treatment discharge offtake at an elevation of 445.5 metres above sea level. The storage in the South Pond below this level has been estimated from topographic analysis as 0.691 million m^3. Any additional storage above this volume will be removed to the water treatment facility via the discharge offtake at a constant discharge rate, which is currently proposed to be 5 m^3/s. The dam will be provided with a spillway located at an elevation of 448 metres elevation, which yields a total storage of 1.544 million m^3. The difference in storage between the elevations of 445.5 and 448 metres is estimated as 0.853 million m^3, which constitutes the active storage available in the South Pond for attenuation of inflows. This has been designed on the basis of hydraulic modelling to provide sufficient storage to accommodate and treat inflows for most storm events (up to the 1 in 1 year return period storm event). Inflows exceeding the design capacity will overspill the South Pond dam via a separate spillway over a saddle of higher ground to the east of the dam, and be routed directly to the North Pond, bypassing the water treatment facility.

In providing the facility for attenuation, the South Pond is designed to be drawn down to the 445.5 metres level for the majority of the time. Storage will only exceed the 0.691 million m^3 associated with this level briefly following heavy rainfall (i.e. for a matter of days), and consequently little of this additional input will be available as a source of make-up water for ore processing. The storage of 0.691 million m^3 therefore approximates the upper limit of water availability for processing make-up water. In addition to this, since the primary function of this pond is to attenuate silt-laden runoff to allow the settling of the coarser fractions of the suspended sediment load, it is anticipated that there will be a loss of storage volume over time due to sediment. This is represented in the process water balance model for the South Pond, leading to calculations of the accumulated sediment volume which progressively reduce the pond storage capacity over time.

In addition to inputs from catchment runoff and incident rainfall on the water surface, the South Pond will also receive excess water from the TMF supernatant pond during the wet season. The South Pond is also to be the default source for make-up water for ore processing. A minimum volume for make-up water abstraction has been specified. This ensures that a residual water storage volume is always left in the pond so that bottom sediments are not disturbed by abstraction. A value of 150,000 m^3 was selected for this parameter.

The North Pond is located downstream of the South Pond and the water treatment facility. It is designed to accept the outflows from the water treatment facility to provide additional settlement capacity before treated runoff from mining areas is finally discharged to the environment. As discussed above, the North Pond will also accept spill from the South Pond that bypasses the treatment facility for storm events of greater magnitude than the design event.

It is proposed that the North Pond will form behind a dam with an embankment with a spill level of 439 metres elevation, which will provide a total storage volume of 1.206 million m^3. A facility has been built into the model whereby a fixed compensation flow can be provided from the pond above a specified storage threshold.

The water balance model has been configured so that the North Pond acts as a 'reserve' source of make-up water for ore processing, in the event that storage in the South Pond is insufficient to meet process plant requirements. Omission of a compensation flow ensures that storage is preserved in the system for make-up water provision. In common with the South Pond, a minimum volume for make-up water abstraction of 150,000 m^3 has been specified to prevent disturbance of bed sediments by abstraction. However, unlike the South Pond, no provision is made for sediment accumulation over time in the North Pond, as this should be minimal. The North Pond also has a separate spillway for high level flows to be discharged into the environment, at levels greater than the standard one-in-one year event.

Surface water will be run into the South Pond from the mine and processing sites using a combination of engineered drainage channels and natural water courses. These are mostly designed in outline in association with the mine and concentrator designs, but will necessarily need to be refined and finalised during construction. The intention is that water following natural creeks will be as clean as possible, with upstream check dams and sediment traps catching at least the coarse sediment as close to its point sources as possible. The combination of steep slopes and high rainfall make it hard to install adequate settling ponds for fine material high in the stream catchments, and hence the importance of the North Pond before the water finally leaves the site. In addition to the main drainage system, each of the waste dumps, stockpiles and borrow areas will have their own sediment ponds

A further significant drainage detail is that the natural drainage of Tokadeh Area F, at the south-eastern extent of the main ridge, has been altered using bunds, ditches and culverts to stop the surface water from flowing into the Bee River catchment and instead to bring it into the northern catchment. This has already been undertaken as part of the engineering for Phase 1 DSO mining, and means that all of the mined areas at Mount Tokadeh flow into the South Pond and North Pond system in the Madayea valley.

At Mounts Gangra and Yuelliton, mine drainage will be run eastwards throughout the life of the mine, so that all altered surface water flows are into the Kahn River catchment, which flows southwards through degraded forest and agricultural land to enter the Dayea River. There will be no altered drainage in the Gba River on the western side of the Gangra-Yuelliton massif: this valley contains considerable areas of primary lowland forest.

For Mount Yuelliton, adequate space exists in the headwaters of the Kahn for the construction of three attenuation ponds. The upper two of these will be sediment ponds, and the lower one will be a treatment pond to remove finer particles to achieve the stringent standard for total suspended solids. For Mount Gangra the drainage options are more complex. A number of diversion channels will be required to prevent mine runoff water entering the Priority 1 environmental constraints area of high biodiversity value on the eastern flanks of the mountain. These will transfer water between catchments and will take most of the flow into the Yuelliton pond system. Further work on the drainage of the Gangra pit is also linked to the final selected alignment of the Gangra-Yuelliton Haul Road, which is subject to further studies and will be addressed in an addendum to the main ESIA. Refinement of the drainage system will also be assessed as part of that work.

All Phase 2 earthworks and other engineering have been scheduled so that sediment ponds are to be the first works to be installed, before any other site clearance is allowed. This will ensure complete control of sediment discharge at all times.

3.3.4 Tailings management facility

The tailings management facility (TMF) is required to dispose of the large volume of waste product from the ore processing and concentration facility described in section 3.2. The material is not chemically hazardous, but there is a lot of it and it needs to be placed carefully so that it remains permanently stable. In total, around 150 million tonnes (60 million cubic metres) of material needs to be placed into the tailings management facility over the 20-year life of the mine and processing plant.

During the Pre-feasibility Study in 2009, six possible sites were examined for the location of the TMF. These were all in the vicinity of the ore resource at Mount Tokadeh, since this is the largest single resource, and it is surrounded by less steep and dissected terrain than the other resources, and close to the existing railway for outward shipment of ore. The main reasons for rejection of two of the sites was environmental (they are in less disturbed, more botanically rich and biodiverse forest). Three other sites were rejected largely because of social issues (they are more densely farmed).

The proposed TMF will be located north-east of the mineralised Mount Tokadeh open pit and directly north of the preferred process plant site. It will lie between a ridge and a tributary of the Dayea River. The site comprises an area of undulating terrain which rises from 430 metres above sea level near the Dayea River to 610 metres along the ridge crest. The site slopes to the north (towards the Dayea River) and to the east (towards the tributary).

The pre-feasibility designs for the TMF, in selecting this option, accommodated the following appropriate statutory guidelines.

- Recommendations from the EU Waste Management Directive (Directive 2006/21/EC).
- Industry Best Available Techniques for the management of tailings.
- The Equator Principles, particularly in reducing environmental, social and resettlement impacts.
- ArcelorMittal's requirements with respect to the safe, efficient and environmentally acceptable storage of the mine waste products.

The summary of the facility design given here therefore makes reference to the geographical features specific to the chosen TMF. The typical design criteria for the preferred TMF site can be summarised as follows:

- Starter capacity: 7 million tonnes of tailings;
- Ultimate capacity: 154 million tonnes of tailings;
- Design seismic acceleration: 0.14 g;
- Embankment construction methodology: upstream; and
- Tailings delivery system: slurry.

In brief, a tailings management facility of this type is fed with the waste product suspended in water as a slurry. This is discharged into a large pond and the suspended material is allowed to settle out. Water is then pumped off the top of the pond and returned to the processing plant for re-use. As the material is deposited, it forms a growing beach. The discharge from the slurry pipe is therefore controlled to allow the development of an even beach, which gradually expands outwards and upwards. This and the pond are retained within an enclosed dam system to ensure complete control and avoid the generation of a catastrophic mudflow under saturated conditions.

In this project, tailings will be slurried to 50% pulp density within the process plant and pumped to the TMF via a dedicated HDPE pipeline. This discharges at the active portion of the TMF, where it will be sequentially spread on to the upstream beach from a valved open-end pipe. Additional tailings will be sequentially discharged from the facility periphery to fill in selected side valleys, to avoid the formation of secondary minor supernatant ponds. The TMF will therefore start with a series of sequentially developed deposition areas to the south and north, combining in 2017 to form one facility approximately 2.5 km long by over 1 km wide (see Figure 3.9), which will then be sequentially raised in the upstream direction to form a facility with an ultimate crest elevation of 505 metres above sea level.

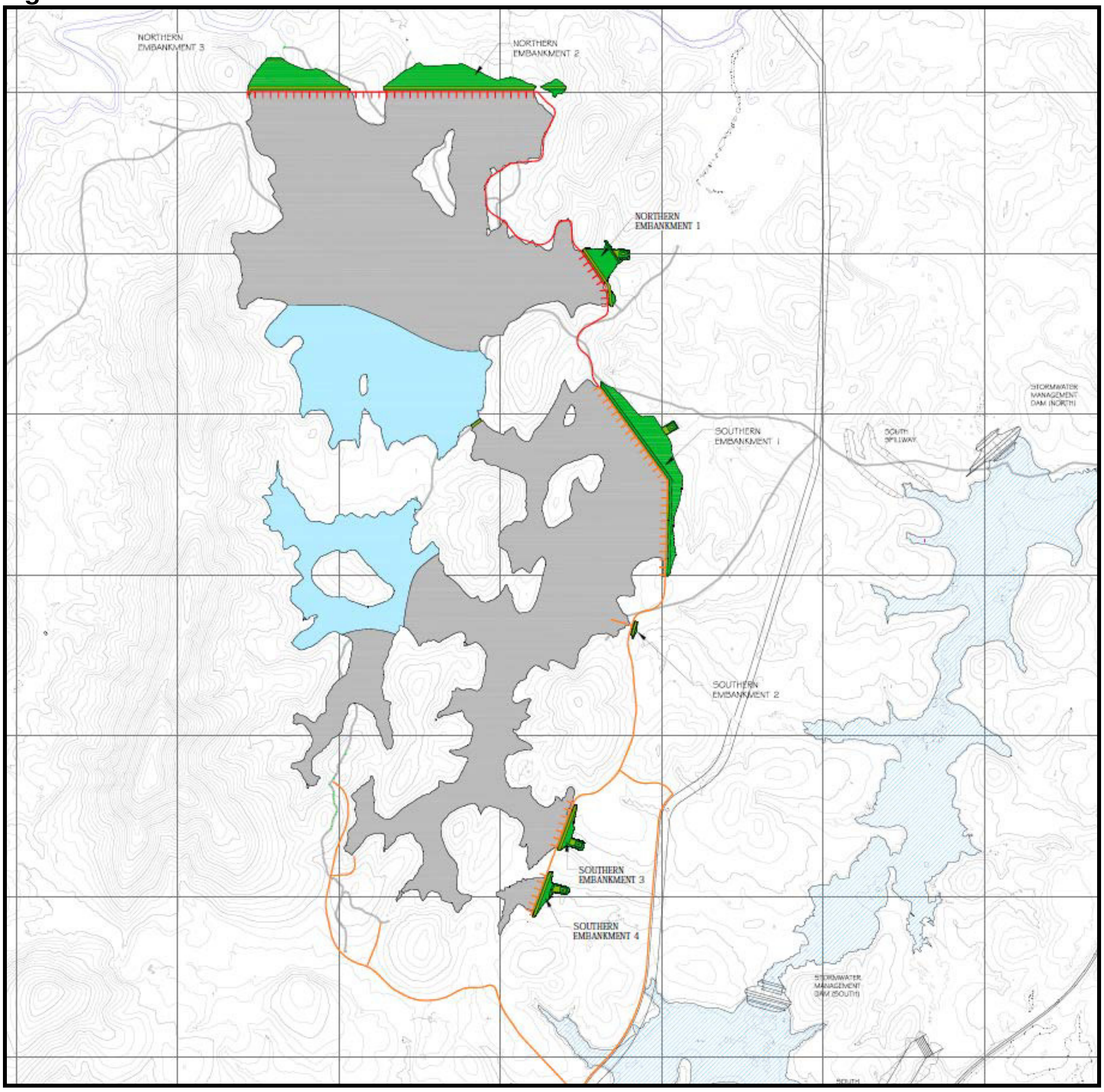
Most important in this is the use of earth dams around the lower-lying terrain, principally the northern and eastern sides, and later also the southern side. The tailings beach is developed from the earthen dams, so that the supernatant water ponds against the flanks of the ridge forming the western side of the TMF. This tailings disposal strategy will ensure effective material deposition within the environs of the TMF, with the supernatant pond confined adjacent to the existing natural topography and away from the embankments: this is a critical design feature to ensure maximised long term stability.

Floating decant facilities with pumps will be provided to abstract the supernatant water from the TMF and return it to the process plant for reuse. Excess water remaining within the supernatant pond during the wet season will be pumped to the South Pond of the drainage system. Any make-up water required during prolonged periods of drought will be pumped from the South Pond, and discharged to the process plant via the water return line.

The construction of the TMF earthworks is as follows. Once the initial pre-deposition embankment works are in place, the TMF will be sequentially constructed upstream. The southern and northern pre-deposition works will involve the construction of starter embankments to the 460 metre elevation level (a maximum of 30 metres high), using compacted laterite to form an upstream slope of 1:2 (v:h) and a downstream slope of 1:3. It is envisaged that following the construction and completion of deposition into the southern section of the TMF, the northern section will be developed and tailings discharged to this area. During operation of the northern TMF area (potentially up to two years), the southern tailings beach will be allowed to consolidate and densify, ultimately to develop suitable foundation characteristics to facilitate commissioning the annual upstream embankment raising programme. Due to the high rate of rise within the northern area, the tailings will not have sufficiently drained and consolidated in one year to form a suitable foundation for an upstream raise during the year of 2016, so the northern embankment will consequently be raised downstream at this time. For subsequent lifts, suitable beach consolidation is expected to facilitate combined annual upstream raises. The development of the beach and earthworks is shown diagrammatically in Figure 3.10.

Sufficient freeboard (2 metres minimum) will be provided at all times to accommodate the probable maximum flood (PMF) event. In the unlikely event that floods greater than the PMF occur (1 in 10,000 year return period), or operator error reduces the freeboard, an emergency siphon spillway will be provided for all construction phases. At closure, a permanent spillway will be constructed across the western ridge to ensure that all surface waters are allowed to discharge freely from the surface of the rehabilitated facility. Prior to closure, there will also be an additional protected spillway built into the staged construction so that, in the event of rapid abandonment due to force majeure, there would be a failsafe provision to avoid over-topping of the actual dam, and the consequent risk of dam erosion and catastrophic failure.

Figure 3.9: Anticipated tailings development as at 2017, at the time the two parts join together

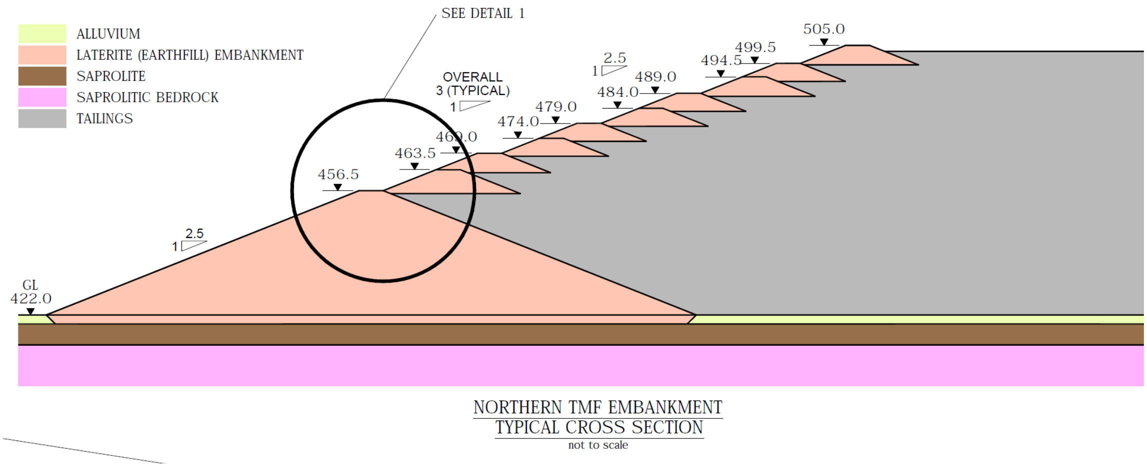


Protection of natural water quality and water resources is a key issue for TMF design. The environmental impact of the TMF on surface waters will be mitigated by the provision of a closed water management system. This is described latter.

A significant consideration in the design, operation and management of a TMF is the water management. This is to ensure the following.

- The TMF is not a safety hazard in respect of overtopping of the dam or inability to allow the deposited tailings to dry.
- The tailings are deposited in a managed process which facilitates the efficient drying out of the tailings, and contains the decant water in a manner which allows its take-off (generally as a recycle back to the plant as the main component of the process water).
- Discharge of contact water directly to the environment is avoided within discharge consent parameters.
- At the end of mine operation the TMF is left in the optimum condition for post-closure rehabilitation to proceed efficiently.

Figure 3.10: Sequential development of the upstream tailings dam



Construction of a TMF requires a significant volume of suitable engineering earthworks materials. At this stage the only borrow areas that have been appraised to identify suitable earth fill or free draining filter and aggregate materials are those for the first two years of construction of the initial dams. Further borrow areas and their management will be the subject of an addendum to this ESIA. It is proposed that the initial starter wall borrow material will be won from a locally established borrow area within the environs of the TMF, including some of it from within the footprint of the TMF itself.

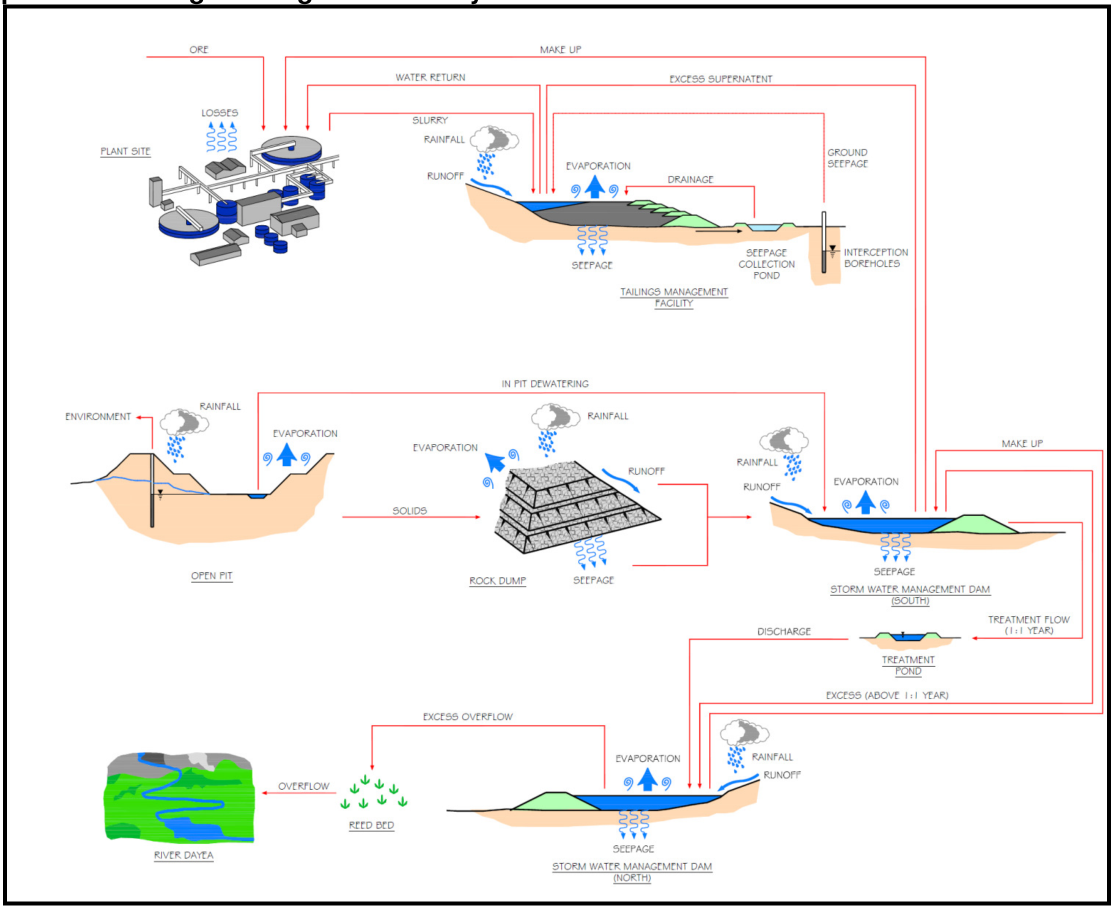
Stability of the tailings dam is to be enhanced by the installation of drainage systems in the earth fill as it is constructed, and the leading of these to seepage collection and treatment ponds at all of the low points around the TMF perimeter. Full stability assessments have been undertaken of a sample of the tailings material and the characterised dam construction materials, using data derived from geotechnical site investigations. During construction and operation, water pressures and stability will be monitored through appropriate instrumentation installed in the developing facility.

In practice the construction of a tailings management facility involves a dynamic design controlled over the years of its development by a specialist team who are required to follow a detailed Operation, Maintenance and Surveillance Manual. This manual is in draft form but will be brought to an advanced state before construction starts.

3.3.5 Process water supply and its management

In order to concentrate the iron ore through mainly gravimetric methods, separate materials and remove the waste to the tailings dam, a large volume of water is required. Most of this is constantly recycled, but seasonal variations mean that there will be evaporative net losses in the dry season and rainfed net increases in the wet season, as well as other gains and losses in ore masses, seepage and other routes. Special provisions must therefore be made to ensure that the right volume of water is maintained in the system for it to operate safely throughout the year. Figure 3.11 gives a diagrammatic representation of the general water balance, which is described in the following paragraphs.

Figure 3.11: Diagrammatic representation of the overall water balance of the process plant and tailings management facility



The TMF will be located in two headwater drainage basins (referred to as TMF South and TMF North, with respective catchment areas of 1.91 km^2 and 1.31 km^2). Tailings slurry will initially be directed to TMF South in Year 1 of the development. It is envisaged that this area will be full by the end of Year 1, and that tailings will then be directed to TMF North in Years 2 and 3 of the development. Throughout the first three years of the Phase 2 development, there will effectively be two separate TMFs, with separate water balances to consider. At the end of Year 3, the South and North TMFs will merge into a single contiguous TMF with a single supernatant pond. For the remainder of Phase 2, the capacity of the TMF will be continually increased through the progressive raising of embankments on its north, east and south sides (the western boundary being defined by a ridge of high ground).

The dynamics of the water balance will be strongly influenced by TMF dynamics, including deposition characteristics and the evolution of the tailings surface and the associated influence that is imparted on the surface and sub-surface hydrology. Tailings will be discharged into the natural valleys within the TMF area via spigots situated along the embankment and also via gravity draining open end outfalls situated along the ring main. The rate of discharge from spigots will be controlled in order to build up the deposits behind the embankment and effectively push the supernatant pond away from the respective embankments. Tailings will initially be deposited in the form of a fan in the valley bottoms and the tailings surface will gradually rise. The coarser fraction of the tailings will settle out first and the finer particles will continue to flow downslope with the suspended particle size continually decreasing with distance from the discharge point (a process known as hydraulic deposition). In areas where there is a sufficient buffer between the discharge point and the supernatant pond, it is expected that only fine silt and clay sized particles will remain in suspension as surface flows discharge into the supernatant pond. Further settlement of fine silt and colloidal particles is expected to occur in the supernatant pond. Treatment of supernatant may be required to ensure a minimum suspended solids content in the water returned to the plant.

Flooded and channelised areas will form on the tailings surface downslope from discharge points. Typically, the channels that form will periodically migrate (known as avulsion) but will continue within a discrete margin, assuming uniform discharge of tailings. Saturated zones are also to be found in the immediate vicinity of the flooded zones.

In reality, the flooded and saturated zones will occupy valley bottoms that may already be occupied by ephemeral or perennial channels. As such, these natural drainage pathways will continue for some time as the tailings beach develops. Other than evaporation losses from the supernatant pond, evaporation will also occur from flooded and saturated zones on the tailings surface. Seepage into the tailings surface will also occur in flooded and saturated zones, as it will through the base of the supernatant pond and generally across the tailings surface during rainfall events. A significant volume of water will also be lost to the interstitial voids in the tailings deposits.

The TMF will also be subject to natural rainfall runoff which is often diverted around smaller TMFs. However, because of the environmental, logistical, engineering and cost constraints associated with peripheral diversions in this case, runoff within the TMF catchment will continue to report to the supernatant ponds. The TMF design consequently maximises use of the confining hills and natural contours, to form a semi-paddock facility with a minimum catchment area.

As mentioned above, the mine stormwater management dam system comprises two in-series attenuation ponds, plus an associated water treatment facility downstream of the southern dam. The southern stormwater management dam (referred to as the ‘South Pond’) receives runoff from the Tokadeh mining and ore processing areas. The South Pond will discharge via the water treatment facility into a further attenuation pond, which then discharges to the Dayea River (the ‘North Pond’).

Other inputs to the South Pond will consist of runoff from the upstream catchment, incidental rainfall on the pond area and excess water pumped from the TMF during the wet season. The outflow from the South Pond (consisting of a constant 'treatment discharge' routed via the water treatment facility plus any spill during extreme wet periods) forms the principal input to the North Pond. However, other inputs to the North Pond consist of runoff from surrounding areas and incident rainfall on the pond surface. Outputs from the North Pond (consisting of an optional constant compensation discharge plus spill) form the outputs from the model.

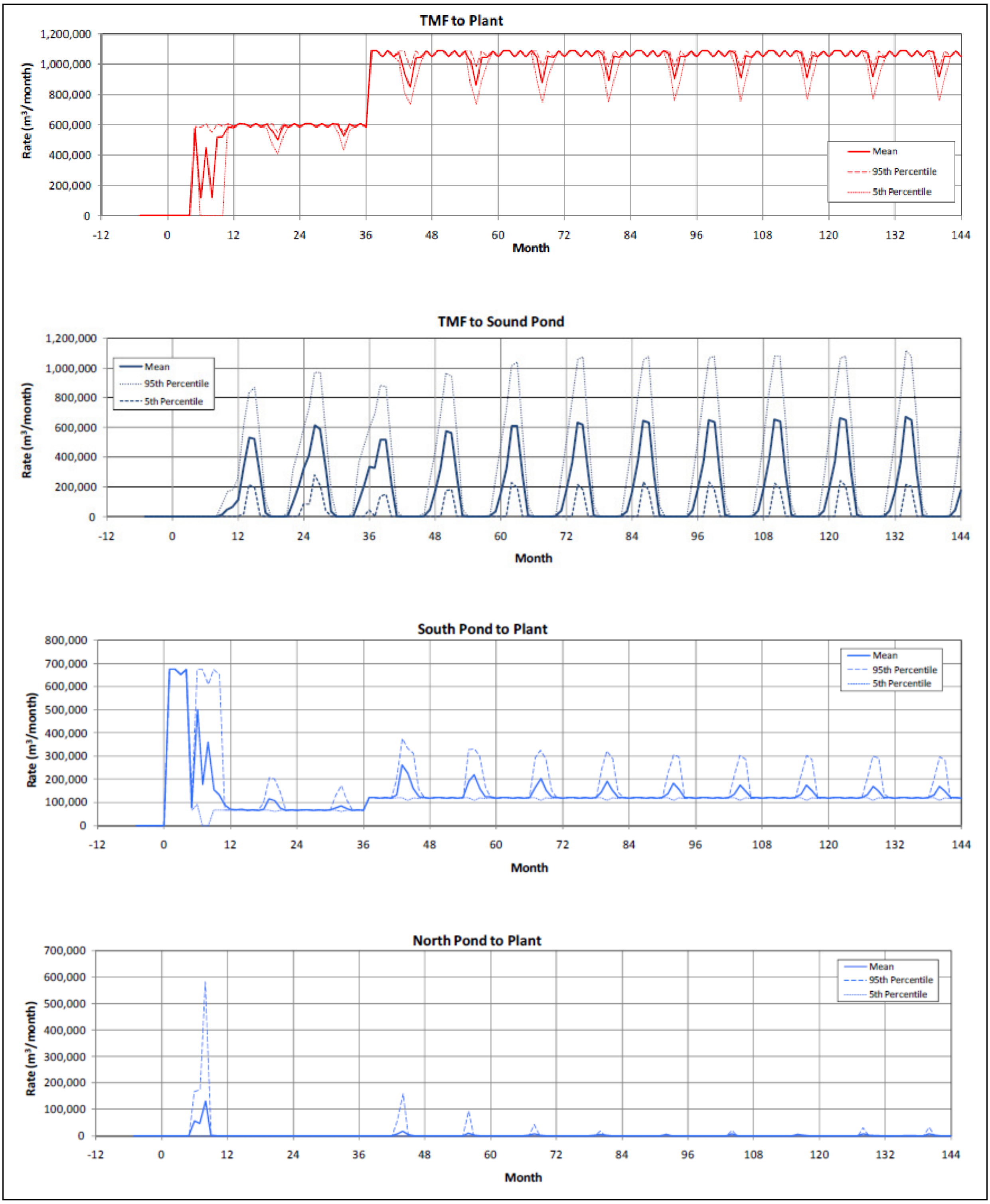
It is proposed that the South and North Ponds will fulfil a dual role, not only providing attenuation for mine runoff, but also acting as a source of make-up water for ore processing. This make-up water will be taken by default from the South Pond. However, where there is insufficient water in the South Pond, additional water will also be taken from the North Pond to make up the shortfall. The various water balance calculations for the different transfers are shown in Figure 3.12.

Sediment deposition and its effects on water storage capacity have been simulated for the South Pond. The source of these sediments is assumed to be catchment runoff only.

Sedimentation has not been simulated for the North Pond, as no silt entrained water from the waste dumps will report to this facility.

In addition to outputs via treatment and compensation discharges, spill when full and abstraction to the process plant, additional losses from both facilities will occur as a result of evaporation from the open water surface, and seepage through the respective embankments and impounded basin areas (although any embankment seepage from the South Pond is assumed to form part of the input to the North Pond).

Figure 3.12: Water balance charts for the processing system



3.3.6 Transport of ore by railway

The purpose of this component of the project is mainly to transport 15 million tonnes per year of concentrated iron ore from the mines in Nimba to the sea port at Buchanan, over a twenty-year period. This is a distance of 255 km from the Tokadeh rail loading site. There will also be limited rail traffic to transport personnel and goods.

Once it has been finished in the concentrator, the ore will sent by conveyor to loading silos positioned directly above the railway. It will be loaded from the silos directly into the rail cars, which is a simple procedure using gravity. The silos will have a minimum capacity equivalent to 1.5 train loads.

As part of the railway refurbishment, extensions have already been completed for the limited LAMCO railway sidings (passing loops), which had been designed for the shorter trains hauled by less powerful locomotives than are now available. At Tokadeh, a linear rail loading track has been selected rather than the more typical loop rail track in order to minimise the site footprint area required.

This arrangement results in the following typical train loading operational parameters and design capacity:

Train Length:	70 wagons;
Car Factor:	95 tonnes per car;
Train Cargo:	6,650 tonnes per train;
Net Loading Rate:	10,000 tonnes per hour;
Reliability:	95%;
Pre Loading Time:	0.62 hour;
Gross Loading Time:	1.21 hour; and
Post Loading Time:	0.21 hour.

The right-of-way, rail bed, rail, sidings, and bridges are to be used as per the old LAMCO operation, and as refurbished for Phase 1.

- Track has been rebuilt with six sidings or passing loops for the 15 million tonnes per year.
- The old LAMCO ore wagons have been refurbished for Phase 1, and will continue to be used in Phase 2.
- The wagons will carry 95 tonnes per car, which was achieved by LAMCO, and is limited by the axle loads on the existing bridges.
- New communications towers are being rebuilt close to the locations of the old LAMCO towers, which are now dangerous, as the final part of the railway rehabilitation.

Rolling stock requirements are governed by the average tonnage per car, which is fixed, the number of cars per train and the train cycle time. The LAMCO tracks were originally designed for 90-wagon trains, each hauled by two locomotives: the passing loops were constructed to this capacity. The maximum train that can be hauled by the General Electric GE4400 locomotives used by ArcelorMittal is 70 wagons. Therefore it is more efficient in terms of locomotive utilisation to run 70-wagon trains with a single locomotive than 90-wagon trains with two locomotives. For any future increase in capacity above 15 million tonnes per year, longer train configurations could be applied using multiple locomotives, but this would need all the passing loops to be extended.

Transport efficiency calculations have suggested that a fleet of five trains of 70 wagons each give the best option. This results in an average of 6.8 trains per day (during a 330 day working year) and a train arriving every 3.5 hours on average. The "catch-up" mode of rail system is the mode in which it would operate after a major disruption. A one-week rail closure, for example, could be caused by a derailment, a bridge failure, or a major failure of the loading system. Once the railway was operational again, the trains would operate at full capacity (that is, with no slack) and all optional maintenance would be deferred. With the catch-up cycle time, the 15 million tonnes per year rolling stock has an annualised capacity of 18.9 million tonnes per year.

The expected average train cycle time is 15.31 hours, calculated as follows:

Preloading:	0.62 hour;
Loading:	1.21 hour;
Post-loading:	0.21 hour;
Loaded transit:	4.4 hours;
Pre-dumping:	0.14 hour;
Dumping:	0.86 hour;
Post-dumping:	0.79 hour;
Empty transit:	4.1 hours;
Breakdowns and meets:	2.0 hours; and
Idle and queuing:	1.0 hour.

The maximum speeds for trains is 60 km/hr loaded and 80 km/hr empty, though there are sections of line where the permitted speeds are significantly slower.

ArcelorMittal is experimenting during Phase 1 with longer trains, which are therefore less frequent. Apart from reducing the number of trains running, they are also more efficient because of reduced overall fuel consumption. It is therefore possible that the 70-wagon train model described above will be altered later to an improved schedule.

Other activities that will be undertaken in connection with railway operation are as follows.

- Continuation of the rail safety education programme that is being undertaken in Phase 1, and finalisation of other mitigation and safety measures.
- Operation of limited additional trains for (a) servicing the track and (b) transporting goods and equipment, particularly fuels, up the line to Tokadeh.
- Continued maintenance of the railway. This will involve some re-grinding, re-welding and re-ballasting, and minor improvements to the vertical alignment. There will also be the routine works of ditch and culvert cleaning, vegetation control, and bridge inspections.

Ore will be discharged from trains on to a stockpile close to the quay in the port concession area at Buchanan. This will be done using a car unloader, which rotates each car in the train in turn, and tips its contents on to a conveyor. This is described in the next section.

3.3.7 Operation of Buchanan Port

Overview

This component of the project is to allow the export from Liberia of up to 15 million tonnes of concentrated iron ore per year. Put simply, trains will run into the Buchanan materials handling area in what is currently the old LAMCO industrial waste land. As they come in, they pass through a car dumper. This is a big cylinder that takes each wagon in turn and turns it upside down to empty out its load of iron ore. The emptied train continues around a loop of track and, after refuelling and checking, sets off again for the Nimba mines. The ore falls out of the cars into a big funnel and on to a conveyor. The conveyor takes it to a big stockpile area. When there is a shipload ready, a berthed ship is loaded by a system of scoops, silos and conveyors.

Train unloading

Bulk handling technology has advanced since the LAMCO days to allow greater productivity and efficiencies of energy and time. In addition, the geometry of the old dumper vault cannot accommodate the expected material properties, and therefore a new vault must be constructed to accommodate a modern rotary dumper and the products now being handled.

Under the new design, rail wagons will be unloaded automatically by a rotary dumper, along with an indexer that positions the wagons into the dumper barrel and automatically advances the train once the dumper completes its cycle; the system can also be operated manually. Being equipped with rotary couplings, the wagons can be dumped in sequence without being uncoupled. The car dumper will be positioned at the start of the track loop, north-east of the port stockpiles, and is designed to allow the locomotives to pass through the barrel structure. Under normal operating conditions the dumper will rotate approximately 160°, or up to 180° as required, to allow for discharge of sticky material and for maintenance.

Dumped material from the railcars falls into a lined dump hopper equipped with a hopper-level monitoring system. To alleviate dust generation, when required a dust suppression water spray will treat the concentrate before and during railcar dumping.

The rail unloading facility is designed for a nominal operating rate of 5,000 tonnes per hour and peak rate of 6,000 tonnes per hour.

The railcar dumper building will be approximately 18 by 15 metres in size, situated about halfway along the north-western side of the port. The building will have a partially clad steel superstructure and a concrete sub-structure resting on bedrock at 17 metres below the ground surface. Considering the close proximity of the ocean shoreline, it is anticipated that dewatering in the form of deep water wells will be required during construction. A concrete tunnel on the south side of the building will support a conveyor that leads towards the stockpiles. The building will be equipped with a 10-tonne crane running its full length. The operation will be monitored from a control room on the south side of the building.

Stockpiling

The former LAMCO stockyard area has been shown to be geotechnically stable and will therefore be re-used. This allows for a capacity of 1,200,000 tonnes of storage (900,000 tonnes in the wet season) in two stockpile lines. Concentrate will be extracted from the dump hopper by two variable-speed belt feeders, and will be conveyed at a nominal rate of 5,000 tonnes per hour to two in-line longitudinal double stockpiles with the following dimensions:

- Length (at top) 83.3 metres;
- Width (at base) 41.7 metres;
- Height 15.5 metres;
- Angle of Repose 38°; and
- Capacity (each) 300,000 tonnes.

The stockpiles will be constructed by a rail-mounted travelling longitudinal stacker running along the north-western side of the piles. The stacker has the flexibility to stack the concentrate in separate piles if product isolation is required. The design capacity is 6,000 tonnes per hour. A dust suppression system (water cannons) will be provided for the stockpiles.

Concentrate will be reclaimed from the stockpiles by a boom-type bucket wheel reclaimer that transfers the material to belt conveyors leading to the ship loading surge bin. The design capacity of the reclaimer is 10,000 tonnes per hour. The reclaimer will be mounted on rails and travel along the south-eastern side of the stockpiles, permitting reclaim at any location along the stockpile and thereby providing flexibility for ship loading. A bypass conveyor belt will also be available to transfer product directly from the rail wagons to the tail end of the reclaim belt conveyor, for direct ship loading without product going into the stockpiles. During these direct-loading operations, the reclaimer can be used to supplement the material transport rate.

Ship loading

The reclaim system to the existing surge bin will consist of two conveyors with a belt discharge sampling system at the transfer point, designed to collect a sample of each ship load. A bottom-discharge sample cutter mounted on the head end of each conveyor will periodically cut the stream of material and deliver the proper increment to a sample divider, which splits off a representative amount into a small container for analysis. The balance of the sampled increment is returned to the belt conveyor after the transfer point.

The surge bin is necessary to smooth out any surges in the ore flow from the bucket wheel reclaimer and to allow the ship loader to change hatches without having to shut down the reclaim system. It is planned to use the old LAMCO 2,000-tonne surge bin, located beside the iron ore quay. The bin will be modified with a newly lined bottom and two new variable speed belt feeders for extraction of the concentrate. The bin has been thoroughly examined to ensure it is in suitable condition for the intended purpose.

A ship loading trade-off study was conducted to provide a technical comparison of two different styles of ship loader layout. A 30-metre rail gauge ship loader similar to the one previously operated by LAMCO was compared to a more modern 15-metre rail gauge type. The 30-metre option is recommended on the basis of the potential reuse of the existing surge bin, ability to use the existing quay for the entire system, and possibly greater ship loader shuttle range.

The ship loader is designed to load Panamax and post-Panamax ships at the existing quay. From the surge bin, the ore will be metered out by two variable-speed belt feeders with a combined nominal capacity of 8,000 tonnes per hour. The belt feeders will transfer to a reversible belt, which in turn transfers the product on to the quayside conveyor. A reversible belt is needed to empty the reclaim system if a problem arises. The travelling ship loader includes a trailing tripper structure and a carriage-mounted boom conveyor capable of luffing and shuttling to allow complete loading coverage of all the ship's hatches as it travels along the quay parallel to the ship. The ship loader is designed to load at a nominal rate of 8,000 tonnes per hour and to handle peaks of 10,000 tonnes per hour.

It is planned to turn most ships around on two tides in order to achieve reasonable berth efficiency. Experience shows that a ship loader fed by a reclaiming wheel with a free-digging rate of 8,000 tonnes per hour can accomplish this for the expected Panamax and post-Panamax vessels. Fully loaded ships of these sizes draw about 12.5 metres of water, so they need to wait for the high tide before they can depart safely (the main channel is only 12.8 metres deep at low tide, which does not give a safe operating freeboard; however, there is a deeper trench to 14.5 metres alongside the iron ore quay).

This arrangement is limited by the berth capacity to a maximum of 16.5 million tonnes per year.

ArcelorMittal is undertaking trials during Phase 1 with transhipment offshore into a larger Capesize vessel. These are ships that can carry up to 180,000 tonnes but need at least 20 metres of water when loaded. By anchoring a Capesize vessel a few miles off the coast and shuttling ore to it using a self-unloading Panamax size vessel, it is possible to load a ship of this capacity within a few weeks. This makes Far Eastern markets economically accessible to Liberian iron ore. At the same time, the company is also undertaking investigations as to the technical feasibility of a pier extended into deep water for the moored loading of Capesize vessels. Whether either of these options is followed depends on the outcomes of these test activities, as well as on the future fluctuations in world markets for iron ore. If an alternative proves worthy of development, then it will be covered by a full addendum to this ESIA.

Capacity

The ore handling described above needs to have supporting infrastructure and logistics in order to function effectively. This section describes the railway system and ancillary facilities that would permit such an operation at Buchanan.

This ore handling system described in the preceding section has the following operational parameters and design capacity for ship loading:

Average ship cargo:	69,000 tonnes per ship;
Average ship turnaround time:	30.5 hours;
Annual maintenance requirements:	200 hours per year; and
System design commitment:	85%; giving
System design capacity:	*16.5 million tonnes per year.*

In order to recover from a disruption, the system could operate in "catch-up" mode by postponing planned maintenance and operating at 100 percent commitment. This would provide an annualised capacity of 20.5 million tonnes per year, or 37 percent peaking capacity. A one-week disruption could be "caught-up" in 2.5 weeks.

Rail layout

The rail layout will consist of an ore unloading track that uses a loop arrangement where a loaded train would be processed in an anti-clockwise direction through the single car dumper. This requires construction of a revised track layout. The selected design cuts across the existing laydown area on its way to the car dumper, and re-joins the existing Phase 1 unloading track near the iron ore quay, to use that as the return part of the loop. A rolling stock maintenance facility would be located at the end of the loop track. Empty trains waiting to depart the port would be positioned at the departure tracks. Other existing Phase 1 tracks and sidings will be maintained for storage purposes as well as for the fuelling facility for fuel wagons and locomotives.

To replace the abandoned LAMCO rolling stock workshops in Yekepa, a workshop is to be located in Buchanan. A review of needs provided operational data in terms of wagon and locomotive kilometres per year, which in turn defined maintenance needs. The proposed workshop layout concept was developed through an analysis of the required maintenance operations, along with an evaluation of the worksites (spots) required for locomotive and wagon maintenance. Wagon maintenance activities assumed the programmed general inspection of wagons every 1.6 million km, with wheel changes based on a 350,000 km wheel life. Locomotive maintenance activities were based on General Electric recommendations for periodic maintenance at intervals ranging from 3 months to 5 years. In Phase 2, once the proposed fuel landing and storage system at Buchanan is installed, the company will switch to low sulphur fuel that is currently unavailable in West Africa. Not only will this reduce emissions of SO_2, but it will also reduce the frequency for oil changes, and therefore the consumption of engine oil.

A single building of 2,880 m^2 is proposed, housing locomotive repair, wagon repair, and other track-mounted equipment repair facilities, along with auxiliary shops in distinct areas. The building will be a steel-framed structure with partial cladding and steel roof trusses, and with five rail tracks to service the trains. Some tracks will be constructed with underground wheel truing pits. The building columns will be supported on conventional spread footings. Concrete floors will be designed as slab-on-grade, and concrete aprons will be constructed around the perimeter of the building. A 50-tonne crane will be installed to service rail tracks No.1 and 2, and a 20-tonne crane to service rail tracks No. 3 and 4. An area between rail tracks No.1 and 2 has been designated for equipment washing. Rail track No.1 will be used for trip maintenance and wheel profiling, and can be accessed by means of platforms installed on both sides of the track.

Three administration and electrical buildings are to be located near the rail unloading facility, stockpiles, and ship loading facilities respectively. These three buildings are identical and measure approximately 36 by 12 metres. They will be designed as steel frame structures with perimeter masonry walls. These buildings will comprise office areas, lunch rooms, storage areas, washrooms, janitor rooms, mechanical rooms and electrical rooms. A control room will be provided only in the building near the rail unloading facility, while regular offices will be provided at the other two locations.

Drainage systems

Buchanan has a very high rainfall and stormwater drainage is a significant consideration. In particular, the avoidance of sediment from the ore stockpiles entering the sea is paramount. LAMCO had a comprehensive series of drainage channels but no sediment settling facilities: after heavy rain the sea would turn red for several days as a result. Such an approach is no longer acceptable.

ArcelorMittal has already reinstated the LAMCO drainage systems, but has also constructed sedimentation basins close to the discharge points into the port. These were constructed in the 2011-2012 dry season as part of overall port refurbishment under Phase 1, and tested well in the particularly heavy wet season of 2012. Remaining to be constructed are drains and sediment collection systems for the main Phase 2 infrastructure, particularly the main ore stockpiles and the railway yards and workshops: detailed designs for these are incorporated in the engineering layouts.

When the iron ore quay itself was reconstructed for Phase 1, it was given a gentle slope away from the sea and into broad but shallow drains alongside the DSO stockpile. These drains lead into sediment collection ponds at either end of the quay. With suitable improvement to make them more maintainable in the longer term, these ponds will continue to be used in Phase 2.

3.3.8 Operation of the townships at Yekepa and Buchanan

The facilities at the two main office and residential communities at Yekepa and Buchanan need to be expanded for Phase 2 of the project, from the Phase 1 refurbished conditions. This is to provide long term accommodation for the larger project's staff.

The townships will not exceed the current concession boundaries and it is not expected that more houses will be required than are currently in existence (though some are still seriously damaged). The layout of the buildings and other infrastructure will therefore remain as before. The main consideration of potential environmental significance therefore relates to services: the provision of power and water, and the disposal of sewerage and solid waste.

Detailed designs for the refurbishment of the townships were part of Phase 1, and the resulting facilities will be constructed as part of the preparation for Phase 2. At Buchanan these will follow the LAMCO infrastructure very closely, except with more modern equipment, as there are no changes to the layouts.

At Yekepa some of the infrastructure will be altered because about half the town is occupied by non-company people and, as long as the company does not need the housing and crime remains under control, there is no purpose to be gained from evicting them. Nevertheless, the long term administration and management of Yekepa needs to be agreed between ArcelorMittal, the Government of Liberia, the County Authority and the communities. The company proposes to commission an in-depth consultation led by a town planner to identify long term options and develop a strategic plan for the preferred option. If this leads to significant changes to the way that Yekepa is laid out and run, then it will be the subject of an addendum to this ESIA.

It is also proposed to build temporary construction workers' camps at both Buchanan and Yekepa. These will provide accommodation for the people involved in the works described above in the building of the Phase 2 infrastructure. The number of people required during construction will be significantly greater than required during operation, when the existing, refurbished former LAMCO housing will be adequate.

At Buchanan, it is expected that the contractor's camp will house up to 200 persons. These will be skilled Liberian technicians from other parts of the country, and regional and expatriate staff. It will not be used for labourers, since they will be brought by bus from the city of Buchanan. The camp will be constructed alongside the existing temporary contractors' accommodation (used in the final Phase 1 reconstruction works) between the UN camp and Loop 1 in the main compound, entirely on brown field land from the LAMCO period.

For Tokadeh a larger number of workers will be required. Estimates vary depending on contractor options, but an absolute maximum of 1200 appears to be adequate. A number of sites were investigated for this accommodation and initially a site was selected close to the Tokadeh industrial area. Concerns over the social impacts of this number of temporary workers from outside the area, mostly single males, and the difficulty of controlling land and the development of businesses around the camp, led to a decision to house the workers in Yekepa itself. With its company history and management, and urban culture, Yekepa is a more suitable location except for the need to transport the workers to and from the construction sites. This will be achieved using a fleet of buses, and the road between Yekepa and Tokadeh will be maintained in good condition to allow for easy transportation. The selected location for the temporary camp is on the site of the former LAMCO rail yards, which have been completely removed as the wagons parked there were taken for refurbishment and re-use, and the rails taken to replace damaged sections on the mainline. This, along with some of the other abandoned industrial facilities (particularly the concrete and asphalt batching plants, rail control offices and the sawmill), provides adequate space for all of the Phase 2 contractors' accommodation needs.

The activities proposed with respect to these camps are as follows.

- Clearance of the bush over the agreed areas.
- Construction of gravel access tracks. These will be constructed as for other laterite tracks: about 7 metres wide to allow vehicles to pass safely and with a rounded profile to shed water.
- Minor alterations to surface levels as necessary to allow its use as planned.
- Installation of surface water drainage systems.
- Installation of boreholes for water supplies.
- Installation of foul water drainage networks, and self-contained underground septic tank and soakaway systems. At Yekepa the camps may be plumbed straight into the main town sewage treatment plant, depending on capacity.
- Erection of security fences.
- Installation of concrete block foundations for the housing, mess, recreation and medical units.
- Construction of pre-fabricated modular housing units on top of the foundation blocks.
- Installation of containerised water treatment plants.
- Installation of low-noise containerised power generators, with integral fuel tanks. The capacity of the generators will be determined once the exact number of occupants has been determined, and their maximum power consumption has been calculated. For obvious economic reasons, the generators will be no bigger than necessary. Because of the limited areas assigned to the camps to minimise landtake, any generator chosen will be of a type designed for use in residential areas.
- Laying of crushed stone pathways and parking areas.

Following the completion of works, the camps are to be removed as follows.

- Removal of the water treatment and generator units.
- Dismantling of the modular housing units and their removal from site.
- Removal of the concrete foundation blocks.
- Scraping up of the crushed stone surfaces.
- Permanent closure of the water supply boreholes and the septic tanks.
- Removal of the security fences.
- Re-grading and loosening of the soil.
- Restoration of vegetation cover through planting with grasses and trees.

3.3.9 Power generation

Overview

A common feature of the facilities described in the sections above, but particularly at the concentrator, is the need for large amounts of energy. Most of this is required to move the large volumes of ore through the various stages of concentration, as well as the water required to facilitate the processing. Iron ore concentration is a power-hungry activity, although haematitic ore has a lower requirement than magnetitic ore, and hence this project has a much lower energy requirement than is sometimes the case for iron ore beneficiation. Ore handling through the transfer, conveyor and stockpile systems will also require considerable power, on account of the large volumes and heavy masses involved.

Tokadeh power supply

It is estimated that the process plant will consume 58.3 MW in the initial oxide ore phase, and that this will increase to 75 MW in the second, transition ore phase. In the absence of an existing high capacity national or regional grid, this will need to be supplied to the site by an in-house power plant.

Power generation will be at 11 kV by 9+1 x 7.590 MW generators running on heavy fuel oil (bunker) out of which one will be in standby mode. Provision has been made in the power generation plant for a future additional generator unit. The units will be sized so that they can supply the site demand while running at 87 to 93.1% of their rated capacity. With the loss of one generator, the remaining units will be capable of handling the total load for a minimum of one hour until the standby unit is brought on line (each generator is rated for a maximum overload capability of 10% for one hour). The selected power plant engine model is the Caterpillar 16CM32C.

For the soft oxide phase of the project, only 10 generators will be purchased (for nine units running, with one unit on standby). In the transition ore phase of the project, an additional one or two generators, (pending on actual meter reading during the soft oxide phase) of similar size will be added to satisfy the increased load. For oxide ore, the following expected load descriptors apply:

- Annual average load: 58 MW;
- Annual net energy to project: 466,400,000 kWh (466.4 GWh).

For transition ore, the description of the load is as follows:

- Annual average load: 75 MW;
- Annual net energy to project: 600,000,000 kWh (600 GWh).

The heat passed out through the exhaust stacks will be recovered using an exhaust flue gas heat recovery system and will be used to heat the heavy fuel oil in the tank farm.

Preliminary emissions data have been calculated, given the following parameters:

- Load: 100%;
- Ambient temperature: 25ºC;
- Individual stacks with 1000 mm diameters;
- Temperature at release point: 315ºC;
- Actual volumetric flow rate at the stated emission temperature: 27 m3/s at 315ºC;
- Stack exit velocity: 30 m/s at 315ºC; and
- Normalised volumetric flow rate (dry): 12.5 m3/s (0ºC, 1 atm).

Under these conditions, anticipated pollutant mass emission rates for NO_x (as NO_2), CO, particulate matter and SO_2 (assuming IFC thermal power plant emissions limits for liquid-fuelled reciprocating engines) are as follows:

- NOx (as NO2): 1450 mg/Nm3 @ 15% O2 results in 24.26 gram/s;
- CO (not regulated in WB II): 80 mg/Nm3 @ 15% O2 results in 1.34 gram/s;
- PM: 50 mg/Nm3 @ 15% O2 results in 0.84 gram/s; and
- SOx (as SO2): 1160 mg/Nm3 @ 15% O2 (suggesting 2% S in fuel) results in 19.41 gram/s.

All four emission parameters above are re-calculated to the expected actual O_2 level of 13%.

Emission parameters are considered acceptable as not-to-exceed figures down to a 50% load, except SO_x which is directly affected by the amount of sulphur entering the engine (i.e. the sulphur content of the fuel). At loads under 75% the specific fuel consumption goes up and relatively higher amounts of sulphur goes in, but otherwise exhaust flow is quite closely proportional to the load and exhaust temperature is generally stable around 300ºC on all loads between 50 and 100% (perhaps -15º to +5º). At higher ambient temperatures the exhaust temperature goes up at the same rate (about 1ºC per 1ºC) while the exhaust flow declines slightly (well under 1% decrease per 1ºC higher ambient temperature).

Calculations of emissions characteristics and air dispersion modelling led to the adoption of stacks of 32 metres in height accompanied by fuel that is specified as containing less than 2% sulphur.

To initiate the main generators, and to provide emergency power in case the main power plant is lost, the plant will be equipped with a 375 kVA black start generator set that will feed power to critical auxiliaries to start one diesel generator set on black start mode (i.e. to provide enough power to start the main generators, which are too big to start from batteries). This unit is sized to provide life safety, including other critical loads. The emergency generator will be a packaged unit in an enclosure suitable for the operating environment, with independent fuel day tanks, controls and cooling system. There will be a battery so the system can be started if the complete distribution system is lost.

Power will be distributed to the process plant from the power plant using duct banks or buried cables. Generation voltage will be at 11 kV. Voltage will be stepped up to 33 kV to feed the process plant and two overhead lines. The overheard lines will be utilised to provide power to the tailings dams and all the ancillary loads.

Buchanan power supply

It is estimated that the port material handling plant will consume a total peak demand of 13.37 MW and with a daily average demand of 7.866 MW. In the absence of an existing high capacity national or regional grid, this will need to be supplied to the site by an in-house power plant.

Power generation will be at 6.6 kV by 4+1 (5 x 4.164 MW) generators running on heavy fuel oil (bunker) out of which one will be in standby mode. Estimated load for the expansion is about 5.5 MW. Space has been provided in the power generation plant for a future additional generator unit. The units will be sized so that they can supply the site demand while running at 76% of their rated capacity. With the loss of one generator, the remaining generators will be capable of handling the total load for a minimum of one hour until the standby unit is brought on line (each generator is rated for a maximum overload capability of 10% for one hour). The selected power plant engine model is the Caterpillar 9CM32C.

For the requirements of the oxide phase of the project, only 5 generators will be purchased (for four units running, with one unit on standby). For the transition ore phase of the project, an additional one generator (possibly more, pending on actual meter reading during the current phase) of similar size will be added to satisfy the increased load. For oxide ore, the following expected load descriptors apply:

- Average load: 13.37 MW;
- Annual net energy to project: 62,933,333 kWh.

Power will be distributed to the process plant from the power plant using duct banks or buried cables. Generation voltage will be at 6.6 kV. Voltage will be stepped up to 33 kV to feed the township estate plant and two overhead lines. The overheard lines will be utilised to provide power to the ship loader, fuel quay and all the ancillary loads.

The heat passed out through the exhaust stacks will be recovered using an exhaust flue gas heat recovery system and will be used to heat the heavy fuel oil in the tank farm.

Emissions data have been calculated, given the following parameters:

- Load: 100%;
- Ambient temperature: 25ºC;
- Individual stacks with 800 mm diameters;
- Temperature at release point: 300ºC;
- Actual volumetric flow rate at the stated emission temperature: 15 m3/s at 300ºC;
- Stack exit velocity: 30 m/s at 300ºC; and
- Normalised volumetric flow rate (dry): 7,2 m3/s (0ºC, 1 atm);

Under these conditions, anticipated pollutant mass emission rates for NO_x (as NO_2), CO, particulate matter and SO_2 (assuming IFC thermal power plant emissions limits for liquid-fuelled reciprocating engines) are as follows:

- NOx (as NO2): 1450 mg/Nm3 @ 15% O2 results in 14.0 gram/s;
- CO (not regulated in WB II): 80 mg/Nm3 @ 15% O2 results in 0.77 gram/s;
- PM: 50 mg/Nm3 @ 15% O2 results in 0.48 gram/s; and
- SOx (as SO2): 1160 mg/Nm3 @ 15% O2 (suggesting 2% S in fuel) results in 11.2 gram/s

All four emission parameters above are re-calculated to the expected actual O_2 level of 13%.

Emission parameters are considered acceptable as not-to-exceed figures down to a 50% load, except SO_x which is directly affected by the amount of sulphur entering the engine (i.e. the sulphur content of the fuel). At loads under 75% the specific fuel consumption goes up and relatively higher amounts of sulphur goes in, but otherwise exhaust flow is quite closely proportional to the load and exhaust temperature is generally stable around 300ºC on all loads between 50 and 100% (perhaps -15º to +5º). At higher ambient temperatures the exhaust temperature goes up at the same rate (about 1ºC per 1ºC) while the exhaust flow declines slightly (well under 1% decrease per 1ºC higher ambient temperature).

Calculations of emissions characteristics and air dispersion modelling led to the adoption of stacks of 32 metres in height accompanied by fuel that is specified as containing less than 2% sulphur.

3.3.10 Fuel and lubricant supplies

The power plants will run on heavy fuel oil (HFO-180) while practically everything else on the project will run on diesel. Consumption estimates are given in Figure 3.13. The approved fuel supplier will supply these fuels by dedicated tanker trips to Buchanan or by dropping partial quantities from tankers coming to Monrovia. The current observed fuel tanker rotation frequency in Monrovia is one ship per month on average.

Figure 3.13. Anticipated project fuel consumption.

	FUEL CONSUMPTION - Litres Per Year					
		Year 1	Year 2	Year 3	Year 4	Year 5
Fluid	Diesel Fuel	HFO-180 CONSUMPTION BY YEAR (litres/year)				
Viscosity grade						
Specification						
Mining Mobile Equipment	42,600,000					
Additional Vehicles (Conc.)	4,250,000					
Additional Vehicles (Port)	4,250,000					
9 Communications Towers	190,000					
Power Plant (Port)	420,000	12,320,616	14,080,704	14,080,704	14,080,704	14,080,704
Power Plant (Conc.)	840,000	77,443,872	95,044,752	98,564,928	102,085,104	137,286,864
Yekepa						
Greenhill						
Diesel Locomotive	12,000,000					
ANNUAL FRESH FLUIDS	64,550,000	89,764,488	109,125,456	112,645,632	116,165,808	151,367,568
ANNUAL WASTE FLUIDS	---	4,488,224	5,456,273	5,632,282	5,808,290	7,568,378

In considering the diesel and HFO supply to Buchanan, several aspects have been taken into account for the average supply lot size definition, the delivery frequency and the storage capacity to be built.

- The upper limit of the lot size is linked to the Buchanan harbour draft: with a 10.50 m maximum draft, the supplier could technically deliver diesel with unit vessel capacity up to 20,000 tonnes and a length overall of up to 180 metres.
- The calculation of the right storage capacity is linked to consumption plus a reasonable safety stock.

According to the available regional chartered fleet and Buchanan harbour access conditions, the followings lot sizes are likely:

- Diesel: 5,000 to 8,000 tonne deliveries;
- HFO: 10,000 to 15,000 tonne deliveries; and
- Frequency: 1 vessel every 3 weeks on average.

The fuel quay is located at the inner, southern end of the Buchanan harbour basin, against the southern breakwater. It has a cleared depth of 10.5 metres, and this was checked during a dredging operation in late 2010. A wrecked tug that was sunk against the quay was removed in 2010. However, although navigable, the quay itself has not been refurbished and is in a dilapidated condition. In LAMCO times, tankers berthed at this quay and discharged both diesel and heavy fuel oil via a pipeline to the tank farm located around one kilometre inland. The pipeline is still intact, but it is badly corroded in places and will be replaced. The valve and pumping system has disappeared and will need to be completely replaced. The fuel storage tanks were damaged by acts of war and a full investigation to the possible re-use has shown that it will not be cost effective to refurbish those.

It is proposed that a modern fuel berthing system will be established at the fuel quay, in place of the devastated LAMCO facilities. Security at the site will comply with the International Ship and Port Facility Security (ISPS) Code, which is an amendment to the Safety of Life at Sea (SOLAS) Convention (1974/1988) that provides the standards for minimum security arrangements for ships, ports and maritime government agencies.

To make the quay usable for this purpose, the following things need to be put in place.

- A dedicated fire fighting system, both on water and on shore.
- Fuel spill handling facilities, both on water and on shore.
- Electricity and lighting. The lighting will need to have deflectors to reduce spillage towards the beach close to the south-east.
- Communications systems.
- An administration office.
- Fuel unloading systems, including hoses with breakaway couplings that shut off immediately in the event of a disconnection.
- Mooring facilities, in the form of bollards and fenders.

Regarding the marine emergency fire fighting and spillage measures, the company already has long leases on two tugs that are equipped with water and foam fire fighting systems, and hydrocarbon dispersant spraying systems.

The storage capacity on the sites has been sized taking into account the calculated consumption forecasts and the anticipated delivery lead-times for the different sites, plus an additional safety capacity in case of spot supply or delivery disruptions. This gives the following capacities per site:

Buchanan:	Diesel:	10,000 m^3 (2 x 5,000 m^3 tanks);
	HFO:	12,000 m^3 (2 x 6,000 m^3 tanks);
Tokadeh:	Diesel:	2,260 m^3 (2 x 1130 m^3 tanks);
	HFO:	6,100 m^3 (2 x 3050 m^3 tanks);
Yekepa:	Diesel:	90 m^3; and
Greenhill:	Diesel:	50 m^3.

In order to ensure uninterrupted supply to the site in case of tank maintenance or any major event preventing the use of a storage tank (e.g. massive fuel contamination), provision has been made for two tanks in each of Buchanan and Tokadeh for both HFO and diesel.

Diesel storage at Buchanan will use two new tanks. HFO storage at Buchanan is based on two tanks of 6,000 m^3 each, with sufficient space for the possible construction of a third tank of 6,000 m^3 at a later stage if it is needed during the peak in consumption during transition ore processing. All tanks at Tokadeh, Yekepa and Greenhill will be new. The approximate diameter for these tanks is 26 m and height is 12 m. All tanks will be founded on engineered fill to satisfy the bearing capacity of the sub-surface strata. The fuel tank farms will be fully bunded.

The tank farm will be fed from the fuel unloading quay via a proposed 12" insulated pipeline of estimated 1,700 m length. For both HFO and diesel, the pumping of product from the quay will be done by the supplying fuel ship. In the detailed design study the aspect of leaving the lines filled with hydrocarbons or any emptying or flushing solution will be addressed. In the event that the Buchanan depot has to be supplied by road from Monrovia, a provision will be made for truck offloading bays within the depot.

Under the ambient temperature pattern (minimum 19℃), the HFO design proposed for both Buchanan and Tokadeh covers:

- Insulation for all HFO pipes; insulation is deemed not required for the tanks;
- Electrical tracing of all HFO pipes: 60 kW required in Buchanan and 7 kW in Tokadeh based on the current locations and pipeline lengths;
- Mass heating of HFO tanks to 45℃ by thermal oil: 310 kW per tank required in Buchanan and 200 kW per tank in Tokadeh; and
- Suction heating to 70℃ by thermal oil: 1400 kW per tank required in Buchanan and 300 kW per tank required in Tokadeh.

HFO sludge will either be mixed with appropriate construction materials for road building or will be incinerated.

The fire fighting facilities will be constructed as per the European fire fighting norms (EN or NF) and the French RAEDHL regulations. These guidelines give the threshold for a complete fire fighting system in terms of fuel storage capacity as 550 m^3, and so such a system is required for both of the Buchanan and Tokadeh depots. Fire water systems will consist of dedicated water tanks, fire water pumping modules, fire water headers with the associated monitors, standpipes, hose reels and sprinklers. Each fuel tank in the tank farms will be protected by an automated foam discharge system. The fire water pump modules will house the fire water pumps, an emergency diesel driven fire water pump and a jockey pump. Automated fire alarm systems will control the fire water systems and will be monitored in the process operations control room at Tokadeh and the fuel management control room at Buchanan.

A loading gantry will be located on a dedicated rail siding for fuel handling at Buchanan. This facility is to be sized so as to be able to receive 7 rail cars at once, 4 for HFO and 3 for diesel. The rail tankers will be standard models with a unit capacity of 53 m^3 and overall length of 14 m. The loading gantry will be connected to the main storage tanks through a 6" pipe for Diesel and 8" for HFO. For ease of rail cars composition and to reduce shunting time, there will be dual loading arms at each of the 7 positions, for each of HFO and Diesel. Nominal flow rates for the loading pumps will be 45 m^3/h for diesel and 50 m^3/h for HFO.

On the same rail siding, there will be a diesel dispensing facility on each end of the rail tanker loading gantry: locomotives can then refuel at any time without impairing the rail tanker loading operations. The benefits of this arrangement against locating this facility 1.5 km away at the railway shop area are:

- Saving on pipelines, and reduction of the dead stock represented by the volume of product staying permanently in the pipeline;

- No additional storage tank required;
- Reduction of staff required (same as for rail tanker operations);
- Reduced safety and security risk.

Unloading of the rail tankers at Tokadeh will be by the reverse of the loading station, with a mirror image in the form of a siding opposite the Tokadeh power plant, a similar size of unloading gantry, and the same capacity pumps and pipes.

The Tokadeh heavy vehicle fuelling station will have the following key features:

- Three dispensing bays sized for Cat 785 trucks (10 m width);
- 4 x 61 m3 of diesel buffer storage;
- Two offloading bays for delivery trucks; and
- Pumps and filtration skids for offloading, transfer and dispensing.

Diesel will be brought to the fuelling station by bridging tankers to avoid the environmental and security risks associated with diesel piping across the industrial area.

There will be an entirely new light vehicle fuelling station at Tokadeh. The existing light vehicle loading and dispensing pumps on the diesel storage depot at Buchanan, Yekepa and Greenhill will remain as they are for Phase 1, with appropriate anti-pollution upgrades.

Lubricant supply

The anticipated requirements of lubricants are shown in Figure 3.14. The supply scheme for lubricants will be by sea transport from a regional hub to Monrovia, and then by road transport from Monrovia to Buchanan City or Tokadeh. Most of the lubricants will be delivered by the supplier in 208 litre drums. However, volumes of two types of lubricant are sufficient to justify a bulk supply chain (power plant engine oil and mining fleet engine oil). The supplier will deliver these lubricants in 20,000 litre Isotanks that will rotate between the regional supply hub and the project sites in Liberia. Isotanks are containerised units, and they will also be supplied by sea to Monrovia, and thence by road to Buchanan City and Tokadeh.

Waste oils will be disposed according to the company's waste management standards in the ArcelorMittal Liberia Environmental Standards Manual, and as described in the Hazardous Materials and Waste Management Plan. It is possible that the chosen international supplier will offer a re-collection and re-export service for treatment and recycling as part of the overall supply package. If not, they will be sold to an EPA-accredited waste oil handling agent, as is currently done in Phase 1.

Figure 3.14. Estimated lubricant requirements.

	SERVICE FLUIDS - Litres Per Year						
Fluid	Engine Oil	Final Drive Oil	Transmission Fluid	Power Steering	Brake/ Hoist/	Power Plant Lube	Locomotive Lube Oil
Viscosity grade	15W40	SAE 60	SAE 30	SAE 30	SAE 10W	SAE 40	
Specification	DEO-ULS	FDAO	TDTO	DEO	TDTO	BN 50 to 55	
Mining Mobile Equipment	119,942	70,264	83,588	31,273	26,079		
Additional Vehicles (Conc.)	15,000	9,000	10,500	4,000	3,250		
Additional Vehicles (Port)	15,000	9,000	10,500	4,000	3,250		
9 Communications Towers						250	
Power Plant (Port)						57,045	
Power Plant (Conc.)						420,575	
Yekepa							
Greenhill							
Diesel Locomotive							72,727
ANNUAL FRESH FLUIDS	**149,942**	**88,264**	**104,588**	**39,273**	**32,579**	**477,870**	**72,727**
ANNUAL WASTE FLUIDS	**149,942**	**88,264**	**104,588**	**39,273**	**32,579**	**130,874**	**72,727**

The original intention was for DSO to be mined at all three mine sites during Phase 1, however subsequently it has been decided by ArcelorMittal to mine both DSO and deeper iron ore for beneficiation during Phase 2 at Gangra and Yuelliton. Of the three deposits, the Tokadeh Main Area and Area F had been previously mined to some extent, while Gangra and Yuelliton Mountains are greenfield sites without any infrastructure in place (other than access roads). Phase 2 of the Western Range Iron Ore Project involves the expansion of mining at Mount Tokadeh and the opening up of mines on Mounts Gangra and Yuelliton. Both concentrated ore and DSO will be mined under Phase 2 at Mounts Gangra and Yuelliton and therefore this assessment includes the DSO footprint as part of the Phase 2 scheme.

As indicated in Section 3.3.1 under the sub-heading of Waste Rock Facilities and Stockpiles, it is important to note that prior to the Phase 1 ESIA, the Environment Office of the Company had identified several environmental ‘no-go zones’, including the western slopes of Mts. Tokadeh, Gangra and Yuelliton and the southern slopes of Mt. Tokadeh. Furthermore, the Phase 1 ESIA produced a ‘constraints map’ that identified areas within and around the proposed mining areas that were considered to be of high biodiversity value and therefore of high priority for conservation. These considerations were integrated into the Phase 2 project design to the maximum extent possible to ensure impact avoidance. The ESIA consultant has continued to improve the accuracy and resolution of the constraints maps for both impact avoidance in the analysis of alternatives (Section 4) and impact assessment purposes (Section 9).

4 ANALYSIS OF ALTERNATIVES

This section describes the history of the identification and selection of project alternatives and has been prepared by the Company. It should be noted that, in the course of the environmental studies that underlie this ESIA, the Consultant engaged in discussions with the Company over the siting of various elements of Phase 2 infrastructure and the Company has attempted to take the Consultant's concerns into consideration wherever possible in its decision making with regard to final layouts.

4.1 Overview

A summary of project development options identified and assessed by ArcelorMittal to date, and how the preferred options were influenced by environmental considerations, is provided in this Section.

The mine infrastructure previously used by LAMCO was already in place, and the location and layout of Phase 1 key infrastructure (such as the rehabilitated 255 km railway line between Buchanan and the railhead at Tokadeh, the service road for the railway, the quarry at Greenhill, and the rehabilitated and upgraded port facilities in Buchanan) further limited the number of alternative project options that were logical to consider during Phase 2. The key alternatives for Phase 2 operations were therefore related to issues such as construction of mine site access, the locations of the tailings management facility, the sites for waste dumps, borrow areas for construction materials and loading areas, as well as the proposed site for the Tokadeh construction camp and power generation.

This Section provides as comprehensive a view as possible of the overall project alternatives, by charting the course of their planning over some thirty years, to the extent that records are available. These have all been based on the obvious premise that the iron ore must be mined from the locations where it occurs. Less obvious, but implicit in the exploitation of the ore, is the fact that iron ore is a low value, high bulk commodity that requires processing into a usable product. Steel making is an energy intensive industry, and since West Africa as a region is short of energy resources and a low consumer of steel products, it has always been more viable to transport the ore to locations with ample energy and bigger markets for steel. This situation may change in the future, but in many respects these basic economic facts underlie the choice of options for an iron ore mining project in West Africa as much as they did when LAMCO was established in Liberia more than 50 years ago. A further consideration with iron ore mining is that it needs to compete with several major producers – notably Brazil and Australia – on a global market. This means that to be viable, a project has to exploit a well proven resource in as efficient a way as possible. Even then it is subject to market fluctuations and is not guaranteed of continuity. During its thirty years of operation, LAMCO ceased production several times when market prices dropped below a viable threshold.

When LAMCO built its infrastructure in the 1960s, and subsequently upgraded some parts in the 1970s and 1980s, it invested well and had high standards of civil engineering. As a result, even after twenty years of non-use, including nearly fifteen years of war and looting, the towns, railway and port were relatively straightforward to rehabilitate. For this reason, no alternatives have been examined for the use of the towns and the railway. No alternative to the existing port was considered for Phase 1, and it forms the basis for the proposed Phase 2 operation. However, because of the expanding scale of the global bulk carrier fleet, the possibility of constructing an offshore, deep water loading pier is being investigated.

Most alternatives therefore relate to the phasing of the mining of different grades of ore, and the ways in which these are handled and processed. Much of this comes down to details which are very small in the overall project, but which have the potential to create or avoid significant environmental impacts. Examples include the exact positioning of infrastructure units, and the routing of rail lines to avoid swamps. Hence this Section describes alternatives at various levels of detail throughout the project, and shows how attempts have been made to reduce the environmental impacts as far as possible.

4.2 Historical Project Options

4.2.1 LAMCO Project Options

The options for mining in Nimba have been documented intermittently for over fifty years. By 1959, LAMCO had undertaken enough exploration to ascertain that there was an exploitable iron ore resource in Liberian section of the main Nimba ridge. At that time there were no plans to exploit the western range mountains, which lie scattered along the far side of the broad Dayea River valley. However, once the Nimba mine was running, the company turned its attention to the western range, and a series of reports in 1971, 1974 and 1975 addressed the feasibility of mining in that area. The Tokadeh mine was opened in 1974. By 1980 it was clear that the Nimba mine would cease operation over the period of 1986 to 1988 as the accessible resource was exhausted, and the western range mines would need to be expanded to provide a viable volume of product: this explicitly meant opening mines at Mounts Gangra and Yuelliton.

The future for the late 1980s and beyond was therefore envisaged by LAMCO as consisting of the Western Area Project. It would mine all three mountains and process the ore through two facilities, which would have similar process flowsheets.

- Nimba Washed Fines would be produced from the wash plant established at Buchanan in 1967 for the Nimba mine.
- Western Area Concentrate would gradually be increased to provide the majority of finished product from a new concentration plant at Tokadeh.

For this project, additional rail spurs totalling 12 km were envisaged, to the concentrator at Tokadeh and to the mines at Gangra and Yuelliton. A power plant was proposed at Tokadeh, running on heavy fuel oil and with an installed capacity of 63 MW, to be located close to the planned new rail loop. Make-up water for the tailings facility was to have been derived largely from two dams on creeks to the east of Zolowee.

The sketched plans from the 1980 feasibility study (Figure 4.1) show the following main features of environmental interest close to Mount Tokadeh.

- A rail loop creating a spur into a new industrial area in the main bowl on the north-eastern side of Mount Tokadeh.
- A main tailings dam in a similar location to that proposed for ArcelorMittal's Phase 2 development, plus a smaller tailings dam between the railway and the mountain.
- An industrial area (concentrator and power plant) built away from the railway mainline, close against the mountain.
- Two dams flooding significant shallow creek valleys to the east of Zolowee.
- A water abstraction pipeline from the Yeti Creek.

At Buchanan, there is only one feature of significant environmental interest.

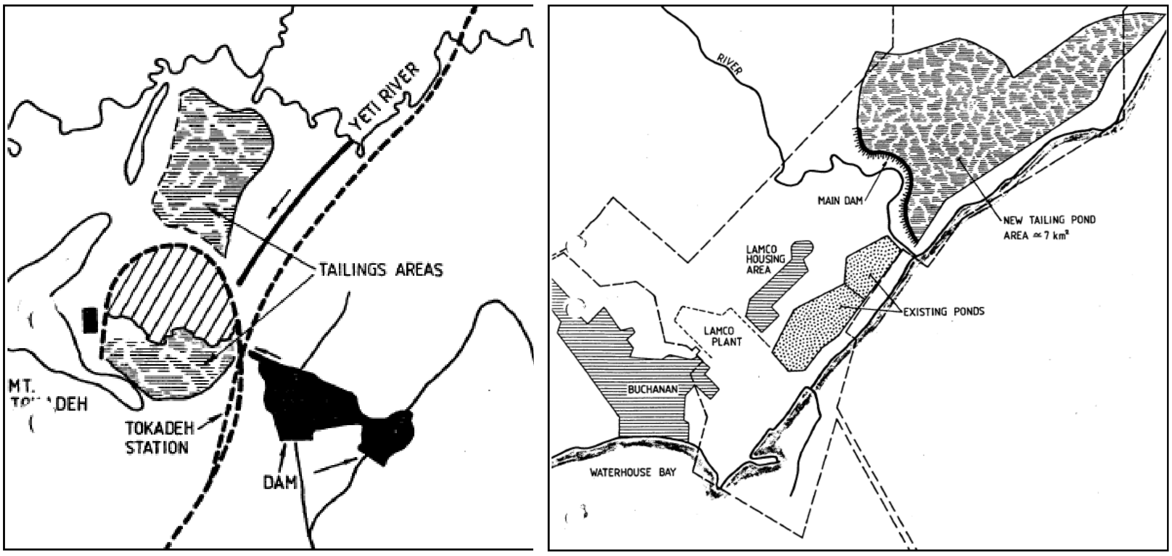
- A proposed very large (7 km2) tailings dam close to the shore, across the diverted Savage River to the south-east of the older tailings dam.

The plans given in the LAMCO 1980 feasibility study were never put into practice. Instead, the project continued with mining at the Nimba and Tokadeh mines contributing ore to the wash plant at Buchanan. In 1984, a new feasibility study was undertaken, for what was envisaged as a new project to replace both the Nimba and Tokadeh mines when the resources ran out. This was called the Gangra/Yuelliton Project and was devised as a reduced Western Area Project. Its plan was to commence mining at the two new mountains and ship the ore to become Nimba Washed Fines at Buchanan. It was due to start in 1990 and to run for 14 years.

The 1984 feasibility study proposed a new rail spur from the mainline to the foot of the eastern slopes of Mount Gangra. Here there would be ore loading silos fed by conveyors from the crushers on both of the mines. Additional power for this would come from a new power plant with an installed capacity of 19 MW, to be built near the industrial facilities at Yekepa and transmitted by high tension cable to the railhead and mine. The power plant was to have been run on heavy fuel oil. At Buchanan the same large new tailings dam was proposed as in the

1980 report (Figure 4.1). It seems that the preparatory infrastructure works for the Gangra/Yuelliton Project were never started.

Figure 4.1: Sketch plans from the 1980 LAMCO feasibility study for the Western Area Project, showing proposed main layouts. Mount Tokadeh is shown on the left (north upwards) and Buchanan on the right (north towards the left).



From the mid 1970s onwards, LAMCO was involved in a number of feasibility studies for exploitation of the Guinea Nimba iron ore deposit. An international consortium was formed under the acronym of MIFERGUI and undertook a series of studies. The general principle was to double the LAMCO throughput on the railway and the Port of Buchanan, from 15 to 30 million tonnes per year. There would have been an 18-km railway extension from Yekepa to the Guinea railhead, and two sections each of about 30 km of the existing railway were to have been doubled to allow extra trains to run in a complex paired two-way arrangement. Ore handling facilities at Buchanan were also to have been expanded. However, although detailed feasibility studies were completed in both 1978 and 1985, none of these works were commenced and the MIFERGUI project was mothballed.

With civil conflict disrupting mining operations from 1989, and the consequent looting of the LAMCO infrastructure (nationalised to become LIMINCO property), there were no further serious studies until 2005, when Mittal Steel commissioned a full feasibility study by W. S. Atkins.

4.2.2 Project Options Considered in 2005

The next feasibility study was undertaken with the aim of re-starting ore production in what was now derelict mines and infrastructure following the ravages of the civil war. In 2005 W. S. Atkins adapted the various plans from the 1980s to propose a project with the following four phases.

Phase 1:	Years 1 to 3:	Development of 5 million tonnes per annum (mtpa) Production Capacity at Tokadeh;
Phase 2:	Years 4 to 5:	Concentrator Construction at Tokadeh and Expansion of Production Capacity to 9 mtpa;
Phase 3:	Years 5 to 16:	Expansion of the Tokadeh Concentrator and Development of an Additional 9 mtpa Production Capacity at Gangra;
Phase 4:	Years 17 to 25:	Development of 9 mtpa Replacement Production Capacity at Yuelliton.

The proposed Phase 1 was very similar to what has actually been put into action by ArcelorMittal: the establishment of a relatively small scale of project to exploit the easily accessible shallow high grade direct shipping ore. From 2005 onwards, it was always clear that this was the best way to get mining started in Nimba, gain some early revenue from the investment and demonstrate that Liberia was back in the mining business.

The main mine developments during Phase 2 were expected to include:
- Site preparation and construction of the primary crusher;
- Installation of downhill conveyor to blending stockpile;
- Installation of transfer station, sample cutter and sampling station;
- Installation of stockpile pad and stacker and reclaimer equipment;
- Concentrator construction and commissioning;
- Construction of elevating conveyor to rail loading bins;
- Construction of new rail loading bins;
- Construction of permanent mine offices;
- Expansion of power station and power supply to concentrator;
- Construction of raw water supply dam;
- Construction of tailings dam and tailings disposal system.

While most of these elements are similar to what is now proposed under the revised Phase 2, there were at that time some significant differences of layout. In particular, the proposed water supply dams in the creeks to the east of Zolowee, were still part of the scheme, following the plan adopted by LAMCO in 1980 (see Figure 4.1).

The Atkins report contained the following assessment of options for the then proposed Phase 2.

“On completion of the phase 1 investment production rises to 5 mtpa. The phase 2 investment, which initially runs concurrently with phase 1, comprises the construction of the first concentrator and associated ore handling facilities at Tokadeh. On completion of the Phase 2 investment in month 36 production at Tokadeh will increase to 9 mtpa.

“These are several alternative schemes for this phase, which determine the location of the concentrator. Some previous studies have shown the concentrator in the industrial area alongside the Tokadeh rail sidings, while another shows it closer to the foot of the mountain, with a rail spur to collect concentrate for transport to Buchanan.

“The alternative schemes are illustrated in Figure 4.2.

“The proposal to site the concentrator at the foot of the mountain does not appear to be the most practical. This proposal will make the existing train loading bins and sidings redundant and require the construction of new rail spur some 5 km to cover a direct distance of only 2.5 km. Even if the rail line was replaced by a conveyor link to the train loading bins, the location of the concentrator at the foot of the mountain will require the pumping of water up to the concentrator and the construction of the buffer stockyard in a restricted valley.

“The preferred option would be to construct the concentrator in the Tokadeh industrial area by the rail line. This will make maximum use of the existing facilities, allow the concentrator and stockyards to be expanded efficiently for Phase 3 and reduce the materials handling costs in Phase 3.

“These options largely centre around the location of the concentrator. If located near the mine the transport of crude ore is reduced but services have to be brought up the mountain. With the opening of Gangra in Phase 3, it would also be more costly to transport ore from Gangra to an expanded concentrator on the slopes of Mount Tokadeh. Alternatively a separate concentrator could be constructed, but this would lose the economies of scale and distribution of services and labour. Consequently construction of the concentrator near the rail loading facilities at Tokadeh is preferred.

“The preferred scheme is shown in Figure 4.2.

"With the preferred scheme ore is brought down from the mine face by trucks to an intermediate crusher/screen station. From this station the ore is conveyed downhill to a stacker and stocked in two linear blending piles."

This explains some of the key flaws apparent in the LAMCO layouts proposed in 1980, and how revised layouts would make the process more efficient.

Figure 4.2: Options for Phase 2 (concentrate mining at Mount Tokadeh) in the 2005 Atkins feasibility study: left, the main alternatives; right, the preferred layout

The main mine developments during Phase 3 were to include the following, to expand mining to Mount Gangra:

- Construction of mine access road;
- Development of haul road;
- Bush clearance and pre-stripping;
- Establishment of waste tipping area;
- Construction of mine workshop;
- Site preparation and construction of primary crusher;
- Installation of downhill conveyor to surge bin;
- Construction of surge bin;
- Installation of elevating conveyor to rail loading bins;
- Construction of rail loading bins;
- Construction of additional ore handling facilities at Tokadeh;
- Expansion of concentrator at Tokadeh;
- Expansion of the raw water supply capacity;
- Expansion of the tailings dam and tailings disposal system;
- Expansion of power station at Tokadeh;
- Installation of power distribution facilities to Gangra.

The Atkins report gave the following assessment of options for the then proposed Phase 3.

> "The construction of [i.e. additional mining at] Gangra will add a further 9 mtpa production of crude ore. This ore will have to be concentrated prior to export. The original plans were to convert the washery in Buchanan into a concentrator and ship all this crude ore to Buchanan. However given the current condition of the concentrator and the added cost of moving the non-concentrated ore, it appears more logical to concentrate the ore near the mine.
>
> "There are two alternative proposals for the location of this concentrator; either at the foot of Gangra or to expand the Tokadeh concentrator. The more logical approach is to expand the existing facility and infrastructure, rather than construct a whole new plant, water supply system, tailings dam, etc at Gangra.
>
> "There are then several alternative schemes for transporting the crude ore the 10 km to Tokadeh, which are shown in Figure 4.3. With all these proposals the ore will have to be crushed at Gangra and conveyed down the mountain. The ore can then either continue to be conveyed across country directly the Tokadeh stockyard and concentrator or conveyed to the Tokadeh/Yekepa rail line and then along the side of the railway to Tokadeh. Alternatively a rail spur can be constructed and the ore transported from the foot of Gangra to Tokadeh by rail.
>
> "The 1984 study favoured constructing the rail spur, however this was largely due to the fact that the ore would then be transported all the way to Buchanan.
>
> "Preliminary costings suggest that the rail alternative could still be marginally preferable over a conveyor, however a more detailed study will be needed before the final selection is made.
>
> "With the preferred alternative, as shown in Figure 4.3, ore mined at Gangra is brought down from the mine face by trucks to a new crusher/screening station with a second station to be constructed at a later date to recover ore from below the level of the first crusher. The crushing stations will be similar to that described for Tokadeh in Phase 2. From the crusher the ore is conveyed down the hill to a new rail spur at the foot of Gangra, complete with two train loading bins and buffer stockyard.
>
> "Ore will be loaded into side/bottom discharge wagons (which were previously used to transport ore to Buchanan in Phases 1 & 2) and taken to the industrial facility at Tokadeh.

> The ore is then discharged into an underground reception pit on a new rail siding and conveyed to the existing crude ore blending stockyard.
>
> "The stockyard would be expanded to allow four piles to be created, with two stacking and two reclaiming. This will allow the ore produced at Tokadeh and Gangra to be kept separately, to allow the concentration process to be tailored to the characteristics of each ore."

The main feature here that was significantly different from the current proposal, was to have been the use of a haul road and rail spur to bring the ore to the processing facilities at Tokadeh, rather than just a haul road as now proposed. Then, as now, the use of a conveyor did not prove economically beneficial.

The main mine developments during Phase 4, to bring the Yuelliton mine on stream, were envisaged to include:

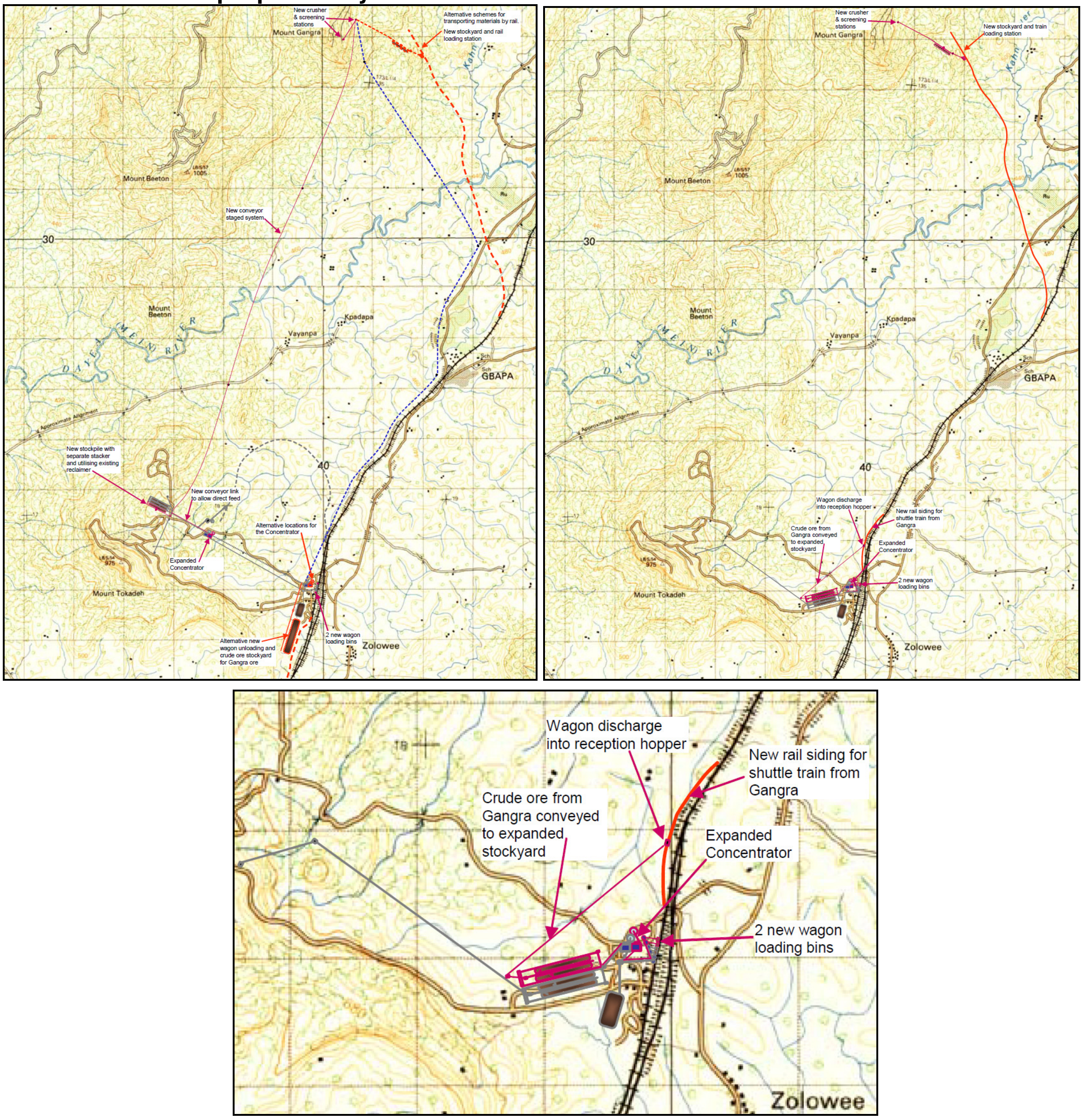
- Construction of mine access road;
- Development of haul road;
- Bush clearance and pre-stripping;
- Establishment of waste tipping area;
- Site preparation and construction of the primary crusher;
- Installation of downhill conveyor to surge bin.

The Atkins feasibility study gave the following assessment of options for the then proposed Phase 3.

> "As the ore reserves are mined out at Gangra, operations will shift to Yuelliton.
>
> "A new crusher station will have to be constructed at the 760m level at Yuelliton, which could consist of the main mechanical components from the Gangra crusher. The crusher will be relocated to ~700m level to recover the ore below the level of the first crusher.
>
> "Ore mined at Yuelliton is brought down from the mine by trucks to an intermediate level crusher/screening station. From this station the ore is conveyed to the ore handling facilities at Gangra and loaded onto the trains for transport to the concentrator at Tokadeh.
>
> "The anticipated layout is shown in Figure 4.4."

No alternatives were explored for the Mount Yuelliton mine at that time. In the light of the proposed layouts given in the Phase 2 ESIA, however, the 2005 layout itself forms an alternative.

Figure 4.3: Options for Phase 3 (concentrate mining at Mount Gangra) in the 2005 Atkins feasibility study: left, the main alternatives; right, the preferred layout; bottom, details of the proposed layout at Tokadeh.



The preferred option for all four phases of the Atkins 2005 scheme is shown in Figure 4.5. Notable features of this are as follows.

- Adoption of the LAMCO 1980 scheme reservoir very close to Zolowee (compare Figure 4.5 with Figure 4.1).
- A proposed tailings dam west of Gbapa, in much the same location as now proposed in the final scheme development.
- An additional, unexplained tailings dam to the east of Mount Tokadeh, which seems to inundate much of the infrastructure.
- Rehabilitation of the railway past Gbapa, to branch off with a spur that crosses the Dayea valley to reach a loading area on the eastern side of Mount Gangra (shown at a point where terrain would have made its construction extremely difficult).

Figure 4.4: Proposed layout for Phase 4 (concentrate mining at Mount Yuelliton) in the 2005 Atkins feasibility study

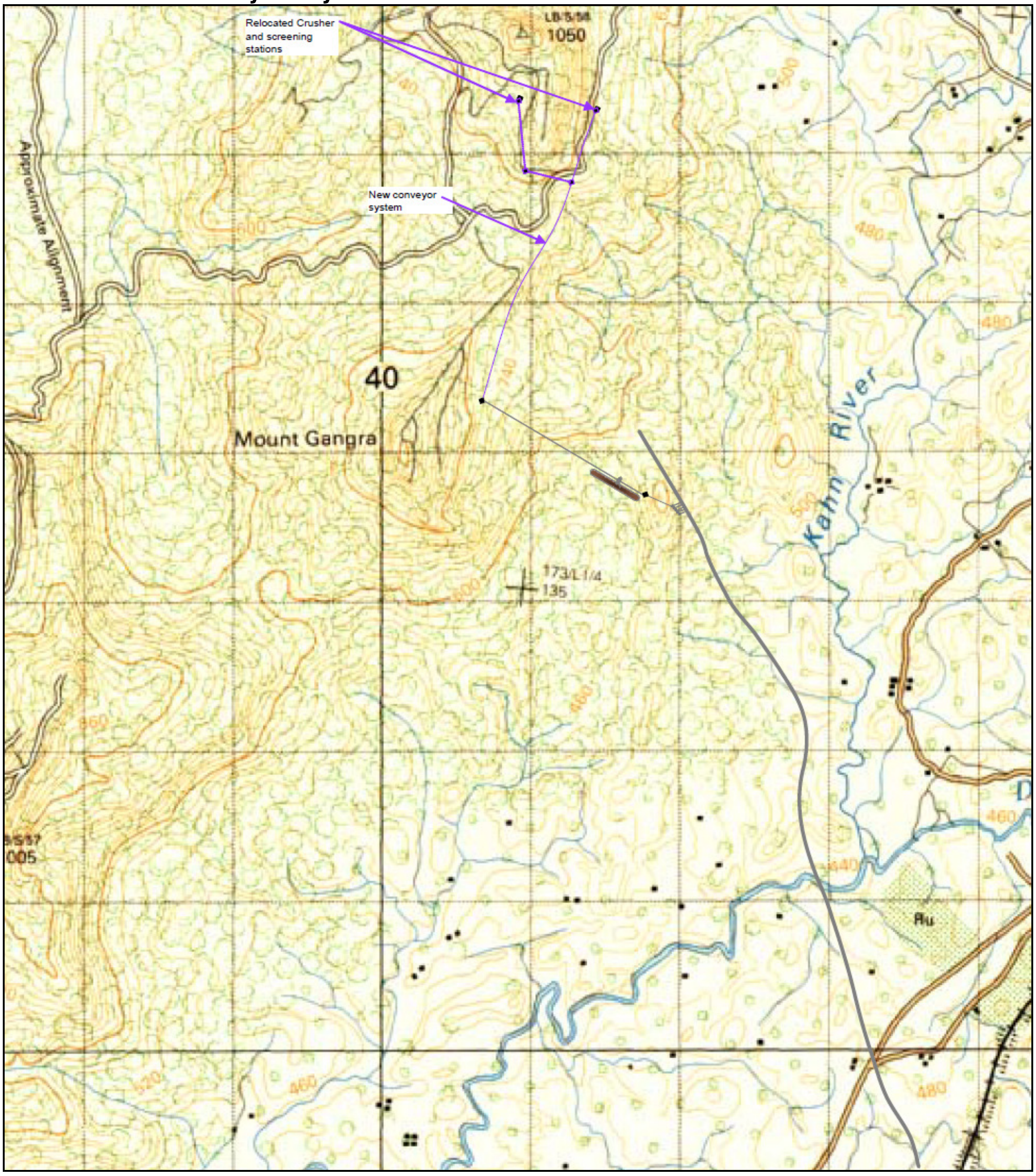
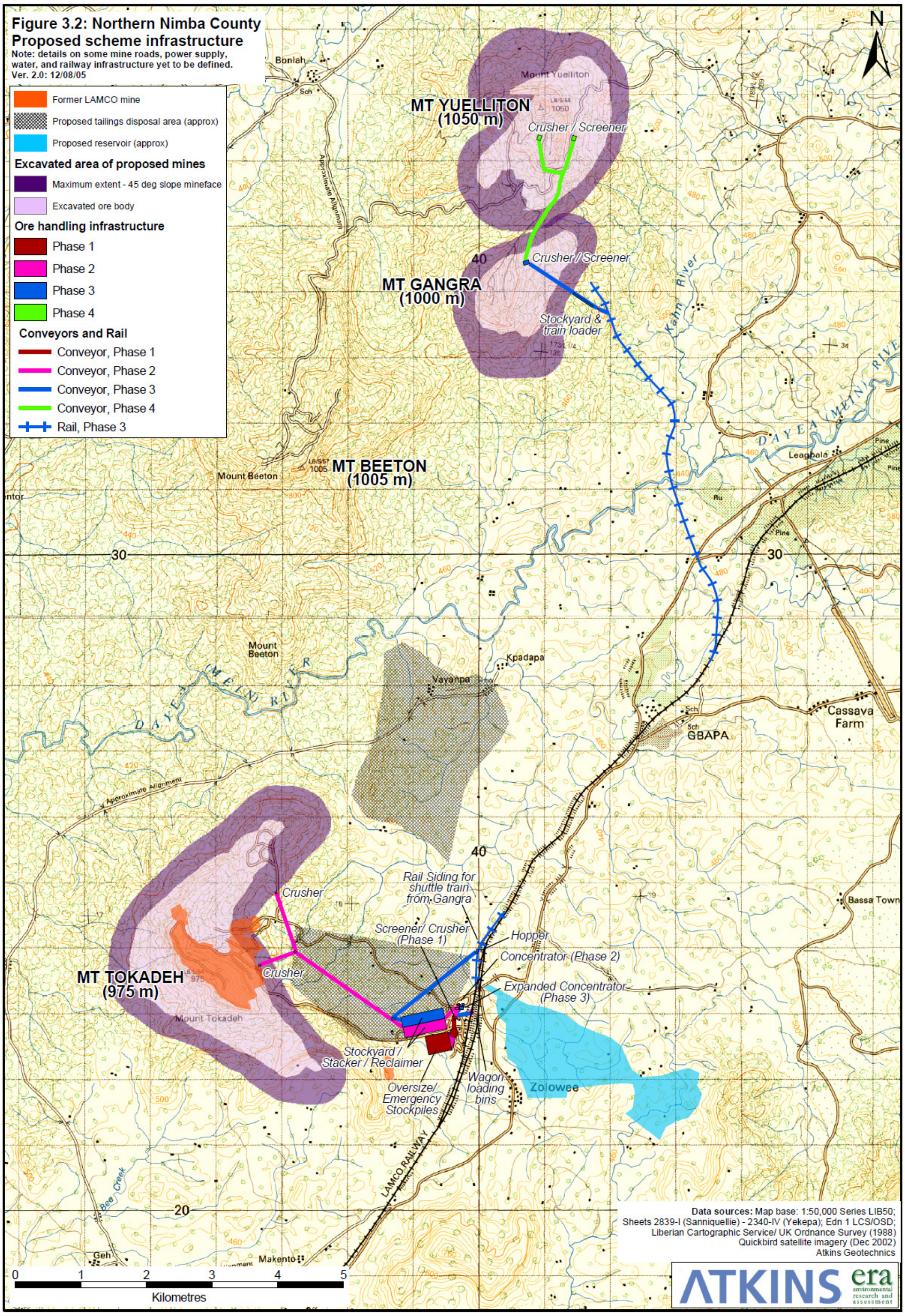


Figure 4.5: Overview of the preferred options for the four-phase development proposed by Atkins in 2005



Ore handling at Buchanan was not well explained in the 2005 Atkins feasibility study. It was complex and evolved in a piecemeal way. It appears to have relied on the refurbishment or the replacement *in situ* of the LAMCO car dumper. There was no rail loop, so the manoeuvring of rail wagons appears complex and time-consuming. However, the general layout of the stockpiles and ship loading facilities in the later phases was to have been broadly similar to the current proposals.

4.2.3 Alternatives Considered in 2008

In 2008, Atkins undertook further work to rationalise and update elements of the scheme design. An initial summary of the possible areas of impact as the project was envisaged in August 2008 is given in Figure 4.6. However, the social development adviser (H. Byrne) intervened to dismiss all infrastructure development east of the railway line, on the grounds of the more settled and productive agriculture to be found there. The primary and secondary impact areas shown in Figure 4.6, with some later refinements, were used as the main areas for detailed biophysical environment studies by Atkins.

By October 2008 Atkins had developed a further revision, which turned out to be the last iteration by that company, and which was itself later superseded. This is shown in the map in Figure 4.7, and its key features are as follows.

- Ore processing and train loading would be centralised to a large area in the valley, approximately equidistant between Tokadeh and the Gangra-Yuelliton massif.
- The railway would be extended in a short spur leading into this area.
- Haul roads would link the mines to the processing area.
- The haul road from Mounts Gangra and Yuelliton would run around the western side of Gangra, through what was later identified as an environmentally sensitive area

This alternative was rejected for a number of reasons, including the refinement of the processing and energy rationalisation in reducing the haulage of the Tokadeh ore, which forms at least two thirds of the total resource.

Figure 4.6: Revised layout options and impact areas collated by Atkins in August 2008

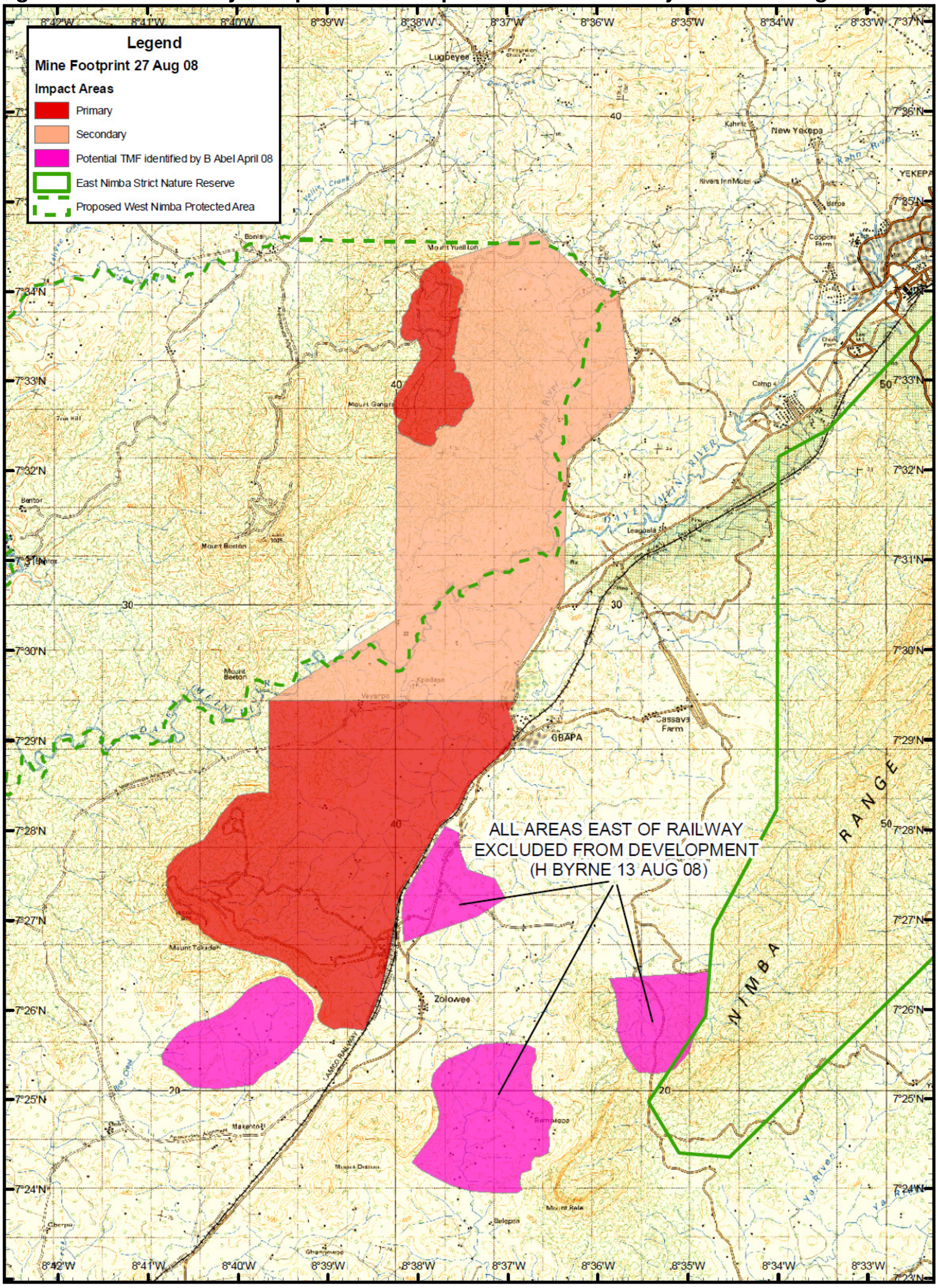
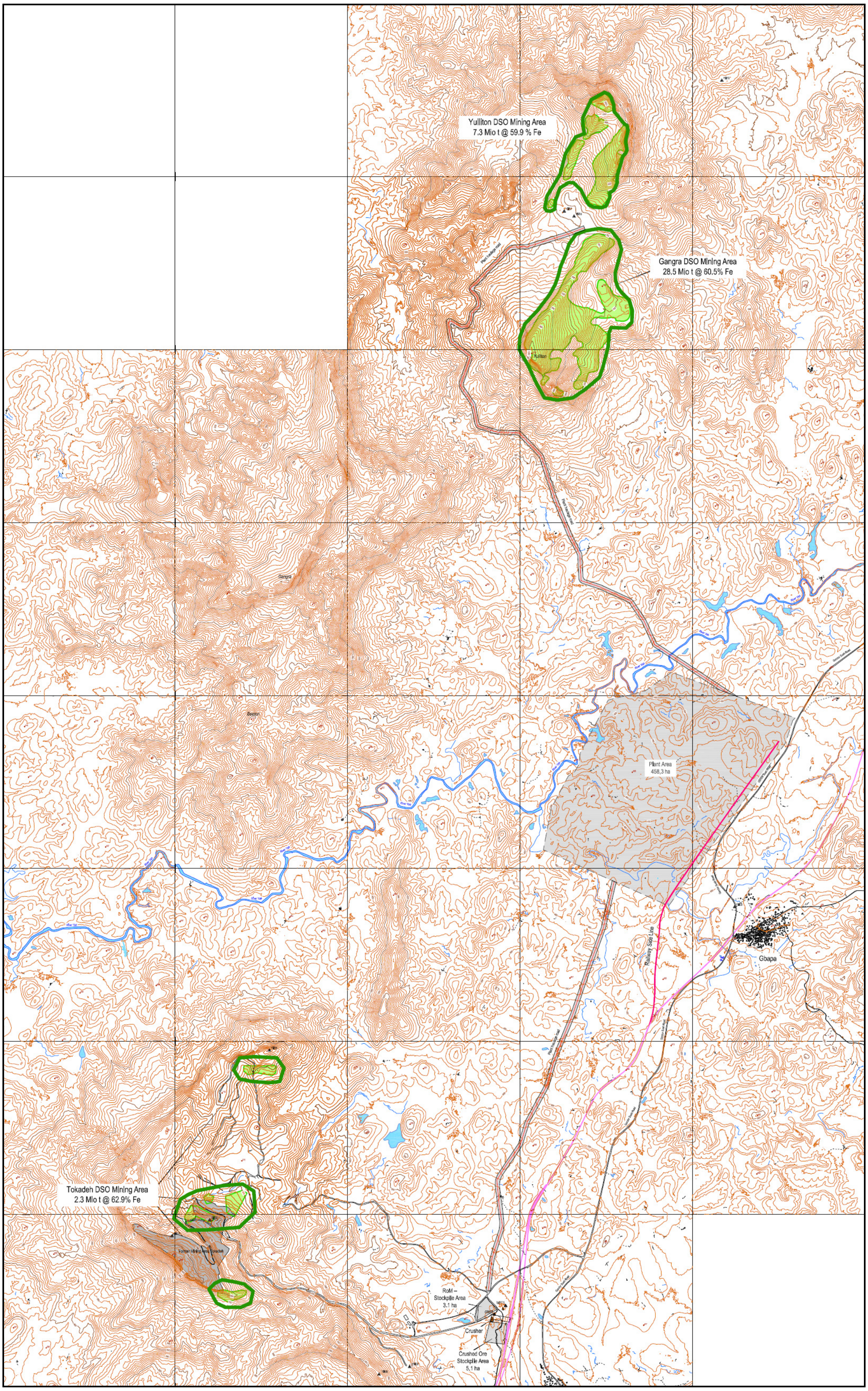


Figure 4.7: Atkins' proposed layouts of October 2008, with a centralised ore processing area



4.3 Pro-Environmental Criteria In Project Alternatives

4.3.1 Geographical Limitation of Project Alternatives

In the planning of the project, a number of alternatives were discounted through the process of identifying areas of key environmental value that must be avoided. In essence, the intention was to reduce the environmental impacts by ensuring that all activities were restricted to areas of lower value as far as it was possible to do so.

The Nimba Western Area Iron Ore Deposits are situated in the middle of one of the remaining high quality rainforest hotspots in West Africa. The Nimba range itself, across a broad valley to the east of the Western Area Deposits, is internationally renowned for its high levels of biodiversity. The part of the range across the border in Guinea, and the other side of the watershed in Ivory Coast, is designated a natural World Heritage Site by UNESCO. The Liberian section was not given this designation because of the damage caused by former mining. However, it is a national Nature Reserve, and it is clear from our studies that the undisturbed majority part still carries a standard of biodiversity that would qualify to join up with the World Heritage Site if the Government of Liberia chose to inscribe it as such.

The principles of environmental exclusion defined by the company and given to its design consultants were therefore as follows.

- The remaining undisturbed forests, and mosaic of forest patches west of the ArcelorMittal concession, are ecologically important (and potentially economically valuable), and need to be preserved for utilisation and conservation. The general locations of these forests are shown in Figure 4.8.
- All mining, infrastructure and other activities must therefore be kept away from the western slopes of Mounts Gangra and Yuelliton; and away from the western and southern slopes of Mount Tokadeh.
- No developments whatsoever were to be permitted within the boundaries of the East Nimba Nature Reserve (most of which falls within the ArcelorMittal concession.
- As far as possible, all drainage should go into catchments that are already affected by former mining activities. In practice this meant that all drainage from Mount Tokadeh should go north-eastwards into the Dayea River; and all drainage from the Gangra-Yuelliton massif should run eastwards into the short Kahn River (and thence to the Dayea) or south-eastwards, straight into the Dayea River. The catchment risk map in Figure 4.9 was used to show the project planners and engineers where the main catchment boundaries lie. These were also mapped at a more detailed scale for site investigations.
- In general, all riverine areas are ecologically important. Riverine forests and water quality must be preserved as far as possible. A buffer zone of 50 metres of undisturbed riparian zone vegetation was specified. Road crossings should be minimised and aligned at a right-angle to the streams. In practice these provisions also had a sound engineering basis in avoiding the saturated ground conditions in the swampy valley bottoms.

An example of the application of the information above is given by the influence exerted on the alignment of the proposed Gangra to Tokadeh haul road. The early alignment took it around the western side of Mount Gangra. Environmental concerns forced its move to the more degraded eastern side of the mountain. The next iteration showed that the alignment was following the gentler slopes, but these tended to coincide with the line of the water courses, and so a number of other adjustments were made. This is illustrated in Figure 4.10. Note, however, that since the final alignment of the haul road has not yet been completed, an environmental permit application will be made as an addendum to the Phase 2 ESIA.

Figure 4.8: Land cover classification showing the better forest areas (continuous greens) in relation to the ore bodies (red outlines).

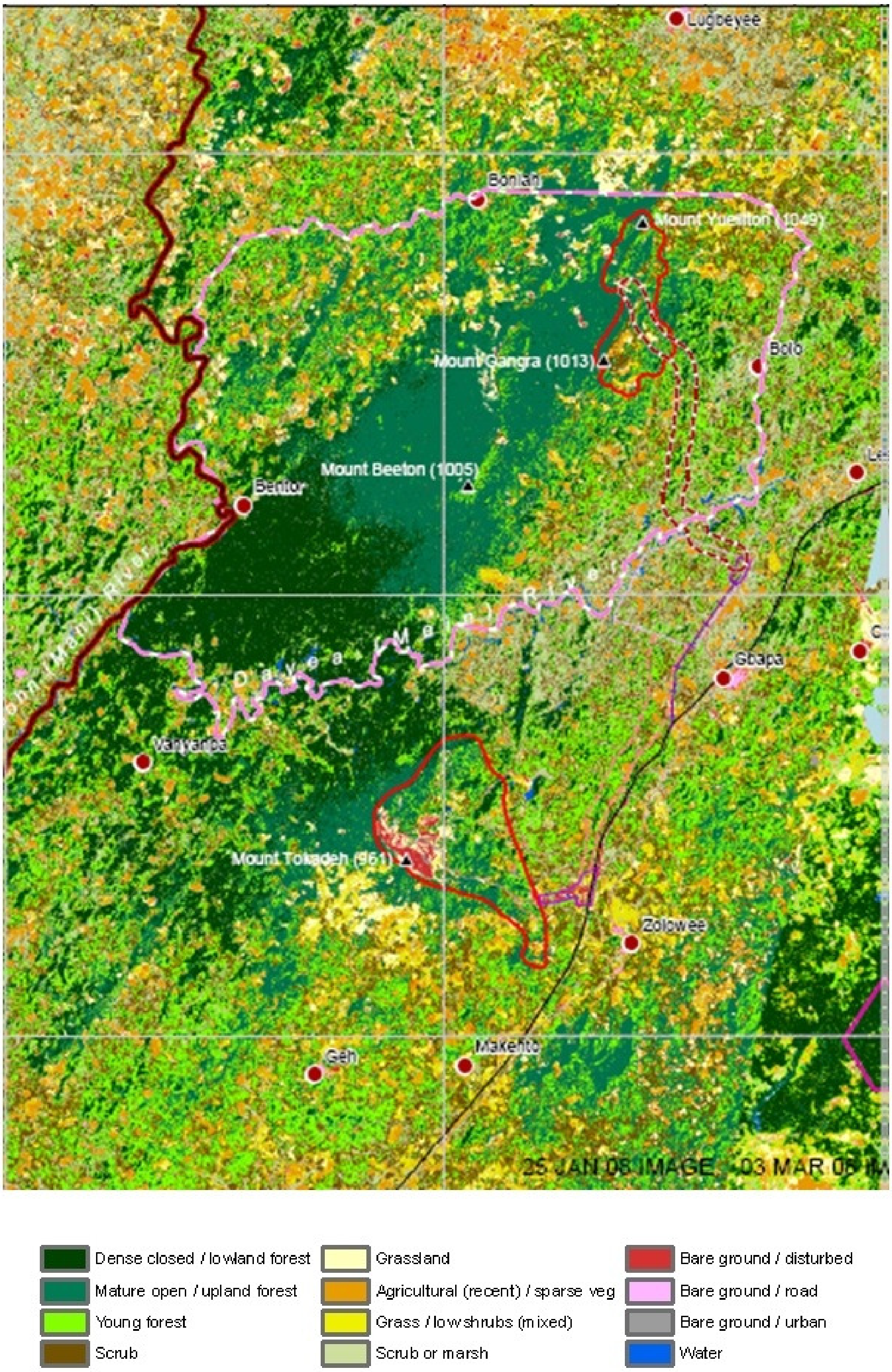


Figure 4.9: Projected catchment risk map.

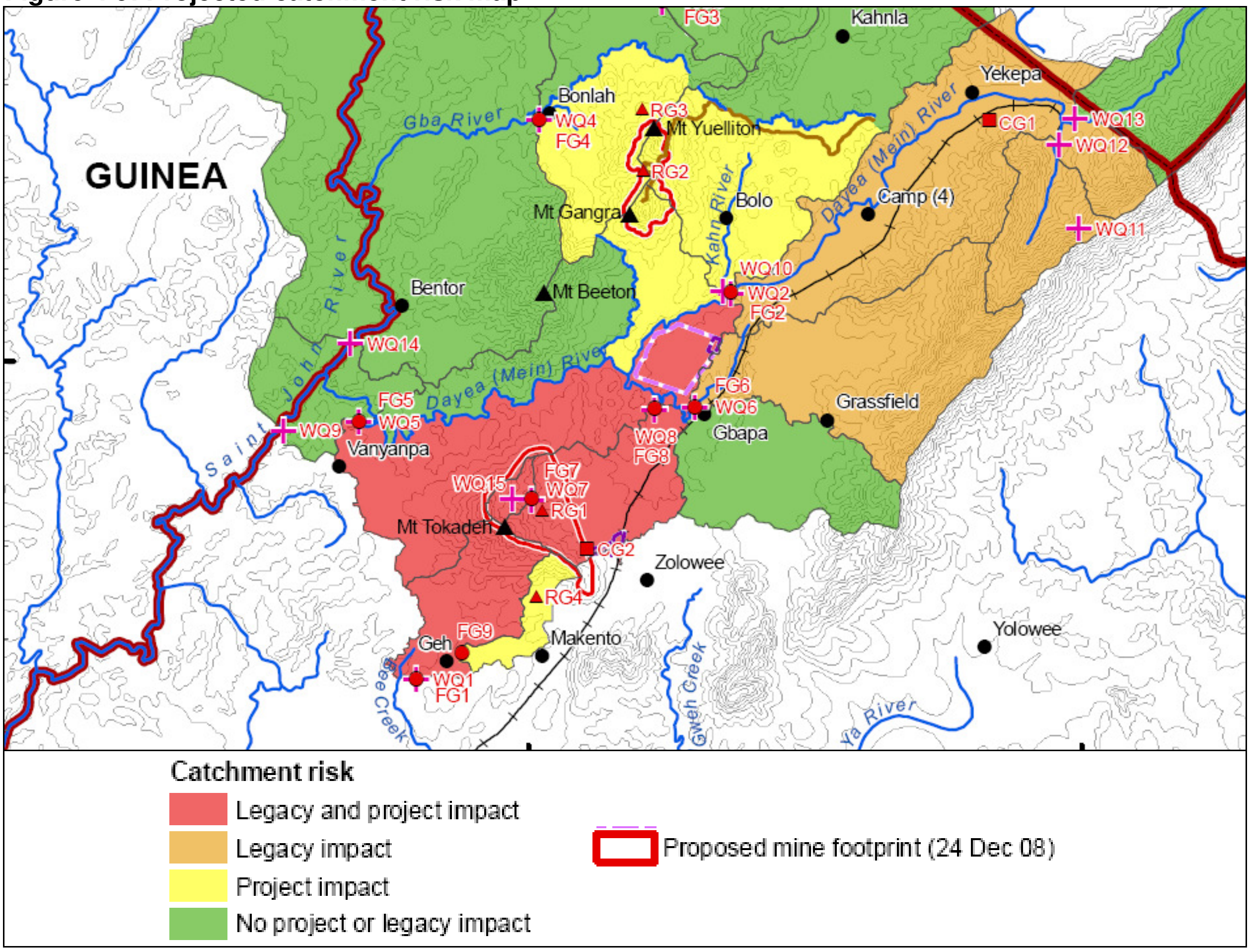
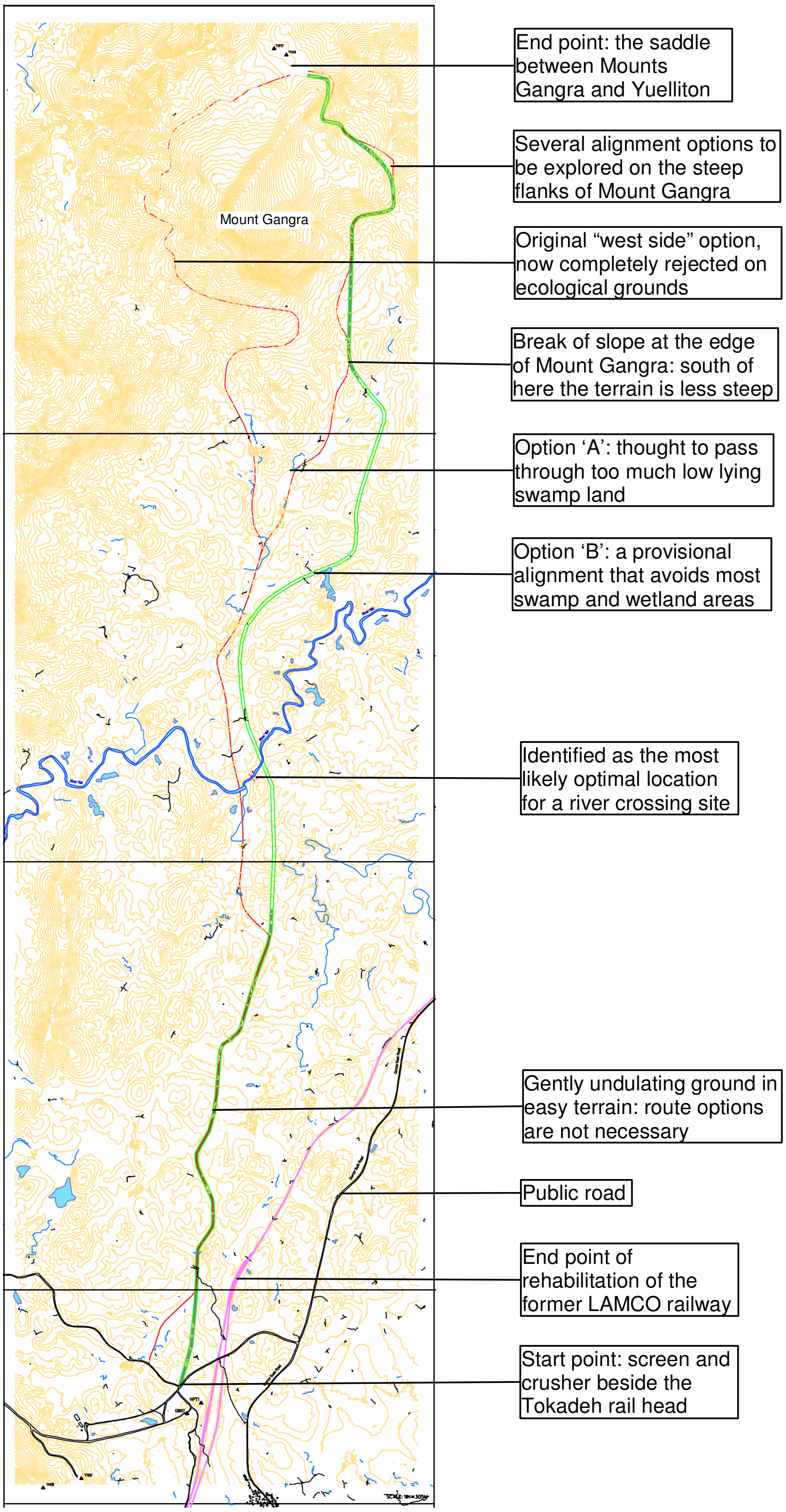


Figure 4:10: Environmental considerations in the alignment of the Gangra to Tokadeh haul road



4.4 Environmental Research Applied to Project Design

Project alternatives were further refined through the use of more and more environmental data as they were gathered over the years from 2005 up to the final Phase 2 feasibility study in 2011. The tables below summarise this information. These showed the project designers and engineers how their designs and the scheduling of their works needed to address the environmental conditions to avoid, for example, soil erosion and wildlife habitat loss.

TECHNICAL AREA	GENERAL FINDINGS	IMPLICATIONS FOR MINE DESIGN
Soils and Geotechnics	The terrain consists of isolated hard mountains protruding above dissected and undulating terrain in more weathered geology. Slopes can be steep on the mountains, but the valleys are dominated by gentler slopes, albeit with complex and variable micro-topography. There are very few mass slope failures, either active or relict, except in man-made slopes (large road cuts, old mine benches and former spoil tips). However, mountain soils tend to be highly erodible when stripped of the vegetation cover, due in part to limited build up of organic matter and the presence of hard underlying material at shallow depth (and also because of steep slopes and intense rainfall). Soils are mainly in situ ferralsols on the slopes and better-drained parts of the dissected plains; and gleysols (groundwater-affected) in the low-lying locations. Soil depth is limited on the mountains, and topsoil depth very shallow: over some areas the high grade ore comes right to the surface. Topsoil volumes for stockpiling will therefore be limited, and so it is important that any weathered material that can be considered as subsoil is also stockpiled for later use in rehabilitation.	• Topsoil is to be removed and stockpiled in shallow layers (maximum 1 metre). • All other subsoil or fine non-ore mineral material must also be stockpiled for later use in site rehabilitation. • No stockpiles should be in areas subject to waterlogging. • Any spoil generated must be placed on slopes not exceeding 30 degrees, in carefully constructed layers, and benched in levels not exceeding 10 metres thickness and with the steps at no more than 35 degrees (1:1.5). • The deposits of spoil must be programmed so that each year's mass can be protected with a dense vegetation cover at the start of each wet season. • All access, mine and haul roads must have full drainage and erosion control measures. Regular turnouts into suitably vegetated areas for dissipation may be preferable to concentrating large volumes of runoff.
Ground water	Significant groundwater discharge and acidified groundwater drainage were not anticipated in shallow DSO, but the possibility of this occurring in deeper mines must be investigated. There is strong evidence that Phase 2 mining will penetrate below the permanent water table. Artesian effects were noted in some strata during exploratory drilling. An initial geochemical assessment suggested that there is potential for limited generation of acid conditions, and this needs to be examined in more detail. The humid environment and prevalence of natural wetlands means that there are extensive areas of ecology that would be affected by an increase in the acidity of water discharged from the mine areas.	• There must be a full investigation into the geochemistry of the mines, and modelling of the leachates that may result. • Possible acid rock drainage must be mitigated through action appropriate to the predicted conditions, and this must be designed as part of the mining plan. • Other consequences of interruptions to the aquifers, such as disrupted springs, must be investigated and modelled in detail.

TECHNICAL AREA	GENERAL FINDINGS	IMPLICATIONS FOR MINE DESIGN
Surface water Resources	LAMCO era mining left much poorly placed spoil and many unstable debris masses that are still eroding on a large scale and causing prolonged downstream damage. These include two major features on the north-facing side of the main Tokadeh ridge, and a number of even bigger erosion-mass failure complexes on the main Nimba range, in the Dayea River headwaters. These are still causing significant disruption to hydrology and damage to riverine ecology (see Figure 4.9 for a map of affected catchments). The active erosion complicates the design of sediment control measures at Tokadeh, and it is clear that quite major slope stabilisation and protection measures will be required. However, this legacy of damage means that if all mine drainage can be directed into the river mainly affected (Dayea), the impacts from new mining will be negligible, as long as they are suitably managed and mitigated. Catchments not affected by former mining generally have good quality water. All rivers carry fine suspended sediment (i.e. clays) even in low flows. This tends not to have adverse impacts in either sedimentation or the smothering of aquatic biology. Silt- and sand-sized particles do, however. For this reason, provision must be made to trap these larger particles. Steep slopes and watercourse bed gradients mean that erosion control measures are also required. The creation of sizeable bare (unvegetated) surfaces on the mine sites will lead to higher peak runoff flows.	• Detailed mine design at Tokadeh must ensure that all bench drainage is towards the north-east (into the Madayea and then Dayea). Drainage towards the south and west would cause more environmental damage, and require complex engineering on very steep slopes. • For the same reasons, detailed mine design at Gangra and Yuelliton must ensure that all bench drainage is towards the east (into the Kahn and then Dayea). • Complete drainage systems are required on all engineered surfaces to cope with runoff from very intense tropical rain storms. • Check dams and attenuation ponds are essential to trap silt- and sand-sized particles and prevent them from leaving the mine sites. • Attenuation ponds must also be designed to reduce peak flows by storing and slowly discharging large volumes. • Check dams are required to prevent erosion wherever increased discharge is likely in natural gullies. These may well be necessary for considerable distances down steep gully profiles, well beyond the demarcated mine areas. • Erosion control and sediment trapping measures must be in place before other earthworks begin. • Vegetated bands must be left along all streams. These should be a minimum of 50 metres in width (an absolute minimum of 15 metres might be accepted exceptionally). • Stockpile areas need to be away from water courses, floodplains and swamps.

TECHNICAL AREA	GENERAL FINDINGS	IMPLICATIONS FOR MINE DESIGN
Ecology and Biodiversity	There is a wide range of habitat, from wetland through dissected valley plains, hillsides and montane forest. This includes a range of vegetation communities and also an accompanying variety of animals. Most habitats have been degraded by human activity, particularly shifting cultivation, hunting and logging, with the exception of some areas of lowland forest to the west of the mine sites. Despite this, there is still a great diversity of species, including some that are now confined to small areas and endangered, both locally and globally. Some are endemic, and so found nowhere else. Species have different habitat needs, and some benefit from even small remaining "islands" of forest. Some rare species are sensitive to noise and light. Close to the ore bodies there are large areas of relatively undisturbed forest that have great biodiversity. The western slopes of Tokadeh, Gangra and Yuelliton, and the southern slopes of Tokadeh, are key parts of the less disturbed forests. They are also the highest elevation forests in the area, and for this reason have additional ecological value. The main Nimba range to the east contains a rich diversity and is fully justified as a protected area. All river systems include wetlands of significant ecological value. Figure 4.8 gives a general impression of the vegetation cover.	• The areas of mining must be confined to the ore bodies themselves and only essential additional areas. • Boundaries must be clearly defined, both on maps and on the ground. • Fencing may also be necessary, or at least a perimeter patrol track and some lines of wire to provide a physical line. • It is absolutely necessary that the western slopes of Tokadeh, Gangra and Yuelliton, and the southern slopes of Tokadeh, are excluded from all mining operations (beyond the lowering of the upper sections). • Wherever possible, areas within the mine that do not have to be disturbed should be marked off and left as ecological "islands". • Mining operations should make as little noise as possible. If this is likely to be significant, noise baffles should be included. • Lighting should be limited in extent and brightness to the minimum required for safe night time working and security. • It must be possible to restore soil and some form of vegetation throughout the mine site at closure.
Air Quality	The largely forested nature of the landscape and the long wet season mean that air borne pollution and ambient dust levels are limited. The low population density means that there are relatively few receptors. Atmospheric dust is highest in the late dry season (January-February) when the Harmattan is blowing from the north, off the Sahel. Otherwise dust is only a nuisance in close proximity to roads.	• The stripping of soil and working of the mine must be programmed to ensure that there is the smallest area of bare ground possible at any one time. • Areas where mining has been completed should be released for restoration as soon as possible. • Stockpiling requirements close to receptors (mainly at the rail loading areas) should be minimised by careful programming. • The mine should be workable using the most efficient machinery arrangement in terms of reducing greenhouse gases to international standards.

TECHNICAL AREA	GENERAL FINDINGS	IMPLICATIONS FOR MINE DESIGN
Noise and Vibration	Vibration is not considered to be an issue of serious environmental concern, although this needs to be investigated in relation to train movements. Ambient noise levels are low in the area, since there is no air traffic or industry, no large town and few vehicles. Noise from project operations might affect either people, or animals living in the surrounding forest: this is dealt with above in Ecology and Biodiversity. Human receptors of noise are scattered sparsely, and no permanent settlements are within the predicted noise effect distance bands for the mine areas. Only two towns (Zolowee and Gbapa) are considered to be within the distance bands of potential noise effects from operations in the Tokadeh area.	• Mining operations should make as little noise as possible. If this is likely to be significant, noise baffles should be included. • If other considerations are equal, then excavations should move towards the nearest potential receptors. • Provision for noise reduction will need to be made at the Tokadeh loading area.
Landscape and Visual Amenity	The landscape is dominated by the geological structure, with ancient mountain landforms rising above the valleys and dissected plains. It is shrouded in forest that is mainly degraded and has patches of cleared ground where shifting cultivation is active. Settlements are generally few, small and isolated. Inhabitants attach limited aesthetic value to the appearance of this landscape, which would be given a high degree of merit in Europe. The landscape is dynamic, both seasonally and over cycles of a number of years, principally through the shifting cultivation rotations. But the iron ore is located on the three main peaks of the west Nimba mountains. Hence mining will affect the skyline views from many locations, through first deforestation and then lowering of parts of the ridges.	• The extent of the mine footprint should be minimised as far as possible. • Vegetation bands should be maintained all around the mine and other infrastructure. • Where space permits, areas or bands of vegetation should be retained within the mine or stockpile areas. • The distinctive landform of Mount Yuelliton should be retained, even if it ends up re-shaped. • Mine closure should include an element of landscaping appropriate to the surroundings.

4.5 Environmental Constraints Mapping

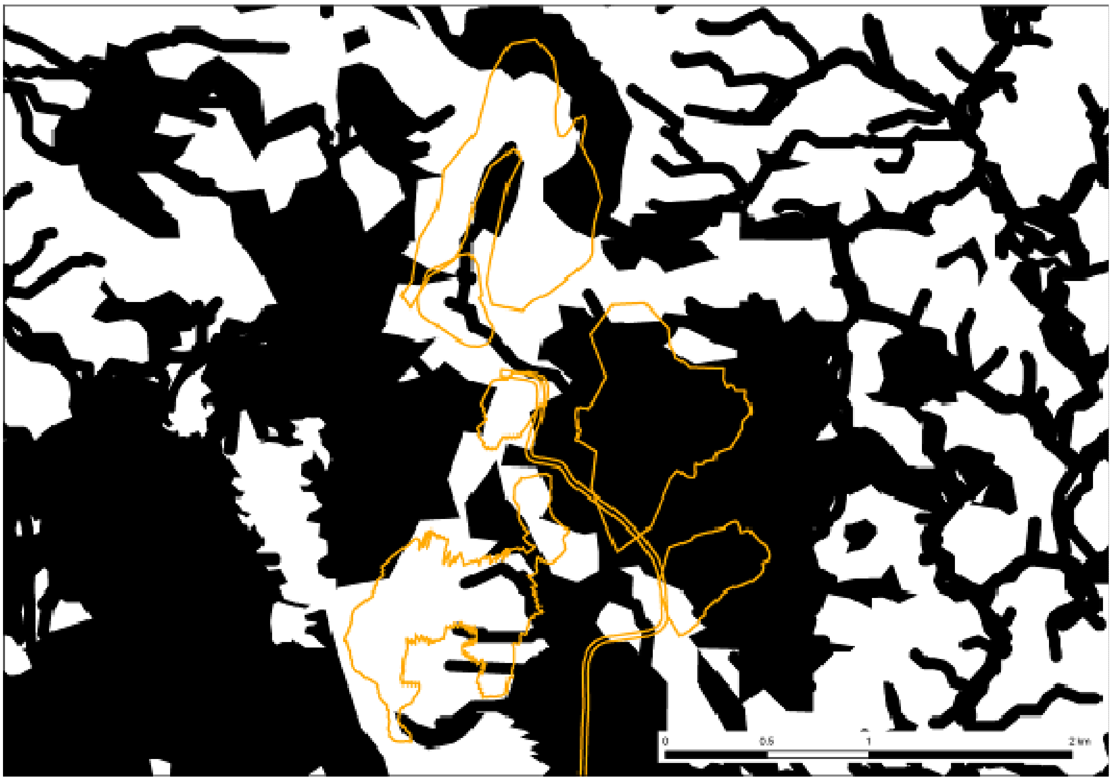
As the environmental studies developed a better understanding of the existing environmental conditions and the interactions between the various biophysical and socio-economic factors, it became possible to be more precise as to what areas were suitable for mining and infrastructure, and what areas carried environmental attributes of significant value.

In order to illustrate this in a practical manner and assist the company's mine and infrastructure planning consultants to avoid environmentally sensitive areas, an environmental constraints mapping system was used. The first published iteration of this is shown in Figure 4.11. It was clear that this was helpful up to a point, but that it did not distinguish adequately between areas of very high environmental importance, and those of lesser importance. It also meant that, if it were to be followed as shown, there could be no project. Nevertheless, it certainly demonstrated that some of the infrastructure had to be re-sited so that it had less significant impacts, and in this respect it contributed to the assessment of alternatives from the first drafts.

A second iteration, shown in Figure 4.12, refined this considerably by showing different categories of environmental significance. This differentiates between very important areas that really must be avoided, and two intermediate categories which should be avoided if possible. This showed more clearly where mine areas and infrastructure were sited on the most sensitive areas of land, and where layout changes are essential: see, for example, the case of the Yahweh Stream on the eastern side of Mount Gangra in Figure 4.12, from where this map showed the importance of relocating the proposed dump sites. An example of negotiation in connection with the constraints maps has been the so-called the Ladder Falls Catchment on Mount Tokadeh (marked in Figure 4.12). This is a small, high level catchment of totally unique character and biodiversity without an equal in the west Nimba mountains. Unfortunately it adjoins the south-eastern boundary of the Tokadeh iron ore resource. Initially it was hoped to have a buffer zone between the edge of the catchment and the mine pit, but this was eventually redrawn to minimise the sterilisation of the ore resource. Hence what is shown in Figure 4.12 is the catchment boundary itself.

It is important to note, however, that the environmental constraints mapping is mainly of value in the re-siting of infrastructure. Given the very high value of iron ore to Liberia's economy, its exploitation still has to take precedence over environmental matters. But this tool has proven extremely useful in assessing project alternatives for the movable infrastructure. The "final" version of the constraints maps and the final mine infrastructure layouts that will be part of the ESIA, should demonstrate a better avoidance of sensitive areas than was apparent in the earlier versions shown in Figures 4.11 and 4.12.

Figure 4.11: Environmental constraints maps for the Gangra-Yuelliton massif (top) and the Mount Tokadeh area (bottom). This is the version given in the Phase 1 ESIA, dated September 2010. Black areas denote constraints (closed forest, Raphia swamp and 30 m stream buffers). Orange outlines show the components of the proposed Phase 1 footprint



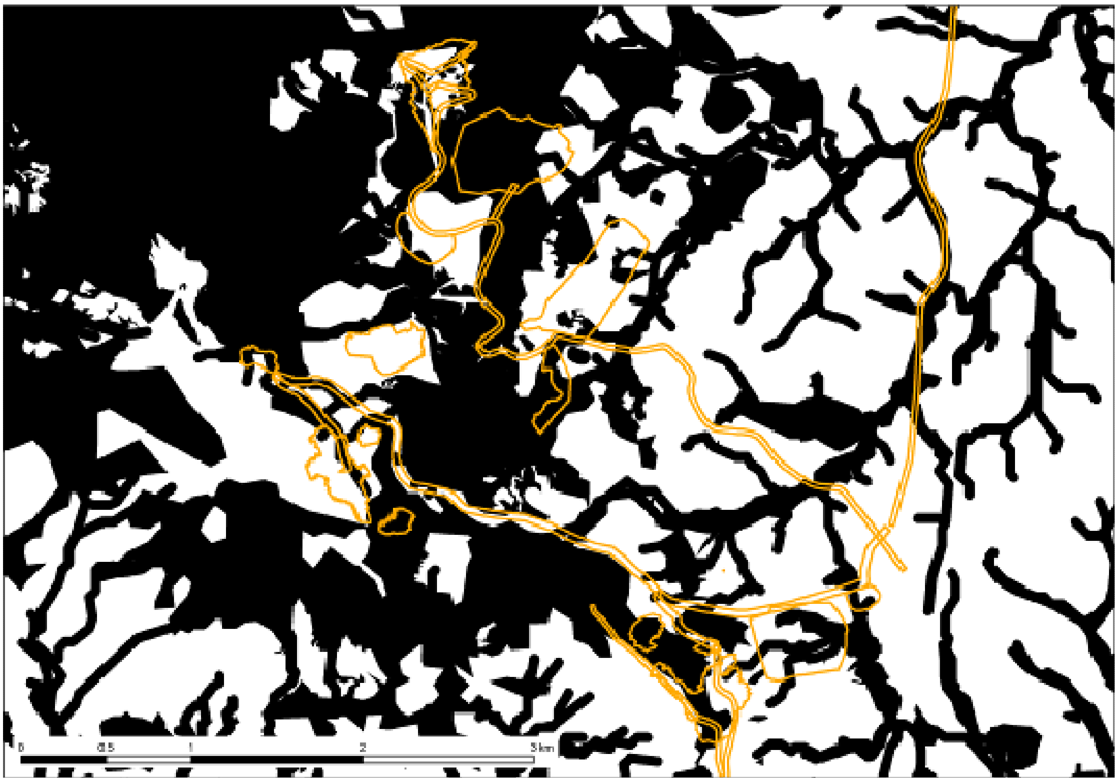
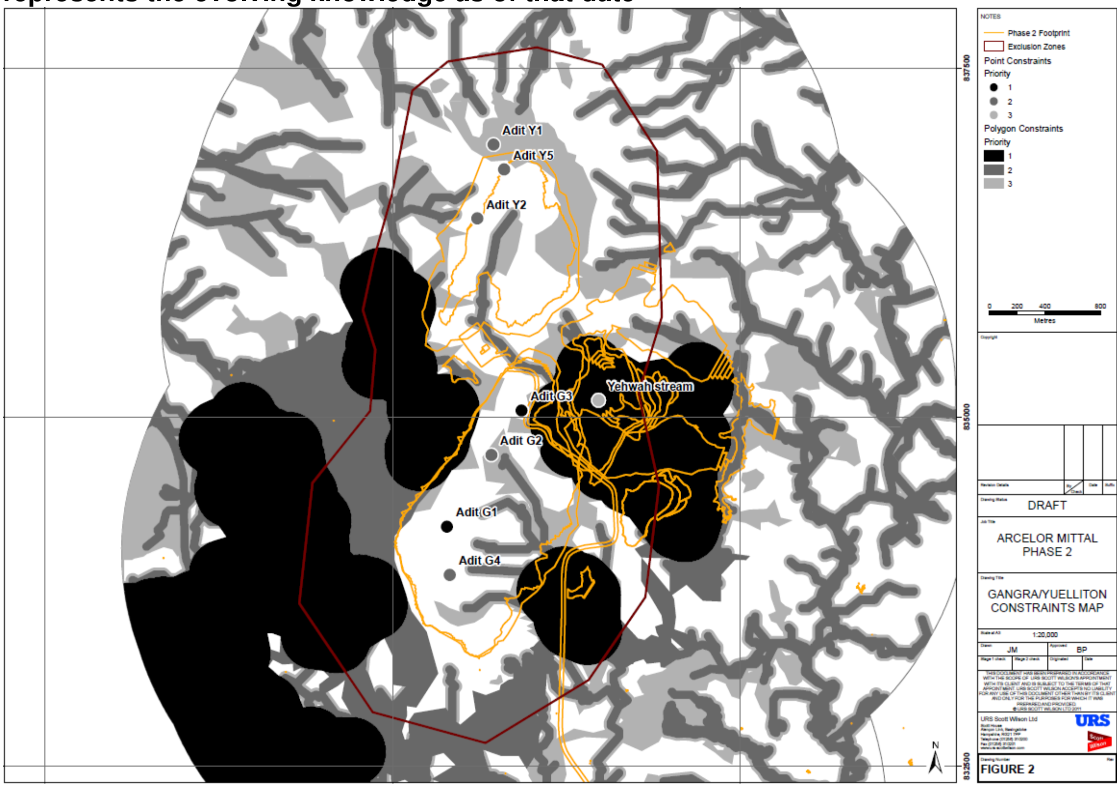
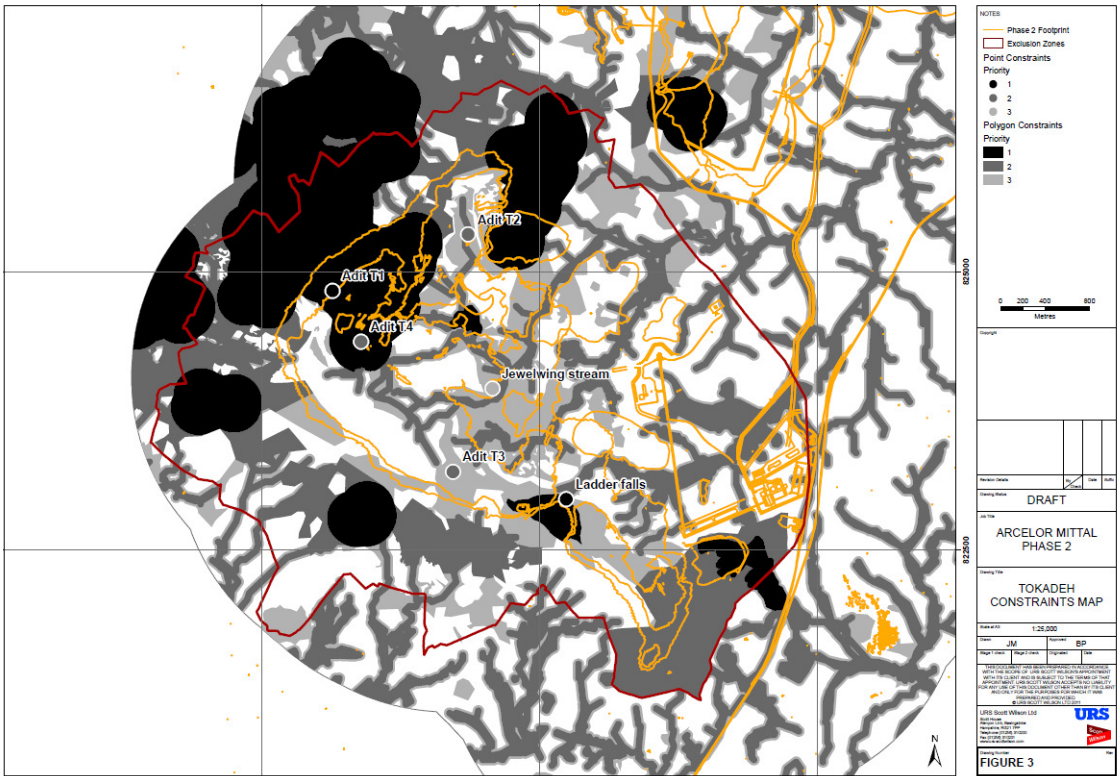


Figure 4.12: Environmental constraints maps for the Gangra-Yuelliton massif (top) and the Mount Tokadeh area (bottom). This is the version issued in December 2011 and represents the evolving knowledge as of that date





4.6 Infrastructure Development Alternatives

4.6.1 Tailings Management Facility

Introduction

The proposed location of the Tailings Management Facility (TMF) to the north-east of Mount Tokadeh and north of the concentrator plant is the result of a staged selection procedure which involved the assessment of six sites under social, environmental and technical aspects. The preferred option is designed to contain up to 154 million tonnes of tailings process waste. Further geotechnical investigations will confirm the ultimate suitability of the site and inform the detailed design. It should be noted that it is not just the stability of the tailings dam and the retained tailings that need to be considered, but also the potential for mine slopes and waste dumps to fail, thus posing a potential hazard to downslope and downstream mine operations, land uses and occupied areas. A report (Phase 2 Volume 3, Part 1.2) has been prepared by URS Scott Wilson on this general subject in the context of the 1982 No Way Camp disaster, and was issued in December 2011 and reissued in January 2013 with reference to a failure that occurred in the LAMCO operational area in the 1970s.

This section provides information on the setting for the detailed assessment of alternatives for the siting of the TMF, in the context of the biophysical and socio-economic environmental conditions of the area.

Land take

Although the area appears to be one of sparsely inhabited bush, in practice there are many people living in the rural landscape. The prevailing practice of shifting cultivation means that households are assigned (by customary title) quite large areas of land, which they cultivate in patches (known locally as "farms") for a short period of one or two years over a long rotation, which may be 40 years or more. Because each patch is used for only a year or so, the landscape has the appearance of being under-utilised. But this is an extensive agricultural system, and it is only sustainable with long periods of fallow. Uncultivated bush is not therefore unproductive within this system, only in a stage between cultivations. In many areas there is also an increasing use of tree crops (rubber, palm, plantain, cocoa etc). Since many farmers do not weed between the trees, it can be difficult to distinguish plantations from bush. Even farms with growing crops of upland rice can be difficult to see sometimes.

There is a strong correlation between undisturbed forest and biodiversity of high quality. Absolute biodiversity is often greater in disturbed or secondary forest, but rarer species tend to be restricted to the primary forest areas. Hence it is important to respect the remaining areas of undisturbed or primary forest. Hunters use most areas of the otherwise less disturbed primary and secondary forests, and provide both protein for the communities and income for their families. It is important to appreciate that most rural communities are extremely poor and reliant on very limited resources. For these reasons it does not take much disruption to push a household's livelihood below the boundary of what is sustainable.

Water resources

Almost all water supplies in rural Liberia are from surface water sources. In some towns there are handpumps to provide drinking water, but all washing is done in streams. Where there is no handpump – in most places – drinking water comes from streams. The tortuous courses of streams through the complex micro-topographic terrain of the lowland bush mean that it is important to check carefully whether a water source supplies a town. In addition, people often occupy temporary huts on their farms for considerable periods during the farming season, and therefore require water in unexpected and unpredictable locations. Beyond that, water is not a scarce resource in rural Liberia at present.

Implications

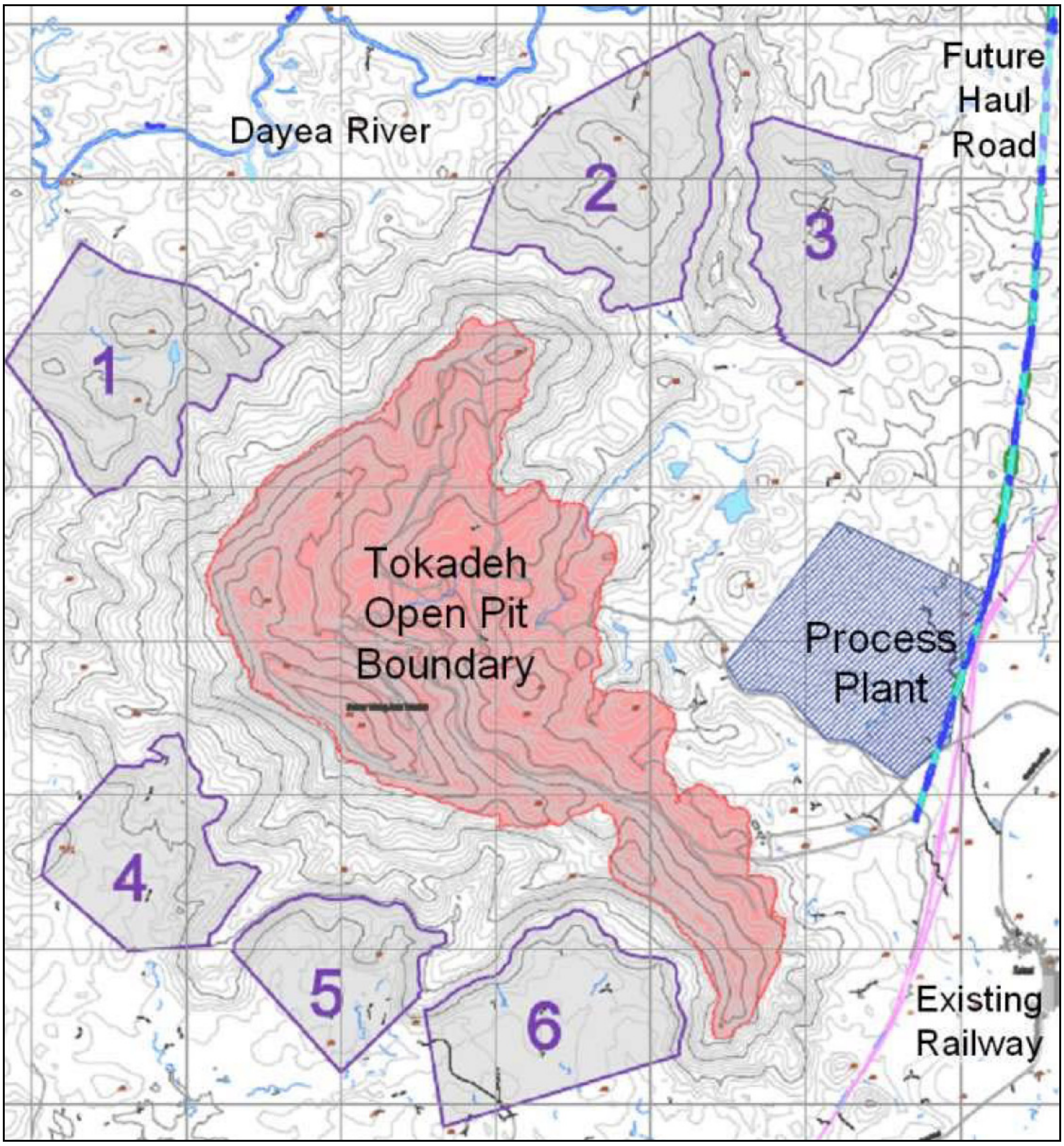
The implications of the factors above are that all land and water take is likely to have impacts on people and their livelihoods, and to require resettlement and compensation. The impacts may not be current, if they are in locations that are presently under fallow, but may only be apparent some years into the future, when a household needs to utilise a particular area for farming as part of a long rotation through the bush.

Increasing pressures on the forest resources mean that undisturbed and primary forest is increasingly scarce. For this reason the government and the conservation organisations advocate retaining these areas as far as possible, at the expense of disturbed (i.e. more utilised) areas. Obviously this is something of a vicious downwards spiral, because take of utilised land automatically increases pressure on undisturbed areas even more.

TMF locations

During the Pre-feasibility Study in 2009, six possible sites were examined for the location of the TMF. These were all in the vicinity of the ore resource at Mount Tokadeh, since this is the largest single resource, and it is surrounded by less steep and dissected terrain than the other resources, and close to the existing railway for outward shipment of ore. The locations of the possible sites are shown in Figure 4.13. Site 3 was that finally selected from the alternatives.

Figure 4.13: Location options around Mount Tokadeh for the tailings management facility studied in the Pre-feasibility Study. Site 3 was chosen as optimal on social, environmental and technical grounds



The main reasons for rejection of sites 1 and 2 was environmental (they are in less disturbed, more botanically rich and biodiverse forest). Sites 4, 5 and 6 were rejected largely because of social issues (they are more densely farmed).

The proposed TMF will be located north-east of the mineralised Mount Tokadeh open pit and directly north of the preferred process plant site. It will lie between a ridge and a tributary of the Dayea River. The site comprises an area of undulating terrain which rises from 430 metres above sea level near the Dayea River to 610 metres along the ridge crest. The site slopes to the north (towards the Dayea River) and to the east (towards the tributary).

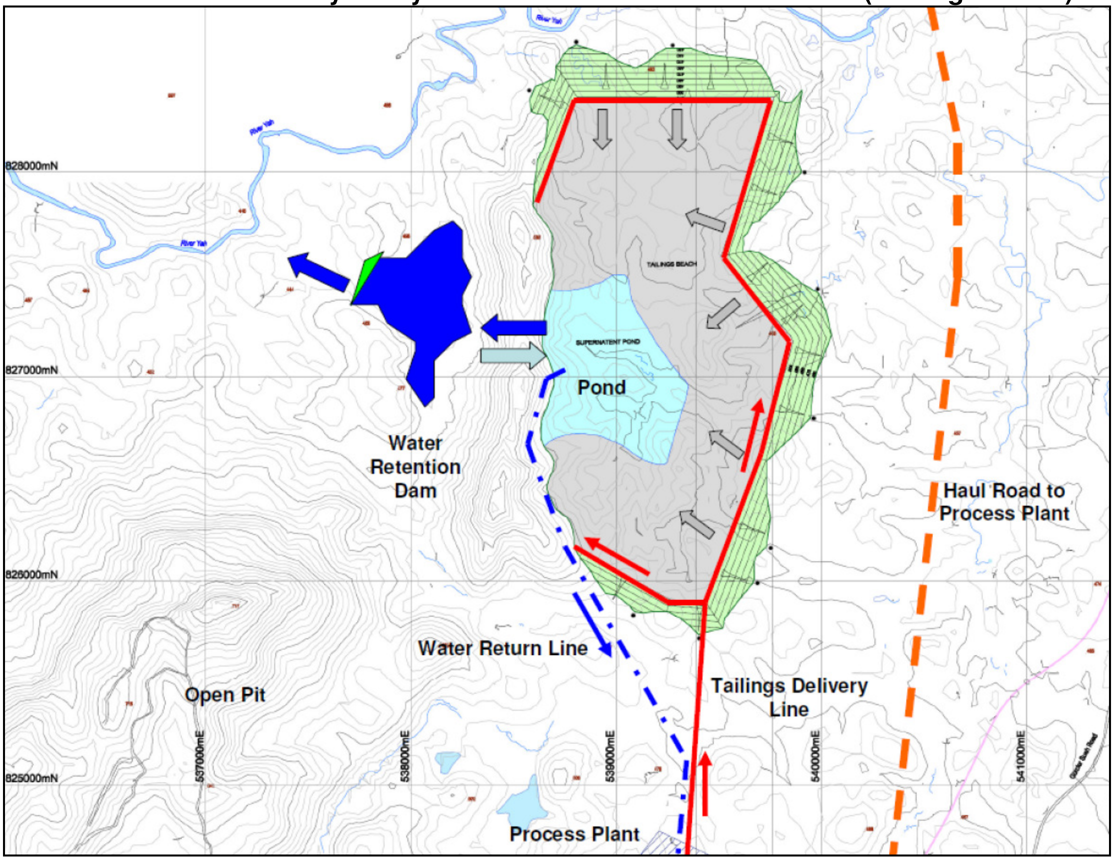
The pre-feasibility designs for the TMF, in selecting option 3 (see Figure 4.13), accommodated the following appropriate statutory guidelines.

- Recommendations from the EU Waste Management Directive (Directive 2006/21/EC).
- Industry Best Available Techniques for the management of tailings.

- The Equator Principles, particularly in reducing environmental, social and resettlement impacts.
- ArcelorMittal's requirements with respect to the safe, efficient and environmentally acceptable storage of the mine waste products.

The summary of the facility design given below therefore makes reference to the geographical features specific to the chosen TMF. Its position is shown in Figure 4.14 in relation to the Tokadeh mine and the processing plant, and to the Dayea River, the railway and public road.

Figure 4.14: TMF and reservoir layout as devised in the Pre-feasibility Study and confirmed in the Feasibility Study. The reservoir was later removed (see Figure 4.15)



From the environmental perspective, the locations chosen during the Pre-feasibility Study, and confirmed during the Feasibility Study, for the concentrator, TMF and reservoir, shown in Figure 4.14, were the least bad. This was for the following main reasons.

- The landtake areas are on land that is not particularly steep or unstable. A small ridge to the west of the TMF offers a natural dam on that side.
- The areas are cultivated, but not intensively. There are few tree crops and no permanent structures. Options east of the railway would have run into large areas of tree cropping and a number of scattered permanent settlements.
- There appeared to be no areas of primary forest affected, and certainly there will be less impact on forests than would be the case for options 1, 4, 5 and 6 in Figure 4.13, where there are some good areas of forest, and also the ranges of primates using the remaining West Nimba forest mosaic. However, later environmental studies showed an area of good quality forest to be present in the south-western corner of the selected TMF area: alternatives to avoid this are considered in detail in Section 4.2.

- The majority of water could be extracted from the Dayea River, which has high flow levels through much of the year, and the water storage for additional dry season requirements could be minimised. Hence the reservoir size could be kept relatively small.
- The amount of additional infrastructure would be minimised (roads, railways, conveyors, pipelines and transmission lines), since the chosen locations fitted well with the existing and planned additional shortest distance access routes.

In 2012 a further value engineering study was undertaken to review the overall TMF design, particularly in relation to access roads and water balancing. This demonstrated that although the TMF itself could not be moved, the water retention dam could be dispensed with, along with the abstraction point on the Dayea River and at least 5 km of associated access roads. It was already known that sediment control ponds would be required for the whole mine, concentrator and TMF sites, but it was only when the detailed engineering design was undertaken that it became clear just how large these would need to be in order to ensure the settling out of sufficient suspended sediment in order to achieve the company’s desired effluent standard (which meets international levels). Once this became clear, it was also possible to create a design that combines both sediment control and water retention. The resulting final proposed layout is shown in Figure 4.15. The use of the settling ponds to meet the water balance for the tailings management facility and thereby avoid an additional reservoir is obviously a better solution.

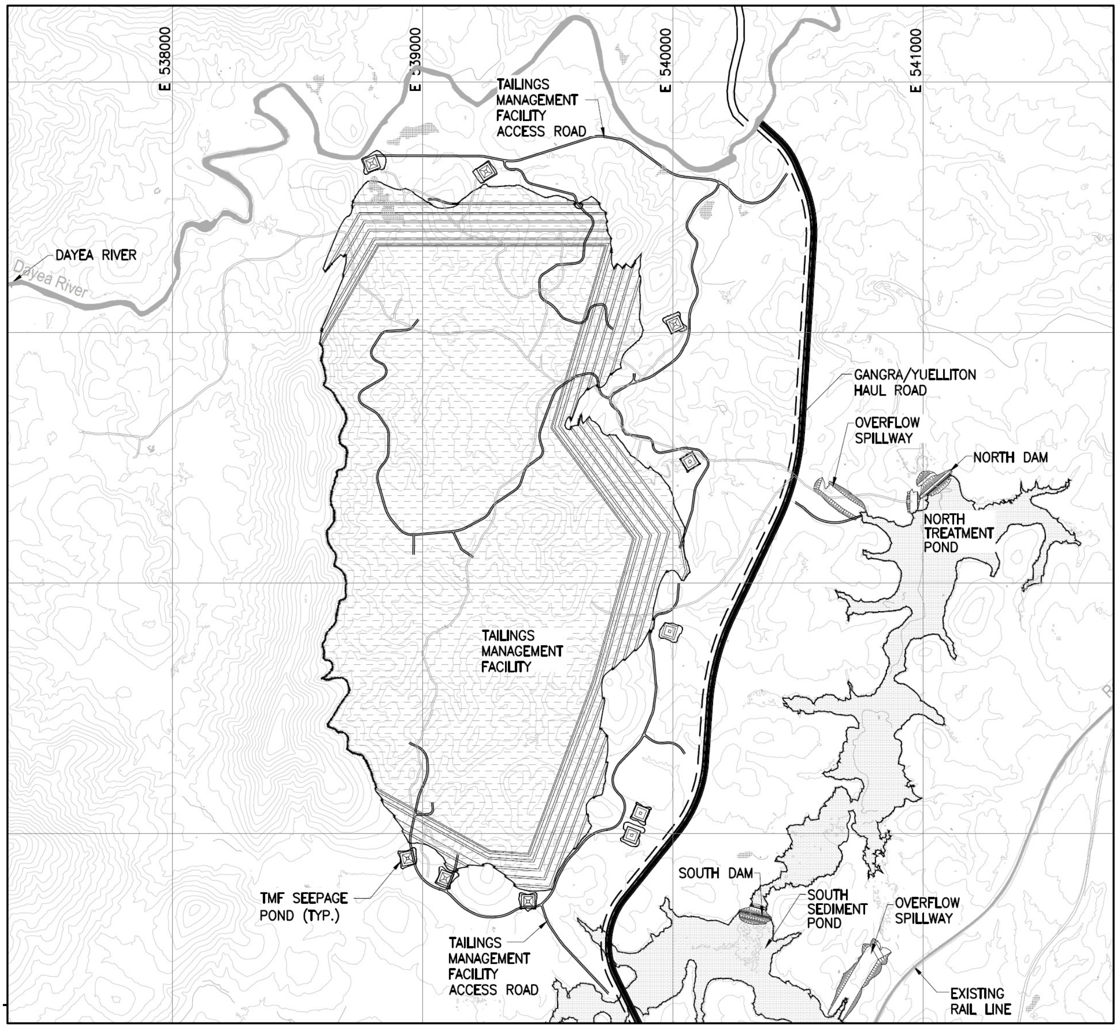
4.7 Tailings Management Facility: Environmental Constraints Areas

During one of a series of meetings to review the tailings management facility, in July 2012, ArcelorMittal requested further details from its consultants concerning the Priority 1 constraints area located on the south-west periphery of the proposed TMF.

The area is shown on the Constraints Map developed by URS and the relevant portion of the map is reproduced in Figure 4.16. The area is of ecological value from both a botanical and zoological perspective. The area shown as black in the approximate centre of the map extract is shown with an indicative outline because the extent of the area of interest has not been mapped in full detail and because a buffer is required around the most biodiverse area. The extent of the constraint area is therefore indicative. The area mapped is the core area of forest within the proposed TMF area, excluding smaller areas of forest and extensions along the edge of this core area (hence the rounded shape), and totals 25.89 ha.

Figure 4.17 has been extracted from the draft report on Phase 2 Forest Botanical Impact Assessment (Phase 2 Volume 4 Part 1.1). It shows an area of Class 4 forest (Nimba Moist Evergreen Forest) occupying the higher ground within Class 2 Upland Secondary Forest on the western periphery of the proposed TMF. Although the Class 4 forest is shown to be located on top of the ridge of high ground, it is considered likely to extend eastwards on to the slopes below. The limits of forest were mapped from high resolution aerial photos and the circles in Figure 4.17 relate to what are effectively point samples, with the radius proportional to “quality”.

Figure 4.15. Final selected layout for the TMF and combined ponds for water supply and sediment control.



This area is important for moist evergreen forest flora and may be a local supply of NTFPs for the villages to the east (e.g. Zolowee and Gbapa). It has a high Bioquality score (230-240) and there are numerous globally rare, Black and Gold Star species present. Although patches of similar floral composition can be found to the west, this is a good sample of moist evergreen forest with its own intrinsic bioquality and is a potential corridor for migrating animals. The photographs in Figure 4.18 show that there is a well-developed forest structure, with a tall canopy and multiple vegetation layers, and streams which are intact and well shaded. Habitats like this are increasingly under threat in the Nimba area, across Liberia, and in West Africa more generally. The incremental loss of this patch of forest could only be explicitly offset with a more tightly defined framework, defining what (area, activity, scheme) is being used to offset what area of forest loss. Also, given that it is an area where non-timber forest products can be sourced by the local population, the site has medicinal value to the communities whose access to medical facilities (hospitals and doctors) is limited.

Figure 4.16: Extract of Biodiversity Constraints Map showing Priority 1 areas in black

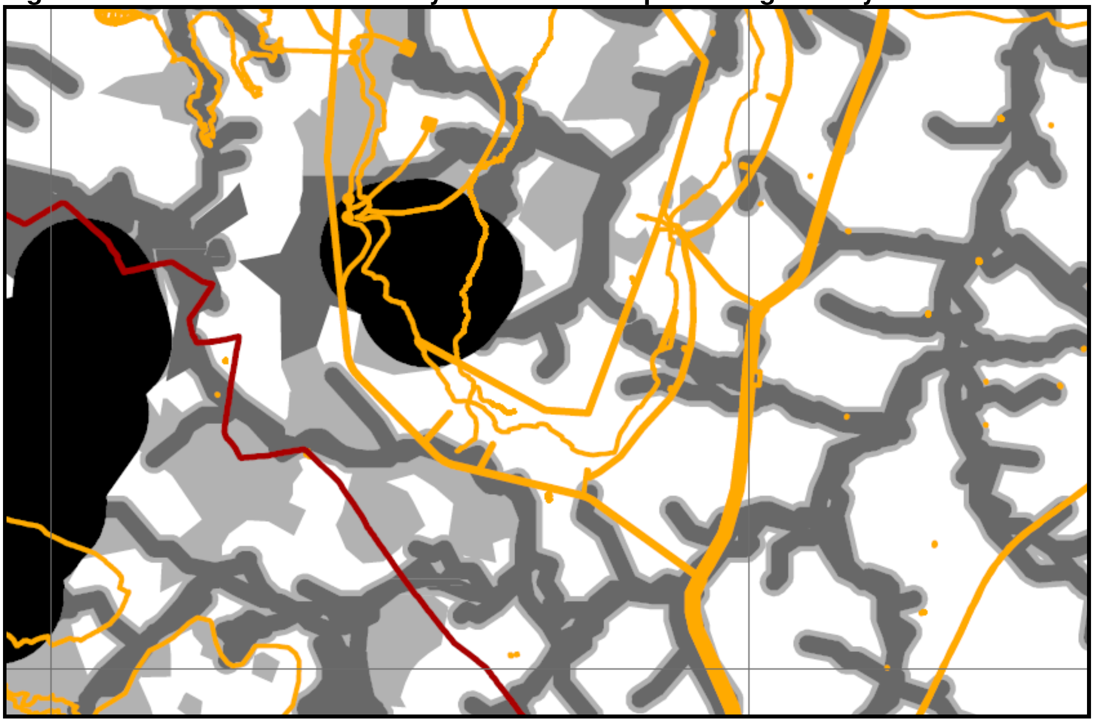


Figure 4.17: Extract from findings of the Phase 2 Forest Botanical Impact Assessment

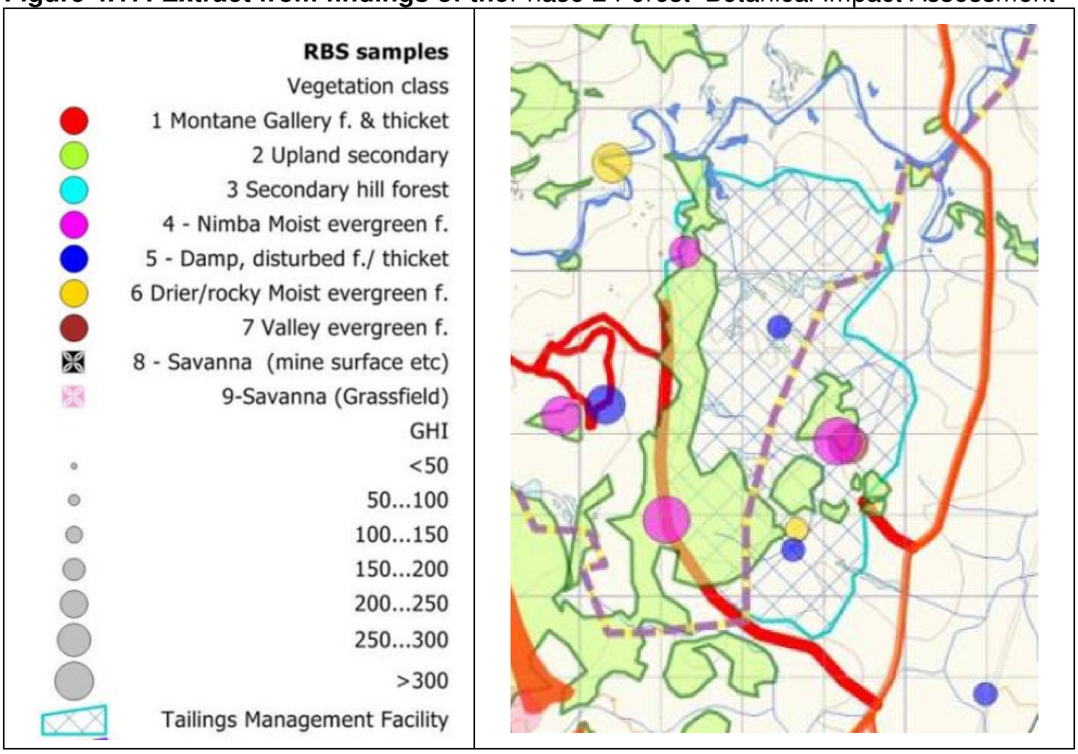


Figure 4.18: Examples of forest habitats

Based on information from baseline surveys this area of forest is a habitat for the following species of global conservation concern:

- **Nimba Flycatcher** *Melaenornis annamarulae* (globally Vulnerable, IUCN Red List). This Upper Guinea (West African forests) endemic has a highly restricted global range, and is known from less than 20 sites in the world. It was found in forest at 565 m, within a Priority 1 area immediately to the west of the area which will be directly affected by the TMF. The loss of forest within the TMF, and nearby from associated roads and other works, is likely to render this habitat unsuitable for Nimba Flycatcher. This species appears to have a healthy population within the East Nimba Nature Reserve which is already protected. Otherwise – in the AML concession – it has only been found at the TMF and at Gangra/Yuelliton. Hence, there are few options to compensate for any loss of its habitat.
- **Yellow-bearded Greenbul** *Criniger olivaceus* (globally Vulnerable, IUCN Red List). This bird species is also endemic to the Upper Guinea forests but is not as restricted in its range as the Nimba Flycatcher. To put the conservation status of these two species in context, there is not a single bird species breeding in the UK which is considered to be at this high a risk of global extinction. It was found occupying habitat in the Priority 1 constraint area within the proposed TMF area.
- **Black-headed Rufous Warbler** *Bathmocercus cerviniventris* (globally Near Threatened, IUCN Red List). This Upper Guinea endemic bird is, like Nimba Flycatcher, known from only a small number of sites globally, but is apparently more tolerant of habitat change. It is found in secondary growth in swamps or at open streamsides, rather than in high forest, and occurs at the edge of the Priority 1 area as well as elsewhere in the TMF area. There is a concentration of this species in lowlands northeast of Tokadeh and in and near the TMF area.
- **Rufous-winged Illadopsis** *Illadopsis rufescens* (globally Near Threatened, IUCN Red List). Another Upper Guinea endemic bird species, this species is abundant in suitable habitat in the AML concession area. It is an indicator of good quality forest of high conservation value.
- **Undescribed butterfly** *Aphnaeus* sp. A previously undescribed species of butterfly was found at a swamp inside the Priority 1 area of the proposed TMF area. Based on the habitats of related species, this is probably a forest species, but virtually nothing is known about it. It may occur more widely, but until this can be confirmed, the Priority 1 area is the only known location in the world for this species.
- **Dragonfly** *Porpax bipunctus*. This species was one of a range of dragonfly and damselfly species found in the proposed TMF area. The West African populations of these species have been assessed as being globally Vulnerable, and may later prove to be of a distinct species.

The proposed TMF area also contains priority 2 and 3 constraint areas. Priority 2 areas include streamside and swamp vegetation which supports Black-headed Rufous Warblers (see above) and a range of aquatic organisms. Priority 3 areas extend stream buffers from 30 to 50 metres and include smaller areas of forest not included in the Priority 1 constraints. Yellow-bearded Greenbul and the Near Threatened Copper-tailed Starling were recorded in these smaller forest areas, in the forest extension running north along the ridge at the western boundary of the TMF area. Another species found in the TMF area, but not restricted to the Priority 1 constraint area, was the bat species *Pipistrellus* cf. *grandidieri*. The West African form of this poorly understood species may represent a distinct taxon, which would probably qualify as globally threatened because of its restricted range and vulnerability to loss of its forest habitat.

Given this significant impact, ArcelorMittal requested its project design consultant, AMEC, to assess alternative layouts for the TMF that avoided damaging the Priority 1 area. This was done in a dedicated report (AMEC: Tailings Management Facility Footprint Site Options Review: 26 June 2012), the key elements of which are summarised here.

The original siting of the TMF was reconfirmed as appropriate, and the potentially greater conservation, engineering and social implications were briefly re-assessed to ensure that there were no valid alternatives. This proved to be the case, so the following alternative footprint options were addressed for the proposed TMF.

- Option 1: Reduction of the current footprint to the northern section of the TMF and increasing the elevation of the confining embankments to store the maximum tonnage (Figure 4.19a).
- Option 2: NE extension – the extension of the northern section of the current TMF to the east (Figure 4.19b).
- Option 3: Western – utilisation of the current water retention dam site (Figure 4.19c).
- Option 4: Eastern extension with the crest elevation restricted to an elevation of 465 m (Figure 4.19d).

Each of these TMF footprint options were addressed with respect to their potential retention volume, footprint area, the upstream method of embankment raising, a variable rate of rise and the required earthfill volume to raise the facility sequentially. The TMF starter and ultimate embankment crest elevations were consequently determined for each option, from depth capacity calculations using a digital terrain model, an assumed settled tailings dry density of 1.3 t/m^3 and a sloped tailings beach profile.

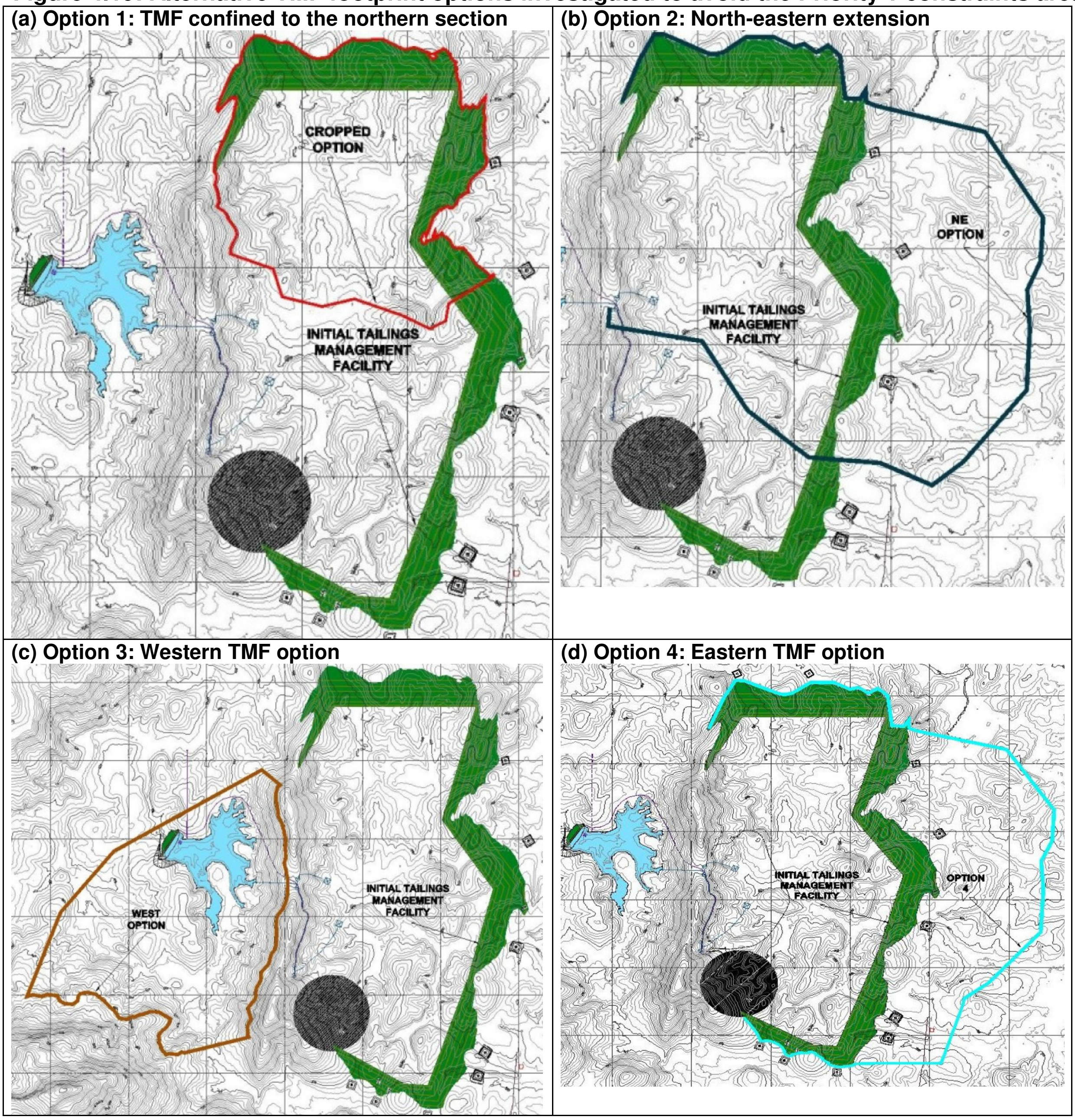
For Option 1, the calculated rate of rise against annual stored tonnage suggests that the rate of rise for the storage of the initial 100 Mt of tailings would be approximately 16 m per annum. This increase in annual tailings thickness would not allow for the effective drainage, desiccation and consolidation of the beach tailings, to form a suitably robust foundation for upstream embankment raising. As the tailings would be weak, high settlement and consolidation should be expected when loaded, leading to upstream embankment failure. The downstream method of construction would consequently be required, taking up a great deal more space and interrupting nearby natural drainage systems. Due to the excessive rate of rise and the requirement for high volume of embankment earthfill (downstream raise), Option 1 was not therefore considered further.

In Option 2, the calculated rate of rise against annual stored tonnage suggests that an initial maximum starter embankment height of 26 m (including 2 m freeboard), would be required for the first two years of tailings deposition. Thereafter, the rate of rise varies from 3.2 m to 7.0 m, with an average tailings beach rise of 4.5 m per annum. Where the annual rate of rise is above 5 m per annum, additional beach drainage systems would be required to facilitate effective drainage and consolidation of the beach tailings. To store 152 Mt of mine life tailings, the maximum embankment height will be 72 m, with an ultimate crest elevation of 492 m. With increased beach drainage systems, this option is technically viable and was consequently considered further with respect to its economics.

With Option 3, the calculated rate of rise against annual stored tonnage suggests that an initial maximum starter embankment height of 36 m (including 2 m freeboard) would be required for the initial two years of tailings deposition. Thereafter, the rate of rise varies from 6.2 m to 9.9 m, with an average tailings beach rise of 6.3 m per annum. This rate of rise is considered higher than is normally targeted for the downstream method of construction. Additional beach drainage will also be required. To store 152 Mt of mine life tailings, the maximum embankment height would be 98 m with an ultimate crest elevation of 518 m. Even with enhanced beach drainage, this option is considered borderline with respect to stability. To develop this site effectively, a larger TMF footprint would be required, reducing the rate of rise, but requiring the sourcing of additional earthfill.

Under Option 4, the calculated rate of rise against annual stored tonnage suggests that an initial maximum starter embankment height of 27 m (including 2 m freeboard), would be required for the initial two years of tailings deposition. Thereafter, the rate of rise would reduce from 5.8 m to 2.7 m, with an average tailings beach rise of 3.5 m per annum. To store 152 Mt of mine life tailings, the maximum embankment height would be 62 m with an ultimate crest elevation of 482 m. In the event that the TMF is restricted in elevation to 465 m RL, to obviate encroachment on to the south-western forestry area, the available retention volume would be reduced to 66 Mt and an additional TMF required to retain the mine life tailings. For this reason, Option 4 was not considered further.

Figure 4.19: Alternative TMF footprint options investigated to avoid the Priority 1 constraints area



To assess the economic implications of the alternatives, the sequential embankment volumes for TMF footprint Options 2 and 3 were addressed with respect to their annual approved earthfill requirement and equated to the current TMF scheme, as summarised in Figure 4.20.

Figure 4.20: Embankment volume comparison

Option		Current		2		3	
YEAR	Cumulative Tonnage	Crest elevation (including freeboard)	Embankment Volume	Crest elevation (including freeboard)	Embankment Volume	Crest elevation (including freeboard)	Embankment Volume
	Mtpa	m	m^3	m	m^3	m	m^3
2014	7.94	458	0.7	440	0.9	447	0.6
2015	15.88	449	0.7	446	0.8	456	0.6
2016	23.82	457	0.9	451	0.9	463	0.6
2017	38.04	464	0.6	458	1.9	473	1.2
2018	52.26	469	0.5	464	2.0	481	1.2
2019	66.48	474	0.4	469	0.7	488	1.3
2020	80.7	479	0.4	473	0.8	494	1.3
2021	94.92	484	0.4	478	0.8	499	1.3
2022	109.14	489	0.4	481	0.8	505	1.4
2023	123.36	495	0.5	485	0.9	509	1.4
2024	137.58	500	0.5	488	0.8	514	0.7
2025	151.8	505	0.6	492	0.8	518	0.4
		TOTAL:	**6.6**	TOTAL:	**12.3**	TOTAL:	**11.9**

The analysis suggests that for Option 2, the north-eastern extension, some 87% of additional approved earthfill would be required to be sourced and utilised during the mine life. For Option 3, the western TMF, some 81% of additional earthfill would be required. Preliminary evaluation of an Option 4a, a western extension to a crest elevation of 482 m RL (i.e. still encroaching on to the prime forest area) suggested that some 50% of additional earthfill would be required, but that pre-deposition quantities would be similar to the current facility. The high level economic analysis is summarised in Figure 4.21.

Figure 4.21: Outline economic analysis of the TMF options

Option		Current	2	3
Approved Earthfill Pre-deposition (Initial 3 years)	Mm^3	2.2	2.7	1.9
Estimated Earthfill cost	M US$	13.2	16.2	11.4
Pre-deposition Minimum Cost Variation	%		23%	-14%
Approved Earthfill Final	Mm^3	6.6	12.3	11.9
Estimated Earthfill cost	M US$	39.4	73.6	71.3
Total Minimum Cost Variation	%		87%	81%
Based on a Unit Rate of US$ 6.0/m^3				

Based on the high level review of the TMF footprint options, equated to the current TMF designs, AMEC concluded the following.

- Option 1 (northern section of the current TMF), is not viable as the footprint area is too small to retain the mine life tailings. In addition, the rate of rise would be excessive, requiring the development of downstream confining embankments to retain the tailings.
- Option 2 (north-east extension) would be possible with increased beach drainage systems, but some 5.7 Mm^3 (87%) more approved earthfill would be required.
- Option 3 (western TMF Area) would require less pre-deposition earthfill (i.e. some 0.3 Mm^3), but to develop the TMF to a level suitable for the safe retention of 152 Mt of tailings, some 5.3 Mm^3 (81%) of additional earthfill would subsequently be required.
- Option 4 (eastern TMF area, crest to 465 m elevation) would only retain some 66 Mt if restricted to a crest elevation of 465 m, and a second TMF facility would be required after year 2020.

- Option 4a (eastern TMF area) would allow for sufficient tailings to be retained if it is increased above the 465 m contour and encroaches into the Priority 1 forest area; however, some 3 Mm^3 of additional earthfill would be required.

The estimated additional earthworks costs for Options 2, 3 and 4 are between US$ 20 and 35 million, exclusive of additional basin and drainage works, and ignoring the wider impacts of landtake for earthfill borrow areas. All of the alternatives would have significantly greater socio-economic impacts, and it is likely that the overall additional costs would have been in the range of US$ 30 to 40 million.

Based on the review of the TMF footprint area, AMEC recommended that the current TMF footprint arrangement be maintained, strong efforts be made to limit development impacts to the Priority 1 forest area above the 505 m contour, and additional funds be allocated to an appropriate biodiversity offset programme.

4.8 Concentrator Location and Layout

The Pre-feasibility Study proposed that the concentrator plant should be located in a new area of land to the east of Mount Tokadeh (see Figure 4.22). It was considered advisable to make use of the available space to ensure that the infrastructure was not crowded, and that there was space for minor design changes as the plant was developed. Subsequent site investigations demonstrated that much of the area proposed for this was dissected by drainage lines and swampy, so that construction in this area would be both technically and environmentally undesirable.

As a result, the concentrator was re-designed to fit on to the brown field site left by LAMCO near the Tokadeh rail loading area. This meant that the infrastructure would be more compact, giving fewer options for later modifications, but also greatly reducing the landtake. Almost everything could be fitted on to the land that had already been damaged, with the exception of the primary crusher (see Figure 4.23 at a comparative scale to Figure 4.12; a larger scale and more detailed plan is given in Figure 4.24). This also had the advantage that initial earthworks could start ahead of the ESIA submission, utilising the 2011-12 dry season, under a Finding of No Significant Impact justified by a Project Brief and a site-specific environmental management plan.

This would be reversible work should the ESIA not lead to a permit, and had the advantage of alleviating pressure for construction activities during subsequent wet seasons. The only part of this design that raised serious concerns was the necessity for a rail loop to enter the site to provide a goods-inward access route. This needed to cross a valley to be used for sediment control at a high level, and would require considerable engineered filling of swamp areas. The location of the loop is shown in Figure 4.24.

It was later realised that a further re-design was advisable to remove the rail loop. This is shown in Figure 4.25. Use was made of the space between the existing railway tracks to provide an additional siding for the off-loading of fuel tankers and other goods wagons. The fuel can be pumped by overhead pipeline to the tanks close to the power plant. This final design appears to be the optimum solution in terms of land take for the concentrator and its associated infrastructure.

Figure 4.22: Location of the concentrator plant as proposed in the Pre-feasibility study. It was located on essentially green field land to the north of the old LAMCO brown field ore stockpiling area

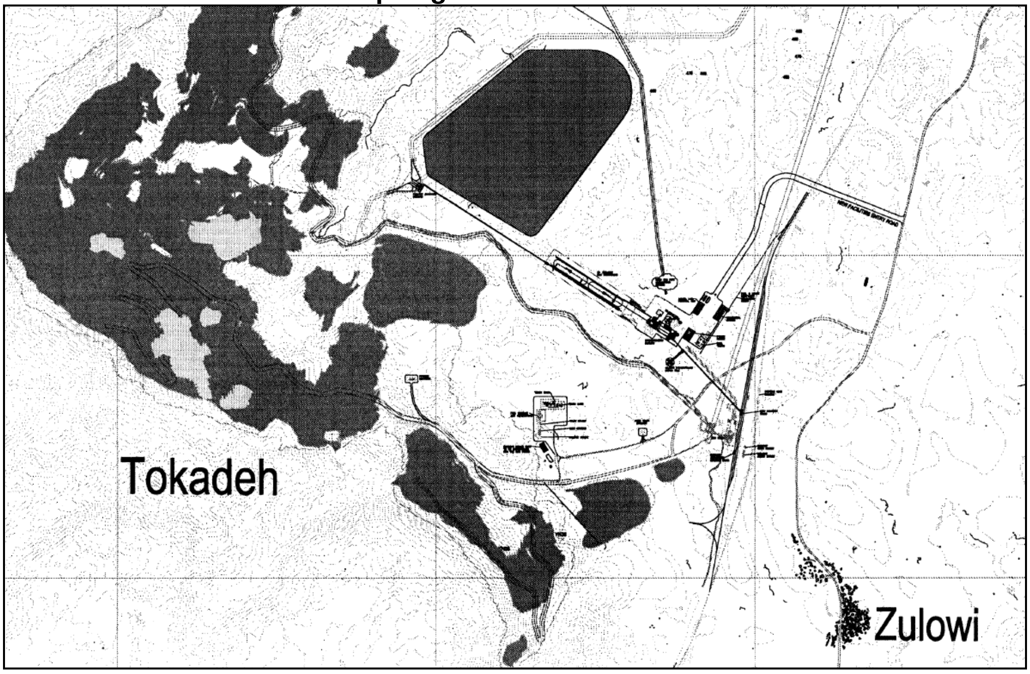


Figure 4.23: The refined location of the concentrator plant as proposed in the Feasibility Study. It was moved southwards from the location shown in Figure 4.22, to be located predominantly on the brown field land of the former LAMCO ore stockpiling area

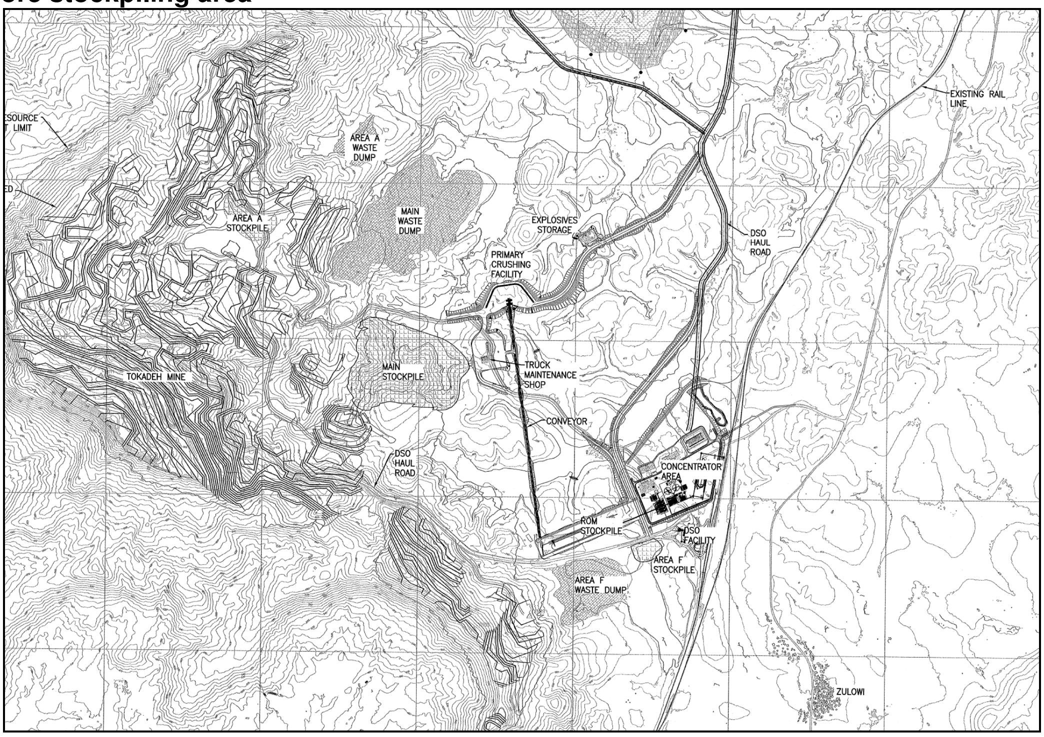


Figure 4.24: Layout of the concentrator plant and associated infrastructure as proposed in the Feasibility Study. Considerable wasted space was apparent in this layout. It also required a rail spur looping across a valley in the upper right part of the plan, to provide the goods-inward route (including fuels)

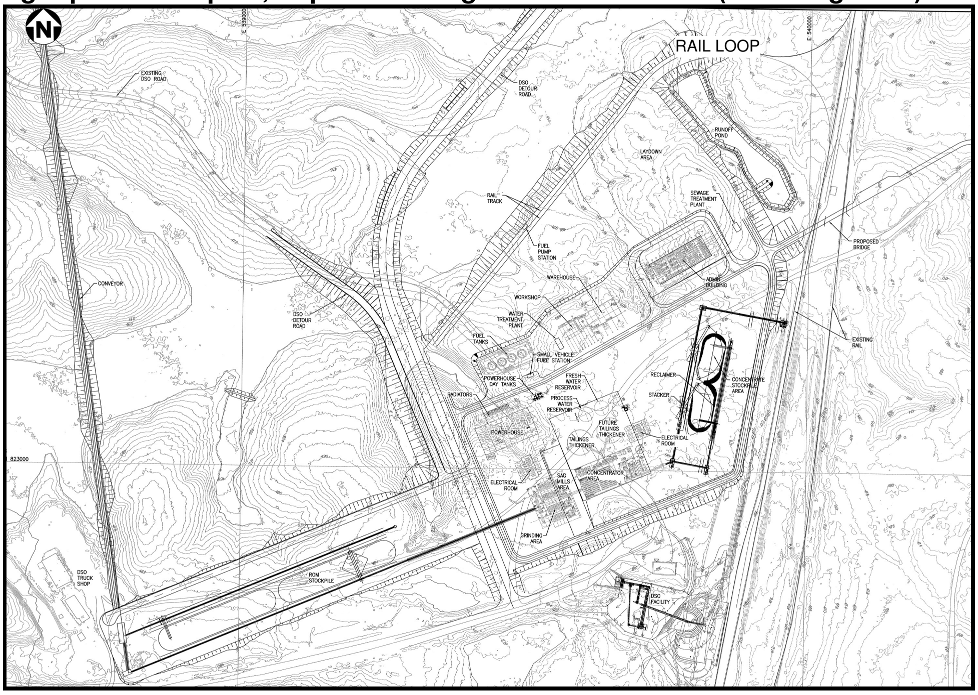
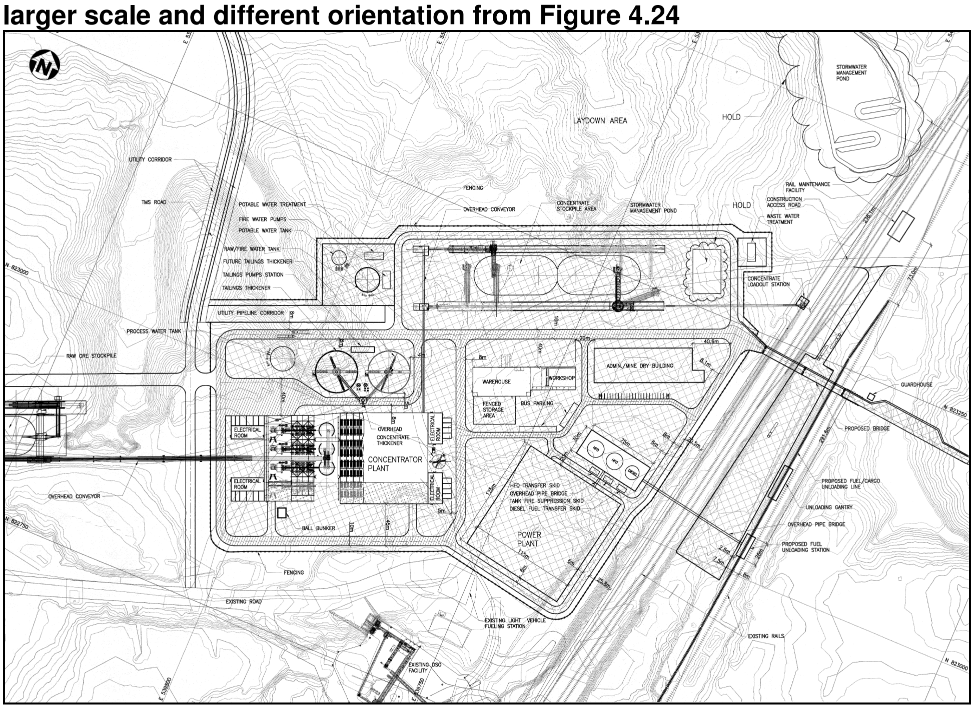


Figure 4.25: The revised concentrator and associated infrastructure layout following detailed design. Better use of space has been achieved and the rail spur removed in favour of fuel handling from a central rail siding. Note the larger scale and different orientation from Figure 4.24



4.9 Stockpiles and Waste Dumps

For each of the three mining sites, alternatives for rock and soil waste dumping were assessed by ArcelorMittal from technical and economic considerations, as well as the results of the preliminary environmental assessment work carried out by Atkins in 2008 and 2009. Because the southern and western slopes of Mount Tokadeh and the western slopes of Mounts Gangra and Yuelliton were defined as environmental 'no go areas', all initially proposed waste dump sites were sited to the north-east of Mount Tokadeh and the north-east of Mount Gangra, and outside of known ore resource areas. Some of these initially proposed sites, however, were in conflict with biodiversity conservation interests and were reviewed by ArcelorMittal in relation to Phase 1 and Phase 2 layout and surface drainage details. As described in section 4.5, through the use of environmental constraints maps, it was possible to identify the least damaging locations for this infrastructure. The final mine layout design ensures that they are in the most stable areas and avoid environmental sensitive sites as far as possible.

4.10 Crusher and Haul Road versus Conveyor Routings

A trade-off study investigated the trucking of run-of-mine (ROM) ore from the Gangra-Yuelliton deposits via a 14 km haul road to a primary crushing system at Tokadeh, versus installing a primary crusher in close proximity to the two deposits. The primary crushed ore from Tokadeh facility would be transported by belt conveyor to stockpiles at the concentrator. The ROM trucking option was selected based on fewer equipment and power source requirements, and lower capital cost.

Eleven alternative routes were assessed for the overland transport of crushed iron ore between the primary crusher and concentrator facility. The chosen alternative, as defined in the Feasibility Report, involves the least wetland crossings and elevation changes.

4.11 Tokadeh Construction Camp

A workers' camp for the construction period for Phase 2 infrastructure is required. At the peak times this will need to house up to two thousand temporary workers. Because of the nature of the construction, these will mainly be unaccompanied male contract workers. The housing of such a group is notoriously problematic and can cause significant disruption to the social fabric if it is not managed carefully. The main environmental and social concerns were as follows.

- The best location for a site of around 10 hectares that could be taken out of its current use for a period of up to three years, and subsequently rehabilitated back to its pre-existing condition.
- The minimisation of mass transportation of workers.
- The minimisation of disruption to local communities through the introduction of different values (such as a massive localised rise in prostitution).
- The control of development of services that are likely to spring up to serve a construction workers' camp, such as makeshift bars, entertainment centres, restaurants and the like.

Other factors, such as water supply, sanitation and power production were considered to be movable factors that would be designed against environmental standards for any particular site option. A location within the actual construction site boundary was rejected on the grounds of safety.

It became apparent that it would not be possible to satisfy all of the issues listed above. A number of options were apparent and were assessed in detail (see summary in Figure 4.26). One, sited just outside the Tokadeh site entrance, was pursued to feasibility level and a layout designed (see Figure 4.27). However, it was eventually concluded that a location in Yekepa itself was better because it would be easier to control the social implications of the influx of workers. The trade-off was that there would be increased traffic on the highway between Yekepa and Tokadeh, but this would be mitigated by improvements to the road.

FIGURE 4.26: SUMMARY OF SITE OPTIONS FOR THE LOCATION OF THE PHASE 2 CONSTRUCTION WORKERS' CAMP

Location	Likely implications
Yekepa	Several options were looked at, but either they were too constrained in size or would cause unnecessary community anguish (e.g. the location that included the football pitch). One potentially suitable place was on the eastern side of the river, between the road and the LAMCO railway sidings. This had the advantage of being partly a brown field site and having no adverse effects on people's livelihoods. Another alternative was on the site of the former LAMCO rail marshalling yards. These were cleared in 2011, with the removal of the ore wagons for re-use on the railway. There are no resettlement issues. Any solution at Yekepa has the disadvantage of a long travel distance, but only within Yekepa town could the company control the surrounding uses of land and the establishment of undesirable service providers.
Edge of Yekepa	No remaining areas large enough were identified that were not close to existing housing areas or under agriculture, though some might be found. Long travel distance was the key concern here.
Camp 4 / Unification Camp	This was the original contractor's camp but is now occupied by a considerable number of people. It is not clear if it has developed similar social structures to traditional towns such as Gbapa and Zolowee. It is surrounded by mainly agricultural land. There would be a long travel distance.
Grassfield	Large flat area ideal for a big camp, well away from any towns (apart from a small hamlet at the eastern end). But a long travel distance, including through Gbapa. It is also a key conservation area.
North-west of Gbapa	An area of good construction land was identified close to the town of Gbapa. This is mainly under agriculture. Travel would be significant, but not as bad as for Camp 4 or Yekepa. However, it would have serious social implications for the nearby town of Gbapa.
Inside Tokadeh exclusion zone	An area could be designated to the west of the railway. However, this would mean mixing the industrial and residential areas, and would give rise to serious safety and security difficulties.
North of Tokadeh access road	Terrain is undulating and not ideal for construction. Limited agricultural use is apparent, but some resettlement would be necessary. It is the closest safe site to the construction area and workers would be able to walk to work.
South of Tokadeh access road	A generally flat area good for construction. It is very close to Zolowee and a relatively intensively used agricultural area.
South of Zolowee	Various locations are possible, but all require transport through the middle of Zolowee. Most would have significant resettlement issues as well.
Sanniquellie	The nearest large town outside the concession. Available areas on the edges of Sanniquellie would be likely to incur complex and costly res .

Within Yekepa a number of locations were considered. It soon became clear that the best possibilities were away from the existing permanent housing, in land that was previously in the LAMCO industrial sector. This was because considerable brown field land space existed in areas no longer required for industrial purposes, and so self-contained camps could be constructed by contractors with no further landtake or disruption (no resettlement required), and in sites around which the company could control the land uses and prevent the development of unsuitable service industries.

A number of different options were proposed (see Figure 4.28). In the end, the area best suited to a temporary camp was determined to be the site of the former LAMCO rail marshalling yards. These were cleared in 2011 with the removal of the last LAMCO rail wagons for recycling by ArcelorMittal for re-use on the railway. The rails on which they were standing were loose as the ties had been eaten by termites, and some were taken for use on the mainline to replace worn rails. Although this gives a somewhat linear layout, the hard-standing and existing drainage of the site make it otherwise ideal. A tentative layout for the camp is shown in Figure 4.29.

Figure 4.27: Trial layout for a possible contractors' camp close to the entrance to the Tokadeh site. This option was rejected mainly because of the difficulty of controlling surrounding land uses

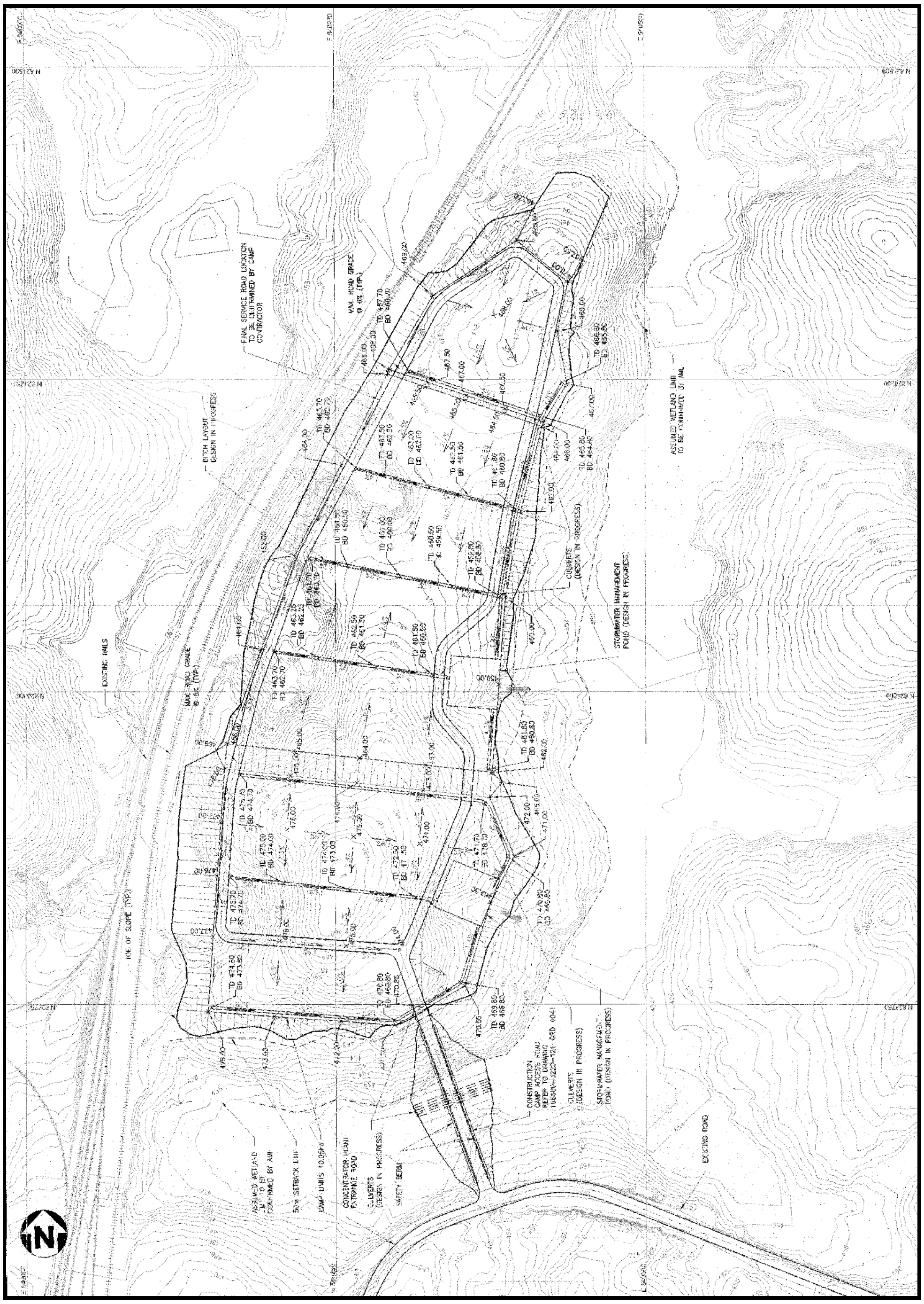


Figure 4.28: Three main site alternatives for the temporary construction period contractors' accommodation camp at Yekepa. Option 2 was chosen as the best

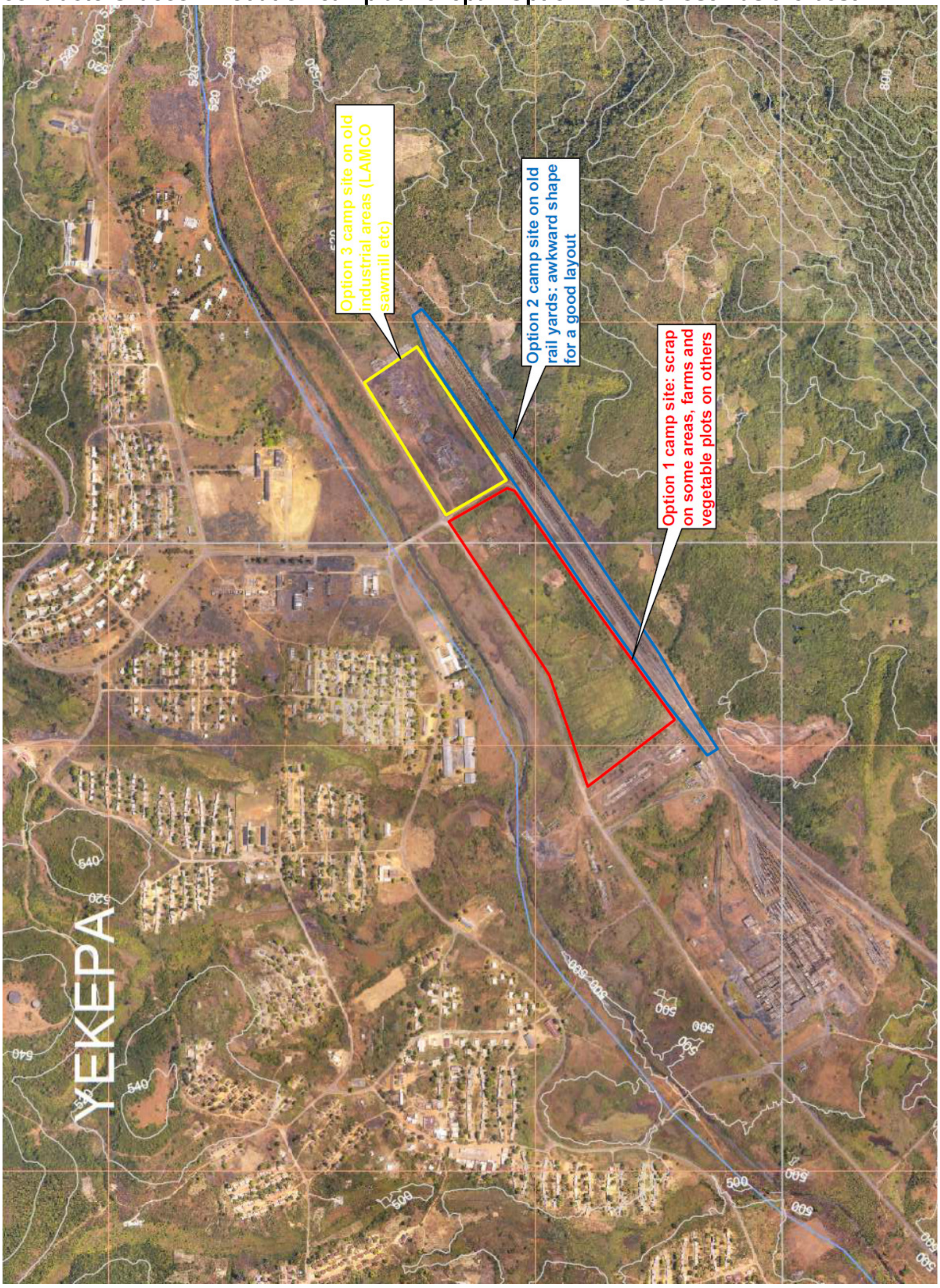
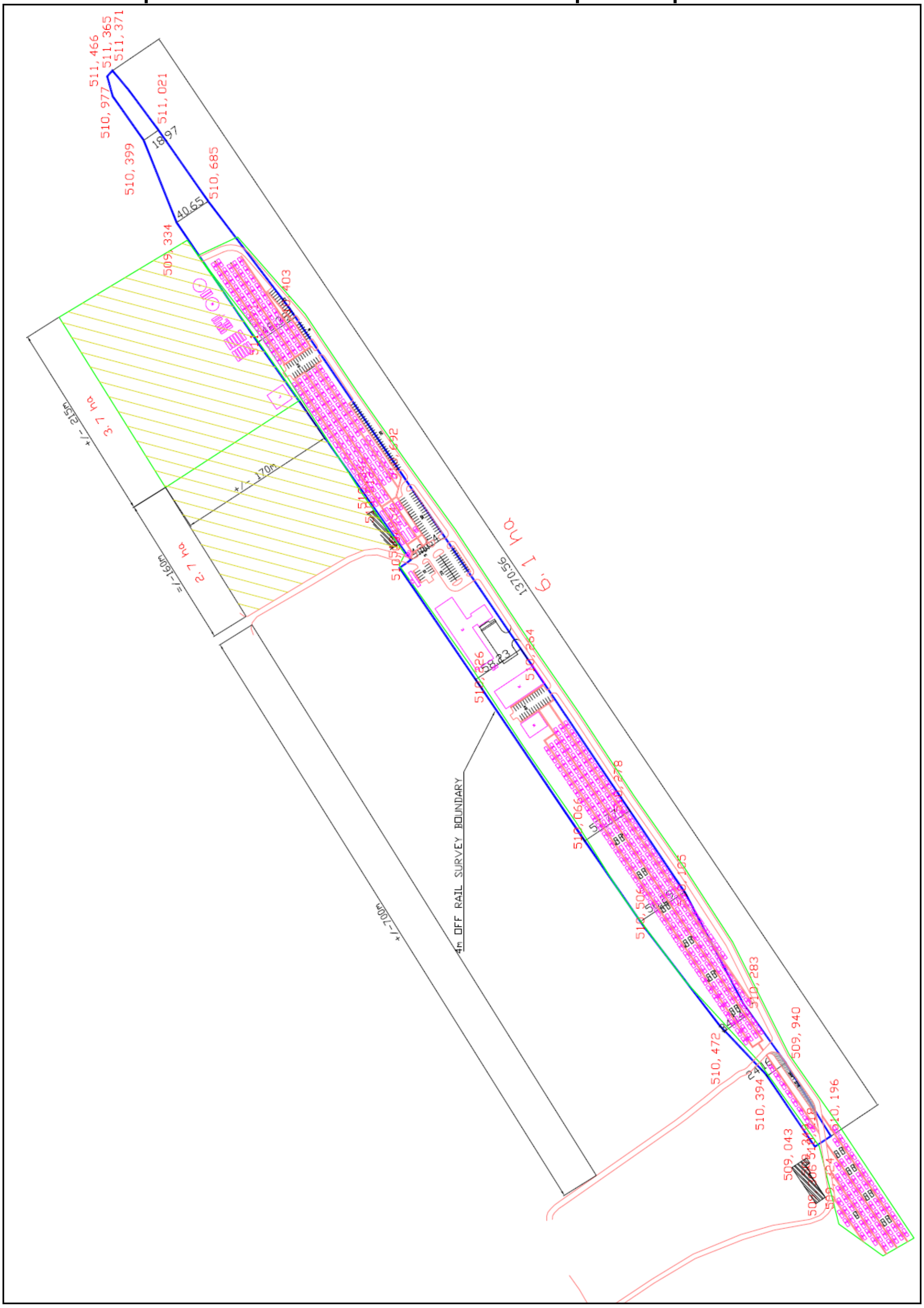


Figure 4.29: Tentative layout design of the preferred option for the temporary construction period contractors' accommodation camp at Yekepa



4.12 Rail Tie Alternatives

A detailed alternatives study was undertaken in November 2007 by Sandwell to assess the optimum choice between concrete and wooden rail ties. While concrete ties would last the life of the project, wood ties would have a life expectancy of 15 to 20 years, with an average of perhaps 17 years. However, fasteners would last for the life of the project and would not have to be replaced. Choosing a low end fasteners option, the wood option became more economically attractive, and also any recuperation of LAMCO fasteners during rehabilitation would reduce the investment cost.

From the practical point of view, the wood tie alternative also offered the following advantages.

- Provide the opportunity for participation of the local population from villages along the network in the rehabilitation of the line (since four men can lift a wood tie, but a concrete tie would have to be inserted by machine).
- Future track maintenance personnel could be chosen from selected participants in the construction, thus strengthening the local responsibility towards the railway property.
- It allowed flexibility to outsource tie supply from different sources including local Liberian hardwood suppliers. LAMCO made extensive use of treated local hardwoods with a 15 to 20 year life. In fact no local sawmills or treating facilities existed to provide tie supply for the rehabilitation of the railway, but this option remains for maintenance during the operation of the railway.
- Security in meeting the deadline for the inauguration of the railway operation.
- Minimisation of damage costs to the infrastructure in case of derailments, in terms of material replacement and time.
- Given the condition of roads in Liberia, especially during the rainy season, it was easier to supply construction sites with wood tie daily requirements than concrete ties during the rehabilitation period.

4.13 Buchanan Site Layout Alternatives

4.13.1 Landside Infrastructure Alternatives

The Buchanan site, where iron ore is to be off-loaded from trains, stockpiled and then loaded on to ships, has been the subject of a number of different options. These have derived from studies of different production levels, and refinements of the different available layouts. In practice they are very similar to most of the activities that were carried out at the site by LAMCO. Since there are few overall options for the ways in which these operations can be conducted, the alternatives explored really come down to possible different layouts.

Consideration was initially given to reconstructing the infrastructure in the same layout as used by LAMCO. The following elements describe the key facilities, and are shown by number in Figures 4.30 and 4.31.

1. Rotary car dumper for unloading iron ore from the rail wagons. Ore was transferred towards the right along a conveyor.
2. Run of mine stockpile. This was created by ore fed from the far end of the piles. There was also a reclaimer system to take the ore to the next stage.
3. Wash plant. Here the fines and impurities were removed and slurried away to the tailings facility. The shippable product was transferred by way of conveyors and silos, to the product stockpile.
4. The main product stockpile, of the shippable product ready for export. This also had a reclaimer to take the ore on its next stage.
5. South-west of the wash plant was a pelletising plant. This baked some of the ore into pellets of about 12 mm diameter to create a different product. From here conveyors took the pellets to a stockpile.
6. The pellet stockpile, close to and parallel to the iron ore quay. An underground reclaimer system took the material on the next stage.
7. From the two stockpiles (i.e. numbers 4 and 6), the selected product was fed by conveyor to the surge bin on the iron ore quay, and from there to the ship loader and into the holds of the bulk carriers.
8. The wash plant appears to have produced a wet by-product that was put into settling ponds to remove the excess water.
9. The tailings from the wash plant were disposed in a laterite bund to the south-east of the main industrial area, just inland from the beach.
10. Diesel fuel for locomotives, machines and vehicles, and heavy fuel oil for the power plants at Buchanan and Yekepa, was landed at a special quay at the southern side of the harbour. From there it was pumped inland along a fixed pipeline.
11. Diesel and heavy fuel oil were stored in large tanks. That for Yekepa was pumped into rail tankers and taken up the line.
12. Power was generated in a dedicated power station, which supplied energy for the entire industrial operation, and also for the residential township.
13. There was a substantial area of workshops, warehouses and offices.
14. There were also various rail loops and sidings for the management of the rolling stock.

Figure 4.30: An aerial view of the LAMCO industrial facility at Buchanan, probably taken during the 1980s. The camera is looking south-west towards the harbour basin and the sea. See text for an explanation of the numbers

The LAMCO facilities were abandoned soon after the start of the civil war, and some, such as the power plant, were systematically looted and destroyed. Since these facilities were based on developments from the 1960s and 1970s, the reconstruction in the present day inevitably involves a number of different approaches. As a consequence, the replacement of the facilities proposed by ArcelorMittal Liberia are quite different from those used by LAMCO. Since most of the LAMCO facilities were therefore not usable, they then became obstacles to the reconstruction of the site. Some could be moved – such as the rail tracks and conveyor frames – but other parts were constructed from massive concrete and are impossible to remove. The ArcelorMittal Liberia layouts therefore had to fit around the major obstacles and this, as well as the more efficient handling system allowed by modern technology, has led to the slightly different proposed layout shown in Figure 4.32.

Even when the main layout shown in Figure 4.32 had been determined, detailed final site assessment demonstrated that refinements were needed. Most notable of these was the design of an alternative return rail loop from the car dumper. Rather than construct a new rail loop across the swampy land of that part of the concession, it was decided better to continue the line along the better-drained western perimeter of the site to link into the existing DSO unloading rail spur. This is shown in Figure 4.33.

Other studies showed further alternatives. The most different was the one proposed in a study by Sandwell, which included a higher level of production for the whole project (see Figure 4.34).

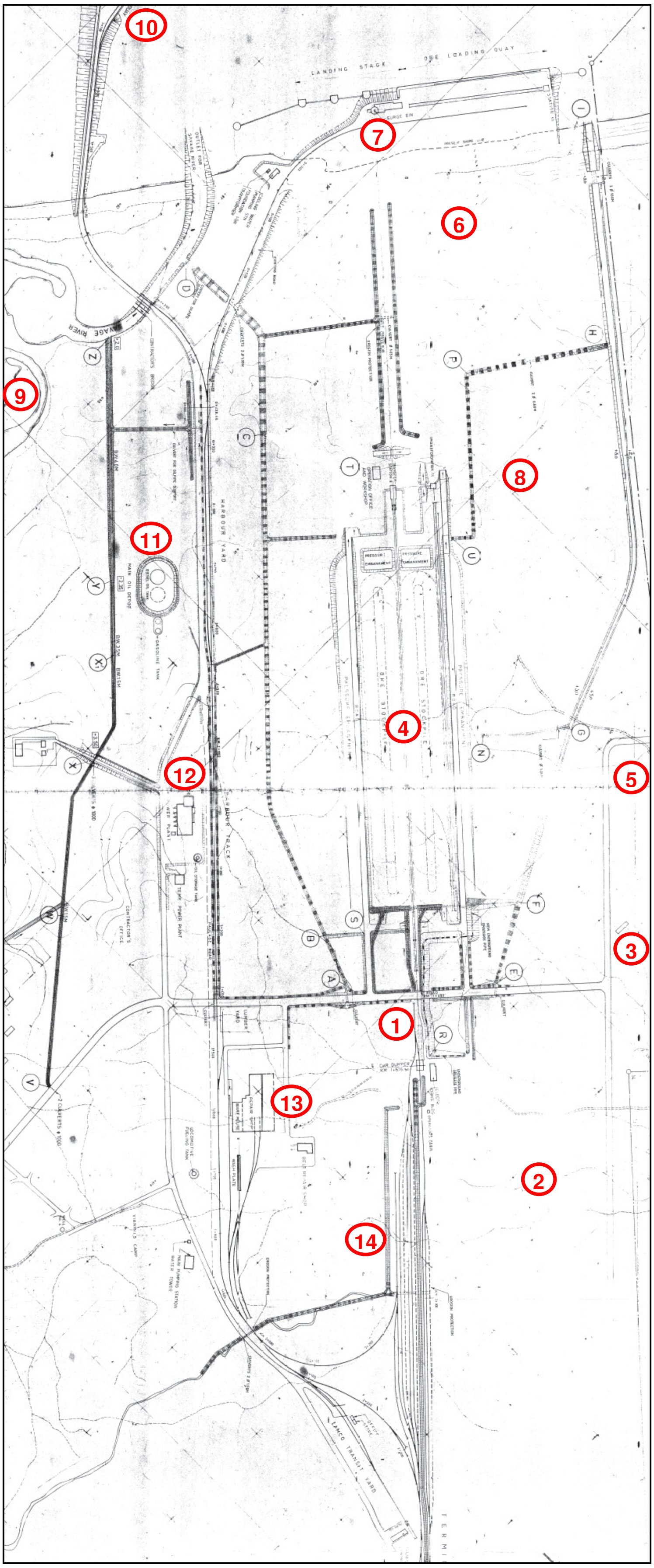


Figure 4.31: General layout plan for the LAMCO facilities. This appears to be an original design drawing, and rather different from what was actually built and is visible in Figure 4.30. See text for an explanation of the numbers

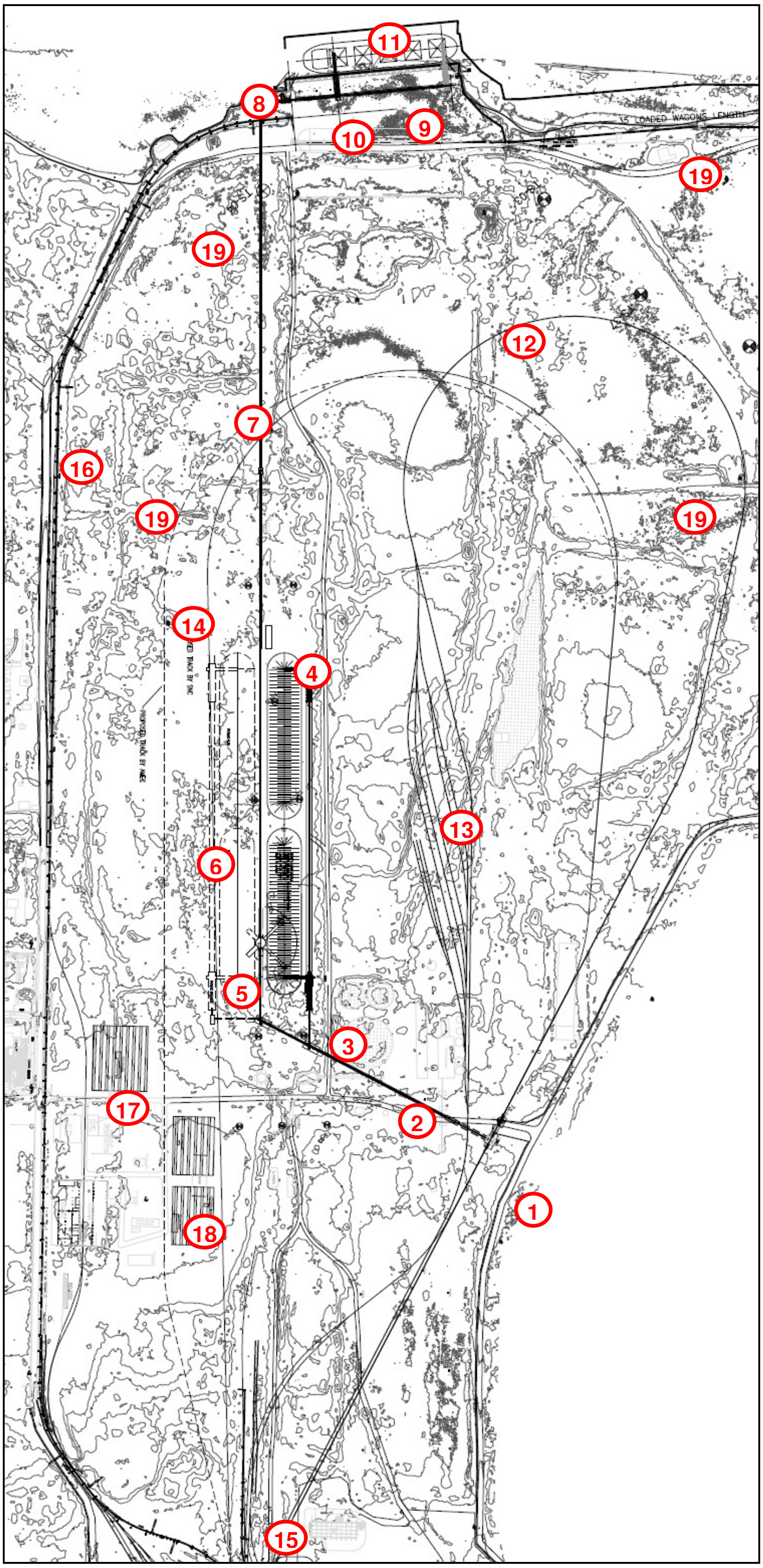


Figure 4.32: Overall layout of the site. There are obvious similarities with the LAMCO layout in Figure 4.41

Key to site layout:

1. Rotary car dumper.
2. Conveyor to stockpile.
3. Stacker at north-eastern end of stockpile.
4. Stacker at south-western end of stockpile.
5. Bucket wheel reclaimer near north-eastern end of stockpile, showing its 90o horizontal swing.
6. Provision for a later second stacker and stockpile parallel to the initial arrangement.
7. Conveyor to surge bin.
8. Surge bin.
9. Conveyor from surge bin.
10. Ship loader.
11. Ship.
12. Rail loop, initially preferred design option.
13. Rail sidings for train marshalling.
14. Discarded design options for rail loops.
15. Rail departure tracks.
16. Existing rail spur to iron ore quay.
17. Existing warehouse and locomotive maintenance shed.
18. Existing workshops.
19. Storm water settlement ponds (four separate ponds).

Figure 4.33: The final layout at Buchanan, showing the removal of loop options 12 and 14 shown in Figure 4.32, and instead the use of the existing DSO rail for the return route. Note that this plan is at a different orientation to Figures 4.30 and 4.32, and also shows the final site drainage plans

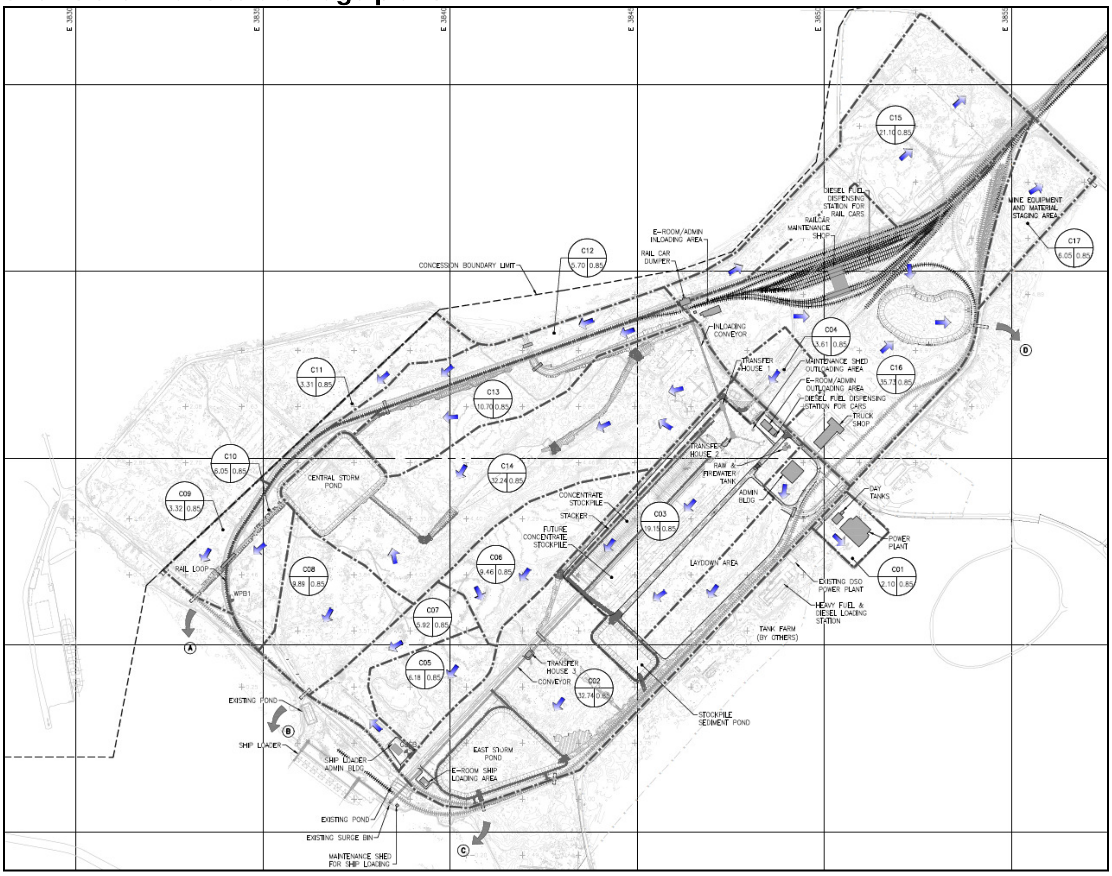


Figure 4.34: A graphic image of the proposed layout from the Sandwell engineering design report of April 2008. This was proposed as a double berth option for an ore throughput of 25 million tonnes per annum

4.14 Marine Side Facility Alternatives

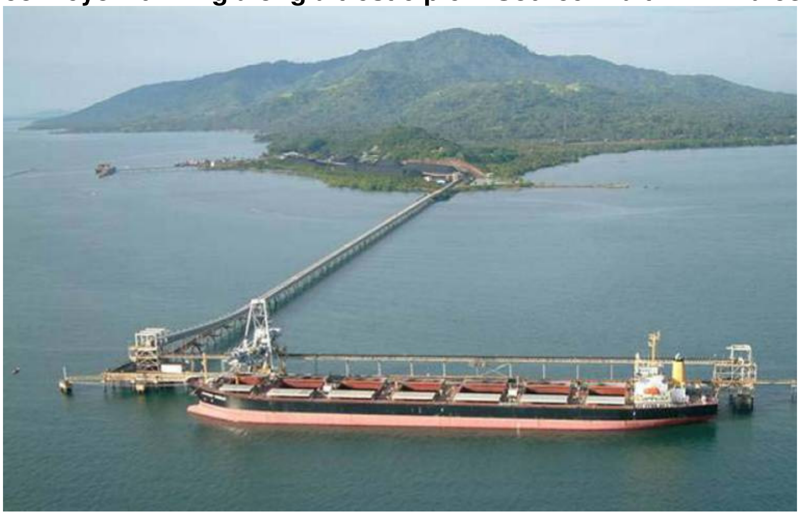
The Port of Buchanan was constructed by LAMCO to handle Panamax and Post-Panamax ships (i.e. ships of the largest size capable of transiting the Panama Canal). These have a maximum draught of 12 metres. To achieve this, the sea bed was deepened by blasting out the hard granitic gneiss that underlies this part of the coast.

Panamax bulk carriers are not now particularly large in terms of the global fleet. They can carry 60,000 to 80,000 tonnes of cargo. Capesize vessels are a larger class of bulk carrier and can typically carry around 175,000 tonnes, although larger ships (normally dedicated to ore transportation) have been built, up to 400,000 tonnes. Capesize vessels were originally those that are too large to pass through the Panama Canal, and so would have to travel via Cape Horn to travel between the Atlantic and Pacific. Previously they could also not pass through the Suez Canal, though many now can since that was deepened to 20 metres (and so do not always have to travel by way of the Cape of Good Hope to reach the Indian Ocean).

Transport economics are such that Panamax ore carriers would make Liberian ore mainly attractive just for Atlantic seaboard markets, which limits its potential value as global steel consumption shifts increasingly from Europe and North America to Asia. No sizeable iron ore industry would now construct a Panamax port, but would automatically go for a Capesize port so that the option of larger vessels was always available, to take advantage of bulk cost savings on longer transport routes. ArcelorMittal has utilised the Port of Buchanan for its DSO operations only because it could be re-opened quite easily and cheaply, which was a requisite for the current small direct shipping ore project.

To increase the potential market value of Liberian ore in the longer term concentrator project, however, ArcelorMittal proposes to investigate the feasibility of constructing a pier to a deep water site that could accommodate Capesize vessels. A typical example of this is shown in Figure 4.35. A conveyor would transport ore along the pier from a stockpile on the shore, and deliver it straight into the hold of the berthed ship. The option of extending a pier some 4 km offshore to reach water that is at least 22 metres deep requires careful consideration of sea and seabed conditions. Only then can a conceptual design be put together, and estimated construction, maintenance and operational costs be calculated to assess the feasibility.

Figure 4.35: An example of deep sea berth for a Capesize vessel, with a loading conveyor running along a trestle pier. Source: Kaltim Prima coal



Three alternatives have been considered for accommodating Capesize vessels at the Port of Buchanan. These are:

- Deepening of the existing harbour basin to allow the berthing of larger and deeper ships;
- Construction of an offshore trestle pier to a deep water location; and
- Transhipment in deep water from a barge or Panamax ship into a Capesize vessel anchored offshore.

This investigation has reached the following conclusions.

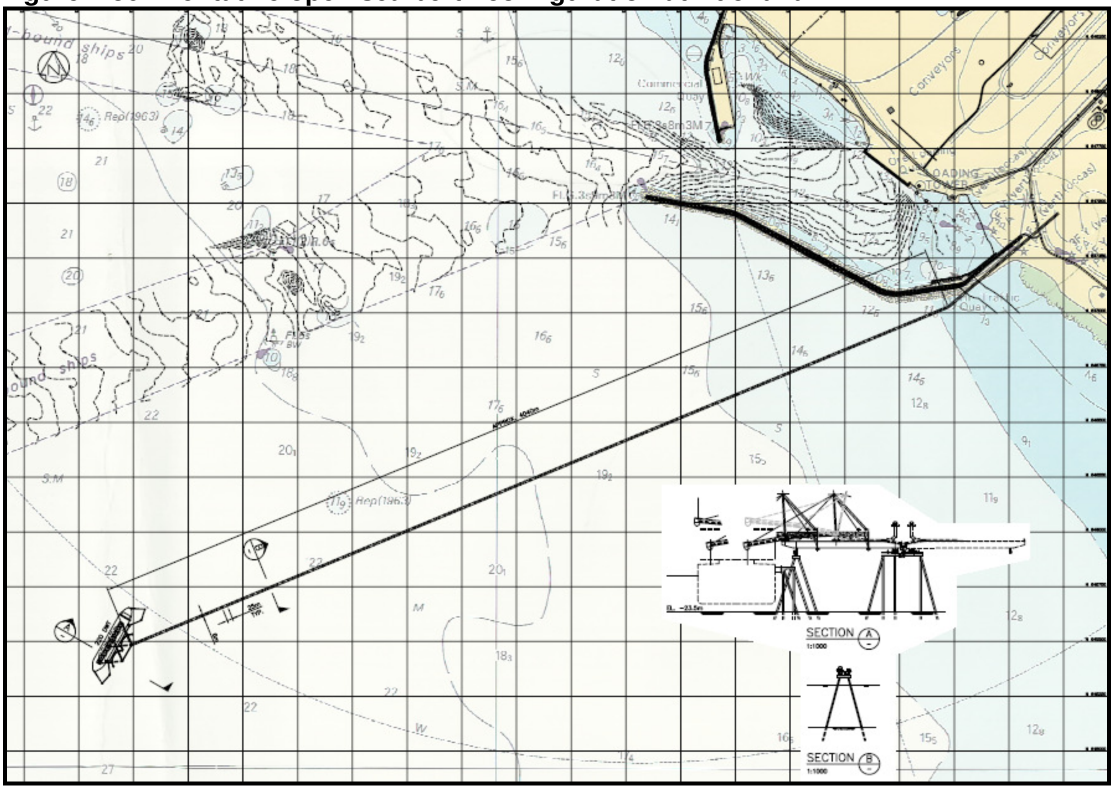
- The development cost of a deep harbour berth with access channel is 2 to 2.5 times higher than a berth with a long trestle pier to deep water and no dredging.
- In addition to the high cost, the development of a Capesize berth within the Buchanan Harbour could face major technical and logistics challenges, and disruption to ongoing operations.
- The conversion of the existing lay-by berth for Capesize vessels is not viable because there is insufficient space for cape vessels to approach.
- The development of the open sea berth is considered to be the current world best practice for dry bulk cargo; however, operational downtime due to sea conditions needs to be established.
- Transhipment may offer a more flexible, lower cost and less environmentally intrusive option and is worth testing as an option.

The design of a pier and open sea berth therefore requires two main areas of site study.

- A bathymetric, side-scan and sub-bottom profiling survey to support the determination of berth location and a trade-off study of causeway versus trestle length (if sand, dredging and causeway is cheaper; if rock, trestle is cheaper); the profiling will support design of the marine piles anchorage system. This would generate a detailed digital terrain model of the sea bed.
- Metocean data capture to assess sea conditions and determine likely berth downtime due to adverse conditions.

It is expected that the pier would be constructed to a loading berth in water of at least 22 metres depth. As shown in Figure 4.36, this would require a pier of 4 km in length at Buchanan.

Figure 4.36: Tentative open sea berth configuration at Buchanan



The company applied in September 2011 for environmental consent to undertake the marine surveys required to establish the viability and design of an offshore loading pier. The surveys were started in early 2012 but are expected to take more than a year to complete. If it is decided that a Capesize loading pier is feasible, both technically and economically, then its location will be determined from the results of this survey. It would then be subject to a full Scoping Study, and an Environmental and Social Impact Assessment.

Transhipment was tested separately following agreement with the Government of Liberia as a suitable way to enhance the marketability of Liberian iron ore, and the acceptance of a comprehensive Environmental Management Plan pending further detailed environmental studies. In this process, a smaller vessel (the transhipping vessel or TSV) shuttles ore out of the port in batches and transfers it to a larger Capesize vessel (ocean-going vessel or OGV) waiting a little way offshore. It is a process used in a number of locations, including Freetown in Sierra Leone and, by ArcelorMittal, Port Cartier in Canada.

ArcelorMittal Liberia has contracted CSL (formerly Canada Shipping Lines) to provide a transhipping service at Buchanan. For the first phase of the project, lasting up to a maximum of three years, CSL is using the M/V CSL Atlas as a transhipping vessel. This is a gravity fed self-unloading Panamax bulker with an articulated boom, capable of fully loading a Capesize bulk carrier with DSO. Key characteristics of the M/V CSL Atlas are as follows:

- 67,634 tonnes DWT bulk carrier;
- Length overall 227.4 m;
- Beam 32.0 m;
- Draft 13.418 m;
- Cargo intake at 12.0 m, 57,000 tonnes (approx);
- Gravity fed self-unloading system;

- Articulated discharge boom;
- Unobstructed cargo holds for easy loading;
- Water proof hatch covers;
- Equipped with bow thruster;
- Discharge rate (tonnes per hour) 2,300 TPH net effective, 4,000 TPH peak; and
- Yokohama fenders.

For the next stage of the operation, the Capesize ocean-going vessel must have a maximum DWT of 180,000 to 200,000 tonnes. The transhipment anchorage must be suitable for year-round operation. Operations at the transhipment anchorage can only occur during "weather working days", which are defined as satisfying all of the following conditions:

- Wind speed is less than or is reasonably forecast to be less than 25 knots;
- Wave conditions are less than 2.0 metres in height;
- Visibility is at least 0.5 nautical miles; and
- Swell is less than 3 metres.

Specialist self-propelled, sea-going and self-unloading barges are in short supply globally. Hence should the company later wish to switch to a purpose built transhipment vessel, CSL proposes to purpose-build a new and self-unloading transhipment shuttle barge. ArcelorMittal Liberia would not consider committing to this option until the system has been proven with the M/V CSL Atlas and the advantages of a Capesize loading pier discounted.

Ultimately the alternative that is selected will be dependent on the technical feasibility and the overall costs, relative to the market destination of the iron ore. For the ESIA of which this document is a part, direct loading into Panamax ships at the iron ore quay within the Port of Buchanan is the selected option. The alternatives are still being evaluated and the final choice will be made when enough information is available.

4.15 Processing and Tailings Facility at Buchanan

In 1980, LAMCO envisaged an expansion of its work beyond the existing mining at Nimba and Tokadeh into the other mountains of the Western Range. This project, which was never implemented, would have involved both a concentrator and a wash plant at Buchanan, together producing a total of 12 million tonnes of concentrated product per year. To dispose of the waste, a large new tailings facility was envisaged, south-east of the tailings ponds created to store the waste from the existing wash plant (see Figure 4.37). Although today there would undoubtedly be a number of social and environmental concerns with the establishment of a new plant of the scale envisaged so close to the city of Buchanan, now much larger than it was in 1980, undoubtedly the biggest impacts would come from the extensive landtake for the tailings dam. Most of the discussion on this alternative is therefore focussed on that highly intrusive aspect of such a project based at Buchanan.

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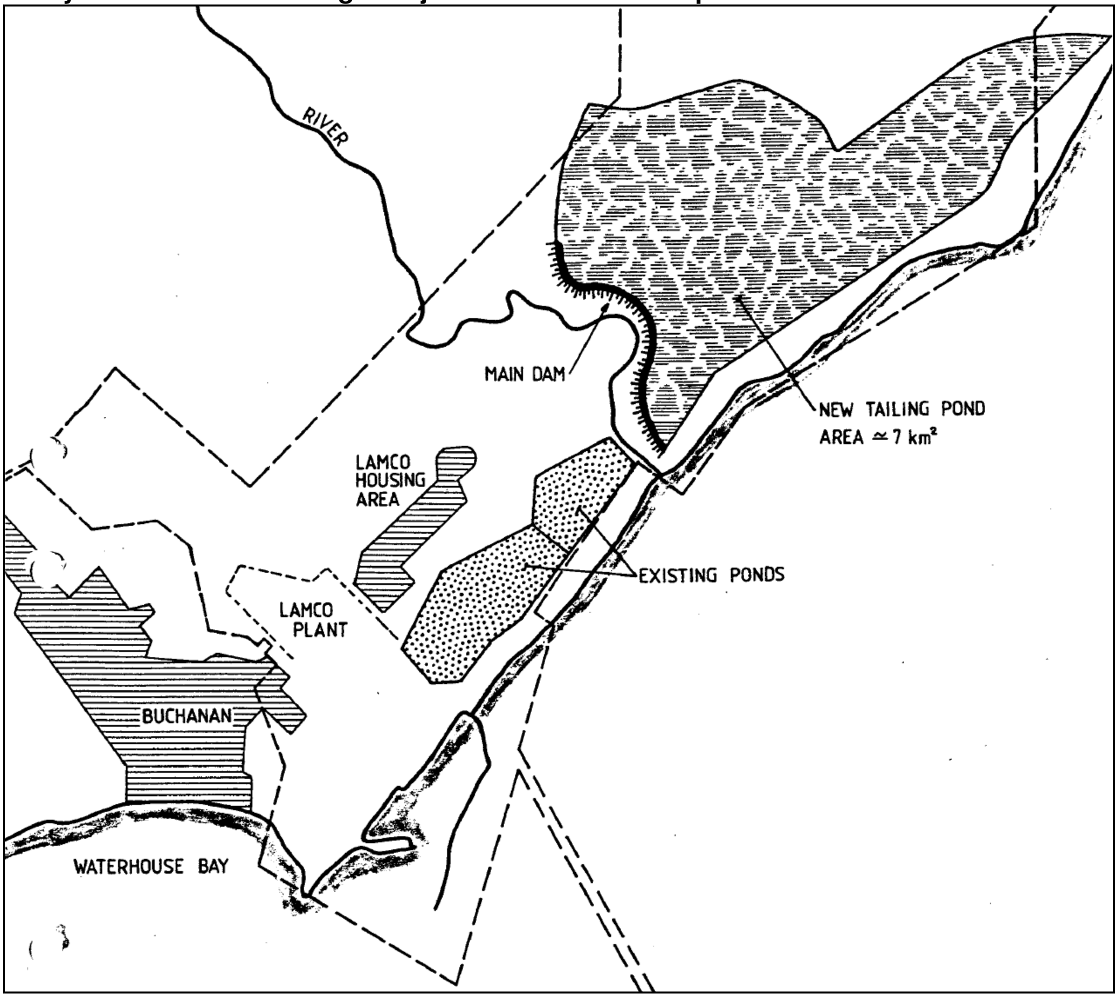
Figure 4.37: Sketch of the proposed Buchanan layout, from the LAMCO 1980 Feasibility Study for the Western Range Project which was not implemented. North is to the left



When the Nimba Western Range concession was established and awarded to Mittal Steel in 2005, a similar layout was envisaged and the concession boundaries drawn accordingly (see Figure 4.38). This option was therefore considered. An immediate disadvantage was that it would involve bringing a very large volume of material 255 km across the width of Liberia only to waste half of it as soon as it got there and was put through the concentrator. In terms of logistical rationalisation and transport economics, as well as fuel saving, it makes a great deal more sense to concentrate ore as close to the mines as possible. According to the current plan, some 150 million tonnes of tailings will be generated in the proposed life of the mines. This would equate to 20,000 train loads requiring 10 million kilometres of locomotive haulage. Any alternative must be favoured that can reduce the vast amount of diesel required to achieve such wasted journeys.

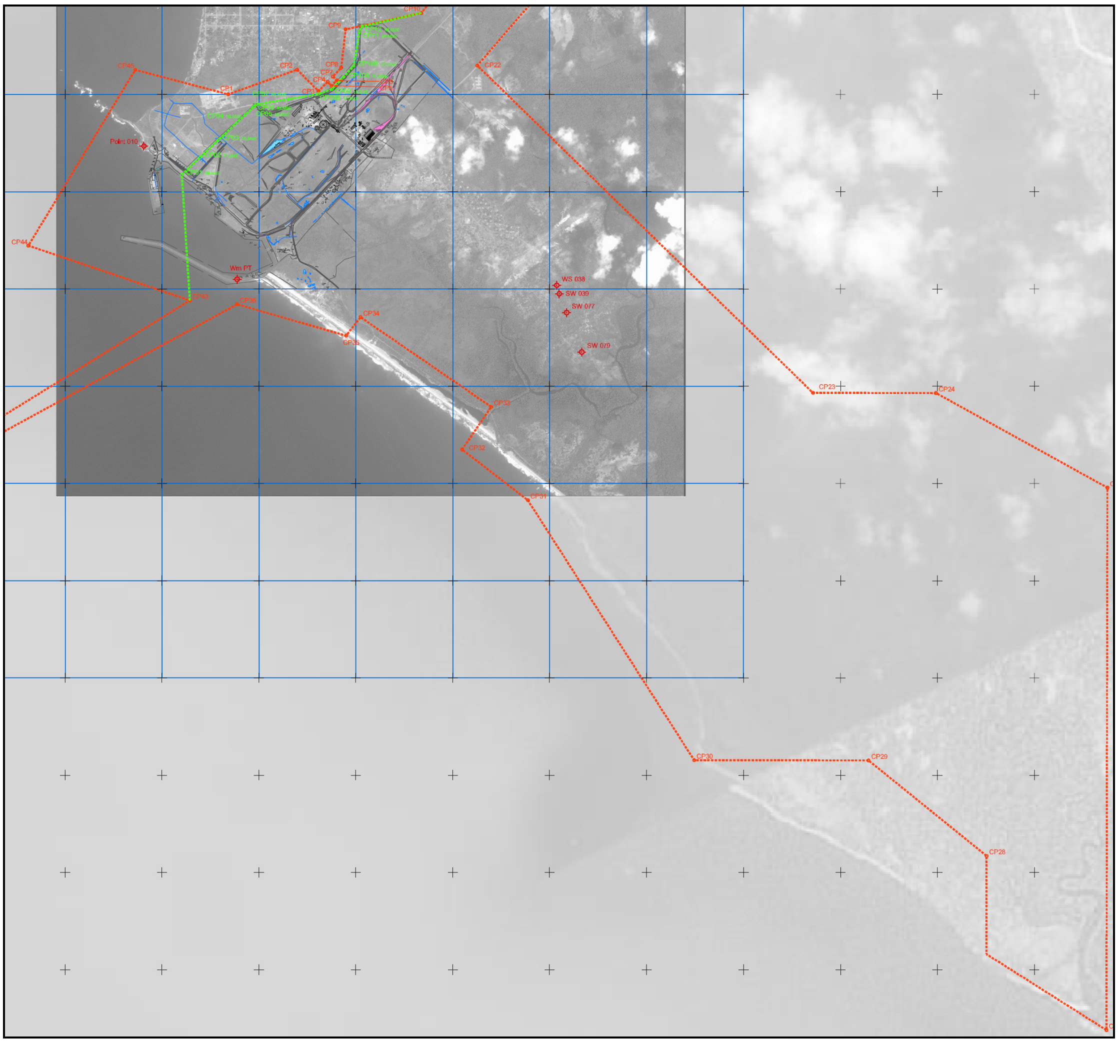
Beyond the economic aspects and the additional carbon wastage, a number of other disadvantages were identified, mainly of environmental significance. Among these were the following.

- The extensive coastal plain is flat and has no natural topography to use as part of the tailings dam. An artificial dam would therefore have to be constructed around the entire periphery of the facility, requiring a vast amount of engineered fill material.
- For some kilometres inland, most of the coastal plain is composed of sandy deposits that derive from Quaternary era raised beaches. This means that seepage rates are high and

that a clay lining would need to be installed under the tailings facility to reduce seepage of contaminants into the underlying aquifer.

- For the same reason, there is no suitable material to use as engineered fill in dam construction. This would have to be found inland and hauled to site. Laterites in this area are more intensively farmed than in Nimba, and hence there would have been very considerable resettlement. A series of haul roads would also be required.

Figure 4.38: Map of the ArcelorMittal concession boundaries at Buchanan, showing the south-eastern extension to allow for a large tailings dam in the area identified by LAMCO. North is upwards



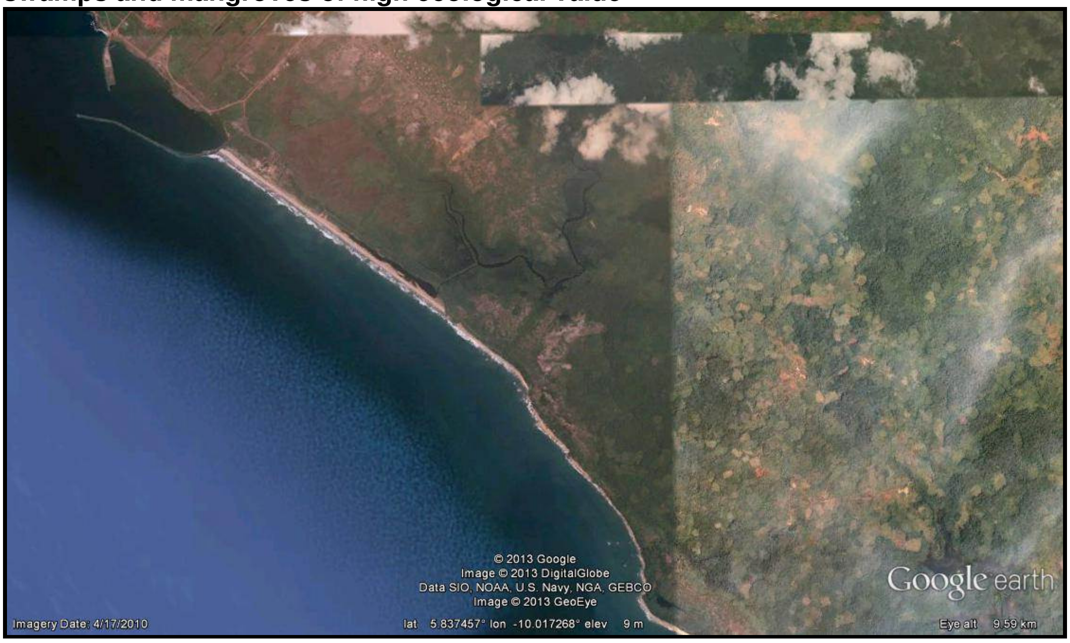
- Water supply would be problematic. Although LAMCO planned to derive this from the Benson Creek estuary, and the ArcelorMittal concession made provision for this, the situation has changed greatly since LAMCO days. The population of Buchanan City is now considerable larger, and the Benson River is heavily used for municipal water supplies, as well as a fishery. It is therefore no longer suitable as a water storage and supply facility, especially in the dry season. No clearly viable alternative water supply scheme has been identified.
- The very intense rainfall at Buchanan would make tailings management extremely difficult during the wet season. It is not clear where excess water would be stored in the wettest months. With monthly rainfall totals of 1.5 metres and semi-annual totals of over 5

metres being quite common, a large surface area of tailings pond would need a large surplus water storage facility for part of the year.

- The coastal plain is also used quite intensively for agriculture (see Figure 4.39). Small rural communities here are relatively stable compared with Nimba (where habitation is clustered into large towns using extensive areas of the surrounding land for shifting cultivation). In this particular coastal area, the community of Balconie consists of a series of scattered villages over a considerable area. These are dependent partly on agriculture and partly on marine fishing, and any relocation would have to ensure access to the sea (i.e. they could not simply be moved inland).
- The fact that relocation of permanent villages would have been required at all is a significant disadvantage of this option, since the tailings management facility selected near Mount Tokadeh does not require the removal of any permanent houses.
- The tailings dam footprint would encompass a number of areas of swamp, mangroves and mixed coastal habitats. These contain a wide range of biodiversity. While this is unlikely to be particularly special in the way that is the case for some of the Nimba rainforest biodiversity, the coastal plain is increasingly threatened by development and fragmentation.
- Infrastructure to support the tailings management facility would have to be run across the upper beach. This would include access roads, flow and return pipelines, seepage collection and water treatment ponds. These would all be concentrated into a narrow corridor between the tailings dam and the higher beach level, characterised mainly by a line of coconut trees. Engineering would be problematic, and impacts on the beach almost inevitable.
- Significant traffic would be generated past the beach that stretches south-eastwards from Buchanan. Close to the city this is widely used for recreation; further away it is a nesting ground for marine turtles, all of which are internationally categorised as threatened or endangered.

The outcome of these concerns was that the company decided against pursuing the option for a processing plant and tailings facility at Buchanan, and determined on placing them close to the mine site in Nimba for both economic expediency and environmental reasons.

Figure 4.39: Google Earth satellite image of the concession area south-east of Buchanan, envisaged as a possible site for a large tailings dam. A patchwork of dense farmland is visible in the eastern section of the image. This is interspersed with creeks, swamps and mangroves of high ecological value



4.16 Construction Materials Sources

The company's consultants have devoted considerable effort to the identification of sources of rock and aggregate for use in construction and as ballast on the railway. Although some alternatives have been found, principally around Sanniquellie, none have been as technically or environmentally good as the three locations previously quarried by LAMCO. These are: Neekreen Quarry in Grand Bassa, accessed by a purpose built haul road that was previously a rail spur, from a point at km 12 from Buchanan; Greenhill in Bong, close beside the railway at km 149; and Glaton Hill, about 2 km south of Yekepa. Since these all have good access and are brown field sites, they have been identified as the primary sources of construction materials for the project, and have therefore been included in all the company's previous environmental permitting applications.

Selected sand and gravels are required for concrete-making for the infrastructure at Buchanan, for the concentrator, and for the filter and drainage units of the tailings management facility and water retention dam. The closest source to the Tokadeh site for sand is the nearby Dayea river channel. However, rivers and streams including their buffers (30 metres to either side) were identified as sensitive areas in the environmental constraints mapping (see section 4.5). Local sand suppliers have led consultants to other sources, including those in the Bee Creek (from which the main water supply for Sanniquellie is abstracted), which they say are approved officially. So far the company's environmental staff have not yet seen any river-based source of sand that they could accept as the subject of an application to the EPA for a permit. At the time of preparing this statement, the intention is that sand will be derived from the rock quarries as a by-product, or brought by rail from yet-to-be approved sources near Buchanan, from inland Quaternary raised beach deposits.

The use of beach sand has been entirely discounted by the company on environmental grounds. This is because the quarrying of sand from the active beach raises the potential for coastal erosion and removes the nesting habitat for the endangered marine turtles that come ashore on the Liberian coast to lay eggs. An example is shown in Figure 4.40 of a commercial sand quarry on Waterhouse Bay to the north of Buchanan. Although the operator claimed to have an official permit, the company refused to allow its consultants and contractors to purchase sand from this location. Ancient beach deposits are available a little way inland along much of the central coast, which provide large deposits of sand that can be extracted at much lower environmental cost. The company considers these to be better locations, but they require more washing to remove accumulated organic material and so are not favoured by contractors.

Fgure 4.40: Sand quarrying from the active beach at Waterhouse Bay, a few kilometres north of Buchanan. The company will not entertain requests from its consultants and contractors to utilise materials from such locations on environmental grounds

Low-permeability earth fill is required for the sequential construction of the tailings dam. For this purpose limited suitable quantities might be obtained from surface soil material obtained from open pit stripping works at the Tokadeh mine. Investigations to identify suitable embankment construction material were the subject of a special study, permitted by the EPA under a Project Brief and environmental management plan. At the time of compiling this statement, that study was still underway. Similarly, low permeability earth fill will be required throughout the mine life to complete sequential construction of the tailings dam. According to the Phase 2 Feasibility Study Report suitable excess material won from open pit stripping works will be stockpiled for use in construction works later in mine life. However, the use of this material for engineering will need to be balanced against the need for soil to restore the mined area. Since the replacement and subsequent management of low permeability soils is problematic in site restoration works, it may well prove advantageous to use any overburden from the mine with these characteristics for dam engineering, and to win suitable replacement soil material from borrow pits in less particular materials; if this happens, then priority will be given to borrowing material for mine rehabilitation from areas already disturbed, since the borrow pits will themselves also need to be restored.

Material for engineered earth fill is also required at Buchanan. As at Yekepa, a number of potential sources have been examined and samples taken to establish the suitability for different purposes. Although the availability of good quality laterite is not very high close to the coast, a number of suitable sites have been identified that meet strict environmental requirements. These are subject to separate environmental studies and permit applications.

4.17 Power Generation

4.17.1 Liquid Fuel Generator Sets

For the level of power generation required, solid fuel (i.e. coal) was discounted since its competitive advantages are only gained at higher capacities. At the level required by the project, the use of liquid fuel generator sets has two main environmental concerns: emissions and fuel handling. Other impacts such as noise are also easier and cheaper to mitigate. Options studied for thermal power generation therefore focussed on identifying the optimal fuel grade to use.

Emissions need to be minimised in order to reduce the amount of pollutants entering the atmosphere close to an important rainforest site. The concentrator and its attendant power plant are to be located in the broad valley between two major forest areas. These are the existing East Nimba Nature Reserve and the highly biodiverse West Nimba forest, in the area to the north-west of Mount Tokadeh, part of which may be designated a Nature Reserve under the proposed project offset programme.

Fuel transportation would be most safely achieved by rail (as was done by LAMCO) and this would be greatly preferred environmentally over road transport. A fully bunded and carefully managed tank farm would be a key requisite if this option is pursued.

Because of the proximity of the potentially sensitive forests to the plant sites, the establishment of liquid fuel generator sets some distance to the south would be preferred. A location near Sanniquellie was considered, but has the disadvantage of requiring the erection of high tension cables to bring power to the operational area, and was discounted mainly because of the impacts deriving from this.

The long term possibility exists of linking into the West Africa Power Pool (WAPP). ArcelorMittal has collaborated closely with the WAPP Secretariat, the World Bank and a number of consultants in this respect. One of the main corridors for power transmission includes a route parallel to the Buchanan-Tokadeh railway, and so there are several ways in which this might be achieved. However, WAPP depends on the finalisation of complex international agreements between the ECOWAS members and at this stage is still only at the concept stage.

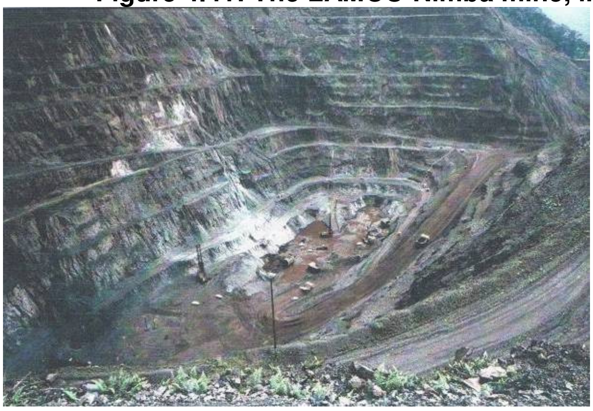
4.17.2 Hydro-electric Power Schemes

While these have the advantages of having no emissions during operation, and requiring no hazardous materials, there can be serious problems of landtake. As discussed above, for reasons of biodiversity conservation most off the areas to the west of the ArcelorMittal concession were designated by the company as off-limits to a large reservoir. A run-of-river scheme on the St John might be feasible, but the nearby section forms the border with Guinea and this would lead immediately into a need for international collaboration. The Dayea valley may offer possibilities, but with the potential of flooding both inhabited areas and infrastructure.

Conversion of the old LAMCO Nimba pit (Figure 4.41) into a reservoir was once thought to be feasible. A reasonable head would be simple to achieve, but recharge rates are too low, especially in the dry season, to generate anything like enough power for the project's industrial operations. Also, this pit is within the East Nimba Nature Reserve, although given the despoliation of the area, its development as a small scale hydro-electric scheme in the future may be acceptable if it came with a package of rehabilitation of the eroding spoil tips and revegetation of the former mine benches along the ridge to the south.

A reservoir to the east of Mount Tokadeh was proposed by LAMCO in 1980 as water storage to supply the proposed tailings management facility. This probably would not have had enough head to be viable for hydro-electricity generation. Also, it is in a relatively densely populated area where there is a considerable proportion of tree crops, which indicates more intensive agriculture, and more organised land registration and utilisation. The town of Zolowee would be badly affected, plus the main agricultural lands for both Zolowee and Gbapa.

Figure 4.41: The LAMCO Nimba mine, in May 1989 and March 2010



A hydro-electric power options study was undertaken in 2010-11 by AMEC as part of the Feasibility Study. This concentrated on the rivers in the northern part of Nimba, to avoid the need for long transmission lines. The results of this are summarised in the table in Figure 4.42.

Figure 4.42: Summary of the potential resources for hydro-electric power in the project area

Sub Catchment	Discharge	Monitoring Point	Coordinates		Elevation	Surface (km2)	Measurements			Estimation		
			East	North			Min. flow (m^3/s)	Mean flow (m^3/s)	Max. Flow (m^3/s)	Design flow (m^3/s)	Head (m)	Power (MW)
Saint John	Atlantic Ocean	WQ 50	E=536352.73	N=851698.42	426.00							
		WQ 49	E=531228.99	N=834223.79	400.00							
		WQ 14	E=530792.66	N=829518.49	393.00	934						
		WQ .9	E=528499.30	N=826773.68	388.00	1240						
		WQ 60				4519	19	136.1	233.5	100	50	41.5
Gba	Saint John	WQ 4	E=537120.33	N=837228.55	419.00	80				3.0	170	4.2
Vellie Creek-Dehn	Gba	WQ 51	E=544807.01	N=841458.69	490.00							
		WQ 3	E=541370.93	N=841031.07	451.00	23	0.14	0.61	2			
Dayea (Mein)	Saint John	WQ 52	E=561731.79	N=842078.91	990.00							
		WQ 13	E=555352.28	N=836870.57	544.00	31						
		WQ 2	E=543369.95	N=831048.98	448.00	102	1.82	4.84	18.22	15	100	12.5
		WQ 5	E=531629.51	N=827022.85	406.00	318						
Kahn	Dayea	WQ 53	E=547095.65	N=839198.09	496.00	64				2.5	60	1.2
		WQ 10	E=543114.75	N=831452.64	440.00							
Seka	Dayea	WQ 54	E=552625.30	N=831618.11	720.00							
		WQ 12	E=554431.88	N=836089.57	560.00	13				1.0	160	1.3
Yiti	Dayea	WQ 55	E=550246.54	N=830703.35	685.00							
		WQ 6	E=542060.72	N=827084.95	450.00	41				3.0	230	5.7
Madayea	Dayea	WQ 56	E=537278.18	N=823927.59	675.00							
		WQ 8	E=540950.45	N=827116.03	452.00	21	0.08	1.11	5.42	2.0	280	4.6
Daileh Gordeh	Madayea	WQ 15	E=536487.36	N=824283.67	788.00	2						
Bee Creek	Ya river	WQ 57	E=535595.60	N=820759.26	478.00							
		WQ 1	E=532960.51	N=815052.81	439.00	20	0.07	1.45	7.12	2.0	40	0.7
Guan	Bee Creek	WQ 58	E=537240.70	N=820409.48	467.00	5	0.13	0.25	0.8			

There are three water courses that appear attractive in terms of available head.

- Vellie Creek and Dehn River, which are tributaries of the Gba River. These are currently unaffected by mining but might be in the future. The estimated potential power is 4.2 MW.
- Yiti River, which receives runoff from the main Nimba ridge with significant sedimentation resulting from unconsolidated workings in the former LAMCO mines. The estimated potential power is 5.7 MW.
- Dayleh Gordeh Creek, a tributary of the Madayea River. This has been badly affected in the past by former LAMCO workings on Mount Tokadeh. The estimated potential power is 4.6 MW.

The most important catchments in the area are the Saint John River and the Dayea River. Scattered flow measurements have been done in both rivers, which allow for a rough estimate of flow for hydro-electric plants. The main disadvantage is that both rivers have a mild slope (the steeper, upper part of the Saint John is in Guinea). This means that to create a significant head for hydro-electric generation would result in higher costs.

- Dayea River receives runoff from the former LAMCO Nimba mine area, with significant sediment loads. The estimated potential power is 12.5 MW.
- Saint John River is the one that presents the highest potential for hydro-electric power development. The estimated potential power is in the range of 30 to 60 MW.

The option of hydro-electric power was not eventually taken forward for the following reasons.

- There is not enough river flow data, and a much longer time series is required. This would delay the establishment of the power system to a date too late to contribute to the early part of the project.
- On the basis of the information gathered, and summarised above, the prospect was not good. At best, only the St John could be considered as potentially producing adequate power.
- High natural sediment loads in the rivers would make hydro-electric power generation problematic due to the silting of intakes and reservoirs, and abrasion of turbines.
- Significant environmental and social issues would need to be considered in the extensive landtake likely to be needed for a reservoir big enough to supply dry season power requirements.

4.17.3 The Nuclear Power Option

The possibility was considered of installing a small nuclear power plant. Sealed modular units that use uranium nitride fuel rods and a lead-bismuth coolant are now available at competitive commercial rates. These are readily transportable to remote sites and have a ten-year lifespan. The technology has been developed by a United States government research institute, partly in collaboration with the US National Aeronautics and Space Administration, since the original intention was to develop a nuclear power system to fuel long space flights. Nuclear power generation would have some compelling environmental advantages over conventional thermal power plants: in particular, there would be no gaseous or particulate emissions, and no need for regular supplies of fuel. The landtake would also have been much smaller. Economically it appeared to have a favourable overall cost.

The advantages of a small nuclear power plant were, however, outweighed by the disadvantages. The manufacturers estimated a five- to seven-year delivery and installation time; there were obvious uncertainties about permitting since Liberia has no previous nuclear installations; the issue of the reprocessing of the spent fuel rods would also need to be addressed. In addition, the continuing political uncertainties in the West Africa region cast doubt over the wisdom of installing such a facility in a remote location.

4.18 Other Options

4.18.1 Alternative Volumes and Financing

A number of alternative strategies were investigated in relation to different levels of production and different financing scenarios. These mostly revolved around modelling of the scale of investment, production levels and mine life period. The proposed option covered by the ESIA submitted was shown to be the best. The alternatives cannot be described in any detail due to the commercial sensitivity of the information used to establish their viabilities.

4.18.2 Interim Wash Plant Option

LAMCO operated a wash plant to create a semi-refined product known as Nimba Washed Fines. An option was considered to emulate this by establishing a new wash plant that would be used to enrich DSO for three years from mid 2013 to 2016. Its maximum productivity would be 30 million tonnes, with a maximum of 10 million tonnes of waste product with a volume of 5 million cubic metres. This alternative was given initial consideration for location at both Buchanan and Tokadeh.

At Buchanan the main advantages identified were that the wash plant could be located next to the old LAMCO wash plant site, and potentially the old LAMCO tailings facility could be re-opened. This would entail a continuation of a previous site use, with no resettlement issues. Identified constraints were the limited understanding of hydrology and hydrogeology in the Buchanan area and in particular the current water users of the Benson River, which was LAMCO's water source (Buchanan has expanded since LAMCO times and there may be much greater reliance on this water source, even though it is part of the concession). Also, the LAMCO tailings dams are in unknown conditions of stability and are very close to a pristine area of coast.

At Tokadeh the main identified advantage was that the company already had a good understanding of most environmental interactions through extensive previous studies. Disadvantages were that the wash plant would be in an entirely new site, a tailings management facility would have to be designed and opened up very quickly, perhaps before it might be possible to complete adequately thorough hydrological and hydrogeological assessments. Also, water supplies may be problematic during the dry season unless a full water storage and recycling system is set up (as planned for concentrate mining), and extensive early resettlement would be necessary.

In the event, the wash plant option did not even go to the pre-feasibility stage for a number of reasons, including some that were not related to the environmental viability.

The final layout details for the mine sites and for Buchanan Port are shown in Dwgs 4.1 and 4.2 and 4.3 respectively and it is these that have been used in this ESIA. The layouts shown in supporting Volumes 3 to 5 inclusive have been superseded. The final layouts (December 2012) are provided and assessed in Volume 1 only. Dwgs 4.4 and 4.5 show the latest proposed locations for the TMF, Concentrator and mine borrow areas.

4.19 No Development Option

In line with international best practice, the "without project" alternative has to be considered. The without project case is essentially the continuation of the existing condition that has been in place since 1992 when the last of the LIMINCO shipments occurred and Liberia's iron ore industry ground to a halt as the civil war became more pervasive. This condition is the baseline case for each of the environmental receptors. In the Nimba area this would involve continual slash and burn in forest areas and ongoing gradual degradation of forest resources. It would also involve on-going social deprivation, including high rates of unemployment or underemployment and poverty in many cases. Aspects of inadequate water supply and sanitation at Yekepa would also continue, though proposed water treatment and waste management plans for Yekepa under Phase 1 are still not implemented. The legacy impacts associated with LAMCO mining in terms of water course pollution would also remain, though there are no plans in place for ArcelorMittal to remedy this under Phase 1, and its remediation under Phase 2 depends on the detail that is finally agreed with the government and other stakeholders for the proposed offset programme.

Along the railway and at Buchanan port the existing conditions would also continue in the without project case. Along the railway there are currently low levels of environmental impact though communities in the corridor suffer from the same limited economic opportunities, low living standards and social deprivations as outlined above for the Nimba area. At the port existing issues concerning potable water supply and contamination from oil storage tank farms would remain, along with the disused ore handling infrastructure derived from LAMCO operations.

The 'with project' case will not necessarily prevent or rectify any or all of the above conditions, though there will be an injection of finance and employment into the local economy and the ESIA-ESMP identifies options and actions for environmental improvements. Some of the negative existing conditions will be addressed as a result of the need to put Phase 2 infrastructure and provisions in place, including water supply and sanitation and, reinstatement of mining and port-handling operations.

The without project case would mean that there would be no mining-induced losses or pressures additional to Phase 1 effects on species or habitats of important biodiversity. Landscape impacts and drainage system pollution would remain at their Phase 1 levels.

The without project case would also mean that Liberia as a nation did not benefit from the generation of around four thousand jobs over a period of some twelve years; since formal jobs are so scarce. It would not receive the royalties from the sale of iron ore, which at the lowest likely market price may yield over US $ 50 million per year during Phase 2, or the considerable employment and other taxes paid by the company. It would not benefit from the ArcelorMittal County Social Development Funds of $ 3 million per year, or the other boosts provided by the company in funding for highway construction, training and capacity building. These are all significant benefits to the socio-economic environment, even if they bring with them certain impacts that need mitigation. In its current condition, Liberia badly needs projects of this nature to help it rebuild after the civil war and to get back on the road towards equitable and sustainable development. This project will be the biggest single contributor to Liberia's gross domestic product for the foreseeable future.

To summarise the following considerations are relevant to the 'no development' option:

- **Contribution to the national gross domestic product (GDP)**. The mining, processing and transportation that would lead to the exporting of 15 million tonnes of iron ore in Phase 2 would provide an additional $2.4 billion of clear income to the government. This figure is derived from the International Monetary Fund, which applied the permanent income approach to the projected revenues of the existing ArcelorMittal iron ore mine at Yekepa (IMF Country Report No. 12/340, November 2012). The present value (2011) of the future stream of revenues was estimated to be US $2.4 billion. The permanent income from this was calculated to be US $20 million per year at constant prices (in current prices the income would rise by inflation). Permanent income would be about 1.3 percent of 2011 GDP.
- **Credibility for other mining companies to invest in Liberia**. A number of other companies are following ArcelorMittal, albeit much more slowly, in anticipation of an increasingly favourable environment in Liberia in which to invest. Abandoning the Nimba Western Range mountains after only extracting the high grade iron ore in the current Phase 1 would be a strong vote of no confidence in Liberia.
- **Driver of economic activity.** The Government of Liberia is counting heavily on the development of its iron ore resources to be the engine that drives economic activity in the country, and to underlie its current plans to be a middle income country by 2030 (through its ambitious development plan of Liberia Rising 2030).
- **The opportunity would be taken up by another developer**. If ArcelorMittal does not go forward with this project, the concession would probably be acquired by another mining company, for which the strategy could be to obtain access to the infrastructure for export of Guinean ore instead of development of the Liberian resource.
- **Operation of the railway**. The railway and highways operated and maintained by ArcelorMittal could fall into disrepair again.
- **Employment benefit**. The thousands of staff employed by the project will benefit from a wide range of skills and training opportunities which would be lost without it, but which will increase the capacity of the national workforce if the project goes ahead.
- **Environmental Protection**. High biodiversity habitats would not be destroyed and the increased pressures on endangered species would not take place. The residual risks associated with downstream pollution in water courses would be avoided. Impacts on land use and cultural heritage would not occur and the negative social impacts identified by this ESIA would not arise. However, the situation is not quite as simple as this implies because there will inevitably be other pressures to develop iron ore resources in this region if this project were not to go ahead. Phase 2 provides opportunities to resolve some of the significant environmental damage already incurred under LAMCO and Phase 1 while also acting as a driver through offsetting programmes to establish an integrated and sustainable framework for the long-term protection of the higher quality critical habitats that neighbour the Phase 2 footprint.

5 ESIA SCOPE AND METHODOLOGY

5.1 Purpose and Scope of ESIA document

5.1.1 Purpose

Under Part III of the Act creating the Environmental Protection and Management Law (EPML) of the Republic of Liberia[2], an EIA License or Permit is required from the Environmental Protection Agency (EPA) prior to commencement of activities specified under Annex 1 of that Law. Consideration of the Project Brief (ArcelorMittal Liberia Ltd, 2008b) by the EPA identified the need for a full Environmental and Social Impact Assessment (ESIA), as the mining elements of the Phase 2 project outlined in Table 5.1 fall into Category 15 (Extractive Industries), 18 (Waste Treatment and Disposal) and 7 (Energy Industry) of Annex 1 (Section 6) of the EPML, while associated ore transport and town infrastructure (including power generation) fall into Category 13 (Building and Civil Engineering Industries). Both mining operations and associated transport and infrastructure are therefore subject to a mandatory EIA process.

Section 8.4 of the Minerals and Mining Law (MML) (GoL, 2000) refers to the need for an "Environmental Impact Assessment Study", to determine "the adverse impact (that)… activities... may have on the environment, and set forth a plan of mitigation and reclamation", to be undertaken prior to granting the Mining License. It does not, however, make any specific reference to the EPML requirement for an EIA Licence or permit or to EPA involvement in such a process, neither does it provide guidance on the scope or level of detail required for such study. ArcelorMittal discussions in 2005 with the Ministry for Lands and Mines (which has responsibility both for implementation of the Minerals and Mining Law and as Line Ministry for the EPA) confirmed that a "strategic" environmental assessment that identified the likely major significant effects of the project on social and biophysical environments, and demonstrated the ability to mitigate significant adverse effects that may arise, would meet the requirements of Section 8.4 of the Minerals and Mining Law in respect of granting a Mining License.

Following completion of the strategic environmental assessment, a Mining Licence was granted and the Company commenced the environmental and social impact studies necessary to meet legislative requirements and obtain the necessary environmental certificates.

The rationale and methods applied to this ESIA study have been based on the EPA's EIA Procedural Guidelines (EPA, 2006). However, it is recognised that, although Section 3.3.3 of the Guidelines requires the ESIA to describe how the project rationale considers "similar projects and methods used therein to identify, predict and evaluate impacts" aside from the long defunct LAMCO/LIMINCO project, there is as yet no precedent for similar projects that have been executed in compliance with current international environmental assessment and mitigation requirements in the Liberian context on which to draw. In the case of the LAMCO/LIMINCO project it is probably true to say that the environment remains in its early stages of recovery from unmitigated impacts. The rationale and methods applied to this ESIA have therefore drawn on international good practice and methods applied elsewhere, in particular those applied in West Africa to mining studies, (e.g. the use of rapid assessment techniques – in this case Biological Preliminary Assessment, (BioPA) - for ecological evaluation) and guidance advocated by the World Bank Group (WBG) and International Council on Mining and Metals (ICMM)). The specific rationale and method are described in each of the reports in Volumes 2-5.

The aspects of the Phase 2 infrastructure and operations that are subject to the Liberian ESIA process have been determined by consideration of their inclusion in Annex 1 of the Environmental Protection and Management Law of the Republic of Liberia (EPML).

This Phase 2 ESIA is a follow up to the ESIA carried out and submitted by the Consultant in September 2010 for Phase 1 Direct Shipping Ore. As is described in Section 7, much of the

[2] Hereinafter throughout this document this law is referred to as the EPML

environmental baseline information used in this ESIA is derived from the same data collected for Phase 1 given the similar geography of the two sets of layouts. However, it has been supplemented with additional fieldwork to allow the specific Phase 2 elements to be assessed. Table 5.1 illustrates the scope and timing of Phase 2 in the wider project context.

TABLE 5.1: PROJECT SCOPE AND PHASING

Scheme Element	**Phase 0 - 2008-2010 -** Enabling Works	**Phase 1 - 2011- 2015 -** Small Scale (Direct Shipping Ore (DSO) Production – the subject of the ESIA/framework ESMP prepared by Scott Wilson (now URS) in 2010	**Phase 2 Concentrator - no earlier than 2014 - 2025** Full Production – the subject of the ESIA reported in this document
Mining	Exploratory drilling at Tokadeh, Gangra and Yuelliton starting in January 2008 and completed in December 2010.	Production at the Tokadeh and Gangra-Yuelliton ore bodies, road transport between Tokadeh and Gangra-Yuelliton, handling and loading of DSO onto trains.	Expansion of production at Tokadeh / Gangra- Yuelliton ore bodies. This will involve the introduction of ore concentration operations, construction of a reservoir, dam and tailings facilities, a power plant, local water abstraction and construction of a new camp at Tokadeh.
Transport of ore between the mines and Buchanan	Rehabilitation of the railway line and associated service and access roads, with low levels of train and truck movement along them. Re-opening and operation of the quarry at Greenhill	The mining will be supported by operation of the existing railway line	Will be supported by additional enhancements to rail infrastructure and increase in number of train movements. Continued utilization of the Greenhill quarry for railway maintenance purposes.
Export of ore from port at Buchanan	Rehabilitation of the landside infrastructure and operation of the port at Buchanan, to support Phase 0 rail rehabilitation. Marine side rehabilitation not required.	Operation of the landside areas of the port to enable receipt and outward export of DSO. (Marine operations - dredging and disposal of materials – were not part of the ESIA. The work was covered by a separate application to the EPA).	Will be supported by additional enhancements to port facilities and entail increased movements of trains and vessels.
Township rehabilitation	Rehabilitation of existing housing and township infrastructure.	Rehabilitation and operation of water, and waste related infrastructure at the township of Yekepa and Buchanan	Will be supported by additional enhancements to community infrastructure

In addition, the Company has scheduled further mineral exploratory work within its Concession subject to Government approval. Potential further mining activity within the wider Nimba Range will have implications for the Consultant's recommendations for compensatory measures contained in this report. It is recommended that the full extent of proposed mining in Nimba Range is reviewed as a whole, once the details are known. Only then can the full extent of impact be assessed and sustainable and meaningful compensatory and offset measures be designed.

5.1.2 Scope

The scope of the environmental issues to be considered in undertaking the ESIA has been determined through consideration of:

- Part III of the EPML;
- the EPA's Guidelines (EPA, 2006);
- relevant international and sectoral guidance including:
- World Bank guidance documents, including the IFC Guidelines (IFC, 2007a-c), and
- the International Council on Mining and Metals;
- the ESIA scoping process and comments and feedback received as a result of the associated consultation;
- the EPA review of the Environmental Scoping Report (URS for ArcelorMittal Liberia Ltd, 2011).

This resulted in an initial detailed Terms of Reference (documented in Section 7 of the Environmental Scoping Report), which was subsequently modified to take account of the EPA's comments. Details of the scope of this ESIA are also documented in the following section.

5.2 Methodology

The general methodology adopted in conducting this assessment follows that outlined in the Liberian Environmental Impact Assessment (EIA) Procedural Guidelines. The approach has been to develop as comprehensive a baseline data set as possible to facilitate the impact assessment and to consult with as wide a range of stakeholders as possible. Volumes 3 (physical environment), 4 (biological environment), and 5 (social environment) of this report contain detailed methodologies as to how baseline data were collected and how, where relevant, these data were evaluated in terms of impact assessment and requirements for mitigation and environmental management. Customised approaches have had to be developed from relevant international good practice because Liberian standards are not yet in place. The baseline data collection and the ESIA process followed are outlined below. The impact assessment itself is contained in Section 9. The layouts shown in supporting Volumes 3 to 5 inclusive have been superseded. The final layouts (December 2012) are provided and assessed in Volume 1 only

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5.2.1 Baseline Data

The baseline data, summarised in Section 7, in its entirety comprises data collected during both Phase 1 and Phase 2 fieldwork programmes. The 2010 baseline data are contained in Volumes 3, 4, and 5 of the Phase 1 DSO ESIA (Scott Wilson 2010) and in the Addendum to it that represented the additional studies. The 2011 – 2012 baseline data collected as part of Phase 2 field investigations are contained within Volumes 3, 4, and 5 of this report. Much of the information contained in the former is derived from studies carried out by WS Atkins for the Company between 2005 and 2009. The methods of analysis applied have largely comprised assessment of available historical information and field surveys. Because the project operational area, covering mines, townships, railway and port, is large and the time available has been relatively short, it has proven cost-effective to combine the use of remote sensing techniques and targeted field surveys and monitoring exercises for all of the technical topic areas. Sources of historical data are limited but have included former LAMCO records in relation to meteorology, and previous ecological records from the Grassfield research station.

An information gap analysis undertaken as part of the Phase 1 ESIA review of baseline data identified a number of gaps in the baseline that required further survey. These included faunal information (namely small mammals, dragonflies, amphibians and reptiles) and gaps relating to non-timber forest products in the mine-affected and adjacent areas and cultural heritage issues. These gaps were filled by the Consultant during the programme of the Phase 1 ESIA and outputs were finalised at the beginning of 2012. The datasets have been utilised for the Phase 2 impact assessment and preparation of draft offset programmes.

In addition, a number of stand-alone gap-filling studies were undertaken in 2011 at the instigation of the Company. These included bush meat surveys and bio-monitoring (faunal surveys) undertaken by Conservation International (CI) and the analysis of meteorological data by the UK Met Office.

It should be noted that the targeted nature of many of the specialist field studies, most notably those connected with botany and zoology, has meant that only certain parts of the project area have been sampled. These sampling strategies were based on the Phase 2 layouts available at the time of the surveys (2011 and 2012) and these were, to an extent, different to those that are now current (Sections 3 and 4) and on which this impact assessment is based. The reasons for this have included engineering developments and decision-making in the interim and the attempt by the Company to avoid the most critical environmental areas identified in the development of its final layout, as described in Section 4.

5.2.2 ESIA Process

The ESIA process applied to the Phase 2 proposals comprised:

- review of policy, legal and admisitrative framework to ensure compliance in scope and methodology;
- review of the June 2011 Feasibility Study report developed by AMEC for the Company and relevant revisions of this report available at the time of the ESIA preparation;
- Review of the Project Description prepared by the Company in February 2013, and contained in Section 3 of this report;
- Review of final layouts and supporting reports and related documentation provided by the EPCM Consultant (AMEC) in July and August 2012 in relation to the Tailings Management Facility and between November 2012 and January 2013 in relation to the remainder of the layout;
- meeting relevant stakeholders initially to identify and collect all existing relevant data;
- meeting EPCM Consultants (AMEC, SNC Lavalin) to obtain design information relevant to the ESIA, as well as to discuss ways in which preliminary findings and outputs from the baseline studies could be included within the development of ongoing layout design;
- review and analysis of this information;
- identification of information gaps as a focus for further investigation (see above);
- initiation of technical studies and stakeholder consultations to expand the data base (see above);
- preparation of reports and other relevant documents.

All aspects associated with the Resettlement, Compensation and Livelihood Restoration of project-affected populations are the subject of separate studies and programmes undertaken by the Company both directly and with specialist inputs provided by rePlan Inc., a consultancy firm working in social development and resettlement. They therefore do not form part of this assessment, although cross-over themes with other related socio-economic aspects are discussed, where appropriate.

5.2.3 Project Elements and Receptor Fields Included in the ESIA

Project Elements

The main project elements included in this ESIA are detailed in Table 5.2. These are differentiated according to the main geographical categories of:

- The use of public roads by project vehicles and heavy goods vehicles transporting fuel and other hazardous materials, although most fuel apparently will be transported by rail. These roads primarily relate to those between Buchanan, Monrovia and Yekepa and alongside the railway between the Port at Buchanan and Yekepa;
- The mine sites of Tokadeh, Gangra and Yuelliton, the exclusion zone around them and all Phase 2 infrastructure, including the Tailings Management Facility, Eastern Sedimentation Pond, the Concentrator and crushing facilities, Tokadeh workshop and related facilities, waste dumps and stockpiles. Distinction is made between construction, operation and mine closure, i.e. temporary, long-term and permanent sources of impact. Related activities such as the handling of toxic and hazardous materials in the mine operational area and the management of drainage are also reviewed;
- Yekepa Township. Yekepa town has seen significant re-development as a result of Phase 0 and Phase 1 and the wide range of social issues that this involves were reviewed in the Phase 1 ESIA. For Phase 2 the range and depth of these issues is likely to be equivalent, if not greater. The Company intends to employ a Town Planner in order to develop an integrated Township Development Plan for Yekepa to address these issues. This will have to be the focus of a separate environmental assessment and mitigation plan prior to Phase 2 implementation, and therefore the township is not covered in any detail in this document;
- Buchanan Estate. Similar issues apply to Buchanan as Yekepa in terms of an increased, largely male work-force, with the social ills that may result;
- Railway, including increased train movements, extensions to sidings and the Greenhill Qaurry and semi-permanent camp;
- Buchanan Port, including increased shipping traffic and site operations, the fuel quay and oil storage.

TABLE 5.2: SUMMARY OF PROJECT ELEMENTS REVIEWED IN THIS ESIA

No	Site	Activity/Issue	Main Source of Potential Impact
1	**Road (and rail) Transportation Between Project Sites**	**1.1** Transport of fuel and other hazardous materials from Buchanan storage to all other project facilities	**1.1.1** Spillages of hazardous, combustible and explosive materials
		1.2 Use of public roads by ArcelorMittal vehicles	**1.2.1** Increased numbers of vehicles on public roads
2	**Mine**	**2.1** Construction and operation of access roads within the mine sites and between related infrastructure	**2.1.1** Permanent landtake for access and haulage
			2.1.2 Run off from roads including water, sediment and leaked hydrocarbons
			2.1.3 Vibrations and noise from traffic

TABLE 5.2: SUMMARY OF PROJECT ELEMENTS REVIEWED IN THIS ESIA

No	Site	Activity/Issue	Main Source of Potential Impact
			2.1.4 Potential for increased road accidents.
			2.1.5 Dust generation and air pollution
			2.1.6 Increased local access
		2.2 Mine Start-up and Operation	**2.2.1** Establishing an exclusion zone
			2.2.2 Construction of Eastern Sedimentation Ponds and the Tailings Management Facility
			2.2.3 Construction of Concentrator and crushing plant.
			2.2.4 Borrow pits for the Concentrator platform
			2.2.5 Construction of Tokadeh workshop, truck shop, admin building and explosives magazine
		2.3 Mine Operation - Tokadeh, Gangra, Yuelliton	**2.3.1** Mine clearing and ore extraction.
			2.3.2 Creation of spoil dumps and stockpiles
			2.3.3 Reduction in ridge line by up to 70m
			2.3.4 Operation of the Eastern Sedimentation Pond
			2.3.5 Operation of the Tailings Management Facility
			2.3.6 Operation of Concentrator and crushing plant, including power generation plant
			2.3.7 Operation of Tokadeh work shop / truck shop & admin. building
			2.3.8 Permanent removal of or prevented access to cultural sites
			2.3.9 Refuelling , storage and handling of oils, lubricants and other toxic, hazardous and flammable materials
			2.3.10 Blasting

TABLE 5.2: SUMMARY OF PROJECT ELEMENTS REVIEWED IN THIS ESIA

No	Site	Activity/Issue	Main Source of Potential Impact
			2.3.11 Changes to groundwater regime and surface water bodies brought about by excavation, drainage diversion, dewatering and abstraction for mine use
			2.3.12 Influx of people, especially men, in search of employment
		2.4 Mine Closure	**2.4.1** Runoff and erosion from disused mine surfaces
			2.4.2 Failure of waste dumps and TMF
			2.4.3 Creation of lakes formed in abandoned workings
3	**Yekepa Township**		**3.1.1** Population expansion
			3.1.2 Use of herbicide and pesticide
			3.1.3 Waste disposal
4	**Buchanan Estate**	**4.1** Estate management	**4.1.1** Areas of standing water and thick vegetation
			4.1.2 Use of herbicide/pesticide
			4.1.3 Increased numbers of residents.
		4.2 Power Generation	**4.2.1** Increased power generation
		4.3 Waste Water	**4.3.1** Operation of new system
		4.4 Water abstraction	**4.4.1** Substantially increased demand for water
		4.5 Solid Waste Management	**4.5.1** Substantially increased volumes of waste to be disposed of
		4.6 Buchanan City	**4.6.1** Population expansion in expectation of employment and other spin-offs.
5	**Railway**	**5.1** Increase in operations: higher numbers of trains	**5.1.1** Increased number of movements
		5.2 Operation of new siding extensions	**5.2.1** Altered train operations in these areas

TABLE 5.2: SUMMARY OF PROJECT ELEMENTS REVIEWED IN THIS ESIA

No	Site	Activity/Issue	Main Source of Potential Impact
		5.3 Greenhill quarry and semi-permanent railway maintenance camp	**5.3.1** Operational impacts such as erosion and runoff contamination.
6	Port	**6.1** Increased ship traffic and site operations.	**6.1.1** Increased shipment of ore and increased usage of fuel, oil and chemicals.
		6.2 Fuel quay and pipeline to oil storage facility.	**6.2.1** Import and storage of oil.

Receptor Fields

The following receptor fields have been examined, both in terms of baseline condition, impact assessment and mitigation:

- **Air:** air quality, including dust and gaseous emissions from the proposed Tokadeh concentrator and power plants;
- **Water:** surface water hydrology, including surface water runoff, erosion, sediment transport and water quality,and hydrogeology, including groundwater and water supply;
- **Land**: terrain and soils, including geology, engineering geology, geomorphology and landscape;
- **Fauna**: zoology, including terrestrial, freshwater and riverine and marine species and their habitats;
- **Flora:** botany, including forests, grasslands and other vegetation classifications;
- **People:** socio-economic aspects, i.e. impacts that affect people.

5.2.4 Stakeholder Consultation and Disclosure

The requirement for stakeholder and public consultation in the ESIA process as specified by the EPML has formed an important element of this ESIA, from raising awareness of the project's potential environmental and social impacts, through informing the assessment process and gaining agreement on the management and technical approaches to addressing potential adverse effects and maximising potential benefits.

Consultations were held with a wide range of stakeholders including:

- The Company management and employees;
- The Company's contractors and suppliers;
- Local communities and individual farmers;
- Representatives of the Government of Liberia and relevant line ministries – specifically the Environmental Protection Agency (EPA) under the Ministry of Lands, Mines and Energy, and the Forestry Development Authority (FDA);
- Local and international NGOs – specifically Fauna and Flora International (FFI) and Conservation International (CI);
- United Nations Mission in Liberia (UNMIL).

Details of the consultation process and results are given in Volume 5, Part 2.

6 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

In order to ensure legal compliance, as part of the Phase 1 ESIA a comprehensive review was undertaken of Liberian legislation, standards and relevant international best practice. This in turn facilitated the determination of assessment criteria appropriate to each technical topic area. For the present Phase 2 report any relevant amendments to legislation or standards were considered as required. In cases where Liberian legislation and standards are not yet in place such criteria have been taken from international approaches.

The following is an extract of the review undertaken for Phase 1. Further details are provided in Volume 2 of this ESIA.

Policy Context

As described in sub-sections 1 to 7 below, the approach to conducting this ESIA was informed by:

1. Liberian EIA legislative and policy requirements;
2. Other Liberian sectoral legislation, including that relating to forestry, wildlife, maritime environment, land tenure;
3. A number of international environmental conventions and agreements to which Liberia is a party;
4. International standards and best practice;
5. Internationally accepted criteria for biodiversity management;
6. Corporate Environmental Policy; and
7. Corporate Environmental Standards.

The section concludes with an overview of the key government institutions with responsibilities for, or an interest in, the ESIA.

6.1 Liberian EIA legislative requirements

In Liberia two principal pieces of legislation relate to EIA:

- The **Environmental Protection Agency Act** (2002), which established the EPA. This stipulates that an EIA be conducted for any activity and project likely to have a significant impact on the environment. The EPA's procedural guidelines for EIA (2006) provide a description of the process and its relevant components.
- The **Environment Protection and Management Law of the Republic of Liberia** (EPML), which is the principal piece of legislation on environmental protection and management in Liberia. This provides the legal framework for sustainable development and management and the protection of the environment by the EPA in partnership with other governmental and non-governmental institutions. Part III of the EPML provides the details for EIA, audit and monitoring and a general format for a compliant ESIA. Part IV, amongst others, makes provisions for environmental standards for water, air, and waste.
- The EPA is mandated to establish regulations relating to environmental standards covering to the full scope of the EPML. Such regulations have not yet been established. Until they are, non-Liberian standards are therefore being applied in connection with the proposed Scheme.

6.2 Other Liberian sectoral legislation

The key pieces of sectoral legislation that include provisions for environmental protection are:

- **The Constitution** (1984) of the Republic of Liberia;
- **The Minerals and Mining Law** (2000) which lays out the ownership and rights to minerals in Liberia and the requirements to explore and to operate mines. Chapter 8 covers Environmental Protection;
- **The National Forestry Reform Law** (2006) is now the paramount piece of forestry legislation. It covers all aspects of commercial and community use of forests including environmental protection (Chapter 8);
- The **Wildlife and National Parks Act** (1988). This covers the policies and objectives, the administration, and the establishment of protected areas, as well as their management including plans, and prohibited acts, controls on hunting, and the establishment of protected species;
- The **Nimba Nature Reserve Act** (2003) establishes the East Nimba Nature Reserve;
- The **National Biodiversity Strategy and Action Plan** (2004) is the key Government policy with regard to biodiversity. Two important guiding principles are those of sustainable use and sound management, and use of the ecosystem approach being critical to sustainable use of biological diversity;
- **The Community Rights Law** (2009). This establishes community rights regarding ownership and use of forest lands resources; and
- **The Inheritance Act** (December 1, 2003): This law gives the same property rights of western marriage to traditional marriage and governs the devolution of estates of inheritance for spouses in either type of marriage.

6.3 International environmental obligations and commitments

Liberia is a party to a series of international conventions, a number of which have relevance to the Scheme, namely:

- The International Convention on Biological Diversity;
- The Ramsar Convention on Wetlands of International Importance;
- The Convention on International Trade in Endangered Species of Wild Fauna & Flora;
- The Convention on the Conservation of Migratory Species of Wild Animals;
- The African Convention on the Conservation of Nature and Natural Resources;
- The United Nations Framework Convention on Climate Change (UNFCCC);
- The Stockholm Convention on Persistent Organic Pollutant;
- The Convention Concerning the Protection of the World's Cultural & Natural Heritage;
- The International Tropical Timber Agreement;
- The International Covenant on Economic, Social & Cultural Rights;
- The Extractive Industries Transparency Initiative; and
- MARPOL, the International Convention for the Prevention of Pollution from Ships.

More details on respective provisions of these conventions and their relevance to the scheme are provided in Volume 2 of this report.

6.4 International standards and best practice

The approach to this ESIA was guided in particular by international standards and best practice. The relevant main documents are:

- IFC Performance Standards and Guidance Notes on Social and Environmental Sustainability (2012);
- IFC Industry Sector Environmental, Health, and Safety Guidelines for Mining (2007).
- IFC Sector Guidelines for Railways (2007);
- World Bank Environmental Health and Safety Guidelines;
- World Health Organisation standards for air and water quality;
- International Council on Mining and Metals' Good Practice Guidance for Mining and Biodiversity (2006). Some aspects of this guidance are considered to be more specific, and hence more prescriptive and strict, that the related more general IFC guidance;
- International Association for Impact Assessment's (IAIA) Best Practice Principles on Biodiversity-Inclusive Impact Assessment (www.iaia.org);
- The Business and Biodiversity Offsets Program's Draft Principles on Biodiversity Offsets (http://www.forest-trends.org/biodiversityoffsetprogram/offsets.php).

6.5 International criteria for biodiversity

The proposed mine sites are close to Mount Nimba, and can be considered topographically as part of the wider Nimba Range. From a global conservation perspective, the Nimba Range is among the most important areas in Africa, with numerous endemic species, many of them globally threatened. Therefore, biodiversity issues are extremely important; and in dealing with them, a number of internationally accepted criteria and classifications will be applied as follows.

- The IUCN-World Conservation Union's **Red List of Threatened Species** (known as the Red List) has been in operation for over 40 years. This provides information on plants and animals that have been globally evaluated using defined criteria to determine the relative risk of extinction, and to highlight those species that are facing a risk of global extinction.
- Conservation International's concept of **Biodiversity Hotspots.** This is used to help set global conservation priorities. A Biodiversity Hotspot is defined as a region that contains at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and it has to have lost at least 70% of its original habitat. Over 50% of the world's plant species and 42% of all terrestrial vertebrate species are endemic to the 34 biodiversity hotspots.
- Areas of high conservation priority identified by the **West African Priority Setting Exercise** co-ordinated by Conservation International (CI) in 1999. This exercise used expert opinion and available data to identify at a finer scale the areas of most conservation priority within the Guinean Forests of West Africa Biodiversity Hotspot.
- Worldwide Fund for Nature's (WWF) concept of an **Ecoregion.** This is a region distinguished by its shared ecological features, climate, plant and animal communities of which 867 land-based ones have been mapped across the globe. The WWF Global 200 Ecoregions are those designated with the intention of conserving examples of the entire range of the world's ecosystems to enable conservation efforts to contribute to a global biodiversity strategy.
- BirdLife International's **Endemic Bird Areas.** These are defined as areas holding two or more restricted-range species, i.e. species with a global range of less than 50,000km^2; and **Important Bird Areas**, defined as areas which support populations of species regarded as critically endangered, endangered or vulnerable (see Red List above), or

with a significant component of populations of restricted-range or biome-restricted species, or an important congregation of water or sea birds.

- IFC recommended guidelines including those for the concepts of **Natural Habitat**, "*where the biological communities are formed largely by native plant and animal species, and where human activity has not essentially modified the area's primary ecological functions*", and **Critical Habitat**, which is a subset of Natural Habitat.

6.6 Corporate environmental policy

As a local operating company of ArcelorMittal, the conduct and operations of The Company are governed by a series of policies and guidelines which set out the corporate environmental and social policy (www.ArcelorMittal.com). The Company's environmental policy is focused on 10 principles as summarised in the policy statement of June 2007:

1. Implementation of environmental management systems including ISO 14001 certification for all production facilities;
2. Compliance with all relevant environmental laws and regulations and other company commitments;
3. Continuous improvement in environmental performance, taking advantage of systematic monitoring and aiming at pollution prevention;
4. Development, improvement and application of low impact, environmental production methods taking benefit of locally available materials;
5. Development and manufacture of environmentally friendly products focusing on their use and subsequent recycling;
6. Efficient use of natural resources, energy and land;
7. Management and production where technically and economically feasible of the CO^2 footprint of steel production;
8. Employment and commitment and responsibility in environmental performance;
9. Supplier and contractor awareness and respect of ArcelorMittal's environment policy;
10. Open communication and dialogue with all stakeholders affected by the Company's operations.

Further global policies of the Company that are relevant to environmental and social impact studies undertaken are:

- Energy Policy;
- Health and Safety Policy;
- Human Rights Policy;
- Diversity and Inclusion Policy;
- Risk Management Policy;
- Anti Fraud Policy;
- Community Engagement Guide; and
- Code of Business Practice;

as well as the following Plans:

- Gender Action Plan; and
- NGO Engagement Plan.

The Company has also stated its commitment to the United Nations (UN) Global Compact, which commits the Company to ten key principles in the areas of human rights, labour, the environment and business conduct. These can be found at

http://www.unglobalcompact.org/AboutTheGC/TheTenPrinciples/index.html

The Company has a Policy on Caring for Nature, described by the Company in the following manner: *Pending updating of the ArcelorMittal global Environmental Policy to be more inclusive of the Company's mining division, and to include the recognition of biodiversity and ecosystems services in areas potentially affected by its operations, in 2012 ArcelorMittal Liberia adopted its own Policy on Caring for Nature. This puts the key concepts of environmental protection relevant to the Company's Liberia operations into straightforward language that is accessible to all literate members of its staff and workforce. It is included in the Environmental Management Plans that are presented as part of Volume 6 of this ESIA.*

6.7 Corporate environmental standards

The Company's 'Environmental Standards Manual' (Vol 6, Part 2 of this document) provides the environmental standards and guidelines that will underlie the overall ESMP and site specific EMPs devised and implemented for further activities under the Scheme. This manual was specifically developed for the Phase 1 and 2 operations and it is an iterative document that will need to be regularly updated as appropriate. The standards and guidelines provided in this manual equally apply to the Company and its contractors and sub-contractors.

The applicable standards were derived from the following main sources:

- Standards derived directly by the Company to form the basis for the implementation of its infrastructure development and mining works;
- Standards attached to regulations in draft by the EPA;
- Other Government of Liberia standards;
- The environment-related sections of the OECD Guidelines for Multinational Enterprises;
- Standards adapted from other international sources, such as the UK Environment Agency, where none so far exist in Liberia;
- The Resettlement Manual (ArcelorMittal Liberia Ltd, 2011);
- The Minerals Development Agreement; and
- The Phase 1 DSO ESIA.

6.8 Authorities Involved

The key institutions that have responsibilities or interest in the ESIA are the following:

- The **EPA** as principal authority for environmental management in Liberia and the body which grants the Environmental Permit. EPA involvement must occur at both national level and through various County and District Environmental Committees in the areas in which the project is located, i.e. Nimba, Bong and Grand Bassa counties. At the national level EPA involvement includes review of Project Briefs, Scoping Studies, ESIAs and ongoing regular interaction with the Company and its consultants to ensure the ESIA studies are progressing as appropriate and are consistent with their requirements. The

District and Environmental Committees' involvement ranges from public consultation at the scoping stage, receipt of the ESIA from the project proponent, dissemination of contents to communities, inviting comment and holding hearings. The EPA is also responsible for establishing environmental quality and management standards and guidelines, and regulating compliance with such standards, as well as implementing measures for pollution control and issuing of relevant licenses.

- **Ministry of Lands and Mines** as line ministry for environmental issues but also in its role with respect to administering and regulating the use of public and private lands in Liberia, including mineral resources through mining licenses. Within this ministry, energy provision is administered by the National Energy Committee. Still within MLME, the Liberian Hydrological Services is a bureau under the Department of Mineral Exploration and Environmental Research, with the mandate to monitor, evaluate, manage and protect water resources and to provide technical support to water users. The Government of Liberia is a 30% shareholder in the Company and also performs the role of regulator to the industry.

- Other sectoral ministries and agencies with an interest in the Scheme, notably the **Ministry of Agriculture** (MoA) and its sub agency - the **Forest Development Agency** (FDA). The MoA regulates the forestry, fishery and agriculture sectors and has specific responsibilities for soil conservation. Other governmental institutions with environment-related responsibilities include the **Ministry of Education**, **Ministry of Public Works**, **Ministry of Health and Social Welfare**, **Ministry of Foreign Affairs**, **National Ports Authority** and the **Liberia Water and Sewer Corporation**.

- **Other relevant stakeholders**. These include local government authorities; potential suppliers, customers and contractors; labour unions; local, national, international NGOs, notably Conservation International (CI) and Fauna and Flora International (FFI)[3]; religious groups, universities and research centres; local and national government officials, multilateral development institutions, project financiers, local business, and industry associations. **Stakeholder representatives** include public representatives of regional, local and village councils; elders and religious leaders; chairmen or directors of local cooperatives and other community organisations; and local NGOs and Local Consultative Forums already set up for consultation of people affected by the Scheme.

[3] CI & FFI are strategic partners of the FDA, and they have collaborative agreements with the FDA.

7 DESCRIPTION OF THE ENVIRONMENT

7.1 Project area geography

7.1.1 Physical features

Liberia lies between approximately 4.5 and 8.5° North and 7.5 and 11.5° West. Buchanan coordinates are approximately 5.5° N and 10.1° W while Yekepa is at about 7.35° N and 8.5° W. Liberia may be divided into three main topographic regions: the coastal plains, the rolling hills, and the highlands. The highlands - a region of undulating plateaus or plains, residual hills and low mountain ranges - are located in the far northwest and north central parts of the country. This is the region in which Nimba County and the Company's Mining Concession is located. Altitudes range from around 450m ASL where the broad open valleys and undulating plains make up the plateau, to 1,700m ASL at Mt. Nimba. The hills and mountains tend to be steep-sided ridges, the slopes of which can have inclinations locally of up to 70°. Buchanan is located on the coastal plain, and the railway runs across all three topographic regions. The St. John River drains the entire area and forms the western border of the Concession and flows south-southwest roughly parallel to the railway line (crossing it twice) to reach the coast immediately west of Buchanan.

The main physical features of the northern part of Nimba County are the Nimba Range (trending northeast and rising to 1400 metres) on the east side, a series of north trending isolated hills and ridges (rising to about 1000 m) in the west and, in between, the broad Dayea (Mein) River valley (general elevation 400 to 500m). The St. John River which forms the border with Guinea is to the west. The county is bordered on the east by the Nuon River which forms the border with Ivory Coast and is the main tributary of the River Cestos (Cess). All these rivers meander across their plains leaving former river remnants which now form small lakes and swamps. The rivers contain a number of rapids and falls where they frequently divide into two or more rock strewn channels.

The Dayea (Mein) rises from the Nimba Ridge in the east and flows into the Saint John River to the west of the mine site (see Figure 2.2 in Section 2). The river receives water from the north-western and eastern sides of the Tokadeh mining area via the Madayea River, and from Gangra and Yuelliton via the Kahn River. The Dayea and the Madayea are severely affected by legacy mining, and a large quantity of sediment has gone into these rivers since LAMCO opened the Tokadeh mine. The impacts on the Madayea River have been lessened to some extent by wetlands which act as a filter for sediment generated further upstream, but the sediment load in the Dayea has caused channel erosion and other changes in the river's geomorphology, in turn releasing more sediment. The impacts are apparent along the length of the Dayea and into the St John River.

The Bee Creek drains the southern and eastern slopes of Tokadeh. The eastern drainage is via Gweh Creek which has been diverted from its natural channel by the railway embankment so that it flows into the Bee Creek further downstream. Bee Creek is also a tributary of the St John. It is a river that has been largely unaffected by legacy mining operations, and therefore will be highly sensitive to future impacts.

Gangra and Yuelliton drain eastward to the Kahn River and northwest to the Gba River. The Gba flows westward into the St John, while the Kahn flows southward to join the Dayea. Neither of these rivers has been affected by historic mining activities; however they cannot be considered pristine as agricultural practices in the area have increased soil erosion, increasing sedimentation in both. Parts of the Buchanan port area are formed on areas of Quaternary raised beach terrace drained by the Savage River which was redirected by LAMCO operations from its former channel that drained directly into the harbour.

7.1.2 Geology

The geology and engineering geology of the project area are described in Phase 1 DSO ESIA Volume 3, Parts 1.1 (Terrain and Soils Baseline) and 1.2 (Engineering Geological Site Specific Observations in Mine and Infrastructure Areas). The geomorphology of the southwestern slopes of the Tokadeh – Gangra/Yuelliton Ridge is given in Phase 2 ESIA Volume 3, Part 1.1 (Geomapping).

Northern Liberia lies within the West African Craton, an assemblage of very ancient Pre-Cambrian rocks that have been radiometrically dated to some 2.2 to 3.0 billion years old. Within the area of the Nimba Range and the Western Area deposits the bedrock can be divided into two supergroups: The Yekepa Supergroup and the Nimba Supergroup.

Probably the most influential factor in the engineering properties of the geological materials in the region is the impact of tropical weathering. The combination of high temperature and rainfall produces the conditions for intense tropical weathering causing decomposition of the rock-forming minerals and a general decrease in rock intact strength and interparticle bonding. This weathered material has not been transported – it is in its original position (*in-situ*) and has only undergone a decompositional change to a soil type material. The result is a weakened ‘skin’ of decomposed material which can be tens of metres thick (*saprolite, tropical residual soils*).

All minerals, except for quartz, are completely weathered by hydrolysis and altered to kaolinite, gibbsite, hematite or goethite. Silica is relatively soluble and is leached from the soil profile. Ferrous and aluminium sesquioxides are relatively insoluble and remain in the profile, giving the soils a strong reddish or yellowish-brown colour. Ferricretes have formed by the relative accumulation of iron oxides in the weathering profile, as more mobile compounds are leached out of the weathering profile.

Distinctive zones can develop in response to variations in the intensity of weathering and movement of minerals. The upper layers will contain rock debris that has been completely weathered to a soil. Lower down in the profile there will be an increasing amount of unweathered or partly weathered rock. Table 7.1 presents a common weathering grade model used by engineers; the base of Grade III is often regarded as the soil/rock boundary.

TABLE 7.1: ROCK WEATHERING GRADES

Weathering Grade	Description	Definition
VI	Residual soil	All rock material converted to soil; mass structure and material fabric destroyed. Significant change in volume.
V	Completely weathered	All rock material decomposed and/or disintegrated to soil. Original mass structure still largely intact.
IV	Highly weathered	More than 50% of rock material decomposed and/or disintegrated to soil. Fresh/discoloured rock present as discontinuous framework or corestones.
III	Moderately weathered	Less than 50% of rock material decomposed and/or disintegrated to soil. Fresh/discoloured rock present as continuous framework or corestones.
II	Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces. All rock material may be discoloured by weathering and may be weaker than in its fresh condition.
I	Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.

In Phase 2 Volume 3, Part 1.1, geomorphological mapping of the mines sites at Tokadeh, Gangra and Yuelliton was prepared primarily to provide a record of the morphology of the mine sites for drainage interpretation purposes. However, the mapping also provides additional information, particularly with regard to possible landslides and structural geology landforms. The observed geology makes broad differentiation between gneiss and itabirites and, as far as soils are concerned, between alluvium, colluvium and residual soil (*in situ* weathered). The distinction of these material types was limited by access and exposure. Alluvium is material that is transported and deposited on river terraces and flood plains by rivers, while colluvium is material (usually fine-grained) that is transported downslope by slope processes. Residual soil is the product of complete i*n situ* weathering of rock.

The Tokadeh map indicates the presence of several landslides on the slopes to the north west of the main ridge line. One of these has a back scarp that is located along the ridge line itself. Spoil dumping and drainage diversion from the Tokadeh mine onto these slopes could reactivate some of these landslides. On the majority of the western slopes of the Gangra-Tokadeh ridge the slopes are again composed of a number of apparent large landslides. Here there is little apparent structural control. The same observations made concerning the management of slopes to the northwest of Tokadeh will also apply here. Extreme care will be required not to disturb these slopes, either by intentional or inadvertent spoil disposal and stockpiling or the direction of mine runoff onto them.

Some 40 years ago cuttings along the railway were excavated in clay-rich residual soils and completely weathered rock to depths of up to 15m with side slopes at 63-70 degrees. Modern practice would generally have specified lower angles for these materials, say 34-45 degrees. Some slopes have undergone surficial failures (slumps) or periodic spalling and vegetation, including small trees, grew unchecked after the line was abandoned.

The railway has now been rehabilitated between Buchanan and Tokadeh. Scrub and trees have been removed, exposing bare, possibly disturbed, soil in places thereby allowing increased dry season desiccation and wet season erosion and rainfall infiltration. These conditions have resulted in new shallow failures which have blocked side ditches and in some cases encroached onto the track. Failures have been exacerbated by ditch clearance work, which has tended to undercut slopes where the side ditch is unlined or has been previously damaged, and where groundwater emerges at the toe of the slope on one side of a cutting. This pattern of instability will at times result in the discharge of high sediment loads to local watercourses and in extreme cases slumped material could block the railway.

7.1.3 Soils

The soil baseline description is provided in Phase 1 DSO ESIA Volume 3, Part.1.1 (Terrain and Soils Baseline) with additional material from an agricultural perspective in Phase 2 ESIA Volume 3, Part 1.2 (Geology, Soils and Land Use). A survey of soil-related problems along the railway line between Tokadeh and Buchanan port is given in Phase 2 ESIA Volume 3, Part 1.5 (Slope Stability and Erosion Survey along the Railway Line). Figure 7.1 shows the mapped distribution of the main soil types found in the mine project area and Table 7.2 provides an explanation for the soil categories shown.

Figure 7.1: Soils map of the study area (for key see Table 7.2)

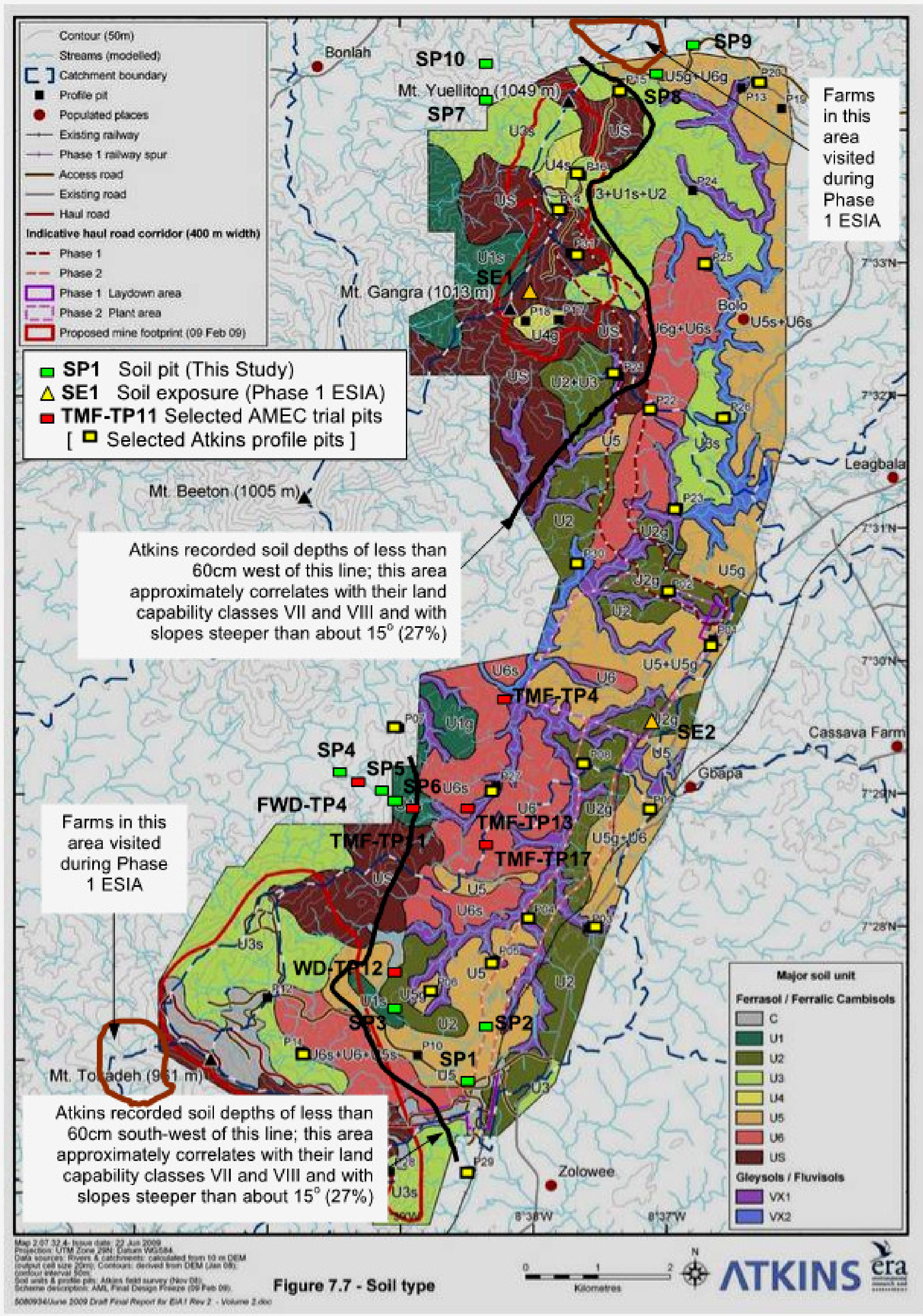


TABLE 7.2: EXPLANATION OF SOIL TYPES IN FIGURE 7.1	
Soil Type and Description	
Upland soils (Ferralsols/Ferralic Cambisols)	
Strong brown to dark red, well drained soils developed in-situ from deeply weathered gneiss or ironstone (iron-ore bearing) bedrock, occurring on undulating to steeply sloping dissected plains and major hill slopes. The soils are mainly deep (>2.0m), fine-gravelly clays and sandy clays with weakly developed subangular blocky structures. Many soils are also gravelly. Sandy soils occur, as do shallow soils overlying very stony and bouldery ironstone.	
U1	Deep, yellowish red clay and/or sandy clay
U2	Deep, yellowish red to strong brown over dark red and/or red clay and/or sandy clay
U3	Deep, dark reddish brown, red or dark red clay and/or sandy clay
U4	Deep, dark reddish brown, red or dark red sandy loam to loamy sand
U5	Deep, strong brown to brown over yellowish red clay and/or sandy clay
U6	Deep, strong brown to (dark) yellowish brown clay and/or sandy clay
US	Shallow, clayey or loamy over ironstone boulders and stones within 0.5m
Valley margin soils (Gleysols)	
Yellowish brown to brown soils occurring at the margins of the dissected plains and valley bottoms on gently sloping to undulating old alluvial or colluvial terraces and in-situ on weathered gneiss or colluvial toe slopes. Soils are clayey or loamy textured, weakly structured, well to imperfectly drained and usually affected by groundwater.	
T1	Deep, (light) yellowish / olive brown clay and/or sandy clay, mottled (plinthite?) below 0.5m. May be groundwater below 1.0m. Imperfectly drained
T2	Deep, strong brown to brownish yellow clay and/or sandy clay. May be groundwater below 1.0m. Well drained
T3	As T2 but clay loam and sandy clay loam textures
Valley bottom soils (Gleysols)	
Mainly deep, very poorly drained, gleyed alluvial soils of varying texture, occurring in the small and usually swampy valley floors within the uplands. The soils are grey, mottled, gleyed and affected by shallow groundwater. Some soils are peaty.	
V1	Deep, greyish mottled over gley clay and/or sandy clay. Groundwater below about 0.5m. Very poorly drained. May be sandy loam below 0.6m
V2	As V1 but sandy clay loam or sandy loam textures. May be loamy sand below 0.6m
Floodplain soils (Fluvisols)	
Dark brown to yellowish brown deep alluvial soils bordering the main rivers and flooded annually. Soil textures are variable and frequently stratified. Soils are well to moderately well drained.	
F1	Dark brown to strong brown clay loam, silty clay loam and/or light clay; may be sandy below 0.6m. May be some mottling. Moderately well drained
F2	Yellowish brown over reddish yellow sandy loam to loamy sand. Well drained
Contaminated soils (Ferralsols/Ferralic Cambisols)	
C	Undifferentiated soils affected by mining
SOIL ASSOCIATIONS	
Gleysols and Fluvisols	
VX1	Valley: V1, V2 and ponds in wet valley floors; T1, T2 and T3 and some upland soils on slightly higher land at valley margins. Shown in Maps
VX2	Valley F1, F2 on floodplains; ponds, swampy clay soils back of floodplain; T1, T2, T3 and some upland soils on slightly higher land at valley margins. Shown in Maps

The soils of the middle and upper slopes are predominantly strong brown, yellowish red and dark red deep clays and sandy clays that are usually gravelly and contain ferruginous staining and concretions (ferrasols). On lower slopes and on terraces close to streams the soils are more variable, generally being browner and sandier than the upland soils. The plain areas are deeply dissected by many small streams that now occupy narrow valley floors that are permanently wet. The soils here are of variable texture and gravel content but all are mottled and waterlogged (Gleysols).

Ferralsols or ferralic cambisols are the deeply weathered, acid, red (hematite) or yellow (goethite) soils of the humid tropics. These soils have diffuse horizon boundaries, a clay assemblage dominated by low-activity clays (mainly kaolinite) and a high content of sesquioxides. These soils, due to their acidity (pH is typically 4.2 to 5.3) have very low organic matter content, and generally have poor fertility. They can, however, be very prone to erosion once vegetation is removed and they become disturbed. In particular it can be difficult for vegetation to re-establish on exposed rocky areas, or in soils that have undergone rapid erosion as a result of land clearance for agriculture or mine development. This is evident at Tokadeh where there are significant erosion losses, attributable to areas of bare ground that have resulted from historic mining activity. Although not subject to previous mining activity, a higher rate of soil loss from undisturbed ground occurs from Mounts Gangra and Yuelliton which is attributable mainly to the steep slopes and sparse vegetation cover in places.

Although 95% of the soils in the mine area are in classes which are generally indicative of soils not suited to cultivation, a shortage of higher quality agricultural land means that in practice substantial levels of shifting non-managed agriculture are taking place in such low quality areas, which therefore have socio-economic value. This means that there is a need to minimise the amount of agricultural land lost, control erosion, and manage topsoil throughout the area.

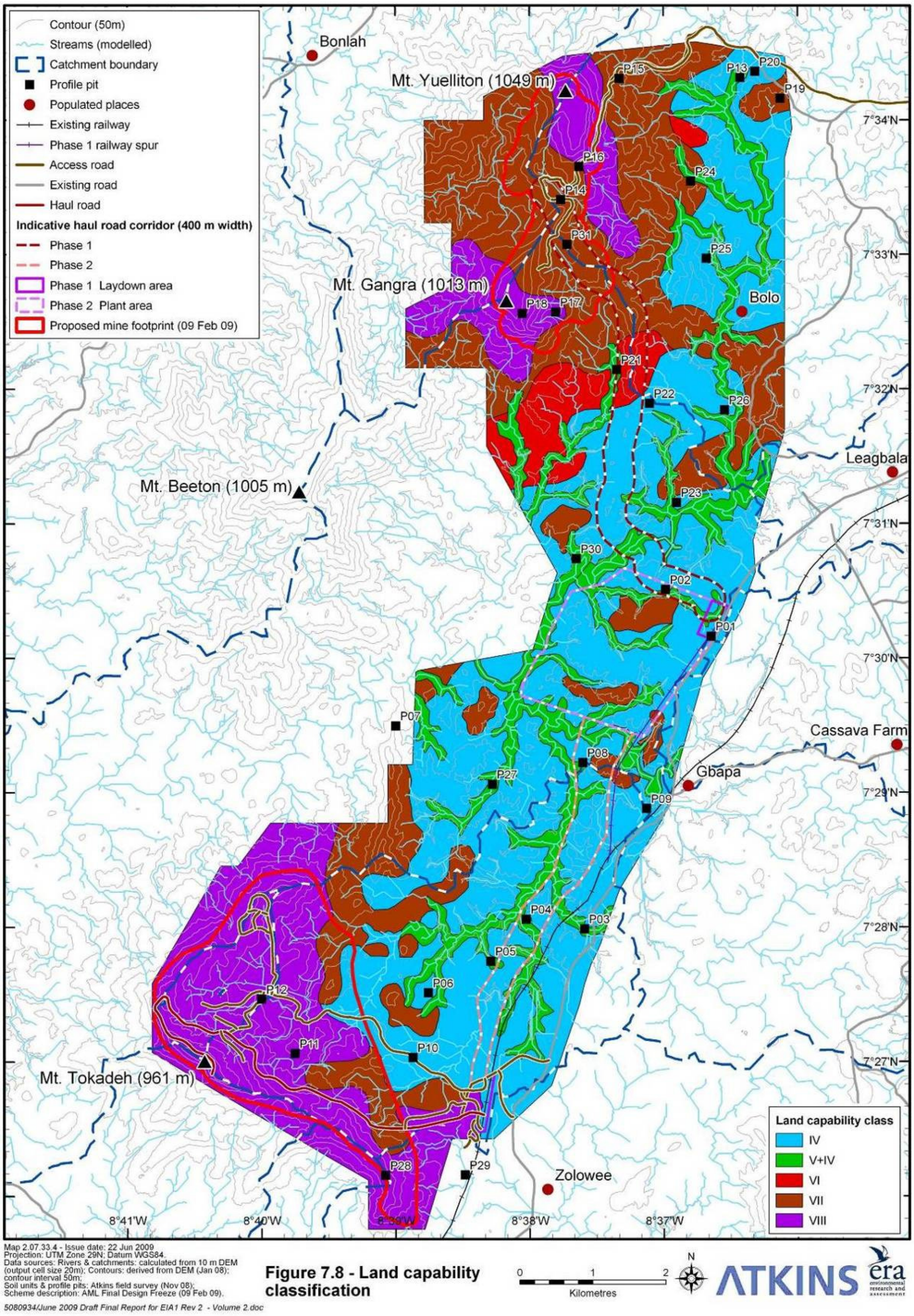
The terrain evaluation supported the findings of the soils study in confirming that landsliding and erosion are infrequent in the natural terrain. Where these occur, they are almost always the result of human modification of the natural landscape and its pattern of surface and subsurface drainage. A particular source is the presence of access and haul roads, and, particularly, former mining and spoil dumping with extreme examples at the former Nimba mine and (to a lesser extent) at Tokadeh. Other occurences are found adjacent to the railway line.

The agricultural land within and neighbouring the mining Concession is farmed by traditional subsistence practices. To assist with future management of soils and land use in these areas, in regard to both improving agricultural production and the reclamation of redundant infrastructure sites, a comprehensive understanding of the land resources (soils and their capabilities) has been required. Phase 2 ESIA Volume 3, Part 1.2 (Geology. Soils and Land Use) contains this review from both an agricultural and soil chemistry perspective. In support of this, a soil survey of 6670 hectares (ha) of the Dayea valley and surrounding area from Zolowee Village – Tokadeh Mountain north to Yekepa was carried out.

The objective of the report was to identify the potentials and constraints of the land resource in terms of agricultural production and suggest alternative farming systems for improved land management with minimal external inputs (i.e. agro-chemicals such as inorganic fertilisers and pesticides). Also addressed are non-soil factors (e.g. crop pests) which influence present agricultural practices and methods of managing these in the future.

Land capability has been mapped in the ESIA studies on an eight-class system. Owing to the very acid soils and low fertility, the most fertile classes, I to III, do not occur and the surveyed land is no better than class IV (Figure 7.2). In general, where slopes are less than 25%, class IV land is better suited to long-fallow shifting cultivation or tree crops such as rubber or coffee and would usually require liming and fertilising to sustain permanent cropping due to the characteristics of the Ferralsols and Ferralic Cambisols present in the area. In this case it is probably uneconomic and undesirable to provide adequate lime and fertiliser to sustain permanent farming. Where slopes mantled in such acidic soils exceed 25%, the land is best suited to tree cropping or left as natural forest. For classes VI to VIII the addition of organic-rich topsoil (e.g. from land stripped for mining operations) could boost productivity but would be of short-term benefit because it would eventually mineralise (i.e. burn up through chemical change). However, despite the indicative agricultural quality provided by this land capability classification, significant farming is occurring, not just in Class IV, but in higher classifications including those on the mountains where Classes VI and VII occur.

Figure 7.2: Land capability classification in the study area (note that the proposed mine footprint as shown has been superseded, though remains approximate)



The soil survey of the Dayea Valley identified four types of soils, distinguished first by their physical attributes and confirmed at a finer level by their chemical characteristics. There are clear physical differences between the four soils which to some extent will guide land use. Analysis of samples taken from the 30 representative soil pits show that in terms of fertility management, these soils are not sufficiently different in their chemical characteristics to require different management. This could be because 28 of the samples were from the Cambisols (13) and Regosols (15) which are the predominant soils of the mapped area. The other two soils identified are the Fluvisols and Gleysols, found in smaller, less contiguous areas along the river and its tributaries. With the exception of the Gleysols, the key to maintaining fertility of these soils will be building and maintaining the organic content since this provides the bulk of the cation exchange capacity (CEC) given that the dominant clay fraction in all these soils (Kaolinite) has an inherently low CEC; and having enough deep rooted plants in the mix to recycle plant nutrients washed deeper down the soil profile. Simply stated, the land should be managed in such a manner that an adequate amount of biomass is produced and incorporated into the top soil to maintain high levels of organic matter, and the crops grown should be a mix of deep and shallow root species to maintain a healthy nutrient cycle.

The Gleysols are a slight exception in that while the methods required to maintain soil fertility will be essentially the same as for the other soils, maintaining a high level of organic matter should be easier as under conditions of poor drainage the organic matter content will degrade more slowly. However, for this reason recycling leached plant nutrients via deep rooted plants will be more problematic.

Local agriculture is centred on rice and cassava production using traditional ‘slash and burn’ cultivation, in which plant nutrients are replenished during a long fallow period and by cutting and burning accumulated vegetation. Swamp rice is grown on valley floors and tree crops such as oil palms, plantains, bananas, rubber, coffee and cocoa are cultivated both for subsistence and sale. Cultivation of tree crops is generally a male role. Some families own small numbers of goats, sheep, pigs, chickens and ducks. Traditional practices also include hunting, gathering medicinal plants and the production of timber, charcoal and iron tools, mostly in areas of remaining forest on the steep upper slopes. These slopes, with the exception of Mount Beeton, are either within Phase 2 mine exclusion zones or within the East Nimba Nature Reserve.

Traditional cultivation requires an average 1.5 ha field worked for one year, followed by an average 8 fallow years. It is estimated that 15 ha of land is required to support a family of five, including a small area of swamp rice and permanent gardens close to dwellings. Current agricultural practices are sustainable until population density rises above a threshold level. At this point fields are either cropped for successive years or the length of the fallow period is reduced, so that soil fertility and crop yields steadily decrease. Local communities appear to be close to this threshold level.

7.1.4 Climate

The climatic characteristics of the study area are described in Phase 1 DSO ESIA Volume 3, Part 2.1 (Hydrology Baseline). Rainfall records and statistics are found in Phase 2 ESIA Volume 3, Part 2 (Groundwater Baseline and Impact Assessment) and Volume 3, Part 3.1 (Hydrology Baseline and Impacts Assessment) and summarised in Section 7.3.1 of this report. Information specifically relating to climate change is provided in Phase 2 ESIA Volume 3, Part 4 (Climate Change Scenarios by the UK Met Office).

The country in general has two seasons – a wet season from March-April to October and a dry season from November to March, though the beginning and end of either season can vary considerably.

Climatic records for the Concession Area and the port at Buchanan are sparse. For the period during the civil conflict between 1989 and 2003 no records were kept, and prior to this most of the records were incomplete. However, even these incomplete pre-war records are now more than 20 years old. Therefore, there are constraints for robust analysis. Furthermore, there is scientific indication that the climate in West Africa is in a period of change.

Historic monthly rainfall records, collected by LAMCO, are available for the 'Nimba Mine Area', 'Lower Buchanan' and, to a very limited extent, 'Yekepa Township'. Some temperature records are available, but data on winds is very limited.

Two fully automated climate stations were installed at Yekepa and at Tokadeh by the Company in 2008, which measure rainfall and a suite of meteorological variables on an hourly basis.

The strong maritime influence at Buchanan means that the temperatures remain constantly within the relatively narrow band of 18℃ to 33℃ (records for 1959-60). Slightly higher maxima and slightly lower minima occur in the dry season, but the range within each band is only about 5℃ throughout the year. The very few records for Yekepa show maximum daytime temperatures of 35℃ in the dry season, but with relatively cold night time temperatures of only 15℃, giving a large diurnal range of some 20℃ in December. The wet season daily variations are much smaller, typically only 10℃, and with the daytime and night time temperatures always between 30℃ and 18℃ respectively.

There are no historic wind records from Nimba. At Buchanan, there are records of wind direction and strength on a daily basis between 1959 and 1963. In general, winds tend to peak at around 8 to 11 m/s, and usually from the west or south, off the sea. Winds appear to be generally lighter from October to December. Severe winds do occur at times. The records show wind speeds of 21.5 m/s from the east-north-east in April 1962, and another of similar strength from the north-east in April 1963. These are in the force 9, 'severe gale' class, which is strong enough to cause minor damage to buildings.

Information on the current status of climate projections over West Africa and extreme precipitation over the Nimba region and its surrounds is provided in the report on Climate Change Scenarios that was specifically prepared for the purpose of the present ESIA (Volume 3, Part 4). The study considered a multi-model ensemble of Global Climate Change runs and found that there is a large range of projected precipitation for a given greenhouse gas and sulphur emission pathway, with a lack of consensus even on the sign of the change. The study thus concluded that it is difficult to derive a robust and reliable signal with sufficient regional detail that would allow drawing conclusions about the future precipitation changes over the Nimba region.

Despite the limitations and uncertainties regarding the trends of climate change in the region, there appears to be a consensus that the rainy season in the Sahel will shift to later in the year. The analysis of extreme events in the Nimba region and its surrounds suggests that return periods are projected to become drier in the north for the period 2021 – 2050 compared to 1961 – 1990. For more concrete data further work would be required and experts state that they cannot currently rule out the possibility that the return periods in reality would become wetter.

As regards extreme precipitation over the Nimba region the main conclusion of the study was that present scientists do not have any way to assess whether extreme precipitation events in the region are likely to become more or rather less intense in the future.

7.2 Air

7.2.1 Air Quality

Air quality (including gaseous pollutants, dust and noise) is covered in Phase 1 DSO ESIA Volume 3, Part 4 (Air Quality Impact Assessment), and Phase 2 ESIA Volume 3, Part 5 (Air Quality Assessment) including the appendix on the Buchanan power plant.

The Phase 2 Volume 3, Part 5 report considers the potential effects of the Scheme arising from changes in air quality associated with dust generation and emissions of gaseous pollutants and fine particulate matter. Changes in air quality can impact on both human receptors and the wider environment, notably on plants of biodiversity value and crop productivity.

An air quality assessment of Phase 1 of the project, involving the production of up to 20 million tonnes of Direct Shipping Ore (DSO), rehabilitation and operation of the railway line to Buchanan and landside port operations was submitted as part of the Phase 1 ESIA in September 2010 (Volume3, Part 4). The principal source of air pollution throughout the entire project area is dust from vehicles travelling along the main highway, local roads and the haul roads within the DSO mine area, all of which are unsealed. During dry conditions, vehicle movements across these roads raise substantial dust plumes, which may affect both populations and vegetation close to the roads. Larger dust particles will be deposited within a relatively short distance (e.g. several hundred metres), but the finer dust particles may be transported much greater distances depending upon the weather conditions. Another source is the *Harmattan*, the dry dusty trade winds that blow from the Sahara during the dry season. Levels of gaseous pollution are very low in the country as the main source is vehicle emissions. Emissions from slash-and-burn activities and domestic cooking represent a localised source. This report extends the scope of the earlier study to incorporate the proposed Phase 2 works.

Receptors and resources considered in this study comprise people in local settlements or in sensitive areas (hospitals and schools etc) or other areas (e.g. agricultural fields) subject to relevant exposure to dust or gaseous pollutants, agricultural crops, flora considered to be important biodiversity, and national greenhouse gas levels.

Potential effects on such resources and receptors resulting from the scheme will comprise: the effects on human health associated with increased levels of fine dust; health effects due to inhalation of toxic dusts; effects on amenity associated with increased rates of dust deposition; effects on human health from gaseous pollutants; effects on plants and crops arising from a blocking of stomata and/or reduction in photosynthetic activity as a result of dust deposition; and effects on greenhouse gas emissions at a national level.

Dust emissions, dispersion patterns and impacts are difficult to predict due to the lack of reliable emission factors for the wide range of scheme activities that might give rise to dust. The assessment used evidence from published reports and other relevant guidance, in conjunction with project specific observations undertaken during a site visit with regard to the distances over which significant impacts might occur. The main air quality impact during the operation of the proposed power plant would be emissions to air from the combustion of fuel within the power plant engines. The air quality impacts of the power plant were evaluated using the plume dispersion model ADMS, which is able to calculate maximum ground level concentrations at sensitive receptors close to the scheme boundary.

The term “dust” is commonly taken to represent particles between 1 and 75µm diameter. Particles that are less than or equal to 10µm diameter are commonly referred to as PM_{10}, those less than or equal to 2.5µm diameter are referred to as $PM_{2.5}$. The larger particles are associated with public perception of “dust nuisance” and the deposition of dust onto vegetation. The smaller particle sizes, i.e. the PM_{10} and $PM_{2.5}$ fractions are most strongly associated with human health effects including respiratory and other diseases.

Due to the tropical climate in Liberia and the predominantly agricultural activities carried out on the land, most of the ground in rural areas is permanently covered by lush vegetation and rain forest. For this reason, even during the dry season there are few naturally occurring sources of windblown dust. The principal local sources of fugitive dust would therefore be from:

- vehicles (in particular heavy lorries) travelling on the local roads, which are largely unpaved; and
- emissions from domestic cooking and farming.

Emissions from domestic cooking and farming may represent localised sources of particulate matter, particularly when vegetation is burned by local people to clear land for the planting of crops. Most farming in the area around the mine sites is, however, carried out without the use of machinery and so dust emissions produced from the working of the land are generally small in scale.

Larger dust particles are deposited within a relatively short distance of the emission source, the process of which is accelerated by the presence of dense vegetation at the sides of roads and the borders of working areas. During the field visits undertaken during the dry season in March 2012, heavy dust staining could be observed on vegetation immediately adjacent to unsealed roads, but at a distance of 10 m to 20 m from the roadside, the evidence of dust deposition was greatly reduced. It is therefore likely that in areas where vegetation screening is in place, the majority of re-suspended or windblown dust from roads and other uncovered areas of ground is deposited within 50 m to 100 m of the source of the emission. Finer dust particles may be transported much greater distances depending upon the weather conditions.

The amenity of residents of villages situated in close proximity to the main traffic routes is particularly affected by dust from passing traffic during dry conditions. Larger vehicles, and vehicles travelling at higher speeds, produce much larger emissions of fugitive dust. Measures to reduce vehicle speeds, such as speed humps, or the wetting of the road surface, were observed during the field visit to make a large positive impact on the magnitude of the emission. Similarly, in areas where roads are sealed, there is a marked decrease in dust emissions to the point where there is no significant impact on amenity.

A summary of the PM_{10} and $PM_{2.5}$ concentrations measured over the period November 2008 to May 2010 is provided in Table 7.3. The seasonal variability of PM_{10} concentrations during this period is reported in greater detail in Table 7.4. Monitoring at Gbapa ceased in April 2009.

TABLE 7.3: MEASURED PM_{10} AND $PM_{2.5}$ CONCENTRATIONS

Site	Data Capture	Period Mean	
		PM_{10}	$PM_{2.5}$
Gbapa	56%	158	27
Zolowee	43%	259	34
Sanniquellie	60%	52	10
Buchanan	54%	66	9

TABLE 7.4: MONTHLY VARIATION IN MEASURED PM_{10} CONCENTRATIONS, NOV 2008 TO OCT 2009

Season	Month	Buchanan		Sanniquellie		Zolowee		Gbapa	
		Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Dry	Nov	51	61	3	3	204	255	99	59
Dry	Dec	131	168	103	158	249	263	397	239
Dry	Jan	153	261	189	571	282	639	238	170
Dry	Feb	110	112	46	88	333	273	28	29
Dry	Mar	62	54	73	107	311	547	107	78
Dry	Apr	15	18	3	5	202	175	46	23
Wet	May	9	17	10	18	296	653	-	-
Wet	Jun	44	22	5	6	146	210	-	-
Wet	Jul	26	25	20	13	86	59	-	-
Wet	Aug	35	41	6	7	528	1105	-	-
Wet	Sep	47	69	11	9	137	64	-	-
Wet	Oct	15	17	12	14	234	266	-	-

The following conclusions may be drawn from these data:

- The period mean PM_{10} baseline concentrations exceed the WHO Interim Target 1 annual mean guideline at Gbapa and Zolowee. Period mean PM_{10} concentrations at Sanniquellie and Buchanan are within the assessment criteria of 70 $\mu g/m^3$;
- There is considerable variation about the mean for PM_{10} concentrations at all sites with greater variations occurring in drier conditions when winds are most likely to transport particulate matter into the study area from the Sahara, increasing the likelihood of the 24-hour mean concentrations becoming elevated; and
- The period mean $PM_{2.5}$ concentrations are well within the WHO Interim Target 1 annual mean guideline at Gbapa, Sanniquellie and Buchanan. At Zolowee, the period mean $PM_{2.5}$ is very close to, but within the criteria. The data indicates that there is a risk of exceedance of the annual mean $PM_{2.5}$ guideline in the area around the monitoring site.

Further analysis of the data shows that there is a marked seasonal effect on airborne concentrations of particulate matter. Measured concentrations during the wet season are typically reduced as dust emissions from unpaved roads would be substantially suppressed, although episodes of high particulate matter concentrations have been recorded in all months. The dry season also coincides with the *Harmattan* winds, which can cause regional-scale dust episodes lasting for extended periods. Although the *Harmattan* is likely to have affected measured particulate matter concentrations during the monitoring period, local sources are still considered to be the predominant source of emission.

The monitoring period at Gbapa was shorter than at the other sites, data collection only took place between November 2008 and April 2009. The period mean and 24-hour mean concentrations reported for this site are therefore very likely to have been elevated by the monitoring period coinciding with the dry season and the *Harmattan*. Monitoring over a longer period would probably have given period mean data lower than that shown in Table 7.3.

The proximity of the Zolowee monitoring site to the unpaved main road from Sanniquellie to Yekepa, means that recorded levels are inevitably dominated by traffic-related dust and this is reflected in the less obvious seasonal pattern at this site. The levels at Buchanan may also have been influenced by the close proximity to a gravel road. As many residential properties within the study area are located a similar distance from such roads, the baseline data can however be considered to be representative of baseline conditions at sensitive receptors. Long-term concentrations of particulate matter within the wider area would be likely to be lower than the values reported.

The measured $PM_{2.5}$ concentrations are significantly lower than the PM_{10} levels (ratios ranging from 0.13 at Zolowee to 0.19 at Sanniquellie). This indicates a significant coarse dust emissions source, consistent with re-suspended dust from unsealed roads.

The baseline diffusion tube survey in the area around the Tokadeh mine site and Buchanan commenced in March 2012. The survey was programmed to run for six months, but site specific difficulties have resulted in some loss of data. At the time of writing, the results of monitoring from March to May 2012 were available for NO_2, and March to July 2012 in respect of SO_2. Results are shown in Table 7.5.

TABLE 7.5: DIFFUSION TUBE MONITORING RESULTS, MARCH TO JULY 2012

Site ID	Location	Mean Measured Pollutant Concentration ($\mu g/m^3$)	
		NO_2	SO_2
T1	Yekepa Workshop	9.0	11.6
T2	Yuelliton – Gangra Road	6.0	1.2
T3	Gbapa	4.5	1.4
T4	Tokadeh Magazine	4.9	1.0
T5	Zolowee	3.9	0.8
T6	Makinto	5.2	0.9
T7	Geh	3.6	1.1
B1	AML office	5.5	1.2
B2	Moore Town Gate	6.7	1.9
B3	Port Gate	15.9	5.6

Although concentrations measured from month to month will vary due to meteorological conditions and seasonality the results indicate that, as expected, baseline concentrations of combustion pollutants within the air quality study area are very low in most locations. Slightly elevated concentrations, in comparison with background levels, are found in close proximity to roads and other emission sources. In Buchanan, slightly higher concentrations of NO_2 were recorded than in the area around the mine sites. This is predominantly due to a greater level of road traffic movements in the port and Buchanan City area in comparison to the mine site, emissions from ships at berth, loading shovels and rail locomotives. The greatest NO_2 value was recorded in close proximity to the train unloading and stocking facility at the port.

At all the monitoring locations in the two areas surveyed, the data indicates that there is no existing risk of a breach of the long term and short term air quality standards for NO_2 and SO_2.

Further details on specific measurements can be found in the two reports mentioned at the beginning of this section.

7.2.2 Noise and Vibration

Noise (and vibration) assessments are dealt with in Phase 1 DSO ESIA Volume 3, Part 5 (Noise Impact Assessment), and Phase 2 ESIA Volume 3, Part 6 (Noise and Vibration Assessment). The noise and vibration assessment is confined to human receptors although the derived noise levels for the operational phase of the project can be used by other specialist areas to assess the effects on fauna.

To quantify the prevailing noise climate at settlements in the vicinity of the mine areas, noise monitoring was carried out at Bonlah and Cassava Fields over a 24 hour period. To quantify the prevailing noise climate at residential areas in the vicinity of the port facility, noise monitoring was carried out within the port area close to the Motown gate and at a location on the boundary of the Red Sea accommodation area over a 24 hour period. In addition, noise and vibration measurements were carried out at three locations along the railway line.

Noise levels were monitored at Bonlah over the period 13//3/12 to 14/3/12. Night-time noise levels drop to 38 dB L_{Aeq} / 34 dB L_{A90} and there are periods of low background noise levels during the daytime of 35 dB L_{A90}.

Noise levels were monitored at Cassava Farm over the period 15//3/12 to 16/3/12. The time history is unusual, with relatively high noise levels during the night-time period. It is likely that some local source is responsible for this. During the daytime, noise levels drop to approximately 38 dB L_{Aeq} / 28 dB L_{A90}.

Noise levels were monitored at Motown Gate in Buchanan Port over the period 21/3/12 to 22/3/12. Daytime noise levels are in the region of 50 dB L_{Aeq} / 42 dB L_{A90}. Night-time noise levels are in the region of 45 dB L_{Aeq} / 40 dB L_{A90}.

Noise levels were monitored at Red Sea accommodation camp in Buchanan Port over the period 22/3/12 to 24/3/12. Daytime noise levels are in the region of 52 dB L_{Aeq} / 47 dB L_{A90}. Night-time noise levels are in the region of 46 dB L_{Aeq} / 45 dB L_{A90}. The relatively steady noise levels during the night-time period, with the L_{Aeq} and L_{A90} noise levels very close, indicates a steady noise source or sources, most likely the air conditioning units employed within the camp.

Noise and vibration levels were measured at Sanniquellie Hospital and Tukpahblee School during train pass-bys. The noise and vibration levels to the operating theatre at Sanniquellie Hospital were above the criterion levels in the applicable guidance.

7.3 Water

7.3.1 Hydrology

The hydrology baseline is contained in Phase 1 DSO ESIA Volume 3, Part 2.1 (Hydrology Baseline), Phase 2 ESIA Volume 3, Parts 3.1 (Surface Water Impacts and Mitigation) and 3.2 (Geochemistry and Water Quality).

With regard to baseline measurements for Phase 2 Volume 3, Part 3.1, the lack of historic data in Liberia has meant that baseline conditions for the freshwater environment have had to be determined largely through the programme of monitoring and modelling undertaken in 2008-9. The monitoring programme involved both targeted surveys and continuous monitoring.

The 2008-2009 study involved collection and analysis of data to aid a better understanding of the existing hydrological and water quality processes, thus enabling an initial assessment of potential project impacts. The 2008-2009 data were reviewed along with the Hydrology Baseline Report as part of this study. The baseline study included data collection from both watercourses impacted by previous mining activity as well as those not impacted by mining. Data and observations made from sites where there is a ‘mining legacy’ impact provide a useful indication of potential impact on watercourses that could arise from Phase 2 activities without appropriate safeguards and mitigation.

Two site visits were undertaken in 2011. The site visits provided an opportunity to appraise the existing conditions in the project areas during wet and dry season periods and to gain an appreciation of the existing surface water systems within the context of the project proposals. Information was also gathered from informal sources during both field visits.

In the baseline data review, the Phase 2 report covers rainfall, the Nimba surface water systems, the Buchanan surface water systems, the geological origin of the soils, and surface water quality.

Rainfall

The rainfall across West Africa declines progressively from the coast towards the Sahel and the Sahara. This is principally due to movement of the Inter Tropical Convergence Zone (ITCZ). The ITCZ is the area encircling the earth near the equator where winds originating in the northern and southern hemispheres come together. It appears as a band of clouds, usually thunderstorms. The ITCZ is formed by vertical motion largely appearing as convective thunderstorms driven by solar heating, which effectively draw air in; these are the trade winds. Generally, the trade winds move in a south-western direction from the northeast in the Northern Hemisphere, while in the Southern Hemisphere, they move north-westward from the southeast. The location of the ITCZ changes with an annual cycle. Variation in the location of the ITCZ strongly affects rainfall in equatorial West Africa, resulting in the wet and dry seasons that typically characterise all tropical regions rather than the cold and warm seasons of higher latitudes.

The largest rainfall in Liberia occurs along the coastline (including Buchanan) where moisture supply from the Gulf of Guinea is highest. The gauge at Buchanan registered an annual average (1959-1980) of 4117 mm, compared to an annual average rainfall of 2728 mm for the Nimba Ridge. However, there is some evidence that such high rainfall totals are confined to the immediate coastline. Both the amount of rainfall and duration of the wet season decrease from the coast to the northeastern part of Liberia, where the Nimba Region is located.

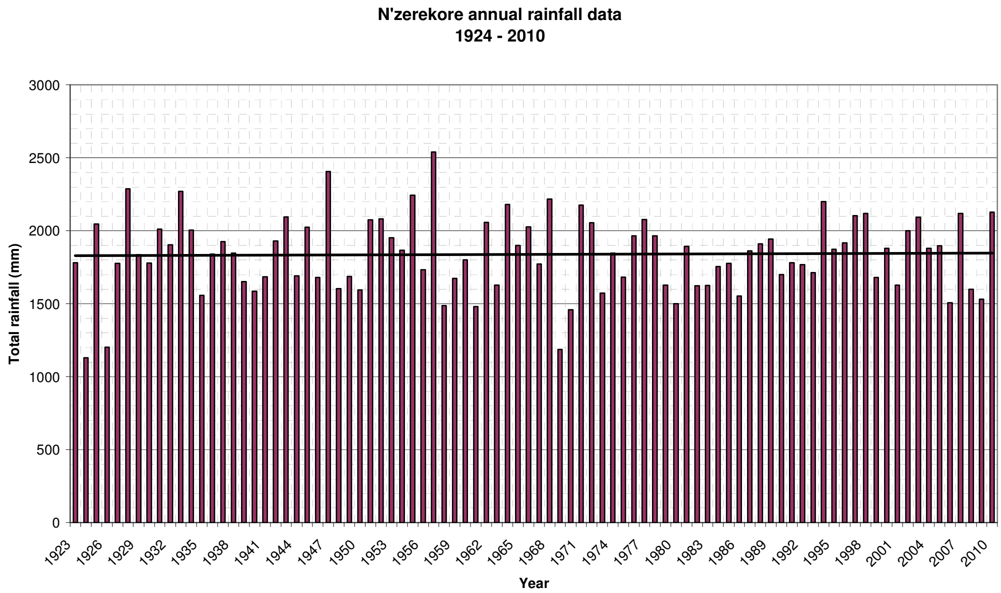
Rainfall from squall lines has been reported in the Nimba region. Squall lines are produced when several convective storm cells merge together in a line, forming a particularly violent line of rainfall. They lead to very sudden and heavy downpour of rainfall.

Although the ITCZ is the primary mechanism for rainfall in Liberia, topography is a significant factor in rainfall distribution. Orographic rain, i.e. rain produced when moist air is lifted as it moves over a mountain range plays a significant role in the distribution of rainfall across Liberia as demonstrated, for example, by rainfall records for 1962 when annual rainfall recorded at an elevation of about 1300 m on the Mount Nimba Ridge was 3509 mm when only 1895 mm of rainfall was recorded at an elevation of about 500 m in Yekepa. There have been plans to collect data at different altitudes in Tokadeh recently, but due to technical issues the two gauges installed by the Company did not record data simultaneously, therefore the spatial variations of rainfall magnitude could not be reported at this stage.

Nimba Rainfall Data - The Phase 1 data was derived from a number of sources within Liberia and in neighbouring Guinea and Ivory Coast, between 1956 and mid-1989. At the time of writing the Phase 1 report there were no data being collected at the mine locations or anywhere else in the project area. The gaps in the data were filled using standard techniques and consolidated into one single data set. As part of the Phase 2 update to fill in these data gaps, a number of rain gauges and weather stations were installed at Tokadeh, Yuelliton and Gangra and in Yekepa. An additional rain gauge was also installed in Sannequille.

In addition to these data, daily rainfall data from 1922 to 2010 for a surrogate location in N'Zerekore and Lola (the Lola gauge data only covers 1979 to 2010) in Guinea, close to the Nimba Area, were obtained and analysed. A study undertaken by the UK Met Office (September 2010) in Phase 1 confirmed the existence of a good correlation between data from N'Zerekore and Sanniquellie, hence the N'Zerekore data is of direct relevance to the Nimba mines sites and can be used as surrogate rainfall data for the Nimba region (see Figure 7.3).

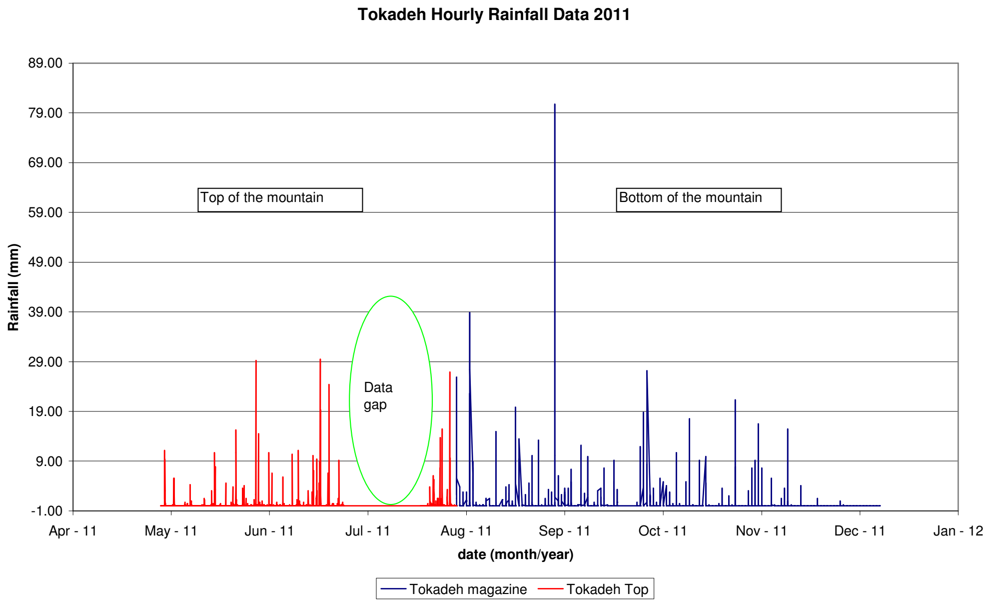
Figure 7.3: N'zerekore annual rainfall data 1924 - 2010



In addition to daily rainfall, the Phase 2 data collection includes automatic rain gauges, which provide data on a continuous basis at short intervals. Automatic rain gauges have been installed at Tokadeh, Yekepa, and Yuelliton and Gangra to provide information on duration and intensity in addition to total depth.

<u>Tokadeh Hourly Rainfall</u> - Hourly rainfall data collected from the weather stations at Tokadeh is presented in Figure 7.4. The data shown in Figure 7.4 was collected between February 2011 and November 2011 and is an amalgamation of data from the mountain top with data from the bottom of the mountain. The amalgamation was necessary because the two gauges did not record data simultaneously. There appears to be no obvious difference in rainfall magnitude between the two locations in terms of hourly rainfall.

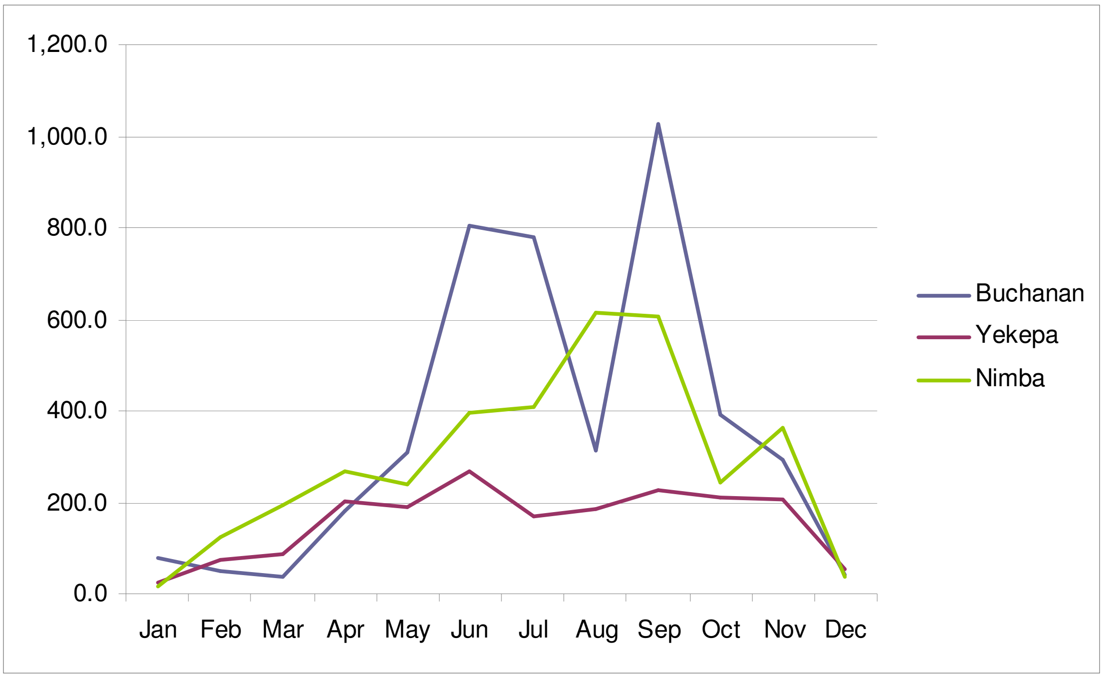
Figure 7.4: Tokadeh Hourly Rainfall (2011)



Buchanan Rainfall Data - The data presented in the Hydrology Baseline report for Buchanan was collected at the weather station in Buchanan. It is stated in the Phase 1 report that the station might have been moved to different locations at different times. It is suggested, however, that the different locations were presumably fairly close to each other (within the Concession Area) and the difference due to location is considered unlikely to be significant in Buchanan anyway, given the flat nature of the area. The distribution of rainfall is similar to that at Mount Nimba; a steady rise from February and a sharp decline of rainfall from the wettest month in September to November, with the highest rainfall occurring between June and September. The annual distribution at Buchanan shows a variation of annual rainfall between just under 3000mm and 6300mm.

Spatial Variability of Rainfall Data - a comparison of annual and monthly rainfall data between Buchanan and Nimba shows that more rain falls in Buchanan. Figure 7.5 shows the monthly distribution of rainfall in Yekepa, Nimba and Buchanan.

Figure 7.5: Comparison of monthly rainfall (mm) at Nimba, Yekepa and Buchanan over the 30-year period of 1959 to 1988



Rainfall Intensity Duration Frequency (IDF) Relationship - The Met Office analysis found a close correlation between N'Zerekore in south-eastern Guinea and data from Sanniquellie,12 km south-west of Tokadeh, which made it possible to mathematically transfer the results for N'Zerekore to Sanniquellie, which provides best estimates of IDF relationships for Tokadeh (Table 7.6).

TABLE 7.6: ESTIMATED RETURN PERIOD FOR DAILY RAINFALL AT TOKADEH RAIL LOADING SITE

Return period (years)	Daily rainfall amount (mm)
2	102
10	133
50	158
100	169

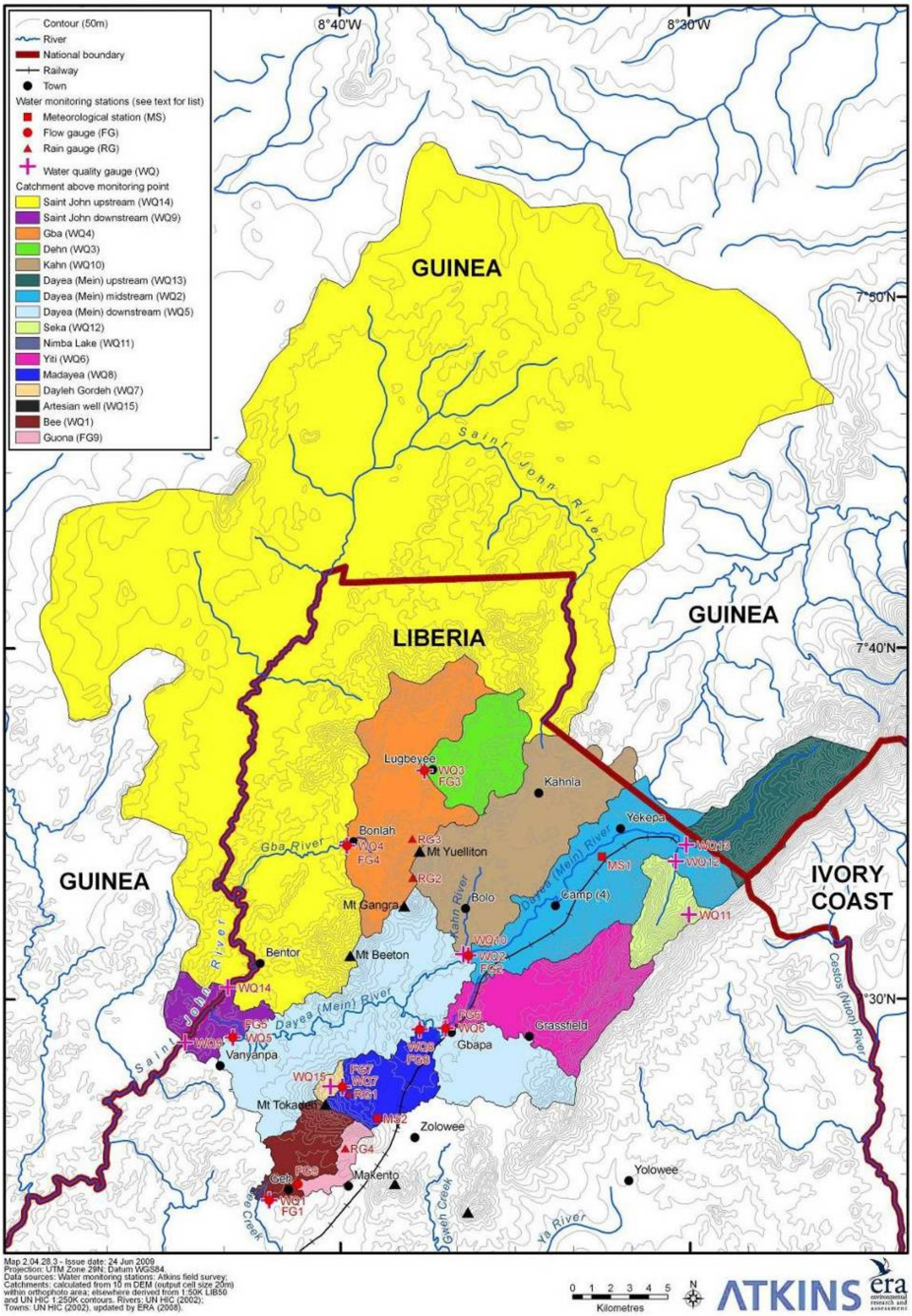
Synthesized rainfall intensity-duration-frequency curves are also presented in the report.

Nimba Surface Water Systems

The network of watercourses in the mining areas and their surroundings is very complex. The headwaters of most rivers in the area start from the surrounding mountains before coming together to form distinct rivers and creeks. A number of swamps and natural lake formations are also found in the area due to the complex topography. The watercourses are generally steep and react very quickly to rainfall events. The concentration time, i.e. the time needed for water to flow from the most remote point in a watershed to the watershed outlet is relatively short and for small catchments in the area (<5km^2) it is less than 3 hours. For catchments with a mining legacy, the concentration time is significantly reduced by the absence of vegetation cover in the mining areas. The rivers carry a significant amount of sediment during and immediately after heavy rainfall events. Usually there is a distinct change in colour from clear (when there is little or no rain) to brown/orange during storm events.

Figure 7.6 shows the system of watercourses around Mount Tokadeh, Yuelliton and Gangra and the surrounding area in Nimba County. The main river system draining the landscape is the St John River and its tributaries. St John River originates from Guinea and flows in a south westerly direction through Liberia towards the coast. Within Nimba County it runs along the Guinea-Liberia border, gathering discharges from a number of tributaries. All of the major watercourses within the Tokadeh, Yuelliton and Gangra mining and Concession Area flow into the St John. The main tributaries of the St John River around Yekepa and the mining areas of Tokadeh, Yuelliton and Gangra are the Dayea River and Gba River and their tributaries.

Figure 7.6: Overview of Nimba River Catchments



There are no continuous flow records for any of the rivers and watercourses in the concession area and the county in general. However, 31 spot gaugings were undertaken on the St John River between period 1958 and 1979 at the road bridge at Baila (border between Nimba and Bong counties) and continuous river level monitoring at eight locations and river flow gauging were undertaken between 2008 and 2010 to derive continuous river flow from water level records. Collection of additional river water levels data and flow gauging was started at the beginning of 2011 and is currently ongoing as part of the continuing baseline data collection. There have been numerous cases of theft and restricted access due to high river levels, which have led to gaps in the data collected. Nonetheless, the water levels and rainfall data collected provide useful information on the hydrological processes of the rivers.

<u>The Dayea River system</u> - The headwaters of the Dayea River rise from the Nimba ridge which spans the Liberia and Guinea border. The headwaters rising from Guinea are characterised by steep gradients, sinuous channel forms, and low clay banks with gravel river beds. In contrast, the headwaters rising from Liberia are heavily impacted by mining legacy from the former LAMCO mine and are characterised by deeply incised channels with brown turbid water due to the high sediment load from runoff generated from rainfall events. Channel bed and bank erosion and deposition of suspended and bed material occurs on different reaches of the river channel. The source of the sediment seems to be the old LAMCO spoil tips around the former LAMCO mine. These were placed on steep slopes in three main locations, two of which are in the Dayea headwaters. The tips were never stabilised, with the result that large scale erosion continues to take place (i.e. deep gully erosion with associated gully side mass failures). Some of these gullies appear to have eroded down through the original soil into the 'gangue rocks' below. The volume of sediment has caused avulsion which has triggered widespread channel erosion releasing even more sediment downstream. This process is ongoing and without measures to stabilise, the erosion will continue the negative legacy impact. The impact extends beyond the confluence with the St John River where there is often a visibly distinct difference between the brown turbid Dayea water joining on the left bank and the cleaner flow in the St John until the flows mix downstream.

Other watercourses within the Dayea River catchment impacted by mining legacy include Seke River, Madayea River, Yiti Creek and Dayleh Gordeh Creek. Baseline observations of these watercourses exhibit similar symptomatic geomorphological responses to mining legacy which typically include:

- fine black sandy material deposited along channel margins (magnetite/haematite derived from the ore bodies);
- orange sandy sediment smothering the channel bed (iron hydroxides and iron loving bacteria);
- exceptionally high sediment loads following rain; and
- landslide scars along the river network, usually triggered by increased channel erosion.

Local people generally cannot use these rivers for drinking water and often not even washing or laundry because the water can turn bright orange following any significant rainfall. Consequently the affected populations must use dug wells, pumps and boreholes to obtain water, some of which can be of poor quality and possibly not from a sustainable source.

The majority of sediment generated from historic mining activities at Tokadeh has been and is still being deposited in two wetland areas where there is a break in slope between the mountain and the valley. The majority of sediment found in the watercourses sampled is classified as 'coarse silt'. Results indicate that there is no significant difference in particle size during different flow conditions. This suggests that similar composition material is entrained in all flows and that it is just the mass of transported material that increases during high flow events. Low proportions of calcium, potassium and magnesium were found in all suspended and source sediment samples, indicating that buffering capacity in all watercourses is limited.

Kahn River - The headwaters of the Kahn River rise from the mountains near the village of Kahnla close to the Guinean border. The river is currently unaffected by mining, but will be significantly affected by mining activities in Yuelliton and Gangra during Phase 2. The stockpile locations, waste dumps and settlement pond outfall are all anticipated to be located within the Kahn River catchment.

Madayea River - The Madayea headwaters rise from Mount Tokadeh, draining the northern face of the mountain. The Dayleh Gordeh Creek is the largest tributary of the Madayea. The Dayleh Gordeh Creek drains the north western face of Mount Tokadeh and combines with other tributaries rising from both Mount Tokadeh and a small area between Gbapa and Zolowee to the east of the railway line to form the Madayea River. Dayleh Gordeh Creek drops steeply from the old mine benches near the ridge through a series of waterfalls and cascades down to the Tokadeh wetland at the break of slope before the confluence with the Madayea. It has obvious existing and ongoing mining legacy impacts from mining activities, from active erosion and landslides, and recent construction of access roads for exploratory drilling and the haul road leading to Tokadeh North for Phase 1. The stream channel has sandy black oxidised iron deposited on the margins and the red ochre silt covering the bed. Recent landslides in unconsolidated mine waste areas high on the former mine benches have contributed significant amounts of sediment to the system. Walkover surveys revealed strong visual evidence that a significant proportion of coarse sediment is deposited in the Tokadeh wetland and hence this acts as a natural filter to reduce the volume of sediment entering the Madayea River. The deposition of Dayleh Gordeh Creek sediment at the Tokadeh wetlands controls the morphological characteristics and sediment dynamics of the Madayea River downstream from the confluence. Localised low pH levels were observed in two wetlands at the foot of Tokadeh associated with the Dayleh Gordeh Creek. This indicates that weakly acid-generating conditions can occur within the stagnant, poorly buffered conditions that exist within these wetlands.

Yetee Creek and Pakuley River - The headwaters of Yetee Creek and Pakuley River originate from the Nimba mountain range to the east. Both rivers flow in a south westerly direction crossing the main road connecting Yekepa and the Tokadeh mining area through culverts near the Village of Gbapa. The two rivers then combine with the Madayea from Mount Tokadeh and discharge into the Dayea. Yetee Creek has a mining legacy and reacts very quickly to rainfall events. In October 2011, flows in the river reached very high levels causing significant flooding and obliteration of the road above the culvert. It is believed that the erosion of the road was triggered by blockage of the culvert by debris upstream, which led to overtopping of the gravel road and its eventual erosion as a result of the shear stresses induced by the fast flowing waters.

The Bee Creek System - The Bee Creek System drains the south western slopes of Mount Tokadeh. The creek flows south west through the village of Gbapa before changing its course to flow in a south eastern direction through Sanniquellie, where it crosses the main road and the railway line. The Bee Creek System does not appear to have a mining legacy impact from Mount Tokadeh; however, it may be affected by Phase 2 mining activities.

The Gba River System - The Gba River catchment drains the western slopes of Mounts Yuelliton, Gangra and Beeton. Gba River flows south west past the village of Bonlah and discharges directly into St John River. The main watercourses of the Gba catchment are Vellie Creek, Dehn Creek, and Leyee Creek. Currently all of these watercourses are in good condition with no mining legacy impacts and are used for drinking water.

Mining Legacy Rivers - One of the key objectives of both the Phase 1 and Phase 2 ESIA monitoring is to differentiate mining legacy impacts from DSO activities or subsequent mining. Catchments which appear to be affected by the mining legacy impacts, and those currently unaffected but which may be potentially impacted by the mining activities, are summarised in Table 7.7 and shown in Figure 2.2 in Section 2.

TABLE 7.7: LEGACY AND POTENTIAL IMPACTS AT MONITORED CATCHMENTS			
River catchment	**Legacy impact**	**Potential impact from new mining**	**Comment**
Bee	limited	✓	Catchment to the south of Tokadeh. Very minor legacy impact. Runoff from the southern part of the mine will enter the Bee catchment.
Dayea	✓		Upper reach receives run-off from Nimba mine area; middle and lower reaches will be significantly affected by Tokadeh, Yuelliton and Gangra mining activities.
Gba		✓	Catchment to the west of Gangra and Yuelliton. Mine layout extends into the Gba Catchment. No direct discharges, but some runoff from the western part of the mine will enter the Gba catchment.
Yeetee	✓		Receives run-off from Nimba mine area. Significant legacy impact. Not affected by mining activities.
Dayleh Gordeh	✓	✓	Small sub catchment of the Madayea River at Tokadeh. Significant legacy impact and significant mining impacts.

Comparison of Phase 1 and Phase 2 Data - One of the main anticipated impacts of Phase 2 is the change in runoff and drainage of the mine sites as a result of Phase 2 activities, particularly for the Madayea River, Kahn River and Gba River. These are the watercourses that will be directly and most significantly affected by Phase 2 activities and any changes in runoff characteristics due to Phase 2 activities are likely to have an impact on the amount of sediment in these watercourses and the Dayea River and St John River.

In order to capture any changes in catchment characteristics, rain gauges were installed at Tokadeh, Yuelliton and Gangra and a programme for monitoring water levels and water quality to provide additional baseline datasets for these rivers was proposed. However, the rain gauges installed at Yuelliton and Gangra did not function properly and water quality data collected in 2011 was very limited. The Phase 1 baseline data also had significant data gaps. As a result of this lack of continuous record of good data and flow gauging data in 2011, it has not been possible to undertake a comprehensive comparison of Phase 1 and Phase 2 data and determine the effects of Phase 1 mining activities on the current Phase 2 baseline data.

The only location where continuous rainfall and water level data were available in 2011 was at the Tokadeh mine site. Data from Tokadeh have been analysed to determine whether any changes in runoff characteristics have occurred in the Madayea River during Phase 1. Analyses of water level time series and rainfall data from 2011 at Tokadeh for an event in September 2011 suggest a much shorter time to peak for the Madayea River compared to the time to peak derived from 2008 events data. The figure suggests a time to peak of 3 hours. This is significantly less than the time to peak obtained from analysis of rainfall and flow data collected in 2008 and needs to be verified with more recent data by the Company environmental monitoring team as it could have significant implications for mitigating runoff and suspended sediments during Phase 1 and Phase 2. It is recommended that the Company environmental monitoring team continues collecting water levels and water quality data and undertake spot gaugings at recommended locations so that the effects of Phase 1 and the required level of mitigation for Phase 2 can be determined based on field data.

Buchanan Surface Water Systems

The Savage River and its tributaries are the main river system draining the Buchanan concession area and Buchanan Port. The original outfall of the river was changed by LAMCO following a channel diversion following the construction of the port in 1961. The current outfall of the main channel to the sea, which discharges the majority of the river flow, is located approximately 3 km to the east of the port. The river flows into the lagoon that has developed behind the sand bar along the coastline and eventually discharges into the sea. A secondary channel, which carries less flows from the Savage catchment and follows the original course of the river discharges directly into the port after the bifurcation.

Significant flows were observed in the main channel of the river during field visits. There are no flow gaugings records for the river. Flow velocities of more than 1m/s were estimated near the bridge crossing the river. In spite of the high velocities observed, the colour of the river water appeared to be relatively clear. The amount of suspended solids measured from a sample taken in the river in November 2011 was very low compared to the Nimba Rivers. In addition to the original course of the Savage River, there are four watercourses which drain the port area and discharge into the harbour. A significant amount of suspended sediments was observed in all four channels during the August 2011 visit to the port. The outfalls in the middle and western end of the port contained more sediment and DSO material than the other two as they drained the area where the DSO stockpiles were located. A boundary separating the fresh sea water from the coloured, contaminated runoff discharging into the harbour was visible at the time of the visit.

Surface Water Quality

To summarise the Phase 1 and Phase 2 Water Quality Data Analysis for both the Nimba and Buchanan water systems:

Sediments

The main findings are as follows.

- The amount of suspended sediment depends on the magnitude of the flow in the rivers. Sediment concentrations are high in rivers after rainfall events and low when river flows are low. Very high concentrations were recorded from spot sampling data collected in 2008 in the rivers with a mining legacy; Dayea River, Dayleh Gordeh River and Yetee River. In contrast, suspended solids concentrations in the rivers without mining legacy, the Deh, Gba, Khan and St Johns were an order of magnitude smaller, regardless of flow.
- Spot sampling data from 2011 were collected during low flows and therefore do not show high concentrations of suspended solids. It is therefore recommended that targeted sampling be undertaken following heavy rainfall events.
- The suspended sediment found in all rivers is classified as fine silt with median particle size ranging between 19 to 28 µm.
- The soil analysis shows similar particle size distribution in the suspended sediment samples, regardless of river flow conditions. It is not clear whether the distribution of sediments has changed during Phase 1. Further sample analysis should therefore be undertaken at Tokadeh to determine whether sediment distribution has changed as a result of ongoing Phase 1 activities.
- The most dominant ions in both suspended and source soil sediments were iron and aluminium.
- The organic matter content of sediments is higher (7 to 28%) in suspended sediments compared to source sediments (3 to 14%).

Metals

The main findings are as follows.

- The level of iron concentration in rivers with or without mining legacy is generally higher than the limit of 100 µg/l set in the Liberian Guidelines and the WHO standard and the 200 µg/l limit set in the IFC standard. Concentration levels of all other toxicologically relevant metals, including the residual heavy metals, were either below the limit of detection or lower than the standard set by WHO for drinking water.
- Relatively high levels of magnesium, sodium and calcium were found in all river samples, with the samples from Buchanan Port and the Savage River containing the highest concentrations due to the effect of salt water from the sea.
- Levels of iron concentration were no greater in legacy catchments than unaffected catchments.

Nutrients

The main findings are as follows.

- The levels of nutrients were very low and were either below the limit of detection or lower than the standard set by WHO for drinking water.
- Modest levels of nitrates were measured in samples taken from rivers close to villages and at the Tokadeh and Yuelliton and Gangra sites.
- Although amoniacal nitrogen was not detected, the presence of detectable levels of nitrates does suggest that there is a measurable impact of human and animal faecal waste and consequently a potential existence of pathogens.

Physical and Chemical Water Quality Parameters

The main findings are as follows.

- The main factor driving the variations in physical and chemical water quality parameters in rivers is runoff generated by rainfall.
- Rivers with a mining legacy were found to be an order of magnitude more turbid than rivers without mining legacy. The higher the flow in the rivers the higher the turbidity compared to the turbidity under low flow conditions in the same river.
- The temperature of river waters in the mining area varies mainly between 20ºC and 25ºC and tends to decrease with increasing flow/water depth in the river.
- pH values measured in all rivers in the mining area normally range from 6.1 to 7.5 according to data collected in-situ and from lab analysis. Low pH values from the borehole within the catchment of the previously planned water storage dam (Section 4) and in the Tokadeh wetlands suggest the existence of localised ARD effects. The continuous data collected in 2008 suggests that pH tends to reduce during storm events.
- High levels of dissolved oxygen (DO) were recorded in all rivers in the mining area and in many cases DO levels were above saturation. DO levels reduce slightly during storm events most likely due to an increase in sediment oxygen demand. Low content of organic matter in sediments and low nutrients in river waters are likely to be responsible for the overall high DO levels.
- Conductivity in all rivers sampled was found to be very low and the absolute levels of concentration of sodium, calcium and magnesium, chloride, sulphates, nitrates and phosphates were also low. Samples from Buchanan, which were affected by sea water, had a high concentration of sodium, calcium and magnesium chloride. The effect of storms on conductivity of river waters is less obvious.

The Phase 2 baseline monitoring so far supports the conclusions of the Phase 1 baseline study and has shown that the main risk to the surface water environment is from high concentrations of fine sediment entrained in surface water systems near the mine site areas. This risk has increased as a result of unmitigated Phase 1 activities. The impact of contamination from heavy metals is shown to be low and ARD effects only occur at a local scale; the effect on rivers is insignificant. The risk of contamination from both heavy metals and ARD is not believed to have been increased by the ongoing Phase 1 activities. The risk of chemical and microbial contamination has not been fully investigated at this stage and should be investigated further as part of the routine monitoring programme by the Company. More data on suspended solids need to be gathered to establish the effect of Phase 1 and planned Phase 2 activities on water quality.

With regard to Phase 2 ESIA Volume 3, Part 3.2 (Geochemistry and Water Quality), this report provides an assessment of the geochemistry and water quality in the Western Area Iron Ore Concentrator Mining Project, focusing in particular on the potential for ARD formation arising from ore, tailings and waste rock materials.

A geochemical materials characterisation study was originally undertaken by AMEC based on a review of the available drill core data and testwork on selected samples. (Although arguably this study should be described under Section 7.3.2 Hydrogeology, it is covered here since it also involves surface water). A field visit was then undertaken in November 2011 with the primary purpose of complementing this geochemical study through reviewing water quality at Tokadeh, Gangra and Yuelliton. Drill core bore holes associated with locations with the potential for ARD were visited and in-situ water quality measurements undertaken. As part of this field visit, locations associated with former LAMCO operations were also visited together with surface water streams draining the existing DSO operation. A photo record of all these locations was made together with *in-situ* measurements of pH, turbidity and electrical conductivity in order to define locations for future water quality monitoring.

The results of the geochemical study indicate that there might be localised areas (or hot-spots) within the deposit with sulphide in sufficient concentration that might lead to ARD generation, but that the majority of the waste material will be non-ARD generating. Furthermore, the short term leaching experiments on all samples tested indicated that the waste rock will not present metal leachability issues: all metals were far below US EPA limits resulting in the samples being classified as non-hazardous.

The study has been complemented with a water quality study with *in-situ* measurements at key sites followed by the chemical analysis of samples from select locations.

Only one location presented any evidence of potential historic ARD from water quality data, with measurable but low sulphate values found at a historic LAMCO open pit. Also one of the Tokadeh boreholes identified by the geochemical study as containing elevated sulphide showed visual signs of discoloration from what could have arisen from previous ARD generation. This was not confirmed by current water quality, however, with net alkalinity determined.

The dissolved values for all of the residual heavy metals in all of the samples are at least two orders of magnitude below the World Bank Environmental Quality Guidelines for effluents adopted for this project. Furthermore, all of these residual heavy metals data are also below the WHO guidelines for drinking water, with a large number of data below detection limits.

All pH measurements at all locations are circumneutral and the natural pH of the local soils is mildly acidic. From consideration of all of the above, any localised ARD from potential hot spots would be expected to have no significant impact on the local environment.

Entrained fines from ultrafine / colloidal (1-1000 nanometres) solids present in surface drainage waters is considered to be the major geochemical issue and environmental challenge to be addressed for this project. While dissolved concentrations of iron are low in the majority of samples, the presence of colloidal material was indicated from total iron assays in the surface water samples at Tokadeh.

Turbidity (and hence suspended sediment) naturally increases in high flows in response to rainfall. However, monitoring results show that turbidity responses in the Gba and Kahn, where there has been no mining, are significantly lower than in the Dayea River where there are obvious mining legacy impacts.

7.3.2 Hydrogeology

The hydrogeology baseline data are provided in Phase 1 DSO ESIA Volume 3, Part 3.1 (Hydrogeological and Groundwater Baseline) and Phase 2 ESIA Volume 3, Part 2 (Groundwater Baseline & Impact Assessment).

The aim of the Volume 3 Part 2 report is to provide an overview of the hydrogeological and groundwater conditions at Yekepa (including the mine area) and Buchanan (the port area) and use this overview to examine the potential effects of the proposed Phase 2 activities.

Using the LAMCO rainfall data (from Nimba Geologist's Camp to represent Yekepa), the annual effective rainfall at Yekepa appears to be about 1,550 mm and at Buchanan about 2,900 mm. Not all of this effective rainfall will recharge the aquifer; some will run off as overland flow and eventually contribute to streams and rivers. From the runoff coefficients derived for the Yekepa and Buchanan areas, more than half of effective rainfall in Yekepa is surface runoff and the remainder provides groundwater recharge. This is consistent for mountainous areas with little soil cover. In Buchanan about 75% of effective rainfall is available to aquifer recharge with the remainder draining to streams and rivers, as the area is flat with a shallow sedimentary aquifer underlying the basement aquifer. However, actual groundwater recharge is normally calculated on the areal extent of the groundwater basin and is significantly affected by aquifer continuity. With the current poor understanding of the groundwater systems in Liberia and the discontinuous nature of the aquifers that affects area of abstraction (in particular Yekepa and Green Hill), estimation of groundwater recharge is difficult. The Hydrogeological Map of Africa indicates that groundwater recharge in Liberia ranges between 300 mm/year and 500 mm/year. The UN Food and Agriculture Organisation gives a figure for Liberia as a whole of 404 mm/year. As Yekepa lies in the drier northern part of Liberia, it is likely that recharge is lower than the FAO figure of 404 mm/year and closer to the lower limit of 300 mm/year. For planning purposes, a value of 300 mm/year has been selected. As Buchanan lies in the wetter coastal part of the country, a value of 500 mm/year has been selected.

Published geological mapping and field observation indicate that bedrock for both the Yekepa and Buchanan areas is predominantly Precambrian gneiss, overlain by weathered rock, overlain by Quaternary deposits. In the Yekepa area, the gneiss aquifer is unconfined, and therefore sensitive to potential contamination from sewage, fuel, oil or other contaminants. Some contamination may be taking place already in association with the now defunct LAMCO sewage treatment works and the present waste disposal at the Yekepa township. The depth of the productive zone of the aquifer is not known. A spring is present on the higher ground to the north of Yekepa. It issues from joints in highly weathered gneiss. In the Buchanan area, the Precambrian gneiss aquifer is in hydraulic continuity with the overlying marine terrace deposits and may also be unconfined. The aquifer will be sensitive to potential contamination from sewage, fuel, oil or other contaminants. The maximum productive depth of the aquifer is not known with certainty, but previously drilled wells have been as deep as 150 m.

At Buchanan, LAMCO undertook extensive drilling and testing of a large number of boreholes in the 1960s and 1970s for the evaluation of the aquifer for water supply potential. However, virtually all the construction and testing data have been lost. As a result, very little is currently known about the hydrogeology of the aquifer underlying Buchanan and its potential for water supply.

The Phase 2 baseline field survey provided further information in regards to the understanding of localised recharge and sustainablitiy. Generally, wells that are not in hydraulic connection to surface drainage channels such as streams and rivers tend to dry up quickly after a few hours of continuous pumping. The village of Kanlah about 4 km north-west of Yekepa Camp has two operational wells that dry up following 4-5 hrs of continuous pumping. These wells may take a day or so to recover and more so in the dryer months.

Wells in hydraulic continuity with drainage systems tend to yield 1-5 l/s continuously without drying up. These include the wells supplying Yekepa camp that are in general proximity to the Dayea River. These wells are likely to be in hydraulic continuity with the river which acts as a recharge to the localised groundwater system. Wells in Buchanan are drilled through the Pleistocene sandy marine terrace deposits and into the weathered zone of the Precambrian gneiss. Abstraction rates are about 1-5 l/s, i.e. similar to the values from the Yekepa wells. The overlying terrace deposits are recharged from rainfall and provide a hydraulic connection to the lower gneiss aquifer. This overlying layer may provide a constant recharge to the weathered basement aquifer by downward leakage. Changes in the water quality of the terrace deposits directly affect the quality of the lower Precambrian gneiss aquifer. At both locations the water table is fairly shallow with water levels ranging between 3 and 11 metres below ground level (m bgl) at Yekepa and between 4 and 7 m bgl at Buchanan. The weathered bedrock is therefore likely to be only partially saturated. The range of seasonal groundwater level fluctuations is not known due to a lack of data. Groundwater levels in the dry season will be lower than during the wet season.

The most effective method to define the baseline conditions and to monitor water quality trends is described in Table 7.8. For this study the most import key indicators of water quality have been limited to the use of simple and easily operated instrumentation i.e. TDS/EC and pH meters. TDS/EC and pH have been used to represent the 'average' water quality. Anthropogenic pollution indicators such as nitrate and ammonium would be useful as additional parameters in the understanding of sources of pollution.

TABLE 7.8 KEY INDICATORS OF WATER QUALITY

KEY INDICATORS		COMMENTS
Surface Water	Flow Rate (m^3/s)	Indicates the physical condition of the stream / river.
Surface and Groundwater	Temperature (^oC)	Affects the solubility and ionic ratio of chemical constituents and activity of organisms.
Surface and Groundwater	Total Dissolved Solids (mg/l)	Increasing values represents increasing mineralization / salinity and reflects a direct relationship to decreasing water quality.
	Electrical Conductivity (µs/cm)	Electrical Conductivity can be estimated from TDS. TDS is used as water classification and potability
	pH	Acidity of the water results in changes in the chemical profile and concentration of the major ions in solution
	Major Ions	Major ions K, Na, Mg, Ca, SO_4, Cl, HCO_3/CO_3 To define the groundwater type and suitability for water usage.
	Minor ions	In particular for groundwater parameters such as Fe, Mn, fluoride and boron.
	Transition (heavy) metals	Some metal ions can be toxic at extremely low concentrations and can be introduced into drinking water either though natural processes or as a result of human activity
	Nitrates, nitrites, ammonia	Links to anthropogenic activities. Liberian permissible limit for potable supply, 40 mg/l as NO_3.
	Faecal coliform	Links to anthropogenic activities and indicator of the deterioration of water quality for potable supply.
Groundwater	Groundwater Levels	Changes in the levels: upward trend, seasonal fluctuation of recharge or recovery of the aquifer, downward trend, nearby abstraction or discharge > recharge.
	Radioactive isotopes	Elevated levels of radionuclide in groundwater typically are becoming an increasing concern to human health especially in areas of basement rock, i.e. radon, isotopes of radium and uranium. Sampling and analysis of these parameters are outside the scope of this study.
	Sea water intrusion of Groundwater	These ratios may be used to detect saline intrusion. Ionic ratios: NaCl, SO_4:Cl, BrCl Isotope ratios: Sr87:Sr86

Unpolluted rain has pH of 5.65 and is in equilibrium with the atmospheric CO2. Table 7.9 provides pH values from the field survey conducted in January 2012 and an explanation of the values of pH obtained.

TABLE 7.9: PH OF SURFACE AND GROUNDWATER

Water Type	pH	Conditions
Rainfall	5.6	Unpolluted air Un-buffered water and uptake of natural levels of CO2 in atmosphere that contain low particulate matter i.e. Sulphur dioxide, Nitrous Oxides.
	< 5.6	Acid rain (elevated levels of particulate matter)
Surface Water*	6.9 - 7.4	Yekepa and Green Hill Surface flows are slightly acidic due to the un-buffered nature of the rainfall and uptake of CO_2 from the atmosphere. Rock matrix of the gneiss aquifer contains little alkaline material but dissolved in the water is CO_2 to $CaCO_3$ and acts as buffer increasing the pH.
	7.2 - 7.8	Buchanan pH tends to be more alkaline due to the availability of buffering material from the marine terrace deposits.
Groundwater	5.6 - 7.0	Yekepa Rainwater infiltrates directly into the weathered and fracture zone of the gneiss aquifer; the pH reflects the rainfall.
	6.1	Green Hill Gneiss aquifer
	6.9 - 8.3	Buchanan Marine terrace deposits overlying gneiss aquifer
Note: pH of surface and groundwater data taken from field survey Jan 2012		

* Pure rainwater is slightly acidic (pH 5.6) as a result of the uptake of carbon dioxide from the atmosphere forming weak carbonic acid. Flowing surface waters at Yekepa, Greenhill and Buchanan generally have pH values in the range 6.5 to 6.9, i.e. near-neutral, reflecting the relatively low buffering effect of Liberian soils developed on Precambrian gneisses deficient in soluble minerals such as calcium carbonate. Some surface waters have been found to have pH values of about 7.4, however. This may indicate chemical changes caused by decomposing vegetation or contamination by either sewage or agricultural fertilisers containing nitrates and phosphates.

Some water samples have been taken for laboratory analysis in December 2011 from the surface water monitoring programme at Yekepa. Table 7.10 tabulates the constituents that have exceeded Liberian drinking water standards.

TABLE 7.10 WATER QUALITY CONSTITUENTS EXCEEDING LIBERIAN DRINKING WATER STANDARD

Suspended solids, Total (mg/l)		Phosphate (mg/l)	
Liberian Standard	10.0	Liberian Standard	0.01
DY4 Dayea middle stream (Gbapa access road)	72.5	YT1 on Gbapa road	0.29
DY5 in Vayanpa	19		
GB1 Zolowee road	11		

Measurements of pH and EC were also undertaken in May 2010 in connection with the Phase 1 baseline. No chemical laboratory analyses were undertaken. The water quality of the Precambrian gneiss aquifer is fresh (i.e. total dissolved solids are less than 1,000 mg/l). However, at Buchanan, due to the proximity of the sea, there may be a risk of saline intrusion as a result of aquifer exploitation. The figures for Yekepa would suggest recharge from rainfall and indicates corrosive water that would need to be treated if it is to be used for human consumption.

Water analyses would need to be undertaken to establish the chemical and bacteriological condition of the groundwater, and the need for further treatment. However, so far the Company has experienced difficulties in getting reliable bacteriological tests carried out because of the risks of sample contamination, lack of high standard laboratories in Liberia and difficulty of transporting refrigerated samples overseas.

The figures for Buchanan would also suggest recent recharge from rainfall. Recent water quality analysis results indicate that the medium-deep boreholes may be prone to bacteriological contamination. Again, additional water analyses would need to be undertaken to establish the chemical and bacteriological condition of the groundwater, and the need for further treatment.

In respect of groundwater abstraction, LAMCO did not use the aquifer to supply the Yekepa township with potable water and no boreholes were constructed. LAMCO supplied water to the Yekepa township and the mine installation from the River Dayea. The water was abstracted from the river upstream of the town and treated in the now disused filtration plant, also located upstream of Yekepa.

The aquifer is currently exploited for public water supply by the Company staff based in Yekepa via a number of shallow wells and recently drilled medium-deep boreholes. Although, mining related activities will require a limited volume of water (mainly for dust suppression) during Phase I (DSO), the overall Company water demand will increase most significantly during Phase 2. At Buchanan, LAMCO used the aquifer extensively to supply the township with potable water and constructed and tested a large number of boreholes for that purpose. However, most of the boreholes cannot be used any more. LAMCO supplied water to its processing plant by pipeline from the Benson River north of Buchanan.

There is also the potential for groundwater to have been contaminated by the tailings placed during LAMCO operations. A well supplying water to the hospital at Buchanan was abstracted at much higher rates to supply water for construction works. After a period of time the iron concentrations increased to a level that discoloured the water and stained toilets and sinks. This potential will require further investigation as it is difficult to see how this contamination is continuing to arise.

Very little is known about the water levels and hydraulic parameters of the pre-Cambrian crystalline weathered aquifer that is used for groundwater supply in Yekepa, Green Hill Quarry and Buchanan but discussions with Company staff indicate current water demand is met from existing wells for mining and domestic purposes. Potable supply is provided from bottled water and water for cooking is treated using a small reverse osmosis plant at Yekepa, Green Hill and Buchanan. At Buchanan, seawater intrusion may eventually affect the wells in proximity to the sea leading to poorer quality groundwater. It remains unclear as to if and when the effects of saline intrusion will occur but as abstraction increases the cone of drawdown will contact the interface of the saline water at depth. This will cause seawater to migrate towards the abstracting wells and deterioration in water quality will occur fairly rapidly.

The value of groundwater recharge at Yekepa was selected to be at 300 mm/year, which is equivalent to a quantity of 9.5 l/s per km^2. Yekepa township extends over an area of about 7 km^2 in the Dayea valley. For planning purposes, this zone will be considered as the zone where groundwater resources will be developed. The total volume of recharge will therefore be about 2,100,000 m^3/year or 66.5 l/s. The value of groundwater recharge at Buchanan was selected to be at 500 mm/year, which is equivalent to a quantity of 15.8 l/s per km^2. The area of the Buchanan concession is about 15 km^2. For planning purposes, this zone will be considered as the zone where groundwater resources will be developed. The total volume of recharge will therefore be about 7,500,000 m^3/year or 237 l/s.

At present, the demand from the Company facilities (both Yekepa and Buchanan as well as the port installations) has not been estimated (Figure 3.7 contains data relating to the mine area). However, considering the estimated total volume of recharge, it would seem that there should be enough renewable groundwater resources to meet the maximum demand of the Company facilities at least during the wet season when recharge takes place.

In the dry season, when rainfall and recharge is limited, demand will have to be met by aquifer storage. Very little is currently known about the hydrogeology of the aquifer underlying either Yekepa or Buchanan and its potential for water supply. Due to the fractured nature of the aquifer, the total volume of water may not be fully available for abstraction by the water supply wells. Confirmation of the volume of water available can be established after undertaking a drilling and testing programme as well as conducting borehole surveys and pumping tests of existing selected wells.

In the Buchanan area, excessive groundwater abstraction can cause contamination of the fresh groundwater because of lateral movement of seawater inland. The risk of contamination is likely to be small during the wet season when water levels remain high due to recharge from rainfall. In the dry season, the risk is higher. Measures to protect the aquifer and groundwater supplies from seawater contamination include abstraction not greater than recharge; wells located at some distance from the coastline at least 100 m or more; baseline monitoring of key water quality indicators to detect migration of seawater.

The dolerite dykes evident along the coastline may act as a barrier to saline intrusion although further investigations are necessary such as the baseline water quality monitoring for salt content.

The calculated potable water requirements are shown in Table 7.11. For the local population in the rural communities, the minimum water consumption may be lower than the international standard of 100 l/day and more like the ‘primitive conditions’ of 15 l/day or 75,000 m^3/yr.

TABLE 7.11 WATER REQUIREMENTS

Location	ArcelorMittal Staff				Mining Operations mainly dust suppression m^3/yr	Local Population m^3/yr
	Current		Forecast Expansion			
	No. Staff	Water demand m^3/yr	No. Staff	Water demand m^3/yr		
Yekepa	300	13000	3000	130,000	6000	500,000
Green Hill	40	1800	50-100(est)	??	??	n/a
Buchanan	350	15000	400 (est)	18000	??	n/a

The following conclusions can be made:

- With the very high rainfall there is little risk that the water demand exceeds supply of surface water. Groundwater for domestic supply is restricted to the immediate groundwater storage within the main gneiss aquifers. It is dependent upon spatial continuity of the aquifer as well locating new wells in proximity to hydraulic connections such as streams and rivers.
- At both Yekepa and Buchanan there is insufficient information available concerning water needs and the provisions for waste water and sewage treatment to be able to finalise the impact assessment and identify any required mitigation.
- At Tokadeh, Gangra and Yuelliton the ultimate depth of pit excavation is not known and so its interface with the water table cannot be assessed.
- At Tokadeh, Gangra and Yuelliton there is the potential for groundwater to become contaminated by sediments, iron content and the product of any fuel or chemical spillages.
- At the mine area in general, there is no information on the groundwater regime and the manner in which the water resources that feed downstream wells are replenished.
- At Buchanan there will be the potential for saline intrusion if drawdown is excessive, though this is considered unlikely. However, this assessment cannot be finalised without the required information in terms of required yield for Phase 2, and without further information regarding groundwater levels and fluctuations as well as water quality baseline monitoring of key indicators to detect migration of saline intrusion.
- At Buchanan there is the potential for legacy-contaminated groundwater to affect potable water supplies, as it appears to be doing already.
- Acidity, especially in groundwater samples, is generally due to the natural pH of rainfall and the lack of buffering agents in the soil matrix such as $CaCO_3$. To confirm this, rainfall samples should be taken and pH readings should be conducted immediately.
- For the railway, there have been no measurable departures from natural hydro environment since its original construction and during its rehabilitation.

7.4 Land

7.4.1 Landscape Character and Visual Amenity

Landscape and Visual Impact are contained in Phase 1 DSO ESIA Volume 3, Part 6 (Landscape Character and Visual Amenity Assessment) and Phase 2 ESIA Volume 3, Part 7 (Landscape and Visual Impact Assessment).

In Phase 2 Volume 3 Part 7, the landscape and visual effects of the scheme are assessed for Phase 2 at the following stages;

- after construction of the concentrator plant, reservoir and tailings facility to serve mining operations at Mount Tokadeh but before commencement at Mount Gangra and Mount Yuelliton;
- during operation, assuming the maximum mine footprint, encompassing Tokadeh, Gangra and Yuelliton mining areas, is operational (i.e. worst case); and
- at Year 15 post operation assuming 15 years of growth of trees/shrubs following rehabilitation of the Mine Site.

It is assumed that the Port facility at Buchanan and the railway from Tokadeh Mine to Buchanan will remain as permanent infrastructure.

Nine distinct landscape character areas (LCAs) were identified within the vicinity of the Mine Site, three of which have been refined into sub units, and seven LCAs in the Port Area.

The Mine Site lies in NCA 01 Gangra-Yuelliton Forest Peaks, NCA 07 Tokadeh Mountain Forests, NCA 06 a) Gbapa Rolling Plain, NCA 02 b)) Dayea (Mein) Valley and NCA 09 Geh /Makinto Farmland Plateau. Buchanan Port is assessed as being within Buchanan LCA 1, the port industrial zone of Buchanan.

Key Characteristics of the LCAs in the Study Area

The key characteristics of the LCAs relevant to the Mine Site and Buchanan Port, taken from the written description in the Phase 1 LVIA, are reproduced in Tables 7.12 and 7.13.

TABLE 7.12: NIMBA LANDSCAPE CHARACTER AREAS (NCA) IN THE MINE SITE STUDY AREA

Ref	Landscape Character Area	Distinctive & Defining Landscape Characteristics	Sensitivity to Change
NCA 01	Gangra-Yuelliton Forest Peaks	Upland forest peaks and distinctive mountain range of Mount Gangra and Mount Yuelliton (to 1040m ASL). Includes areas of A1, A2 and A3 defined by the geotechnical terrain classification. Landform often steep sided with mid and lower slopes of the mountain range forming complex and irregular dissected gullies and slopes. Dominant vegetation cover is dense forest with some small variations of localised wetland or clearance.	**High**
NCA 02	River Plateaus, sub divided into: a) Kahn Undulating Plains; and b) Dayea (Mein) Valley.	Wide undulating river plateau ranging between 440m and 540m ASL with localised, rounded hills forming high points. Includes areas of B1, B2 and B3 defined by the geotechnical terrain classification. Relatively dense network of watercourses located in the western extents of this character area. Vegetation cover and land use include extensive clearance for a diverse range of farming that contributes to a mosaic of clearance patterns. Consideration of cultural, social and geographical distinction of Rivers Kahn and the Dayea (Mein) have led to definition of sub areas: *Kahn Undulating Plains* Situated between Mounts Gangra and Yuelliton and the lower and more open ground around Yekepa. A low ridge defines the transitional boundary between the adjacent Dayea (Mein) Valley sub area. Identified settlement is relatively dense towards the centre of the character area and noted on the foothills of mountains. *Dayea (Mein) Valley* Bordered by Mounts Gangra, Yuelliton and also Beeton with distinctive valley formed by Mount Tokadeh. Beyond Tokadeh the narrow valley broadens and becomes a wide undulating plain. Topography is notably lower than sub-area 2a at approximately 440m to 480m ASL. Identified settlement in this area is evenly dispersed. A relatively dense network of watercourses form tributaries to the River Dayea (Mein).	**Medium**
NCA 03	Yekepa Valley Plain	Yekepa township dominates this area. The area is influenced by the Dayea (Mein) River and development is closely linked to river floodplain (at approximately 500m ASL). Beyond the floodplain, landform rises sharply and settlement gives way to the diverse mosaic of rotational slash and burn farming. Includes areas of B1, B2 and A3 (in a transitional area of character) defined by the geotechnical terrain classification. Bare earth associated with roads and built development is distinctive and highly visible from the higher ground. Fringes of the town are transitional as clearance for built development gives way to farming. Mining associations influence the area with features such as the large semi-derelict workshop present on the edge of town. Lack of vegetation cover facilitates clear and long range views towards mountain ranges to the east and west.	**Low**

TABLE 7.12: NIMBA LANDSCAPE CHARACTER AREAS (NCA) IN THE MINE SITE STUDY AREA

Ref	Landscape Character Area	Distinctive & Defining Landscape Characteristics	Sensitivity to Change
NCA 04	Nimba Range, sub divided into: a) South Nimba Ridgeline; b) Nimba Foothills; and c) LAMCO Historic Mines.	A large scale and extensive ridgeline. Includes areas of A1, A2 and A3 defined by the geotechnical terrain classification. The area is sub-divided into *South Nimba Ridgeline* A distinct ridgeline feature the slopes of which are regular, steep sided and reach approximately 840m ASL in the southern region. Lower slopes are less regular and give rise to the formation of a number of incised valleys. The entire area is dominated by primary forest. *Nimba Foothills* Foothills of the northern extent of the main Nimba ridgeline and a thin transitional area ranging from 540m to 840m ASL; in general the landform undulates between levels of 600m to 700m ASL. Topography of this area is distinctive from upper slopes of the main ridge and the lower undulating plains to the west. The area is generally well forested with clearance limited to areas where landform is less severe. *LAMCO Historic Mines* Significant section of the northern extent of the range; landform similar to the main ridge with peaks of up to 1300m ASL. Presence of the former LAMCO mine is apparent through extensive vegetation clearance and excavation resulting in artificial, engineered features dominated by grassland and scrub. Abandoned machinery, infrastructure also influences the character and are detracting features in the immediate landscape.	Sub areas A and B: **High** Sub Area C : **Medium**
NCA 05	Beeton Forested Foothills	Landform comprises undulating topography between 400m to 440m ASL rising to around 500m in the transitional area to the north east forming the lower foothills to the broken ridge of Mount Gangra. Includes areas of A2, A3 and B1 (in a transitional area of character) defined by the geotechnical terrain classification. Little vegetation clearance with majority of cover comprised of high forest (including areas of primary forest). The limited variation distinguishes the area from surrounding plains as the mosaic of rotational clearance is not apparent.	**Medium**

TABLE 7.12: NIMBA LANDSCAPE CHARACTER AREAS (NCA) IN THE MINE SITE STUDY AREA

Ref	Landscape Character Area	Distinctive & Defining Landscape Characteristics	Sensitivity to Change
NCA 06	Farmland Plateau, sub divided into: a) Gbapa Rolling Plain; b) Cassava Farm Plateau; and c) Zolowee Valley Plains.	Generally similar areas of undulating farmland mosaic; distinguished by presence of settlement and geographical scale. Undulating landforms that include distinctive rounded hills generally ranging from 440m to 480m AOD with occasional high points (often to 500m ASL). Includes area B1 as defined by the geotechnical terrain classification. Absence of the major watercourses through these areas however a network of minor watercourses is relatively extensive. Clearance of forest is common throughout the farmland plains, with a combination of land uses contributing to a complex mosaic of clearance. Identified settlement through these areas is also relatively dense. Subdivisions are defined as: *Gbapa Rolling Plain* Notably higher than the wider Farmland Plateau and it ranges between 500m to 580m ASL. Large patches of forest remain intact (appears to be dominated by secondary forest). The former airfield forms a distinctive element within this area. *Cassava Farm Plateau* Gbapa is a key settlement in the area, located close to the junction of the main road with minor roads *Zolowee Valley Plains* Area includes more extensive areas of flat ground and has a comparatively dense pattern of identified settlement that is dispersed evenly throughout the more complex mosaic of clearance and farming types.	Sub areas A and B: **Low** Sub area C: **Medium**
NCA 07	Tokadeh Mountain Forests	Topographically distinct and separated from the Beeton to Yuelliton ridge. Foothills are irregular faced slopes around 500m ASL with slopes increasing in steepness and uniformity towards the upper peaks. Summit of Mount Tokadeh is approximately 940m ASL but upper peaks and ridgeline are approximately 860m ASL. Includes areas of A1, A2 and A3 defined by the geotechnical terrain classification. Largely forested with some variation in the form of wetlands and relatively limited forest clearance. Area includes extensive clearance resulting from former mining activity (and associated infrastructure). From some locations the former mine benches are a visible feature on the upper ridgeline of Mount Tokadeh. Infrastructure is also present on foothills, including access roads, workshops and loading areas.	**High**
NCA 08	Bassa Forest Foothills	Topography less severe than adjacent areas with shallower slopes and rolling, undulating profile that typifies the wider valley between the mountain ranges. Partly out of the scope but natural extent of area A3 defined by the geotechnical terrain classification. Presence of occasional defined hills such as Mount Bele, which reaches an approximate height of 850m ASL create distinctive features. Land use comprises forest and cleared farmland, variation in the cleared farmland areas is limited and this contributes to a simple mosaic. Identified settlement is limited and dispersed widely.	**Medium**

TABLE 7.12: NIMBA LANDSCAPE CHARACTER AREAS (NCA) IN THE MINE SITE STUDY AREA

Ref	Landscape Character Area	Distinctive & Defining Landscape Characteristics	Sensitivity to Change
NCA 09	Geh /Makinto Farmland Plateau	Extensive rolling plain between 440m and 480m ASL with occasional low points at 420m ASL. Includes area B1 defined by the geotechnical terrain classification. Forest has been extensively cleared and the resulting rotational farming has created a diverse mosaic. Major settlement in this area includes the villages of Geh and Makinto, both located on the main road. Other identified settlement is relatively extensive and distribution tends to be concentrated in the east of the character area.	**Low**

TABLE 7.13: BUCHANAN LANDSCAPE CHARACTER AREAS (BCA) IN THE PORT AREA

Ref	Landscape Character Area	Distinctive & Defining Landscape Characteristics	Sensitivity to Change
BCA 01	Buchanan Port & Rail Terminal	Flat areas of operational and former operational land within the AML Concession and adjacent to it which are part of the Tokadeh rail-link and unloading/shipping facility. Includes land used by Buchanan Renewables for rubber stockpiles and timber storage. Industrial in nature. Includes the AML offices/hospital and other non-residential buildings and non publically accessible land including the breakwaters/jetties.	**Very Low**
BCA 02	Residential AML/UN	New residential units and former LAMCO houses occupied by the UN & AML. Planned development of generally low density, with the exception of recent AML temporary residential accommodation.	**Low**
BCA 03	Former operational areas/tailings lagoons	Land not currently used as part of the port or DSO operations, which is re-vegetated/unoccupied, including the tailings lagoons. Non residential/non industrial brownfield land being reclaimed by nature.	**Very Low**
BCA 04	Buchanan City Urban Fringe	Urban fringe residential areas – primarily the district of Motown which borders the north of the AML concession. The area comprises low rise medium density housing within a well wooded context.	**Medium**
BCA 05	Foreshore/Beach	Areas of publically accessible open beach.	**Low**
BCA06	Open Sea	Open water beyond the port.	**Very Low**
BCA 07	Farmland Plain	Agricultural hinterland to port & foreshore.	**Low**

The appraisal of the baseline landscape at the Mine Site and Buchanan Port identified the following:

Mine Site

Overall it is assessed that the landscape context of the Mine Site, consisting largely of relatively dense secondary forest and limited areas of cleared land in agricultural use or re-foresting following agriculture, is of medium quality and value, although it is clear that there are pockets of locally higher quality landscape within the study area, such as in the vicinity of Mount Nimba and the steep upper slopes of Mounts Gangra and Yuelliton. As a result of the distinctive nature of their peaks, side slopes and gullies, and density of forest cover, Tokadeh, Gangra and Yuelliton mountains are considered to be of high landscape value. The Dayea (Mein) River valley and that of its main tributaries (the Kahn and Madayea) are considered to be of medium landscape value. The area has considerable natural beauty and is internationally valued for the character of the forest habitats. There are also various community associations with landscape. The distinctive shape and visibility of the peaks of Gangra, Yuelliton and Tokadeh from surrounding areas make them important local landmarks, but the importance attributed by local communities relates more to associations with their uses (e.g. ancestral significance; present cultural, ritual or religious uses; hunting and farming; collection of medicinal plants; etc), rather than to the visual aspects.

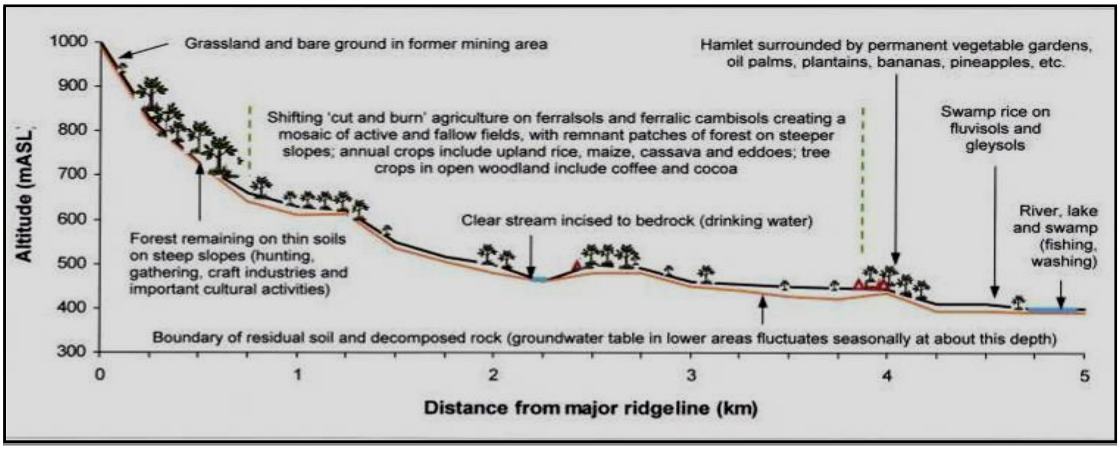
Railway and Buchanan Port

Once the railway leaves Nimba County it passes through a varied landscape of hills and valleys of relatively low landscape value. At Buchanan the beach east of the port is the only area with notable landscape value. Overall it is assessed that the landscape context of Buchanan Port, which is predominantly a re-use or re-establishment of former port activity within an area created for that purpose, is of low quality and value.

7.4.2 Land Use

Certain aspects of Land Use are covered in Phase 2 ESIA Volume 3, Parts 1.1 (Geomapping) and 1.2 (Geology, Soils and Land Use). A schematic cross-section of the altitudinal variation in land use in the mine project area is shown in Figure 7.7.

Figure 7.7: Schematic cross-section illustrating traditional subsistence practices within the mine concession area



Cultivated and fallow fields, forested areas and local community boundaries were identified from project maps and aerial photographs, the Phase 1 ESIA investigations and discussions with Company staff. The distribution of farmland adjacent to proposed mining areas and possible areas where displaced farmers could be relocated is indicated on Dwg 7.1. During the course of Phase 2 mining Tokadeh, Gangra and Yuelliton mountains will be excavated in a series of benches to maximum depths of about 400m below present summit levels within the ultimate pit outlines shown on Dwg 7.1. Mine buffer (exclusion) zones, within which agriculture will not be permitted, will extend a nominal 500m beyond the ultimate pit boundaries, widening in places to a maximum 1km at Tokadeh. The exclusion zone is coloured red hatching on Dwg 7.1.

Homesteads are surrounded by permanent vegetable gardens, worked mainly by women, with coffee and some other crops. Swamp rice is grown on fluvisols and gleysols on low terraces and valley bottoms. Clear streams on higher ground traditionally supply drinking water while rivers on lower ground are used for washing and supply fish. Some families own small numbers of goats, sheep, pigs, chickens and ducks. Soils in fields close to homestead gardens tend to be impoverished by frequent cropping, while more distant fields are more fertile because they are left fallow for longer periods.

Shifting cultivation – or perhaps more appropriately (as locally practiced) slash and burn - is the standard farming system in North Nimba. This is a low input farming system whereby each cropping period is followed by a long fallow which naturally replenishes soil fertility and at the same time prevents any weed growth and changes any congenial habitat for other pests and diseases. The only input from the farmer is his/her and other family members' labour, though extra labour is sometimes employed. Such a farming system results in large areas within the community with a highly mixed biodiversity. This is a very sustainable farming system as long as the population density is relatively low, as large areas of land are required to sustain each farming family.

Upland farm sizes within the Concession were found to range between 0.1 and 10 acres with the average 3.0 acres (1.2 ha), and the fallow period following each cropping ranging from 3 to over 30 years with the majority of fallow being between 6 and 10 years. Assuming that there is no land pressure in the Dayea Valley, a sustainable land holding would require a period of three times the number of fallow years required to restore soil fertility to a level that will produce an average crop yield. Thus given an average of 3 acres cleared and planted each year and (say) an average of 10 years fallow each farmer would require a minimum of 30 acres (12 ha).

New land is normally planted to upland rice with small areas containing a mix of other crops (e.g. maize, chilli peppers, bitterball, okra, squashes etc.). Cassava is inter-planted with these crops and produces in the second and subsequent years until the natural vegetation becomes too prolific. Since the farmer lacks machinery to till the soils there is little disturbance of the soil or the root system or the previous fallow, thus the natural vegetation re-establishes itself quickly and within two to three years will have overgrown the cassava and be well on the way to returning to forest. Even though the farming operation does not significantly disturb the soil surface, where clearing is done on steep slopes significant soil erosion can occur, removing some of the natural soil fertility and thus partly accounting for the length of fallow required to replenish soil fertility.

Land use within Buchanan Port derived from air photo interpretation and from observations in the field is shown in Phase 2 Volume 3, Part 1.1, and also as Dwg 7.2. The key points to note from the interpretation are the Quaternary terraces upon which the accommodation loops and some of the ore handling areas are constructed, the drainage depression and associated swamp areas of the Savage River and the areas of made ground and LAMCO legacy port infrastructure. The approximate original course of the Savage River is shown. The flow in this river was diverted to the east as part of the LAMCO preparations for port construction.

7.5 Fauna

Zoological aspects of the environmental studies to date can be found in Phase 1 DSO ESIA Volume 4, Part 1 (Zoological Assessment and Mitigation), and in Phase 2 ESIA Volume 4 Part 2 (Zoological Assessment) plus Appendices and in the Addendum to the Phase 1 ESIA – the additional faunal studies.

Phase 2 ESIA Volume 4, Part 2 summarises the state of knowledge of the fauna of the areas in and close to the proposed areas of mining and infrastructure for Phase 2 iron ore mining at Mts Tokadeh, Gangra and Yuelliton in Nimba County. It also incorporates information on the coastal and marine fauna around the port at Buchanan, from which iron ore will be shipped. It is based on field studies conducted up to Apr 2012, and a review of previous studies. Studies which were not published as part of the Phase 1 ESIA or Phase 1 additional studies have been included as Appendices, but are also summarised here. In addition to these studies, the report draws on information collected for the Phase 1 ESIA, additional surveys to augment that assessment and studies on bushmeat and larger mammals.

From a global conservation perspective, the Nimba Range is among the most important areas in Africa, with numerous endemic species, many of them globally threatened. The importance of this area is recognised by its inclusion in national and international conservation priority schemes, including the following:

- Mt Nimba is an Alliance for Zero Extinction site, because it is home to species found nowhere else on Earth;
- The Upper Guinean Forests of West Africa, which include the Nimba Range, constitute a Biodiversity Hotspot;
- The Guinean Moist Forests of West Africa, which include the Nimba Range, constitute a Critical Ecoregion;
- The Upper Guinea Forests of West Africa, which include the Nimba Range, constitute an Endemic Bird Area;
- The Nimba mountains are recognised as one of only nine Important Bird Areas in Liberia;
- The Liberian part of Mt Nimba is designated by the Liberian Government as the East Nimba Nature Reserve;
- The forests of West Nimba have been proposed for national forest and protected area status in the past, and are now a Community-managed Forest.
- The contiguous areas of Mt Nimba in Guinea and Ivory Coast are designated as strict nature reserves and as World Heritage Sites.

The Consultant has made a qualitative assessment of which areas within and surrounding the Concession Area are believed to constitute habitat of "significant importance" to globally Critically Endangered, Endangered, Endemic or Restricted-Range species. However, in the absence of accurate estimates for most species either of local or global population size, it is difficult to make such assessments definitive. The Consultant advises that they should be reviewed by a competent external referee or referees. A map showing areas that are considered by this study to be of 'critical habitat' is shown on Dwg 7.3.

From the perspective of local communities, the forests, streams and swamps of the Nimba Range deliver irreplaceable values and services, including sacred sites, forest products such as timber, medicinal plants, bushmeat and freshwater fish, and regulation of water quality and flow. Some local people believe that they can transform into wild animals, such as chimpanzees or pythons, and because of this connection with forest animals, there is considerable local support for the concept of preserving areas of forest habitat where they can roam.

7.5.1 Mammals

Six globally-threatened mammal species have been recorded from the proposed Phase 2 sites (highlighted yellow in Table 7.14). A further two species have been recorded in the past but not recently, and five species may be present, but have either not been confirmed or are known from Mt Nimba only in Guinea/Ivory Coast.

Four more threatened species probably once occurred but if they did they are now locally extinct. Table 7.14 lists the globally threatened mammals that occur or could occur in the Concession area.

TABLE 7.14. GLOBALLY THREATENED MAMMALS THAT OCCUR OR COULD OCCUR IN THE ARCELORMITTAL CONCESSION.

Scientific Name	English name	IUCN Red List	Site			
			Tk	GY	EN	WN
Pan troglodytes verus	West African Chimpanzee	EN	●	●	●	●
Cercocebus atys atys	Sooty Mangabey	VU (NT)	●	●	●	–
Cercopithecus diana diana	Diana Monkey	VU	–	–	○	–
Colobus polykomos	Western Black-and-white Colobus	VU	●	–	–	–
Rhinolophus guineensis	Guinean Horseshoe Bat	VU	–	–	–	–
Rhinolophus ziama	Ziama Horseshoe Bat	EN	–	–	–	–
Hipposideros marisae	Aellen's Roundleaf Bat	VU	–	●	–	–
Hipposideros lamottei	Lamotte's Roundleaf Bat	CR	–	–	–	–
Micropotamogale lamottei	Nimba Otter Shrew	EN	●	–	●	–
Liberiictis kuhni	Liberian Mongoose	VU	–	–	–	–
Genetta johnstoni	Johnston's Genet	VU	–	–	–	–
Cephalophus jentinki	Jentink's Duiker	EN	–	–	○	–
Cephalophus ogilbyi brookei	Ogilby's (Brooke's) Duiker	LC (VU)	–	●	–	–
Cephalophus zebra	Zebra Duiker	VU	–	–	–	–

Note: Threat status for relevant subspecies is given in parentheses, where different from global status of species as a whole. Abbreviations: Tk (Tokadeh), GY (Gangra/Yuelliton), EN (East Nimba Nature Reserve), WN (Gba Community Forest, West Nimba). Symbols: ● (recorded during surveys), ○ (recorded from literature), – (not recorded, but may be present). In addition, Western Putty-nosed Monkey *Cercopithecus nictitans martini*, Upper Guinea Red Colobus *Procolobus badius badius*, Pygmy Hippopotamus *Choeropsis liberiensis* and African Elephant *Loxodonta africana* may once have occurred but if so, are now locally extinct.

The best estimate of numbers of West African Chimpanzees in the Gba Community Forest (West Nimba) is 26 individuals (range 10-67). Based on maps of encounter rates of chimpanzee nests and other signs, these individuals appear to be from two groups: one in the vicinity of Gangra/Yuelliton, and one close to Vincent Village. The ranges of both groups overlap with the proposed Phase 2 footprint. There is little information on chimpanzee numbers and distribution in the East Nimba Nature Reserve, but based on observations of nests and other signs, there seems likely to be at least two groups: one in the Yiti Valley, and one at the southern end of the reserve, extending into the Blei Community Forest on Mt Bele.

The other globally endangered mammal confirmed to occur within the proposed Phase 2 footprint is the Nimba Otter Shrew. This species appears to occur sparsely within the Concession as capture rates have been low. It might be naturally scarce, or might have declined because of mortality in fish traps, and habitat modification from mining and agriculture.

Apart from West African Chimpanzee, at least two other globally threatened primates occur. Of these, Sooty Mangabey was recorded on multiple occasions within the proposed Phase 2 footprint. This is a species which often moves along the ground, and is thus less closely tied to unbroken canopy than the Western Black-and-white Colobus and Diana Monkey.

The globally vulnerable Aellen's Roundleaf Bat, an Upper Guinea endemic with a very restricted range, was found in two adits at Mt Gangra. Both adits are within the proposed

Phase 2 resource pit (mining areas). No evidence has been found of the Critically Endangered Lamotte's Roundleaf Bat or the Endangered Ziama Horseshoe Bat in the Concession area.

In addition to the globally threatened species listed above, a further four species of Near Threatened or Data Deficient mammals include a bentwing bat *Miniopterus (schreibersii) villiersii* at Mts Gangra and Yuelliton (which seems likely in fact to be a new species whose conservation status has not been evaluated). Two species for which evidence was found during the BioPA surveys, and which appear plausible, were Slender-tailed Squirrel *Protoxerus aubinnii* (Data Deficient) and Leopard *Panthera pardus* (Near Threatened). The African White-bellied Pangolin *Phataginus tricuspis* (Near Threatened) has been recorded from Mts Tokadeh and Yuelliton, including from a camera trap in the case of the latter.

Two further mammals recorded from the proposed Phase 2 sites (within the proposed TMF area) are not listed in Table 1, because they have not yet been evaluated by the IUCN, but may well qualify for threatened status once formally assessed. These are the bats *Hypsugo (=Pipistrellus) (crassulus) bellieri* and *Neoromicia (=Pipistrellus) roseveari*.

Two Rare, restricted-range shrew species, Buettikofer's Shrew *Crocidura buettikoferi* (Near Threatened) and *Crocidura* cf. *Nnimbasilvanus* (Not Evaluated), have so far been found only in East Nimba and West Nimba, respectively. Another species is known only from East Nimba (based on indirect evidence collected during BioPA surveys): is the African Golden Cat *Caracal aurata* (Near Threatened). There are other mammal species of some conservation concern which may occur in the concession area, but for which it is difficult to obtain direct or definite evidence. These include the elusive Olive Colobus *Procolobus verus*, the rarely seen Bourlon's Genet *Genetta bourloni*, the enigmatic Leighton's Linsang *Poiana leightoni*, the mysterious Giant Ground Pangolin *Smutsia gigantea* and the secretive Lowland Bongo *Tragelaphus eurycerus eurycerus*.

7.5.2 Birds

Two globally-threatened bird species have been recorded from the proposed Phase 2 sites. At least seven other globally-threatened species also occur in the wider concession area. Table 7.15 lists globally threatened birds that occur or could occur in the Concession area.

TABLE 7.15: GLOBALLY THREATENED BIRDS THAT OCCUR OR COULD OCCUR IN THE ARCELORMITTAL CONCESSION.

Scientific Name	English name	IUCN Red List	Site			
			Tk	GY	EN	WN
Scotopelia ussheri	Rufous Fishing Owl	VU	–	–	○	–
Bycanistes cylindricus	Brown-cheeked Hornbill	VU	–	–	○	●
Ceratogymna elata	Yellow-casqued Hornbill	VU	–	–	●	●
Lobotos lobatus	Western Wattled Cuckoo-shrike	VU	–	–	●	–
Criniger olivaceus	Yellow-bearded Greenbul	VU	●	●	●	●
Schistolais leontica	Sierra Leone Prinia	VU	–	–	●	–
Melaenornis annamarulae	Nimba Flycatcher	VU	●	●	●	●
Picathartes gymnocephalus	Yellow-headed Picathartes	VU	–	–	○	–
Malimbus ballmanni	Gola Malimbe	EN	–	–	–	●

Note: Abbreviations: Tk (Tokadeh), GY (Gangra/Yuelliton), EN (East Nimba Nature Reserve), WN (Gba Community Forest, West Nimba). Symbols: ● (recorded during surveys), ○ (recorded from literature), – (not recorded). In addition, White-breasted Guineafowl *Agelastes meleagrides* and Timneh Parrot *Psittacus timneh* once occurred in East Nimba but are now believed to have been locally extirpated.

Yellow-bearded Greenbul is found in good forest throughout most of the areas visited in East and West Nimba, as well as in the proposed Phase 2 sites. It is dependent on closed-canopy forest. Judging by the number of observations of this species during baseline surveys, the concession area supports an important population.

Nimba Flycatcher is associated with emergent forest trees, particularly on slopes. It is known only from a few sites globally: one in Sierra Leone, seven in Guinea, four in Liberia, six in Ivory Coast and one in Ghana. In Taï National Park, densities have been estimated at four birds per km^2. Densities are probably lower than that in the Nimba area, but the species is difficult to detect, and the spread of observations suggests that the area supports an important population of this species.

The most significant new finding from recent surveys is the occurrence of Gola Malimbe in West Nimba. This species was only previously known from one site in Sierra Leone, one site in Guinea, three sites in Ivory Coast and from a relatively small area in Liberia spanning parts of Grand Gedeh and Sinoe Counties. It is apparently quite abundant in good forest in West Nimba, and therefore this new population is likely to be of global importance.

Rufous Fishing Owl and Western Wattled Cuckoo-shrike have so far only been found in East Nimba, but could occur in West Nimba. Sierra Leone Prinia is a high altitude species, only found in East Nimba. Yellow-headed Picathartes is known from East Nimba and from a forest fragment outside any protected area or community-managed forest (west of Bonlah).

In addition to the globally threatened species listed above, a further seven species of Near Threatened or Data Deficient birds: Crowned Eagle *Stephanoaetus coronatus* (newly assessed as Near Threatened in 2012), Blue-moustached Bee-eater *Merops mentalis*, Yellow-footed Honeyguide *Melignomon eisentrauti*, Green-tailed Bristlebill *Bleda eximius*, Black-headed Rufous Warbler *Bathmocercus cerviniventris*, Rufous-winged Illadopsis *Illadopsis rufescens* and Copper-tailed Glossy Starling *Lamprotornis cupreocauda*. The first two of these species were previously listed as Least Concern, but newly assessed as Near Threatened in 2012.

Of these species, Black-headed Rufous Warbler is of particular concern, because it has a very restricted global range (although it is often locally abundant in the places where it occurs), and in the concession area its population is concentrated in areas which will be disturbed by mining at Tokadeh and by the construction of the tailings management facility.

Another species found in the proposed Phase 2 sites, which is not formally red-listed, but which can be considered to be of conservation concern in West Africa is the Hartlaub's Duck *Pteronetta hartlaubii*. In addition, the species totals for the proposed Phase 2 sites (209 species at Tokadeh, 183 at Gangra/Yuelliton) indicate a rich and diverse avifauna at both sites, including many Guineo-Congolian biome restricted-species.

The West Nimba forest supports a population of the Gola Malimbe, known from few other sites in the world. Both West and East Nimba forests (including open habitats at high altitudes, and good forest within the proposed footprint at Tokadeh and the tailings area) also qualify as critical habitat because of their significant importance to endemic and/or restricted-range species such as Nimba Flycatcher and Sierra Leone Prinia.

Lowland swamps and streams, including those in the tailings area, may qualify as critical habitat because of their unusually high densities of the Upper Guinea endemic Black-headed Rufous Warbler.

7.5.3 Amphibians

At least two and probably three species of globally threatened amphibians have been recorded from the proposed Phase 2 sites. The presence of the Guinea Screeching Frog at Tokadeh could not be confirmed, but calls consistent with this species were heard in suitable habitat. A further three globally threatened amphibian species occur in the wider concession area, but have only been recorded in East or West Nimba.

Of these, the species of most conservation concern is the Nimba Toad: the East Nimba Nature Reserve is the only known location in the world for the Liberian subspecies (considered by some to be a unique species in its own right). Table 7.16 lists the globally threatened amphibians that occur or could occur in the Concession Area.

TABLE 7.16: GLOBALLY THREATENED AMPHIBIANS THAT OCCUR OR COULD OCCUR IN THE ARCELORMITTAL CONCESSION

Scientific Name	English name	IUCN Red List	Site			
			Tk	GY	EN	WN
Arthroleptis crusculum	Guinea Screeching Frog	EN	○	–	●	–
Nimbaphrynoides (occidentalis) liberiensis	Liberian Nimba Toad	CR	–	–	●	–
Kassina arboricola	Ivory Coast Running Frog	VU	●	–	–	–
Conraua alleni	Allen's Slippery Frog	VU	●	●	●	●
Phrynobatrachus annulatus	Ringed River Frog	EN	–	–	●	–
Hylarana occidentalis	Ivory Coast Frog	EN	–	–	–	●

Note: Abbreviations: Tk (Tokadeh), GY (Gangra/Yuelliton), EN (East Nimba Nature Reserve), WN (Gba Community Forest, West Nimba). Symbols: ● (recorded during surveys), ○ (possibly heard but not confirmed), – (not recorded).

The Guinea Screeching Frog has only been confirmed with certainty in the East Nimba Nature Reserve. This species is quite abundant within the high altitude grasslands on the Guinean side of the Nimba range, and was found at the old LAMCO mine site. Based on calls heard in October 2010, this species might also occur on the mining benches at Tokadeh, but this could not be confirmed by later surveys.

The Liberian Nimba Toad is known only from a small area of derived grassland or forest edge habitat above 1200 m within the East Nimba Nature Reserve. It is among the species of greatest conservation priority in the whole of West Africa, as it is confined to this site alone which has been damaged considerably by past (LAMCO) mining activities. The Ringed River Frog (something of a misnomer as its habitat is leaf litter and it is not tied to waterbodies) has been found only in East Nimba. It is restricted to West Africa, and according to the IUCN it has only ever been found at around 5 sites.

The Ivory Coast Running Frog has been reported only from Tokadeh, from within the proposed Phase 2 resource pit. It is restricted to West Africa and according to the IUCN is known only from around 5 sites worldwide. The Allen's Slippery Frog was found widely in good quality forest streams throughout the concession area, and the Ivory Coast Frog was found at several sampling sites in West Nimba, and also near to (but outside) the East Nimba Nature Reserve.

The proposed Phase 2 sites support, in addition to the threatened species listed above, a further nine species which are considered globally Near Threatened or Data Deficient: Togo Toad *Amietophrynus togoensis*, *Hylarana fonensis*, Cochran's Running Frog *Kassina* cf. *cochranae*, Big-eyed Forest Treefrog *Leptopelis macrotis*, Sierra Leone Water Frog *Petropedetes natator*, Allen's Puddle Frog *Phrynobatrachus alleni*, *Phrynobatrachus guineensis*, Liberian Puddle Frog *Phrynobatrachus liberiensis* and *Ptychadena submascareniensis*.

In addition to these species, at least another five species of Near Threatened or Data Deficient amphibians have been found in the wider concession area but outside of the proposed Phase 2 sites: *Arthroleptis langeri*, Nimba Reed Frog *Hyperolius zonatus*, *Leptopelis occidentalis*, *Phrynobatrachus phyllophilus* and *Ptychadena pujoli*. The only specimen ever found of *Phrynobatrachus hieroglyphicus* was collected in the East Nimba Nature Reserve in 1969. Other species, while not listed as being of global conservation concern, are rare or range-restricted, such as the African Giant Toad *Amietophrynus superciliaris chevalieri*, of which the West African subspecies may in fact prove to be a distinct endemic species.

The ridge tops above 1200 m in the East Nimba Nature Reserve, mainly covered by derived grassland, constitute critical habitat as they are the only known habitat for the Liberian Nimba Toad, and they also provide habitat for the Guinea Screeching Frog. Lowland tropical forest in East Nimba (including forests outside the Nature Reserve) provides critical habitat for the Ringed River Frog and the endemic frog *Phrynobatrachus hieroglyphicus*. Lowland tropical forest in West Nimba provides critical habitat for the Ivory Coast Frog: based on current information, habitat occupied by this species does not extend into the close vicinity of the proposed Phase 2 sites. The extensive areas of lowland tropical forest in West Nimba also appear to meet the criterion as being of "significant importance to endemic and/or restricted-range species" of amphibians.

7.5.4 Reptiles

One globally threatened reptile species has been recorded from the proposed Phase 2 sites: African Dwarf Crocodile. This species is also listed on CITES Appendix 1, which means it is considered threatened with extinction by CITES and international trade is prohibited. Table 7.17 lists the globally threatened reptiles that occur or could occur in the Concession area.

TABLE 7.17: GLOBALLY THREATENED REPTILES THAT OCCUR IN THE ARCELOR-MITTAL CONCESSION

Scientific Name	English name	IUCN Red List	Site			
			Tk	GY	EN	WN
Osteolaemus tetraspis	African Dwarf Crocodile	VU	●	–	○	●

Note: Abbreviations: Tk (Tokadeh), GY (Gangra/Yuelliton), EN (East Nimba Nature Reserve), WN (Gba Community Forest, West Nimba). Symbols: ● (reported by local people to occur), ○ (occurs near edge of Reserve, not confirmed inside), – (not recorded).

The IUCN Red List does not give a comprehensive picture of which reptile species found in the concession area are threatened, because the conservation status of most West African reptiles has not yet been evaluated. This should be addressed in the near future, possibly in connection with the Company's Offsetting Programme (Section 9).

African Dwarf Crocodiles inhabit mainly streams and swamps in forested areas. They were reported from several swamps at Tokadeh, including from a forest swamp within the proposed Phase 2 mining pit footprint. Holes said by local people to be used by this species were observed at Bassa Village, close to the East Nimba Nature Reserve. African Dwarf Crocodiles were also recorded in two villages, Vanyanpa and Makento, having been collected by local people somewhere in the West Nimba–Tokadeh area.

Other reptile species of conservation concern found in the concession area include the Slender-snouted Crocodile *Mecistops cataphractus* (Data Deficient, CITES Appendix I) in the Dayea River, the Serrated Hinge-back Tortoise *Kinixys erosa* (Data Deficient, CITES Appendix II) in farmbush north of Tokadeh, and the African Rock Python *Python sebae* (CITES Appendix II).

With 55 confirmed reptile species, and up to 83 species when probable/possible species are included, the concession area clearly supports a very rich reptile fauna. It also supports species with restricted ranges (or which might prove to be species with restricted ranges when their taxonomy is more fully resolved) including the very rare Western Cave Gecko *Cnemaspis occidentalis*, of which only eight specimens had ever been collected previously. This gecko was found in three adits at Mts Gangra and Tokadeh, all of which are within the proposed Phase 2 resource pit footprints and will be destroyed by mining. The potential to translocate it will need to be addressed as part of the Company's Offsetting Programme.Based on what is currently known of the conservation status of reptile species in West Africa, no evidence has been found to indicate the presence of critical habitats within the proposed Phase 2 footprint. For its importance to a number of endemic/restricted-range species, including *Lygosoma nimbense* and *Typhlops manni*, the main Nimba ridge (within Guinea and Ivory Coast as well as the East Nimba Nature Reserve in Liberia) appears to meet the criteria for critical habitat. However, the habitat requirements of these species are not well understood, so it is not currently possible to define the limits of critical habitat for these species with any precision.

7.5.5 Freshwater fish

Two globally threatened fish species were recorded from the proposed Phase 2 sites. *Rhexipanchax nimbaensis* will be directly affected as it occurs within the footprint of the proposed water retention dam north of Tokadeh. *Barbus eburneensis* also occurs within the footprint of the proposed water dam, and also within the footprint of the proposed resource pit at Tokadeh. A third globally threatened species, *Doumea chappuisi*, occurs near to Mts Tokadeh and Gangra/Yuelliton, but while it was recorded in the vicinity of the Phase 2 sites and will be affected by mining activities there, was not recorded within the proposed Phase 2 footprint. Table 7.18 lists the globally threatened fishes that occur or could occur in the Concession area.

TABLE 7.18: GLOBALLY THREATENED FISHES THAT OCCUR IN THE ARCELORMITTAL CONCESSION

Scientific Name	English name	IUCN Red List	Site			
			Tk	GY	EN	WN
Doumea chappuisi		VU	●	●	●	●
Rhexipanchax nimbaensis	Mt Nimba lampeye	VU	●	●	●	●
Barbus eburneensis	"Carp"	VU	●	●	●	●

Abbreviations: Tk (Tokadeh), GY (Gangra/Yuelliton), EN (East Nimba Nature Reserve), WN (Gba Community Forest, West Nimba).
Symbols: ● (recorded during surveys).

It is understood that these species may be down-listed to Least Concern as better knowledge of their habitat requirements and population status come to light. However, other fish species in the area, which have not been evaluated or in some cases appear to be new to science, may warrant recognition as globally threatened species. Until such time as changes to the official Red List are made, the Consultant advises a conservative approach, assuming that species listed as threatened are in fact threatened.

Both *Doumea chappuisi* and *Rhexipanchax nimbaensis* (listed by the IUCN as *Procatopus nimbaensis*) are found commonly in streams in the Concession Area, and both appear to be resilient to some degree of habitat degradation. *Barbus eburneensis* was found at more sites and generally in higher numbers than any other species in the survey.

At least seven species of fishes were found which do not conform to any described species, and are likely to be new to science. Some or all of these species may have very restricted geographical ranges and therefore might meet some of the criteria to be listed as globally threatened. At present, they would be listed as Data Deficient because virtually nothing is known about them. These new species belong to the genera *Amphilius*, *Chiloglanis* (cf. *occidentalis*), *Marcusenius*, ?*Marcusenius*/*Brienomyrus*, *Petrocephalus* (cf. *pellegrini*), *Brycinus* (cf. *longipinnis*) and *Barbus*. Two of them have been found only in West Nimba, underlining the importance of the relatively pristine streams there. A further two species of *Labeobarbus* (cf. *wurtzi* and cf. *sacratus*) may also be new species: these were only found in the Seka Valley (East Nimba) and Yiti River on the main Yekepa-Sanniquellie road, respectively. Although recorded at relatively few sites, they are likely to be more widely distributed in the larger, deeper, fast-flowing stretches downstream of the main sampled areas, an observation supported by the good catch of adult *L.* cf. *wurtzi* in rapids in the Kahn River.

The impacts of past mining activity on fishes are apparent in that sites which were closest to areas previously subject to mining were noticeably depauperate in fishes. No fishes at all were recorded at the outflow of the Blue Lake. There has been some recovery of areas further downstream, such as in the vicinity of Yekepa, although some forest stream species such as *Nimbapanchax leucopterygius* and *Epiplatys olbrechtsi* are absent or rare from areas immediately downstream from past mining sites. Such species may be particularly vulnerable to mine impacts, particularly siltation and the absence of forest cover and resultant deeply undercut banks.

The presence of an alien invasive species, *Oreochromis niloticus* (which is native elsewhere in Africa) is of concern, because this species is noted for displacing other fish species and causing their extinction. Every effort should be made to ensure that this species is not spread further, e.g. by aquaculture activities.

The Yiti (or Eytee) River in West Nimba (not to be confused with the Yiti River in East Nimba) supports a diverse ichthyofauna, with 16 species from a single site, including several species new to science and which therefore are in all probability endemic to the region. Based on the limited information available, this catchment qualifies as critical habitat for its importance to endemic and restricted-range species. Other small streams, including where the a water retention dam was planned (site 8 in Volume 4, Part 2, Appendix 4) and in the saddle between Mts Yuelliton and Gangra (site 11) support high numbers of the sensitive forest stream species *N. leucopterygius* and/or *E. olbrechtsi* and. Thus, they are of considerable importance for freshwater fishes, but might nottherefore qualify as critical habitat. In relation to the first of these stream sites, the Consultant understands that the revised proposed location for the water retention dam, as of March 2013, is in a different area and is no longer a threat to this stream. The Consultant suggests a precautionary approach, assuming that all small forested stream catchments potentially comprise critical habitat for fishes.

7.5.6 Freshwater Crustaceans

There remains some uncertainty over the occurrence and status of species of conservation concern in the concession area and indeed Liberian Nimba as a whole. A precautionary approach is advised, taking the assumption that records of globally threatened species are assumed to be correct until there is strong evidence that they are not. The Consultant also advises that further fieldwork be conducted to clarify the status of crustacean species in the concession area.

The Lugbe River Crab *Liberonautes lugbe* (Critically Endangered) certainly occurs in the concession area, and the only records of this species ever, from anywhere in the world, as far as the Consultant is aware, are from farmland near Lugbe, 4 km north of Mount Yuelliton. During BioPA surveys in 2009, this species was reportedly found in small streams in catchments at Gangra/Yuelliton, Tokadeh, and the East Nimba Nature Reserve. However, the species was not recorded at all during surveys in 2012, so its status remains unclear. Anecdotal verbal information suggests that it may have been found in streams to the north of Lugbe, not far across the border in Guinea[4].

[4] Pers comm.. J. Howell

The Lobster Claw Crab *L. rubigimanus* (Endangered) was recorded by both recent surveys (in 2009 and 2012) and while there are no previous published records from Liberian Nimba, it is known from elsewhere in Liberia and also from Guinean Nimba, so there seems little doubt that this species is indeed present. Both the 2009 and 2012 surveys concur that this species is found in small streams throughout the concession area, including catchments at Gangra/Yuelliton, Tokadeh, and the East Nimba Nature Reserve.

The Dwarf River Crab *L. nanoides* (Endangered) was reported only from the 2009 surveys, and these records appear unlikely to be correct, given that the only other known records of this species are from a single locality in the St Paul River in Bong County, Liberia. Its habitat there was rocky parts of the fast-flowing waters of the river, which during the rainy season was up to 100 m wide and 1-3 m deep at the collecting station. This sort of habitat does not occur in the Concession Area.

The Nimba Stream Crab *L. nimba* (Vulnerable) was reported only from the 2012 surveys, and could be expected to occur, as it is present in Guinean Nimba. However, the records in 2012 are from streams at altitudes of 536 to 895 m, while this crab is previously known from cracks in rocks at higher altitudes of around 1300 m. It seems unlikely to occur anywhere except in East Nimba.

A further species reported from the railway corridor at Bleisi and Bonle, but not within or near the Concession Area in Nimba County, is the Grandbassa River Crab *L. grandbassa* (Critically Endangered). These records would extend the known range of this species from Grand Bassa County to Bong County, but there were no observations to locate substantiating specimens. The new records are from within the St John catchment, from where this species was described, and therefore may be plausible.

Two baseline surveys of freshwater crustaceans have now been conducted in the Company's Concession Area, but regrettably they have failed to clarify the status of the globally threatened crab species which are known from the area. The first survey (BioPA), conducted in January 2009, reported five species of crabs: *L. latidactylus*, *L. lugbe*, *L. nanoides*, *L. paludicolis* and *L. rubigimanus*. The second survey, conducted in January 2012, reported three species, one of which had not been reported in the 2009 survey: *L. latidactylus*, *L. nimba* and *L. rubigimanus*.

There are discrepancies between both of these surveys and what is otherwise known of the freshwater crabs of this part of West Africa. If correct, the records of *L. nanoides*, *L. nimba* and *L. rubigimanus* would be the first for this part of Liberia (indeed, in the case of *L. nimba* species, the first for Liberia), and the 2009 records of *L. lugbe* would be the only records of this species since its discovery, anywhere in the world. However, there is insufficient corroborating evidence (e.g., specimens, photographs or details of identification features and habitat use) to be fully confident that these new records are valid.

Based on the small amount of published information, and the global Red List, five *Liberonautes* species can be expected to occur in the Nimba area. There are published records of only three of these species from the Liberian side. A sixth species, *L. chaperi*, is mapped as probably occurring in the general geographic area, but is restricted to large rivers and not mentioned for the Nimba area.

If *L. lugbe* is truly confined to a small area close to Lugbe, then this area would qualify as critical habitat. In the absence of more detailed information, the Consultant suggests provisionally defining the sub-catchment enclosing Lugbe as critical habitat for this species.

Given the uncertainties described above, it is not possible to further define critical habitat for crab species with any precision. In the absence of more detailed information, all small forested stream catchments should be considered as potentially comprising critical habitat for *L. rubigimanus*.

7.5.7 Dragonflies and Damselflies

No globally threatened dragonflies or damselflies were found in the Concession Area, but two Near Threatened species (*Phyllomacromia funicularioides* and *Sapho fumosa*), as well as other species of conservation concern, were found in the proposed Phase 2 sites. Even excluding probable and possible species, there were 11 Upper Guinea endemics and two regionally (West Africa) Vulnerable species in the proposed Phase 2 sites, plus a further seven Upper Guinea endemics and five Data Deficient species in the wider concession area. The conservation status of a further two species has not been evaluated. The total number of species recorded to date from the concession area, 159, is considerably greater than the total number of dragonflies and damselflies found in the whole of Europe (c. 120 species).

Three species were highlighted as being particularly sensitive to the planned mining activities. *Atoconeura luxata* and *Sapho fumosa* inhabit clear and rocky forest streams, particularly favouring fast-flowing sections, a habitat found especially on mountain slopes. Mining in the concession thus either directly destroys their habitat or degrades it through siltation and erosion of streams. *Porpax bipunctus* occurs at sites on the forest floor where leaflitter is soaked by seepage or flooding from adjacent streams, but lacks open water. A strong population was found on Tokadeh and also at a site for the proposed tailings facility. However, it was also observed in West Nimba. If the West African population proves to be sufficiently distinct, it may be recognised as a separate species, which would be evaluated as globally Vulnerable.

As there are no globally threatened species in the Concession Area, critical habitat would only be identified on the basis of its importance to endemic or restricted-range species. The Yiti (or Eytee) catchment in West Nimba was identified as the highest conservation priority for dragonflies in the concession area, and supports a “very rich and characteristic species assemblage of an intact lowland rainforest stream system.” At least 18 species of conservation concern are found there. The Consultant believes that this catchment meets the criteria for critical habitat for dragonflies and damselflies. The “ladder falls” at Tokadeh supports a number of important species, including several species which have not yet been formally described. Although it is a small site, it is considered to be critical habitat due to its high bio-diversity and possible presence of species new to science.

7.5.8 Butterflies

The conservation status of most butterflies has not been evaluated by the IUCN, and thus there are no species known to be globally threatened in Liberia. However, there is sufficient understanding of the habitat requirements and rarity of many species to make some observations on the conservation significance of the butterfly fauna in the Nimba Range.

One species was found in the Concession Area which is listed as Data Deficient on the IUCN Red List: the Giant African Swallowtail *Papilio antimachus*. This is the continent’s largest butterfly, yet among its least known. This species was recorded from Mount Gangra, Mount Tokadeh, the proposed tailings management facility, Mount Beeton and the East Nimba Nature Reserve. These observations included the largest aggregation ever observed of this species (14 individuals together) on Mount Beeton. The Giant African Swallowtail uses hilltops to display and locate mates, and thus the destruction of Mounts Yuelliton, Gangra and Tokadeh could have a large effect on its population.

Two species of Aphnaeus new to science were discovered during the surveys for Phase 2. Although it seems likely that they occur more widely, these species have so far only been found at the proposed site of the Tailings Management Facility near Tokadeh/Gbapa, and the top of Mount Gangra.

Many of the species found in the Concession Area are restricted to intact tropical forest habitats, and therefore will be negatively affected by the loss and degradation of such habitats by mining and associated infrastructure. Such species include *Bicyclus istaris, Calleagris* *landbecki, Celaenorrhinus rutilans, Charaxes hadrianus, Cymothoe hartigi, Euriphene lomaensis, Euriphene taigola, Katreus johnstoni* and *Melphina statira*, among others.

As there are no globally threatened species in the Concession Area, critical habitat would only be identified on the basis of its importance to endemic or restricted-range species. Upper Guinea endemic butterflies are found in good quality forest habitat throughout the Concession Area. Mount Beeton, with its exceptional assemblage of tens of thousands of hilltopping butterflies, would appear to qualify as a “habitat of significant importance to endemic and/or restricted-range species”. These butterflies also depend on the surrounding lowland forest. Mt Beeton and the surrounding West Nimba forest will become even more important with the loss of Mounts Yuelliton, Gangra and Tokadeh, the only other peaks of comparable height in West Nimba.

A particular priority is to collect further information on the distribution of the two new species of Aphnaeus. So far, these species have only been found within the proposed footprint for Phase 2 (Mount Gangra and the proposed site of the Tailings Management Facility), so their habitats would qualify as critical habitat for endemic species. Although it seems likely that both species will prove to be more widespread, a precautionary approach would dictate that these habitats be regarded as irreplaceable critical habitat until there is confirmation of this.

7.5.9 Coastal and marine environment

Buchanan Port

Three species of globally threatened sea turtles, one shark and one damselfly have been recorded from the area close to Buchanan Port (Table 7.19). Two more globally threatened sea turtles might occur, but there have been no definite recent records. All of the turtle species are threatened locally. Fanti fishermen catch them as bycatch in gill nets and target them using special cast nets. In contrast, the Kru people focus on collecting turtle eggs, and occasionally killing adults when they encounter them on nesting beaches.

TABLE 7.19: GLOBALLY THREATENED SPECIES THAT OCCUR, OR MAY OCCUR, AT BUCHANAN

Scientific Name	English name	IUCN Red List
Dermochelys coriacea	Leatherback Turtle	CR
*Eretmochelys imbricata**	Hawksbill Turtle*	CR
Chelonia mydas	Green Turtle	EN
*Caretta caretta**	Loggerhead Turtle*	EN
Lepidochelys olivacea	Olive Ridley Turtle	VU
Sphyrna lewini	Scalloped Hammerhead Shark	EN
Agriocnemis angustirami	[a damselfly]	VU

*Note: Hawksbill Turtles and Loggerheads occur along the coast of Liberia and based on local reports they could also occur at Buchanan, but there are no recent confirmed records at Buchanan.

The Leatherback is one of the world’s most threatened marine animals. The West African population could be the most important in the world, but there is little information on its size or population trends. Leatherbacks have been reported by local people to nest on beaches adjacent to Buchanan, and on 9 March 2011, around 150 hatchlings were collected on the beach to the south of the Port by a local fisherman. Green Turtles are targeted by Fanti fishermen for their meat, and caught both as bycatch in gill nets, and with a specially designed turtle cast-net. They seem likely to nest on beaches near Buchanan, but there is no direct evidence of this.

Olive Ridleys have been identified from a photograph of a turtle on the beach south of Buchanan taken by the Company's Environmental Officer in 2010. Like the other turtles, they are vulnerable to being hunted for meat, and their eggs are collected as food.

A single specimen of a juvenile male Scalloped Hammerhead Shark was recorded in 2011. It was captured inside the Buchanan harbour. The Eastern Central Atlantic subpopulation has been assessed by the IUCN as globally Vulnerable, largely through unsustainable levels of fishing (target and bycatch) by pelagic longline fleets.

The damselfly *Agriocnemis angustirami* has previously been found only near Freetown and Kenema in Sierra Leone, and from Monrovia in Liberia. At Buchanan, it was very numerous in mangrove and swamp forest along the Savage River, between the tailings plateau and the residential "loop" area.

Assessing the conservation significance of the marine fishes found in the port area is more difficult, because there is little information on the conservation status of these species in West Africa. Buchanan harbour and nearby areas support a diversity of fishes, including some quite large specimens. Larger fishes were more abundant outside than inside the harbour, perhaps because recent dredging in the harbour removed much of the three-dimensional structure of the seabed habitats, making benthic habitats within the harbour less suitable.

The beaches close to Buchanan where Leatherbacks, Olive Ridleys and probably other species of turtles nest might qualify as critical habitat, but there is so little information on the numbers of nesting turtles here or elsewhere in Liberia that a quantitative assessment of their significance is impossible at present. Similarly, it is not possible to determine from the capture of a single specimen of Scalloped Hammerhead whether Buchanan harbour is of "significant importance" for this Endangered species.

Marine Fishes

Bottom-set gill netting was the technique employed to conduct ichthyofaunal sampling within and outside of Buchanan harbour. This technique was employed despite having lower catchability (lower species coverage) as compared to more active techniques such as bottom trawling. The reason for this is the presence of a large amount of material within the harbour, such as a wreck, metal scraps and rocks which can result in trawl nets being destroyed. This in turn poses a potential hazard to vessels using the area as the lost nets can get entangled in their propellers. In order to obtain maximum species coverage, two gill nets with mesh sizes of 40mm and 25mm, selective for large and small fish respectively, were used.

A cumulative richness of 42 fish species was recorded within and outside the harbour during sampling using both types of nets over both the sampling trips in August-September 2011 and June-July 2012 respectively. This included 28 and 29 fish species being recorded from within and outside the harbour respectively. Of these 13 and 14 species were exclusively found within and outside the harbour respectively and 15 were common to both areas. Of the 42 species recorded during this assessment, one (*Sphyrna lewini*) was globally endangered, five species were in the Least Concern category (*Caranx crysos, Elops lacerta, Euthynnus alletteratus, Rhizoprionodon acutus* and *Scarus hoefleri*), while the status of the remaining 36 species (86%) has not been evaluated. Twenty nine species (69%) had ranges restricted to Eastern Atlantic Ocean off West Africa.

In terms of the Icthyofauna, except for a single specimen of a juvenile scalloped hammerhead (*Sphyrna lewini*), none of the other fish species captured during this assessment were of global conservation concern. Besides fish, sea turtles are the other species of conservation concern that are regularly sighted within the harbour. The lack of baseline information however makes it difficult to ascertain the reason for lower fish richness and abundance within the harbour. According to the port manager, the harbour basin is required to be dredged very infrequently (once every five years). This is also because the redirection of the Savage River, which used to flow into the harbour, has removed a source of sediment. If allowed to remain undisturbed for a period of time, it is likely that fish will return to the harbour area.

7.5.10 Other Taxa

No further studies were carried out during the Phase 2 assessment on termites, ants, molluscs or moths. Information was collected on these taxonomic groups during the BioPA studies for Phase 1, but because of a paucity of information on their global ranges, ecology and conservation status, it is difficult to use such information to fully evaluate their value and sensitivity. No species in these taxonomic groups has been identified as being globally threatened. Four species of terrestrial molluscs found during the surveys are endemic to Mount Nimba, but these are generally abundant and common within their small ranges, and not restricted to specialised habitats, so it would be unrealistic to attempt to conserve every location in which they are found. The Phase 1 report concluded that for molluscs, a habitat approach, rather than a species-based approach, is probably most appropriate for these species, combined with offsetting of any unavoidable residual habitat loss.

7.6 Flora

Data on the Botanical Surveys are contained Phase 1 DSO ESIA Volume 4 Part 2 (Botanical Assessment and Mitigation)and Phase 2 Volume 4, Parts 1.1 (Forest Botanical Impact Assessment) and 1.2 (Grassland Botanical Baseline & Impact Assessment).

7.6.1 West Nimba Concession Area

Volume 4 Part 1.1 completes a baseline survey of the vegetation and flora of the West Nimba concession area in northern Nimba County as a basis for a Phase 2 mining ESIA.

The survey builds on an earlier baseline study for Phase 1 conducted in April-June 2010, referred to as RBS2010. The results of the 2011 RBS (Rapid Botanical Survey) and NTFP studies are analysed and presented in this report, in the context of the 2010 findings. The vegetation of the area is described, highlighting both globally significant biodiversity conservation issues and locally significant conservation issues based on the local uses of the flora. Management recommendations are made in the context of these issues.

The Nimba mountain area in general has a long-standing reputation as a global biodiversity hotspot. However, the physical limits or arrangement of this hotspot - the pattern in which globally rarer species are distributed across the landscape - has never been very clear, an omission of some concern when planning how to reduce impacts when a significant proportion of the mountains may ultimately be removed during mining.

The survey focused on Mt. Beeton and surrounding lowlands, these being a hitherto little explored part of the proposed Gba Community Forest (GCF), and a proposed offset area for the mining footprint areas on Mts. Tokadeh, Gangra and Yuelliton. Extra botanical samples were also taken in the area of a Tailings Management Facility (TMF), a part of the Phase 2 mining footprint whose location was not decided at the time of the Phase 1 ESIA, and also partially inside the GCF boundary. A few other RBS samples were scattered in other survey gaps around the concession, but a large proportion of the rest of the concession was surveyed and reported on in RBS2010.

The Rapid Botanic Survey (RBS) method is aimed at vascular plants, i.e. flowering plants and ferns. In total, 31,775 records were made of plants (9,878 in 2011) across 249 RBS sample areas (including 75 samples in 2011). Use is also made of data from 101 smaller plots made in savanna in 2012, including Buchanan port, visited also by the authors in December 2011, and Green Hill Quarry samples. Excluding the savanna survey, 21,497 voucher specimens were collected (including 7,436 in 2011), and so far a total of 1358 species have been fully named. A further 150 taxa have temporary, so-called, vague names.

The results were assessed using standard statistical vegetation analyses, particular Non Metric Multidimensional Scaling (NMS) to show how the plant communities vary around the landscape in terms of species content. As is usual, the flora varies to a large extent in a continuum and vegetation classes are defined using arbitrary cut-off points with this continuum. Seven woody vegetation classes were recognised based primarily on ordination of the whole flora, and 1-3 abundance scores in all RBS samples; and two savanna classes (classes 8 and 9) were based on a reanalysis of the 2010 samples. It is demonstrated that lowland moist evergreen forest is the most important formation in terms of both locally useful and globally rare species, and in terms of land coverage. It is subdivided into three classes (4, 6 and 7) of moist evergreen forest based not on the full species composition and abundance scores, by which criterion the classes overlap, but on a separate analysis of canopy tree composition that is also recorded in RBS samples.

The vegetation cover map has been updated based on new Google Earth imagery in the east of the survey area and WorldView-2 imagery purchased especially (see Dwg 7.4). There is considerable variation in forest class on a very local scale, e.g. due to drainage patterns in the landscape, and more GIS work would be needed to produce a fully interpolated vegetation map.

The pattern of global biodiversity value is discussed in terms of bioquality - the concentration of globally rare plant species in a local plant community - for it is this aspect which is inherent in the concept of a global hotspot, the basis for most global concerns about mine impacts in the survey area. A precise, standardised index of bioquality, the GHI (Genetic Heat Index), is calculated for a plant community by categorising plant species into various Stars of different global range and conservation priority; and then deriving a weighted average for samples to reflect mean global rarity value of the species in the sampled community. The rarest two, Black and Gold Stars, are represented by many (circa 120) species throughout the area, including the mine footprint areas: both the species and samples are listed and priorities are discussed.

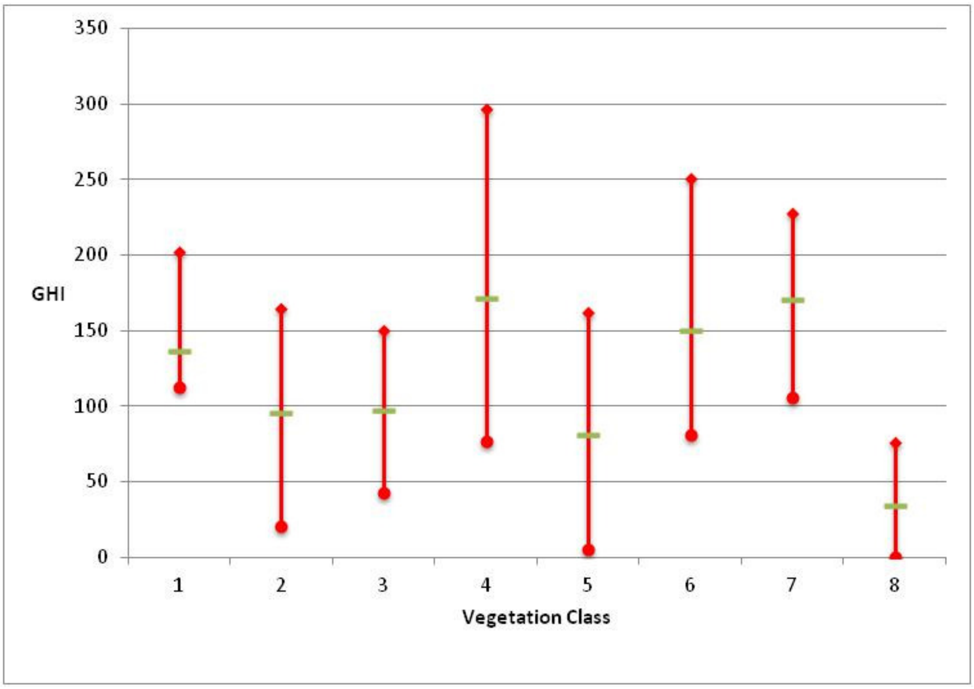
A high GHI signifies that an area is relatively rich in rare species such that a loss or degradation of the area would represent a significant erosion of genetic resources from the world (see Dwg 7.5). It was noted in the earlier Phase 1 baseline study report that the lowland forest area to the SW of Mt. Beeton towards Vanyampa had the highest GHI in the survey area. However, at that time there were very few samples on the top of Mt Beeton and very few around it. The new survey results from the Gba Community Forest area confirm a generally elevated GHI in the class 4 and 7 Evergreen forests in Western Nimba, especially between Mt. Beeton SW to the Dayea River and Vanyampa. It is locally reduced in disturbed areas, e.g. with class 3 vegetation, such as in old logging and/or mining parts of the forest in Beeton.

Zoo Hill (a forested Hill north of Bentor reputed to have a high large animal population due to some level of local control from Bentor) was sampled floristically in three places. Interestingly, these 3 Zoo Hill samples cover the three nuances of lowland evergreen forest class, yet all three have equally unexceptional – almost identical - GHI scores. Yet south of Bentor, similar evergreen forest samples from vegetation classes 4, 6 and 7 have GHI scores two or three times higher.

This again reflects the general overall similarity of the whole flora of the forest subclasses – with mere shifts in the dominance of some tree species. It is interesting though that globally rarer species are concentrated towards the Dayea River, suggesting different factors influence these compared to perhaps globally more widespread species that have more weight in determining the forest class as a whole.

Bioquality scores are sumarised by vegetation class in Figure 7.8. There is quite a range of variation in all classes, though the evergreen forests 4 and 6 reach the highest scores, and savanna and secondary vegetation is generally lower, i.e. with lower concentrations of globally rare species.

Figure 7.8: Bioquality by forest class, showing mean, max and min GHI for RBS samples of each vegetation class.



Using the RBS results, supported by aerial photography, the main vegetation classes are summarised with a complete check-list of all plants sampled and their Star ratings.

This study confirms that:

- Forest is the most important vegetation type in the surveyed area from a global biodiversity point of view, varying from riverine to sub-montane classes;
- Fortunately, there is a significant area of high bioquality, less disturbed forest in the lowlands to the west of the main mining footprint and in the East Nimba Nature Reserve to the east.

However, there is also a large proportion of disturbed or secondary forest and fallow in the area and most of this contains relatively few plants of global conservation concern. Much of the forest e.g. on Mt. Gangra has already been heavily disturbed at various stages in recent decades, not least by mine exploration, and including fire in the last few years, and this is associated with lower bioquality scores.

The local importance of plant resources is addressed separately from the global concerns, making use of the same RBS database. To address the local importance of the vegetation, an NTFP (Non Timber Forest Product) survey was conducted in 7 villages across the concession. A definition of NTFPs was used to include:

- species of disturbed areas and fallow as well as forest;
- species managed in some way, but not agricultural crops *per se;*
- species used as timber in local construction but not that extracted by large-scale industrial loggers (although the latter species list may well be a subset of the former);
- species ‘used’ in abstract ways e.g. as symbols or indicators.

NTFP Surveying was conducted in 7 communities of the concession: Bahpa, Bentor, Gbapa, Makinto, Sehyigeh, Vanyampa and Zolowee. Within each community the team worked with two 'Zoes' – local experts in plant use. Three RBS samples were conducted with each community in three different vegetation classes (21 NTFP-RBS samples out of a total of 249 RBS samples). In each sample, c. 100 species were collected and subsequently identified, and Mano names and usage notes were recorded. A shortlisting exercise was conducted to identify the most important species across the concession area. A workshop with the Zoes was then held to prioritise these shortlisted species on 'the amount of effort AML should invest in protecting or regenerating them'. How hard the species was to obtain, where it lives, and if anyone had any experience with its regeneration were topics of discussion.

421 of 651 (65%) NTFP-surveyed species were recorded as useful. 75% of recorded species have a Mano name. More (257) species are used medicinally than for any other use category; 173 species are used as materials; 103 have social uses; and 76 species are used as food. Fewer species have environmental uses (e.g. shade trees, fertilizer), are used as poison, animal food or food additives. 168 species have uses in more than one use category.

65 useful species were shortlisted for their particular importance. All of them are traded locally. 62 of these are non-pioneer, non-herbs, i.e. slow to grow to a useful state and vulnerable to disturbance from mining operations. About 30 of these species are considered by the communities to be difficult to obtain in the necessary quantities; the others are locally common.

NTFP-RBS sampling occurred mainly in Vegetation classes 4-7 in 2011. All species occurring in more than four samples were categorised by their vegetation preference, defined as the vegetation class in which a species is present in the highest proportion of samples. The greatest number of NTFP species (147 species) are found in Vegetation class 4, i.e. primary or late successional, low or mid altitude, moist evergreen forest. This vegetation type also supplies the greatest number of shortlisted 'key' NTFPs. Vegetation class 5, low or mid altitude secondary vegetation with many pioneers, provides fewer NTFP species (53 NTFP species prefer this disturbed Vegetation class), and 11 of the shortlisted NTFP species. While the low-mid altitude late successional forest is the most useful vegetation type (Vegetation class 4), different species are found preferentially in each vegetation type, so the vegetation classes are complementary to each other in terms of NTFP provision.

The largest mining impact on NTFP availability to date is that a majority of the surveyed villages (Vanyampa, Zolowee, Makinto, Gbapa) have had their forest access restricted by the demarcation of Tokadeh. A major portion of the forest from which those villages used to benefit is now inside the Tokadeh mine demarcation: they used to collect from the forest at least weekly, but have been told they are no longer allowed to go there. This is strongly reflected in the perceived availability of key NTFP species (a list dominated by forest species). Forest species are considered hard to find by the Zoes of Vanyampa, Zolowee, Makinto, Gbapa, and also Bahpa, whose forest is at Gangra/Yuelliton and a long distance to walk to. Only Vanyampa and Bentor (two communities in the proposed W. Nimba community forest) say that forest species, and therefore a majority of the key NTFPs, are easy to find.

It is concluded from the new surveys that the Gba Community Forest (GBA) area includes much high priority forest which, if AML is able to contribute to biodiversity and NTFP conservation of this area leading to a halt to long term loss of forest cover, would indeed represent a substantial offset for biodiversity lost in the mine areas.

However, Class 1 and 2 vegetation is missing from within the GBA community forest area, and loss of this type in Yuelliton, together with general loss of ecological and NTFP services due to Phase 2 activities, could be offset by montane restoration activities in East Nimba old mine areas.

7.6.2 Old Mine Sites and Other Areas

Volume 4 Part 1.2 is concerned with the grassy vegetation types in the project area, including former mining sites, Greenhill Quarry and Buchanan Port.

Although the impact of the mining activities of the LAMCO/LIMINCO was harmful to the forest vegetation of the region, not enough information remains available on the recolonization of the vegetation of the former mining sites. The destruction of the higher altitude forest cover, the levelling of rock massifs, the removal of the top soil and the disturbance caused by the mining activities also led to the degradation of the forests of the piedmont. These forest areas in the piedmont were replaced locally by vast areas of savannahs.

In this context, and because of the resumption of mining activities, a study was undertaken to identify and evaluate these grassy formations within the mining concession in Northern Nimba, and particularly in the area around Yekepa. This mission, undertaken in two phases, had the following main objectives:

- To survey the main herbaceous vegetation types, particularly grass species, which covered the former mining sites of Northern Nimba;
- To determine the likely impacts of the mine and infrastructure proposals on the savannah vegetation types;
- To identify appropriate mitigation measures for the mining impacts and produce practical management prescriptions to implement them.

During October, November and December 2011, botanical surveys were carried out in the former mining sites, as well as in the sites of Greenhill Quarry and Buchanan Port. Mining at Nimba ceased in the 1990s due to the civil war, allowing the vegetation to re-colonize mine areas. The initial forest vegetation which covered the mountains of Northern Nimba was replaced by savanna vegetation. The plateau forests have been eroded by rainfall runoff and have also evolved towards a savanna vegetation. At Buchanan, the original swampy and woody vegetation was eliminated following clearing and spoil disposal to facilitate the harbour activities. A total of 139 herbaceous species were found within 75 surveyed plots in the savannas of the former mining sites at altitude and in the plateau savannas of Northern Nimba. Twenty one plots at Buchanan contained 94 herbaceous species. Finally, 31 herbaceous species were listed in two sites in the area of Greenhill Quarry.

This recolonizing vegetation has strong floristic diversity. The family of Poaceae (grasses) dominates in the herbaceous layer of the various studied sites. The herbaceous vegetation which colonized the mining sites of Northern Nimba (Old Mine, Blue Lake and Mount Tokadeh) and certain parts of the North Nimba plateaux represents an intermediate phase before the return of forest vegetation. Grasses, such as Anadelphia leptocoma, Loudetia phragmitoides, Melinis minutiflora, Hyparrhenia diplandra var. diplandra and Sporobolus dinklagei are perennial species which ensure good cover of the ground.

7.7 People

Human aspects of the study area are covered by Phase 1 DSO ESIA Volume 5, Parts 1.1 (Socio-Economic Baseline) and 1.2 (Social Impact Assessment/Social Management Plan), and Phase 2 ESIA Volume 5, Parts 1 to 3. The Phase 2 Parts comprise:

- Part 1 Socio-Economic Baseline
- Part 2 Social Impact Assessment (dealt with in Section 9)
- Part 3 Cultural Heritage (dealt with in Section 7.7.2)

7.7.1 Socio-economic baseline

Phase 2 ESIA Volume 5, Part 1 provides an analysis of the existing socio-economic conditions in three areas which were identified as a gap in existing baseline documents, yet will be impacted by iron ore mining activities. The three areas are as follows.

- Buchanan Port area: During Phase 2, up to 15 million tonnes of concentrated iron ore will be exported from Buchanan port per year. The administrative centre for the mining operation is also located at Buchanan port, along with the administrative centre for two of its key subcontractors.
- Greenhill Quarry (GHQ): Blasting will be necessary at the quarry from time to time while ballast is needed for railway maintenance.
- Land which will be used for the Tailings Management Facility (TMF): Around 150 million tonnes of slurry from the concentrator needs to settle in a tailings facility over the 12-year life of the mine and processing plant. The TMF is planned between Mount Tokadeh and Mount Beeton, south of the Dayea River.

A baseline survey was carried out among the communities that were affected by Phase 0 and 1 mining activities in 2008-2009. These communities included Yekepa, Camp 4, Gbapa, Zolowee, Makinto, Sehigeh, Bonlah, Lugbeyee, Kanlah and associated hamlets in the Yekepa concession area. In 2008-2009, a baseline was also carried out among communities living along the railway. The survey used for the Phase 2 assessment replicated the method used in 2008-2009 to allow for comparable data to be collected.

The communities that may be affected by Phase 2 activities were identified using specific criteria for each study area.

In Buchanan, data from the URS Scott Wilson scoping report was used to identify the main potential socio-economic impacts of concession activity at Buchanan port. Those identified were:

- Increased opportunities for employment around the port area;
- Changes in air and water quality as a result of both a) port activities and b) an increase in the number of people living in the Concession Area;
- Changes in fish population as a result of port activities.

Based on these potential impacts, it was decided that all communities within the Concession Area should be included in the population of interest (Dwg 7.6). To fully capture the impact of potential increased employment, communities located along the Company bus route were also included. The bus route runs from the Company's local hospital around the peri-urban areas of Own Your Own, Flower Mill, Gorzohn, Kpendey and Jacob Town. These communities are to be located on the southern and eastern peri-urban areas of Buchanan.

Thus communities within the Concession Area and communities located along the bus route formed the impact group, i.e. the population impacted by Company activities. To allow for impact to be assessed as accurately as possible, sampling was also carried out on a control population. This population was matched with the population identified as potentially impacted by Company activities on two criteria: distance to Buchanan and main economic activity.

In GHQ (Dwg 7.7), communities identified as potentially impacted by activities at the quarry were defined as those located within 1.5km of the quarry. All those living within 750m of the quarry were required to evacuate the area during blasting. The 1.5km buffer allowed the survey to capture households who live just outside the 750m buffer but who use the land within the 750m buffer.

The population affected by the construction of the TMF was defined as the population living within the area where the facility will be built, plus a 500m buffer zone around that area (Dwg 7.8). Those using the land within this buffer zone were included in the 'impacted' population. The population living where the proposed pipe carrying the slurry from Mount Tokadeh to the TMF will be built was also surveyed. A 30m buffer zone was established along the route of the pipeline.

The data collected for the baseline survey show that people are engaging in a large number of strategies to earn income. Most income is earned through trade rather than through formal employment. The key finding from the data on income is that there is reasonable variation in income within the sample (difference between maximum and minimum is US$24,792) indicating that some individuals benefited from the trade economy while others made barely enough to feed themselves. The average income per capita recorded was higher than the average income recorded in the Phase 1 ESIA (US$157 railway communities and US$87 for mine affected communities) and that reported in the UN Human Development Index (US$320). The highest average income recorded was in GHQ (US$528). The average income recorded in the Buchanan sample was similar at US$515 per annum. The lowest average income recorded was in the TMF where on average individuals earned US$421.

To identify the key factors that contribute to lower incomes, a multiple regression analysis was carried out to examine the effect of sex, age, education, stranger status and farmer status. It was found that education, sex and farmer status had strong effects on income. Each grade attained at school resulted in an increase in individual income over the preceding 12 months by on average US$54. Females on average earned US$266 less over the 12 months prior to the survey than males. Farmers earned, on average, US$260 less than non-farmers.

Women also emerged as disadvantaged on education, health and political influence indicators. Women were less likely to attend school and if they did attend, were more likely to drop out before they graduated from high school than men. Women were less likely to receive Yellow Fever, polio, hepatitis and measles vaccinations. Finally, women were less likely to attend community and political meetings.

The second key finding was that much of the economy in all study areas depended on communally accessed natural resources. In Buchanan, three of the largest five wealth generating activities depended on communally accessed natural resources. In GHQ and the TMF, at least one of the largest five wealth generating activities depended on communally accessed natural resources.

While the Company is providing employment to local communities and indirectly providing people with capital to invest in enterprise, overall more money is being made from fishing, selling fruit and vegetables, palm oil and charcoal. These sources of income are dependent on communal access to the resources. Resettlement, increased shipping activity and an increasing population is likely to put pressure on these resources.

A third key finding is that people living within the Concession Area have poor access to basic facilities including health clinics and elementary schools. Communities living in the Concession Area in Buchanan were more likely to use river water as their main source of drinking water than communities living a similar distance from Buchanan outside the Concession area.

A fourth finding was that people living in the three study areas are not as reliant on subsistence farming as perhaps they are perceived to be. Overall just 38% of households grew rice and 56% grew cassava. There were some differences in the cultivation of subsistence crops between the study areas. In Buchanan, just under 30% of the population grew rice and under 40% grew cassava. More people grew subsistence crops in the TMF and GHQ; 70% grew rice and cassava in the TMF; 60% grew rice and 80% grew cassava in GHQ. When asked about what strategies they used during the hungry season, 40% reported no change in their activities indicating that these people's income earning activities were not affected by seasonality. Of those who did change their strategies, the strategies were dispersed resulting in low numbers in each category.

The most commonly reported strategies were business, fishing, formal employment, and credit. Most people's protein intake came from the consumption of fish. Most households reported eating fish on a daily basis. In addition to fish, bushmeat was a significant source of protein; 66% of households reported eating bushmeat at least occasionally, 21% weekly.

Very few interviewees had received any type of training. Overall, 11 interviewees out of 95 reported that they had received training from NGOs, 3 interviewees received training as part of a Disarmament, Demobilisation and Reintegration (DDR) programmes, 2 received training from ‘big companies’ (LAMCO and Odebrecht) and 1 received training from the Government of Liberia. Interest in skills training was analysed by study area.

In Buchanan, the top five skills that interviewees expressed an interest in were food production, hairdressing/beauty, entrepreneurship, mining and masonry. In Greenhill Quarry, the top five skills that interviewees were interested in were entrepreneurship, fruit and vegetable cultivation, driving, animal husbandry and cocoa cultivation. In the TMF, the five skills that interviewees were most interested in acquiring were mechanics, hairdressing/beauty, driving, food service and masonry.

The majority of the sample was Christian. Some Christians practiced a mixture of traditional beliefs and Christianity. However, the number of people who identified themselves as practicing traditional beliefs may not reflect the actual numbers; there was some reluctance among interviewees to profess belief in African Science and many of the traditional belief systems practiced in Liberia involve secrecy.

In Buchanan, 5% reported that they worshipped in special places in the forest. In GHQ and TMF, a higher proportion reported worshipping at sacred places. In GHQ and TMF, 19% and 18% reported worshipping in special places in the forest. In the TMF, 4% reported worshipping a sacred rock and 3.5% a sacred stream. There is a sacred rock located within the area to be occupied by the proposed waste dump.

It is clear from these findings that commonly accessed natural resources (sea, rivers, forests and bush) are of utmost economic and spiritual importance to the people living in areas impacted by mining activities. Any developments within these areas will have to be carefully planned to provide alternative resources to ensure that livelihoods and places of worship are not negatively impacted.

7.7.2 Cultural heritage

The Cultural heritage findings are contained in Phase 2 ESIA Volume 5, Part 3.

Nimba County is primarily made up of members of the Gio and Mano ethnic groups. Other Liberian ethnic groups are represented in the county, particularly in the major towns, as follows: Sapo (12%), Krahn (10%), Gola (5%) and Bassa (2%). The remainder represent less than 1% including Americo-Liberian, Vai, Kru, Lorma, Kissi, Grebo and Gbandi.

The 2008 census indicates that Liberia is composed of 85.6% Christians, 12.2% Muslims, and 0.6% practitioners of exclusively traditional (indigenous) religion.

There is limited literature and research relating to the religious demography and cultural heritage of northern Nimba County. However from the literature available, an important aspect of religious worldviews in this area is the relative unimportance of an omnipotent ‘god’ in relation to the individual spirits within objects. These individual spirits are understood to be responsible for certain aspects of daily life, and therefore, it is believed that they require appropriate acknowledgment and attention especially if a problem arises so that it can be quickly resolved positively. It is important to note that these spirits were never feared, or viewed as good or evil in nature; rather, they were viewed as ambivalent spirits that had power, and for this reason they deserved respect. This is not to say, however, that malevolent forces do not exist in the Mano beliefs.

The fieldwork for the cultural heritage impact assessment was conducted by the Phase 2 ESIA Consultant. In total, fourteen communities were surveyed by the field team. The findings of the research indicated the presence and social importance of traditional beliefs such as animal belief practice[5], animal-spirit doubles[6], secret societies, and monotheistic religion.

Animal belief practice

Most of the details surrounding the worldview and activities surrounding the animal practices are secret and only revealed to those who are members. However, key informants were able to give certain details surrounding the practice. Many informants were reluctant to speak about the practice in the presence of other people, especially those who were not also ‘in animal’. Therefore, the key interviews were conducted privately or with small groups of people who were close friends, of the same gender and/or in the same family.

The existence of the ‘animal practice’ in this part of Nimba County was found to be relatively widespread and is considered to have significant social importance that should not be overlooked. Although membership is a secret, it was not difficult to talk to people about it, particularly those who were involved in it themselves. This information was gathered in one-to-one interviews that were conducted without notice and at random. The team found evidence of people who were ‘in animal’ in every community; it is likely that additional people were also ‘in animal’, but were reluctant to discuss it because, as they explained, if potential (human) enemies knew that they were ‘in animal’, then that enemy might go into the forest to kill the person’s animal double if they ever had a disagreement – which was considered a subtle way of harming their enemy. It was learnt that each animal had its own area on the mountain to roam and was deemed safe from hunters and other animals. To move from one area to another was considered dangerous for the animal and it was reported that there had been incidents in the past in which the animal was forced to move which then resulted in injury or death (to the human and the animal).However the confirmed existence of animal practice and being ‘in animal’, is increasingly being threatened by the Company operations on the mountains in which they live. Every informant who claimed to be ‘in animal’ also complained that they had lost their habitat and they were in ‘serious danger’, ‘between life and death’, ‘hungry’, and/or ‘hiding and running away’. This was attributed to the fact that Mt Tokadeh was in the process of being mined, and some exploration drilling had happened at Mts Gangra and Yuelliton. They report incidents of flying rocks, loud noises, other animals attacking them, and inability to find food because the forest has been destroyed. Informants whose animals resided in Gangra or Yuelliton, explained that they had heard what was going to happen on the mountains, and had since moved their animals down the mountain, and were similarly in ‘serious danger’, and unsure of where to go.

Poro/Sande

Fragmentary accounts in literature suggest that the Poro society existed up to 400 years ago. A common theory to explain their emergence describes political upheaval and migration among Mande-speaking people along the Guinea Coastal region. At this time it was believed that those who belonged to this society were from powerful landowning families and being a member of the society would demonstrate loyalty to one another in new territories if they were to come across another member. Sande, the female counterpart to Poro, also exists throughout the region. A Sande initiate will have received practical training in how to care for the home, children and her future husband. They also learn about the ‘mysteries of fertility and reproduction’, secret Sande songs and dances, and how to make medicines ‘to influence or even kill their husbands’.

The Poro and Sande’s political importance is inextricably linked to the power it is believed to harness, and specifically the bush in which this power is believed to reside. Initiations are an indispensible aspect of Poro and Sande societies. It is within the sacred bushes, where the Bush Devil lives, where initiations occur.

[5] This is the belief that certain individuals have a ‘dual spirit’ that resides simultaneously in their human form (who lives in the village) and in one or more animals (who live in the mountain forests of their homeland). The human and the animal are spiritually tied together to the extent that if the animal is harmed or killed, the human will experience illness/injury or death

[6] People behaving as animals for example on all fours, eating uncooked rice and worms, howling and digging with their hands – while tending to their farm

Over time, however, as a result of many factors not necessarily related to the Company operations operations, the existence of Poro and Sande societies in Northern Nimba County has lost much of its social importance. Consequently, there have been far less frequent, less public (i.e. no community festivities for the return of initiates) and much shorter initiation ceremonies occurring in all of the towns.

Sacred creek, rocks and trees

In each community there exists at least one sacred site in the form of a tree, rock or stream/creek/river. It is believed that a particular spirit resides in these sacred sites or objects. According to tradition, regular sacrifices needed to be made to the spirits. There are sacred places in Gbapa (Guele Gbeih, Gnimgbinhi, Goue-Gbah, Guebehi, Golo-Gleh, Gouanpah, Gbeayee, Douopah Louapah), Zolowee (Dimi, Gouegbahee, Dimibleen, Blei), Zortapa (Guegbableen, Zoweguebleen, Tohgbouo, Vehi) and Bonlah (Zowedah, Puldeh, Bleen, Lozilee, Gbarglan, Gueoah douapah). Baseline data provided by the Company indicates that one sacred rock is located in the proposed Tokadeh waste dump area.

8 ASSESSMENT OF IMPACTS AND PROPOSED MITIGATION

8.1 Knowledge Gaps in the Impact Assessment

In accordance with Section 14-1i of the Environmental Protection and Management Law of Liberia (EPML), the "gaps in knowledge and uncertainties which were encountered in completing the required information" need to be provided in the ESIA report. A number of such gaps exist as shown in Table 8.1. Discussions with the Company indicate that these gaps will be addressed in the Environmental Management Plan as the designs progress. It is recommended that they be reviewed environmentally when the information is available so as to ensure compatibility with environmental protection.

TABLE 8.1: GAP ANALYSIS FOR PHASE 2 ESIA

Information for Phase 2 ESIA	Information Availability	Outstanding Information for Phase 2 Assessment
Project description	Report 'Feasibility Study – Mining (29/11/12). Very limited information on engineering details. Phase 2: 2013-2026: Iron Ore Mining, Concentration and Transportation: Project Description. Greater information on project details (01/2/13).	The Project Description is a good outline of intended activities and functions. Implementation designs and details are largely yet to be defined (see below). An up-to-date overall project sequencing programme, indicating when different project activities will be commenced, completed and functional is not available.
Location of mine access roads	Available	Detailed design pending further investigations.
Ultimate extent of Phase 2 works and exclusion zone for forest and agricultural land take plus interface with environmental constraints map	Final mine pit, mining and auxiliary infrastructure layout provided, including TMF, stockpiles, waste dumps and drainage storage/sediment retention facilities.	Borrow areas for the Tailings Management Facility are only confirmed for Year 0 and Year 1 (also see below in terms of physical/biological impacts of borrow areas). The Gangra/Yuelliton – Tokadeh Haul Road alignment is provisional pending confirmation. The post-Year 1 borrow areas and G/Y-T Haul Road will be the subject of Addenda to this ESIA when the details are known. The sources of other construction material, for use as aggregate, are excluded from this ESIA, except in general terms.
Ultimate pit depth in relation to groundwater and groundwater management.	Ultimate pit depth provided through a series of cross-sections. Draft Hydrogeology report provided but this contains little information on groundwater regime.	Information on groundwater regime is missing and dewatering requirements are unclear. Hydrogeological investigations and the need for dewatering to enable excavation beneath the water table are to be carried out and assessed later and therefore are excluded from this ESIA, except in general terms. Investigations and designs will need to be prepared that are consistent with the Company's EMP and international standards.
Locations of proposed stockpiles and waste dumps in relation to	Final footprint layouts	

TABLE 8.1: GAP ANALYSIS FOR PHASE 2 ESIA		
Information for Phase 2 ESIA	**Information Availability**	**Outstanding Information for Phase 2 Assessment**
environmental constraints map		
Geotechnical, drainage and slope management details of stockpiles and waste dumps	Final layout and cross-sections and concept – level text	Details of foundation preparation, stability considerations missing, and final topography shown is largely incomplete – a stability review cannot therefore be undertaken at this stage. This will be a requirement of later investigations, analyses and design that are consistent with the Company's EMP and international standards. No drainage details for the Waste Rock Facilities (waste dumps) are provided, neither are details as to how debris will be prevented from rolling/washing into the drainage channels below. These are therefore excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Stormwater Management in mine areas	Stormwater concept notes provided. Stormwater/drainage management plans provided are at concept stage and lacking in detail.	Design and feasibility level details of mine drainage and provisions for erosion control and sediment control. These are therefore excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Stormwater Management outside of mine areas	Plans and description of the eastern sediment control facility. This will also act as a water storage facility for the TMF.	Selection of 1 in 1 year design event is not clear, and dredging disposal sites not known. Confirmation required as to how sediment storage will be monitored and managed to prevent surcharge and details as to how ultrafine/colloidal material will be settled out of discharged water so as to conform to IFC standard. Details as to how runoff from mine area, WRFs and stockpiles will be channelled safely to sediment retention facility missing. These are therefore excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Tailings Management Facility	Final layouts and preliminary design details	Borrow pit locations beyond Year 0 and 1 are not confirmed. These are therefore excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards. An

TABLE 8.1: GAP ANALYSIS FOR PHASE 2 ESIA

Information for Phase 2 ESIA	Information Availability	Outstanding Information for Phase 2 Assessment
		integrated full site topsoil management plan will also need to be developed. These will need to be the subject of an addendum to this ESIA.
Runoff control from truck maintenance plateau	General drainage of concept level shown	Details missing. These are therefore are excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Mine water supply for dust suppression and workforce facilities, and wastewater treatment provisions	Concept level notes	Locations and rates of extraction not known. These details are therefore excluded from this ESIA, except in general terms. Details of water fluxes are to be subject to further development and refinements. Designs will be developed later that are consistent with the Company's EMP and international standards.
Dust, noise and light suppression/control	Concept level notes	These details are excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Containment of fuels and other potentially harmful and polluting materials	Site plans provided	Details missing, including timings of provisions prior to Phase 2 start-up. These details are excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Mine topography and drainage reinstatement	End of Phase 2 final plan and profiles provided	Details missing as to how the large ponds shown on the mine plans are going to be drained/reinstated. This issue is related to hydrogeology and will require further investigation as discussed above. These details are excluded from this ESIA, except in general terms. Designs will be developed later that are consistent with the Company's EMP and international standards.
Type of locomotives and frequency of operations	Feasibility Report June 2011 and Project Description	
Rail to port to ship transfer details	Feasibility Report June 2011 and Project Description	
Berthing details, volumes/rates	Feasibility Report June 2011 and Project Description	
Port drainage management	Buchanan Stormwater Management Plan provided	This is a reinstatement of the former LAMCO system with improved

TABLE 8.1: GAP ANALYSIS FOR PHASE 2 ESIA		
Information for Phase 2 ESIA	**Information Availability**	**Outstanding Information for Phase 2 Assessment**
	showing concept level layout	sedimentation ponds and is covered under a separate environmental permit. Therefore not part of this ESIA.
Hoardings and other methods for dust control	Feasibility Report June 2011 only	No further details provided, presumed as per current Phase 1 provision
Yekepa township	None regarding township development plan	An addendum will be required to this ESIA when the township development plan is in place.
Greenhill Quarry Camp	None	Phase 2 housing requirements and subsequently power generation, water supply and waste water management details are not confirmed.

Due to reasons of a) insufficient information regarding confirmed layouts and designs and potentially b) insufficient baseline data due to post-baseline survey layout change, it was agreed with the Company that the following would not be covered in any detail in this ESIA, and would need to be addressed during subsequent ESIA addenda:

- the Gangra-Yuelliton to Tokadeh haul road;
- TMF borrow pits;
- Yekepa town development and relates aspects.

8.2 Impact Assessment

Each of the specialised assessment reports contained in Volumes 3, 4 and 5 include an assessment of impact and recommended outline mitigation. This Volume 1 summarises the findings of these studies and provides an assessment of impact significance in each case. Volumes 3-5 should be referred to for further details.

8.2.1 Impact Assessment Methodology

Impact assessment methodology requires the following steps:

1. The source of impact to be identified (see Table 5.2);
2. The impact receptors to be identified and defined;
3. The impact *severity* (or *magnitude* – see below) to be assessed, a function of *magnitude* and *probability* of occurrence (Table 8.2);
4. The assessment of the sensitivity of the environmental receptor or resource to the impact when it occurs.

Combining these parameters yields an assessment of impact *significance* (Table 8.3).

Table 8.2: Assessment of Impact Severity

	Receptors						Probability			
Magnitude	Air	Water	Land	Fauna	Flora	People	Low	Moderate	High	Severity
V Low										V Low
Low										Low
Med										Medium
High										High
V High										V High

Magnitude of Impact

Impact magnitude was assessed in terms of area of extent, area of potential influence, volume and intensity, e.g. the size of the mine footprint, the volumes of spoil material to be disposed of, the predicted noise levels and the sources of sediment to be released to streams and water supply. Many of these assessments were undertaken in a qualitative way due to lack of available data. Magnitudes were assigned to each source of impact according to each receptor with the following categories:

- Very Low
- Low
- Medium
- High
- Very High.

The area of vegetation clearance and excavation for the mine sites, for example, falls into the *Very High* magnitude category, while that for the Tokadeh workshop is much more localised and is assigned a value of *Low.* As these impact sources have the potential to affect different receptors in different ways, magnitudes assigned often vary between receptors. Furthermore, some impact sources do not lend themselves very easily to magnitude assessments based on areal extent or volume. Dust, changes to landscape character and handling of oils and lubricants, for example, fall into this category, and in other cases the areas of potential effect or the numbers involved cannot be determined and a judgement-based assessment is required. This applies, for example, to the potential influx of job-seekers in Buchanan and the increased demands for bushmeat as a result of population increase and food scarcity.

Recourse has been made to various specialist reports contained in Volumes 3, 4 and 5 to yield the required information and GIS has been used to assist in determining areas affected. For example, the specialist report on landscape character has provided assessments of change magnitude, both in terms of landscape character and visual effect, while the land use and botanical mapping has, for example, allowed areas of farmland, Moist Evergreen Forest and Environmental Constraints zones to be calculated for the Phase 2 footprints.

It should also be noted that certain impact sources will not be applicable to certain receptors, e.g. drainage from mine areas is unlikely to affect air quality, and hence a category of *Not Applicable* has been assigned.

Impact Probability

For the Phase 1 DSO ESIA, impact probability, together with impact magnitude, were assessed in order to derive impact severity. Probability was assessed according to whether the source of impact was considered likely to occur during the construction, operational or closure period. For the Phase 2 assessment it has been assumed that the potential sources of impact will occur, i.e. probability in all cases will be high or certain.

On this basis, impact severity becomes a function of impact magnitude alone.

Receptor Sensitivity

The sensitivity of environmental receptors and resources to potential impacts requires the assessment of the:

- relative abundance, quality and regenerative capacity of natural resources in the area;
- absorption capacity of the natural environment to accommodate these impacts without significant loss of value or sustainability.

The baseline studies described in Volumes 3, 4 and 5 and summarised in Section 7 of this Volume 1 report contain assessments of environmental sensitivity. For landscape and visual impact, noise and air quality this has been done in a formal tabulated way, while for other receptors sensitivity is inferred according to descriptions of value or rarity, degree of potential loss and recoverability.

An element of professional judgement was required to assign receptor sensitivity, particularly where the receptor details are relatively poorly understood or where sensitivity could not be quantified, as indeed was the case in most situations.

Significance of Effects

Combining the severity of impact and sensitivity of environmental receptors and resources, the likely significance of impact is determined (Table 8.3). Note that the impact magnitudes and the resultant effects can be either adverse or beneficial.

Table 8.3: Significance of Effects

	Sensitivity of Receptor to Impact				
Magnitude	V High	High	Medium	Low	V Low
Very High	Major	Major	Substantial	Moderate	Slight
High	Major	Substantial	Moderate	Slight	Slight
Medium	Substantial	Moderate	Moderate	Slight	Negligible
Low	Moderate	Slight	Slight	Negligible	Insignificant
Very Low	Slight	Slight	Negligible	Insignificant	Insignificant
Not Applicable	Not Applic	Not Applic	Not Applic	Not Applic	Not Applic
Positive Impact					

Note: a blue colour has been assigned in the Impact register (see below) to denote an expected beneficial physical or biological impact

8.2.2 Impact Register

Table 8.4 shows the impact register developed using the approach described above to derive impact significance for each of the five main receptor fields (Air, Water, Land, Fauna, Flora and People) for each of the categories of project activity and source of impact.

The register divides project elements according to the categories shown in Table 5.2. These are shown in the columns headed **Site** and **Activity/Issue**. The sources of impact associated with these activities are listed in the column headed **Main Sources of Impact** while the expected or anticipated key impacts for each of the six receptors are summarised in the column headed **Key Impact Type**. These last two columns have been used in the assessments of impact magnitude, receptor sensitivity and impact significance shown in the following columns using the colour coding shown in Table 8.3. It will be noted that construction effects and operational effects have been differentiated, and the project element of *Mine Closure* has been added in order to allow for short term construction, medium term operational and long term post-operational effects.

Given that both positive and negative outcomes can, in some cases, be anticipated from the same activity, the Impact Register indicates this in blue for physical and biological effects while Table 8.5 shows separately the anticipated beneficial socio-economic effects (these cannot be shown simultaneously on the Impact Register. The likely significance of beneficial effects is assessed as either: Low, Moderate or High.

In the remaining columns of the Impact Register, outline mitigation measures are proposed and existing Company offset measures are described. The impact significance is reassessed based on the assumption that the recommended mitigation measures are fully and properly implemented. A reduction in impact significance is so-achieved through a reduction in impact magnitude. Receptor sensitivity remains unchanged by impact mitigation, i.e. only a reduction in impact magnitude through mitigation can affect impact significance. The offset measures are not taken into consideration in the revised levels of impact significance as these relate to compensatory measures to be undertaken outside of the immediate impact location or area. For example, the loss Moist Evergreen Forest from the higher altitudes of Gangra and Yuelliton cannot be replaced by the strengthening of managed forests and protection zones at lower altitudes elsewhere, no matter how important these offsetting measures happen to be.

Cumulative impacts are not specifically covered in this register, as it would become too complex and unwieldy to do so. Cumulative effects are discussed separately in Section 10 and are summarised in Table 8.5 in relation to socio-economic considerations. As far as this impact assessment is concerned, there will be significant overlap in the physical and socio-economic environment between Phase 1 DSO effects, largely unmitigated, and potential effects from Phase 2. Some of these unmitigated effects are described in Vol 3, Part 1.4 in terms of drainage and sediment control and Vol 5, Part 2 in terms of socio-economic effects. The degree to which Phase 2 impacts, as well as those remaining from Phase 1, can be reduced to the residual levels shown in Table 8.4 by timely and effective mitigation will need to be monitored and reviewed, and it is recommended that a pre-Phase 2 audit be undertaken by the EPA to establish the extent to which Phase 1 mitigation has been implemented prior to granting an environmental clearance certificate for Phase 2.

TABLE 8.5: SUMMARY OF ANTICIPATED POSITIVE SOCIO-ECONOMIC IMPACTS

Project component	Positive impacts	Anticipated Significance
All project areas	Increased economic opportunities through direct & indirect employment. This in turn should contribute to a better standard of living & increased wealth, assisting families to afford education & medical treatment.	
	Economic contributions to the local, regional & national tax revenue through Personal Income Tax, taxation charges applied to company operations & from commercial enterprises supplying the company operations as well as those trading in the area will collectively provide revenue to the Government of Liberia which could contribute to the development of the country.	
	The Company and the Liberian Ministry of Public Works have signed a US$40mn MoU to jointly construct the Ganta-Yekepa corridor in Nimba County Improved access is likely to help the socio-economic development of the regions as it will increase trading potentials, including cross border, and access to further education and medical facilities. The construction of this road will reduce vehicle operating costs and travel times.	
	Increase in wage earning population in areas of operations should lead to increased spending and therefore create additional opportunities for goods and service providers.	
	Corporate Responsibility Department has undertaken a number of initiatives relative to socio-economic development in area of operations. These include: building of market halls, a school, a youth centre, provision of hand water pumps, all of which are critical infrastructure that contribute to people's welfare.	
	Social Development Fund is anticipated to contribute to the socio-economic development of affected counties. Also the processing of allocated funds through the Government should support the governance of Liberia emerging from a post-conflict environment.	
	Provision of education to employee's dependents will improve literacy levels & educational attainment. Also general increased affluence surrounding the mining activities may mean people are better able to afford schooling. Collectively this will improve levels of education and potentially that of girls.	
	Training of work force and establishment of vocational training centres will assist building the human capital of Liberia.	
	The Company's scholarship programme which is developed to help young Liberian graduates obtain advanced degrees from accredited academic institutions is expected to contribute to building the human capital of Liberia. (http://www.arcelormittal.com/corp/news-and-media/news/2013/feb/01-02-2013)	
	Medical cover provided to employees and their dependents will improve health. This in turn will contribute positively towards infant mortality, life expectancy and general well-being of the population in areas of operations.	
Yekepa Town ship	Refurbishment of township will lead to improved living conditions for company employees providing electricity, running water and sanitation.	
	Street lighting is likely to deter crime.	
	The initiative to sponsor a child trust will help pay for the education and related costs for families who are unable to afford education of their children.	
	Various initiatives including construction and running of the youth club, theatre hall & sponsoring of sports activities will contribute positively towards the social cohesion of Yekepa, thus improving the social capital.	
	Hospital facility is accessible to employees and non employees who are willing to pay for conventional treatment. These health services will contribute to the improvement of the medical health of the communities which in turn will contribute positively towards infant mortality, life expectancy and general well-being of those elements of the population who can afford to pay.	
	Public health /malaria interventions will reduce the number of cases of malaria.	

TABLE 8.5: SUMMARY OF ANTICIPATED POSITIVE SOCIO-ECONOMIC IMPACTS

Project component	Positive impacts	Anticipated Significance
	HIV/AIDS clinic will provide necessary treatment and assist in improving perception of those living with HIV.	
	Dedicated and secure waste disposal site will improve quality of living & health of residents.	
Railway	Increased economic opportunities through employment (upkeep of the track).	
Greenhill Quarry	Increased economic opportunities through direct and indirect employment.	
	Yorpea clinic provides free medical facilities which will contribute to the improved health status of neighbouring villages.	
Port	Refurbishment of township will lead to improved living conditions for company employees providing electricity, running water and sanitation.	
	Street lighting will likely deter crime.	
	Public health /malaria interventions will reduce the number of cases of malaria.	
	HIV/AIDS clinic will provide necessary treatment and assist in improving perception of those living with HIV.	
Buchanan City	Hospital facility is accessible to employees and non-employees who are willing to pay for conventional treatment. These health services will contribute to the improvement of the medical health of community which in turn will contribute positively towards infant mortality, life expectancy and general well-being of those elements of the population who can afford to pay.	
	General increased affluence surrounding the port activities may mean people are better able to afford schooling. Collectively this could improve levels of education and potentially that of girls.	

NB

High Moderate Low

Table 8.4: Environmental and Social Impact Register

Page numbering of this Table is independent of the main text.

Table 8.4: Environmental & Social Impact Register

No	Site	Activity / Issue	Main Sources of Impact (positive and negative)	Key Impact Type	Impact Magnitude						Receptor Sensitivity						Impact Significance Without Mitigation (combines Magnitude with Sensitivity)						Prevention, Control and Mitigation Strategy	Post-Mitigation Impact Magnitude						Significance of Residual Impact						Offsets
					Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	
1	Road (and rail) Transportation Between Project Sites	**1.1** Transport of fuel and other hazardous materials from Buchanan storage to all other project facilities	**1.1.1** Spillages could arise from traffic accidents, theft, vandalism, terrorist activity or the use of inappropriate means of transportation	**Air**: Chemical evaporation; **Water**: surface and possibly groundwater become polluted with hydrocarbons and other hazardous materials; **Land**: soil becomes contaminated; **Fauna** and **Flora**: damage to vegetation, damage & threat to habitats and fatalities will occur; **People**: water sources (including for drinking) become contaminated, agricultural land becomes sterilised. There is also a danger from fire or explosion.																			ArcelorMittal to ● implement strict codes of practice in relation to the safe, controlled and protected transport of fuel between project sites, including the establishment of an Emergency Response Plan to respond effectively to any spillages that do occur and the provision of emergency response teams and equipment to deal with fire and contamination hazards. ● transport all fuel and hazardous materials by rail, wherever possible													None
		1.2 Use of public roads by ArcelorMittal vehicles	**1.2.1** Increased numbers of vehicles on public roads	**Air**: vehicle exhaust pollution and increased dust; **Water**: surface water becomes polluted by runoff from roads that contains leaked hydrocarbons and dust; **Land**: soil becomes contaminated by any hydrocarbon runoff; **Fauna** and **Flora**: roadside habitats may become contaminated by any leaked hydrocarbon and dust, roadside faunal populations may be affected by noise & vibration. Potential increase in the number of road kills. Movement of vehicles, equipment, materials and food supplies into and between sites may potentially introduce invasive, non-native and pest species which may harm local species, ecosystems and crops; **People**: increased traffic accidents for road users and pedestrians, noise and vibration impacts on households that are located in close proximity to roads.																			Liaise with the Ministry of Public Works to contribute to inventories and condition surveys of all public roads, bridges and culverts to be used by the project vehicles, and contribute to their rehabilitation and maintenance, as necessary. ArcelorMittal to: ● ensure project vehicles are well maintained ● carry out community safety awareness campaigns ● implement driving safety awareness policies and ongoing campaigns to ensure safe driving ● continue operating radar gun speed traps ● maintain close liaison with Liberian National Police traffic control units.													None
2	Mine	**2.1** Construction and operation of access roads within the mine sites and between related infrastructure	**2.1.1** Permanent landtake for access and haulage	**Air**: none; **Water**: Roads will act as a barrier to surface runoff and significantly disrupt drainage pattern; **Land**: Land use will change within RoW and soil will be disturbed and spoil will need to be dispoed of; **Fauna** and **Flora**: Forest areas will be removed, some aquatic habitats will be removed, roads will act as a barrier to faunal movements; **People**: agricultural land will be removed and sources of (Non-Timber Forest Products) NTFPs will be reduced. These activities currently provide sources of livelihood particularly relevant to women.																			ArcelorMittal to: ● implement measures to control dust, such as regular watering of excavations and stockpiles. ● provide workforce with necessary protection against dust inhalation ● use modern and well-maintained plant to avoid oil leakages and reduce air pollution ● minimise road construction to serve purpose; ● carry out road construction in such a way as to minimise loss of soil and transport of sediment into streams (incl. minor streams) by following good engineering practice (using rip rap, sediment traps, etc.) ● maximise the use of excavated material in access road construction ● ensure that road designs include hydrological assessment and building of effective road drainage and culverts ● ensure that drained water will be controlled and watercourses/wetlands protected from sedimentation and pollution. Ensure adequate erosion protection to cut slopes and fill slopes, including the control of water and scour protection beneath culverts ● include provision for return of all non-public roads to a natural condition during mine closure ● minimise vehicle movements in relation to traffic safety, avoid using public roads to the maximum extent possib ● provide security and restrict access around active road construction working areas ● update and expand its current transport rules and regulations into a comprehensive Traffic Management Plan ● implement driving safety awareness policies. ● develop & implement land acquisition & compensation prior to land take for access roads, ensuring appropriate ● implement public awareness campaigns for the conservation of certain types of fauna that would otherwise be ● prevent public access to mine access roads and establish a sustainable conservation strategy designed to pro													None
			2.1.2 Run off from roads including water, sediment and leaked hydrocarbons	**Air**: None; **Land**: Erosion from exposed surfaces, ie cut slopes and fill slopes and beneath culverts and turnouts. Potential soil contamination through oil/diesel spillages etc; **Water**: Spillages of oil, fuel and other hazardous/toxic substances into water courses; **Fauna** and **Flora:** Pollution to downstream habitats; **People**: Water sources may become affected. Agricultural plots adjacent to roads may become polluted																																
			2.1.3 Vibrations and noise from traffic	**Air**: Effect of air pollution through noise; **Water**: None; **Land**: None; **Fauna**: Fauna will be affected by noise and vibration; **Flora**: None; **People**: There will be a local increase in noise levels as a result of the construction and operation of new roads.																																
			2.1.4 Potential for road accidents	**Air**: None; **Land**: None; **Water**: None; **Fauna**: Slight increase in road kills; **Flora**: None; **People**: Potential for fatalities and injuries to drivers and others.																																
			2.1.5 Dust generation and air pollution	**Air**: Dust will be significant during construction and moderate during operation of unsealed roads, gaseous pollution will result from vehicle exhausts; **Land**: None; **Water**: Dust will be washed into water-courses, both naturally and from dust-suppression measures; **Fauna** and **Flora**: Dust will pollute roadside habitats; **People**: Mine access roads are generally away from human habitation and so the main hazard is to road construction and maintenance crews.																																
			2.1.6 Increased local access	**Air**: None; **Water**: None; **Fauna** and **Flora**: Although access will be prohibited, there may be increased opportunities for hunters to illegally access parts of the forest hitherto remote for bushmeat hunting. The Company reports no increased slash and burn in the Phase 1 areas so far; **People**: Mine access roads will be off limits to local drivers.																																

No	Site	Activity / Issue	Main Sources of Impact (positive and negative)	Key Impact Type	Impact Magnitude	Receptor Sensitivity	Impact Significance Without Mitigation (combines Magnitude with Sensitivity)	Prevention, Control and Mitigation Strategy	Post-Mitigation Impact Magnitude	Significance of Residual Impact	Offsets
					Air / Water / Land / Fauna / Flora / People	Air / Water / Land / Fauna / Flora / People	Air / Water / Land / Fauna / Flora / People	Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate	Air / Water / Land / Fauna / Flora / People	Air / Water / Land / Fauna / Flora / People	
2	Mine	**2.2** Mine Start-up and Operation	**2.2.1** Establishing an exclusion zone	**Air**: None; **Water**: None; **Land**: See '**People**'; **Fauna** and **Flora**: The exclusion zone may act to reduce hunting for bushmeat and slash and burn agricultural practices within it; **People**: Further agricultural landtake, and sources of NTFPs reduced. Break up of traditional affiliation with the land and water bodies, loss of access to agricultural land, loss of access to forest for hunting and NTFP as well as loss of access to sites of cultural and religious significance. Increased pressure on other areas for agriculture, hunting and forest products, and also possible migration of farmers and their dependents to Yekepa and other urban areas in search of income. Creation of the exclusion zone will prevent access to sites of artisanal diamond mining and prospecting for corundum within it. These activities currently provide sources of income generation particularly relevant to women.				ArcelorMittal to: • Develop & implement a Resettlement Action Plan (RAP), incl. land acquisition & compensation to be implemented prior to land take, ensure appropriate disclosure of information and consultation & the informed and meaningful participation of those affected in compliance with IFC Standards • establish a Livelihood Restoration Plan and Assistance to Vulnerable Project Affected Persons (PAPs) Plan. Programmes for PAPs includingwomen, female-headed households, elderly and disabled should include training in income generation activities, vocation, small and medium term enterprise/cottage industries, and literacy improvements, provide access to micro finance options through collaboration with Local NGOs/international NGOs. PAPs should be considered on a case by case basis to offset potential disadvantages • Instigate implementation of Agricultural Intensification Programme including agroforestry and conservation agriculture. • establish a procedure to give priority employment to people directly affected by landtake • work with Community Forestry Management Bodies to identify suitable areas where medicinal plants can be re • provide access to alternative fuel sources to compensate for lost access to fire wood • conduct a comprehensive food security assessment after resettlement and compensation has been paid to es • provide vocational training and apprenticeship programmes that can assist affected people to acquire skills to • provide small and medium term enterprise/cottage industries training, vocational training to assist affected hou			Implementation of Community Development Programme encompassing exoanded agricultural intensification programme and support to small and medium enterprises to offset agricultural landtake and loss or disruption of livelihoods, and reduce opening of further land to slash and burn agriculture; offering communities improved food security. Establish an appropriate alternative rural livelihood / handicraft initiative targeted specifically for women within the community development programme.
			2.2.2 Construction of Eastern Sedimentation Ponds and the Tailings Management Facility (including Year 0 and 1 borrow pits).	**Air**: Clearing of vegetation (with effects on oxygen/carbon balance), removal of topsoil and earthworks will result in dust generation. Construction plant will result in gaseous emissions. **Water**: Construction will create significant change to drainage pattern (including reduction in springs and swamp/wet areas), may potentially result in significant erosion and sedimentation once vegetation is removed, polluting downstream watercourses; there will be potential for any construction materials and fuel or oil spills to become washed into water courses; **Land**: Erosion of soil as a result of vegetation clearance and drainage disturbance. Significant change to landform. **Fauna** and **Flora**: Habitats will be removed and / or disturbed including one Level 1 environmental constraints area will be significantly removed, various Level 2 and 3 areas will be removed. Downstream aquatic habitats will be affected by reduced water supply and pollution. Construction noise will have a temporary impact on local fauna. Endangered bats currently residing in previous exploration adits will have habitats removed. **People**: Do				ArcelorMittal to: In addition to the relevant measures identified for Activity 2.2.1 • conduct ground investigation sufficient to understand and define ground conditions. Develop robust design, including worst credible water and seismic condition • top soil should be removed and stockpiled for planting of sedimentation pond bunding and borrow area reinstatement • utilise constraints map to carefully review footprints of the TMF site and phasing of development to minimise physical impacts on land, forest resources, wildlife habitats and surface water • strictly no extraction of construction materials from rivers and other sensitive areas (see constraints map). Preferably use coarse sands produced at the crusher site, though NB the drainage management system shhould be in place and operational before any Phase 2 mining can commence • final TMF design will be made once tailings samples have been analysed • ensure that effects of earthworks will be confined to one catchment, where possible • control erosion to protect slopes / watercourses, regulate water discharge and run off • conduct routine monitoring of downstream water quality • design method of working to enable phased forest clearance and replanting, so that at any one time, the exten • maximum reuse of excavated materials and safe disposal of any construction spoil in previously designated ar • make provision for the control of dust and noise • maintain forest between TMF/Eastern Sedimentation Pond and visual receptors for screening purposes • find suitable alternative roosting areas for affected bats and use suitable techniques for their translocation.			Building on Phase 1 Biodiversity Offset Programme develop and implement a Phase 2 Biodiversity Offset Programme to facilitate the conservation efforts within the areas of high biodiversity and valued habitat, following international best practice (BBOP standard) and considering some combination of: forest restoration within ENNR and support for forest protection in ENNR and West Nimba CF. Forest protection elsewhere in Liberia is a possibility, but would require an additional assessment of the quality of the forest in a proposed location. Potential impacts to downstream aquatic habitats will require to be offset through the protection of other similar habitats in East and West Nimba. Instigate implementation of a Community Development Programme encompassing an expanded agricultural intensification programme and support to small and medium enterprises to offset agricultural landtake and loss or disruption of livelihoods, and reduce opening of further land to slash and burn agriculture; offering communities improved food security. Artisanal fisheries will have to be replaced to ensure that rele
			2.2.3 Construction of Concentrator and crushing plant.	**Air**: Clearing of vegetation, removal of topsoil and earthworks will generate dust. **Water**: There will be potential for any construction materials and fuel or oil spills to become washed into water courses; **Land**: the concentrator, crushing plant and related facilities are to be located on previously disturbed ground; **Fauna** and **Flora**: fauna may be locally affected by noise and vibration, habitats will be removed and / or disturbed and become contaminated by any spills; **People**: Potential for accidents in the workplace and noise and vibration hazards to construction workers.				ArcelorMittal to: • ensure all provisions for waste and runoff management are in place, including fuel and oil storage facilities with adequate containment controls in the event of spillages • make provision for the control of dust and noise • maximise reuse of excavated materials and safe disposal of any construction spoil in previously designated areas, preferably in areas to be filled • apply industry standards to health and safety in the workplace.			None
			2.2.4 Borrow pits for the Concentrator platform	**Air**: dust from borrow pit operation. **Water**: borrow pits will further disturb drainage patterns and contribute sediment and any fuel/oil spillages to watercourses downstream; **Land**: Land will be disturbed by borrow pits and soil potentially contaminated; **Fauna** and **Flora**: Habitats may be removed and /or disturbed and polluted by uncontrolled runoff from borrow pits; noise will have a local effect on fauna; **People**: Agricultural and forest lands used for community purposes will be removed and any pollution to runoff will affect water sources downstream.				ArcelorMittal to: • carefully locate borrow areas to minimise land take of high bio-diversity and agricultural use • implement erosion and runoff control from borrow areas • maximise the use of borrow from land to be developed for other mining purposes, eg TMF and Eastern Sedimentation Pond • implement borrow area restoration when complete • provide alternative livelihood for local farmers as offset • implement dust and noise control.			Instigate implementation of a Community Development Programme encompassing an agricultural intensification programme and support to small and medium enterprises to offset agricultural landtake and loss or disruption of livelihoods, and reduce opening of further land to slash and burn agriculture; offering communities improved food security. Artisanal fisheries will have to be replaced to ensure that relevant PAPs are not deprived of sources of protein. Establish an appropriate alternative rural livelihood / handicraft initiative within the community

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					Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	
			2.2.5 Construction of Tokadeh workshop, truck shop and admin building	**Air**: Clearing of vegetation, removal of topsoil and earthworks will generate dust; **Water**: There will be potential for any construction materials and fuel or oil spills to become washed into water courses; **Land**: the workshop, truck shop and related facilities are to be located on previously disturbed ground; **Fauna** and **Flora**: fauna may be locally affected by noise and vibration and habitats may become contaminated by any spills; **People**: Potential for accidents in the workplace and noise and vibration hazards to construction workers.																			ArcelorMittal to: • ensure all provisions are in place to contain any spillages of potentially toxic and polluting materials during construction • maximise reuse of excavated materials and safe disposal of any construction spoil in previously designated areas, preferably in areas to be filled.													
		2.3 Mine Operation - Tokadeh, Gangra, Yuelliton	**2.3.1** Mine clearing and ore extraction.	**Air**: Clearing of vegetation (with effects on oxygen/carbon balance), removal of topsoil and earthworks will generate dust. **Water**: Catchment areas removed or significantly disturbed. Significant changes to drainage patterns. Potential for increased runoff rates leading to increased flooding. Potentially high sediment loads in stream channels draining from the mine area. Potential pollution from spills of oil and chemicals reducing downstream water quality. There is insufficient knowledge of the groundwater table to define how it will interface with the mining, though indications are that dewatering will be required. The potential exists to pollute groundwater from mine spillages and runoff; dewatering may lead to lowering grounwater table locally. **Land**: Loss of ridge top (see below) and valley side, potential for soil erosion. Slope excavation may cause slope failures, including increased size and frequency of natural slope failures, with resultant downstream/downslope effects. Mine operation has a medium to high visual impact from Yekepa and Dayea R farmland. **Fauna** and **Flora**: Removal of vegetation, inclu																			ArcelorMittal to: • ensure that western slopes of Gangra and Yuelliton ridge and western and southern slopes of Tokadeh are unaffected by mining or any related infrastructure; • ensure pit design to international standards and carry out geological investigations sufficient to be able to model underlying structural geology. Implement drainage and erosion control works so that erosion and sediment are minimised prior to entering the sediment control ponds at Tokadeh, Gangra and Yuelliton. Ensure that all mine and related runoff is contained from Gangra and Yuelliton mine areas, preventing it from entering the drainage system below or Level 1 and 2 environmental constraints areas; • investigate and monitor groundwater regime, including the implications of any required dewatering for groundwater supply and groundwater quality. • remove and stockpile topsoil for later reuse during restoration and/or offsetting. • develop a site-specific EMP for the development and management of the mine, incuding all drainage, runoff, se • ensure site safety and work-place operations meet international standards and implement all industry standard • develop & implement RAP, incl. land acquisition & compensation to be implemented prior to land take, ensure a • establish a Livelihood Restoration Plan and Assistance to Vulnerable PAPs Plan. Programmes for PAPs includ • Instigate implementation of Agricultural Intensification Programme including agroforestry and conservation agri • establish a procedure to give priority employment to people directly affected by land take • work with Community Forestry Management bodies to identify suitable areas where medicinal plants can be re • provide access to alternative fuel sources to compensate for lost access to fire wood • conduct a comprehensive food security assessment • provide apprenticeship programmes that can assist affected people to acquire skills to enhance their employab • provide small and medium term enterprise/cottage industry training, vocational training to assist affected house													Building on Phase 1 Biodiversity Offset Programme develop and implement a Phase 2 Biodiversity Offset Programme to facilitate the conservation efforts within the areas of high biodiversity and valued habitat, following international best practice (BBOP standard) and considering some combination of: forest restoration within ENNR and support for forest protection in ENNR and West Nimba CF. Forest protection elsewhere in Liberia is a possibility, but would require an additional assessment of the quality of the forest in a proposed location. Potential impacts to downstream aquatic habitats will require to be offset through the protection of other similar habitats in East and West Nimba. Instigate implementation of a Community Development Programme encompassing an agricultural intensification programme and support to small and medium enterprises to offset agricultural landtake and loss or disruption of livelihoods, and reduce opening of further land to slash and burn agriculture; offering communities improved food security. Artisanal fisheries will have to be replaced to ensure that rele
				People: Agricultural land will be removed and sources of NTFPs will be reduced. Break up of traditional affiliation with the land and water bodies, loss of agricultural land, loss of forest and loss of access to forest for hunting and NTFP. Increased pressure on other areas for agriculture, hunting and forest products, and also possible migration of farmers and their dependents to Yekepa and other urban areas in search of income. These activities currently provide sources of income generation particularly relevant to women. Pollution to surface water and groundwater will affect downstream water sources. Damage to fisheries may deprive communities of food and protein. Agricultural land will become inundated by iron rich sediment. Noise and night lighting will have some extrusive effects, especially at Zolowee. Potential for work-place accidents.																			• maximise reuse of excavated materials and safe disposal of any construction spoil in previously designated areas, preferably in areas to be filled. • make provision for the control of dust and noise.													Offset loss of habitats including higher altitude ridgeline habitats through the protection and restoration of similar habitats in East and West Nimba. Establish an appropriate alternative rural livelihood / handicraft initiative targeted specifically for women within the community development programme.
			2.3.2 Creation of spoil dumps and stockpiles.	**Air**: Clearing of vegetation, removal of topsoil and earthworks will generate dust. Dust will be blown from unprotected waste dumps and stockpiles. **Water**: Runoff from and failure of dumps could pollute and erode water courses; **Land**: Significant change to existing topography. Failure of waste dumps could occur if not designed and constructed properly; **Fauna** and **Flora**: Although the mines sites are focussed away from Level 1 environmental constraints, nevertheless there may be some loss of these areas. Level 2 streams and other Level 2 and Level 3 areas are affected. Failure of dumps and runoff from them could lead to further damage and/ or disturbance of habitats downstream, including habitats of rare and endangered aquatic species. **People**: Waste dumps and stockpiles remove large areas of land previously used by local population. Impact on downstream fisheries could deprive communities of traditional sources of food and protein. These activities currently provide sources of income generation particularly relevant to women A sacred rock is located within the footprint of the proposed Tokadeh w																			ArcelorMittal to: • locate these facilities away from environmental constraints areas to greatest extent possible. • design facilities to be stable and provide runoff and erosion control. • develop emergency response plans with local populations in the event of a failure. • notes above regarding provision of alternative livelihoods apply. • remove and stockpile topsoil for later reuse during restoration. • make provision for the control of dust and noise. • maintain forest between waste dumps and visual receptors for screening.													

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					Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	**Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate**	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	
2	Mine		**2.3.3** Reduction in ridge line by up to 70m	Air: None (covered under mine clearance and excavation); **Water**: Possible influences on local climate, however predictions have proven inconclusive. Reduction of ridgeline removes catchment area, slows down natural runoff rates. **Land**: Natural landform is significantly removed/disturbed; **Fauna** and **Flora**: Some habitats on the Tokadeh / Gangra-Yuelliton are unique in terms of their vegetation composition. These will be lost. **People:** High visual impact, including removal of views of ridgeline forest.																			ArcelorMittal to: • reform smooth topography along lowered ridge line as part of Mine Closure and re-establish forest vegetation as quickly as possible to the greatest extent possible • ensure that western slopes of the Tokadeh/Gangra/Yuelliton ridge are unaffected by excavation or spoil or mine runoff. A key element to be considered is the optimisation of the final contours in order to possibly reproduce the current landform and to enable the finished landform to appear integral with the remaining adjacent landscape.													
			2.3.4 Operation of the Eastern Sedimentation Pond	**Air**: None; **Water**: Eastern Sedimentation Pond acts as a barrier to downstream flow of water and may reduce groundwater supplies. Overtops during flood events into the headwaters of the Dayea River with potential to contribute high sediment loads during such events. Acts as a stilling basin to control runoff from the Tokadeh mine and acts as a settling pond for eroded and transported sediments. Basal seepage has potential to leak into underlying fractured gneiss aquifer, thereby affecting groundwater quality and potentially causing further impact on associated surface streams and wetlands; **Land**: None; **Fauna** and **Flora**: Starves streams and other aquatic habitats immediately downstream of water. **People**: Potential for workplace accidents. Potential for water source contamination through seepage from the pond, if mine runoff contains toxic materials.																			ArcelorMittal to: • ensure ESP is adequately dredged to reduce likelihood of overspill into Madayea R. Manage discharges to ensure that they comply with the World Bank standards. • develop a Water Mangement Plan including a robust assessment of the flow regime in the Dayea and 'critical flow rates' to be permanently maintained to ensure sustainable resource utilization (fish, crustaceans and other wildlife; resource use; water supply for downstream users), thereby considering potential effects of climate change over a 20y period - however, the current proposal is for the ESP to be self sustaining, thus requiring no abstraction from the Dayea River • develop a site-specific EMP to include all areas directly and indirectly affected by the operation of the ESP and all related facilities • install and maintain required monitoring systems; use an impermeable/low permeability liner to prevent/reduce basal infiltration into the subgrade. • develop and implement site-specific EMPs which would have to include a comprehensive closure plan to cover the post-operational long-term management of the site • ensure site safety and work-place operations meet international standards • a constant minimum dry season compensation flow of 0.25 m3/s will be provided from the North Pond to ensur													None
			2.3.5 Operation of the Tailings Management Facility - 150 million tonnes (60m^3) of material to be stored, with ultimate tailing deposit dimension of 2.5km x 1km.	**Air**: None; **Water**: TMF acts as a barrier to downstream flow of water. Basal seepage has potential for iron-rich water to leak into underlying fractured gneiss aquifer, water courses downstream become choked with sediment and eroded if debris flow occurs due to TMF failure; **Land**: Potential debris flow in the event of TMF failure would affect land downstreaam; **Fauna** and **Flora**: starves streams and other aquatic habitats immediately downstream of water, habitats become choked with sediment from debris flow if TMF fails; **People**: Potential debris flow runout should TMF fail - could lead to fatalities and loss of livelihood. Potential for work-place accidents.																			ArcelorMittal to: • ensure TMF is designed and operated in such a way as to reduce the likelihood of failure. • carry out the required ground investigations to confirm analytical model. • establish and operate an exclusion zone around the area of potential runout (note that if this exclusion zone is effectively in place then the sensitivity of the relevant downstream population to debris flow runout reduces from Very High to Moderate (loss of land/loss of livelihood) and the overall Impact Significance reduces accordingly). • develop a site-specific EMP to include all areas directly and indirectly affected by the operation of the TMF and all related facilities; • install and maintain required monitoring systems; use an impermeable/low permeability liner to prevent/reduce basal infiltration into the subgrade. • develop and implement site-specific EMPs which would have to include a comprehensive closure plan to cover the post-operational long-term management of the site. • ensure site safety and work-place operations meet international standards and establish emergency response plan in respect of potential TMF failure													
			2.3.6 Operation of Concentrator and crushing plant, including power generation plant	**Air**: Zolowee is the nearest settlement potentially affected by stack emissions. Gaseous emission (NOx,SOx,CO2,CO) from power plant and dust from crushing plant will present local air quality effects. CO2 emissions will contribute to global climate change. **Water**: Potential pollution by fuel/oil spillages. Dust suppression washout; **Land**: Potential for soil contamination from any spillages; **Fauna** and **Flora**: Dust from crushing plant will impact local vegetation and wildlife. Noise may impact local faunal populations; potential contamination to habitats from fuel/oil spillages; **People**: Stack emissions and human health covered under Air Quality receptor. Predicted noise levels from operation of the concentrator and power plant are significant only at Zolowee. Potential water source contamination from any spillages. Potential for work-place accidents.																			ArcelorMittal to: • Use max 2% sulphur content to fuel. • Stormwater runoff control and spillage containment facilities. • Use industry standards for the operation of the power plant facility including the control of gaseous emissions. • Use industry best practice methods to reduce noise levels at source. • establish a site-specific EMP • maintain and operate equipment in accordance with manufacturer's specificatoins. • provide workforce with appropriate PPE and training. • ensure site safety and work-place operations meet international standards. • retention and treatment pond(s) to be provided with downstream oil/sediment separator to treat stormwater runoff; • apply dust suppression measures to the greatest extent													None
			2.3.7 Operation of Tokadeh work shop / truck shop & admin. building	**Air**: None; **Water**, **Land**, **Fauna** and **Flora** and **People**: Potential for accidental spillages/leakages of toxic/hazardous materials. Potential for workplace accidents																			ArcelorMittal to: • design and operate sites in line with relevant corporate standards; • provide workforce with appropriate PPE and training.													None
			2.3.8 Permanent removal of or prevented access to cultural sites	**Air**, **Water**, **Land**, **Fauna** and **Flora**: None; **People**: There will be potential loss of cultural heritage sites (for example sacred stone beneath Tokadeh waste dump) and loss of access to other areas of cultural significance.																			ArcelorMittal to: • minimise disturbance to these sites wherever possible. • carry out community-managed relocation of important cultural and religious sites. • provide managed access to remaining sites, subject to health and safety													None
			2.3.9 Refuelling , storage and handling of oils, lubricants and other toxic, hazardous and flammable materials	**Air**: Odour; **Water**: Potential for spillages into water courses; **Land**: Potential for spillages into soil; **Fauna** and **Flora**: Potential contamination to habitats; **People**: Potential contamination of drinking water and other possible land use impacts. Danger from explosions and fire.																			ArcelorMittal to: • ensure that industry standards are followed in the handling of hazardous and toxic materials. • ensure adequate containment facilities around fuel/oil storage/handling areas and that adequate anti-theft measures are in place													None

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			2.3.10 Blasting	**Air**: Source of dust; **Water**: None; **Land**: None, though there may be slope stability effects from over-blasting; **Fauna** and **Flora**: Noise impact on fauna; **People**: Possible risk from flyrock, also danger if explosives are stolen. There is also the small possibility of UXO from the civil war.				ArcelorMittal to: • ensure use in accordance with manufacturer's specification and in accordance with international safety procedures regarding the handling, storage and use of explosives and blast design. Follow Government of Liberia and UNMIL regulations for explosives.			None
			2.3.11 Changes to groundwater regime and surface water bodies brought about by excavation, drainage diversion, dewatering and abstraction for mine use	**Air**: None; **Water**: Groundwater is considered to be relatively deep in the mine area, though there is no specific information available and consequently GW impacts are considered likely to be moderate. Raised nitrate levels from explosive residues are possible. Final pit profiles indicate lakes are likely to form. **Fauna** and **Flora**: Existing surface water bodies, including the Gbapa Swamp may become drained. **People**: Potable groundwater may be affected - this may already be affected by legacy issues, DSO effects and the age and inadequacy of existing water supply boreholes				Further information is required on the groundwater regime before this aspect can be fully assessed. The Gbapa Swamp and other water bodies of high biodiversity require protection from draw-down. Control of toxic and hazardous materials must prevent pollutants from entering groundwater. Groundwater monitoring is required both at the mine site and downstream close to potable users so that impacts can be assessed and resources evaluated. Provide additional deep boreholes/wells and provide maintenance and spare parts for existing wells.			None
			2.3.12 Influx of people, especially men, in search of employment	**Air**: None; **Water**: Increased pressure on water resources and waste water management; **Land**: Increased wastes to be disposed of; **Fauna** and **Flora**: Increased pressure on bushmeat and forest clearance for agriculture; **People**: Increased pressure on all local resources and potential source of social conflict and anti-social behaviour, especially against women.				ArcelorMittal to: • prevent the hunting of bushmeat among its own employees and encourage the public not to hunt bushmeat through conservation awareness campaigns and provision of alterrnative sources of food and protein. • clearly indicate the number and skills required for available positions., e.g. by using national media. This may help to limit the influx of job-seekers to the numbers required • adopt and implement a policy of Zero Tolerance on alcohol, drugs and violence for all employees. • implement awareness programmes for relevant issues (nature conservation, health and hygiene, financial management). • develop skill-based training within the affected community • provide access for hospital services for non-employee community members of affected communities. • continue to operate the incinerator for medical waste. • carry out awareness campaigns to control the spread of STDs. • build on existing AML public relations programme and consider employing a public information officer in each county who will perform public relations to disseminate accurate and timely information regarding the project			None
2	Mine	**2.4** Mine Closure	**2.4.1** Runoff and erosion from disused mine surfaces	**Air**; None; **Water**: Continued pollution through eroded sediments and water quality effects. Also increased runoff causes greater flood potential. **Land**: Continued erosion creates gullies and possibly slope instability. **Fauna** and **Flora**: Water course pollution affects downstream habitats. **People**: High sediment yield reduces potable water quality and floods inundate land use.				Mine Closure Plan requires comprehensive attention to mine slope and fill/spoil slope restoration, including landscaping of slopes, drainage management, revegetation and the implementation of a monitoring and Emergency Management Plan. Post-operational stability assessment for TMF and stabilisation measures where required. Maintenance of exclusion zone in the event of TMF failure. ArcelorMittal to: • develop the Framework Mine Closure Plan into a full Mine Closure Plan according to the ICMM best practice schedule; • establish a financing mechanism for the Mine Closure Plan; • implement the Mine Closure Plan in a timely way.			None
			2.4.2 Failure of waste dumps and TMF	**Air**: Dust emission during failure; **Water**: water courses become blocked with sediment and scoured by debris flow; **Land**: Erosion and sedimentation; **Fauna** and **Flora**: Habitats polluted/choked by sediment; **People**: Potential fatality and loss of land/livelihood.							
			2.4.3 Creation of lakes formed in abandoned workings	**Air**: None; **Water**: None; **Fauna** and **Flora**: None: **People**: Potential safety hazard and possible source of mosquito breeding areas							
3	Yekepa Township	**3.1** Township management	**3.1.1** Population expansion in expectation of employment and other spin-offs. Increased numbers of residents.	**Air**: None; **Water**: Increased demand for groundwater resources; **Land**: Increased demand for additional land; **Fauna**: fauna could be impacted by pollution and also increased hunting. **Flora**: potential for increase in slash and burn in adjacent areas; **People**: influx, physical and economic displacement of current residents; antisocial/unacceptable behaviour from residents.				ArcelorMittal to: • develop Township Masterplan. • implement Township Environmental Management Plan. • maintain short vegetation around buildings and reduce areas of standing water. • generally minimize pesticide applications / use type to minimise effect on non target species • provide adequate resources for increased numbers of residents, including accommodation, water, sanitation, waste disposal and health facilities (see below) • provide housing with power, plumbed potable water and sewerage system for all employees. • provide health care/hospital access for all employees. • adopt and implement a policy of Zero Tolerance on drink, drugs and violence for all employees. • adopt and implement a policy of Zero Tolerance on hunting or acquiring bushmeat for all employees.			None
			3.1.2 Use of herbicide/pesticide	**Air**: None; **Water**: Herbicides and pesticides can become flushed into water courses; **Land**: soils could become contaminated; **Fauna and Flora**: potential to pollute aquatic habitats and can be harmful to wildlife in general; **People**: Potential to pollute drinking water.							None
			3.1.3 Substantially increased volumes of waste to be disposed of set against the background of present inadequate provision for Solid Waste Management	**Air**: Odour; **Water**: Potential for leachates to contaminate surface water and groundwater. **Land**: Potential for soil contamination from landfill leachates. Inadequate potable water increases use of bottled water with increased need for disposal. **Fauna and Flora**: Inadequate collection, storage and disposal is a hazard to fauna. Fauna may also be adversely affected by contaminated water and soil. **People**: Potential pollution to potable water supplies, odours, scavenging and possible injury to scavengers.							None

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4	**Buchanan Estate**	**4.1** Estate management	**4.1.1** Areas of standing water and thick vegetation	**Air**: None; **Water**: None; **Land**: None; **Fauna** and **Flora**: None; **People**: These areas will pose a potential hazard as breeding grounds for mosquitos or refuges for snakes	ArcelorMittal to: • implement Township Environmental Management Plan. • maintain short vegetation around buildings and reduce areas of standing water. • generally minimize pesticide applications / use type to minimise effect on non target species • provide adequte resources for increased numbers of residents, including accommodation, water, sanitation, waste disposal and health facilities (see below) • provide housing with power, plumbed potable water and sewerage system for all employees. • provide health care/hospital access for all employees. • adopt and implement a policy of Zero Tolerance on drink, drugs and violence for all employees. • adopt and implement a policy of Zero Tolerance on hunting or acquiring bushmeat or turtles for all employees.	None
			4.1.2 Use of herbicide/pesticide	**Air**: None; **Water**:Herbicides and pesticides can become flushed into water courses; **Land**: soils could become contaminated; **Fauna** and **Flora**: potential to pollute aquatic habitats and can be harmful to wildlife in general; **People**: Potential to pollute drinking water.		
			4.1.3 Increased numbers of residents. The Contractors camp at Buchanan will house 200 staff.	**Air**: None; **Water**: Increased demand for water and increased potential to pollute water; **Land**: Additional land may be required for housing and waste disposal. **Fauna**: fauna could be impacted by pollution and also increased hunting. **Flora**: None; **People**: Antisocial/unacceptable behaviour from residents.		
4	**Buchanan Estate**	**4.2** Power Generation (small generators will be substituted by a central power plant before the start of Phase 2)	**4.2.1** Increased power generation (ArcelorMittal employees only).	**Air**: Noise, vibration and air pollution from generators ; **Water**: Potential spillages of HFO into water courses. **Land**: Potential spillages/leakes of HFO into soil. **Fauna** and **Flora**: Potential impact on neighbouring aquatic life from HFO spillage or leakage to water courses. Leakages and spills potentially impact local flora. **People**: Access to power improves standard of living for AML employees and street lighting helps fight crime. Noise pollution from power plant to occupants of Loop 1. Potential for air pollution to residents if <2% sulphur content to diesel is not used. Note that the High magnitude assigned relates to generator noise levels for Loop 1	Arcelor Mittal to: • review condition of previous generator sites; clean up as required in accordance with applicable corporate standards. • review design and operation of new power plant to ensure compliance with relevant standards. • ensure that stand-by generators will operate to standard (suitably sited, storage sites for diesel and oil properly built; noise baffles/double housing, personnel trained). Noise barriers to protect Loop 1 residents • maintain and operate power plant and generators to specifications and use low sulphur (<2%) diesel. • regularly monitor emissions to ensure compliance, including contingency measures in the event of failure. • ensure that fire fighting equipment is available and relevant personnel trained. • position lights such as to minimise light pollution. • conduct awareness campaign on power saving. • ensure that diesel storage and handling is secure and that adequate protection and containment is provided against spills. Ensure that spill kits are available at all fuel storage and handling sites.	None
4	**Buchanan Estate**	**4.3** Waste Water	**4.3.1** Operation of new system - in place as of March 2013 for Phase 1 requirements (ArcelorMittal employees only). Requirements and provisions for Phase 2 are not known.	**Air**: None; **Water**: New waste water treatment system for Phase 1 will be installed according to AML in March 2013. Pipework already in place. Malfunction or inadequate design capacity could potentially pollute water courses/groundwater. Potential for March 2013 system to be inadequate for Phase 2 requirements. **Land**: potential contamination from disposal of sludge; **Fauna** and **Flora**: Potential contamination of habitats; **People**: Diseases could become communicated through inadequate waste water management. Also possible odours.	ArcelorMittal to: • implement the Township Environmental Management Plan and ensure new sewerage system is capable of fulfilling Phase 2 requirements. • establish plan of system - network, depths etc. • check all house connections to ensure that all houses are connected to the system. • ensure at all times that the system is fit for purpose; take corrective measures as required. • implement precautionary measures during construction to protect workers from health hazards. • dispose of contaminated waste appropriately in accordance with Township Environmental Management Plan • review proper functioning of the new WWTP prior to the start of Phase 2; take remedial measures as required. • maintain the new WWTP in accordance with manufacturer's specifications. • implement a discharge monitoring programme which includes contingency arrangements in the event of operational failure. • appropriately dispose of sludge in accordance with a waste management strategy contained in the Township Environmental Management Plan. • carry out performance monitoring (effluent quality).	None
4	**Buchanan Estate**	**4.4** Water abstraction	**4.4.1** Substantially increased demand for water, set against the background of present (5 boreholes in use)	**Air**: None; **Water**: Potential to contaminate groundwater if further drilling introduces contaminated water, i.e. allows polluted surface water to pass into underlying aquifers.; **Land**: Potential contamination of soil; **Fauna** and **Flora**: Potential knock on effects from possible groundwater pollution; **People**: Potential to reduce or deplete potable water available in local community wells/BHs. Communities already report reduced water supplies due to population growth in the area.	ArcelorMittal to: • implement the Township Environmental Management Plan and map which identifies pipework and contaminated wells; • investigate groundwater resources in the area to ensure that the project usage does not affect local public water supply by undertaking a comprehensive drilling and testing programme; • 4 additional boreholes exist and may be brought into use as required • 2 UN boreholes may be relied on in an emergency situation; • provide additional deep bore holes/wells and ongoing maintenance and spare parts for wells in affected communities. • carry out detailed hydrogeological studies to establish sustainable offtake. • create a water use and conservation strategy as part of the Township Environmental Management Plan. • carry out systematic and routine groundwater level and quality monitoring, including contingency measures in the event of non-compliance with standards. • provide water treatment if necessary to ensure potable water quality. • explore alternative options for water supply (rain water harvester etc) • promote water use awareness programme and a comprehensive public health familiarisation for the wider com • develop, implement and monitor public health awareness programme .	None

No	Site	Activity / Issue	Main Sources of Impact (positive and negative)	Key Impact Type	Impact Magnitude						Receptor Sensitivity						Impact Significance Without Mitigation (combines Magnitude with Sensitivity)						Prevention, Control and Mitigation Strategy	Post-Mitigation Impact Magnitude						Significance of Residual Impact						Offsets
					Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	
4	**Buchanan Estate**	**4.5** Solid Waste Management	**4.5.1** Substantially increased volumes of waste to be disposed of set against the background of present inadequate provision for Solid Waste Management	**Air**: Odour; **Water**: Potential for leachates to contaminate surface water and groundwater. **Land**: Potential for soil contamination from landfill leachates. Inadequate potable water increases use of bottled water with increased need for transportaion to sites and disposal of bottles. **Fauna** and **Flora**: Inadequate collection, storage and disposal is a hazard to fauna. Fauna may also be adversely affected by contaminated water and soil. **People**: Potential pollution to potable water supplies, odours, scavenging and possible injury to scavengers.																			ArcelorMittal to: • implement the Township Environmental Management Plan including a policy of waste minimisation and recycling. • predict types and quantities fof waste for Project and construct waste stream assessment. • ensure that waste will be segregated into hazardous and non-hazardous waste; all waste types to be disposed of in the appropriate manner for each. • find new or upgrade existing site to a properly managed and fully lined facility capable of managing all predicted inert waste • keep full records of waste transfers, type and quantity to be maintained to ensure that an auditable chain of custody is in place. • implement waste awareness programme. • ensure that staff will wear PPE when handling hazardous waste. • take all necessary measures to have a new, up to standard landfill site operational prior to the beginning of Phase 2. • investigate if any wild dumpsites were created during Phase 1; collect waste and dispose at the new landfill site, clean up abandoned sites as appropriate to avoid environmental pollution, minimize erosion and avoid stagnant water or any other risk to public health. • ensure that medical waste is incinerated in an EPA-approved facility; • prepare documentation of all action taken.													Potential recycling of waste for rural industry and handicrafts
4	**Buchanan Estate**	**4.6** Buchanan Town	**4.6.1** Population expansion in expectation of employment and other spin-offs. Population pressure in Buchanan is already being felt as a result of in-migration and it is expected that Phase 2 will result in signficantly increased numbers. No figures are available.	**Air**: None; **Water**: Increased demand for potable water and possible increase in water pollution due to untreated waste. **Land**: Increased demand for housing and land and increased solid waste to be disposed of. **Fauna and Flora**: Increased incidence of bushmeat and sea turtle hunting. Increased demand for firewood leads to further depletion of forests. **People**: Increased anti-social behaviour, pressure on resources gives rise to deprivation and conflict, overcrowding and disease, potential for increased violence against women.																			ArcelorMittal to: • clearly indicate the number and skills required for available positions., e.g. by using national media. • adopt and implement a policy of Zero Tolerance on drink, drugs and violence for all employees. • implement awareness programmes for relevant issues (nature conservation, health and hygiene, financial management). • develop skill-based training within the affected community • provide access for hospital services for non-employee community members of affected communities. • continue to operate the incinerator for medical waste. • carry out awareness campaigns to control the spread of STDs. • carry out detailed survey and impact assessment of turtles. • build on existing AML public relations programme and consider employing a public information officer in each county who will perform public relations to disseminate accurate and timely information regarding the project													
5	**Railway**	**5.1** Increase in operations: higher numbers of trains .	**5.5.1** Increased number of movements (from 1 train/day in Phase 1 to 3 per day in Phase 2) and longer trains (up to 140 wagons). 15 million tonnes/year of concentrated ore will be transported by rail over the 255km from mine to port.	**Air**: Diesel emissions to the atmosphere. **Water**: Potential of spills to wider environment, most notably the St John's River. Derailments could result in significant pollution. **Land**: Excessive use of herbicides to control trackside vegetation could contaminate soils. Also potential for earthworks failures to pose a risk to rail safety; **Fauna and flora:** Excessive use of herbicides to control trackside vegetation could contaminate habitats. Watercourse/river pollution will affect aquatic fauna. Risk to livestock crossing the line. **People**: Safety hazard to communities along the railway and pedestrians crossing the line. Increased noise, vibration and light pollution. Increased risk of workplace accidents including possible derailment effects. Sanniquellie Hospital operating theatre will experience significant vibration effects. Noise will be experienced at the hospital and Tukpahblee School.																			ArcelorMittal to: • develop and implement rail safety standards / procedures and reform/stabilise at-risk slopes; • impose strict train operating procedures, including speed limits, visual and audible warnings, etc.; • step up the rail and road safety procedures as soon as operations increase; • ensure that rail operations will be in line with applicable noise standards; • ensure that all affected communities are aware of the AML grievance mechanism. • develop an Emergency Response Plan including pollution control in the event of accidents; • train appropriate personnel in accordance with the requirements of the Emergency Response Plan; • maintain rolling stock and rail infrastructure to a high standard; • employ manual vegetation clearance along the railway as far as possible; • use only herbicides that are approved by the EPA, and follow safe operating procedures in their use; • ensure that used oil from the locomotives' operation will be managed in accordance with the relevant corporate standards / in line with international best practice; • provide ongoing railway safety awareness for communities; • use low sulphur (<2%) diesel (to reduce emissions and reduce oil change frequencies) • r													None
5	**Railway**	**5.2** Operation of new siding extensions (already constructed) at Gaye Peter Town, Blezi, Grebo, Bakhon, Yila, Tropoi, Kitoma. Extended lengths are between 500m and 1,000m	**5.2.1** New train operations in these areas, however they will be slow moving and therefore the risk of derailment and pedestrian injury will be lower.	**Air**: Diesel emissions to the atmosphere; **Water**: Potential of spills to wider environment. Derailments could result in significant pollution; **Land**: Excessive use of herbicides to control trackside vegetation could contaminate soils; **Fauna and flora**: Excessive use of herbicides to control trackside vegetation could contaminate habitats. Watercourse/river pollution will affect aquatic fauna. Risk to livestock crossing the line; **People**: Safety hazard to communities along the railway and pedestrians crossing the line. Increased noise, vibration and light pollution. Increased risk of workplace accidents including possible derailment effects.																			ArcelorMittal to: • develop and implement rail safety standards / procedures; • impose strict train operating procedures, including speed limits, visual and audible warnings, etc.; • step up the rail and road safety procedures as soon as operations increase; • ensure that rail operations will be in line with applicable noise standards; • ensure that all affected communities are aware of the AML grievance mechanism. • develop an Emergency Response Plan including pollution control in the event of accidents; • train appropriate personnel in accordance with the requirements of the Emergency Response Plan; • maintain rolling stock and rail infrastructure to a high standard; • employ manual vegetation clearance along the railway as far as possible; • use only herbicides that are approved by the EPA, and follow safe operating procedures in their use; • ensure that used oil from the locomotives' operation will be managed in accordance with the relevant corporate standards / in line with international best practice; • provide ongoing railway safety awareness for communities; • use low sulphur (<2%) diesel (to reduce emissions and reduce oil change frequencies)													None
5	**Railway**	**5.3** Greenhill quarry and semi-permanent railway maintenance camp	**5.3.1** Operational impacts such as erosion and runoff contamination.	**Air**: Minor source of dust from excavation and crushing, minor source of gaseous pollution from machinery; **Water**: Potential release of sediment, spillage of liquid hydrocarbons and chemicals, use of water resources for warer supply and discharge of sewage effluent; **Land**: Potential for soil contamination from spillages of fuel, oil and chemicals; **Fauna** and **Flora**: Potential for habitat contamination from spillages of fuel, oil and chemicals; **People**: Zowienta and Greenhill villages may experience population influx with social issues that this brings.																			ArcelorMittal to: • address all issues through a site specific Environmental Management Plan to adopt appropriate strategies for all phases of quarrying, including successive closure and rehabilitation of mined areas. • ensure that hazardous materials will be handled and stored in line with the relevant corporate environmental standards. • ensure that there is a comprehensive closure plan in place in order to prevent post-operation pollution effects.													None

No	Site	Activity / Issue	Main Sources of Impact (positive and negative)	Key Impact Type	Impact Magnitude						Receptor Sensitivity						Impact Significance Without Mitigation (combines Magnitude with Sensitivity)						Prevention, Control and Mitigation Strategy	Post-Mitigation Impact Magnitude						Significance of Residual Impact						Offsets
					Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	Monitoring, auditing and grievance management should be applied to all potential impact categories, where appropriate	Air	Water	Land	Fauna	Flora	People	Air	Water	Land	Fauna	Flora	People	
6	Port	**6.1** Increased ship traffic and site operations.	**6.6.1** Increased shipment of ore and increased usage of fuel, oil and chemicals. Max. 18 vessels / month. Panamax vessels have a 69,000 tonne capacity. Up to 1.2 million tonnes of concentrate will be stockpiled at the port at any one time and the throughflow of concentrate to ship will be up to 10,000 tonnes per hr. The railcar dumper building will require deep excavation and dewatering.	**Air**: Potential for dust and gaseous emissions; **Water**: Construction of ore storage shed has reduced opportunity for ore-contaminated runoff, however, potential for spillages remains in the handling process, in the harbour (or nearshore, depending upon operational design) resulting in increased turbidity plus potential for oils/fuels/chemicals to spill/leak into water courses, groundwater or harbour. Deep (below water table) excavation for the railcar dumper building could pollute groundwater and proximity to shoreline could result in saline intrusion/ pollution effects; **Land**: Landscape is improved as a result of removal of LAMCO concentrator. Land is potentially polluted by spillages of oil/fuel/chemicals; **Flora** and **Fauna**: Increased turbidity will cause eutrophication and algal blooms, reducing oxygen levels to sedentary marine species, harbour/nearshore water pollution will result in mortalities, bilging and ballast water discharge may introduce invasive species, port lighting will effect turtle nesting and increased human population in general will place pressure on turtles from hunting. Maintenance dredging may adversely affect bottom cond Increased port operations will result in significant noise le																			ArcelorMittal to: • design port with hard standings / suitable drainage to prevent contaminated run off, including appropriately designed / dimensioned sediment traps and oil-water separators. • ensure adequate cover to stockpiles at all times • ensure protection to groundwater during deep excavations • design port lighting to minimise impacts on turtle nesting • regularly monitor discharge water quality. • ensure that ship refuelling and shipping operations will be in line with international best practice and Liberian Maritime Regulations (irrespective of the location of registration of the ship). • ensure that ship operators will be contractually bound to follow national regulations and international conventions and guidelines on dumping, ballast operations, and the prevention of pollution. • use suction dredging rather than bulk dredging techniques • develop and implement health and safety standards and procedures. • build good community relations through a robust and effective community liaison unit. • implement public awareness campaigns concerning turtle nesting conservation and establish a monitoring and rewarded public participation programme • 2 m high noise barrier to NW of port to protect Motown.													"Out of kind" offset, e.g. sea turtle conservation
6	Port	**6.2** Fuel quay and pipeline to oil storage facility.	**6.2.1** Import and storage of oil. Ship supply: Diesel: 5,000 to 8,000 tonne deliveries; HFO: 10,000 to 15,000 tonne deliveries. Frequency: 1 vessel every 3 weeks on average. Storage: Diesel: 10,000 m3 (2 x 5,000 m3 tanks); HFO: 12,000 m3 (2 x 6,000 m3 tanks). The tank farm will be fed from the fuel unloading quay via a proposed 12" insulated pipeline of estimated 1,700 m length. HFO sludge will either be mixed with appropriate construction materials for road building or will be incinerated.	**Air**: Potential pollution from HFO sludge burning; **Water**: spillage/leakage of fuel at quayside, from pipeline or from oil storage facility; **Land**: spillage/leakage of fuel from pipeline or from oil storage facility. Need to excavate land for pipeline and provide land for siting and foundation of oil storage facility; **Fauna and Flora**: Potential contamination of habitats; **People**: Potential for explosions and fire, and other workplace accidents. Potential contamination to groundwater and water supply.																			ArcelorMittal to: • implement a site-specific EMP for the safe handling of oil from quayside to storage facility, have in place an Emergency Response Plan in the event of a spillage, rehearsed fire-fighting and pollution containment procedures and facilities also in place. International standards will need to be followed in the design, construction and maintenance of all oil handling facilities.													None

9 IMPACT ASSESSMENT

This section describes the background to the impact assessment provided in Table 8.4. It summarises the main impact assessments and mitigation recommendations of the studies contained in Volumes 3 to 5. These should be consulted for further details.The discussion is divided primarily according to each of the main receptor categories: Air; Water; Land; Fauna; Flora; People. Within each of these receptor categories, discussion is further divided according to the principal project locations, namely: Public Roads; Mine Sites; Buchanan Estate; Railway and Buchanan Port, as provided in Table 8.4. Although Yekepa Township is included in this breakdown, it is excluded in detail from this ESIA due to there being inadequate information regarding development details.There has been very little change since the ESIA for Phase 1 was carried out and the Township Development Plan is still in preparation. However, the Consultant's Social Impact Assessment Specialist has been able to gauge some of the Phase 2 issues relating to Yekepa, and some of these are described in Section 9.6.

Each section is split into Impact Assessment and Mitigation, and Residual Impact. Levels of Impact Significance are assigned in conjunction with Table 8.4.

9.1 Air

9.1.1 Air Quality

Table 9.1 lists the air quality standards adopted for the ESIA. Air quality is discussed separately under gaseous pollution and dust pollution.

TABLE 9.1: AIR QUALITY STANDARDS ADOPTED FOR THE ESIA

Pollutant	Averaging Period	Standard	Standard Derived From	Sources
Dust deposition	30 days	600 mg/m^2/day (not to be exceeded more than three times per year, no two sequential months)	South African action level for residential areas (SANS 1929, 2004)	Mining operations, roads, agriculture and various non-anthropogenic sources
PM_{10}	24 hours	150 µg/m^3 (99th percentile)	IFC (adopted from WHO Guidelines, Interim Target 1)	Mining operations, vehicle exhausts, railway locomotives, power generation
	Annual mean	70 µg/m^3		
$PM_{2.5}$	24 hours	75 µg/m^3 (99th percentile)		
	Annual mean	35 µg/m^3		
Nitrogen dioxide (NO_2)	1 hour	200 µg/m^3	IFC (adopted from WHO Guidelines)	Vehicle exhausts, railway locomotives, power generation
	Annual mean	40 µg/m^3		
Sulphur dioxide	10 min mean	500 µg/m^3	IFC (adopted from WHO Guidelines)	Railway locomotives, heavy fuel oil-fired power generation
	24 hours	125 µg/m^3	IFC (adopted from WHO Guidelines, Interim Target 1)	
Carbon monoxide	8 hours	10 mg/m^3	IFC (adopted from WHO Guidelines)	Vehicle exhausts, railway locomotives, power generation

PM_{10} and $PM_{2.5}$ are fine particulate matter with aerodynamic diameters of less than 10 and 2.5 micrometres respectively

9.1.1.1 Public Roads

a) Gaseous Pollution

Impacts

Increased emissions of carbon monoxide and nitrogen dioxide will result from increased vehicles (both project-related and private) using public roads, most notably between Monrovia, Buchanan and Yekepa. Impact Significance without mitigation is considered likely to be Insignificant/Negligible.

Mitigation

The use of modern and well maintained engines, with low emission rates, and the adherence to speed controls should minimise the effects. The adoption of a rationalised programme of vehicle use should help to reduce the number of journeys.

Residual Impacts

Residual impacts on air quality are considered likely to be Insignificant/Negligible.

b) Dust Pollution

Impact

The greatest potential for fugitive dust emissions is likely to arise from the passage of trucks along unsealed public roads and mine access roads. This is unlikely to represent a problem during the wet months when there is consistently more than 1mm of rainfall per day. Impact Significance without mitigation is considered likely to be Insignificant/Negligible.

Mitigation

Measures to seal sections of road where they pass through populated areas, and the upgrade of the Yekepa to Ganta highway to a national blacktop standard would significantly reduce emissions arising from dust re-suspension. On gravel roads regular grading and removal of windrow material will help to reduce volumes of silt, as will dust suppression through watering during dry windy periods. Further from the roadside, thick vegetation screening reduces such impacts so that the majority of the dust is deposited within 50 m to 100 m of the source. Limiting the speed of project-related traffic travelling along unsealed roads would reduce the magnitude of dust.

Residual Impacts

Residual impacts on air quality are considered likely to be Insignificant/Negligible.

9.1.1.2 Mine Sites

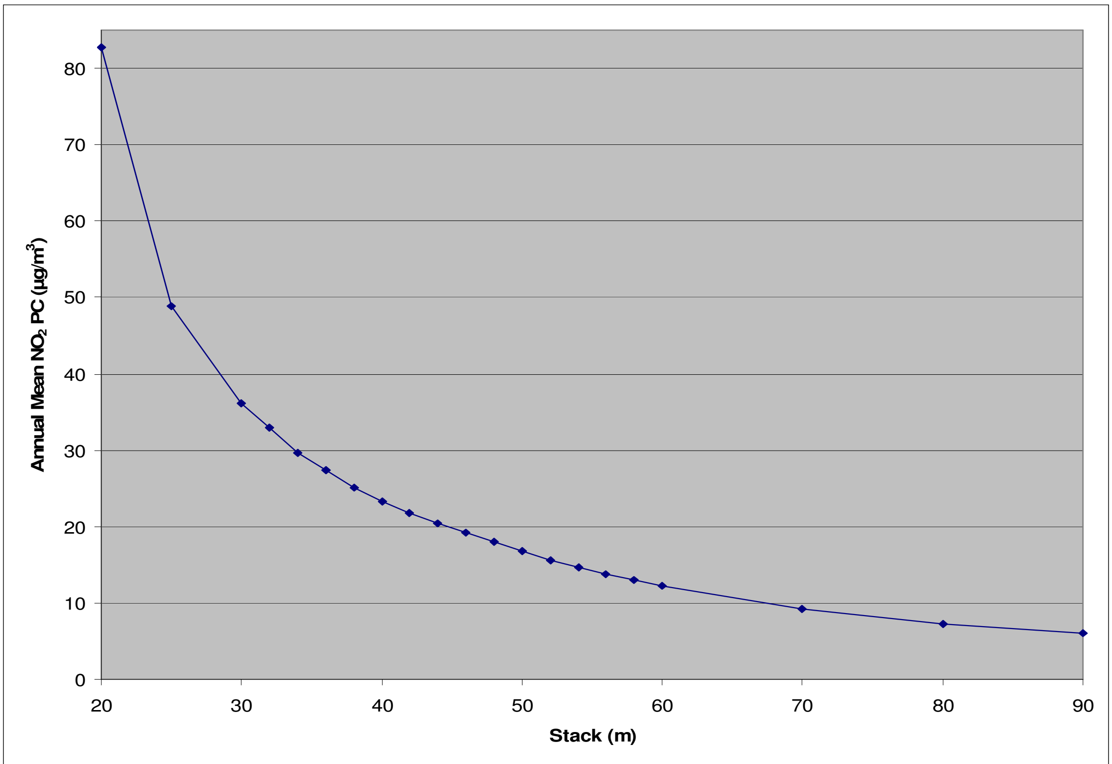
a) Gaseous Pollution

Impacts

These relate primarily to exhaust emissions (nitrogen dioxide and carbon monoxide) from vehicles using access roads, carbon monoxide from railway locomotives at Tokadeh sidings, nitrogen dioxide, sulphur dioxide and carbon monoxide emissions from the power plant at Tokadeh, the release of carbon dioxide by combustion of cleared vegetation and the evaporation to the atmosphere of chemicals from spillages. The Impact Significance associated with vehicle emissions, the burning of cleared vegetation and the evaporation of chemicals from spillages is considered likely to be Insignificant/Negligible.

Emissions from the main stack of the proposed power plant at Tokadeh have been modelled at stack heights between 20 m and 90 m. Figure 9.1 shows the process contribution (PC) to annual mean NO_X concentrations. The purpose of the graph is to evaluate the optimum stack height in terms of the dispersion of pollutants which would occur, against other constraints of further increases in release height. Analysis of the annual mean curve shows that the benefit of incremental increases in stack height up to 30 m is most pronounced. At heights above 32 - 35 m, the curve flattens and the air quality benefit of increasing stack height further is reduced. It is therefore considered that 32 m represents a height at which site-specific constraints and the diminishing benefits of further increases in release height begin to outweigh the benefits to air quality.

Figure 9.1: Predicted Process Contribution to Maximum Annual Mean NO_X Concentrations at Stack Heights between 20 m and 90 m



Nitrogen Dioxide (NO_2)

The predicted change in annual mean NO_2 concentrations that would occur during the operation of the power plant, at the selected sensitive receptors, is presented in Table 9.2. The predicted impact on short term NO_2 concentrations is presented in Table 9.3.

TABLE 9.2: PREDICTED IMPACT ON ANNUAL MEAN NO_2 CONCENTRATIONS

Receptor	Description	Annual Mean NO_2 Concentration (µg/m^3)			
		Background	Process Contribution	Predicted Environmental Concentration (PEC)	PEC % AQS
R1	Zolowee N	3.9	9.7	13.6	34
R2	Zolowee S	3.9	5.3	9.2	23
R3	Makinto	5.2	2.4	7.6	19
R4	Geh	3.6	0.9	4.5	11
R5	Gbapa	4.5	2.4	6.9	17
R6	Vayanpa	3.6	1.7	5.3	13
R7	Kpadapa	3.6	1.5	5.1	13
Air Quality Standard (IFC)				40	

The results in Table 9.2 show that the operation of the power plant would not cause a risk of exceeding the annual mean NO_2 air quality standard at the selected sensitive receptors where relevant human exposure would occur. Due to its proximity to the concentrator site, the most affected residential location would be Zolowee, where the predicted environmental concentration (PEC) would remain below 35% of the annual mean standard.

As for the annual mean, the largest impact on short-term NO_2 concentrations would be seen in Zolowee. At this location and with the other sensitive receptors considered within the assessment, there would not be a predicted exceedance of the 1-hour IFC standard.

TABLE 9.3: PREDICTED IMPACT ON MAXIMUM 1 HOUR MEAN NO2 CONCENTRATIONS

Receptor	Description	1 hour Mean NO_2 Concentration (µg/m^3)			
		Background	Process Contribution	Predicted Environmental Concentration (PEC)	PEC % AQS
R1	Zolowee N	7.8	67.6	75.4	38
R2	Zolowee S	7.8	58.0	65.8	33
R3	Makinto	10.4	51.7	62.1	31
R4	Geh	7.2	41.8	49.0	25
R5	Gbapa	9	50.9	59.9	30
R6	Vayanpa	7.2	50.4	57.6	29
R7	Kpadapa	7.2	47.3	54.5	27
Air Quality Standard (IFC)				**200**	

Sulphur Dioxide (SO_2)

The predicted change in 24-hour mean SO_2 concentrations that would occur during the operation of the power plant at the selected sensitive receptors, with maximum 2% sulphur content in the fuel, is presented in Table 9.4. The predicted impact on 10-minute SO_2 concentrations is presented in Table 9.5.

The results show that there would be a low risk of exceeding the short-term air quality standards for SO_2 at sensitive receptor locations. The predicted maximum 24-hour and 1-hour concentrations are around 35% and 78% of the air quality standards respectively.

TABLE 9.4: PREDICTED IMPACT ON 24 HOUR MEAN SO_2 CONCENTRATIONS

Receptor	Description	24 Hour Mean SO_2 Concentration (µg/m3)			
		Background	Process Contribution	Predicted Environmental Concentration (PEC)	PEC % AQS
R1	Zolowee N	0.9	42.7	43.6	35
R2	Zolowee S	0.9	23.0	23.9	19
R3	Makinto	1.0	8.1	9.1	7
R4	Geh	1.1	4.4	5.5	4
R5	Gbapa	1.4	8.5	9.9	8
R6	Vayanpa	0.9	8.1	9.0	7
R7	Kpadapa	0.9	8.4	9.3	7
Air Quality Standard (IFC)				**125**	

TABLE 9.5: PREDICTED IMPACT ON MAXIMUM 10 MINUTE MEAN SO_2 CONCENTRATIONS

Receptor	Description	10 Minute Mean SO_2 Concentration ($\mu g/m^3$)			
		Background	Process Contribution	Predicted Environmental Concentration PEC	PEC % AQS
R1	Zolowee N	1.8	387	389	78
R2	Zolowee S	1.8	252	254	51
R3	Makinto	2	178	180	36
R4	Geh	2.2	113	116	23
R5	Gbapa	2.8	122	125	25
R6	Vayanpa	1.8	117	119	24
R7	Kpadapa	1.8	189	191	38
Air Quality Standard (IFC)				**500**	

Carbon Monoxide (CO)

The predicted change in 8-hour mean CO concentrations that would occur during the operation of the power plant, at the selected sensitive receptors, is presented in Table 9.6. Although no baseline data are available, due to the lack of large combustion sources in the area it is very unlikely that the air quality standard would be exceeded.

TABLE 9.6: PREDICTED IMPACT ON 8 HOUR MEAN CO CONCENTRATIONS

Receptor	Description	8 Hour Mean CO Concentration ($\mu g/m^3$)			
		Background	Process Contribution	Predicted Environmental Concentration PEC	PEC % AQS
R1	Zolowee N	-	7.77	7.8	<0.1
R2	Zolowee S	-	3.28	3.3	<0.1
R3	Makinto	-	1.61	1.6	<0.1
R4	Geh	-	1.25	1.2	<0.1
R5	Gbapa	-	1.52	1.5	<0.1
R6	Vayanpa	-	1.11	1.1	<0.1
R7	Kpadapa	-	1.07	1.1	<0.1
Air Quality Standard				**10,000**	

The analysis has shown that emissions of gaseous air pollution from the proposed power plant at the Tokadeh concentrator site are acceptable with a stack height of 32m and a fuel sulphur content of less than 2%. Modelling of the plant operating on 4% sulphur content fuel, however, predicts that the Process Contribution (PC) would be more than 100% air quality standard at stack heights up to approximately 65 m, and more than 90% of the standard with at stack heights up to approximately 80 m. For this reason, it is recommended that the sulphur content of HFO fuel specified for use in the concentrator power plant is maintained below 2%, as per IFC guidelines. If supplies of HFO with sulphur contents in this range cannot be guaranteed by the supplier, then there is a risk that the short term air quality standard for SO_2 could be exceeded in Zolowee with a stack height of less than 80 m above ground level.

The Significance of Impact (on people) associated with the operation of the power plant at Tokadeh using 4% sulphur content fuel is considered to be Substantial.

Mitigation

The use of less than 2% sulphur content fuel.

Residual Impact

The residual impact (on people) using less than 2% sulphur content fuel is considered to be Slight.

b) Dust

Impacts

In the mine area, the principal sources of dust emissions will be associated with a range of Scheme activities including:

- Initial site preparation and construction works;
- Soil stripping/overburden handling and storage;
- Drilling and blasting of ore within the extraction area, where this is necessary;
- Excavation of ore material;
- Transportation of ore from the mine to the concentrator processing area;
- Ore crushing and blending;
- Screening and stockpiling activities;
- Processing of ore within the concentration plant;
- Loading of ore onto rail wagons for onward transport;
- Emissions from the power plant stack.

There are no schools, hospitals or other highly sensitive sites close to the project related sources of dust. The closest main population settlements to these dust generating activities are the towns of Gbapa and Zolowee (1 km and 2 km respectively). These are too distant to be affected by either dust nuisance, associated with the larger particles, or health effects associated with fine particulate matter. A resettlement programme prior to the implementation of Phase 1 relocated the residents or users of other scattered buildings and farming land within the spatial scope that could potentially be affected by dust impacts.

For this reason, there are a very limited number of sensitive receptors within the areas that could be affected by the mining, ore processing and loading operations.

Occasional dust plumes extending beyond the boundary of the mine footprint cannot be completely excluded, and will be dependent upon local weather conditions. Whilst the smaller dust particles can potentially be transported up to one kilometre, this extent of dispersion will be limited by the very low wind speeds recorded in this area, and it is expected that any impacts would mostly be restricted to within 200 metres of the mine footprint boundary. There are no sensitive receptors within 200m of the Gangra-Yuelliton mine area or the Tokadeh footprint. Without mitigation, particularly during dry periods of weather, or during periods of activity close to the mine footprint boundary, it is potentially possible that there could be significant impacts on human receptors.

The Significance of Impact (on people and wildlife) of dust generated from the mine and its associated infrastructure is considered to be Moderate.

Mitigation

The application of standard best practice measures for the mining and minerals extraction sector within a formal EMP would be capable of controlling emissions to a level where effects on sensitive human receptors would not be significant. Any deposited material would be composed of silt-sized particles and any material that settled on vegetation would be readily displaced during periods of precipitation. Emissions during the wet season would be greatly reduced as dust emissions from unpaved roads would be substantially suppressed.

The proposed primary crusher is an enclosed process, which along with the inherent moisture content of the run of mine ore would limit the potential for fugitive dust emissions. Dust collection and suppression systems are to be provided for each crusher, comprising a misting system on the dump pockets, plus bag filters and fans at the crusher discharge point to the apron feeders and transfer to the conveyors. These measures, combined with a distance of more than 2 km to the nearest residential properties, mean that no significant impacts on human receptors are expected. Crushed ore would be transferred to the blending and stocking area by belt conveyor, thereby removing the dust generation potential associated with truck movements along an unsurfaced haul route.

Crushed ore blending system and stockpiling and reclaiming equipment would be fitted with water cannons for dust suppression. The stockpiles are at least 1.5 km from the nearest residential dwellings at Zolowee and so significant impacts on human receptors are not expected.

The ore beneficiation process within the concentration plant is primarily a wet process and as such will not represent a significant source of dust. Misting and sprinkler systems are fitted to conveyors and transfer points. Tailings are pumped to the tailings management facility for emplacement as slurry, and will not generate dust emissions.

The concentrate is sent via conveyor to a longitudinal stockpile, which will be reclaimed using a boom bucket reclaimer and sent to a surge bin for direct train loading, thereby minimising fugitive dust arisings. Front-end loaders would not be needed for the loading process unless there are problems with the main train loading system.

The predicted change in annual mean PM_{10} concentrations that would occur during the operation of the power plant, at the selected sensitive receptors, is presented in Table 9.7. The results show that the impact on local concentrations of particulate matter from the operation of the power plant would be very low in comparison to existing baseline concentrations. Although the PM_{10} air quality standards are predicted to be exceeded or at risk of exceedance, this is overwhelmingly due to existing concentrations rather than the predicted impact of the operational power plant.

TABLE 9.7: PREDICTED IMPACT ON ANNUAL MEAN PM_{10} CONCENTRATIONS

Receptor	Description	1 Hour Mean PM_{10} Concentration ($\mu g/m^3$)			
		Background	Process Contribution	Predicted Environmental Concentration (PEC)	PEC % AQS
R1	Zolowee N	259	0.34	259.3	370
R2	Zolowee S	259	0.18	259.2	370
R3	Makinto	158	0.08	158.1	226
R4	Geh	158	0.03	158.0	226
R5	Gbapa	158	0.08	158.1	226
R6	Vayanpa	158	0.06	158.1	226
R7	Kpadapa	158	0.05	158.1	226
Air Quality Standard (IFC)				**70**	

Residual Impact

The residual impact (on the atmosphere, people and wildlife) employing all mitigation measures is considered to be Moderate because of the large quantities of dust that will be generated by excavation that can only be mitigated to a certain degree.

9.1.1.3 Buchanan Estate

a) Gaseous Pollution

Impact

Dispersion modelling of emissions from the Buchanan power plant has demonstrated that a stack height of 32 m would be sufficient to ensure there would not be a breach of ambient air quality standards at sensitive receptor locations if the plant is operated within emissions limits specified by IFC guidance. The short term NO_2 standard would be at risk of being exceeded in a small area to the west of the power plant, within the port development boundary. However, members of the public would not be present at these locations. If the operation of ten or more engines is required at a later transition ore phase of the project, a supplementary assessment will need to be carried out.

Liberia represents a very small proportion of the total CO_2 emissions within the sub-Saharan region, and the Phase 2 Scheme would be very unlikely to change this position. The proposed mitigation would minimise CO_2 emissions to the lowest level possible.

The Significance of Impact (on people) using 4% sulphur content fuel is considered to be Substantial.

Mitigation

The use of less than 2% sulphur content should reduce emissions to acceptable levels.

Residual Impact

The residual impact (on people) using less than 2% sulphur content fuel is considered to be Slight.

b) Dust

Buchanan Estate

Impacts

In terms of particulate emissions from the power plant, the results show that the impact on local concentrations of particulate matter from the operation of the power plant would be very low in comparison to existing baseline concentrations. Although the PM_{10} annual mean air quality standards are predicted to be at risk of exceedance, this is overwhelmingly due to existing concentrations and not the predicted impact of the operational power plant.

The Significance of Impact is considered to be Insignificant/Negligible.

9.1.1.4 Railway

Impacts

Given the low frequency of railway movements, significant dust effects on human populations due to operational rail movements are not considered likely. In fact, the use of the railway for bulk carrying, i.e. not only for ore transport, would lead to a reduction in road traffic and a reduction in generated dust.

At Greenhill Quarry, there are no residential properties within 200 m of the quarry or processing and loading areas, so there is limited potential for dust impacts to occur from these sources. Properties close to the unsealed access road may however be affected by re-suspended road dust during dry weather.

The Significance of Impact is considered to be Insignificant/Negligible.

Mitigation

Covering railway wagons and/or applying water suppression measures will reduce dust levels. Limiting the speed of project related traffic would reduce the magnitude of dust on the Greenhill Quarry access road. The use of less than 2% sulphur content to diesel fuel would reduce emissions of gaseous pollution.

Residual Impact

The residual impact is considered to be Insignificant/Negligible.

9.1.1.5 Buchanan Port

Impact

Any effects associated with the construction of Phase 2 landside rehabilitation works would be occasional and temporary in nature. The majority of construction activities would take place towards the centre of the port, at a distance of around 500 m from the nearest human settlements in Buchanan, and are highly unlikely to give rise to significant impacts. The installation of the new rail loop and railcar dumper building would however take place within 100m of the boundary of the site, and suitable mitigation would therefore need to be employed in these areas to prevent significant impacts occurring. Even with the application of mitigation, occasional impacts cannot be discounted.

In terms of port operations, the stocking area and stacker reclaimer would be situated towards the centre of the port landside facility, around 500 m from the nearest residential receptors. Significant impacts on dust deposition rates and particulate matter concentrations would therefore be unlikely to occur at such a distance from the source. Ship loading operations would take place at the southern end of the port development, more than 1 km from the nearest human receptors.

The proposed location of the railcar dumper building is within 50 m of the western boundary of the port, and within about 100 m of the nearest residential properties. The dumper itself would be partially enclosed within a steel clad building. During tippler operations, there would be a low overall potential for significant emissions of dust and particulate matter to occur due to the inherent moisture content of the ore and the enclosure of the tipping mechanism.

Significant effects from time to time could occur from the stockpile yard at the closest properties unless appropriate dust suppression is applied.

Occasional increases in dust deposition rates at small numbers of receptors may occur at times when activities are carried out during times of very dry and windy weather. However during these times background concentrations of particulate matter would also become elevated and the overall effect would be of slight adverse significance.

The Significance of Impact (in relation to People) associated with these various dust sources is considered to be Moderate.

Mitigation

Mitigation measures should include shelters and wind shields for vulnerable stockpiles and the use of water suppression measures, as described in Section 3.

Residual Impact

The residual impact significance is considered to be Slight.

9.1.2 Noise and Vibration

9.1.2.1 Public Roads

Impacts

Increased traffic (both project-related and private) as well as increased volumes of heavy goods vehicles can be expected to result in increased noise and vibration.

The level of Impact Significance (in relation to People) is considered likely to be Moderate. In relation to Fauna it is considered to be Moderate.

Mitigation

The use of modern engines and restricted speed limits will serve to reduce noise levels to an extent. Vehicle restrictions in certain areas and certain times of day, and especially at night, will also assist in reducing noise and vibration effects.

Residual Impact

The level of Residual Impact Significance in relation to People is considered likely to be Slight. In relation to Fauna it is considered to be Moderate.

9.1.2.2 Mine Sites

Impacts

In the absence of national standards, World Health Organisation (WHO) Guidelines and World Bank/IFC criteria are applicable. The World Bank/IFC criteria are based on the WHO guidelines and provide noise limits from industrial and mining facilities. Noise impacts should not exceed the levels presented in Table 9.8, or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.

TABLE 9.8: WORLD BANK / IFC CRITERIA

Receptor	One Hour L_{Aeq} (dB(A))	
	Day (7AM to 10PM)	Night (10PM to 7AM)
Residential, institutional, educational	55	45
Industrial, commercial	70	70

A noise model for the construction of the concentrator plant and power plant at Tokadeh was implemented in the SoundPLAN suite of programs. SoundPLAN is a commercial software package which implements a range of calculation methodologies, including ISO 9613-2 for the propagation of noise from industrial noise sources, which can be employed for construction operations.

The model included:

- ground elevation data;
- construction plant (represented as point noise sources);
- selected receptors around the mine areas.

Predicted noise levels at the selected receptors in the vicinity of the mining areas are provided in Table 9.9.

TABLE 9.9: PREDICTED CONSTRUCTION NOISE LEVELS AT CHOSEN RECEPTORS

Receptor	Predicted Noise Level dB $L_{Aeq,\ 1\ hour}$			
	Earthworks	Piling	Concreting	Steelworks
Bonlah	<20	<20	<20	<20
Cassava Farm	<20	<20	<20	<20
Gbapa	<20	<20	<20	<20
Zolowee	35	33	32	34

The predicted construction noise levels at Bonlah, Cassava Farm and Gbapa are substantially below 20 dB $L_{Aeq,\ 1\ hour}$. At Zolowee, predicted construction noise levels range between 32 and 35 dB $L_{Aeq,\ 1\ hour}$. These predicted noise levels are below the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$ in Table 9.8).

Taking the noise levels measured at Cassava Farm as representative of those at Zolowee, minimum ambient noise levels are in the region of 38 dB L_{Aeq}. The addition of construction noise will result in a total noise level of 40 dB L_{Aeq}, an increase of 2 dB(A) over the prevailing minimum ambient noise level.

The significance of this increase is assessed as Negligible.

A model of Gangra and Tokadeh mine areas was implemented in the SoundPLAN suite of programs.

The model included:

- ground elevation data;
- mine plant (represented as point noise sources and line noise sources);
- rail head plant (represented as point noise sources);
- haul roads (vehicles represented as moving point sources);
- power plant (represented as one point noise source);
- concentrator plant (represented as point noise sources, line noise sources and industrial buildings); and
- selected receptors around the mine areas.

The model was employed to calculate noise level contours at a height of 2 metres above ground level within an extended area covering the Gangra and Tokadeh mine areas and surroundings. The calculated noise levels are worst-case 1 hour L_{Aeq} values, assuming all plant is operating simultaneously. Predicted noise levels at chosen receptors in the vicinity of the mining areas are provided in Table 9.10.

TABLE 9.10: PREDICTED NOISE LEVELS AT CHOSEN RECEPTORS

Receptor	Predicted Noise Level dB $L_{Aeq,\,1\ hour}$
Bonlah	25
Cassava Farm	22
Gbapa	36
Zolowee	44

At Bonlah, the noise level from mining activities is substantially less than the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$ in Table 9.8).

Minimum night-time background noise levels at Bonlah are in the region of 34 dB L_{A90}. The noise level contribution from mining activities will result in an increase in background noise levels of 1 dB, which is substantially less than the 3 dB referenced in the IFC Guidelines.

The significance of the effects of noise from mining activities at Bonlah is assessed as Negligible.

At Cassava Farm, the noise level from mining activities is substantially less than the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$ in Table 9.8).

Minimum background noise levels at Cassava Farm are in the region of 28 dB L_{A90}. The noise level contribution from mining activities will result in an increase in background noise levels of 1 dB, which is substantially less than the 3 dB referenced in the IFC Guidelines.

The significance of the effects of noise from mining activities at Cassava Farm is assessed as Negligible.

At Gbapa, the noise level from mining activities is substantially less than the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$ in Table 9.8).

Taking the noise levels measured at Bonlah as representative of those at Gbapa, minimum night-time background noise levels at Gbapa are in the region of 34 dB L_{A90}. The noise level contribution from mining activities will result in an increase in background noise levels of 4 dB, which just exceeds the 3 dB referenced in the IFC Guidelines. The significance of the effects of noise from mining activities at Gbapa is assessed as Negligible or Slight.

At Zolowee, the noise level from mining activities exceeds the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$) by 2 dB.

Taking the noise levels measured at Bonlah as representative of those at Zolowee, minimum night-time background noise levels at Zolowee are in the region of 34 dB L_{A90}. The noise level contribution from mining activities will result in an increase in background noise levels of 10 dB, which substantially exceeds the 3 dB referenced in the IFC Guidelines.

The significance of the effects of noise from mining activities at Zolowee is assessed as Substantial.

No predictions of vibration levels to sensitive receptors around the mine sites have been carried out. Prediction of ground borne vibration from blasting without site specific measurement data is not an accurate exercise.

The level of Impact Significance is considered likely to be Negligible for all human receptors other than those at Zolowee, for which a value of Substantial is considered likely.

Mitigation

The noise contribution from mining activities at Zolowee is dominated by noise from two sources. These are the power plant and the SAG mills. At this stage no detailed information regarding the noise emission levels of the individual components (building breakout, ventilation openings, stacks, radiators etc.) of the power plant is available. The Company has supplied an estimated noise level at 100 metres distance from the power plant, from which a sound power level has been derived for use in the noise model. Once more detailed data become available, the calculations should be revisited to confirm the noise contribution of the power plant at Zolowee. Based on the present calculations, attenuation of the SAG mills by 10 dB(A) (for example, by partial enclosure) and attenuation of the power plant by 10 dB(A) (for example, by silencing to stacks and ventilation openings, and uprated cladding to the building) will reduce the noise contribution from mining activities at Zolowee by 6 dB(A) to 38 dB $L_{Aeq,1\ hour}$. This level is below the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$.

Other components of noise mitigation should include:

- All construction plant and equipment should comply with national, or international, noise emission limits (for example European Commission Directive 2000/14/EC, European Commission Directive 2000/14/EC);
- Proper use of plant with respect to minimising noise emissions and regular maintenance. All vehicles and mechanical plant used for the purpose of the works should be fitted with effective exhaust silencers and should be maintained in good efficient working order;
- Selection of inherently quiet plant where appropriate. All major compressors should be ‘sound reduced’ models fitted with properly lined and sealed acoustic covers which should be kept closed whenever the machines are in use and all ancillary pneumatic percussive tools should be fitted with mufflers or silencers of the type recommended by the manufacturers;
- Machines in intermittent use should be shut down in the intervening periods between work or throttled down to a minimum;
- Where appropriate, plant and equipment such as skips and chutes can be lined with noise attenuating materials. Materials should be handled with care and be placed, not dropped. Materials should be delivered during normal working hours; and

- Where practicable, all ancillary plant such as generators, compressors and pumps should be positioned so as to cause minimum noise disturbance, i.e. furthest from receptors or behind noise barriers. If necessary, acoustic enclosures should be provided and/or acoustic shielding.

A monitoring programme should be designed to ensure that noise levels during both peak construction periods and at resting times are captured at points where sensitive receptors are located.

The mine operator should employ appropriate blast design to minimize the effects of blasting at sensitive receptors. Additionally, a programme of ground vibration and air overpressure monitoring should be put in place.

Residual Impact

If the mitigation measures outlined above are implemented the level of Impact Significance is considered likely to be Slight.

9.1.2.3 Buchanan Estate

Impacts

At the nearest receptors in Loop 1 of the port accommodation, the noise level from port activities is 57 dB $L_{Aeq,1\ hour}$. This exceeds the night-time free-field criterion of 42 dB $L_{Aeq,1hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$) by 15 dB. Taking the measured noise levels at Red Sea as representative of those at Loop 1, minimum night-time background noise levels at Loop 1 are in the region of 45 dB L_{A90}. The noise level contribution from port activities will result in an increase in background noise levels of 12 dB, which substantially exceeds the 3 dB referenced in the IFC Guidelines. The significance of the effects of noise from port activities at Loop 1 is assessed as major.

The level of Impact Significance for Loop 1 is considered to be Substantial.

Mitigation

At this stage no detailed information regarding the noise emission levels of the individual components (building breakout, ventilation openings, stacks, radiators etc.) of the power plant is available. The Company has supplied an estimated noise level at 100 metres distance from the power plant, from which a sound power level has been derived for use in the noise model. Once more detailed data become available, the calculations should be revisited to confirm the noise contribution of the power plant at Loop 1. Based on the present calculations, attenuation of the power plant by 12 dB(A) will reduce the noise contribution from port activities at Loop 1 to 45 dB $L_{Aeq,1\ hour}$. The mitigated noise level contribution from port activities will result in an increase in background noise levels of 3 dB, equal to the criterion referenced in the IFC Guidelines.

Residual Impact

The level of Residual Impact Significance based on the mitigation proposed above is considered likely to be Insignificant/Negligible.

9.1.2.4 Railway

Impacts

With Phase 2 in operation, train pass-bys will increase from 4 per 24 hour day to 7 per 24 hour day. Additionally, the Phase 2 trains will consist of 2 locomotives and 140 wagons, whereas the current Phase 1 trains consist of 1 locomotive and up to 80 wagons. During locomotive pass-by at the closest approach to any receptor, noise levels will increase due to there being 2 locomotives instead of 1. As a worst case, noise levels will increase by 3 dB. During wagon pass-by, noise levels are unlikely to increase significantly from the current levels, as the noise levels will be dominated by the limited stretch of wagons closest to the receptor. The duration of the elevated noise levels will, of course, increase (by approximately 75%). During locomotive pass-by at the closest approach to any receptor, vibration levels will increase due to there being 2 locomotives instead of 1. As a worst case, vibration levels have been assumed to double. During wagon pass-by, vibration levels are unlikely to increase significantly from the current levels, as the vibration levels will be dominated by the limited stretch of wagons closest to the receptor. The duration of the elevated vibration levels will, of course, increase (by approximately 75%).

Makinto Crossing

The measurements at Makinto Crossing showed that noise levels at a distance of 10 metres from the nearside line peaked at 84 dB(A) during locomotive pass-by and then were relatively constant at 75 dB(A) as the wagons passed by. The duration of the pass-by elevated noise levels was approximately 2 minutes 30 seconds. With Phase 2 in operation, peak noise levels will increase by 3 dB to 87 dB(A) during locomotive pass-by. During wagon pass-by, noise levels will stay at around 75 dB(A). The duration of the pass-by elevated noise levels will increase to 4 minutes 24 seconds. The measurements at Makinto Crossing showed that vibration levels at a distance of 10 metres from the nearside line were 0.3 to 0.5 mm/s peak particle velocity with isolated peaks up to 0.7 and 1.2 m/s. These peaks may have been due to faults with particular wagons. Assuming a doubling in vibration levels for Phase 2 operation, vibration levels will be in the range 0.6 to 1.0 mm/s. These levels are significantly below the guideline levels which may result in cosmetic damage.

Sanniquellie Hospital

The measurements at Sanniquellie Hospital showed that free-field noise levels at a distance of 1 metre from the façade of the operating theatre peaked at 85 dB(A) due to the locomotive horn. During locomotive pass-by, levels were 72 dB(A) and then were relatively constant at 61 dB(A) as the wagons passed by. The duration of the pass-by elevated noise levels was approximately 1 minute 55 seconds. With Phase 2 in operation, noise levels during locomotive pass-by will increase by 3 dB to 75 dB(A). During wagon pass-by, noise levels will stay at around 61 dB(A). The duration of the pass-by elevated noise levels will increase to 3 minutes 21 seconds. The Sanniquellie Hospital operating theatre has glazed windows. Assuming a conservative reduction in noise level (outside to inside) of 23 dB(A), internal noise levels due to the locomotive horn will be approximately 62 dB(A). This significantly exceeds the $L_{Amax,f}$ criterion value of 50 dB(A). Allowing for the significant low frequency components during locomotive and wagon pass-by, internal noise levels to the operating theatre will be approximately 52 dB(A) during locomotive pass-by (just exceeding the $L_{Amax,f}$ criterion, and 38 dB(A) during wagon pass-by. Averaged over 1 hour, during which there is a train pass-by, internal noise levels will be in the region of 33 dB(A), which is significantly below the 40 dB $L_{Aeq,1\ hour}$ criterion.

In the absence of Liberian guidance, measured vibration levels at the operating theatre have been assessed for disturbance using the methodology provided in Health Technical Memorandum 08-01: Acoustics, published in the United Kingdom. This document provides robust guidance on the effects of vibration on specific spaces within hospitals and is considered to be an appropriate method for this assessment.

The methodology is based on deriving the frequency weighted acceleration (using the W_g weighting in British Standard BS 6841) and dividing this derived frequency weighted acceleration by the reference value (0.005 m/s^2). The resulting Multiplying Factor is compared to the values in Table 9.11 below, which is taken directly from Health Technical Memorandum 08-01.

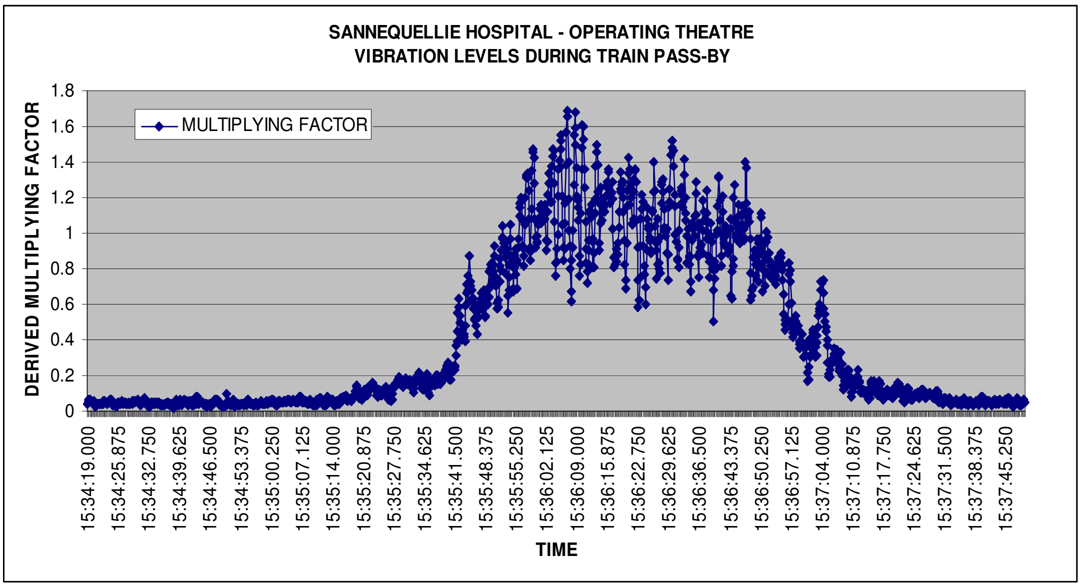
TABLE 9.11: HTM 08-01 VIBRATION CRITERIA

Room Type	Multiplying Factors Corresponding to a Low probability of Adverse Comment
Operating theatre, precision laboratory, audiometric testing booth	1
Wards	2
General laboratories, treatment areas	4
Offices, consulting rooms	8

Inspection of the values in Table 9.11 shows that the Multiplying Factor corresponding to a low probability of adverse comment for operating theatres is 1.

The ground vibration measurements taken at Sannequellie Hospital were processed to provide frequency weighted acceleration values for the period of the measured train pass-by. These values were divided by the reference value (0.005 m/s^2) to provide Multiplying Factors, which are shown in Figure 9.2.

FIGURE 9.2: SANNIQUELLIE HOSPITAL VIBRATION ANALYSIS



Inspection of Figure 9.2 shows that the Multiplying Factor during a train pass-by exceeds the suggested value of 1 for a low probability of adverse comment. Maximum values are up to 1.7.

With the proposal to run longer trains with 2 locomotives, the vibration levels will likely increase (possibly by a factor of 2 during locomotive pass-by), although it is not possible to be specific on this.

Tukpahblee School

The measurements at Tukpahblee School showed that noise levels peaked at 80 dB(A) during locomotive pass-by for the empty train and then were relatively constant at 70 dB(A) as the wagons passed by. The duration of the pass-by elevated noise levels was approximately 1 minute 48 seconds. With Phase 2 in operation, peak noise levels will increase by 3 dB to 83 dB(A) during locomotive pass-by. During wagon pass-by, noise levels will stay at around 70 dB(A). The duration of the pass-by elevated noise levels will increase to 3 minutes 9 seconds. The school windows do not have glazing and will provide in the region of 10 dB(A) reduction in noise levels from outside to inside. Thus, train pass-bys will continue to result in elevated noise levels to classrooms. However, there will only be 2 to 3 train-pass-bys per day within school hours during Phase 2, each lasting for approximately 3 minutes, and these are unlikely to result in a significant disturbance to teaching. It is concluded that no mitigation to reduce noise levels is required.

The measurements at Tukpahblee School showed that vibration levels were highest during a loaded train pass-by. Vibration levels were generally in the range 0.2 to 0.3 mm/s, with an isolated peak up to 0.64 mm/s. Assuming a doubling in vibration levels for Phase 2 operation, vibration levels will be in the range 0.4 to 0.6 mm/s with a possible peak up to 1.3 mm/s. These levels are significantly below the guideline levels which may result in cosmetic damage.

The school was built fairly recently in 2006. No information regarding the robustness of the foundations is available. As with many buildings, there will have been a certain amount of ground settlement leading to damage in the intervening period. Whilst ground vibration levels from the railway are too low to result in direct damage to the school fabric, the vibration levels during train pass-bys may have accelerated natural ground settlement resulting in the damage which is evident.

The levels of Impact Significance are considered likely to be Slight for the school and Substantial in relation to vibration for the hospital.

Mitigation

The railway is on an embankment for a significant stretch in the vicinity of the hospital. The provision of a noise barrier to the railway, which would provide useful reductions in noise levels, may not be practicable. The provision of high performance double glazing to the operating theatre will provide a reduction of approximately 35 dB(A), reducing train horn noise to the required internal $L_{Amax,f}$ level of 50 dB(A).

The provision of a noise barrier or high performance double glazing will not reduce vibration levels to the operating theatre. Possible options to reduce vibration levels include:

- Provision of a floating floor to the operating theatre;
- Relocation of the operating theatre.

The provision of a floating floor will require a detailed study of existing and predicted vibration levels in the operating theatre and consequent calculations to specify the floor details.

It is possible that relocation to the other side of the hospital might be sufficient, but this would require further measurements and analysis to confirm. If not, then movement to another location would be recommended. This would entail significant upheaval and expense but will resolve both noise and vibration problems.

No specific mitigation is proposed at Tukpahblee School to reduce vibration levels. However, it is recommended that a watching brief is kept on the further development of cracks to the structure, perhaps combined with some further longer term measurements.

A shunting whistle could also be employed at the sidings at Tokadeh. This would reduce the noise impact to Zolowee, particularly at night.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight for the school and Moderate for the operating theatre because one of the key issues will be vibration effects which cannot be effectively mitigated without relocation.

9.1.2.5 Buchanan Port

Impacts

A model of Buchanan Port and surroundings was implemented in the SoundPLAN suite of programs. SoundPLAN is a commercial software package which implements a range of calculation methodologies, including ISO 9613-2 for the propagation of noise from industrial noise sources, including ports.

The model included:

- ground elevation data;
- port plant (represented as point noise sources and line noise sources);
- power plant (represented as one point noise source);
- locomotives (represented as moving point sources); and
- selected receptors around the port area.

The model was employed to calculate noise level contours at a height of 2 metres above ground level within an extended area covering the port and surroundings. The calculated noise levels are worst-case 1 hour L_{Aeq} values, assuming all plant is operating simultaneously. At the nearest receptors in Motown, the noise level from port activities is 48 dB $L_{Aeq,1\ hour}$. This exceeds the night-time free-field criterion of 42 dB $L_{Aeq,1\ hour}$ (equivalent to a façade noise level of 45 dB $L_{Aeq,1\ hour}$) by 6 dB. Minimum night-time background noise levels at Motown Gate are in the region of 40 dB L_{A90}. The noise level contribution from port activities will result in an increase in background noise levels of 9 dB, which substantially exceeds the 3 dB referenced in the IFC Guidelines.

The level of Impact Significance in the case of Motown is considered likely to be Moderate.

Mitigation

The provision of a 2.5 metre high barrier to the north western boundary of the port area, as detailed in the Phase 1 assessment, will reduce the noise level from port activities to 40 dB $L_{Aeq,1\ hour}$. The mitigated noise level contribution from port activities will result in an increase in background noise levels of 3 dB, equal to the criterion referenced in the IFC Guidelines.

The intrusion of noise from locomotive horns at Motown has been raised. For safety reasons, the horn is sounded every time the train moves in the yard.

The horn is primarily employed to warn people when the train is approaching crossings etc., possibly at speed. Consequently, the horn noise is very loud. It may be possible to employ a shunting whistle when moving in the port area, rather than the horn. This would reduce the noise impact, particularly at night.

Residual Impact

The level of Residual Impact Significance for Motown is considered likely to be Slight.

9.2 Water

9.2.1 Hydrology

9.2.1.1 Public Roads

Impacts

These relate largely to spillages of fuel, oil and other toxic materials from vehicle breakdowns and accidents on public roads. Spillage of dangerous cargos during vehicle accidents could have much greater effect. Increased volumes of sediment may also prove locally significant.

The level of Impact Significance is considered likely to be Substantial.

Mitigation

A reduction in the number of accidents through the extension of a Traffic Management Plan and public awareness campaigns as to traffic safety and the need to protect the environment. The implementation of Emergency Response Plans in the case of major spillages and standard clean-up kits on project vehicles should assist in reducing this hazard. Consideration should be given to transporting all hazardous materials by train, where this permits.

Stream crossings in particular should be carefully planned and designed to minimise sediment-laden runoff into them, during and after construction. It is essential that staff in the field are fully briefed on the importance of this, and fully trained in techniques to minimise sediment runoff, such as the construction of simple check dams and installation of culverts and sediment traps at stream crossings.

Residual Impact

The level of Residual Impact Significance is considered likely to be Moderate.

9.2.1.2 Mine area

a) Changes to Rainfall-Runoff and Drainage Patterns

Impacts

Yuelliton and Gangra are located within three catchments: the River Kahn catchment, the River Gba catchment and a sub-catchment of the Dayea River. The mountains define the watersheds of these watercourses with several headwaters arising from them. The western face of Gangra drains into the Gba River whilst the eastern face drains into the Kahn River. Most of Yuelliton drains into the Kahn River. A small part of the mountain drains into the Gba and part of the southern end drains into the sub catchment of the Dayea River. Of all the three rivers draining Yuelliton and Gangra, the Kahn River will be the most affected by Phase 2 mining operations. Most of the runoff from both mountains flows into the Kahn and the stockpile locations, waste dumps and settlement pond outfall are all located within the Kahn River catchment. None of the three rivers currently has a mining legacy.

Analysis of the baseline data collected in 2008 shows that the Kahn currently reacts slower to rainfall compared to Madayea River at Tokadeh, which has a pre-existing mining legacy. The clearance of large areas previously covered with forest and vegetation for mining and other ancillary infrastructure will lead to the catchment reacting quicker to rainfall and an increase in peak flows and runoff volumes. This is likely to have a high impact on surface water hydrology and drainage.

In addition to this accelerated runoff will be the effect of the Phase 2 works on catchment areas and water resources. The construction of sediment ponds (see below) and the TMF will effectively reduce catchment areas of first order streams significantly and will cause some drainage channels and springs located outside of the mine and TMF footprint to dry up. This may have ecological and water use implications further downstream, including groundwater.

The level of Impact Significance is considered likely to be Major, particularly in terms of disturbance to drainage lines and water bodies.

b) Erosion and Sedimentation

Impacts

The main sources of sediment at Tokadeh, Gangra and Yuelliton are:

- Excavation of large areas for mining;
- Construction or access roads and haul roads;
- Runoff from stockpiles;
- Runoff from waste dumps;
- Slope erosion and failures.

The entrainment of fine sediments in surface watercourses is the most significant type of contamination in the mining areas. Already in Phase 1, large areas that were previously covered by forest and vegetation have been cleared for mining and to construct access roads. These areas are being eroded during rainfall events and the fine sediments are being deposited in watercourses in the mining areas and beyond. During Phase 2 even more areas will be cleared for the extension of the mine area and construction of the TMF and sediment control ponds and the haul road connecting Tokadeh, Yuelliton and Gangra. The risk of contamination from fine sediments exists both during the construction and operation stages and the impact it will have on the environment, without mitigation, is predicted to be high.

It has not been possible to quantify the amount of suspended sediments from the mining areas or differentiate quantitatively between mining legacy and Phase 1 impacts on sediment loads in the Tokadeh watercourses due to the limited amount of sampling that has been carried out to date. However, a sample taken before the Company's operations started in 2008 from the Dayleh Gordeh River near the bridge crossing of the Tokadeh North haul road contained 1,713 mg/l, which is well above the recommended level of 50mg/l. Large amounts of sediment and very turbid flows were also observed in the Madayea River at the exit of the mining area and in other watercourses within Tokadeh.

Other sources of sediment contamination include stockpiles, waste dumps, natural and artificial slopes.

The level of Impact Significance is considered likely to be Major.

c) Water Quality

Impacts

The sources of contamination in the mining areas can be divided into 5 categories: entrained fines; acid rock drainage; leaching of heavy metals; chemical and microbial contamination.

Entrained Fines

Entrained fines from ultrafine and colloidal solids present in surface drainage waters is considered to be the major geochemical issue and environmental challenge to be addressed for this project. While dissolved concentrations of iron are low in the majority of samples, the presence of colloidal material was indicated from total iron assays in the surface water samples at Tokadeh.

Acid Rock Drainage

The results of the geochemical study indicate that there might be localised areas (or hot-spots) within the ore deposits with sulphide in sufficient concentration that might lead to ARD generation, but that the majority of the waste material will be non-ARD generating. Furthermore, the short term leaching experiments on all samples tested indicated that the waste rock will not present metal leachability issues: all metals were far below US EPA limits resulting in the samples being classified as non-hazardous. This geochemical study has been complemented with a water quality study with in situ measurements at key sites followed by the chemical analysis of samples from select locations. Only one location presented any evidence of potential historic ARD from water quality data, with measurable but low sulphate values found at a historic LAMCO open pit. Also one of the Tokadeh boreholes identified by the geochemical study as containing elevated sulphide showed visual signs of discoloration from what could have arisen from previous ARD generation. This was not confirmed by current water quality, however, with net alkalinity determined. All pH measurements at all locations are circum-neutral and the natural pH of the local soils is mildly acidic. From consideration of all of the above, any localised ARD from potential hot spots would be expected to have no significant impact on the local environment.

Heavy Metals

The dissolved values for all of the residual heavy metals in all of the samples are at least two orders of magnitude below the World Bank Environmental Quality Guidelines for effluents adopted for this project. Furthermore, all of these residual heavy metals data are also below the WHO guidelines for drinking water, with a large number of data below detection limits. According to the baseline data, iron, which is naturally high in the region, already occurs in high levels even in rivers without a mining legacy. The only exception to this is iron found to occur, for example, in higher concentrations than the recommended levels in the Kahn River (380mg/l in December 2011 and 432mg/l in February 2012); a river so far unaffected by mining.

Despite the ongoing Phase 1 activities, samples taken from Tokadeh in 2011 and 2012 do not contain the highest level of iron. Higher levels of iron were found in the Bee Creek and the Gborsin River. The Bee Creek headwater located on the southern face of Tokadeh is not currently receiving direct runoff from the mine and the Gborsin River is also not hydrologically connected to any of the Tokadeh surface water systems. The high level of iron in Bee Creek is therefore considered to be due to legacy effects rather than Phase 1 impacts.

The low levels of iron in the railway southern drain suggest that the iron contamination from the stockpile is localised and does not affect watercourses beyond Tokadeh. The expectation however is that, without required runoff control, levels of iron contamination as a result of Phase 2 would be significant.

The Tokadeh Wetlands samples from 2008 have been shown to contain very high levels of iron. The wetlands effectively act as sediment traps and they tend to contain larger quantities of precipitated iron, in the form of red iron hydroxide deposits and organic muds. The level of iron concentration in the wetland samples were however in the same range as samples from other watercourses.

Chemical Contamination

The main sources of chemical contamination are from oil leakage and spills during construction and under normal operating conditions. The likely types of contaminants are typically hydrocarbons. The components of the Phase 2 plans for Tokadeh from which such contamination can occur include storage, plant and machinery associated with:

- Ore and concentrator handling;
- Tailings Management Facility (TMF);
- Flocculants in the material dredged from sedimentation ponds;

- Fuel storage and distribution;
- Workshop;
- General/mobile maintenance shop (Tokadeh);
- Power generation and distribution;
- Leakages of nitrates from explosives.

The potential impact of chemical contamination, without mitigation, is high, because the probability of spillage and leakage to watercourses of chemical is considered to be high.

Sewage and Microbial Contamination

It is understood that a sewage treatment plant will provide treatment quality to international standards. However, there is a risk of contamination from effluent disposal and monitoring is required to ensure that the level of nutrients and microbial contamination in treated effluent are below stipulated international standards. The location of the treatment plant and the design and operational details of the plant are not known at this stage. Therefore baseline monitoring at the planned discharge point of the plant cannot be undertaken. This should be done once details of the plan and the exact discharge location are known. Presently, impact assessment cannot be sensibly undertaken due to lack of details.

The current baseline data collection does not include microbials because of the short holding times required for microbial testing, which cannot be met due to the absence of a certified laboratory in Liberia. The analysed results for samples from Tokadeh show small amounts of nitrates with the highest level recorded within the Dayleh Gordeh catchment (0.995mg/l in December and 0.747mg/l in February 2012 and 1.1mg/l in December 2008). In contrast, the amount of nitrates recorded in June 2008 in the Dayleh Gordeh catchment was below the level of detection. Discharge of untreated sewage will increase the level of nutrients and pathogens above the existing levels in the receiving watercourses. The potential impact of microbial and sewage contamination, without mitigation, is considered high.

Potential Receptors affected by Surface Water Impacts

The three categories of receptors identified are communities living within and outside of the mining area that use river water for various purposes, aquatic habitats and sensitive ecological sites connected to the watercourses. The water quality of the rivers that downstream communities depend on will be affected by both Phase 1 and Phase 2 activities. In addition to using river water for drinking purposes the communities within the Dayea catchment fish from the Dayea River and its tributaries. In particular, the increase in suspended sediments and turbidity in these rivers is likely to affect fish stock quality and quantity and the entire ecosystem of the watercourses. Ecologically important sites connected to the contaminated watercourses could also be affected. The potential impacts of Phase 2 activities on local community livelihoods are therefore considered to be high.

The level of Impact Significance is considered likely to be Major.

Mitigation

Mitigation measures required to be put in place to reduce levels of impact significance to acceptable levels involve those designed to:

- reduce the magnitude of effects at source, i.e. those to prevent or reduce:
    - drainage disturbance
    - the generation of sediment by erosion
    - the spillages of chemical contaminants into streams
- maximise the containment of runoff and sediment so as to control what is eventually released to the drainage system.

Research by Forsyth et al. (1995) suggested that significant reductions in the nitrate level of mine discharge water can usually be achieved through care and attention to detail in the mining operation, and that this would not necessarily have much impact on costs. They recommended four main options to be followed to reduce nitrate levels through careful management, with increasing economic costs:

1. Develop and implement explosive management practices;
2. Evaluate and improve the level of blasting efficiency;
3. Change to a more water resistant explosive product; and
4. Assess treatment options (i.e. address the problem through downstream remedial work).

Monitoring should also be continued and extended in order to demonstrate the effectiveness of the mitigation and to identify and quantify any polluting events or conditions that require rectification.

Reduction of source magnitude

In terms of runoff from the mine and other cleared areas, there is little that can be done to reduce ultimate volumes, but the rate of overall runoff from the mine sites can be reduced by progressively opening up areas to vegetation clearance, topsoil stripping and mining excavations. This way the total area exposed to accelerated runoff at any one time would become less. This would also lead to reduced concentrations of sediment. Erosion can be reduced from slopes by minimising the areas that need to be cleared in the first place, and stream erosion can be reduced by increasing the storage areas for rainfall runoff and reducing flow rates through the use of inward-sloping benches, temporary collection ponds and checkdams in stream courses. Major earthworks activities should, where possible, be undertaken during the dry season in order to reduce the potential for sediment entrainment.

Slopes, waste dumps and stockpiles need to be designed to profiles that are stable in the short and long term, and adequate attention needs to be paid to underlying structural geology in order to minimise the potential for deep-seated slope failures. At present there is insufficient information supplied to be able to confirm that these conditions have been adequately addressed. A review of the design of the TMF suggests that the geotechnical ground model is incomplete and this will need to be resolved prior to final design and construction. Failure of the TMF could have significant downstream consequences, both in terms of sediment supply to the Dayea River and downstream land uses and public safety (Section 9.6).

In terms of chemical contamination of runoff the use of industry standards in relation to the handling and storage of toxic and hazardous materials should be rigorously applied and sewage and other forms of site generated waste should be properly contained at source, treated and carefully disposed of.

Containment

The layout details provided for both the Tokadeh and Gangra-Yuelliton mine sites indicate that it is intended for all runoff to be contained and controlled by the use of settlement ponds and water treatments systems.

Tokadeh

For Phase 2, the Eastern Sedimentation Pond System (comprising of two main attenuation ponds – north and south) is designed to act as a large stilling and sedimentation basin for runoff (Dwg 9.1). The Company has confirmed that these drainage control provisions will be constructed prior to any Phase 2 mining at Tokadeh.

The Stormwater Management Plan for Tokadeh (dated November 2012) provides outline details of the system. It will be designed to cater for the annual flood[7] and the south and north

[7] The annual flood is the size of flood which, from magnitude-frequency analysis, is expected to occur on average once each year

ponds will have a capacity of 1.5 million m^3 and 1.2 million m^3 respectively. The south sediment pond is expected to receive all runoff from the Tokadeh mine site. The north sediment pond will receive treated runoff from the south sediment pond via a controlled spillway at a rate of up to $5m^3/sec$ and will also receive all drainage from the TMF to its immediate west. For flows greater than the annual flood, all runoff will flow uncontrolled from the south to the north pond and from the north pond to the Madayea River, and thence to the Dayea River once the ponds are full. There is no indication as to the size of the annual event or the volumes of water that will enter the Madayea River once the design storage is exceeded, as this will depend on the magnitude-frequency curve of storm events. Furthermore, the south sediment pond will be the receptor of all transported sediment from the Tokadeh mine area and there are no calculations to show how rapidly it will fill, thereby reducing its water retention capacity. The south sediment pond will be used to regulate water supply to and from the TMF and provide water to the Tokadeh crusher and concentrator plant. According to water balance calculations in the Pre-feasibility Study (ArcelorMittal, January 2010)[8], the overall requirement of the combined processing plant and tailings system is 12,900 m^3 per hour or 3.58 m^3/s.

Another issue concerning the runoff from Tokadeh is the extent to which runoff will remain watertight within the enclosed system described above. During Phase 1, the existing mine haul road has formed an artificial barrier, which cuts off the upper parts of the catchments of the Dayleh Gordeh, East Madayea and West Madayea rivers. This has led to surface water runoff being partly transferred to the Bee Creek catchment to the south, via the railway side drain. The sub-catchment of the Gweneh Creek at the foot of the eastern end of Tokadeh near the DSO facility area has also been truncated by the railway line: the area now drains into the railway side drain. As part of the Phase 1 drainage management system, the Company has diverted all of the drainage water from the Tokadeh mine haul road northwards into the Madayea catchment. In addition, drainage from the currently mined areas in the headwaters of the Geneh Creek is also diverted in this way. However, most of the DSO loading area still drains southwards towards the village of Maketo through the drains alongside the railway line. The initial section of this drain is often filled with DSO material washed in by the rains during the rainy season, so that the drain itself acts as a stilling basin. There is, as yet, insufficient information available regarding the details of the Phase 2 layout to determine what will be the final drainage pattern in this area.

Two further issues also need to be considered:

a) the extent to which contributory sediment volumes can be reduced through erosion control and intermediate sediment traps, and

b) the frequency with which sediment ponds will need to be dredged to maintain water retention capacity.

Linked to the second issue is the question as to where dredged sediment will be disposed of (presumably into the nearest waste dumps, but this might affect stability) and what runoff and sediment management system will be put in place during and after Mine Closure. There are no details available as yet that address these issues.

It should be pointed out, however, that the present proposal for water supply to the TMF and concentrator/crusher facility via the Eastern Sedimentation Ponds is a significant improvement, environmentally, on the previous proposals. In the latter case, abstraction of water was required from the Dayea River at certain times of the year and overflows from the TMF, potentially with high sediment concentrations, were scheduled to be discharged back into the river. The Eastern Sedimentation Ponds will act as a buffer, supplying all water requirements and providing a sediment trap for mine runoff. The average residence time of water in each pond is hydrologically calculated to be 3 days. There are outline indications that flocculation may still be required at times in the northern pond to achieve the IFC standard of 50mg/l maximum discharge to downstream water-courses for 95% of the time. The

[8] ArcelorMittal, January 2010: Pre-Feasibility Study Liberia Western Range Iron Ore

hydrological and sedimentological regime of the proposal will need to be reviewed when the design and operational details are known.

The potential for iron-rich seepage water to enter groundwater from the sedimentation ponds and the TMF requires consideration, including the requirement for impermeable liners.

Residual Impact

Without further information concerning: a) the design of excavated, fill and spoil slopes against failure; b) the protection of slopes and stream channels against erosion; c) the design of the drainage management system; and d) the full extent to which all runoff and sediment from mine and mine infrastructure areas will be captured, processed and then released, it is difficult to assess residual impacts. Precedent from Phase 1 would suggest that significant impact reduction might be difficult to achieve and a design capacity based on the annual flood will mean that there may be significant discharges of high sediment concentration, depending upon the timing of various sized floods in relation to pond capacity. The use of the annual flood as the operational maximum should therefore be reviewed. Currently, runoff from Tokadeh mine surfaces and other disturbed areas is observed contributing significant quantities of sediment to streams and, if designed and implemented properly, the proposed Phase 2 scheme should improve upon this situation.

The level of Residual Impact Significance at Tokadeh is considered likely to vary between Negligible to Major. Major because of the fact that changes to the drainage pattern are irreversible. In terms of runoff and sediment transport the Residual Impact Significance should reduce to Moderate on the assumption that a proper hydrological assessment and design is prepared, reviewed and fully implemented.

Gangra-Yuelliton

With regard to Gangra-Yuelliton the details of the drainage control system are less developed and are defined as being at concept stage only. The Stormwater Management Plan (dated November 2012) states that:

Because the G/Y site is located at the downstream end of such a large drainage system, the external areas will need to be kept separate from the proposed stormwater system. However, due to the topography of the mine sites, this will necessitate that two separate stormwater management systems be constructed. The first stormwater management system will treat the runoff from the Yeulliton mine pit, a portion of the Gangra mine pit as well as the Yeulliton North East Waste Dump and the Yeulliton East Waste Dump. As noted on the drainage area plan, the drainage area for this stormwater system will be approximately 1,100 hectares. The preliminary locations for the two ponds are shown on the drainage area plan (DAP). The second stormwater management system will treat the runoff from the main portion of the Gangra mine pit as well as the Gangra South East Waste Dump. The drainage area for this stormwater system shall be approximately 458 hectares. The Gangra stormwater system will require two sediment ponds due to the topography. One for the mine pit and one for the waste rock stockpile. The preliminary locations for the ponds are shown on the DAP. These two stormwater management systems are currently at the concept stage. The next step will be the commencement of the hydrological modelling so that the design can be progressed to basic design.

The layout of this drainage management system is shown in Dwg 9.2. There is insufficient detail available to confirm whether or not the proposed drainage measures will be sufficient to control all runoff and sediment, and the layout itself shows some inconsistency between drainage structures and the underlying topography. This will need to be assessed independently once the details are available and mining activities should not be allowed to commence until a) the design is confirmed to be adequate and b) the containment measures are properly implemented.

Now that drilling is complete at Gangra and Yeulliton, the geochemistry of the drill core database should be reviewed and samples selected for testwork in order to check the ARD potential of the materials at these locations.

The settling behaviour of the entrained fines in surface drainage waters needs to be addressed, and consideration given to the need for including a flocculant addition system during both the construction and operational phases of the project. The final delivery of all runoff to the drainage system will need to satisfy the requirements of the IFC whereby maximum suspended sediment content is no greater than 50 mg/l for 95% of the time.

The current monitoring network should be updated to include watercourses downstream of all waste dumps, settlement ponds and stockpiles. Monitoring should also be undertaken in the watercourse draining the southern end of Yuelliton into the Dayea River. River water quality and continuous flows in the Kahn and Gba Rivers should continue to be monitored to determine the effects of the mining activities on both rivers and to provide robust data for the evaluation of sediment concentrations from a river without a mining legacy.

Finally, the Mine Closure Plan must design and implement measures to reinstate the drainage system to a pattern that is as close as possible to the pre-mine state with trialled and proven measures to reinstate vegetation and deployment of other means to protect slopes and drainage channels from erosion, and stabilise slopes and waste dumps so that they remain stable in the long term and do not contribute sediment to the drainage system.

Residual Impact

Without further information concerning the protection of slopes and stream channels from erosion, the design of the drainage management system and the full extent to which all runoff from mine and mine infrastructure areas will be captured, processed and then released, it is difficult to assess residual impacts. Precedent from Phase 1 would suggest that significant impact reduction might be difficult to achieve.

The level of Residual Impact Significance is considered likely to be Major, given that no details have been made available concerning how runoff, erosion and sediment will be controlled. If a similarly effective sediment entrapment system is designed and constructed for Gangra-Yuelliton as that planned for Tokadeh then it is recommended that the Level of Impact Significance is reduced to Moderate.

9.2.1.3 Buchanan Estate

Impact

The envisaged hydrological impacts associated with Phase 2 expansion and operation of Buchanan Estate relate primarily to the potential to contaminate surface water through increased and inadequate waste disposal and the potential for leakages of fuel, oil and other industrial contaminants from power supply, workshops and other installations. Effluent from waste water treatment could pollute local water courses if not properly controlled.

The level of Impact Significance is considered likely to be Moderate.

Mitigation

The Company intends to install a new sewage and waste water treatment system and upgrade the existing facilities for solid waste disposal in line with international practice. This is likely to prove a significant improvement on the previous provisions where leakages from broken and blocked pipework had been reported. It is confirmed by the Company that these new systems will be sufficient to cater for the increased capacity required for Phase 2 operations. However, there is a risk of contamination from effluent disposal. Therefore monitoring is required to ensure that the level of nutrients and microbial contamination in treated effluent are below stipulated international standards. The location of the treatment plant is not known at this stage but it is understood that it will discharge into a tributary of the Savage River near Loop 1

Extension. Water samples are collected from the Savage River in the vicinity of Loop 1 Extension as part of the ongoing monitoring work. Once details of the plan and the exact discharge location are known, monitoring should be undertaken upstream and downstream of it.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight.

9.2.1.4 Railway

Impacts

Potential impacts to arise from Phase 2 operation of the railway include leakages of diesel and oil from locomotives and the possible spillage of iron ore cargo into drainage systems. Other sources of hydrological contamination include the use of chemical herbicides to control trackside vegetation. Increased sediment in runoff may result from any track-side earthworks.

Other potential impacts to the physical environment include pollution incidents at the maintenance Estate due to spillages or leakages of oil or other hazardous and toxic materials. At Greenhill Quarry the potential sources of contamination include:

- Chemical contamination from vehicles and machinery;
- Fine sediment in the pond that can reach watercourses if the dam of the pond breaches.

The level of Impact Significance is considered likely to be Slight.

Mitigation

The significance of these impacts should be minimised by the use of industry standard controls on the handling of hazardous materials and the deployment of comprehensive safety controls to prevent accidents and derailments. Locomotives should be well-maintained so as to minimise the potential for leakages. Maximum use should be made of manual methods of track side vegetation control and only those herbicides approved by the EPA should be used.

Regarding the continued operation of Greenhill Quarry, no detailed design has been provided to inform the ESIA. However, it was observed during site visits that a series of settlement ponds have been constructed to remove the fine material from the water before it is recycled back to the pond. It is understood that the fine material collected from the settlement ponds is used for construction purposes.

There is already a wastewater treatment plant at Greenhill Quarry, built during the railway rehabilitation phase. Water samples are collected from the watercourse connected to the pond as part of the ongoing monitoring. Monitoring should be undertaken upstream and downstream of the point of effluent discharge from the wastewater treatment plant.

It is essential that staff in the field are fully briefed and trained in techniques to minimise sediment runoff, such as the construction of simple check dams and installation of culverts and sediment traps at stream crossings.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight.

9.2.1.5 Buchanan Port

Impacts

The potential surface water impacts associated with the Phase 2 operation of the port relate to the leakage or spillage of fuel, oil and hazardous chemicals, and the contamination of the surface drainage system with spilt, washed or wind-blown iron ore. For Phase 2 the basic operation will be similar to Phase 1, i.e. it will involve the unloading of wagons, stockpiling of ore, and loading of ships. There will be a Phase 2 fuel quay, oil pipeline and tank farm facility with overhead gantry to dispatch fuel to locomotives. Spillages could arise from any of these processes and facilities, and contaminants could be quickly washed into the harbour if not properly controlled.

Pollution arising from within and outside Buchanan harbour will increase as a result of Phase 2 port activities. Oil pollution is one of the major hazards associated with port and shipping operations. The main source of oil pollution at the port of Buchanan is likely to be the bilge oil released from vessels. This is generated during tanker cleaning operations and also during filling operations. There is also potential for major spillage from oil tankers if they use this area.

There has also been a legacy of hydrocarbon contamination from LAMCO operations and subsequent war damage to the abandoned facilities. The Company has carried out investigations to demonstrate that some hydrocarbon pollution in the vicinity of the LAMCO oil tank farm does exist, though this is more an issue for soil and groundwater contamination than surface water pollution. The Company has also ascertained that there are high levels of iron content and arsenic in the LAMCO tailings in the port area.

Given the anticipated size of the Phase 2 workforce at the port there is a potential for contamination from sewerage and other waste materials if these are not treated and disposed of properly. The potential to pollute and otherwise affect harbour and marine waters is covered under faunal impacts (Section 9.4).

The level of Impact Significance is considered likely to be Substantial.

Mitigation

International standards will need to be followed in the design, construction and maintenance of all oil handling facilities. A site-specific EMP should be devised and implemented for the safe handling of oil from quayside to storage facility, and an Emergency Response Plan should be put in place to respond swiftly to any spillages that do occur. International standards should be followed for ship operation and port protection practice, such as the IFC Environmental, Health, and Safety Guidelines for Ports, Harbours, and Terminals (2007) and AML emergency action plan. In this regard the Company should prepare a plan detailing the method of intervention, steps to be taken and responsibility of personnel during an emergency spill or leakage.

Ballast water management should follow the guidelines proposed by the ‘International Convention for the Control and Management of Ship’s Ballast Water and Sediments’. These and the applicable corporate standards must be enforced and closely adhered to. As regards the avoidance and control of oil spills the regulation of ship discharge is crucial. Appropriate mechanisms should be put into place for the management of accidental spillage. These include the use of recovery vessels, oil fences and chemicals used to treat oil spills (for example dispersants, surface washing agents, bioremediation agents and miscellaneous oil spill control agents).

The Company has located its Phase 2 facilities in its layout design to avoid the areas of known legacy contamination. The port should be designed with hard standings and suitable drainage to contain any contaminated runoff, including appropriately designed and dimensioned sediment traps and oil-water separators. During Phase 1 the Company constructed a storage shed to protect DSO from rainfall runoff. Phase 2 will stockpile concentrated ore in a different location. Any ore suspended in runoff water will be captured in a large sedimentation pond shown in Dwg 4.3 at the southern end of the main onshore port facility area. This and the other sedimentation ponds will be required to help prevent other land-based pollutants from entering the harbour, and all drains and roads should be cleaned before the onset of the wet season to avoid land-based pollutants from flowing into the sea.

Residual Impact

The level of Residual Impact Significance is considered likely to be Moderate.

9.2.2 Hydrogeology

To a large extent the potential sources of surface water contamination described above have the potential to pollute groundwater and water supplies derived from it wherever surface water is in hydraulic conductivity with the water table or perched water tables.

The impact assessment for hydrogeology and groundwater is constrained by a lack of data. This applies as much to the assessment of groundwater yield and groundwater quality at Yekepa and Buchanan as it does to the assessment of impacts likely to arise, for example from mine and port operation. One of the key recommendations made during the Phase 1 ESIA, that equally applies to this ESIA, is for a greater investment in groundwater investigation and groundwater modelling so that yields, quality and impacts can be understood and predicted more effectively.

9.2.2.1 Mine Sites

Impacts

Spillages and leakages of fuel, oil and other contaminants could pass through surface water bodies and the soil to contaminate groundwater. Communities bordering the mine area have already indicated that their well water supplies contain elevated levels of iron content, but some of these may have fallen into disrepair and may in fact be due to naturally high levels of iron or LAMCO legacy.

The engineering studies carried out on behalf of the Company indicate that, at Tokadeh at least, dewatering will be required in order to be able to progress mining operations beneath the water table. This will mean that any contamination that may arise as a result of mining, whether it is from ARD, heavy metals or from chemical sources, will directly enter the groundwater. There is insufficient knowledge of the groundwater regime of the area, and its relationship with downstream users, to be able to determine what effect this might have.

It is understood from the Company that all water supply to the mine will be derived from surface water and there will be no groundwater abstraction for this purpose.

The level of Impact Significance is considered likely to be Moderate.

Mitigation

As with surface water hydrology, it will be important to adopt all necessary safeguards to protect the groundwater from contamination. This should include the adoption of industry standards in the handling and storage of hazardous materials including the use of containment measures around storage facilities, workshops, power generating facilities and other fixed plant locations.

A programme of groundwater investigation and well monitoring is recommended to enable the groundwater regime to be modelled and the quality of drinking water to be assessed prior to, during and after Phase 2 operation.

Residual Impact

The level of Residual Impact Significance is considered to be Slight to Moderate.

9.2.2.2 Buchanan Estate

Impacts

Potential impacts relate primarily to the quantity and quality of the existing water supply and the potential to contaminate it through leakages from power generating facilities, drilling operations for groundwater, waste disposal and sewage treatment. All of these effects could lead to pollution and contamination of the physical environment, including groundwater. The use of chemical herbicides to keep grass and weeds down around the Estate compound and the use of pesticides to control the insect population could also cause soil and water pollution effects.

The quantity and quality of the aquifer at Buchanan Estate is not known because drilling records from LAMCO investigations are no longer available. On the basis of current best estimates, the aquifer recharge value for Buchanan Estate is 7.5 million m^3/year with a total volume available from dry season storage of 0.91m^3/year. It is not yet clear what the potable water demands will be for Buchanan Estate during Phase 2, but it has been reported locally that some communities have observed a reduction in potable water supply from wells, perhaps as a result of the recent increased demands for water. Excessive pumping has yielded iron-rich groundwater at certain times; presumably a function of legacy contamination.

Seawater intrusion may eventually affect the wells in proximity to the sea, leading to poorer quality groundwater. It remains unclear as to if and when the effects of saline intrusion might occur but as abstraction increases the cone of drawdown will contact the interface of the saline water at depth. This will cause seawater to migrate towards the abstracting wells and deterioration in water quality will occur fairly rapidly.

The level of Impact Significance is considered likely to be low to Moderate.

Mitigation

The following are recommended.

- Groundwater resources should be assessed in detail through ground investigation, water quality testing and monitoring to ensure adequacy for drinking water. This is specifically to ensure that there is sufficient yield and quality to supply Estate and port needs without impacting neighbouring communities.
- Handling of fuel, oil and hazardous substances should be according to international standards and best practice.
- Waste disposal facilities should be designed, constructed and operated to international standards and lined to prevent any leaching of contaminated substances to the groundwater.
- Consideration should be given to sea level rise and the impact that this might have on the possible migration of pollutants from the port area.
- Measures to protect the aquifer and groundwater supplies from seawater contamination include abstraction not greater than recharge; wells located at some distance from the coastline (at least 100 m or more); baseline monitoring of key water quality indicators to detect migration of seawater.
- The above should be undertaken as part of a wider Township (Estate) Management Plan that includes integrated sewerage and waste water treatment, waste disposal, water supply and pollution control.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight for the Estate and Moderate for Buchanan City due to increased demands for potable water.

9.2.2.3 Railway

Impacts

The potential to pollute surface water may also affect groundwater and therefore the discussion given in Section 9.2.1.4 will largely apply.

The level of Impact Significance is considered likely to be Slight.

Mitigation

Again, the provisions recommended in Section 9.2.1.4 will largely apply to groundwater as well.

Residual Impact

The level of Residual Impact Significance is considered likely to be Insignificant/Negligible.

9.2.2.4 Buchanan Port

Impact

The potential sources of groundwater contamination are similar to those described above for surface water hydrology. It is already known that LAMCO legacy contamination has given rise to soil pollution, and presumably this has affected groundwater as well.

The level of Impact Significance is considered likely to be Moderate to Substantial.

Mitigation

The Company maintains that it is the Government of Liberia's responsibility to resolve issues of legacy pollution at Buchanan Port and has located all infrastructure so as to avoid known areas of contamination. In terms of Phase 2 operations, it will be necessary to apply all procedures designed to prevent spillages of hazardous and toxic materials and to have measures in place to contain any spillages that might occur.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight to Moderate.

9.3 Land

9.3.1 Landscape Character and Visual Amenity

This section describes the anticipated landscape and visual impacts likely to be associated with Phase 2. These relate principally to planned activities at the mine sites and at Buchanan Port.

9.3.1.1 Mine Sites

a) Landscape

Impacts

Overall it is assessed that, during mining construction and operation, the development would have a substantial adverse effect on landscape character in the Gangra-Yuelliton forest peaks and the Tokadeh montane forests, arising principally from modification of landform and removal of tree cover. Effects on other landscape areas are largely indirect and of lesser significance with the exception of river terraces, which are assessed as being of Moderate significance.

Mitigation

Landscaping of the lowered Tokadeh and Gangra-Yuelliton ridge lines, reforestation of other slopes and operational areas as far as possible, to reproduce the natural profile and re-establish a forest cover forms the main element of landscape restoration.

Residual Impact

Post-rehabilitation of the mine, allowing for the successful establishment of a degree of vegetation 15 years after mine closure, it is assessed that effects on landscape character will decline and be partly mitigated. However, the landform modification is such that effects will remain at Major significance for Gangra-Yuelliton and Tokadeh.

The TMF will become re-vegetated once operations cease, although the level surface will be locally incongruous within the context of the natural topography. It is assumed that the edges of the lakes and the TMF will be re-vegetated with woody species (trials with plants are underway) such that the rehabilitated elements of the Mine Site are substantially integrated back into the landscape.The level of Impact Significance is considered likely to be Moderate in relation to the TMF.

b) Visual Impact

Impact

The visual envelope is characterised by the following factors:

- Elevated but distant views of the Yuelliton and Gangra Peaks are obtained from the Nimba Ridgeline (ENNR);
- Views from lower lying land along the Dayea Valley bottom are extremely variable and dependent on context and the presence of intervening vegetation cover and landform.
- For many locations, visibility of the mine footprint is restricted to the peaks of Tokadeh, Yuelliton and Gangra with lower lying areas of the mine site screened by landform and dense forest.
- Views of Tokadeh are generally separate from Gangra Yuelliton due to distance – in other words there are few locations where all three are visible simultaneously.
- The majority of existing views of the Mine Site are obtained in close proximity from within the 500m buffer zone adopted for resettlement purposes;
- Views from the Yekepa to Saniquellie Road are limited to occasional views of the peaks of Tokadeh, Yuelliton and Gangra, but not simultaneously and often singularly, where gaps in the roadside forest and an elevated location in the landform combine to create a viewpoint.
- Views from Yekepa and New Yekepa include the distinctive outline of Mount Yuelliton.

Views of the proposed Mine Site from within the study area are obtained in close proximity and from more distant elevated locations, including the main Nimba ridge. For most areas at lower elevations, including the majority of villages, visibility of the Mine Site is restricted by tree cover to the upper sections of the three mountains which form part of it, i.e. Mount Tokadeh, Mount Gangra and Mount Yuelliton. From locations to the west of the Tokadeh and Gangra-Yuelliton ridgelines, the forested nature of the slopes will not be changed by the proposed development although the distinctive outline of both peaks will be permanently removed and there will be a reduction in the height of Mount Yuelliton of approximately 100m whilst that of Mount Gangra will be approximately 70m. Note however that, according to the cross-sections, the maximum depth of mining, including pit depth below original ground, will be of the order of

200m, though a proportion of this will be shielded by *in-situ* ground left remaining either side. If this remaining ground is removed as well, then the visual effects will be significantly greater.

Potential visual effects relate to:

- Clear felling/removal of trees over the extraction and mine-related areas;
- Modification of landform from natural slopes to a mined landform of faces and benches which exposes the underlying geology and results in a change in colour from the green of the forest to the red tones of the laterite/iron ore which underlies it;
- Removal of the distinctive peaks of Mount Gangra-Yuelliton, involving a reduction in the height of Mount Yuelliton by approximately 100m and of Mount Gangra by approximately 70m;
- Views of machinery and processing plant (e.g. the concentrator plant & crusher);
- Views of stockpiles and rail loading for transportation to Buchanan;
- Lighting at the concentrator plant and the working areas in the context of a largely unlit environment, Yekepa being the main exception.

Other elements of the Mine Site such as spoil heaps and the TMF will not be visible due to the screening landform/forest in the fore and middle ground.

The level of Impact Significance is considered likely to be Modrate from receptors at Buchanan and very high from a recreational perspective, i.e. if viewed from the East Nimba Ridge. Elsewhere visual impact significance both during construction, operation and post-operation is considered likely to be Slight.

Mitigation

Mitigation of the potential visual impacts of the Mine Site has been incorporated into the design of the extraction areas and the Mine Closure Plan in the following ways:

- Substantial retention of the western slopes of the landforms such that visual impact from locations to the west are limited;
- Landscaping of the lowered Tokadeh and Gangra-Yuelliton ridge line to reproduce the natural profile and re-establish a forest cover;
- Retention of sufficient forest areas or blocks of trees to act as screening;
- Siting of the concentrator plant, TMF and waste dumps at a low elevation within forest retained for screening purposes;
- Rehabilitation of the Mine Site through scarifying and landscaping, topsoiling, and re-vegetation.

Residual Impact

The lowering of the ridge lines of Tokadeh and Gangra-Yuelliton will remain a significant landscape impact, but it will only be noticeable from distant elevated views. At 15 years post closure of the Mine Site operation, visual impact will, subject to successful rehabilitation and re-vegetation, decline in magnitude and significance to a maximum of moderate adverse. This reflects the fact that the most visible sections of the workings will be partially but not fully integrated back into the landscape, and of reduced visual impact.

The level of Residual Impact Significance is considered likely to be Slight to Moderate.

9.3.1.2 Buchanan Port

a) Landscape

Given the context of the development in an operational port and comparison with the former extent of tailings lagoons and industrial activity, it is considered that no adverse effects on the landscape will occur. In fact, the removal of the concentrator plant at the port will result in a slight landscape improvement.

The level of Impact Significance is considered to be slightly positive.

b) Visual Impact

The visual envelope is characterised by the following factors:

- Long views are very limited, with the exception of locations along the beach, due to the screening effect of dense vegetation in the flat landscape;
- The majority of existing views of the Buchanan Port site are obtained in close proximity from the roads adjacent to it;
- Access to locations in close proximity to the port and unloading rail facility is limited by perimeter fences distant from it;
- The height of the concentrator plant, estimated to be in excess of 20m, results in it being the most visible element outside of the secure port. Cranes in the secure port area form the other visible element;
- Views from residential areas under the control of the Company and UN are limited by distance and intervening vegetation;
- Views, principally of the concentrator plant, are obtained from Motown, the nearest residential suburb of Buchanan.

Views of the operational port are extremely limited as a result of the amount of vegetation cover which provides screening in the flat landscape and the restrictions on access to the facility which arise from security fencing. The most visible and intrusive element of the port facility is the redundant concentrator plant.

The potential visual effects relate to:

- Continued use of the rail terminal, stockpiling of iron ore pre-shipping and loading/unloading of the ore;
- Lighting is currently present and at levels appropriate for the industrial context;
- Positive improvements in visual amenity resulting from the removal of the concentrator plant.

The level of Impact Significance is considered to be slightly positive.

Mitigation

The removal of the redundant concentrator plant, which currently forms the most visible element of the site from all external locations will reduce visual impact from the port facility in comparison with the existing/baseline situation. No other mitigation measures are proposed.

Residual impact

There will be an overall slight improvement in visual impact.

9.3.2 Land Use

9.3.2.1 Mine Site

Dwg 9.3 shows the location and extents of the Phase 1 and Phase 2 footprint, the Phase 1 and Phase 2 exclusion zone and the Phase 2 additional landtake for Year 0 TMF, Year 1 TMF and concentrator borrow pits and also the additional landtake in relation to Borrow Pits for the life of the mine.

The total area of landtake comprises the Phase 1/Phase 2 mine and mine facility footprint and the safety (exclusion) zone around it. Table 9.12 shows the distribution of land use types within the Phase 1/Phase 2 footprint. These land uses will be removed as a result of the works and they total 1781.51 ha in area. Including the additional landtake for the borrow areas that fall outside of the Phase 1/Phase 2 footprint the total land use to be replaced by mining activities equals 1942 ha. Table 9.13 describes what is meant by the various mine facility classifications.

The total area of landtake within the exclusion zone buffer (outside of the mine footprint) is 2146.38 hectares as shown in Table 9.14. Therefore, the total landtake from the mine footprint, exclusion zone buffer area and additional landtake for borrow areas amounts to 4,088 ha (the combined totals from Tables 9.12 and 9.14). Of this there are 384 ha of farmland, 728 ha of palm-rich secondary forest and 12 ha of plantation. Combined with village areas of a little over 8.5 ha, the total of what might be defined as community or private land that is either permanently or periodically productive that will either be destroyed or removed from public use for the period of the Phase 2 operation is approximately 1,132 ha. Some of the forest areas will also be important sources of NTFP but these cannot be quantified from these figures. A total of 1,475 ha of forest will be destroyed by the Phase 1/Phase 2 footprints including additional land take for known borrow areas, of which 233 ha is considered to be high quality from a biodiversity perspective. All of this land is classified as Level 1 environmental constraint areas. A total of 250 ha of land within the footprint and known borrow areas is considered to be Level 1 environmental constraint area, and will therefore be lost.

TABLE 9.12: LAND TAKE REQUIREMENTS ACCORDING TO LAND USE CATEGORY AND PHASE 1 & PHASE 2 ELEMENTS

Component	Total area (ha)	Forest area (ha)	Moist Evergreen Forest (ha)	Montane Forest (ha)	Farmland (ha)	Other Land Cover (ha)	Level 1 constraints (ha)	Level 2 constraints (ha)
Concentrator	50.11	23.92	0.52	0.00	0.19	25.48	0.52	13.81
Treatment Pond	146.05	93.85	2.93	0.00	26.69	22.58	2.93	123.74
TMF	303.81	192.20	68.45	0.00	31.51	11.65	68.45	135.25
Topsoil & Vegetation Stockpile Area	14.74	9.36	0.00	0.00	5.35	0.03	0.00	3.19
Ditches	5.27	2.20	2.21	0.00	0.59	0.27	2.21	4.01
Gangra Mine Site	332.70	269.76	16.99	0.15	33.05	12.75	27.81	115.90
Yuelliton Mine Site	254.39	200.93	14.23	5.89	22.02	10.89	20.82	78.79
Tokadeh Mine Site	613.24	323.19	97.61	0.00	32.53	159.91	103.66	192.78
Mine Roads	24.29	14.15	6.70	0.00	0.09	3.36	6.70	12.80
TMF Roads	4.42	3.74	0.04	0.00	0.58	0.07	0.04	1.85
Haul Road	32.49	18.32	6.26	0.00	5.78	2.12	6.26	13.80
TOTAL (ha)	**1781.51**	**1151.62**	**215.94**	**6.03**	**158.38**	**249.10**	**239.41**	**695.91**

Additional landtake from Year 0, 1 and Concentrator Borrow Areas	41.68	29.07	5.40	0.00	5.41	1.80	5.40	5.65
Additional landtake in relation to Borrow Pits for the Life of the Mine	118.49	61.57	5.61	0.00	44.99	6.31	5.61	17.76
TOTAL (ha)	**160.16**	**90.64**	**11.01**	**0.00**	**50.40**	**8.11**	**11.01**	**23.41**

TABLE 9.13: EXPLANATION OF TABLE 9.12 COMPONENTS	
Concentrator	Concentrator
Treatment Pond	Yuelliton Sediment Pond, Yuelliton Treatment Pond, Gangra North Sediment Pond, Gangra South Sediment Pond, Sediment Control Ponds, Gangra Treatment Pond, North Treatment Pond, South Sediment Pond, Concentrator Sediment Control Dam, Overflow Spillway, North Dam, Dams, South Dam
TMF	TMF, TMF Seepage Pond
Topsoil & Vegetation Stockpile Area	Topsoil & Vegetation Stockpile Area
Ditches	Ditches
Gangra Mine Site	Gangra Mine Site, Gangra South East Waste Dump
Yuelliton Mine Site	Yuelliton Mine Site, Yuelliton North East Waste Dump, Yuelliton East Waste Dump
Tokadeh Mine Site	Tokadeh Mine Site, Tokadeh Waste Dump
Mine Roads	Mine Roads
TMF Roads	TMF Roads
Haul Road	Haul Road
Additional landtake from Year 0, 1 and Concentrator Borrow Areas	Concentrator Proposed Stockpile Areas for Topsoil and Vegetation, Proposed Concentrator Borrow Areas for Approved Engineering Infill, Year 0 Additional Stripped Topsoil Areas, Year 0 Pre Dep Proposed Borrow Areas for Approved Engineering Infill, Year 1 Additional Stripped Topsoil Areas, Year 1 Proposed Borrow Areas for Approved Engineering Infill
Additional landtake in relation to Borrow Pits for the Life of the Mine	Potential Additional Borrow Areas for Approved Engineering Infill, Proposed Stockpile Areas for Topsoil and Vegetation, Year 3 Proposed Borrow Areas for Approved Engineering Infill, Year 4 & 5 Proposed Borrow Areas for Approved Engineering Infill, Year 6 & 7 Proposed Borrow Areas for Approved Engineering Infill, Year 8 & 9 Proposed Borrow Areas for Approved Engineering Infill, Year 10 & 11 Proposed Borrow Areas for Approved Engineering Infill

TABLE 9.14: LAND TYPE COVERAGE WITHIN THE EXCLUSION ZONE BUT OUTSIDE THE PHASE 1/PHASE 2 FOOTPRINTS

Land Cover Type	Area (Hectares)
Montane Forest	1.40
Secondary Forest on Lower Slopes	319.70
Secondary Forest Slopes	14.63
Moist Evergreen Forest	663.82
Palm Rich Secondary	373.73
Raphia Swamp	53.85
Secondary	277.78
Broken Forest	148.92
Broken Forest 800-1000	16.77
Farms	175.59
Legacy and Existing Mine Related Areas	48.39
Plantation	1.77
Submontane Forest	36.40
Villages	4.38
Water	5.60
Uncategorised	3.63
TOTAL	**2146.38**

The values in Table 9.14 have been calculated based on the below buffer distances of the components.

Component	Buffer Distance
Ultimate pit limits	500 metres
Waste dumps, stockpiles, TMF, TMF seepage ponds and sediment dams	100 metres
Concentrator and associated infrastructure, pipelines, access roads, haul roads and sediment ponds (other than their dams)	50 metres
Gangra Haul Road	50 metres

Farmland loss will be high in Gbapa community. Possible areas previously and currently worked for diamonds by artisans in the southern part of Gbapa community will also be affected by the exclusion zone.

Farmland of seven communities will be directly affected by Phase 2 mining (Table 9.15). Areas of land that will be abandoned have been calculated and are intended to provide a relative scale of farmland losses in each zone. Of particular note, Table 9.12 indicates that Tokadeh mine contains the largest of affected farmland (32.53 ha) within four adjacent communities, while the combined are of affected farmland within the tailings management facility (TMF) is 31.51 ha. Mines at Ganga and Yuelliton affect 52.07 hectares of farmland in three communities, and the haul road to Tokadeh is likely to cross about 5.78 ha of farmland (and areas of possible artisanal dimond workings) in Gbapa community.

TABLE 9.15: BROAD OVERVIEW OF FARMLAND LOSSES DURING PHASE 2

Project Development Zone	Community	Farmland to be Abandoned (1)	Remarks
		General Character	
Tokadeh mine exclusion zone	Sehi Geh	Lower slopes below major ridge and undulating plain	Farmers may have received monetary compensation
	Makinto		
	Gbapa		
	Zolowee	Lower slopes below major ridge, undulating plain, valley floors	Loss of forest on upper and lower slopes below ridge; farmers have received monetary compensation
Tailings Management Facility (TMF)	Gbapa	Lower slopes below minor ridge and undulating plain	Farming in the north and east; diamonds in south-east
Tokadeh-Gangra - Yuelliton Haul Road (nominal 50m width)	Gbapa	Undulating plain, valley floor and terraces	Passes through diamond mining area and extensive farmland on the North Gbapa plain
Gangra and Yuelliton mine exclusion zone	Bolo	Lower slopes below major ridge and undulating plain	Loss of forest on upper and lower slopes below ridge; farmers may have received monetary compensation
	Lugbeyee	Lower slopes below major ridge and undulating plain	
	Bonlah	Lower slopes below major ridge	

The level of Impact Significance on land use is considered likely to be Major.

Mitigation

Possible areas in which displaced farmers might be relocated have been identified from the desk study and rapid reconnaissance, and are shown on Dwg 7.1. The extent and availability of these land resources need to be verified through the consultation process at the community and regional level. These identified areas have a similar range of soils to that of farmland that will be lost to mining, but it is obvious that the total area is less, even if it is verified that all shown possible areas are available, and therefore it will not be feasible to relocate every displaced farmer on equivalent land if agriculture is based solely on traditional practices. Moreover, land that may be available to resettle farmers should not include the steep forested upper slopes that are important to traditional local culture and subsistence. There will be some limited, opportunities for relocating farmers within their existing communities or for resettlement in Barpa and New Yekepa. These options would only be open to farmers with strong kinship ties, however, and would require approval by the communities concerned.

Attitudes to the different traditional roles of men and women in farming also need to be considered. 'Free Land' Areas between Yekepa Town and Leagbala could support up to ten additional families using traditional farming methods and, if land bordering the Dayea River could be farmed more intensively, this number could probably be increased. Some additional land is also available around Camp 4.

Current land tenure is complicated by the co-existence of customary tenure and formal land ownership. It is important to verify types of landholding, tribal obligations and the boundaries of communities and protected areas. In particular, the legal status of the 'Free Land' needs to be clarified. If Glaton Hill Quarry in the northern part of the 'Free Land' is reopened, careful planning would be needed to delineate areas intended for farmland, forest and quarry reserves.

Innovative, sustainable agricultural methods should be encouraged, incorporating shorter fallow periods, crop diversification and intensification, and a balanced use of fertilisers, leguminous cover crops and lime. The objective is to increase productivity whilst maintaining optimum soil nutrient levels, and also to improve post-harvest handling to reduce crop losses. New initiatives are more likely to be understood and accepted by farmers if they are founded on existing skills and knowledge. They should initially concentrate on traditional food crops, with gradual introduction of perennial crops and livestock.

These measures are being incorporated into various compensatory and offsetting programmes under development by the Company, including: Resettlement Action Plan; Land Access Programme; Agricultural Intensification Programme; Livelihood Restoration Programme, a Vulnerable Person's Programme and an Offset Programme.

Residual Impact

Despite the various programmes identified above (and in Section 9.6), it will prove difficult to replace lost agricultural land with suitable alternative land and without increasing pressure on other land uses and land resources in the process.

The level of Residual Impact Significance is considered likely to be Major.

9.3.2.2 Buchanan Estate

Impacts

Phase 2 facilities within Buchanan Estate will take place within the existing Estate set up and so therefore no further land will be required. The only exception to this will be the need to establish a suitable alternative landfill site, but the location for this facility is expected to be in the same location as the existing site and the borrow pits adjacent to it.

The level of Impact Significance is therefore considered to be Insignificant/Negligilble.

9.3.2.3 Railway

Impacts

The railway sidings at Gaye Peter Town, Blezi, Grebo, Bakhon, Yila, Tropoi and Kitoma have been extended under a separate permit. There are no other known land take requirements for railway operation under Phase 2 outside of the mine area and Buchanan Port.

The level of Impact Significance is therefore considered to be Insignificant/Negligible.

9.3.2.4 Buchanan Port

There are no known additional land requirements at Buchanan Port for Phase 2.

The level of Impact Significance is therefore considered to be Insignificant/Negligible.

9.3.3 Land Stability

9.3.3.1 Mine Sites

Impacts

The potential for slope and stream channel erosion has been discussed in Section 9.2.1.2 b) in relation to the contribution of sediment to mine runoff.

Slope stability, i.e. the potential for excavated slopes, dumps, TMF and embankments to fail and thus contribute quantities of sediment to the drainage system was also discussed in Section 9.2.1.2 b) and the conclusion is that further investigative and design work is required before the risk posed by these potential hazards can be fully assessed. The potential for the TMF to fail has been examined by the Company's engineering consultant and the likely runout from such an event has been calculated. Such an event would damage or inundate agricultural land downstream in the Dayea River. The ESIA Consultant has reviewed the 2012 report *Slope Stability Assessment for the Tokadeh, Gangra and Yuelliton Open Pits* Prepared by the Company's engineering consultant. While the analysis of bench stability appears to be in accordance with international standards, the potential for failure along deeper geological structures needs to be further assessed and confirmed as exposures emerge during excavations.

The level of Impact Significance is considered likely to be Major.

Mitigation

Given that most elements of the mine earthworks and related infrastructure are at concept or feasibility level, there is expected to be a following phase during which geotechnical investigation, analysis and design will confirm ground conditions, slope designs and the potential for landslides. It is also acknowledged that some elements of the works, including for example the progressive construction of the TMF over time, can only be finalised during operation. It is recommended that engineering geological maps and sections are prepared that allow the stability of each mine site to be assessed in terms of actual ground conditions, including underlying structural geology. The exclusion zone should be defined to allow for landslide/failure runout potential and an Emergency Response Plan should be put in place to cater for such an event should it occur.

The Mine Closure Plan developed for Phase 1 operations included well-considered provision for slope protection and recolonisation through the use of bio-engineering measures and the draft document prepared by the Company for Phase 2 closure includes the same.

The herbaceous vegetation which colonized the mining sites of Northern Nimba (Old Mine, Blue Lake and Mount Tokadeh) and certain parts of the North Nimba plateaux represents an intermediate phase before the return of forest vegetation. Grasses, such as *Anadelphia leptocoma, Loudetia phragmitoides, Melinis minutiflora, Hyparrhenia diplandra* var. d*iplandra* and *Sporobolus dinklagei* are perennial species which ensure good cover of the ground. Reforestation of mine sites by bio-engineering techniques will be possible once slopes have been stabilised against deeper-seated erosion and instability using civil engineering measures. Intensification of the herbaceous layer, prevention of bushfires (including slash and burn) and the introduction of woody species would facilitate a reasonably rapid return of forest cover. However, wherever there is pressure on the land for its utilisation other than for forest, for example for use as agriculture in the mine sites, then this process will be slowed or reversed.

Residual impact

There will remain a risk of slope instability, either through failure along underlying geological planes of weakness that have not yet been identified, or through failure of waste dumps or the TMF. The degree of risk cannot be ascertained at this stage without further information. Commitment to the use of bio-engineering measures and good restoration practice to reinstate mine and other operational areas to productive grassland and forest cover should allow long term residual land stability impacts to be reduced once geotechnical engineering requirements are satisfied.

The level of Residual Impact Significance is considered likely to be Moderate to Significant. A greater understanding of the underlying structural geology will reduce the uncertainty in the potential for slope failures and the design can be modified accordingly. There will always be an element risk from large slope failures and the consequences of such an event taking place are considered to be high. Thus, even with a more thorough geological model, a runout exclusion zone and a well-designed and rehearsed emergency response plan, it is recommended that the level of Residual Impact Significance should not be reduced to less than Moderate.

9.3.3.2 Buchanan Estate

Impacts

There are no envisaged land stability impacts associated with the Phase 2 operation of Buchanan Estate.

9.3.3.3 Railway

Impacts

Several slope failures have been identified along the railway, and these have tended to block the side ditch and, in extreme cases, disrupt the use of the tracks.

The level of Impact Significance is considered likely to be Moderate.

Mitigation

Slope stabilisation, including cutting back slopes and drainage work, is now required at specific locations along the railway. It is considered impractical to re-profile all 'suspect' slopes to a lower angle, particularly if they are currently stable. It is therefore proposed that remedial work is limited to those slopes where significant failures have occurred (i.e. slumped material has blocked the side ditch and steep or overhanging back scarps have been formed). Adjacent slopes should be monitored on a regular basis (for example, annually) to determine whether further stabilisation work is required. Soil slope stability will be improved once side ditches are repaired and lined so that water is efficiently removed and the toes of slopes are not undercut. Stability should also increase once grasses and other low-growing vegetation have become established. These works would also prevent sediment being carried into the drainage systems.

No embankment slope failures were observed during the ESIA fieldwork, but informal site discussions with Company site staff indicated that some instability problems had been encountered during track rehabilitation, possibly related to correction of uneven gradients over embankments. It would be expected that settlement of embankments would have been largely completed over the period since they were constructed, and therefore the cause of the problems experienced may have ceased. It is also conceivable that material in the lower layers of some embankments has been softened where the groundwater level is high or where surface water has been impounded by inadequate drainage. Drainage conditions on the upstream side of all major embankments should therefore be checked and appropriate remedial work carried out. If problems persist at a particular embankment, it will be necessary to carry out a detailed geotechnical investigation in order to determine whether it needs to be strengthened.

Creek and river crossings should also be monitored regularly. Erosion protection measures (e.g. gabion baskets, riprap) could then be installed before serious problems develop.

Residual impact

Residual impacts should become reduced if the above recommendations are put in place.

The level of Residual Impact Significance is considered likely to be Slight.

9.3.3.4 Buchanan Port

Impacts

There are no envisaged land stability impacts associated with Phase 2 operation at Buchanan Port. The potential for foundation failure is not reviewed here.

9.4 Fauna

9.4.1 Mine Sites

Impacts

This review combines some of the key findings from the zoological studies undertaken for both Phase 1 and Phase 2, given that these areas significantly overlap, and that DSO will now be mined as part of the oxide ore in Phase 2 at Gangra-Yuelliton. Further details are contained in Volume 4 of both the Phase 1 ESIA and this Phase 2 ESIA.

Summary

From a global conservation perspective, the Nimba Range is among the most important areas in Africa, with numerous endemic species, many of them globally threatened. The importance of this area is recognised by its inclusion in national and international conservation priority schemes, including the following:

- Mt Nimba is an Alliance for Zero Extinction site, because it is home to species found nowhere else on Earth;
- The Upper Guinean Forests of West Africa, which include the Nimba Range, constitute a Biodiversity Hotspot;
- The Guinean Moist Forests of West Africa, which include the Nimba Range, constitute a Critical Ecoregion;
- The Upper Guinea Forests of West Africa, which include the Nimba Range, constitute an Endemic Bird Area;
- The Nimba mountains are recognised as one of only nine Important Bird Areas in Liberia;
- The Liberian part of Mt Nimba is designated by the Liberian Government as the East Nimba Nature Reserve – one of just three formal protected areas in the country;
- The forests of West Nimba have been proposed for national forest and protected area status in the past, and are now a Community-managed Forest.

The Nimba Range includes “habitat required for the survival of critically endangered or endangered species” including West African Chimpanzee, Nimba Otter Shrew, Nimba Toad, Ringed River Toad and several crab species. For some of these species, it also qualifies as an area with “special significance for endemic or restricted-range species.” The forests of West Nimba also support populations of Critically Endangered, Endangered and restricted-range species, and the main forest block could well meet the criteria for Critical Habitat as the forests, ridge tops and East Nimba do (as defined by the IFC Performance Standards 2012). The proposed mine sites lie at the periphery of West Nimba, and in themselves might not fill those criteria, but unmitigated downstream impacts of mining would almost certainly be considered as affecting Critical Habitat for Nimba Otter Shrew and for crabs, as would unmitigated induced impacts such as increased hunting and clearance for agriculture, for West African Chimpanzee and other large mammals.

From a zoological perspective the most important habitat is the lowland tropical forest. There are pockets of high value forest within the Phase 2 footprint. The swamp at Tokadeh contains a concentration of species of conservation concern. Edge effects will also occur whereby noise and vibration and the effects of dust will reduce the quality of adjacent habitats. Without full mitigation, downstream impacts will result in loss of habitat and choking of wetlands and some fatality to aquatic wildlife due to sediment effects, and iron rich sediments in particular, and reduction in water quality. Globally-threatened species (Critically Endangered, Endangered or Vulnerable) which will suffer some reduction in suitable habitat include, at a minimum, those listed in Table 9.16. Old mining adits at Tokadeh are considered likely to house populations of a globally threatened bat species, and these will be destroyed by the Phase 2 operations. Unmitigated downstream impacts (pollution or loss of swamps and small streams) would affect Critical Habitat for the Endangered Nimba Otter Shrew.

The numbers of globally threatened species (Critically Endangered, Endangered or Vulnerable) which will suffer some reduction in suitable habitat include, at a minimum, the following. At Tokadeh they include: four mammals, two birds, one amphibian, one reptile, four fishes and three crustaceans. At Gangra-Yuelliton, they include: two mammals, three birds, two amphibians and three crustaceans. In addition to these species, hundreds of forest-dependent species, including Near Threatened and Data Deficient species, and species endemic to Upper Guinea, will also lose suitable habitat. Most of these species are dependent on forest habitat, and in addition, one of the mammals, as well as the amphibians, reptile, fishes and crustaceans, are closely tied to freshwater habitats. However, it should also be noted that the proposed mine sites constitute only a small proportion of the total area of suitable habitat for most of these species, and so from the perspective of their global populations, the effects of direct land take and edge effects are likely to be relatively small.

The induced effects of any increases in hunting, fishing and farming in the wider Nimba area could likewise have long term impacts far in excess of those from the direct loss of habitats. Hunting and trapping is probably already at unsustainable levels for species such as the larger hornbills, Grey Parrot, Jentink's Duiker, West African Chimpanzee, and other rare mammals. The eventual loss of these and other forest-dependent species from West Nimba is a distinct possibility, and could be hastened by the increased human pressures that will result from both Phase 1 and Phase 2 mining.

TABLE 9.16: GLOBALLY THREATENED SPECIES THAT WOULD BE AFFECTED BY HABITAT LOSS

Gangra-Yuelliton	Tokadeh
Mammals	**Mammals**
1. West African Chimpanzee	1. West African Chimpanzee
2. Sooty Mangabey	2. Sooty Mangabey
3. Aellen's Roundleaf Bat	3. Western black-and-white Colobus
	4. Nimba Otter Shrew
Birds	**Birds**
4. Green-tailed Bristlebill	5. Green-tailed Bristlebill
5. Yellow-bearded Greenbul	6. Yellow-bearded Greenbul
6. Nimba Flycatcher	7. Nimba Flycatcher
Amphibians	**Amphibians**
7. Kassina arboricola	8. Conraua alleni
8. Conraua alleni	
9. Arthroleptis crusculum	
	Reptiles
	9. West African Dwarf Crocodile
Fish	**Fish**
10. Barbus eburneensis	10. Barbus eburneensis
11. Doumea chappuisi	11. Doumea chappuisi
12. Procatopus nimbaensis	12. Procatopus nimbaensis
13. Aphyosemion viride	13. Aphyosemion viride
	14. Nimbapanchax petersi
	15. Barbus boboi
Crustaceans	**Crustaceans**
14. Lugbe River Crab	16. Lugbe River Crab
15. Lobster Claw Crab	17. Lobster Claw Crab
16. Dwarf River Crab	18. Dwarf River Crab

Downstream effects on aquatic species will be experienced over a wider area, and have the potential to affect a substantial proportion of the global population of localised and threatened species, most notably the Lugbe River Crab and Nimba Otter Shrew. The main activities affecting aquatic invertebrates in the concession area are likely to be:

1. Direct loss of habitat in mining areas, waste dumps and stockpiles;

2. Removal of vegetation in catchments will affect seasonal patterns of flow, leading to greater peak flows and diminished dry season flows;

3. Loss of forest cover along small streams at Gangra and Yuelliton will result in greater exposure of the water to sunlight and make these streams unsuitable for some species. Some crab species, for example *L. nimba,* are intolerant of the greater fluctuations in water temperature and oxygen content that occur in streams when forest canopy is removed.

4. Increased suspended sediment loadings in streams as a result of exposed soil and runoff from mining areas, waste dumps, haul roads and stockpiles;

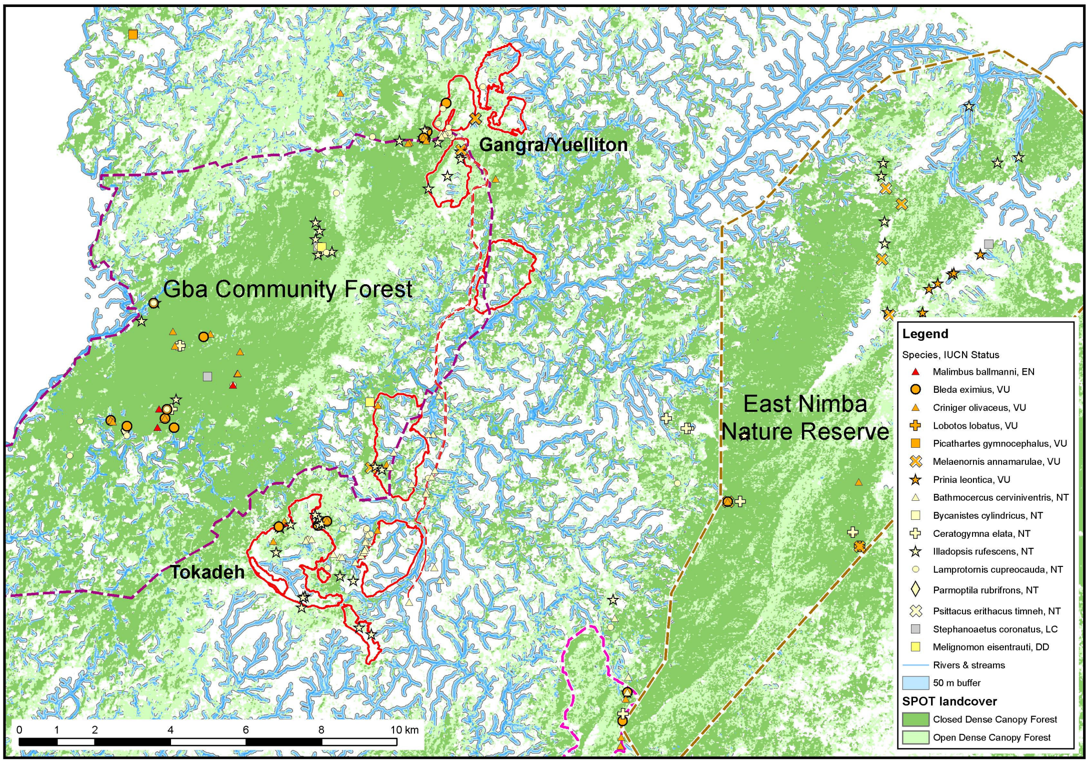
5. Increased pollution from oil, detergent, sewage and other pollutants as a result of increased human population in the concession area.

Selected Species Groups

Birds

Figure 9.3 shows the distribution of Globally Threatened, Near Threatened or Data Deficient bird species encountered during baseline surveys in the Company's Concession Area. It shows the Phase 1/ Phase 2 layout, and the figure is a useful indicator of the value of the Phase 2 sites in this regard.

Figure 9.3: Distribution of Globally Threatened, Near Threatened or Data Deficient bird species encountered during baseline surveys in the Company's Concession Area



Despite the fact that habitats in the proposed Phase 2 mining areas have been damaged by previous mining, road-building, fires, farm clearance and logging, they still support quite a rich avifauna. Two globally-threatened bird species and up to six species of global conservation concern have been recorded from the proposed Phase 2 sites. At Tokadeh and on Gangra-

Yuelliton, near-threatened species encountered include Black-headed Rufous Warbler, Rufous-winged Illadopsis and Copper-tailed Glossy Starling, while Vulnerable species include Green-tailed Bristle Bill and Nimba Flycatcher. As well as continuing to support threatened species and many forest species, the West Nimba area is also showing signs of the incursion of non-forest species as a result of reductions in forest cover.

The mine sites comprise a relatively small and peripheral part of the West Nimba forest block, and as they are composed mainly of disturbed and fragmented habitats, their value is lower now than it would have been in the past. However, in the context of ongoing forest loss in Liberia and the rest of the overall Upper Guinea Rainforest region across humid West Africa, any remaining fragments of closed canopy forest (such as those in the northernmost waste dump at Tokadeh and the waste dump and stockpile at Gangra) must be considered as being of high conservation value for birds. Such valuable habitat is found in the larger blocks of less disturbed forest, but also in smaller patches of good quality forest, disturbed forest which has regeneration potential, lowland swampy habitats occupied by Black-headed Rufous Warbler and Hartlaub's Duck, and high-altitude forest edge and shrubby habitats occupied by Sierra Leone Prinia. The West Nimba forest can be considered to be Critical Habitat for the Endangered Gola Malimbe, and both West and East Nimba forests (including open habitats at high altitudes, and good forest within the proposed footprint at Tokadeh and the TMF area) also qualify as Critical Habitat because of their significant importance to endemic and/or restricted-range species such as Nimba Flycatcher and Sierra Leone Prinia. Lowland swamps and streams, including those in the TMF area, may qualify as Critical Habitat because of their unusually high densities of the endemic Black-headed Rufous Warbler.

Dragonflies and Damselflies

Several important species of dragonfly have been recorded in Phase1/Phase 2 mining areas, including:

- One globally endangered on Gangra-Yuelliton;
- Three globally near-threatened at Tokadeh, Gangra and Yuelliton; and
- Two regionally vulnerable at Tokadeh/TMF.

The valley in which the main Gangra-Yuelliton waste dump is proposed, for example, harbours several well-forested headwaters of the Kahn River. Dumping waste into valleys affects the hydrology of its stream systems and increases silt-laden run-off into them.

Butterflies

The Giant African Swallowtail *Papilio antimachus* (Data Deficient), the largest butterfly in Africa, was seen hill-topping in the ENNR and on Mount Gangra. The Giant Scarce Sprite *Katreus johnstoni*, a rare butterfly indicative of “high quality forest”, was encountered at the site of a proposed waste dump in at Tokadeh. Two species new to science were found only within the proposed Phase 2 footprint area (one on Mount Gangra and one at the site of the proposed Tailings Management Facility).

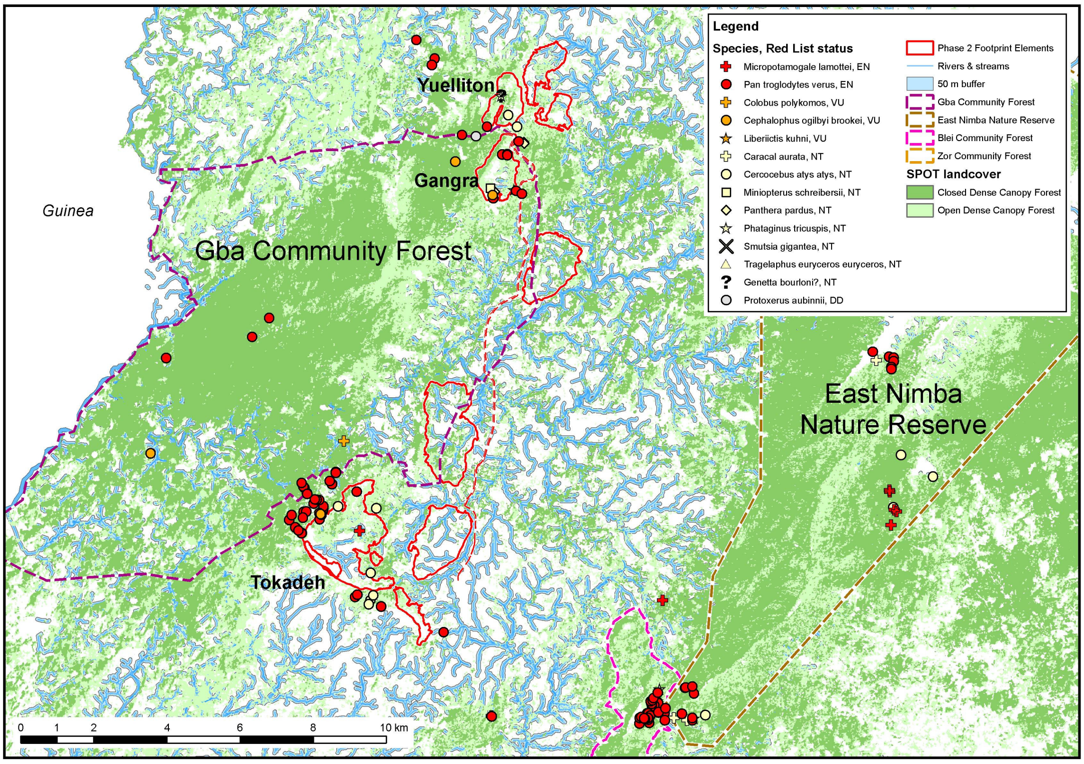
During field surveys of the mine sites, 51 species of the Nymphalidae family were recorded in just six days, which indicates that butterfly diversity in general is high. The majority of interesting records were obtained on the summit of Mount Gangra. The IUCN red-listed *Papilio antimachus* was detected hill-topping above the canopy. *Iridana hypocala* – a species believed not to occur west of the Dahomey Gap – was collected displaying, and a male of an undescribed *Aphnaeus* in the *A. liberti*-group was also caught hill-topping. The majority of the very few Lipteninae species were also recorded from the summit of Gangra, including the very rare *Mimeresia moyambina*, *Eresina fusca* and two *Epitola* species: *Cerautola crowleyi*, *Stempfferia ciconia*. The species composition, especially the large number of rarities, despite the very low detected richness, clearly indicates a high diversity of butterflies on Mounts Yuelliton and Gangra. The presence of hitherto undescribed species, which might prove unique to the upland forests of West Nimba, emphasises the conservation importance of these montane habitats.

The implementation of Phase 2 will require the removal of the summits of Mounts Gangra and Yuelliton and the lower ridges at Tokadeh and Gbapa. These habitats will be removed completely by mining and the result will be the elimination of the butterfly fauna of these areas. The loss will be irreversible because many forest-dwelling butterflies have limited ability to disperse through large open (hostile) areas, which serve as ecological barriers. Even if the Gba Community Forest in Nimba West becomes a biodiversity offset area, it lies very far from the other protected area (ENNR), and dispersal of butterflies and gene-flow between populations in the two areas would be improbable.

Mammals

Figure 9.4 shows the distribution of Globally Threatened, Near Threatened or Data Deficient mammal species encountered during baseline surveys in the Company's Concession Area. It shows Phase 1 layout and not Phase 2, but the two are similar and the figure is a useful indicator of the value of the Phase 2 sites in this regard.

Figure 9.4: Distribution of Globally Threatened, Near Threatened or Data Deficient mammal species encountered during baseline surveys in the Company's Concession Area



The West Nimba area is of global significance for its primate populations, with a healthy population of West African Chimpanzees (Endangered), at least four monkeys (including two globally Vulnerable species) and three or four species of prosimians. All of these species are highly dependent on forest habitats. They are coming under increasing pressure in West Nimba from deforestation for farming and hunting for bushmeat. Mining might increase those pressures, by adding to the local human population, increasing access and displacing some farmers, but even without mining, all of those threats are likely to continue increasing. Already, the Upper Guinea Red Colobus might have been hunted to local extinction, and the Diana Monkey might not be far behind it.

Arguably the mammal of highest conservation significance that has been confirmed to occur in the proposed mining area is the Nimba Otter Shrew. This is a highly restricted freshwater endemic, with a global range size (Area of Occupancy) of only 10,851 km^2. Thus the total area of the habitats in which it is found is smaller than that of Nimba County. It has been identified as one of the top 100 most Evolutionarily Distinct and Globally Endangered mammals in the world. Otter shrews are not closely related to either otters or shrews: their closest cousins are the strange hedgehog-like tenrecs of Madagascar.

A number of old mine adits were located on Mounts Gangra and Yuelliton during Phase 1 DSO Additional Faunal Surveys in December 2010). These adits are mostly above 800 m, with some of them above 900 m. Since these adits are expected to be destroyed or disturbed during the Phase 2 operations, it was suggested that bats be translocated and a basic procedure was outlined in the Addendum to the Phase 1 ESIA (URS 2011). Amongst the bats to be translocated there are three species of special concern. *Hipposideros marisae* is listed as Vulnerable (IUCN 2011), and *Rhinolophus hillorum* as Near-Threatened (IUCN 2011). *Miniopterus schreibersii villiersi* is probably a new species (*Miniopterus villiersi*) which has not been evaluated, but is endemic to the Upper Guinea forests. Of the threatened species, only two were recorded within the tailings management facility (*Pipistrellus crassulus bellieri* and *Pipistrellus* cf. *grandidieri*). The Company has identified possible locations to construct new habitats for translocation in similar elevation sites in the ENNR, and has opened discussions with the Reserve's Co-Management Committee for permission to undertake this work.

Further species of high conservation concern might occur, but are difficult to detect, and their presence in the proposed mining areas is not confirmed. The most important of these are Liberian Mongoose (Vulnerable), Johnston's Genet (Vulnerable) and, in less disturbed parts of West Nimba, it is possible that Pygmy Hippopotamus (Endangered) occurs. For most of these species, protection of intact forest habitat is a key priority, so their discovery would not greatly alter the management recommendations for the area. The direct impacts of habitat loss on chimpanzees due to Phase 1 and 2 mining will be relatively small.

The available information is sufficient to indicate that the area is of global conservation significance for mammals. Pockets of forest at Gangra and Yuelliton and at Tokadeh continue to support mammals of global conservation concern. Freshwater habitats are also important, and despite the legacy impacts of past mining activity, continue to support Nimba Otter Shrew at Tokadeh.

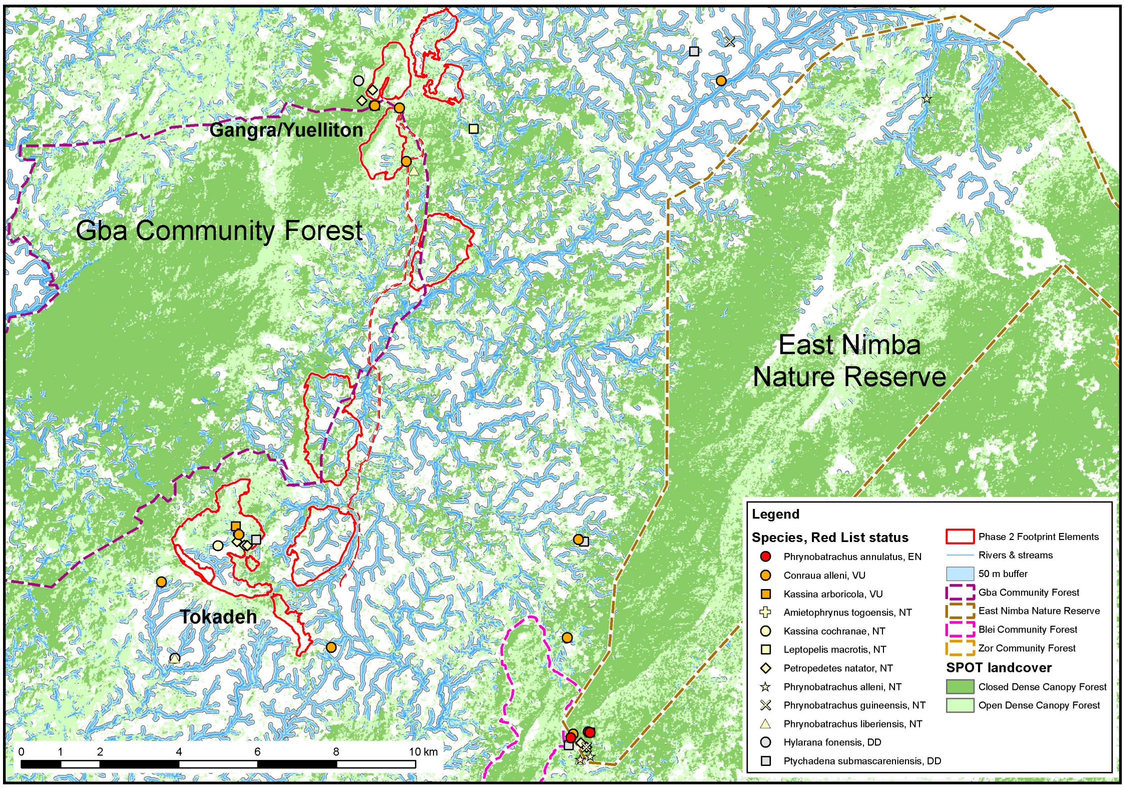
Reptiles

One globally threatened reptile species has been recorded from the proposed Phase 2 sites: African Dwarf Crocodile. This species is also listed on CITES Appendix 1, which means it is considered threatened with extinction by CITES. African Dwarf Crocodiles mainly inhabit streams and swamps in forested areas and were reported from several swamps at Tokadeh, including from a forest swamp within the proposed Phase 2 mine.

Amphibians

Figure 9.5 shows the distribution of Globally Threatened, Near threatened or data Deficient amphibian species encountered during baseline surveys in the Company's Concession Area. It shows Phase 1 layout and not Phase 2, but the two are similar and the figure is a useful indicator of the value of the Phase 2 sites in this regard.

Figure 9.5: Distribution of Globally Threatened, Near Threatened or Data Deficient amphibian species encountered during baseline surveys in the Company's Concession Area



Although the Nimba Toad *Nimbaphrynoides occidentalis* (Critically Endangered)[9] and Ringed River Frog *Phrynobatrachus annulatus* (Endangered) were not found in the proposed mine sites, a number of other globally Vulnerable and Near Threatened species were found. At least two and probably three globally threatened amphibian species have been recorded from the proposed Phase 2 sites. The presence of the Guinea Screeching Frog at Tokadeh could not be confirmed, but calls consistent with this species were heard in suitable habitat. The Ivory Coast Running Frog has been reported only from Tokadeh, from within the site of the proposed Phase 2 resource pit. It is restricted to West Africa and according to the IUCN is known only from around 5 sites worldwide. In addition, the proposed Phase 2 sites support a further nine species which are considered globally Near Threatened or Data Deficient: Togo Toad *Amietophrynus togoensis*, *Hylarana fonensis*, Cochran's Running Frog *Kassina* cf. *cochranae*, Big-eyed Forest Treefrog *Leptopelis macrotis*, Sierra Leone Water Frog *Petropedetes natator*, Allen's Puddle Frog *Phrynobatrachus alleni*, *Phrynobatrachus guineensis*, Liberian Puddle Frog *Phrynobatrachus liberiensis* and *Ptychadena submascareniensis*.

Fishes

Four of the species found during the BioPA surveys are considered globally Vulnerable (*Barbus eburneensis, Doumea chappuisi, Aphyosemion (Archiaphyosemion) viride* and *Procatopus (Rhexipanchax) nimbaens*). All four of these species were found in streams in or downstream of the proposed mine sites. Mining activities will inevitably have major adverse

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[9] *N. liberiensis* is now considered a junior synonym of *N. occidentalis* (Sandberger et al. 2010)

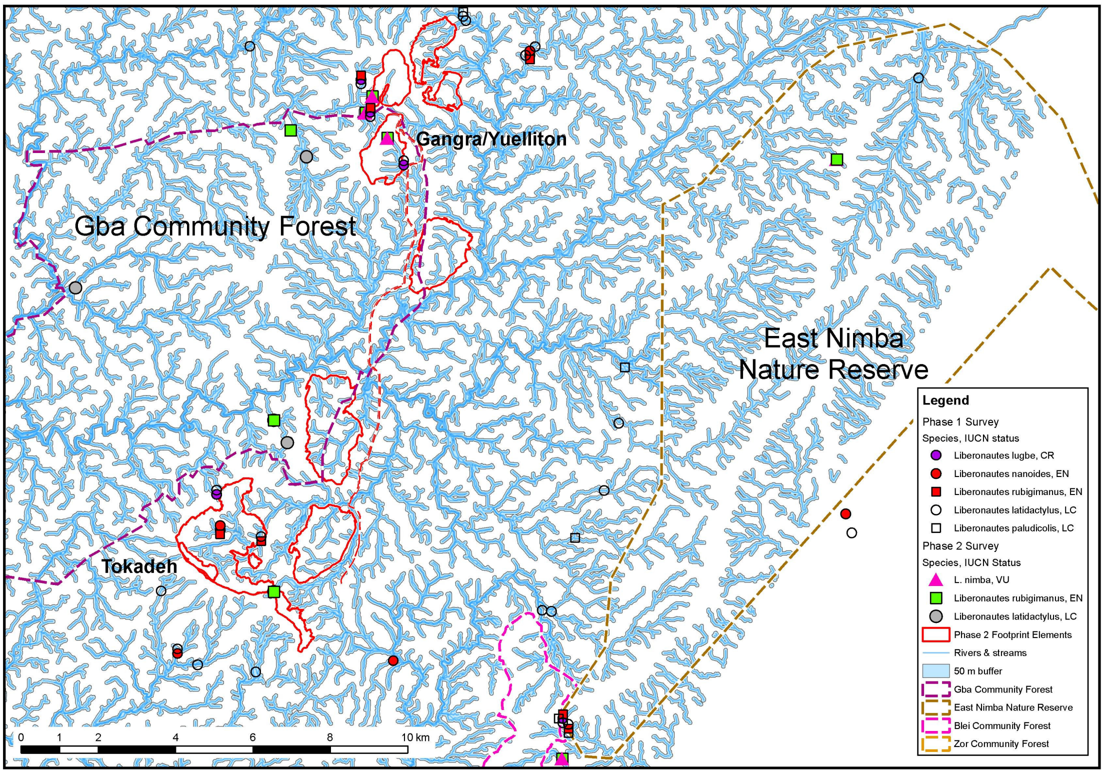
impacts on the fish populations of these streams. Even if sediment and other pollutants are contained within the sedimentation ponds described in Section 9.2.1.2 b), the effect on flow regime, i.e. an increased incidence of low and very low flows may significantly affect fish populations. The current intention is to maintain a base flow of treated water from the northerly of the Eastern Sedimentation Ponds into the Madayea River, but other streams, draining to the east of the TMF and to the east of Tokadeh may experience significantly reduced low flows. Fish populations in the Dayea and Gba Rivers in particular are prone to the effects of increased sediment load and degraded habitats. Furthermore, the rural populations that are at least partially dependent on fish and crustaceans for animal protein may not be among those people best able to capitalise on the economic opportunities offered by mining. The streams in the previously mined area around Yekepa have recovered well from earlier degradation, and contain high fish diversity and fish numbers demonstrating the resilience of fish, but nevertheless they lack forest stream-dwelling species such as *Nimbapanchax.leucopterygius* and *Epiplatys. olbrechtsi*. They support in particular the fauna of fast-flowing rocky streams, such as the amphiliids, *Labeobarbus* spp and *Labeo parvus*.

Crustaceans

Freshwater crabs must be treated as a high priority group, as two Critically Endangered species are known from the area of influence, one of them (the Lugbe River Crab *Liberonautes lugbe*) was reportedly found in small streams at Gangra-Yuelliton and Tokadeh., and the other (the Grandbassa River Crab *Liberonautes grandbassa*) was reported from the railway corridor (see below).

Figure 9.6 shows the distribution of Globally Threatened, Near threatened or data Deficient crab species encountered during baseline surveys in the Company's Concession Area. It shows the Phase 1/ Phase 2 site layout, and the figure is a useful indicator of the value of the Phase 2 sites in this regard.

Figure 9.6: Distribution of Globally Threatened, Near Threatened or Data Deficient crab species encountered during baseline surveys in the Company's Concession Area



Bushmeat

An indirect source of impact will be the increased pressures on bushmeat hunting as a result of a likely population increase, reduced livelihoods among local farmers and improved access to forest areas. The Near Threatened bat *Eidolon helvum* occurs within the Company's concession area, both at Yekepa and Buchanan. It is recommended that this species be given special protection by informing employees and local hunters not to hunt it. Hunting is probably the biggest threat to this species. Shooting by local hunters is probably more likely at Yekepa than at Buchanan.

The level of Impact Significance on zoology in general is considered likely to be Major.

Mitigation

The Consultant has already provided advice on how certain components of the proposed Phase 2 footprint could be designed to avoid some impacts described above and the Company has used the Environmental Constraints Maps (Dwgs 9.4 and 9.5) to assist in designing layouts so as to avoid sensitive areas as much as possible. According to the IFC (2012) guidelines, mitigation should 'be designed to achieve no net loss of biodiversity where feasible.' Attention should be focused on protecting areas of high value forest and habitat on slopes adjacent to the Phase 2 mining areas and the tailings and waste dump sites. The Company has committed itself to the total protection of slopes to the west of Gangra-Yuelliton and to the west and south of Tokadeh.

The majority of the species of conservation interest in the Nimba area are wholly or partly dependent on forest habitats, so the conservation of what remains of those habitats in the area is a key priority. Where feasible, adjusting the exact locations of the Phase 1 and Phase 2 layouts, particularly those where there is good forest cover east of Gangra and east of Tokadeh Area A, would be the single most effective way of reducing the project's direct impacts on birds. Key priorities for the conservation of amphibians are the protection of watercourses, especially streams in intact forest, leaf litter habitats in intact forest; and for the Nimba Toad, high altitude grasslands and ridges above 1200 metres in the ENNR. The occurrence of four globally threatened fish species adds yet more weight to the conclusion that protection of freshwater habitats from adverse impacts of mining should be of the highest priority in West Nimba. Within the catchments where some impact is unavoidable, these impacts should be mitigated by minimising the transport of sediment and pollutants into watercourses.

As recommended in the Phase 1 ESIA, mitigation will be required of the indirect impacts of the mining project on habitats and species within the wider area surrounding the proposed mining sites. This should include measures to ensure that the influx of workers does not result in increased rates of land clearance, bushmeat hunting and water pollution from domestic sources. To control land clearance will require initiatives on two fronts: first, to strengthen protection of existing forests, and second, to improve agricultural productivity with the specific aim of reducing further demand for farmland. To help meet the first objective, support to the managers of the East Nimba Nature Reserve and the West Nimba (Gba), Blei and Zor Community Forests to develop effective management systems and employ patrols would be appropriate. For the second, extension support and farmer field schools to improve productivity on existing farmland will be needed. The Consultant understands that some progress is already being made in this regard through the Company's Phase 1 Biodiversity Conservation Programme.

To reduce hunting, effective enforcement of the East Nimba Nature Reserve as a no-hunting zone is needed. The ENNR is under-resourced and has limited capacity to carry out effective patrols, so additional support to the Reserve office could have a relatively large impact for a modest investment. As mentioned in the Phase 1 ESIA, resources are needed to pay for local representatives in communities surrounding the ENNR (who act as local guards as well as ambassadors), for maintaining the boundary demarcation, for vehicles, fuel and uniforms, and in the medium-term, for relocating the Reserve headquarters to a more suitable location. The Company should also adopt a zero-tolerance policy on illegal bushmeat hunting, trading and consumption.

Measures also need to be put in place to minimise the risk of increases in pollution from oil, detergent, sewage and other pollutants as a result of all Phase 2 mining and related activity and the increased human population in the Concession Area. Such measures will include the adoption of all necessary international standards and protocols in the transport, storage and handling of fuels, oils and other hazardous materials. Also included should be the full rehabilitation of sewage and waste water treatment facilities at Yekepa, appropriate facilities for sewage disposal on-site at Gangra-Yuelliton and Tokadeh, and provision of alternatives to car-washing in the Dayea River (e.g. a car-washing area with simple primary treatment of grey water to prevent detergent and oil entering the river).

Residual impact and bio-diversity offsets

Even when all required avoidance, reduction and mitigation measures are implemented, there will be appreciable residual impacts of mining in the proposed Phase 2 sites. If the proposed Phase 2 mining plans are approved and proceed, these impacts are more or less inevitable. Residual impacts following avoidance, reduction and mitigation measures will include:

- Loss of high biodiversity ('critical') habitat within resource pit and waste dump areas at Tokadeh, where 104 ha of Level 1 constraint (mostly moist evergreen forest, but also some swamp forest) will be lost;
- Loss of high biodiversity ('critical') habitat within resource pit and waste dump areas at Gangra, where 28 ha of Level 1 constraint forest will be lost;
- Loss of high biodiversity ('critical') habitat within the resource pit and waste dump areas at Yuelliton, where 3.5 ha Level 1 constraint forest will be lost;
- Loss of high biodiversity ('critical') habitat within the Tailings Management Facility, where 68 ha of Level 1 constraint forest will be lost gradually up to 2026 as the tailings elevation rises to its final level of 503 m;
- Loss of high biodiversity ('critical') habitat within currently proposed borrow pits for the concentrator and mine operation, where 11 ha of Level 1 constraint forest will be lost;
- Loss of approximately 719 ha of Level 2 constraint area, including riverine habitats;
- Additional loss of forest from the mine footprints and borrow areas not mapped as Level 1 or Level 2 constraint area is estimated at 890 ha.

In total, including roads and other miscellaneous infrastructure, a total of 250 ha of Level 1 constraints area will be lost. Biodiversity offset measures cannot replace what has been lost, but they can provide a degree of compensation through investment in protection and biodiversity strengthening elsewhere. These include:

1. Improved protection of East Nimba Nature Reserve. The capacity of reserve management to control illegal activities such as hunting, logging and fires and to patrol and monitor is currently limited. Financial support, perhaps channelled through a third party organisation to avoid conflict of interest, would help improve capacity;

2. Build capacity to protect and monitor habitats and species in the West Nimba Gba Community Forest. This area is a high priority for conservation in northern Nimba County, second only to the ENNR. Financial support for conservation, and assistance to local people to build capacity in biodiversity monitoring and regulation of activities such as hunting, will be important in ensuring that this new Community Forest delivers real conservation outcomes;

3. Conduct habitat restoration trials in East Nimba, on former mine surfaces. The Consultant understands that a tree nursery has been developed and some initial trials established. Such trials will be most useful if they are scientifically rigorous, with controls and replicates, and well-documented;

4. Build capacity to protect and monitor habitats and species in the Blei and Zor Community Forests;

5. Protect or restore habitats outside of the ENNR and Community Forests. Some important biodiversity exists only or mainly outside these areas: for example, populations of Black-headed Rufous Warbler in swamp forest and secondary forest, and the colony of White-necked Picathartes west of Bonlah, which is deserving of a local management protection agreement. A strategic approach, to restore connectivity between West and East Nimba, or between West Nimba and other forests in Guinea, could be taken;

6. Implement or support conservation activities elsewhere in Liberia. The Consultant recommends that this option is considered only if it proves impossible to develop sufficient offsets within the concession area.

The Company has developed a Framework for a Proposed Offset Programme (see Volume 8 of this ESIA) that it intends to develop into a full programme by the time Phase 2 mining starts operation, and which will follow on from the current Phase 1 Biodiversity Conservation Programme.

The level of Residual Impact Significance is likely to be Major.

9.4.2 Buchanan Estate

Impacts

There may be an increased level of poaching of wildlife on the Estate during Phase 2 as a result of greater numbers of occupants. Wildlife may also be adversely affected by any polluting episodes that may arise, such as oil or chemical spillages and untreated waste water disposal. The level of Impact Significance is considered to be Slight.

Mitigation

Employee-awareness campaigns should be introduced concerning the need to protect wildlife. The Township Development Plan should cater for pollution control.

Residual Impact

The level of Residual Impact Significance is considered to be Slight.

9.4.3 Railway

Impacts

The potential impacts of the operation of the railway are likely to be much less than those of Phase 1 and Phase 2 mining, as there will be very little new infrastructure to impinge on existing habitats. Critically Endangered (CR) and Endangered (EN) species of crab have been encountered in some streams crossed by the railway (Figure 9.7). Attention will be needed to minimise any run-off of sediment or pollutants (including spilt diesel fuel and oil from locomotives) during operation, especially into the many watercourses that are crossed by the railway. Any derailments leading to ore being deposited in streams and rivers will pollute habitats and affect fauna. The use of some herbicides to control track-side vegetation could adversely affect wildlife.

The level of Impact Significance is considered likely to be Slight.

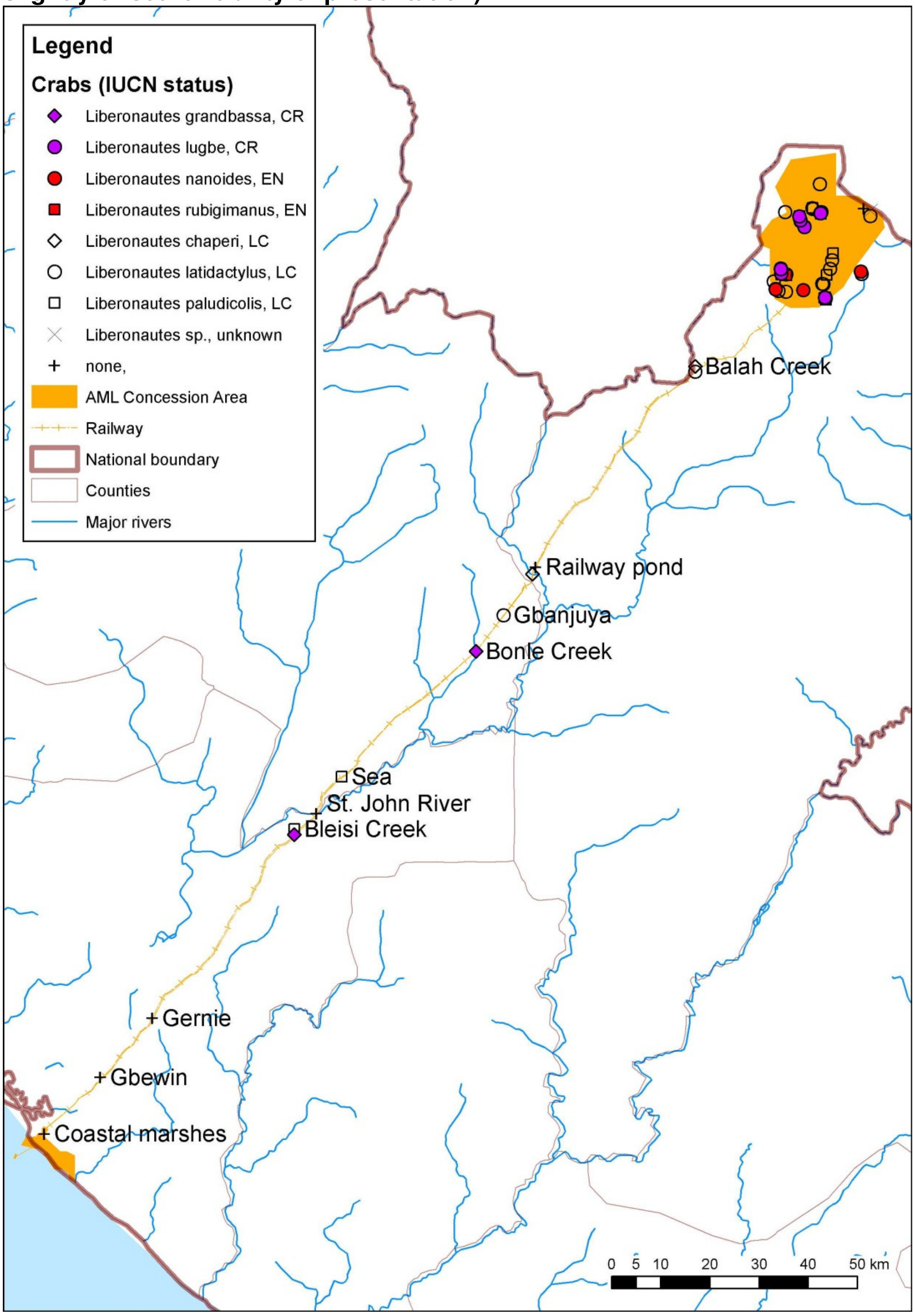
Mitigation

Employ all precautions to prevent spillages of toxic materials and to control railway operations such that accidents and derailments are minimised. Only use EPA-approved herbicides.

Residual Impact

The level of Residual Impact Significance is considered likely to be Slight.

Figure 9.7: Locations at which crabs were sampled along the railway (the symbol + indicates sampling points at which no crabs were found). Overlapping points are slightly offset for clarity of presentation)



9.4.4 Buchanan Port

Impacts

Those activities that could potentially give rise to surface water and harbour/offshore contamination described in Section 9.2.1.5 would have an immediate effect on all terrestrial and marine fauna and their habitats. Runoff from the ore stockpiles at the harbour has potential to increase water turbidity, and to cause eutrophication and algal blooms from nutrient enrichment, commonly associated with iron addition. The disposal of untreated sewerage can have the same effect, and the increased workforce associated with Phase 2 operations at the port could give rise to such an outcome if adequate treatment and disposal measures are not put in place. Algal blooms can cause lowered oxygen levels, which can result in the mortality of sedentary marine species and the avoidance of the port area by mobile species, such as fish. Sewage that finds its way into surface drainage systems and harbour water can also lead to dangerous levels of coliform bacteria.

Maintenance dredging (which may be required occasionally) is known to have considerable impact on the marine environment and needs careful consideration. The superficial sediments removed during maintenance dredging can contain high levels of contaminants. These could include fallout contaminants from the atmosphere as well as those arising from biological activity in the water column, point source discharges and surface runoff from the port and the surrounding area. This, and the other potential sources of contamination outlined above, could have a negative effect on marine life, including local fisheries.

Bilging and ballast water discharge has potential to facilitate the spread of invasive species which can be another source of threat to the native species.

By far the greatest concern, however, is the impact of port operations, and expanding human population, on the sea turtles that use Buchanan beaches for nesting. There are 3 species of globally threatened turtles that use these beaches namely Leatherback (*Dermochelys coriacea*), Green Turtle (*Chelonia mydas*) and Olive Ridley (*Lepidochelys olivacea*). The Hammerhead shark (Sp*hyrna lewini*) is another globally endangered species that occurs in the waters around the port of Buchanan. It is assumed that all of these species will be directly or indirectly affected by port operations or increasing vessel traffic related to Phase 2 operations. As regards sea turtles, increased lighting to facilitate ship movement and for the port to comply with international security standards poses a threat to nesting and hatchling sea turtles through disorientation.

If the current rate of exploitation continues, the long-term survival of sea turtles in the Buchanan area is unlikely. Added to this is the increased use of the beach by project staff and others, and an overall increase in the population caused by job-seekers and migrants could lead to both disturbance to turtle nesting sites and greater pressure on turtle meat and eggs for consumption.

There is also a small risk that turtles foraging inside the harbour could be caught in dredging equipment. Dredging operations should be monitored for turtle mortalities, and if any occur, mitigation measures such as turtle deflectors or adjustments to the timing of dredging should be implemented.

The terrestrial habitats of most conservation interest are those along the present and former course of the Savage River. The Consultant understands that no works are planned in this area during Phase 2. The mangrove swamps that are important areas for fish nurseries should therefore remain unaffected by Phase 2 operations.

Birds nesting in buildings and abandoned vessels in the port and harbour areas could be disturbed by rehabilitation, demolition and salvage operations.

The level of Impact Significance is considered likely to be Substantial.

Mitigation

Mitigation measures required to prevent terrestrial and marine fauna and their habitats from being affected by pollution have been described in Section 9.2.1.5.

Some of the basic protocols to minimise impacts associated with dredging operations include the carrying out of operations in calm conditions and the use of suction rather than bucket dredgers. This will help lower the spread of particulate matter and contaminants in the water column. Dredging operations should be timed as much as possible so as not to coincide with the peak nesting and hatching season of sea turtles or the breeding season of other commercially important fish species.

One of the most important issues to consider during dredging operations is the selection of appropriate sites for the disposal of dredged sediments. This will depend on the characteristics of the dredged sediments, which will have to be classified based on their potential to pollute the environment. This classification has to be based on an appropriate set of tests on the standard of pollution that is required according to international legislation. Some of the standard tests include the water leaching (elutriate) test which is used to evaluate the short-term release of contaminants from dredged sediments into open water.

Regarding ballast water, according to the convention it is obligatory for ships to carry out the exchange of ballast waters in the open ocean (i.e. at least 200 nautical miles from the shore and in water at least 200 m deep).

With respect to the sea turtles, zero tolerance policies and public awareness campaigns regarding the hunting of bush meat and eggs should be put in place. This could include the instigation of beach patrols in conjunction with the police department. Some further investigations as to the locations and patterns of turtle nesting sites along the beach would assist in defining this issue and clarifying mitigation. Subject to international lighting regulations, it will be of critical importance to ensure that problem lighting is turned off at night especially during the peak nesting season. In cases where the use of lights in unavoidable, this should involve lighting with the least disruptive spectral properties. Also the planting of native vegetation on the dunes above the high tide line and along the fuel quay at Buchanan can help provide natural orientation cues for the hatchlings and help reduce the impacts of artificial lighting.

Recommendations for sea turtle conservation and monitoring at Buchanan include the following:

- Develop a turtle conservation initiative with the full involvement of local people
- Conservation education;
- Performance-based payments for protection of sea turtles and nests;
- Sea turtle tagging programme;
- Sightings programme to record observations of turtles;
- Bycatch monitoring and mitigation;
- Manage light pollution around the port.

Along beaches where turtles are known to nest, any developments incorporating artificial lights (buildings, street lights) should be avoided. If such developments are unavoidable, consideration should be given to siting lights so that they are not in line-of-sight to the beach, or are switched off at night. Preferably a light-free buffer zone should be established along the beach, with any buildings or infrastructure sited well back from the beach.

The demolition of structures and the salvage of vessels should be undertaken in August/September and May-October respectively to avoid the main nesting season for these birds.

The level of Residual Impact Significance is considered likely to be Moderate.

9.5 Flora

9.5.1 Mine Sites

Impact

Dwg 7.5 provides a map that demonstrates the bioquality values inside the footprint areas and in the forests surrounding them. Most footprints include some globally fairly rare species, in harmony with most of the forest surrounding them. The botanical survey for Phase 1 was used by the Consultant, in combination with zoological studies to develop the Environmental Constraints Maps for the Phase 1 ESIA. These maps, as discussed above, were then used by the Company to avoid as many of the higher value ecological areas as possible in the layout design for Phases 1 and 2 (Dwgs 9.4 and 9.5). The Phase 1 and 2 botanical surveys used the star rating and Genetic Heat Index systems (Dwg 7.5, Section 7.6) to assess botanical value. Black Star species are endemic and are of top ranking priority in terms of global rarity, whereas Gold Star are of some conservation concern and Blue Star slight conservation concern. In total 14 Black Star species were recorded in the Phase 1 footprint, with 4 encounters on Yuelliton, 17 on Tokadeh and 17 on Gangra. A total of 38 (25 different species) sightings of Black Star species were therefore made within the Phase 1 footprint, compared to 134 outside of it. Gold Star species are not so locally critical, being on average three times more widespread globally than Black Star species, but they also contribute to the general community GHI score wherever they occur: a dense aggregation of Black and Gold Star species contributes to a high GHI for the area.

Table 9.17 explains how the GHI relates to the degree of botanical value of any given area and Table 9.18 shows the GHI assigned to the various parts of the Phase 1 botanical survey area. From the table it can be seen that Mounts Tokadeh, Gangra and Yuelliton have a ‘warm’ GHI and are approximately middle of the range among the sub-regions examined. Dwg 7.5 shows the distribution of the various star categories and the GHI in the Concession Area, and it can be seen that Tokadeh and the TMF especially represent outliers of warm to fairly hot GHI. Tokadeh and Yuelliton contain a number of Black Star species and are therefore indicative of good bio-quality habitat.

Table 9.17: Explanation of GHI values in relation to the presence of Black and Gold Star species

GHI	Degree of Hotspot
600-1200	Extremely important: global hotspot with a high proportion of Black (and Gold) star species.
300-600	Hot - with many Black and usually many Gold Star species also.
150-300	Warm – often with many blue and gold and a few black Star species
75-150	Tepid; usually a few Gold or a few Blue Star species of conservation concern; occasionally single Black Star species, diluted by many more of less concern
35<75	Cool; maybe occasional Blue Star species, but no particular concentration of note
<35	Cold

Table 9.18: GHI assigned to the various study area sub-regions classified in the Phase 1 botanical survey

	Sub-regions (= minor area in database)	No. species	GHI
2	Beeton SW	257	239
	Nimba herbarium records from the Wageningen herbarium for N Nimba county	1069	211
3	Bele-Detton	324	195
8	Nimba S-Grassfield	431	191
5	Gangra-Yuelliton	661	180
10	Vanyampa	394	180
9	Tokadeh Mt	649	174
1	Beeton Mt	408	172
6	Nimba E side	359	156
7	Nimba Mt N	328	153
4	Dayea N. & Yekepa	338	132
11	Zolowee-Gbapa	371	128

The additional impacts associated with the Phase 2 mining footprint on Mounts Tokadeh, Gangra and Yuelliton are significant because these areas represent a large proportion of the North Nimba evergreen forest, and a number of species found there are uncommon outside the area, as reflected in the elevated GHI scores in some of the forest patches. Also, the eastern portion of Tokadeh especially is rich in many locally used plant species.

The TMF has a variety of vegetation classes. The swampy area to be flooded and lost within the TMF itself is typical local swamp class 5 forest, characterised by *Raphia, Hallea, Laccosperma* and others. Better forest is found in a small patch of Class 7 riverside forest, and the Class 4 lowland Moist Evergreen Forest on the ridge of hills that will border the TMF. This area has a higher GHI (230-240) and may be a good source of NTFPs for the local community. It is strongly recommended that as much of this slope forest around the TMF is retained as is possible.

The areas of the Phase 2 footprint that have a GHI of greater than 200 are shown below (see also Dwg 7.5).

Element	Area (Hectares)
Sediment Control Ponds	0.16
TMF	143
Topsoil & Vegetation Stockpile Area	3

One important observation that has significant implications for mitigation (see below) is the fact that the originally proposed footprint for the Gangra to Tokadeh haul road has a GHI of 203 and contains three Black Star species despite it being in an area that has only recently (in the last eight years) been abandoned by farming. It shows that, providing the background supply of propagules from developed forest is not too far away, perhaps less than 200 metres, biodiversity on old farmland can return rapidly. Devalued areas can be restored in terms of GHI and biomass in a few decades. One challenge is to make old mine surfaces, which do not recover vegetation nearly so rapidly, behave like abandoned farms (see below).

Some of the tributaries to the Dayea River and other rivers downstream of the mine sites are bordered with thin strips of riverine vegetation, and are home to a few very rare plant species. Some of these act as corridors for animals migrating through the increasingly fragmented landscape. A species of *Combretum* liane, either a new species or the very rare *C. fuscum*, has been found in a few spots along these riverbanks. Many of these riverine environments will be destroyed or significantly damaged as a result of the Phase 2 footprint and its immediate downstream effects.

Invasion by alien species such as *Chromolaena odorata* and disturbance from increased activity of people and vehicles could significantly impact remaining forest areas and other habitats. Phase 2 mining and associated activities, including construction of roads and other infrastructure, have the potential to affect freshwater habitats profoundly (both streams and swamps) downstream of the proposed mining areas. Although downstream impacts need to be considered in the context of a region with legacy issues from past decades of mining on Mount Nimba and on Mount Tokadeh, areas previously unaffected by mining, including the sub-catchments immediately downstream of Mounts Gangra and Yuelliton, will also be significantly affected if runoff, sediment and potential contaminants are not adequately controlled.

One potential positive ecological impact is that no farming will be allowed within the exclusion zone around the sites, and therefore some forest that might have been cleared for farming will remain *in situ*. However, the wider issue of improved access to forest areas and increased demand for forest land and its resources needs to be considered. Although the Company is not directly responsible for habitat loss caused by local inhabitants and illegal loggers who move into the area, these activities are indirectly linked with mining, since population growth around the mine, and the consequently increased local market for food and other products, increases the demand for forest clearance for timber and land for farming. Commercial scale illegal logging often follows improved access for exploration and mining, and this is certainly the case in Nimba with extensive "pit sawing" activities taking place. Farming is likely to be more extensive and damaging, since migrants often establish themselves in forested areas, creating settlements that then become villages and accelerate the process of forest clearance.

The level of Impact Significance is considered likely to be Major.

Mitigation

a) Protection

It is strongly recommended that the Environmental Constraints Maps continue to play a critical role in the detailed design of the layouts of mine areas and related infrastructure. Preserved small patches of forest are valuable, both as stepping stones linking the biodiversity between East Nimba Nature Reserve and the high quality West Nimba Forest to the west. They also act as small pockets of intrinsic value that increase the bio-quality of fallow regeneration around them. They are also potential reservoirs for NTFPs and many play a role in protecting the physical environment.

It is recommended that the forested slopes around the TMF are retained as much as possible. This is important from the point of view of: a) Level 1 environmental constraints conservation; b) soil erosion prevention; c) the local supply of NTFPs for the eastern villages (e.g. Zolowee and Gbapa); and d) its role as a potential corridor for migrating animals. If this can be achieved by the time the mine at Tokadeh is fully operational, it is likely this will be the closest source of NTFPs for many communities that previously collected from the Tokadeh forest. Other such small forest patches, for instance on low hills to the east of Gangra-Yuelliton and to the west of the Dayea River, also deserve specific high priority protection, not least as isolated sources of seeds and as stepping stones for some migrating forest species. Sacred groves are also another source of NTFP species for the communities. The protection of these areas, or establishment of a new sacred grove if the current location cannot be saved, would also increase the NTFP supplies to the villages as well as preserving cultural heritage (Section 9.6).

As far as individual species are concerned, the endangered *Cassia fikifiki* at Tokadeh, *Uapaca chevalieri* on the ridge top at Gangra and *Combretum cf. fuscum* at Tokadeh need special conservation attention.

It is essential that a local NTFP team map the locations of two individual *Okoubaka aubrevillei* trees, and their coordinates made known to the Company's planning offices. This tree received the highest score (for investment/protection by the Company) of any species during the Consultant's NTFP 2011 workshop with the Zoes, and should therefore be treated as a serious priority for protection. *Okoubaka aubrevillei* is traded throughout the coastal countries of West Africa (and in the Concession Area). It is also exported to Europe for medicines.

It is implicit that the recommendations made in Section 9.2.1.2 b) concerning the control of runoff and the prevention of erosion and surface water contamination are of critical importance to the protection of downstream habitats and that measures are taken to restrict vegetation and topsoil clearance to only those areas where it is absolutely necessary. Dust suppression measures will also be required to prevent adverse effects on plant life.

b) Restoration: Mine Closure Plan

Section 9.2.1.2 b) has provided recommendations as to how drainage management must feature strongly in site restoration and form a key role in the Mine Closure Plan. The botanical surveys undertaken in the various sites found a strong proportion of long-lived grasses which intervene at present in the fixation of the terrace benches and sometimes of the terrace flanks. It is thus desirable to use these same species, which are indigenous, to strengthen the existing plant cover or to colonise areas following cessation of mining. It is recommended that this process takes place progressively, i.e. as soon as parts of the mined area have been worked out, they are landscaped and replanted. Both for herbaceous and woody plants, it is necessary to avoid the use of exotic species. In all the situations, this plant cover will only be temporary, monitored strictly and established with the aim of facilitating the installation of stronger and more resistant native plants which will contribute to the reconstruction of the original ecosystem. Volume 4, Part 1.2 contains details on recommended species and planting methods. Volume 7 contains the Company's Framework Mine Closure Plan which also considers these techniques for land rehabilitation.

A significant reduction in the incidence of bushfires must represent a priority objective within the framework of reforestation of the mine sites and the protection of neighbouring forest. Awareness needs to be raised accordingly among the local population.

Residual Impact and Offsets

A significant area of montane and moist evergreen forest will be lost, retained moisture levels in forest canopies and soils will be reduced and riverine environments will be adversely affected. The local dry season humidity may decline, and this could have a serious impact in terms of increased bush fires in the landscape as a whole. While attempts have been made for the Phase 2 layouts to avoid as many of the Level 1 environmental constraints areas as possible, an important area of moist evergreen forest will be progressively destroyed as the TMF is developed, and important Level 1 constraints areas on Yuelliton will be affected by drainage channels discharging runoff and sediment from the Phase 2 mine area on the ridge and slopes above. The undertaking of the Company to avoid any damage to the slopes to the west of Gangra, Yuelliton and Tokadeh and to the south of Tokadeh is very important as a conservation measure, but it is inevitable that some waste rock material and possibly mine runoff will find its way on to these slopes as the ridge lines are lowered.

The influx of population that is predicted to accompany Phase 2 and other possible future mining developments in the region will have repercussions on preserved forest areas in and around the Phase 2 footprint and the areas of higher bio-quality forest to the west. The large *Hyparrhenia diplandra* savanna of Yekepa-Huo, at the Guinean border may also be impacted as could the savannas of Grassfield and those to the south.

Over time the landscape will become increasingly fragmented and more intensively managed, and a greater density of pioneer-dominated vegetation can hardly be avoided, even if particular forests are better protected (see below). The remaining areas of medium to high bio-diversity will probably become increasingly 'corralled' and may eventually become seriously denuded or even destroyed if integrated and sustained protection is not implemented.

Considering the need to preserve large blocks of forest, the provision of support to the protection of the large forest from Vayampa-Beeton-northwards should be one of the main aims of biological offsetting. This potential conservation area is equivalent to or better than the areas to be lost to Phase 1 and 2 mining and its enhanced management could be seen as compensating for the inevitable losses described above. This area of high quality forest is currently not mined, but it has been designated as Community Forest by the FDA, over-turning the previous plan for a protected area, and potentially putting it more at risk from logging, forest fires and especially clearance for farms, depending on the priorities for management agreed by the community and the FDA. This is almost the last significant remnant of this special Nimba type of moist evergreen lowland forest, and has recorded the highest sample values of bio-quality, even compared to similar forest samples from East Nimba Nature Reserve. It is imperative, therefore, that it is protected.

It is also important to consider these proposals in the light of the likely more widespread development in the area. Offsets and other forms of impact compensation must be sustainable and largely unaffected by future developments, including encroachment by agriculture and future mining projects. The fact that many of the villagers have seen their access to forest restricted by the Company's activities is probably the largest single impact on NTFP species availability to date. Prevented access, vegetation removal and disturbance, and population growth, will all have consequences for NTFP species availability, and will result in pressure on other areas of forest for NTFPs.

Support for long term conservation of the lesser disturbed forest of the West Nimba Gba Community Forest would therefore represent a highly worthwhile offsetting measure. Already degraded or farmed land in the area can be prioritised for appropriate management, but large areas of forest need to be kept fully intact if the area is to be effective as a biodiversity and bio-quality conservation area. This detailed strategy will take several years of survey and work, but at least half of the existing high bio-quality forest area should be left more or less intact, with no felling of trees. Nevertheless, this forest area lacks high altitude forest, similar to that in the Gangra-Yuelliton footprint and so support of the expansion and recovery of these high altitude vegetation classes in East Nimba is recommended. The establishment of nurseries for the subsequent rehabilitation of forest on the top of East Nimba Nature Reserve, i.e. above 1000 metres, and old mining surfaces elsewhere, could help compensate. It is recommended that collaboration with SMFG be undertaken to attempt to restore some of the high value Nimba savanna species on the very top of Mount Nimba, although this high return investment is not particularly likely to be easily achieved, due to the lower altitude of the Liberian Nimba peaks.

The present level of protection of natural habitats in the ENNR is very low, allowing continuous encroachment on the reserve including logging and farming. The future of neither the ENNR nor the Gba Community Forest is secured, and the goals of the environmental offset programme (Volume 8) cannot be achieved without strict protection of the natural habitats through law enforcement and the active presence of forest rangers. Furthermore, Mount Beeton, located in the Gba Community Forest, lies inside the Company's concession area and probably contains iron ore deposits. This cross-interest could potentially cause conflicts between local communities, the Company, the government and the long term goal of protecting the remaining high bio-quality forests of the region. Parts of the Gba Community Forest and the ENNR therefore require special protection arrangements to be developed and implemented.

Moderate exploitation of NTFPs from other areas has little impact on the GHI value of forests, and every opportunity should be taken to support the communities using these forests to continue to do so in a way that sustains the forest biodiversity and NTFP supply.

The Company, through its Phase 1 Biodiversity Conservation Programme, is embarking on a programme of strengthening the prospects of livelihood restoration through agricultural intensification and conservation agriculture techniques. This should help deflect project-affected communities away from the forest, but further investment will be required to assist in establishing the long-term forest conservation goals outlined above.

The level of Residual Impact Significance is considered likely to be Major.

9.5.2 Railway, Buchanan Estate and Buchanan Port

There are no known habitats or botanical species of conservation concern along the railway, in the vicinity of Buchanan Estate or at the Port. However it will be necessary to implement all provisions and safeguards fully concerning the transportation and handling of toxic and hazardous materials and to minimise disturbance to surrounding vegetation. The use of herbicides to control trackside vegetation and grass at Buchanan Estate could affect other flora and will need to be implemented according to international best practices. Drains will need to be regularly cleared from roadsides to collect any toxic materials that may accumulate due to leakages and road runoff residues. Wastewater and sewage treatment at Buchanan will need to be undertaken in such a way as to minimise the release of harmful materials to the environment. It is understood that Phase 2 operations at the port will not involve the removal of any of the mangroves that fringes the lagoons.

9.6 People

Social impacts consequent to Phase 2 activities are similar to those identified in the Phase 1 ESIA, but potentially far more significant. The mitigation identified in the Phase 1 ESIA, which was a condition of statutory consent for the Phase 1 mining activities, has seen slow progress addressed, and it is considered that the negative impacts of Phase 2, cumulatively with those residual from Phase 1, will have a larger impact on communities and, in some cases, they will be irreversible.

9.6.1 Public Roads

Impacts

Increased traffic (both project-related and private) using public roads may lead to an increase in the number of accidents, both between vehicles and involving pedestrians. Furthermore, traffic accidents involving fuel tankers and other vehicles transporting hazardous materials, could lead to explosions, fires and spillages, with implications for worker and public safety.

Dust and gaseous air pollution generated from the increased use of public roads could form a health hazard to communities living in close proximity. In the absence of suitable mitigation measures there could be the potential for significant impacts on human populations to occur during periods of dry weather, particularly at any remaining properties within 200 metres of the Gangra-Yuelliton haul road. Any effects would be occasional, temporary and minor in nature, given the locations of the closest receptors and the low wind speeds generally occurring in the area.

Traffic safety will also be a consideration within project areas, including the mine, the port and townships.

The level of Impact Significance is considered likely to be Substantial.

Mitigation

The rationalising of vehicle movements to minimise project traffic, the introduction of speed and driving restrictions, the update and expansion of the company's transport rules and regulations into a comprehensive Traffic Management Plan, and the implementation of traffic safety campaigns should reduce the potential for road accidents. It is recommended that service road safety campaigns take place regularly, specifically targeting schools. Safety awareness should be carried out using a local Non-Governmental Organisation (NGO) building on previous awareness exercises.

Drivers and crew members that handle hazardous materials must be trained and provided with PPE and spill kits so that the direct risks to them and other people should be reduced should a spillage occur.

Consideration should be given to transporting fuel and other potentially hazardous materials by rail instead of road.

Dust suppression measures and regular grading of gravel roads should help to reduce dust generation. Controlled vehicle speeds should reduce the amount of dust entrained into the atmosphere. Modern engines should be used to meet low emission standards (US EPA tier 3 and appropriate EU Regulation emissions limits) in order to minimise gaseous air emissions.

As regards transport of hazardous materials (especially heavy fuel oil and diesel), priority should be given to rail transport as this would be much safer – and also less energy consuming – than road transport by trucks. The Hazardous Materials Management Plan (Volume 6, Part 3.7) and Fuel Handling Standards (Volume 6, Part 2) should be followed and regularly monitored according to international compliance and reporting procedures as part of the Company's environmental policy.

Residual Impact

The level of Residual Impact Significance is considered likely to be Moderate.

9.6.2 Mine Sites

Impacts

Plans for Phase 2 mining are on a far larger scale than for Phase 1, and will result in socio-economic change. The population in the mine project communities number around 15,000 in ten towns. This population is likely to increase substantially, as a direct and indirect result of the employment opportunities and economic activity created by mining operations. Without adequate controls, this is likely to lead to increased pressure on resources.

Direct impacts relate primarily to involuntary resettlement, permanent land-take and related physical and economic displacement of farms from the Phase 1 / Phase 2 exclusion zone. Land acquisition and compensation for the Phase 1 exclusion zone has already taken place, but little progress has been made on livelihood restoration so far, and therefore Phase 1 and 2 impacts in this regard are considered likely to be cumulative. Loss of access to spiritual and cultural sites (Dwg 9.6), loss of land for agriculture and loss of access to NFTPs (including for medicinal use, food, firewood, house-building and handicraft materials) are likely to be the main drivers of social impact. Furthermore, access to sites and areas of cultural heritage significance outside the Phase 1 and 2 footprint but within the exclusion zone may increase levels of impact. The direct loss of land may also result in migration to other farming areas and towns, such as Yekepa, which will place increased pressure on land and resources. The traditional affiliation to land and particularly to important forest areas will be broken. As well as the impact on livelihoods and the increased vulnerability of food security, other effects will include potential construction and mining impacts on the availability and quality of drinking water brought about by increased sediment load and other potential pollutants entering water courses and groundwater (Section 9.2.2.1). Surface water and groundwater pollution could also negatively affect crop yields and result in a reduction in fish stocks downstream.

Consultations with government, tribal leaders and communities found that stakeholder engagement and information dissemination by the Company during Phase 1 was minimal. Consequently, stakeholders feel uninformed; there is a high level of mistrust, fear and disappointment.

Communities living downstream of the mine sites could be at risk from the potential failure of the TMF, waste dumps or natural slopes undercut by mining excavation. The risk posed by slope failures arising from the mine sites is discussed in Section 9.3.3.1.

There is a potentially significant risk to workers employed at the mine and related facilities from traffic accidents, slope failures, industrial accidents and the handling of hazardous materials, including explosives.

The level of Impact Significance is considered likely to be Major.

Mitigation

Mine planning should involve a comprehensive programme of community consultation with full public participation, including disadvantaged groups, and compensatory measures designed to be applied on a sustainable case-by-case basis. This should be undertaken as part of the Resettlement Action Plan (RAP) and the compensation and livelihood restoration programmes being developed by the Company (see Volume 6, Part 1). Procedures for giving priority employment to people that are affected by land-take should also be developed. The Agricultural Intensification Programme Framework, designed by the Consultant within a broader Community Development Programme will help enable alternative livelihoods to be secured as a parallel mechanism to the RAP but will require careful planning and resourcing. Vocational training in alternative livelihoods forms an important component of this. Public awareness campaigns will be required to alert the local community to the dangers from mine-related traffic and also the dangers posed by communicable diseases that could rise as a result of in-migrants searching for work opportunities. Measures will need to be taken to manage job-seeker expectations, especially including those of incoming young males living in local communities. For the new temporary work estate a master plan for development, operation and decommissioning should be established. The Company is, at the time of writing, commencing work on improved agriculture management within its Biodiversity Conservation Programme, together with a livelihoods restoration component within the Phase 1 Resettlement Action Plan. Combined, these initiatives have the following objectives:

- Increase understanding of conservation agriculture through awareness and education
- Establish and organise community dwellers into cooperatives
- Build the capacity of community dwellers in the new farming techniques (Conservation Agriculture)
- Demonstration of the acquired conservation agriculture knowledge
- Assess markets for farm products
- Ensure better forest management practices
- Mitigate unsuitable farming practices
- Ensure food security
- Reduce environmental farming pollution
- Establish farmer field schools that ensure rational conservation practices
- Stabilisation of farming practices that aim to help reduce deforestation and environmental pollution.

Other programmes recently established by the Company include:

- Land Access Programme;
- Vulnerable Person’s Assistance Programme; and
- Cultural Heritage Programme.

Public consultations will also be required to evaluate fully the requirements for relocating some of the cultural heritage sites that will be affected by the scheme (Volume 5). It is understood that the Company has already carried out these consultations with regard to Phase 1 and has identified suitable sites with community agreement. Consideration should be given to providing controlled access to remaining cultural and spiritual sites that will be unaffected by the works but which will be located within the exclusion zone. Supervised access to NTFPs within the exclusion zone should also be established and areas of important forest should be retained to the greatest extent possible, for this reason, such as that on the slopes above the TMF.

Indications suggest that, while a Resettlement Action Plan and a Livelihood Restoration Plan are being progressed for Phase 1, they have not yet been implemented in accordance with

IFC Performance Standards. The Livelihoods Restoration Plan should consider provision of alternative land for affected households (see Dwg 7.1 for example) to allow for continuation of agricultural activities consistent with previous land use. Livelihood restoration initiatives should consider an agricultural intensification programme, rural handicraft development initiatives, cottage industries, provision of micro credit to assist entrepreneurship, vocational training, local hiring policies and scholarships for schooling. Some progress has been made in these fields by the Company but Phase 2 mitigation will require more robust systems to be put in place.

An enhanced and more accountable community engagement strategy is required, supported by an expanded and reorganised management reporting structure. It is recommended that Community Liaison Officers and Assistants (CLOs and CLAs) indigenous to the project areas should be recruited (if candidates with suitable skills can be found) in order to improve two-way communication and to allow more of the community who have little or no education, including women, to understand activities fully that will affect them, and to be better placed to contribute to consultations. As with all Company staff, CLOs and CLAs should be provided with a programme of continuous professional development and undergo training. Frequent consultations should take place between an augmented team of CLOs and CLAs and communities to disseminate accurate and timely information and to keep the communities and stakeholders informed. Internal monitoring and evaluation of all public information dissemination should take place to ensure that the audiences are targeted correctly and information is circulated and updated in a timely and appropriate manner.

The exclusion zone should be extended to include the potential runout area from possible mine slopes failures, including excavated slopes, waste dumps and the TMF. Mitigation for these hazards is discussed in Section 9.3.3.1.

The health and safety plan for all Mine Site and related operations should be comprehensive and include provision for all possible workplace accidents and related effects.

Despite the above, it is important to note that there are several positive outcomes to be realised as a result of the project. These are summarised in Table 8.5 and must be considered in relation to the overall impact assessment (Section 11).

Residual Impact

The Residual Impact Significance arising from Phase 2 is considered to be Major, partly because of the observed levels of mitigation with regard to Phase 1, but also because Phase 2 impacts are significant and complex, and replacement and restoration of livelihoods in an area where agricultural and forest resources are becoming increasingly scarce will be extremely difficult.

9.6.3 Yekepa Township

Impacts

Until the Township Development Plan for Yekepa has been developed and details emerge regarding housing, water supply, sewage and waste water treatment, solid waste disposal, other municipal services, and health and safety safeguards are available, the impact of Phase 2 on the socio-economic environment at Yekepa cannot be undertaken. The concerns regarding Phase 1 impacts expressed in the ESIA for Phase 1 still largely remain, as little appears to have been put in place to address the mitigation measures proposed. The main impacts envisaged are summarised below; they cannot be expanded upon or ruled out until more detailed plans are available. The Company has indicated that it is in the process of preparing for a full consultative, multi-stakeholder town planning exercise to help determine strategies for the company and non-company parts of Yekepa. An addendum to this ESIA is strongly recommended once these details are available.

- Unregulated settlement
- Tensions between employees and landless and jobless migrants
- Increased incidence of communicable diseases as a result of population influx
- Public disorder and violence, especially against women, including exploitation
- Price inflation due to increased demands and reduced agricultural production
- Food security issues
- Economic downturn following project completion could lead to hardship
- Borehole abstraction of water by the Company may reduce community supply
- Increased population generates increased waste to be disposed of
- Public health hazards from increased sexual activity
- Public health hazards from inadequate sanitation and medical resources
- Accidents due to increased township road traffic
- Accidents due to spillages of fuel and other harmful materials.

On the positive side, economic opportunities will arise from project operations through direct and indirect employment of skilled and unskilled workers. This in turn will generate a climate for petty trading and service provision within local communities where the operations are taking place. With more people in a better financial position, earnings may be spent on schooling and health for families. Improving infrastructure of service roads to provide access to communities is likely to stimulate market trading and income generating opportunities, and to enable communities to access health and high school education facilities which are generally not available in rural areas, thus benefitting human and personal capital. Table 8.5 contains further details of potential positive social impacts.

The level of Impact Significance is considered likely to be Substantial.

Mitigation

Controls, where practicable, will need to be put in place on in-migration to Yekepa township to manage the pressure on land and water resources, and this should involve liaison with border control and the enforcement of the need for work permits for foreign migrants.

Mitigation measures relate principally to the development and implementation of a Township Development Plan that would include provision for sewage and waste water treatment, minimising waste, recycling waste, waste segregation and safe disposal. The Company's current Township Management Plan is given in Volume 6, Part 3.8. The Hazardous Materials Management Plan (Volume 6, Part 3.7) should also be strictly adhered to. Compliance with international and manufacturers' standards on plant maintenance will enable safe operations and polluting emissions to be controlled. A drilling investigation and well water monitoring investigation should be carried out to assess aquifer yields and groundwater quality. The need for drilling supplementary boreholes should be updated as part of the Yekepa Township Development Plan. Regular testing of water quality, both surface water and groundwater, will allow compliance to be monitored. Contingency arrangements should be in place for all relevant operations and the technical personnel trained accordingly. Opportunities should be taken to extend provisions put in place for Company and other project staff to benefit the local community and seek ways in which social tensions are minimised and impacts upon disadvantaged members of the community are avoided.

A migration influx study should be undertaken to support the measures outlined above. In addition, a comprehensive baseline health risk assessment should be undertaken to understand the epidemiology of the project-affected area. Public health awareness campaigns in relation to hygiene and the spread of communicable diseases, women's health, HIV/AIDS awareness and gender-based violence should be planned and carried out on an on-going basis for all project-affected communities. Medical outreach clinics, such as the one established at Yorpea near Greenhill quarry are recommended.

Residual Impact

The likely levels of residual impact cannot be ascertained until a full impact assessment can be undertaken and mitigation details are made clearer.

The level of Residual Impact Significance is considered likely to be Slight.

9.6.4 Buchanan Estate (and Buchanan City)

Impacts

Most, if not all, of the issues (both positive and negative) discussed above for Yekepa township will also apply to Buchanan Estate and the adjacent Buchanan City. Job-seekers will be attracted to Buchanan City in the same way as they are to Yekepa, and in fact residents in Buchanan have described how water resources have become depleted as a result of increased population pressure already. The main difference between the two urban areas will be the fact that resettlement and land expropriation is not planned under either Phase 1 or Phase 2 at Buchanan, and so the same pressures caused by displaced farmers and other land users will not be replicated. A further difference lies in the fact that the potential for employment at the port will not be as great as it is at the mine.

Other issues include the potential impacts of increased groundwater consumption, increased waste generation and improperly treated sewage from the Estate on drinking water and human health, and the potential for increased road traffic accidents. Residents in Loop 1 of the Company's compound could be adversely affected by noise from the proposed power plant.

Positive impacts are expected to include increased provision of employment among the local workforce, communication benefits, increased provision of health care and schooling for company employees and the community, improved water supply and sanitation, access to electricity, increased opportunities for local enterprise and training brought about by the investment in infrastructure, as well as opportunities to address issues concerning existing disadvantaged groups.

The level of Impact Significance is considered likely to be Substantial.

Mitigation

Opportunities should be taken to provide potable water to the wider community through the provision of additional water wells. This should be based on the aquifer yield and quality testing and monitoring referred to above. Promoting awareness programmes on water use and a comprehensive public health familiarisation for the wider community will contribute to the sustainable use of local water resources.

Information disclosure should take place concerning the size and skills needs of the required workforce in order to minimise inflated expectations and control, through the Township Management Plan, the influx of in-migrants and job seekers to the Town. Employment should take full regard of ethnic and gender issues and the need to benefit disadvantaged groups as much as possible. Skills training programmes should be undertaken to enhance employment opportunities. The continued use of local labour for the maintenance of green spaces will help to generate local income. A zero tolerance policy will be required with regard to alcohol and drugs abuse and violence. Provision should be made for health care and leisure facilities, provision of safe and adequate drinking water, and the control, management and disposal of all waste and waste water.

A comprehensive baseline health risk assessment should take place, as a clear understanding of epidemiology of the project-affected area needs to be established. Public health awareness campaigns in relation to hygiene and the spread of communicable diseases, women's health, HIV/AIDS awareness and gender based violence should be planned and carried out on an on-going basis for all project-affected communities. The current subsidised public access to the Company's hospital at Buchanan should be continued.

Residual Impact

The level of Residual Impact Significance is considered likely to be Moderate.

9.6.5 Railway

Impacts

The potential safety hazard posed by an increased frequency of trains along the railway corridor is considered the prime impact for communities and to a lesser extent noise and vibration disturbance, though Sanniquellie Hospital is likely to be an exception (Section 9.1.2.4).

The level of Impact Significance is considered likely to be Substantial.

Mitigation

It is recommended that railway safety campaigns take place regularly, specifically targeting schools. Safety awareness should be carried out using a local Non--Governmental Organisation (NGO) building on previous awareness exercises.

It is recommended that the Company review the existing rail safety procedures to minimise the potential for rail accidents and derailments, and to have in place an Emergency Response Plan in the event of such an accident. A site-specific Environmental Management Plan should be implemented for the operation of the railway and the maintenance Estate at Greenhill (Volume 6, Part 3.5).

Noise and vibration effects are dealt with in Section 9.1.2.4).

Residual Impact

The level of Residual Impact Significance is considered likely to be Moderate.

9.6.6 Buchanan Port

Impacts

Many of the residents of Buchanan City are dependent upon fish stocks for their livelihood. Any polluting, dredging or vessel operational effects that might reduce these stocks would therefore be a potential source of impact.

Increased levels of employment opportunity at the Port could give rise to tensions between local people, job-seekers and employees (Section 9.6.4). There is an increased risk of workplace accidents arising from a greater degree of activity at the Port.

Positive impacts are expected to include increased provision of employment among the local workforce, communication benefits, increased provision of health care and schooling for company employees and the community, improved water supply and sanitation, access to electricity, and increased opportunities for local enterprise and training brought about by the investment in infrastructure, as well as opportunities to address issues concerning existing disadvantaged groups.

The level of Impact Significance is considered likely to be Moderate.

Mitigation

With regard to the reduction of impacts to fish stocks, Sections 9.2.1.5 and 9.4.4 apply. The health and safety plan for all port operations should be comprehensive and include provision for all possible workplace accidents and related effects.

Residual Impact

The Residual Impact Significance is considered likely to be Moderate.

9.7 Offsetting of Significant Residual Impacts

It is clear from this discussion that, even with mitigation, a number of residual impacts will remain: some at Substantial and Major levels. Therefore, in order to follow international best practice, the Company has committed to three major offset initiatives.

County Social Development Fund

In the Amended Mineral Development Agreement between the Government of Liberia and ArcelorMittal, Article 12, is the following provision.

"It is the objective of the Parties hereto that the Operations shall be carried out in a manner that is consistent with the continuing economic and social viability of centers of population that have formed and which may form as a result of such Operations during the term of this Agreement. Upon request of the GOVERNMENT at any time, the CONCESSIONAIRE shall consult with the GOVERNMENT and the communities to mutually establish plans and programs for the implementation of this objective, and thereafter the CONCESSIONAIRE shall in good faith cooperate with the GOVERNMENT with regard to its efforts concerning the realization of such plans and programs.

"To that effect, the CONCESSIONAIRE shall provide an annual social contribution of US$ three (3) million which shall be managed and disbursed for the benefit of Liberian communities in Nimba, Bong and Grand Bassa Counties by a dedicated committee to be formed by the CONCESSIONAIRE and the GOVERNMENT. Disbursements and allocations by the committee to the said Counties of the annual social contribution shall be subject to final GOVERNMENT approval, provided, however, that all disbursement or allocation to the said Counties shall be, on an annual basis, in the proportion set out in Appendix H. Disbursements and allocations by the committee and the GOVERNMENT shall be subject to independent audit in accordance with generally accepted accounting principles."

This annual contribution from the Company to the people of Liberia has become known as the County Social Development Fund. It is completely separate from the budgets for resettlement, compensation, community liaison and corporate responsibility activities, and in this respect represents a social offset programme. This will be continued throughout the period of the Phase 2 Project, and will amount to over US$ 60 million in this period.

Upgrading of the Ganta-Yekepa Highway

Although more of a mitigation measure than an offsetting one, the Company has made an undertaking with the Government of Liberia to fund the upgrading of the 70 km national highway from Ganta to Yekepa. The Implementation Agreement for this project has a maximum budget of US$ 40 million and is expected to take place between 2013 and 2016. This will have mainly economic benefits to Nimba County, but which will also bring a number of social benefits (such as reduced dust nuisance to the roadside communities).

Biodiversity Offset Programme

The main environmental impacts that cannot be effectively mitigated, as the foregoing sections demonstrate, relate to the loss of forests and habitats for a wide range of plants and animals. The Company proposes to undertake a biodiversity offset programme that builds on the pilot work undertaken by its Phase 1 Biodiversity Conservation Programme (BCP). The BCP started in 2011 and is scheduled to continue until 2015. From that time onwards it is expected that a larger and longer term offset strategy will be followed. A framework for this is described in Volume 8 of this ESIA.

10 CUMULATIVE AND TRANS-BOUNDARY IMPACTS

10.1 Potential Cumulative Impacts

The potential cumulative impacts caused by the land-take relate to economic displacement, mono-industrialisation of Yekepa, loss or displacement of cultural heritage sites, land pressure and the status of women in society. The positive cumulative impacts relate to the long-term improvement of the human and personal capital of the country.

The involuntary resettlement and economic displacement of farmers on Mounts Tokadeh, Yuelliton and Gangra may have the cumulative impact of causing impoverishment and long-term hardship to affected households. Losing the only productive capital as well as access to forest products, which are integral to livelihood and survival strategies, may over time cause community health problems, accentuate already vulnerable food security and heighten levels of poverty which will have ramifications on households' ability to pay for schooling. This in turn will cause urban migration, seeking wage-based employment, permanently changing indigenous people's traditional way of life and breaking the traditional affiliation to the land. The ramification of urban migration will cause overcrowding in the built up areas which, unmanaged, could lead to a deterioration of community health, the proliferation of communicable diseases and a possible increase in social tension, as well as crime.

Over time Yekepa may become mono-industrial, with the majority of people being employed directly by the Company or a contractor and service industries being set up to support the activities or engaging in activities dependent on the mine. In the case of LAMCO, when operations stopped the entire town was impacted because it was solely dependent on the mining operations to support the residents. Note, however, that the civil war would have curtailed economic growth and Yekepa is a small and remote town, where opportunities for economic development are limited unless inward investments are made. Furthermore, the steel industry is a volatile market and business and employment opportunities in places like Yekepa will respond to this. In LAMCO times there were periods when production was stopped, and more recently the suspension of investment by the Company against the global economic crisis of 2008-09 shows that livelihoods based on this sector are always somewhat vulnerable. In comparison, activities at the Port of Buchanan will not be negatively impacted in this way because other large industries operate within the area.

The permanent removal and disturbance of cultural heritage sites and areas may, along with economic pressures, contribute to the cultural change of indigenous people and the abandoning of cultural practices, resulting in the gradual loss of traditional belief systems that have been handed down the generations. This is also perhaps mirroring what might be happening naturally, and part of the Offset Programme might be an initiative to rekindle interest in traditional culture and society among the younger generation,

Finding alternative land available for farming is already reported as a source of conflict, as the indigenous people have a traditional affiliation with land, more conflicts are envisaged to arise with the mounting pressure on land and the increase in population. This could damage the social fabric of farming communities.

With few employment opportunities for women in the port and mine operations and as the land take disrupts agricultural activities, so too the income-generating activities in which women are predominantly engaged will be affected. These changes will concentrate the economic power of households in the hands of men and increase women's dependence on husbands or male relatives. The loss or reduction of the female income in a household may cumulatively exacerbate social problems common to the context such as gender-based violence, lack of public health and education, which consequently impacts negatively on family life. However, women often dominate the petty trading sector throughout Africa and the increased petty cash available through implementation of the project could result in increased activity in this field.

Providing employment either through direct or indirect opportunities is likely, in time, to place people in a better financial position to fund education and improve livelihoods. Furthermore the provision of improved free or subsidised health and education within the project-affected areas will also contribute to improved human and personal capital of the county.

10.2 Trans-Boundary Impacts

The mine area is entirely within Nimba County, but drainage is to the St John River which forms the border between Liberian Nimba and The Republic of Guinea. In the lower reaches, the St John River flows through Bong and Grand Bassa Counties. For this reason, any project related activity which causes pollution to enter the north Nimba tributaries of the St John will potentially have an adverse impact on the adjacent natural resources and people of Guinea and the downstream counties of Liberia.

Another potential trans-boundary impact is that on wide-ranging species such as primates who may have territorial claim or range across the border into Guinea, or even into Ivory Coast. The area proposed as the West Nimba Protected Area is part of a trans-boundary forest habitat of high bio-quality and it is crucial that this area is treated as an ecological resource of global importance. Unfortunately the FDA has agreed that this area be managed as a community forest. This will place extreme pressure on the critical habitats and wildlife known to be present there.

Economic migration is already evident with prospective job seekers travelling across the borders from Guinea and Ivory Coast to Yekepa in hope of benefiting from the Phase 2 mining operations. The consequent impact could develop into conflict with local communities also aspiring for these same opportunities (Volume 5). Risks of trans-boundary epidemic disease transmission such as influenza and meningitis are possible with the proximity of the borders and the amount of people travelling across it. Added to the local disease spectrum other diseases passed by expatriates working for the Company and its contractors could be carried across the border such as multi-drug resistant tuberculosis with a consequential negative effect.

As the road networks between Yekepa and Sanniquellie improve and other roads are opened up, it is envisaged that more cross-border trading will take place between Guinea, Ivory Coast and Liberia. Levies on goods being imported will provide economic contributions to the national tax revenue of Liberia and increased trading between the countries may provide income generating opportunities for residents along the Yekepa – Sanniquellie road and possible trading opportunities for people living in mine-affected communities and Yekepa.

10.3 Cumulative and Trans-Boundary Impacts Combined

Mining in the Liberia-Guinea-Ivory Coast area around Nimba (Table 10.1) is likely to focus on the topographical high points that are important for biodiversity. Therefore the cumulative impacts may be serious in that much of the habitat on hills and mountains is removed over a wide area. Competing rail corridors and ports may lead to further environmental damage.

Attempts by the Company to engage with the proponents of these other projects did not progress beyond an exploratory meeting in London in October 2011, with Rio Tinto and BHP Billiton. Vale expressed an interest in attending but was blocked by another party. None of the other companies were in a position to share pertinent information, and so the examination of potential future cross-border environmental impacts proved to be impossible beyond pure speculation.

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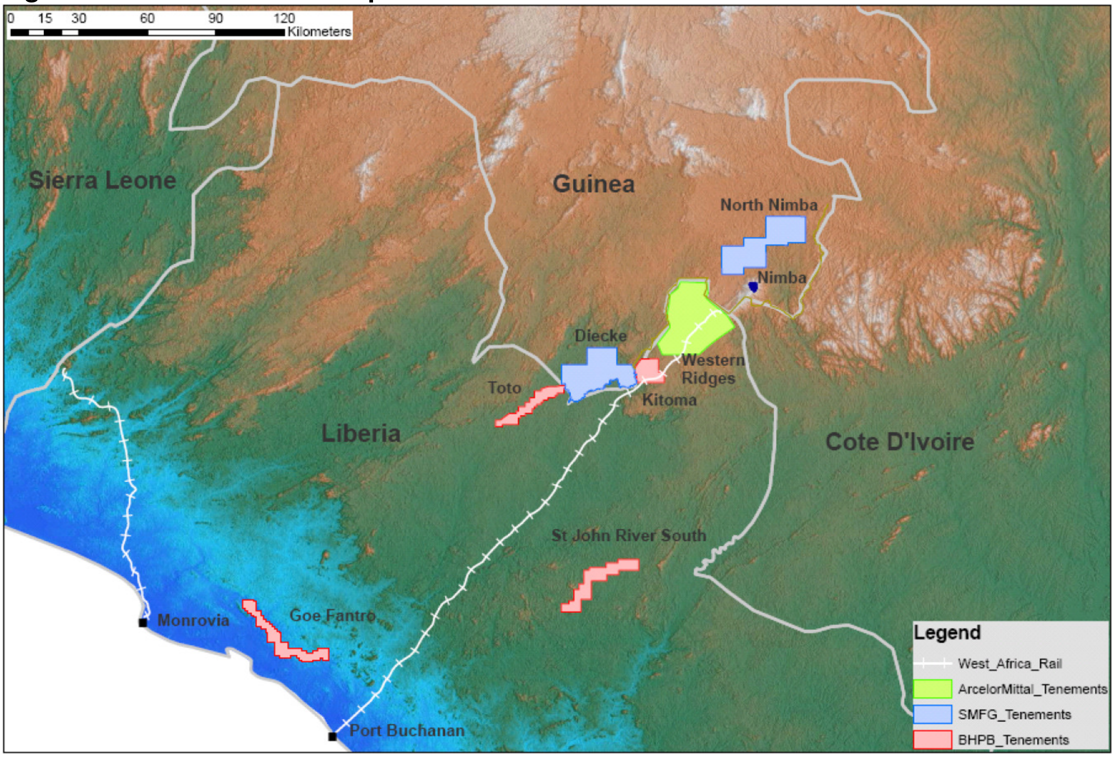
TABLE 10.1: THE VARIOUS PROJECTS IN THE REGION

Area	Concessionaire	Transportation corridor	Status
Nimba, Liberia, Guinea and Ivory Coast	ArcelorMittal (Liberian Nimba Western Area Deposits).	Through Liberia and Buchanan.	Phase 1 mining in progress. Phase 2 (post 2015) in design and ESIA.
	Société des Mines de Fer de Guinée (SMFG), dominated by BHP Billiton and Newmont (Guinea Nimba, plus Nimba North and Diecke exploration blocks)	Through Liberia to a new port. Previously considered a corridor within 100 km each side of the ArcelorMittal railway, and then focussed only on the existing railway.	Design and ESIA started in 2011 and due for completion about 2013. Fatal flaw review in 2012 (outcome not known). BHP Billiton is planning to sell its stake to a Brazilian buyer.
	Unknown, formerly Tata Steel (Ivory Coast Nimba)	Presumably entirely through Ivory Coast.	Not known.
Simandou, Guinea	Vale with the BGR Resources (blocks 1 and 2)	One of three possible routes through Liberia, most likely with a port at Didia.	Design and ESIA started in 2011. Target date not known. Project said to be suspended.
	Rio Tinto with Chinalco (blocks 3 and 4)	North-westwards through Guinea to a port near Conakry.	ESIA in progress and was due for completion by mid 2012, but subsequently delayed. Project said to be suspended.
Kalia, Guinea	Bellzone Mining with China International Fund Limited	North-westwards through Guinea to a port near Conakry. May be a link-up with Rio Tinto.	Not known.
Kitoma, Liberia	BHP Billiton	Not known, but must be ArcelorMittal railway or close to it.	Exploration underway. Initial environmental studies in progress. BHP Billiton has placed it on the market
Diecke, Guinea	BHP Billiton	Not known, but a corridor through Liberia is most likely to be the only economic option.	Exploration underway. BHP Billiton has placed it on the market

Locations (Figure 10.1)

- The Guinea Nimba project is close to Yekepa (actually closer than Tokadeh).
- The Ivorian Nimba resource is not known, but it lies north-east of the Guinea Nimba resource. At present it is “locked” into a World Heritage Site.
- Simandou is a ridge running about 100 km north to south. The southern end is about 100 km north-west of Yekepa.
- Kalia is located just north of the northernmost point of Sierra Leone, about 400 km north-west of Yekepa. Kalia may be far enough away from Nimba that we do not need to be concerned with it.
- Transport corridors through Liberia may be close enough to have an impact.

Figure 10.1: Location of Prospects Referred to in Table 10.1



11 EXPECTED RESIDUAL ADVERSE AND BENEFICIAL EFFECTS

The anticipated residual adverse and beneficial effects of the project are summarised in Tables 11.1 and 11.2 respectively. Further details on anticipated positive effects and opportunities are summarised in Table 8.5.

TABLE 11.1: ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT – ADVERSE RESIDUAL IMPACTS (ASSUMING FULL MITIGATION IS APPLIED)
All
Injuries and fatalities due to mine/rail/port and traffic accident are to be expected, as with any project of this nature, even with full precautionary measures and mitigation. Industrial accidents, including those involving hazardous materials can be minimised but in practice not eliminated entirely. Any spillages of hazardous materials will potentially impact the environment.
Mine Infrastructure Construction
Permanent removal of prominent mountain landform. Even with comprehensive mine restoration plans, slope re-vegetation will take many years to re-establish. The landscape value provided by the Gangra-Yuelliton ridge will be inevitably diminished.
Permanent land-take for the mines and their infrastructure will result in the loss of 209 hectares of agricultural land (plus an additional 176 ha that will be taken out of production during mine operation due to the exclusion zone), 227 hectares of evergreen forest and 1249 hectares of other forest. 250 hectares of Level 1 biological constraint area (high biodiversity habitat) will be removed as part of the Phase 1/Phase 2 footprint and known borrow areas. This will include removal of tall, close canopy forest, removal or damage to swamps and streams; loss and fragmentation of habitats and loss of some sedentary species. There are up to 38 sightings of 25 different Black Star botanical species within the Phase 1/Phase 2 footprint. Globally-threatened wildlife species will suffer some loss of habitat. The anticipated increased influx of population is expected to lead to increased demand for bush meat and possibly slash and burn agriculture. Impairment of downstream water users through reduction or pollution of drinking water and damage to aquatic species that represent food/protein resources for the local population (fish, crustaceans).
Permanent removal of 1 sacred rock in the area of the Tokadeh waste dump.
There will be some people who experience a permanent reduced level of livelihood, even with comprehensive plans for compensation and alternative livelihood provision.
Mine and Plant Operation/ Maintenance
The planned control of runoff and sediment for the mine should contribute significantly to a reduced level of impact to water-courses and habitats downstream. However, the details are still being developed and there remains a considerable risk of pollution if the design is inadequate or is not properly implemented and monitored. It is recommended that the details are reviewed independently once they are available and before any Phase 2 mining related activities take place. The effects of runoff from Phase 1 remain a significant residual impact that can be rectified with the appropriate measures in place. There will remain a risk from slope failures, including failure of entire slopes, waste dumps, stockpiles and parts of the TMF. These outcomes would have knock-on effects for the safety and livelihood of communities downstream/downslope as well as habitats. These aspects are part of the ongoing design and will require technical review prior to implementation.
Reduction of income-generating opportunities for women will exacerbate social problems e.g. public health and education.

Mine and Plant Operation/ Maintenance
The groundwater table could be penetrated by mine excavations and drilling operations, thus providing direct hydraulic connectivity between potentially polluted surface runoff and groundwater. There is insufficient data on groundwater and hydrogeology to assess these risks, and it is recommended that these assessments form part of the ongoing design studies. There is certainly a need for additional groundwater data from drilling investigations and monitoring.
Loss of access to other sacred groves and animal practice sites. There will also be some break of traditional affiliation to land.
Dust will remain a residual impact, though the effects will be limited.
Some long term potential for adverse impact on streams and rivers due to runoff from unsealed road surfaces.
Townships
Some adverse effects, including pressure on resources (esp. water and wildlife, food), generation of solid waste and wastewater, hostilities, health and noise impact, and imbalances between social groups caused by in-migration, gender imbalance, overcrowding of townships are considered inevitable, even with full mitigation. Alcohol abuse, prostitution, risks of HIV/AIDS and STD and abuse of under-age/disadvantaged individuals can be expected to increase. Many of these and further non-mitigatable social and socio-economic impacts are also expected to occur in connection with the operation of the temporary work camp near Yekepa
Over-reliance on the mono-industry of iron ore in Yekepa will lead to a loss of employment opportunities and a decline in township facility provision once Phase 2 is complete, or if there is a decline in steel or iron ore markets, despite all practical attempts to the contrary
Railway Operation
Depending upon the mitigation adopted there may be significant vibration effects at Sanniquellie Hospital operating theatre.
Port Area Operation
There will be a residual risk from spillages into the harbour and at sea. A larger workforce, and increased migrants to Buchanan will probably result in increased risk to sea turtles, despite conservation efforts.

TABLE 11.2: SUMMARY OF POSITIVE ENVIRONMENTAL AND SOCIAL EFFECTS (EXCLUDES OFFSETS, SEE TABLE 8.5 FOR FURTHER DETAILS)
Mine Infrastructure Construction
Significant temporary effect on local communities supplying labour and other services for the construction activities – and downstream effect on local suppliers of goods and services due to increase in local community income;
Significant effect on future employment prospects of trained personnel;
Significant long term effects on wider biodiversity conservation if the Company is able to invest effectively in the creation of a Northern Nimba Conservation Area, that strengthens the East Nimba Nature Reserve and formalises conservation arrangements for the West Nimba forests.
Mine and Plant Operation/ Maintenance
Significant contribution of royalties, taxes and MDA payments to the Government of Liberia, enabling extensive development at the national and county levels (on the assumption that this is then invested in people and services);
Significant long term positive impact on the economy of the local community, counties and country with downstream benefits to suppliers of goods and services due to increase in local community income as well as company purchases;
Significant effect on future employment prospects of trained personnel and facilities of health, schooling etc for employees and their families.

Townships
Beneficial impacts will include the access to education and health services as a benefit to employees and their families and increased wealth and standard of living. Significant long-term potential beneficial impact even after mine closure, assuming Yekepa continues as a major town in the area with improved facilities (schools, hospital, water supply, power generation, street lighting etc.) Increased traffic will result in communication benefits (e.g. markets) and encourage the development of road side support enterprises and other related economic opportunities. Company offices can be allocated to other uses and houses reoccupied.
Railway Operation
Significant long term potential for 'other user' access to the railway to stimulate development along the line to the benefit of trackside communities.
Port Operation
Significant effect on future employment prospects of trained personnel and benefits to employees and their families.

12 MONITORING

Monitoring will be a key element of the Company's Environmental Managament Plans. It is already made clear in Volumes 3-5 that monitoring will be required to help augment the environmental data acquired so far, especially with regard to hydrology, where there remain significant gaps. Monitoring will also be required to assist in some of the offsetting programmes and to assess the progress and performance of mitigation. Table 12.1 provides some guidance as to monitoring scope and frequency, but Volumes 3-5 should be used as the basis for designing a detailed programme.

TABLE 12.1: GUIDANCE ON MONITORING SCOPE AND FREQUENCY

Sector	Impact to be Monitored	Monitoring Method	Frequency	Responsibility
Physical Environment	Climate and atmosphere	Rainfall, temperature windspeed	Daily, except for continuous raingauges	Company Environmental Officer
	Run-off related soil erosion and sediments from mine, waste dump and stockpile surfaces	Stream discharge, turbidity, water quality. NB all streams draining from mine and other facilities	Weekly and 3 (?) hours after an above normal rainfall	With the Contractor's Environmental Compliance Officer (ECO)
		Effectiveness of re-vegetation of redundant sites/roadsides/etc	After especially heavy rainfalls plus annual inspection	Company Environmental Officer
	Groundwater	Yield and water quality monitoring, Yekepa, Buchanan, mine villages	Daily	Company Environmental Officer
	Noise and air quality	Air quality at mine sites, port and main receptors, including noise and vibration monitoring at Sanniquellie Hospital	Daily	Company Environmental Officer
		Dust levels and suppression methods	Weekly during dry season months	Company Environmental Officer
	Hazard Substance Handling and Storage	Dispensing and transport of petroleum products	Rotational Weekly Spot Checks	With the company Health and Safety Officer
		Handling and Storage of Explosives	Random monthly	With the Contractor

TABLE 12.1: GUIDANCE ON MONITORING SCOPE AND FREQUENCY				
Sector	**Impact to be Monitored**	**Monitoring Method**	**Frequency**	**Responsibility**
	Waste Management Plan	Handling and Disposal of solid and liquid waste	Monthly Spot Checks	With the ArcelorMittal Health and Safety Officer
Biological Environment	Illegal activity	Protection of Turtle Nesting Beaches	Regular Patrols in February/ March	With Community and FDA
		All project employees/suppliers hunting, buying bushmeat	Irregular patrols and reported activity	Company Environmental Officer
	Revegetation Programme	Review of past and present plantings	At least annually with full report	Company Environmental Officer
	Education	Awareness Programme Effectiveness	Annual Review	With Community Liaison Office
Human Environment	Community Development Programme	Environmental Impact of Programme Implementation	Monthly	With Community Liaison Office
	Health and Safety	Potable Water Quality, Work and road accidents involving project property	Monthly	Company Environmental Officer
	Social Action Plan	Plan Achievements & Effectiveness	Quarterly, unless developments occur that require more frequent monitoring	Community Liaison Officer

13 APPENDIX 1: REFERENCES

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14 APPENDIX 2: SCHEDULE OF THE PROJECT PERMITTING DOCUMENTS

Liberia Western Range Iron Ore Projects (DSO and Concentrator): Schedule of Permitting Documents

Document type	Title	Summary of permitted activities	Submission date	Validity of permit
Project Brief (1)	Exploratory Drilling at Mount Tokadeh (Phase 0)	Exploratory drilling at Tokadeh	Dec 2007	Work completed
Project Brief (2)	Refurbishment of Buchanan to Yekepa Railway and associated service and access roads (Phase 0)	Rehabilitation of the railway and service roads	March 2008 Renewed 2011	Expired 11 April 2012
Project Brief (3)	Phase 1 Mining and Transportation of Iron Ore, 2011-2015: the Nimba Western Range DSO Iron Ore Project	Not applicable	Jun 2008	Led to ESIA-1
Project Brief (4)	Exploratory Drilling at Mounts Gangra and Yuelliton (Phase 0)	Exploratory drilling at Gangra and Yuelliton	Aug 2008	No expiry date
Scoping Document	Phase 1 Mining and Transportation of Iron Ore, 2011-2015: the Nimba Western Range DSO Iron Ore Project	Not applicable	Oct 2008	Led to ESIA-1
Project Brief (5)	De-silting of the Port of Buchanan (Phase 0)	One-off de-silting of the Port of Buchanan	Jul 2010	Work completed
ESIA (1)	Phase 1 Mining and Transportation of Iron Ore, 2011-2015: the Nimba Western Range DSO Iron Ore Project	Mining of DSO; operation of the railway and port for DSO; operation of the towns; all up to 2015.	Sep 2010	Valid to April 2014
Project Brief (6)	Initial Investigations for the Tokadeh-Gangra Haul Road (Phase 1)	Track opening and geotechnical drilling along the haul road alignment	Oct 2010	Expired 24 January 2012
Project Brief (7)	Phase 2 Mining, Concentration and Transportation of Iron Ore, 2013-2026	Not applicable	Nov 2010	Led to ESIA-2
Project Brief (8)	Geotechnical Drilling and other Site Investigations for Project Phase 2	Geotechnical and hydrogeological drilling in Phase to infrastructure and TMF areas	Nov 2010	Expired 21 February 2012
Scoping Document	Phase 2 Mining, Concentration and Transportation of Iron Ore, 2013-2026	Not applicable	Jan 2011	Led to ESIA-2
Project Brief (9)	Rehabilitation of Iron Ore Handling Facilities at the Port of Buchanan (advance Phase 2)	Rehabilitation of train unloading, stockpiling and ship loading facilities; rail infrastructure; fuel handling and power generation; re-opening of Neekreen quarry; searches for materials elsewhere; repair of dolphins; investigation for capesize pier	Sep 2011	8 November 2014
Project Brief (10)	Advance Earthworks on a Brown Field Site near Mount Tokadeh for Project Phase 2 (advance Phase 2)	Advance earthworks on a brown field site; creation of a temporary construction camp; extension of rail sidings	Nov 2011	8 November 2014
Addendum (1) to ESIA-1	Addendum to ESIA-1: Additional Zoological Studies	Gap-filling research on zoological issues	Dec 2011	As for ESIA-1
Project Brief (11)	Re-opening of Glaton Hill Quarry for Project Phase 2	Provision of aggregate for Phase 2 construction	Mar 2012	1 September 2014
ESIA (2)	Phase 2 Mining, Concentration and Transportation of Iron Ore, 2013-2026	Mining of lower grade ores; installation and operation of a concentrator; creation of a tailings management facility; operation of the railway and port for	Mar 2013	
Addendum (2) to ESIA-1	Addendum to ESIA-1: Coastal Environmental Studies at Buchanan	Transhipment of iron ore into capesize vessels at sea off the Port of Buchanan	In preparation	As for ESIA-1
Project Brief (12)	Additional material sources for construction works at Buchanan	Extraction of laterite for construction works	In preparation	
Project Brief (13)	Operation of a geological laboratory at Yekepa	Geological testing laboratory	In preparation	
Project Brief (14)	Upgrading of the Ganta-Yekepa Highway	Upgrading of the Ganta-Yekepa Highway	In preparation	
Project Brief (15)	Translocation of bats from old LAMCO adits to new habitats	Bat translocations	In preparation	

15 APPENDIX 3 LIST OF PROJECT TEAM MEMBERS INVOLVED IN PREPARING THIS ESIA

The URS ESIA team comprised a Project Director, a Project Technical Direcor, an ESIA Coordinator/ URS Project Manager and technical specialists in Social Development, Anthropology, Human Rights, Botany, Zoology, Geomorphology, Soils and Terrain, Hydrogeology, Hydrology, Geochemistry and Acid Rock Drainage (ARD), Air Quality, Noise & Vibration, Ladscape and Visual Amenity, Geographical Information Systems (GIS).

The team was composed of Liberian, regional and International experts.

The various studies that contributed to this assessment brought together many specialists from a range of organisations. These specialists are listed below.

Martin Edge	URS Regional Director
Gareth Hearn	Project Technical Director
Tanya Romanenko	ESIA Coordinator/ URS Project Manager
Melanie Pörschmann	Environmnetalist / EIA / EMP Specialist
James Mitchell	GIS/Mapping Specialist
Alpha Robinson	Hydrologist
George Brown	Field Surface Water Technician
Clive Hallett	Geochemistry & ARD Specilist
Geoff Pettifer	Tropical Soils/Geotechnical Specialist
Cyrus Weah	Certified Environmental Evaluator
Deneys Schreiner	Geotechnical Engineer
Howard Wong	Hydrogeologist
Nigel Weir	Landscape Specialist
Alf Maneylaws	Noise and Vibration Specialist
Danny Duce	Air Quality Specialist
Thomas Johnson	Certified Environmental Evaluator
Samuel W.D.Wesley	Certified Environmental Evaluator (2009)
Ben Phalan	Conservation Zoologist
Ara Monadjem	Small Mammals Specialist
Françoise Lemaire-Dowsett	Ornithologist
Johannes Penner	Herpetologist
Bill Branch	Herpetologist
Denis Tweddle	Freshwater Fisheries Specialist
Savel Daniels	Freshwater Decapod Crustacea Specialist

KD Dijkstra	Dragon flies and Damselflies Specilaist
Szabolcs Sáfián	Butterflies Specialist
Torben Larsen	Butterflies Specialist
Aaron Savio Lobo	Marine & Coastal Ecology
Korvah Vanyanbah	Forestry Development Authority, East Nimba Nature Reserve
Moses Darpy	East Nimba Nature Reserve Volunteer
Peter Farnloe	Forestry Development Authority, East Nimba Nature Reserve
William Zolo	Forestry Development Authority, East Nimba Nature Reserve
Roger Luke	Forestry Development Authority, East Nimba Nature Reserve
Kate Blacklock	Social Development Specialist
Duke Davies	Social Development Consultant / Certified Environmental Evaluator
Marvee Sirleaf	Assistant Social Development Consultant
Aoife McCullough	Socio-economic Baseline
Lis Vikman	Socio-economic Baseline Enumerator
Steffen Fischer	Socio-economic Baseline Enumerator
Katie Hebditch	Socio-economic Baseline Enumerator
Ewurabena Yani Akofur	Socio-economic Baseline Enumerator
Eric Bontor	Baseline survey assistant (yekepa)/ interpretation and liaison with communities, also NTFP
Rosemaries Wonbenyakeh	Baseline survey assistant (Yekepa)/ interpretation and liaison with communities, also NTFP
Limcy Rose	Baseline survey assistant (Yekepa)/ interpretation and liaison with communities, also NTFP
Patrick	Baseline survey assistant (Buchanan)/ interpretation and liaison with communities
Maria	Baseline survey assistant (Buchanan)/ interpretation and liaison with communities
Elija Smith	Baseline survey assistant (Buchanan)/ interpretation and liaison with communities
Elija Reeves	Baseline survey assistant (Buchanan)/ interpretation and liaison with communities
Lucy Daxbacher	Human Rights Specilaist
Gwendolyn Heaner	Cultural Heritage Specilaist

Pierre Poilecot	Botanist, Grasses
Ouo OuO Haba	Botanist, grassland & Forest
William Hawthorne	Botanist, Forest
Patrick Ekpe	Field RBS Team Leader
David Bilivogui	Field RBS Team Leader
Cicely Marshall	Reaserch Assistant / Coordinator of NTFP Survey
Steven Heathcote	Reaserch Assistant / Coordinator of RBS Survey
James Kpadehyea	Forestry Development Agency
Daniel Dobor	Forestry Development Agency, Zwedru

In addition, ArcelorMittal staff assisted and / or participated in various studies. These included:

John Howell	ArcelorMittal Environmental Adviser
Alvin Poure	ArcelorMittal Environment Coordinator, Yekepa Certified Environmental Evaluator
Forkpayea Gbelee	ArcelorMittal Environment Coordinator, Buchanan Certified Environmental Evaluator
Wing Crawley	ArcelorMittal Biodiversity Conservation Programme Co-ordinator
Nyononpine Williams	ArcelorMittal, Biodiversity Officer
James Davis	ArcelorMittal Environmental Assistant, Yekepa
Jerry Fumba	Community Liaison Office, Yekepa
Joseph Bassama	Infrastructure Engineer, Greenhill Quarry

16 APPENDIX 4 QUALITY ASSURANCE CERTIFICATION

URS Infrastructure & Environment UK's Safety, Quality and Environmental Management Systems are certified by SGS. The procedures and processes are assessed against the requirements of three international standards:

- ISO 9001 (Quality Systems),
- ISO 14001 (Environmental Management Systems), and
- OHSAS 18001 (Occupational Health and Safety Assessment Series).

The certificates are included in this Appendix.

The project technical Direcor is a Chartered Environmentalist. His Certificaed is also included herewith.

Certificate GB11/84310.00

The management system of

URS Infrastructure & Environment UK Limited

Scott House, Alencon Link, Basingstoke,
Hampshire, RG21 7PP, UK

has been assessed and certified as meeting the requirements of

ISO 9001:2008

For the following activities

Planning, engineering, design, management and environmental consultancy.

This certificate is valid from 25 January 2013 until 27 June 2015 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 23 April 2015
Issue 7. Certified since 19 April 2005

Multiple certificates have been issued for this scope
The main certificate is numbered GB11/84310.00
This is a multi-site certification.
Additional site details are listed on subsequent pages.

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SGS United Kingdom Ltd Systems & Services Certification
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SGS 9001 08 0311 M7

UKAS MANAGEMENT SYSTEMS
005

Certificate GB11/84308.00

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This certificate is valid from 25 January 2013 until 27 June 2015 and remains valid subject to satisfactory surveillance audits.
Re certification audit due before 23 April 2015
Issue 6. Certified since 04 April 2005

Multiple certificates have been issued for this scope
The main certificate is numbered GB11/84308.00
This is a multi-site certification.
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UKAS MANAGEMENT SYSTEMS
005

Certificate GB11/84315.00

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URS Infrastructure & Environment UK Limited

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Hampshire, RG21 7PP, UK

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For the following activities

Planning, engineering, design, management and environmental consultancy.

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Re certification audit due before 23 April 2015
Issue 6. Certified since 24 June 2005

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UKAS MANAGEMENT SYSTEMS
005

SocEnv

Society for the Environment

This is to certify that

Dr Gareth James Hearn

in membership of

Institution of Civil Engineers

has been registered by the Society for the Environment
and is hereby authorised to use the style or title of

Chartered Environmentalist

and to use after their name the designatory letters 'CEnv'

Chair of the Board

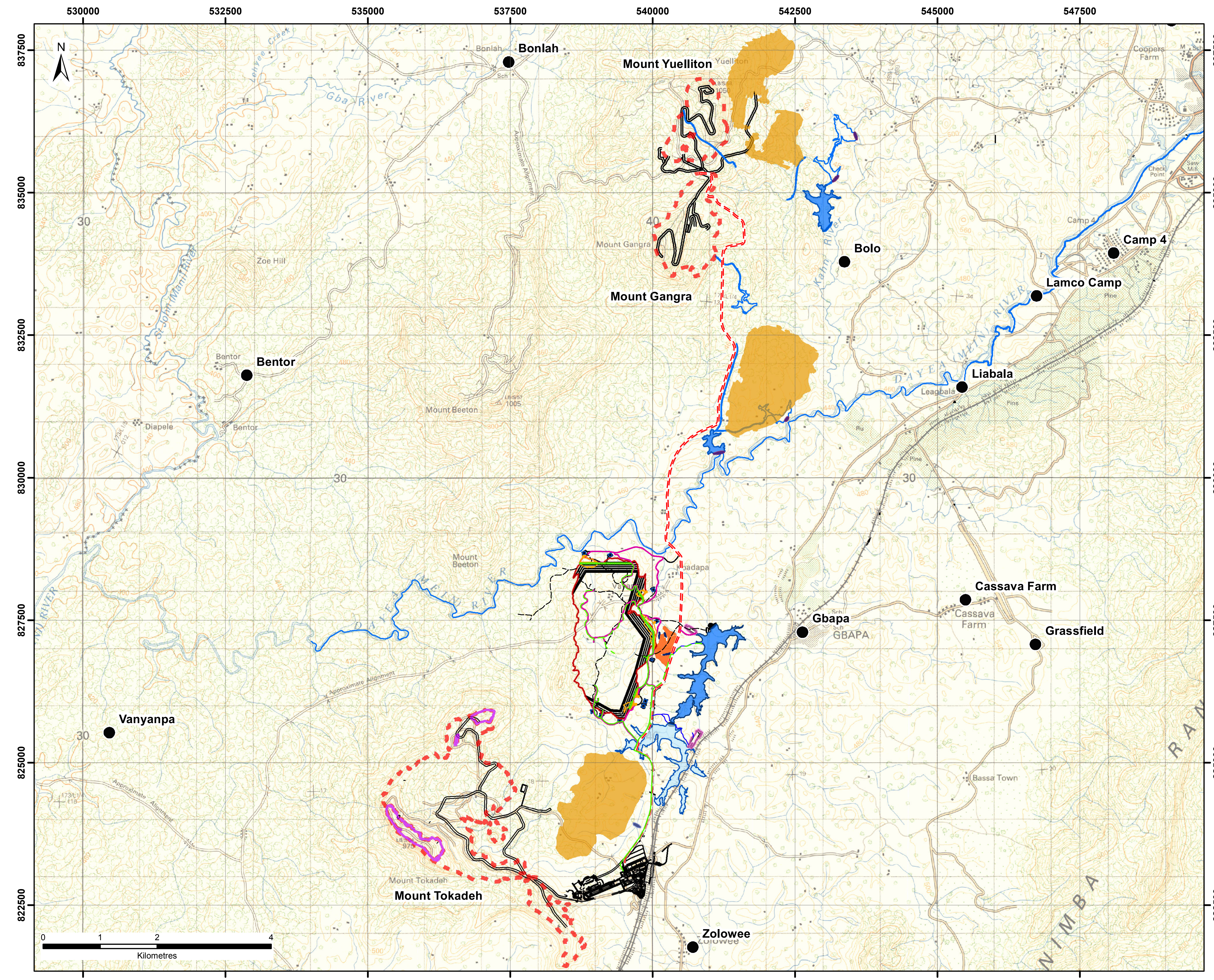
Chair of the Registration Authority

Date of Award 14/04/2005

Registration No 1562

This certificate is the property of the Society for the Environment
Returnable on request or de-registration

17 DRAWINGS



NOTES

- Tailings Reclaim Pipeline
- Tailings Pipeline
- Access Roads Embankments
- Proposed Access Roads
- Proposed Roads
- Temporary Tracks
- Haul Road (tentative alignment that needs confirmation)
- Dam
- DSO
- Mine Site
- Overflow Spillway
- Sediment Control Dam
- Sediment Pond
- TMF
- TMF Seepage Pond
- Treatment Pond
- Waste Dump
- Sediment Control Ponds
- Topsoil & Vegetation Stockpile Area

Projection:
UTM Zone 29N; Datum WGS84.

Source
©DigitalGlobe, Inc., All Rights Reserved.
1:50,000 Mapping: LIB50 2840/II (1988), LIB50 2839/I (1988),
Site Layout based on drawings: 166580-3200-121-PLP-0001 (14/12/2012) and 166580-6200-121-PLP-0001 (14/12/2012)
Stockpile Sedimentation Control Ponds: Eastern Storm Water Management Sedimentation Control Pond Stockpile Areas General Arrangment - 7879010023/9040J Rev A (15/11/2012)
Proposed Stockpile Area: TMF Embankment Proposed Year 0
Borrow Areas Management - 7879010023/9040A Rev A1 (16/10/2012)
TMF Reclaim Pipeline: 166580-3620-165-GAD-1950 (October 2012)
TMF Tailings Pipeline: 166580-3620-165-GAD-1940 (October 2012)
Access Roads: 166580-3620-165-GAD-1801 (September 2012)

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title
MINE AREA GENERAL LAYOUT

Drawn	Checked	Approved	Date
JM	TR	TR	18/02/2013

URS Internal Project No. 47059315
Scale @ A3: 1:60,000

URS Infrastructure & Environment UK Limited
Scott House
Alençon Link, Basingstoke
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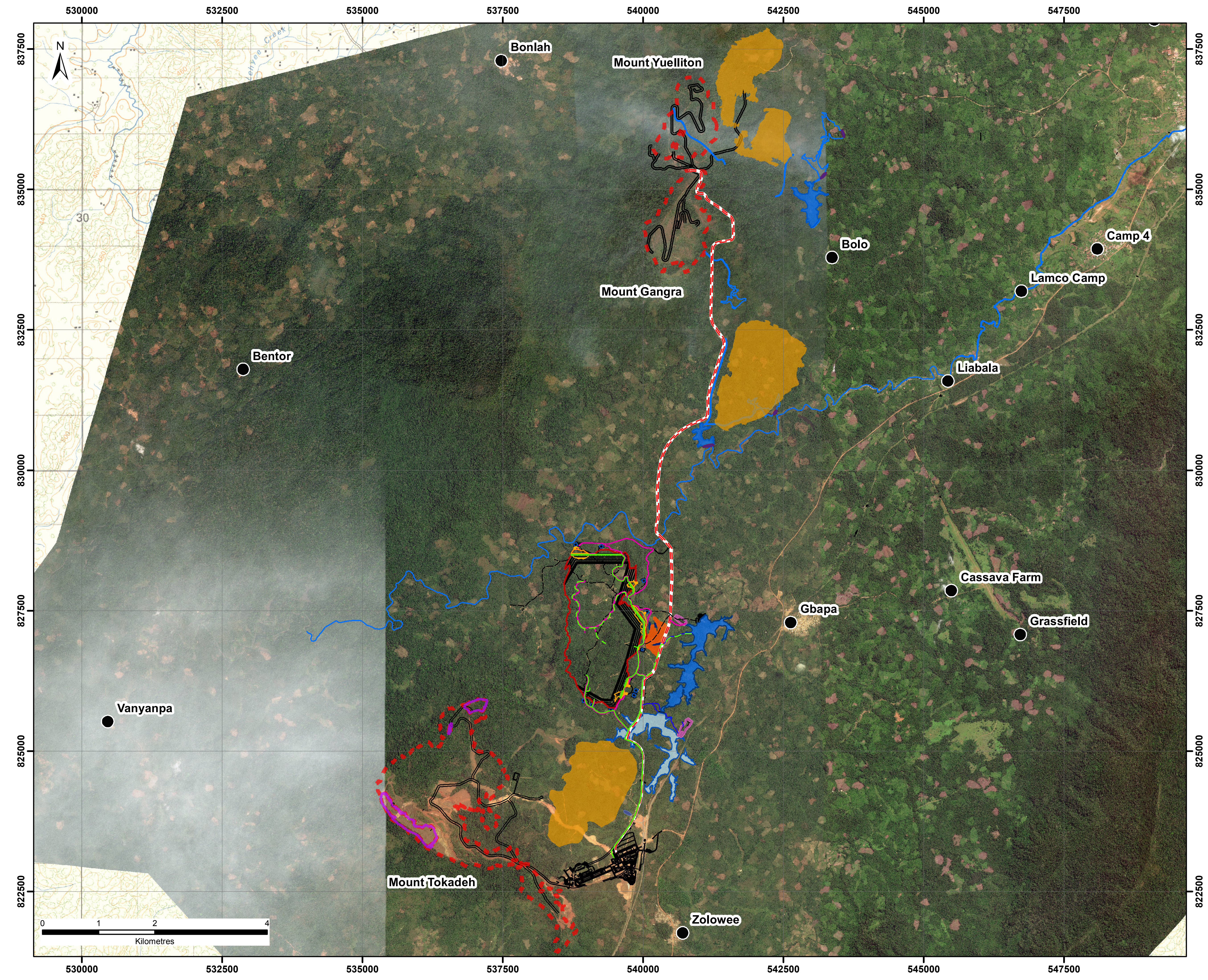
Drawing Number
DWG 4.1
Rev



NOTES

- Tailings Reclaim Pipeline
- Tailings Pipeline
- Access Roads Embankments
- Proposed Access Roads
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- TMF Seepage Pond
- Treatment Pond
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- Sediment Control Ponds
- Topsoil & Vegetation Stockpile Area

Projection:
UTM Zone 29N; Datum WGS84.

Source
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1:50,000 Mapping: LIB50 2840/II (1988),
LIB50 2839/I (1988),
Site Layout based on drawings:
166580-3200-121-PLP-0001 (14/12/2012)
and 166580-6200-121-PLP-0001 (14/12/2012)
Stockpile Sedimentation Control Ponds:
Eastern Storm Water Management Sedimentation Control Pond Stockpile Areas General Arrangment - 7879010023/9040J Rev A (15/11/2012)
Proposed Stockpile Area:
TMF Embankment Proposed Year 0
Borrow Areas Management - 7879010023/9040A Rev A1 (16/10/2012)
TMF Reclaim Pipeline:
166580-3620-165-GAD-1950 (October 2012)
TMF Tailings Pipeline:
166580-3620-165-GAD-1940 (October 2012)
Access Roads:
166580-3620-165-GAD-1801 (September 2012)

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title
MINE AREA GENERAL LAYOUT

Drawn	Checked	Approved	Date
JM	TR	TR	18/02/2013

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Drawing Number	Rev
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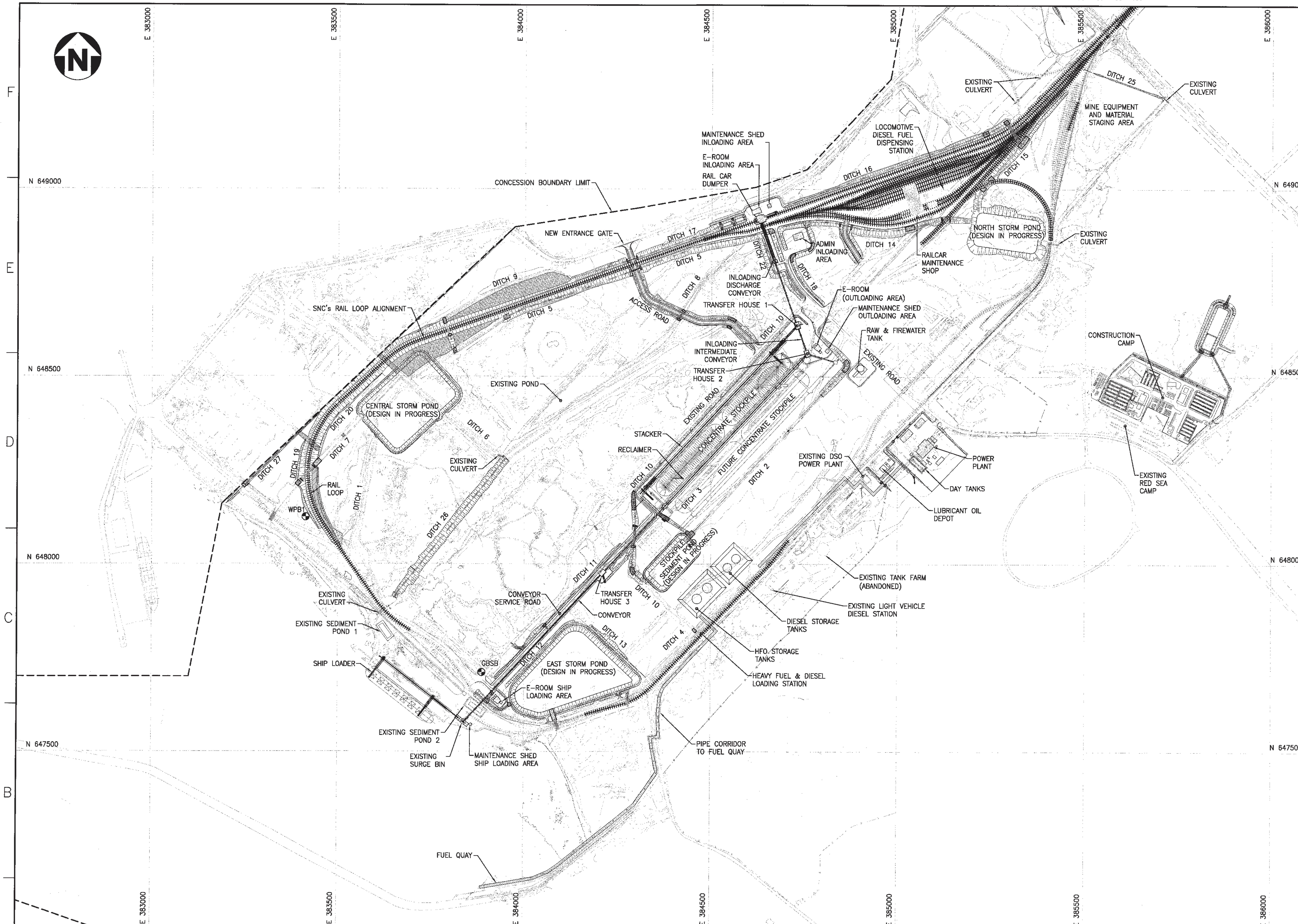
DWG 4.3



GENERAL NOTES:

1. GEOGRAPHIC COORDINATE SYSTEM SHOWN IS IN WGS84 UTM, ZONE 29N.
2. ALL COORDINATES, DIMENSIONS, AND ELEVATIONS ARE IN METERS, UNLESS NOTED OTHERWISE.
3. EXISTING GROUND CONTOUR DATA PRODUCED BY BSF SWISSPHOTO AG., FROM LIDAR SURVEY AND SUPPLEMENTED BY ODEBRECHT CONSTRUCTION INTERNATIONAL INC. GROUND SURVEY DRAWINGS.
4. FOR GEOTECHNICAL INFORMATION REFER TO: ON-SHORE GEOTECHNICAL GROUND INVESTIGATION-BUCHANAN PORT, LIBERIA, EMERSON MOORE GEOSCIENCES LTD., DATED MAY 2009.
5. SURVEY MONUMENTS/SITE BENCHMARKS; SURVEY NAIL SET IN CONCRETE FILLED 1-1/2" PIPE SUPPORTED BY A CONCRETE PYRAMID SET ON A CONCRETE FOUNDATION; PIPE IS DRIVEN APPROXIMATELY 1m INTO GROUND. MONUMENTS SET BY INGENIEURBURO M. OSTENRIEDER (IMO) DATED 07.10.2007.

WPB1	GBSB
N 648124.520	N 647711.279
E 383413.572	E 383886.966
EL 3.467m	EL 6.154m

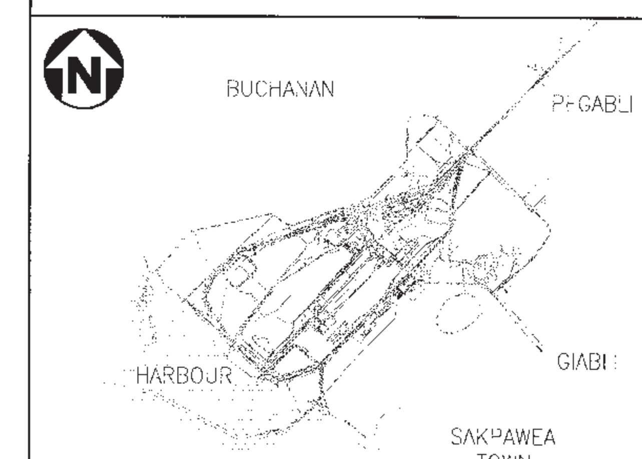
LEGEND:

- MONUMENT/BENCHMARK
- EXISTING RAIL
- FUTURE RAIL
- EXISTING CULVERT
- C01 PROPOSED CULVERT
- CONCESSION BOUNDARY
- EXISTING FENCE
- EXISTING DITCH
- CONCRETE PAVED AREAS
- DESIGNATED AREA FOR SPOIL STOCKPILE
- FILL AREA
- 150mm THICK.-GRANULAR AREAS
- FIRE ROUTE

ABBREVIATIONS:

UTM	–	UNIVERSAL TRANSVERSE MERCATOR GEOGRAPHIC COORDINATE SYSTEM
WGS	–	WORLD GEODETIC SYSTEM
N	–	NORTHING
E	–	EASTING
m	–	METRE (UNIT)
DSO	–	DIRECT SHIP ORE

0m 50 100 150 200 250
1:5000



KEY PLAN

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP
0	17OCT12	ISSUED FOR CONSTRUCTION	AR	PP	KB	RC	RH
A	15MAR12	ISSUED FOR SQUAD CHECK	KL	AB	KB	KK	

REF	NUMBER	TITLE
	REFERENCES	

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LICENSED PROFESSIONAL ENGINEER K.A. BOBECHKO 17 OCT 2012 PROVINCE OF ONTARIO

CLIENT PROJECT MGR. DISCIPLINE MGR. ENGINEERING MGR.

ArcelorMittal

amec

PROJECT PHASE	EPCM	AREA 4200
PROJECT NO. 166580	ACTIVITY NO.	
SCALE 1:5000	PACKAGE CODE	

	BY	DDMMMYY
DSN	NA	07MAR11
DRN	KL	07MAR11
CHK	KB	07MAR11
APP	RP	07MAR11

SUBJECT: LIBERIA IRON ORE PROJECT BUCHANAN PORT SITE PLAN

CLIENT DWG. NO.

DRAWING NO. 166580-4200-121-PLP-0001 REV. 0

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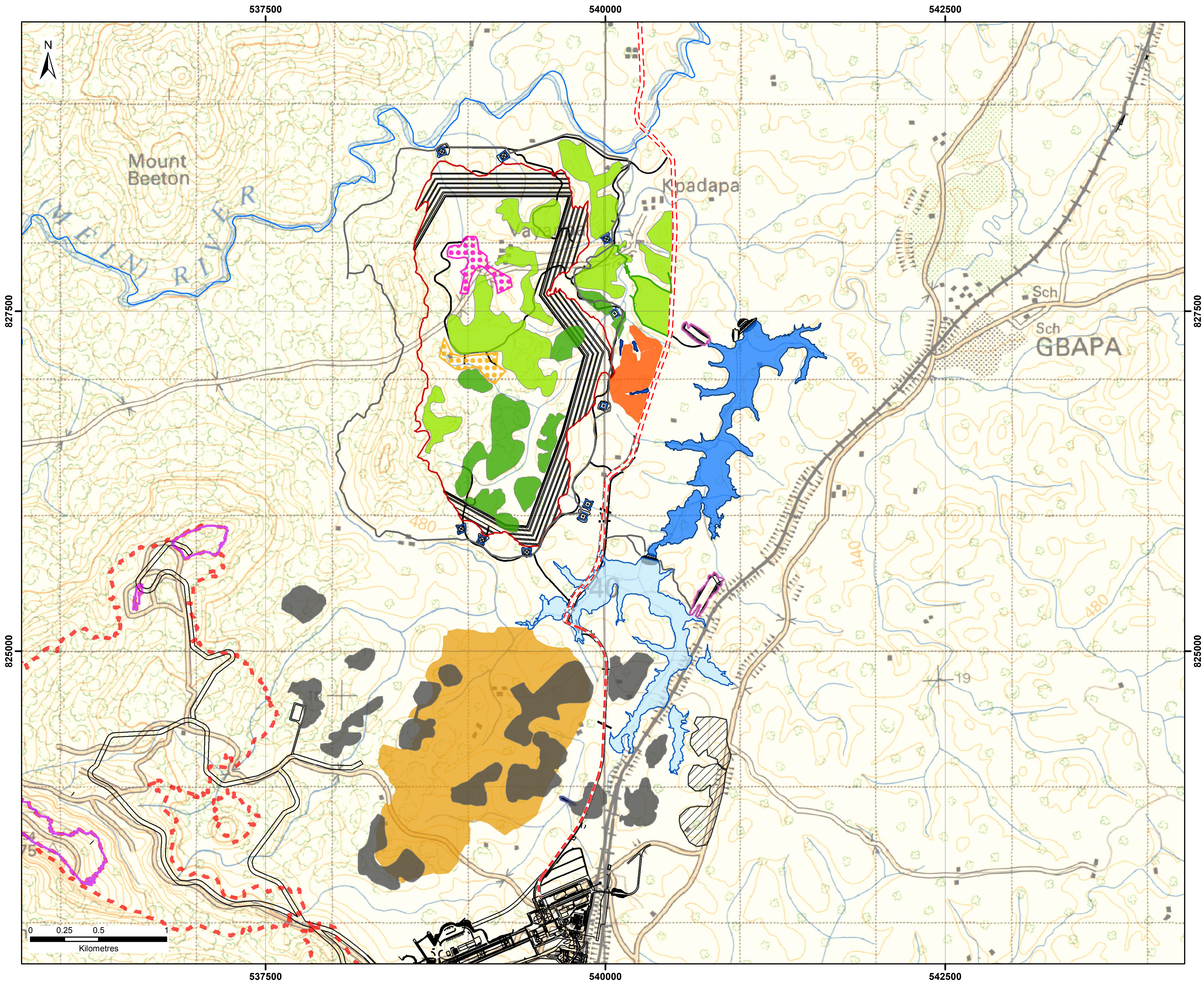
SAVED: 17-Oct-12 3:46 PM



NOTES

Borrow Area Access Roads

- Access Road
- Year 1 Access Road

Borrow Areas

- Year 0 Additional Stripped Topsoil Areas
- Year 1 Additional Stripped Topsoil Areas
- Concentrator Proposed Stockpile Areas for Topsoil and Vegetation
- Year 0 Pre Dep Proposed Borrow Areas for Approved Engineering Infill
- Year 1 Proposed Borrow Areas for Approved Engineering Infill
- Proposed Concentrator Borrow Areas for Approved Engineering Infill
- Haul Road (tentative alignment that needs confirmation)
- DSO
- Mine Site
- Overflow Spillway
- Sediment Control Dam
- Sediment Pond
- TMF
- TMF Seepage Pond
- Treatment Pond
- Waste Dump
- Sediment Control Ponds
- Topsoil & Vegetation Stockpile Area

Projection:
UTM Zone 29N; Datum WGS84.

Source

1:50,000 Mapping: LIB50 2840/II (1988),
LIB50 2839/I (1988),
TMF Embankment Proposed Year 0
Borrow Areas Management - 7879010023/9040A Rev A1 (16/10/2012)

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title
YEAR 0, YEAR 1 AND CONCENTRATOR BORROW AREAS

Drawn	Checked	Approved	Date
JM	TR	TR	10/03/2013

URS Internal Project No.	Scale @ A3:
47059315	1:25,000

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Drawing Number	Rev
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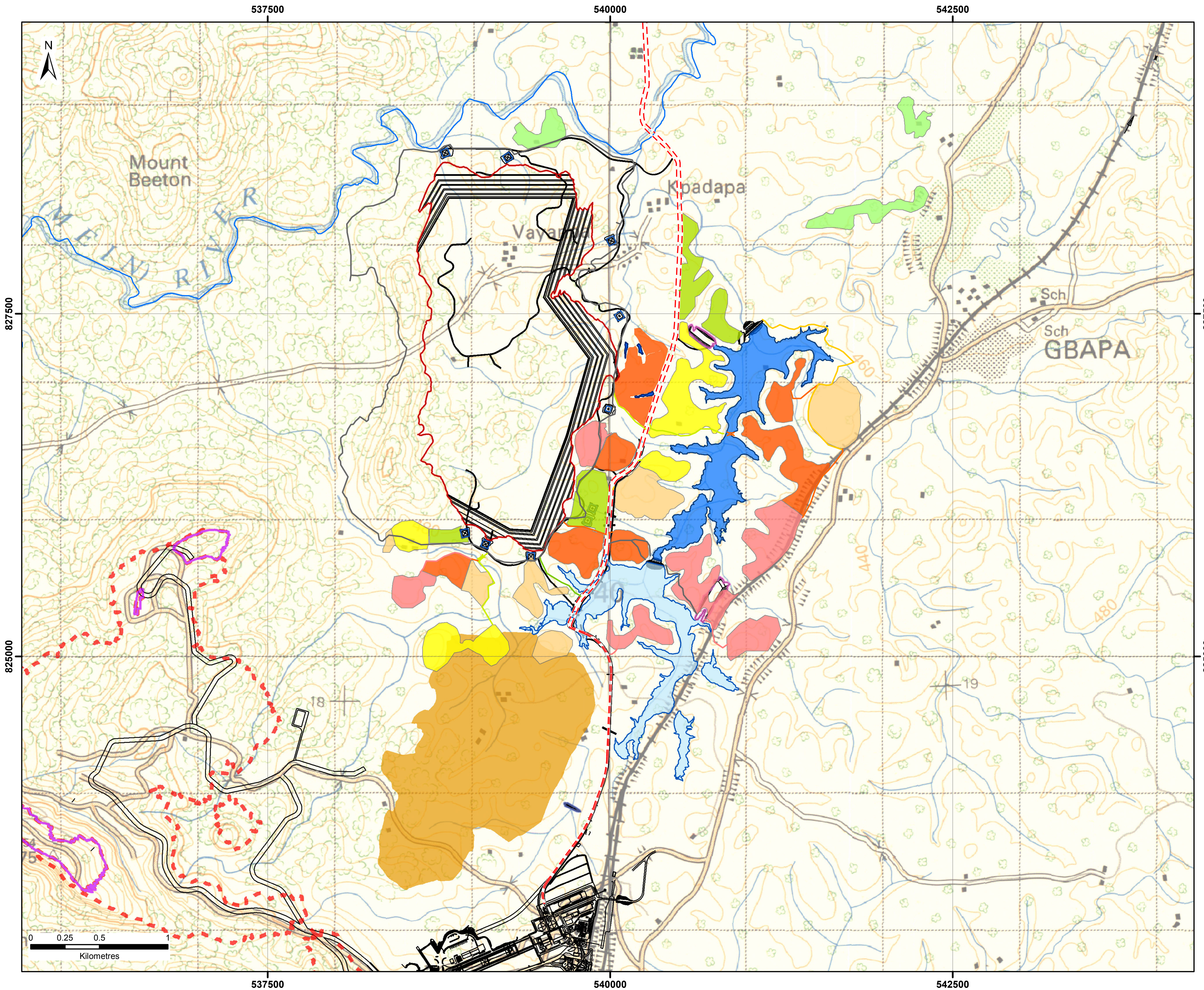

NOTES

Borrow Area Roads

- Access Road
- Year 3 Access Road
- Year 4 & 5 Access Road
- Year 6 & 7 Access Road
- Year 8 & 9 Access Road
- Year 10 & 11 Access Road

Borrow Areas

- Year 3 Proposed Borrow Areas for Approved Engineering Infill
- Year 4 & 5 Proposed Borrow Areas for Approved Engineering Infill
- Year 6 & 7 Proposed Borrow Areas for Approved Engineering Infill
- Year 8 & 9 Proposed Borrow Areas for Approved Engineering Infill
- Year 10 & 11 Proposed Borrow Areas for Approved Engineering Infill
- Potential Additional Borrow Areas for Approved Engineering Infill
- Haul Road (tentative alignment that needs confirmation)
- DSO
- Mine Site
- Overflow Spillway
- Sediment Control Dam
- Sediment Pond
- TMF
- TMF Seepage Pond
- Treatment Pond
- Waste Dump
- Sediment Control Ponds
- Topsoil & Vegetation Stockpile Area

Projection:
UTM Zone 29N; Datum WGS84.

Source

1:50,000 Mapping: LIB50 2840/II (1988),
LIB50 2839/I (1988),
TMF Embankment Proposed Year 0
Borrow Areas Management - 7879010023/9040A Rev A1 (16/10/2012)

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title
BORROW AREAS FOR THE LIFE OF THE MINE

Drawn	Checked	Approved	Date
JM	TR	TR	10/03/2013

URS Internal Project No.
47059315

Scale @ A3:
1:25,000

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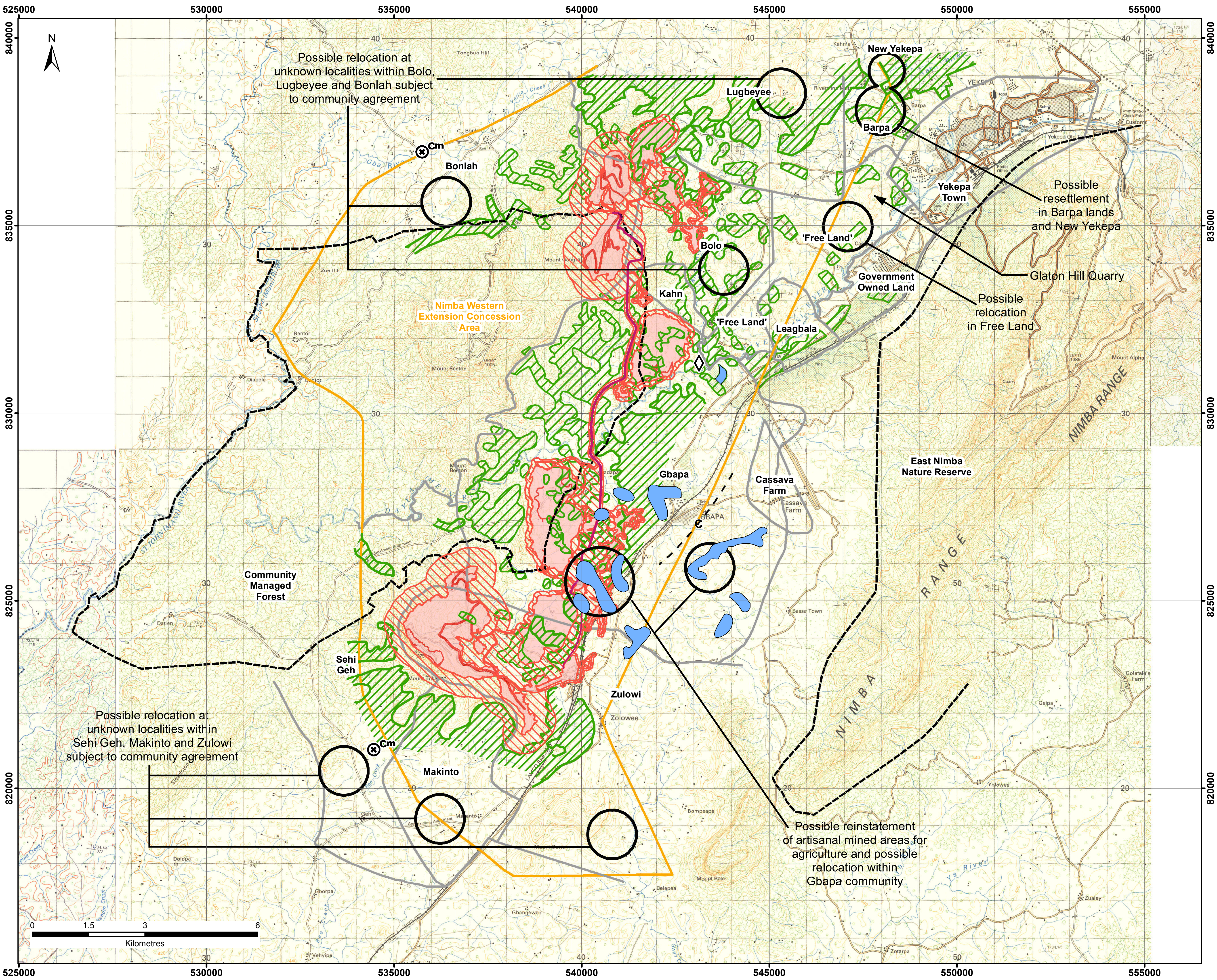
Drawing Number
DWG 4.5

Rev



NOTES

- Proposed Haul Road
- Phase1/Phase 2 Layout
- Phase 2 Exclusion Zone

Potential Mineral Resources (other than Iron)

- Diamond, kimberlite source rock (1)
- Graphite mineral locality (1)
- Corundum, approximate location (2)
- Diamond, isolated placer (1)
- Boundaries of Nature Reserves and Protected Areas
- Nimba Western Extension Concession Area
- Community and local administrative boundaries
- Farmland in the immediate vicinity of mining areas (including fallow and recently abandoned farms)

(1) Mineral localities from 1:350,000 scale 'Geologic, Geophysical and Mineral Localities Map of Liberia - a Digital Compilation', Sheet 1: Geology and Mineral Localities (USGS, 2007). Artisanal mining (particularly for diamonds) has been, or is being, carried out at some of these localities. The location and extent of any workings is presently unknown.
(2) Identified by field workers during the current Phase 2 studies.

Revision Details	By Check	Check Date	Suffix

Purpose of Issue: FINAL

Client: ArcelorMittal

Project Title: NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title: DISTRIBUTION OF SOILS AND EXISTING AGRICULTURAL PRACTICES IN THE MINING CONCESSION AREA (LAND AVAILABILITY NEEDS TO BE FIELD-VERIFIED AND UPDATED AS IT IS BASED ON 2011 OBSERVATIONS)

Drawn	Checked	Approved	Date
JM	GP	GH	17/05/2012

URS Internal Project No.	Scale @ A3
47059315	1:90,000

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Fax (01256) 310201
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Drawing Number	Rev
DWG 7.1	

NOTES

- Waterlogged Ground
- Site Visit Notes
- Drainage
- Terrace and Tailings Plateau Edges
- Previous Course of Savage River

Landuse

1. Area partially used for log storage
2. Bare Ground
3. Beach
4. Breakwater
5. Building
6. Covered Stockpile
7. Creek
8. Culvert
9. Dock
10. Drainage Ditch
11. Dry Grasslands
12. DSO Stockpile
13. Dwelling
14. Hardstanding
15. Industrial
16. Lagoon
17. Laydown Areas. Some Grass, Mostly Sand
18. Leakage from fuel spill collector
19. Mainly Dense Bushes
20. Mainly Grass
21. Mango & Palms
22. Mostly Grasses & trees
23. Ocean
24. Palm Trees
25. Pipeline Corridor
26. Pond
27. Railway
28. River
29. Road
30. Road bridge over dry creek
31. Sands
32. Scrub
33. Scrub & Trees
34. Sewage Treatment Works (Old)
35. Standing Water
36. Swamp
37. Swamp: Sago, Scattered Trees and Bushes.
38. Sword Grass
39. Sword Grass and Trees, Sago
40. Tailings?
41. Tank
42. Track
43. Trees
44. Trees and Bushes on Flank of Tailings Plateau
45. Waterlogged during wet season
46. Waterlogged Ground
47. Waterlogged Mangrove, Standing Water

API assessment performed using aerial photographs dated 2nd February 2008. Previous course of Savage River digitised from Buchanan 1:50,000 mapsheet, DMATC (1969), Series G744, Sheet 2636 III (1969)

Purpose of Issue: FINAL

Client: ArcelorMittal

Project Title: NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title: BUCHANAN PORT LANDUSE AND DRAINAGE INTERPRETATION

Drawn	Checked	Approved	Date
JM	GH	GH/ME	24/01/2012

URS Internal Project No.	Scale @ A1
47059315	1:5,800

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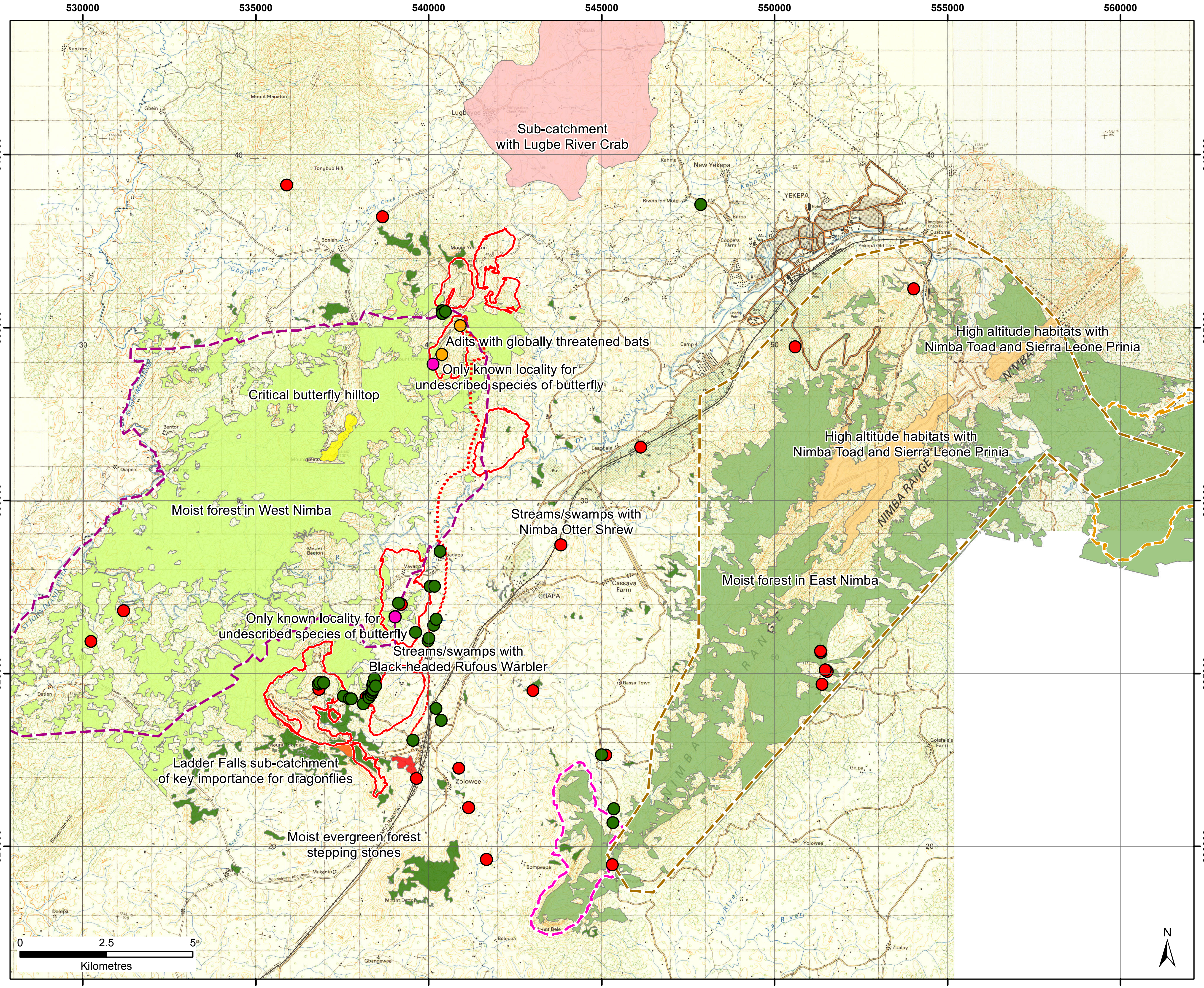
Drawing Number	Rev
DWG 7.2	



NOTES

- Adits with globally threatened bats
- Only known localities for undescribed species of butterflies
- Streams/swamps with Black-headed Rufous Warbler
- Streams/swamps with Nimba Otter Shrew

Critical Habitat

- Critical butterfly hilltop
- High altitude habitats with Nimba Toad and Sierra Leone Prinia
- Ladder Falls sub-catchment of key importance for dragonflies
- Moist evergreen forest stepping stones
- Moist forest in East Nimba
- Moist forest in West Nimba
- Streams/swamps with Nimba Otter Shrew
- Sub-catchment with Lugbe River Crab
- Haul Road (tentative alignment that needs confirmation)
- Phase 2 Footprint Elements
- Gba Community Forest
- East Nimba Nature Reserve
- Blei Community Forest
- Zor Community Forest

Projection:
UTM Zone 29N; Datum WGS84.

Source

1:50,000 Mapping: LIB50 2840/II (1988); LIB50 2940/III (1988); LIB50 2839/I (1988); LIB50 2839/IV (1988)

Source

Purpose of Issue

FINAL

Client

ArcelorMittal

Project Title

NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title

CRITICAL HABITAT

Drawn	Checked	Approved	Date
JM	WH	TR	13/12/2012

URS Internal Project No. 47059315

Scale @ A3: 1:100,000

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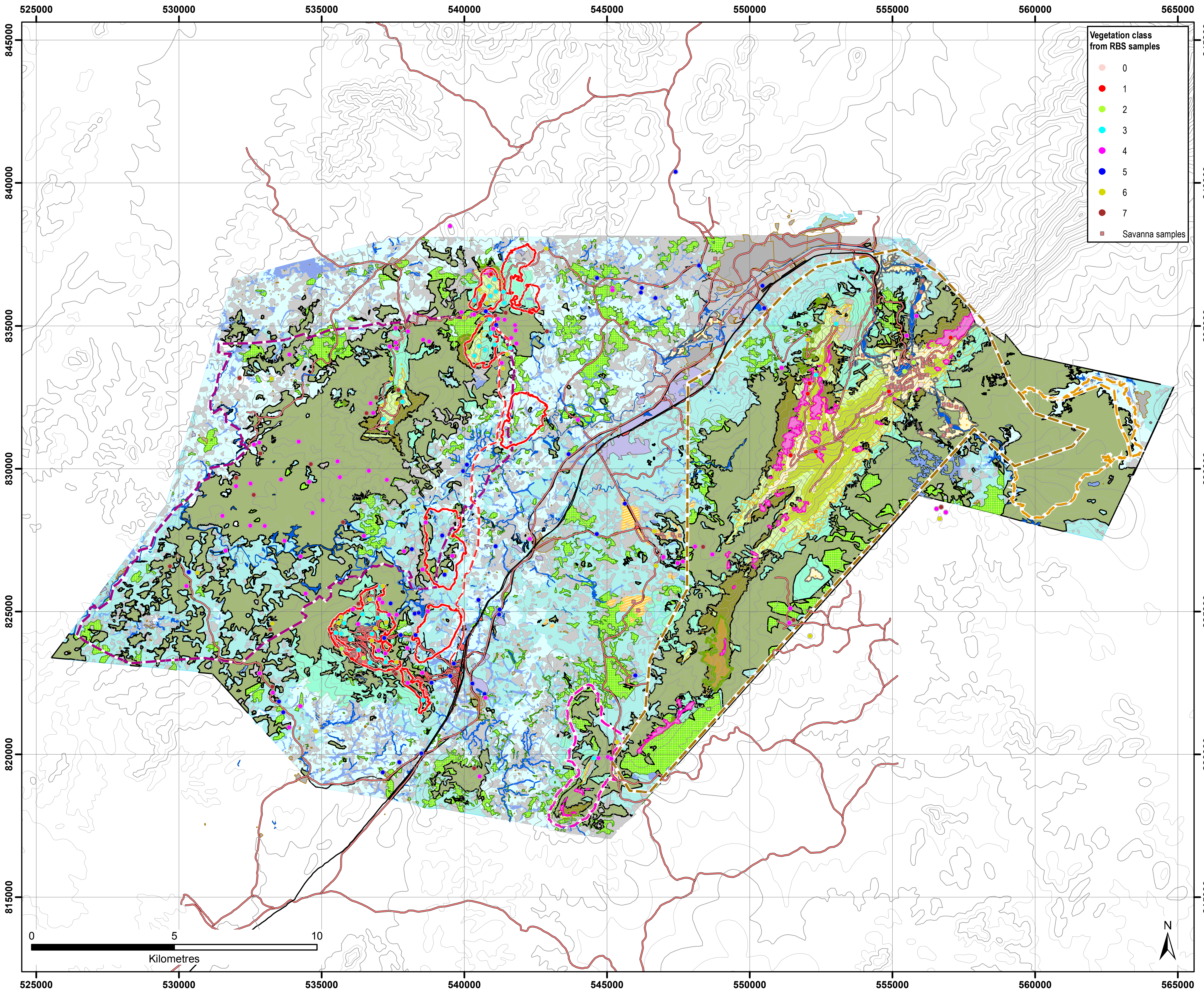
Drawing Number

DWG 7.3

Rev



NOTES

- Haul Road (tentative alignment that needs confirmation)
- Phase 2 Footprint Elements
- Legacy and Existing Mine Related Areas
- Roads
- Water
- Streams
- Settlement
- Vegetation Class 1-Montane Forest (980-1320m)
- Vegetation Class 1-Disturbed upland (>1000m)
- Submontane forest (800-1000m)
- Broken forest (800-1000m)
- Vegetation Class 4.6 and 7 - Moist evergreen forest (415-785m)
- Vegetation Class 3 - Secondary forest slopes (800-1000m)
- Vegetation Class 3 - Secondary forest on lower slopes (<800m)
- Broken forest (<800m)
- Vegetation Class 5 - Raphia/ swamp (415 - 785m)
- Vegetation Class 5 - Secondary (500 - 1170m)
- Vegetation Class 5 - Palm rich secondary (500 - 1170m)
- Plantation (Previously planted with exotic species but now in many cases overtaken by indigenous forest species)
- Farms (Active farms or young fallow)
- Vegetation Class 8 - Lowland savanna (415 - 785m)
- Vegetation Class 9 - Upland/wet savanna (830 - 1270m)
- East Nimba Nature Reserve
- Gba Community Forest
- Blei Community Forest
- Zor Community Forest

Source

Contours: Humanitarian Information Centre for Liberia

Purpose of Issue

FINAL

Client

ArcelorMittal

Project Title

NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title

VEGETATION COVER MAP

Drawn	Checked	Approved	Date
JM	TH	TR	06/12/2012

URS Internal Project No.	Scale @ A3:
47059315	1:120,000

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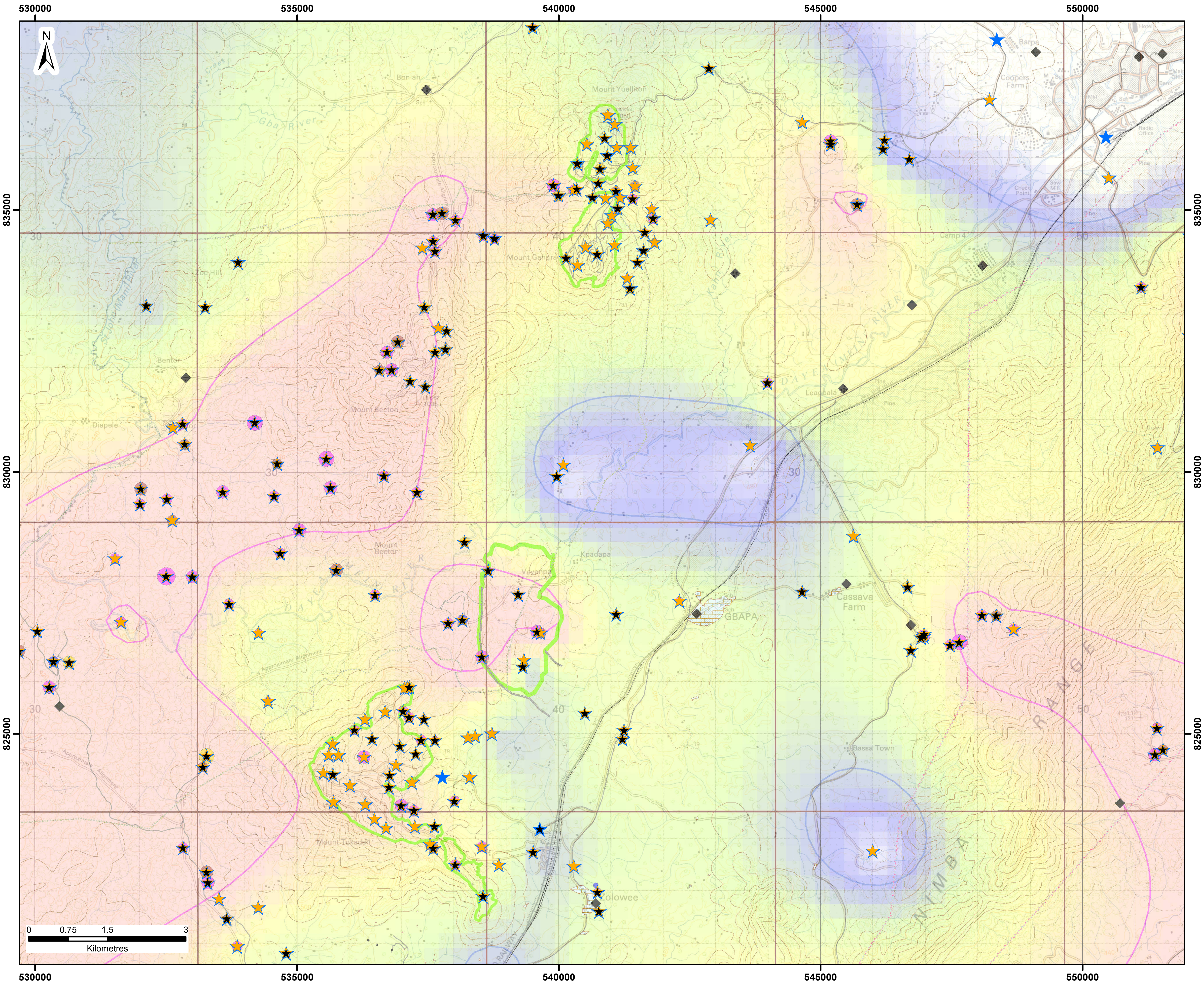
Drawing Number	Rev
DWG 7.4	



NOTES

★	Black Star Species
★	Gold Star Species
★	Blue Star Species
	Mine / TMF footprints
	Community Forests & E. Nimba N.R.
	Rail
	Roads
	Villages
	Areas
	Points
	RBS samples (colour=Veg class)
	1
	2
	3
	4
	5
	6
	7
	RBS samples sized by GHI
	<50
	50...100
	100...150
	150...200
	200...250
	250...300
	>300
	Interpolated GHI surface
	GHI surface contours
	<0
	0...100
	100...200
	>200
	205 (fairly hot)
	167 (warm)
	128 (tepid)
	89 (cool)

Projection:
UTM Zone 29N; Datum WGS84.

Copyright

1:50,000 Mapping: LIB50 2839/I (1988); LIB50 2840/II (1988)

Revision Details	By	Check	Check Date	Suffix

Purpose of Issue

FINAL

Client

ArcelorMittal

Project Title

NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title

BIOQUALITY

Drawn	Checked	Approved	Date
JM	TR	TR	11/02/2013

URS Internal Project No.	Scale @ A3:
47059315	1:65,000

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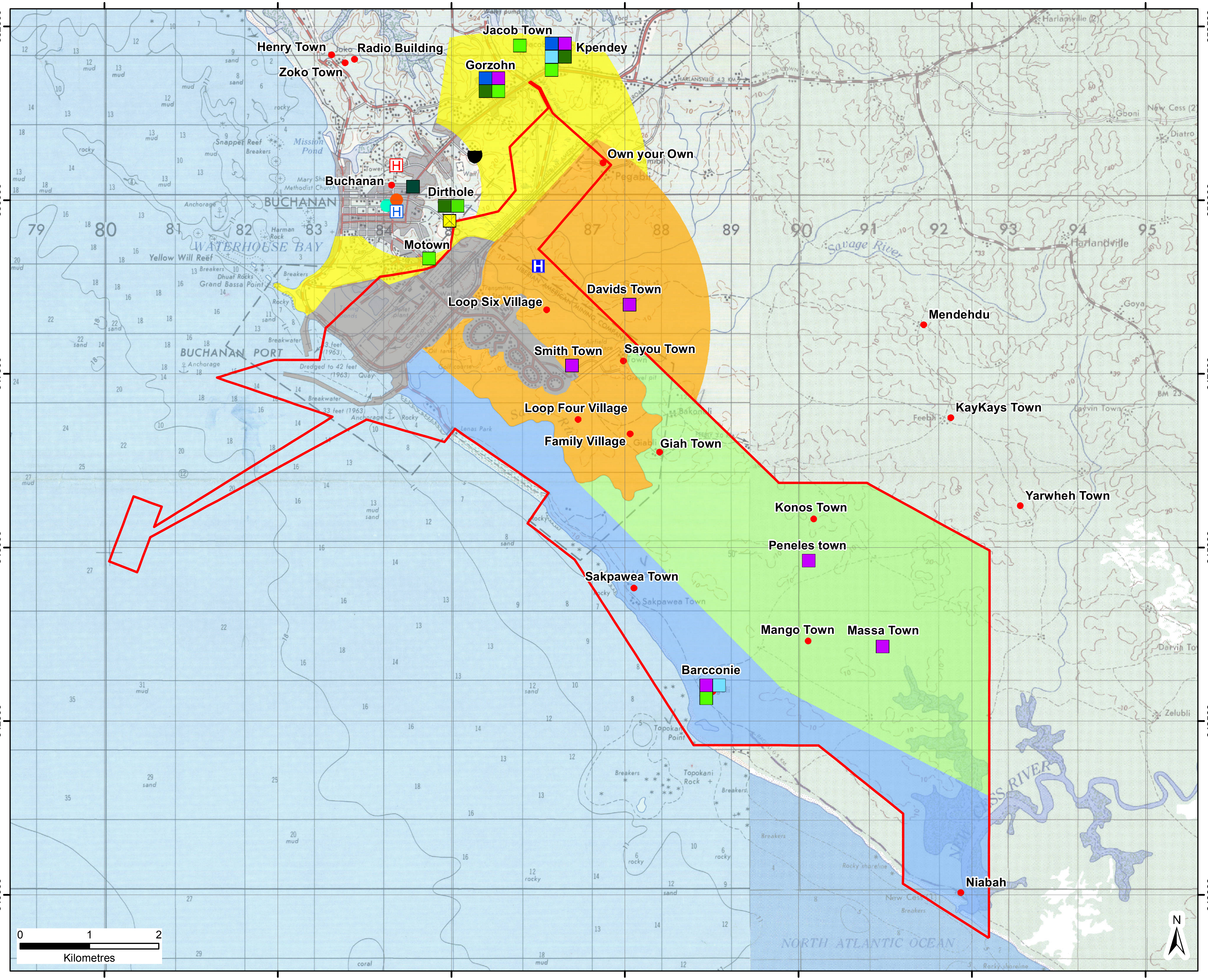
Drawing Number	Rev
DWG 7.5	



NOTES

- Concession Area
- Port Area
- Stratum 1
- Stratum 2
- Stratum 3
- Stratum 4

Facilities in Buchanan

- Bassoh High School & Buchanan Community College
- Catholic Hospital
- District HQ
- Government Hospital
- Main Market
- Police Station
- Post Office
- AML Hosptial

NB:
Duon Quinn Town is not represented on this map as it was not surveyed. There is a primary school in Duon Quinn Town

Place names may vary

Projection:
UTM Zone 29N; Datum WGS84.

Revision Details	By Check	Check Date	Suffix

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title
LOCATION OF MAIN FACILITIES
FOR THE POPULATION LIVING
IN THE IMPACTED AREAS
IN BUCHANAN

Drawn	Checked	Approved	Date
JM	AMcM	TR	09/02/2012

URS Internal Project No.	Scale @ A3:
47059315	1:50,000

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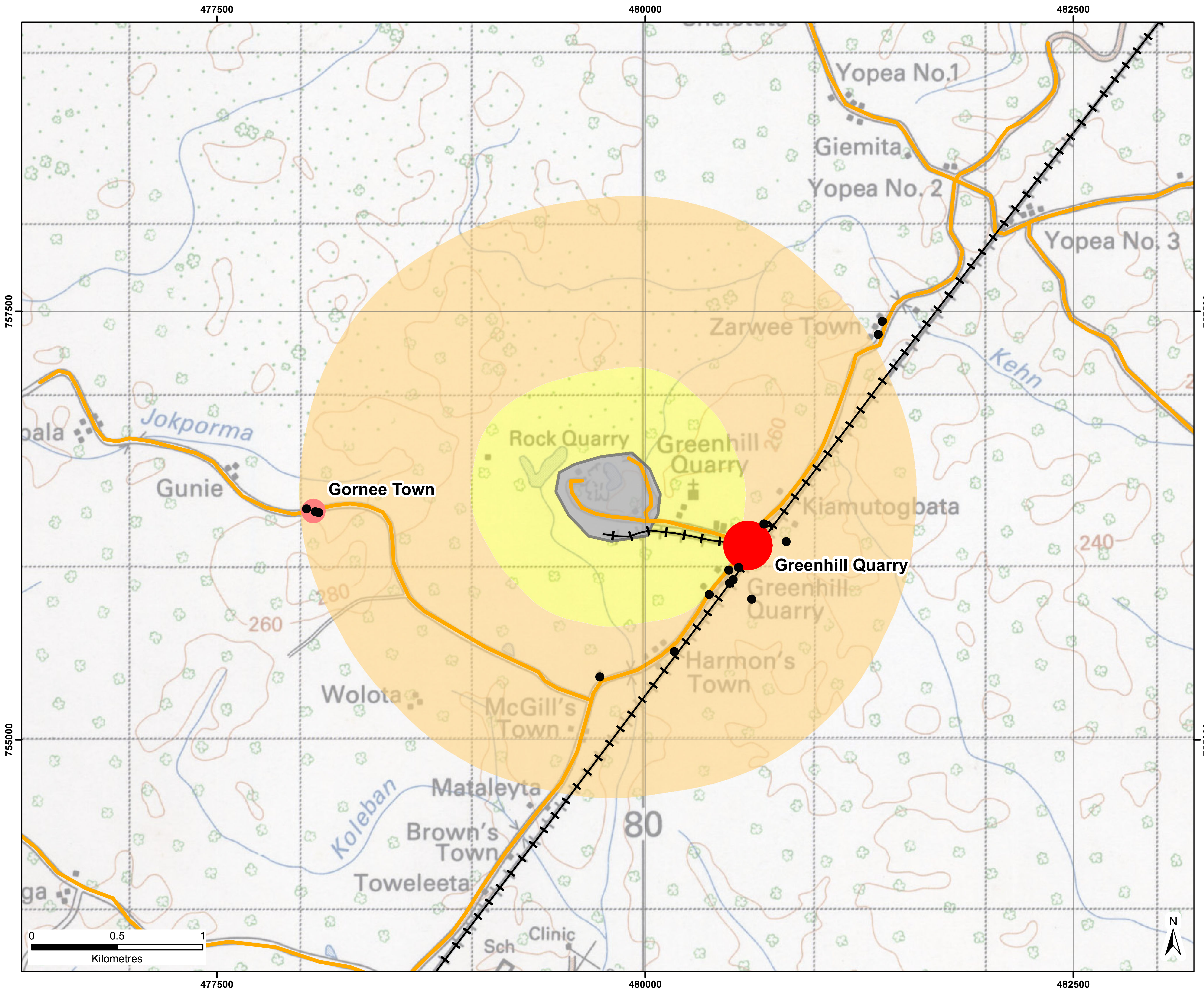
Drawing Number	Rev
DWG 7.6	



NOTES

- Survey Locality

Population

- 120
- 967

- Road/Track
- Quarry Site
- AML Railway
- 500m Blasting Buffer
- 1.5km Research Area

NB:
Place names may vary

Projection:
UTM Zone 29N; Datum WGS84.

Copyright
1:50,000 Mapping: LIB50 2738/I (1987)

Maps based on originals created
by K. Hebditch for *theIDLgroup*

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title
POPULATIONS IDENTIFIED
AS IMPACTED BY PHASE 2
ACTIVITIES IN
GREENHILL QUARRY

Drawn	Checked	Approved	Date
JM	AMcM	TR	09/02/2012

URS Internal Project No.	Scale @ A3:
47059315	1:20,000

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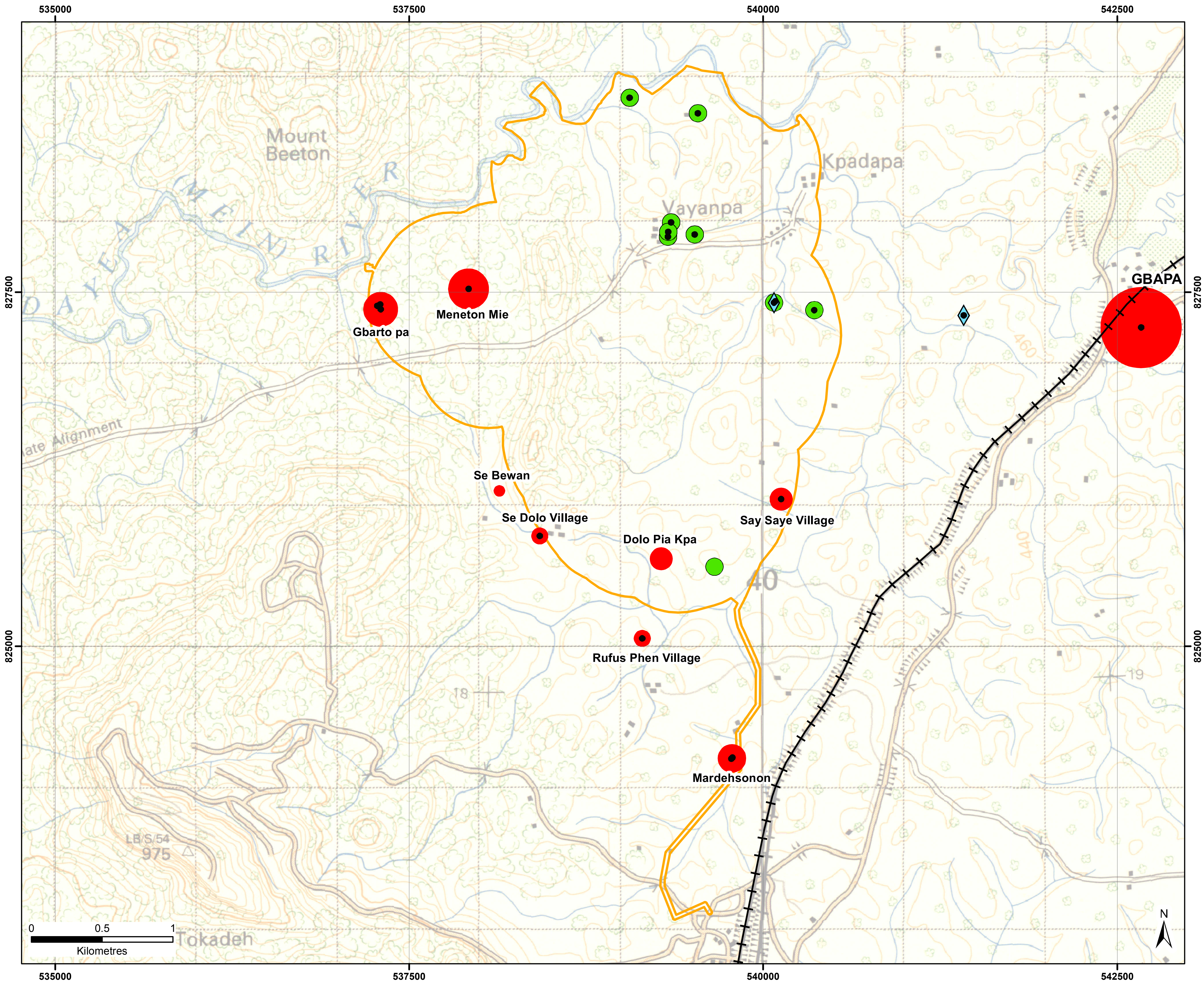
Drawing Number	Rev
DWG 7.7	



NOTES

- Diamond Pit
- Surveyed Farm Kitchen
- Survey Locality

Village Population

- 8
- 11
- 12
- 21
- 22
- 23

- Railway
- TMF + 500m Buffer Boundary

NB:
Place names may vary

Projection:
UTM Zone 29N; Datum WGS84.

Copyright
1:50,000 Mapping: LIB50 2940/III (1988);
LIB50 2839/I (1988)

Maps based on originals created
by K. Hebditch for *theIDLgroup*

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title
POPULATIONS IDENTIFIED
AS IMPACTED BY PHASE 2
ACTIVITIES IN NIMBA COUNTY
IN ADDITION TO PROJECT AFFECTED
POPULATION IDENTIFIED BY PHASE 1

Drawn	Checked	Approved	Date
JM	AMcM	TR	09/02/2012

URS Internal Project No.	Scale @ A3:
47059315	1:24,000

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Drawing Number	Rev
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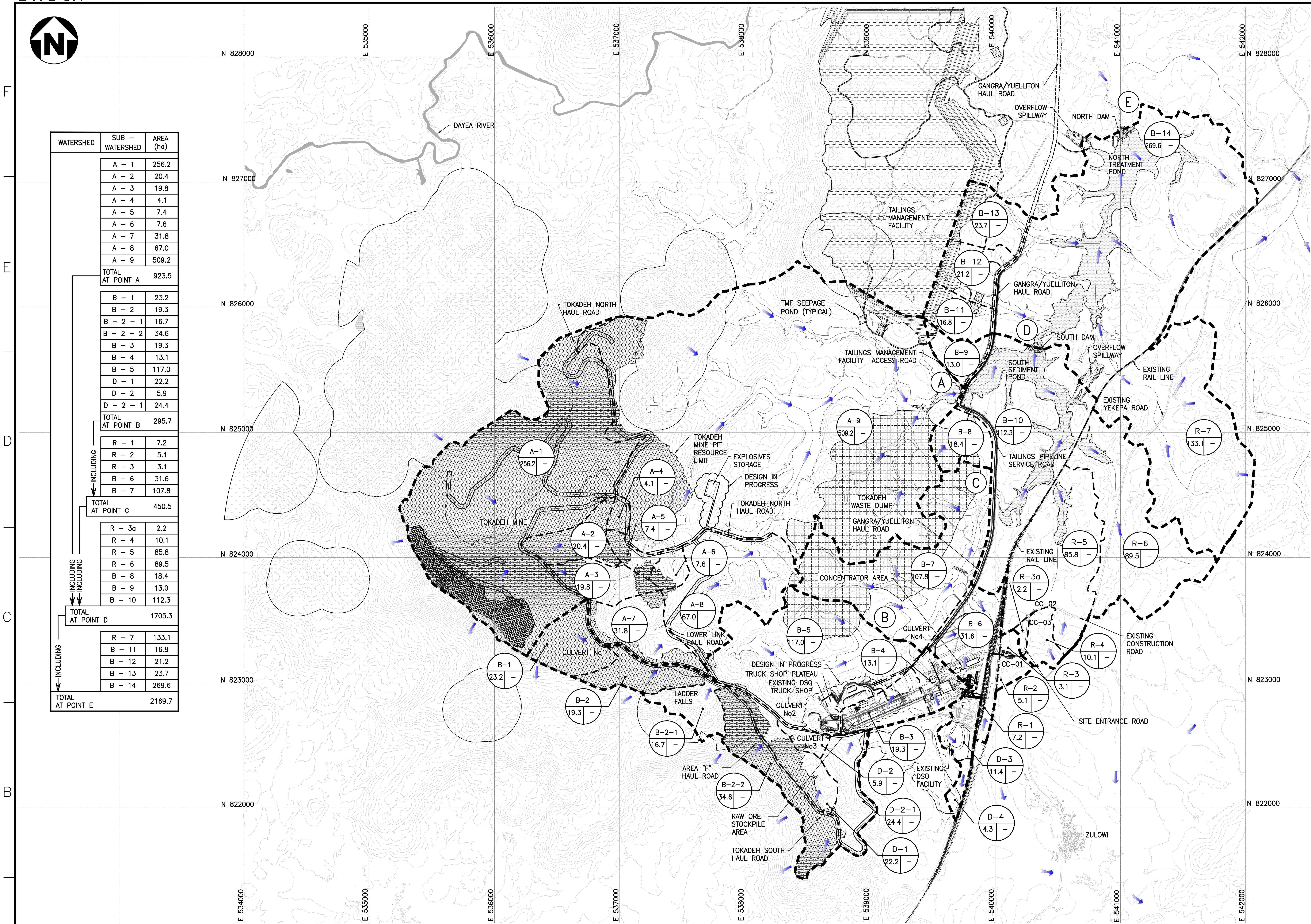
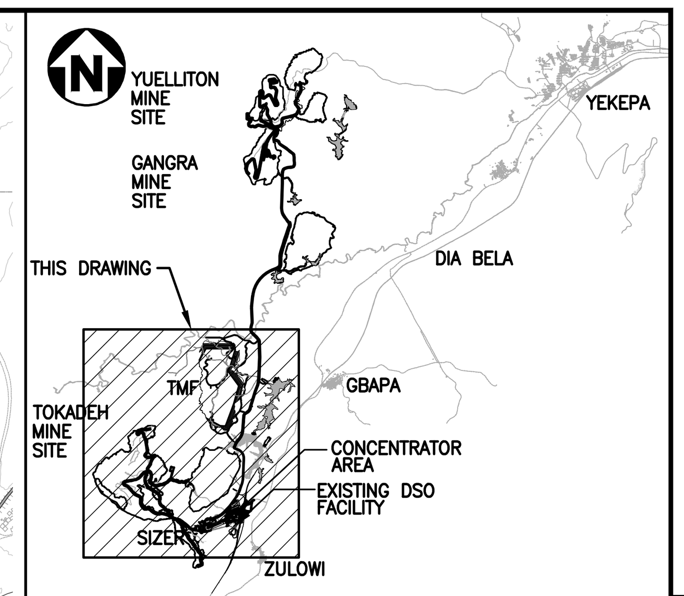
DWG 9.1



WATERSHED	SUB – WATERSHED	AREA (ha)
	A – 1	256.2
	A – 2	20.4
	A – 3	19.8
	A – 4	4.1
	A – 5	7.4
	A – 6	7.6
	A – 7	31.8
	A – 8	67.0
	A – 9	509.2
	TOTAL AT POINT A	923.5
	B – 1	23.2
	B – 2	19.3
	B – 2 – 1	16.7
	B – 2 – 2	34.6
	B – 3	19.3
	B – 4	13.1
	B – 5	117.0
	D – 1	22.2
	D – 2	5.9
	D – 2 – 1	24.4
	TOTAL AT POINT B	295.7
INCLUDING	R – 1	7.2
	R – 2	5.1
	R – 3	3.1
	B – 6	31.6
	B – 7	107.8
	TOTAL AT POINT C	450.5
INCLUDING INCLUDING	R – 3a	2.2
	R – 4	10.1
	R – 5	85.8
	R – 6	89.5
	B – 8	18.4
	B – 9	13.0
	B – 10	112.3
	TOTAL AT POINT D	1705.3
INCLUDING	R – 7	133.1
	B – 11	16.8
	B – 12	21.2
	B – 13	23.7
	B – 14	269.6
	TOTAL AT POINT E	2169.7



KEY PLAN SCALE: N.T.S.

GENERAL NOTES

1. GEOGRAPHIC COORDINATE SYSTEM SHOWN IS IN WGS84 UTM, ZONE 29N.
2. ALL COORDINATES, DIMENSIONS, AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
3. EXISTING GROUND CONTOUR DATA PRODUCED BY BSF SWISSPHOTO AG., FROM LIDAR SURVEY.
4. CONTOURS AT 10m INTERVAL.
5. ALL STOCKPILE AND WASTE DUMP LOCATIONS TO BE CONFIRMED BASED ON MINE PLAN, ENVIRONMENTAL CONSTRAINTS AND GEOTECHNICAL DESIGN BY AMEC E&I.
6. LOCATION AND CONFIGURATION OF STORM DRAINAGE PONDS ARE PRELIMINARY AND SUBJECT TO CHANGE BASED ON SOIL CHARACTERIZATION, STORM WATER MANAGEMENT REPORT AND DESIGN OF RETENTION DAMS BY AMEC E&I.

LEGEND

- EXISTING CONTOUR
- A — STORM WATER DISCHARGE POINT
- DRAINAGE FLOW DIRECTION
- STORMWATER MANAGEMENT POND
- WASTE DUMP AREA
- PIT SHELL
- DSO PIT SHELL
- ENVIRONMENTAL CONSTRAINED AREA
- TAILING MANAGEMENT FACILITY
- CULVERT No1 — CULVERT AND CULVERT IDENTIFICATION
- CC-01 — CULVERT AND CULVERT IDENTIFICATION
- WATERSHED CATCHMENT BOUNDARY
- SUB-WATERSHED CATCHMENT BOUNDARY
- C-2 — CATCHMENT AREA NUMBER
- 3.3 — RUNOFF COEFFICIENT
- AREA (ha)

ABBREVIATIONS

- N – NORTH
- E – EAST
- m – METRE (UNIT)
- ha – HECTARE
- DSO – DIRECT SHIPPED ORE
- UTM – UNIVERSAL TRANSVERSE MERCATOR GEOGRAPHIC COORDINATE SYSTEM
- No – NUMBER
- TMF – TAILING MANAGEMENT FACILITY
- N.T.S. – NOT TO SCALE

0m 150 300 450 600 750
1:15000

REV	DDMMMYY	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
D	14NOV12	RE-ISSUED FOR DESIGN	MG	AB	AV	JJ	SR	
C	27SEP12	RE-ISSUED FOR DESIGN	AV	NA	AB	JJ	SR	
B	02MAY12	ISSUED FOR DESIGN	AV	MD	AB	JJ	KK	
A	22FEB12	ISSUED FOR SQUAD CHECK	AV	MD	AB	JJ	KK	

REF	NUMBER	TITLE
2	3240-121-PLP-0002	CONCENTRATOR AREA STORMWATER DRAINAGE PLAN
1	3200-121-PLP-0001	TOKADEH MINE SITE – GENERAL SITE PLAN

REFERENCES

STAMP/SEAL

CLIENT PROJECT MGR. DISCIPLINE MGR. ENGINEERING MGR.

PROJECT PHASE: EPCM

AREA: 3240

ArcelorMittal

amec

PROJECT NO.	ACTIVITY NO.		BY	DDMMMYY
166580		DSN	AV	22FEB12
		DRN	AV	22FEB12
SCALE	PACKAGE CODE	CHK	MD	22FEB12
15000		APP	KK	22FEB12

SUBJECT: LIBERIA IRON ORE PROJECT
TOKADEH MINE SITE –
OVERALL STORMWATER MANAGEMENT PLAN
DRAINAGE AREA PLAN

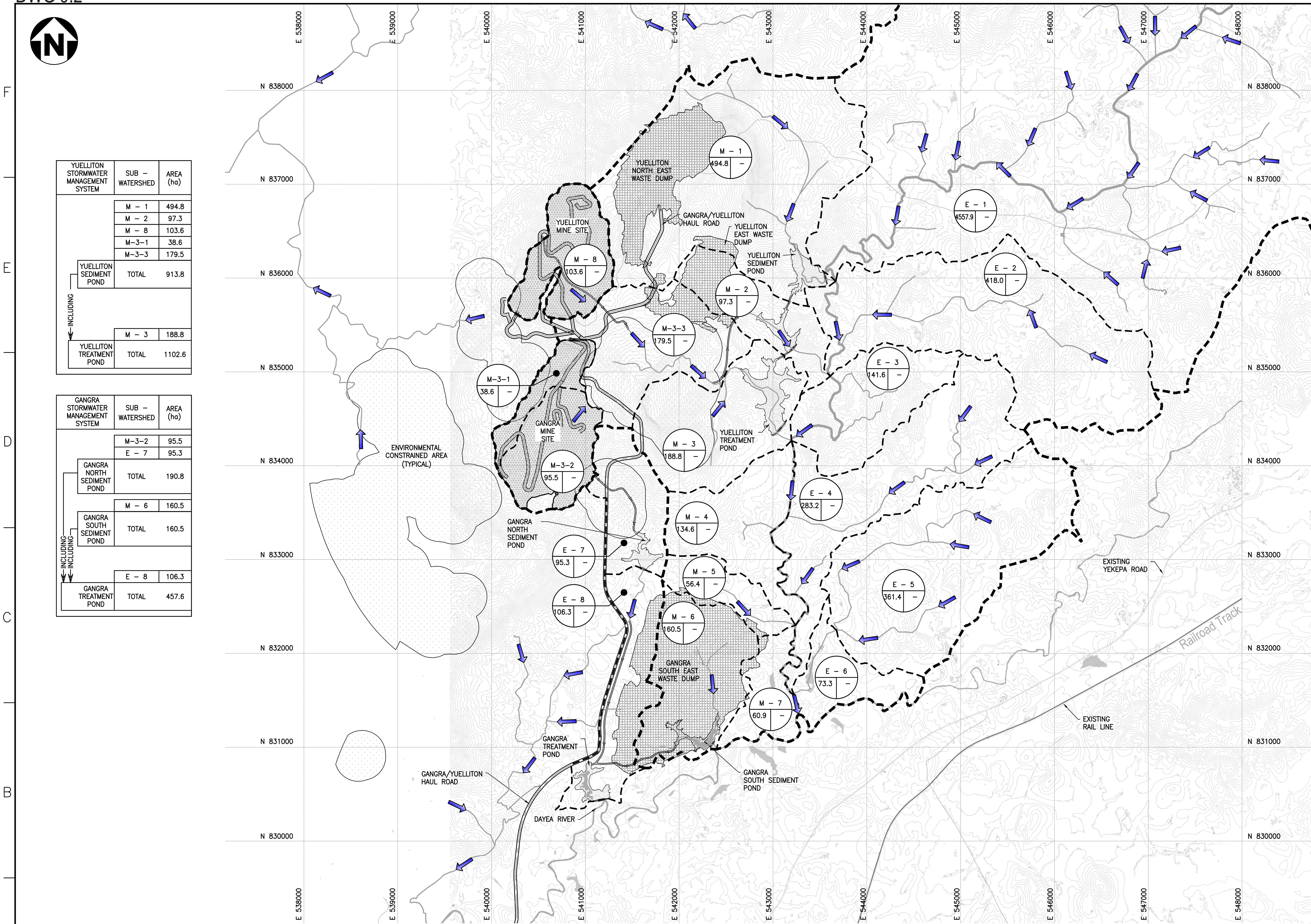
CLIENT DWG. NO.

DRAWING NO. 166580-3240-121-PLP-0001 REV. D

PLOTTED: 30-Nov-12 11:43 AM USER: WENG, SOPHIA
SAVED: 30-Nov-12 11:41 AM

CAD FILE: P:\CAD\Civ\Files Out\FTP\ESIA Nov 29 2012\SWM Plans\CAD\166580-3240-121-PLP-0001.dwg

DWG 9.2



YUELLITON STORMWATER MANAGEMENT SYSTEM	SUB – WATERSHED	AREA (ha)
	M – 1	494.8
	M – 2	97.3
	M – 8	103.6
	M–3–1	38.6
	M–3–3	179.5
YUELLITON SEDIMENT POND	TOTAL	913.8
INCLUDING	M – 3	188.8
YUELLITON TREATMENT POND	TOTAL	1102.6

GANGRA STORMWATER MANAGEMENT SYSTEM	SUB – WATERSHED	AREA (ha)
	M–3–2	95.5
	E – 7	95.3
GANGRA NORTH SEDIMENT POND	TOTAL	190.8
	M – 6	160.5
GANGRA SOUTH SEDIMENT POND	TOTAL	160.5
INCLUDING INCLUDING	E – 8	106.3
GANGRA TREATMENT POND	TOTAL	457.6

KEY PLAN — SCALE: N.T.S.

GENERAL NOTES

1. GEOGRAPHIC COORDINATE SYSTEM SHOWN IS IN WGS84 UTM, ZONE 29N.
2. ALL COORDINATES, DIMENSIONS, AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
3. EXISTING GROUND CONTOUR DATA PRODUCED BY BSF SWISSPHOTO AG., FROM LIDAR SURVEY.
4. CONTOURS AT 10m INTERVAL.
5. ALL STOCKPILE AND WASTE DUMP LOCATIONS TO BE CONFIRMED BASED ON MINE PLAN, ENVIRONMENTAL CONSTRAINTS AND GEOTECHNICAL DESIGN BY AMEC E&I.
6. LOCATION AND CONFIGURATION OF STORM DRAINAGE PONDS ARE PRELIMINARY AND SUBJECT TO CHANGE BASED ON SOIL CHARACTERIZATION, STORM WATER MANAGEMENT REPORT AND DESIGN OF RETENTION DAMS BY AMEC E&I.

LEGEND

- EXISTING CONTOUR
- EXISTING STREAM FLOW DIRECTION
- DITCH
- PIT SHELL
- ENVIRONMENTAL CONSTRAINED AREA
- STORMWATER MANAGEMENT POND
- WASTE DUMP AREA
- WATERSHED CATCHMENT BOUNDARY
- SUB-WATERSHED CATCHMENT BOUNDARY
- M – 2 / 3.3 / – : CATCHMENT AREA NUMBER; RUNOFF COEFFICIENT; AREA (ha)

ABBREVIATIONS

N – NORTH
E – EAST
m – METRE (UNIT)
ha – HECTARE
UTM – UNIVERSAL TRANSVERSE MERCATOR GEOGRAPHIC COORDINATE SYSTEM
TMF – TAILING MANAGEMENT FACILITY
DSO – DIRECT SHIPPED ORE
N.T.S. – NOT TO SCALE

NOT TO BE USED FOR CONSTRUCTION

0m 200 400 600 800 1000
1:20000

PLOTTED: 29–Nov–12 10:20 AM USER: WENG, SOPHIA
SAVED: 23–Nov–12 4:10 PM

REV	DATE	REVISION / ISSUE DESCRIPTION	DRN	CHK	APP	APP	APP	APP
A	14NOV12	ISSUED FOR ESIA / SQUAD CHECK	MG	AB	AV	JJ	SR	

REF	NUMBER	TITLE
1	6200-121-PLP-0001	GANGRA / YUELLITON MINE SITE – GENERAL SITE PLAN

STAMP/SEAL

PRELIMINARY

CLIENT PROJECT MGR. DISCIPLINE MGR. ENGINEERING MGR.

PROJECT PHASE: EPCM

AREA: 6200

PROJECT NO.: 166580

SCALE: 20000

	BY	DDMMMYY
DSN	AV	14NOV12
DRN	MG	14NOV12
CHK	AB	14NOV12
APP	SR	14NOV12

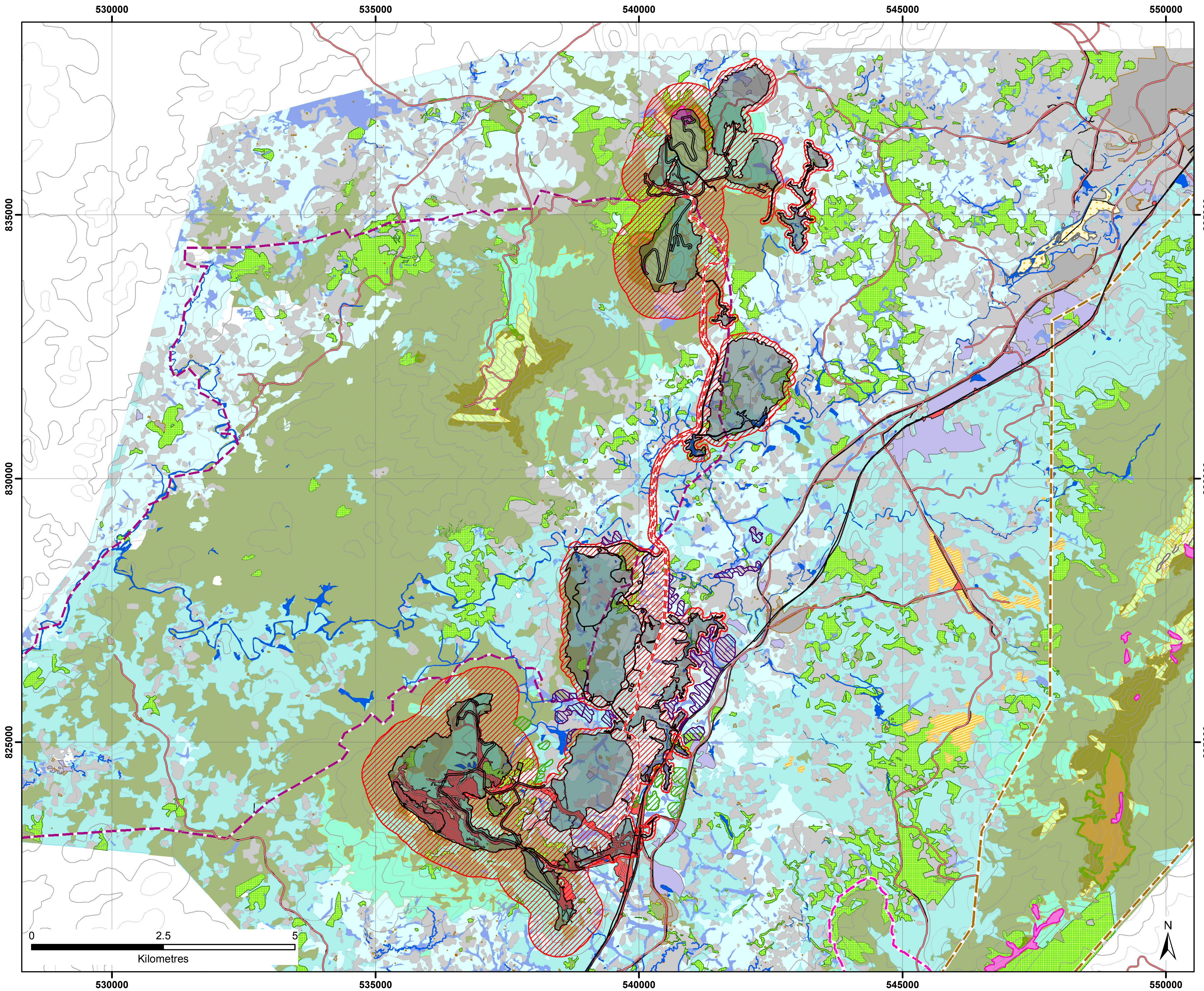
ArcelorMittal

SUBJECT: LIBERIA IRON ORE PROJECT
GANGRA/YUELLITON MINE SITE
OVERALL STORMWATER MANAGEMENT PLAN
DRAINAGE AREA PLAN

amec

CLIENT DWG. NO.

DRAWING NO.: 166580–6220–121–PLP–0001 REV. A



NOTES

- Haul Road (tentative alignment that needs confirmation)
- Phase 1 and Phase 2 Footprint Elements
- Phase 1 and Phase 2 Exclusion Zone
- Additional landtake from Year 0, 1 and Concentrator Borrow Areas
- Additional landtake in Relation to Borrow Pits for the Life of the Mine
- Legacy and Existing Mine Related Areas
- Roads
- Water
- Streams
- Settlement
- Vegetation Class 1-Montane Forest (980-1320m)
- Vegetation Class 1-Disturbed upland (>1000m)
- Submontane forest (800-1000m)
- Broken forest (800-1000m)
- Vegetation Class 4.6 and 7 - Moist evergreen forest (415-785m)
- Vegetation Class 3 - Secondary forest slopes (800-1000m)
- Vegetation Class 3 - Secondary forest on lower slopes (<800m)
- Broken forest (<800m)
- Vegetation Class 5 - Raphia/ swamp (415 - 785m)
- Vegetation Class 5 - Secondary (500 - 1170m)
- Vegetation Class 5 - Palm rich secondary (500 - 1170m)
- Plantation (Previously planted with exotic species but now in many cases overtaken by indigenous forest species)
- Farms (Active farms or young fallow)
- Vegetation Class 8 - Lowland savanna (415 - 785m)
- Vegetation Class 9 - Upland/wet savanna (830 - 1270m)
- East Nimba Nature Reserve
- Gba Community Forest
- Blei Community Forest
- Zor Community Forest

Source

Contours: Humanitarian Information Centre for Liberia

Purpose of Issue

FINAL

Client

ArcelorMittal

Project Title

NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title

LANDTAKE

Drawn	Checked	Approved	Date
JM	TR	TR	04/03/2012

URS Internal Project No.	Scale @ A3:
47059315	1:65,000

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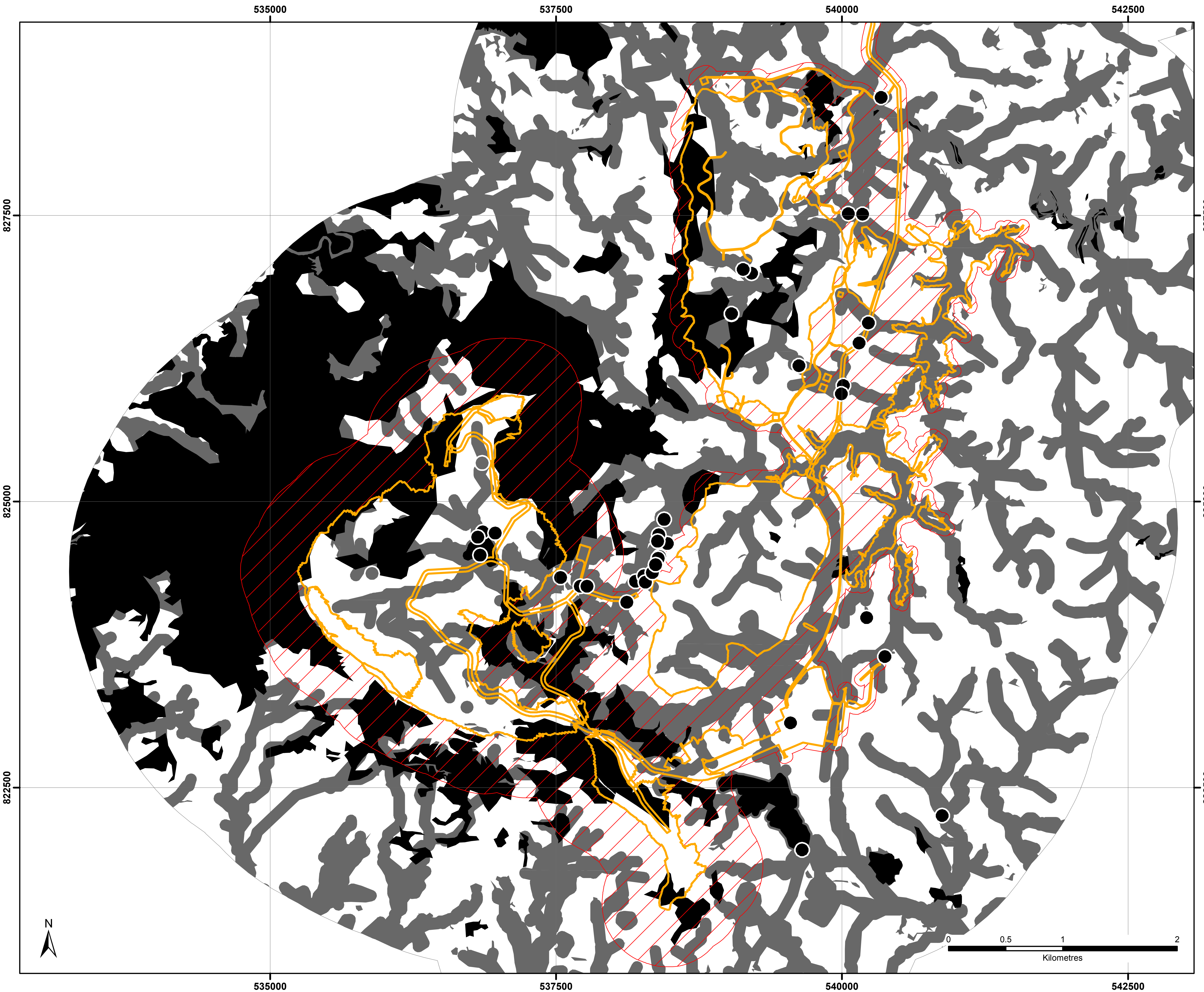
Drawing Number	Rev
DWG 9.3	



NOTES

Phase 1/Phase 2 Footprint Elements
Phase 1/Phase 2 Exclusion Zone

Point Constraints
- Level 1
- Level 2

Polygon Constraints
- Level 1
- Level 2

Copyright

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue

FINAL

Client

ArcelorMittal

Project Title

NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title

CONSTRAINTS MAP
FOR TOKADEH

Drawn	Checked	Approved	Date
JM	TR	TR	15/03/2013

URS Internal Project No.	Scale @ A3:
47059315	1:30,000

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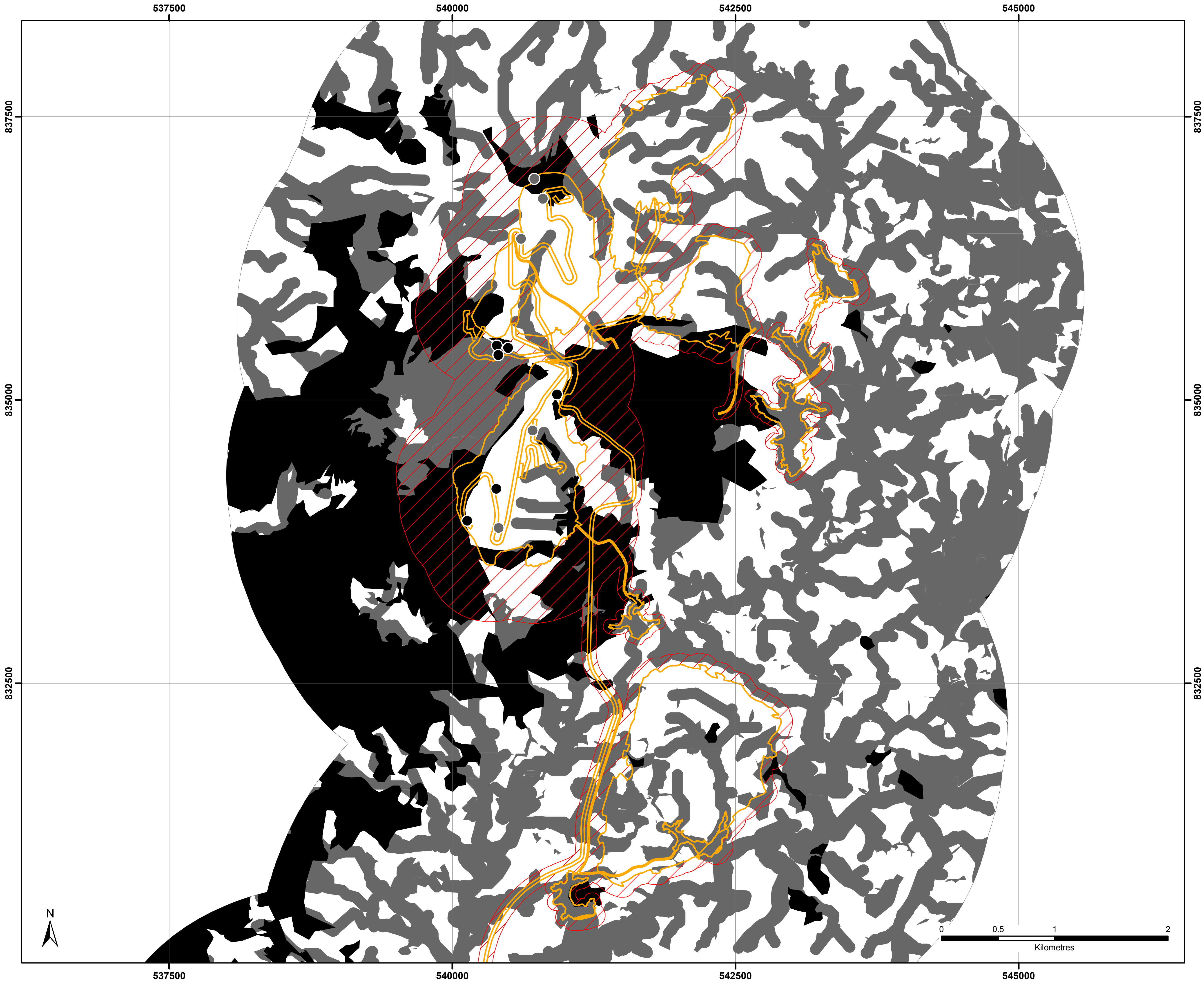
Drawing Number

DWG 9.4

Rev



NOTES

Phase 1/Phase 2 Footprint Elements
Phase 1/Phase 2 Exclusion Zone

Point Constraints
- Level 1
- Level 2

Polygon Constraints
- Level 1
- Level 2

Copyright

Revision Details	By / Check	Check Date	Suffix

Purpose of Issue: FINAL

Client: ArcelorMittal

Project Title: NIMBA WESTERN AREA IRON ORE CONCENTRATOR MINING PROJECT ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Drawing Title: CONSTRAINTS MAP FOR GANGRA/YUELLITON

Drawn	Checked	Approved	Date
JM	TR	TR	15/03/2013

URS Internal Project No.	Scale @ A3:
47059315	1:30,000

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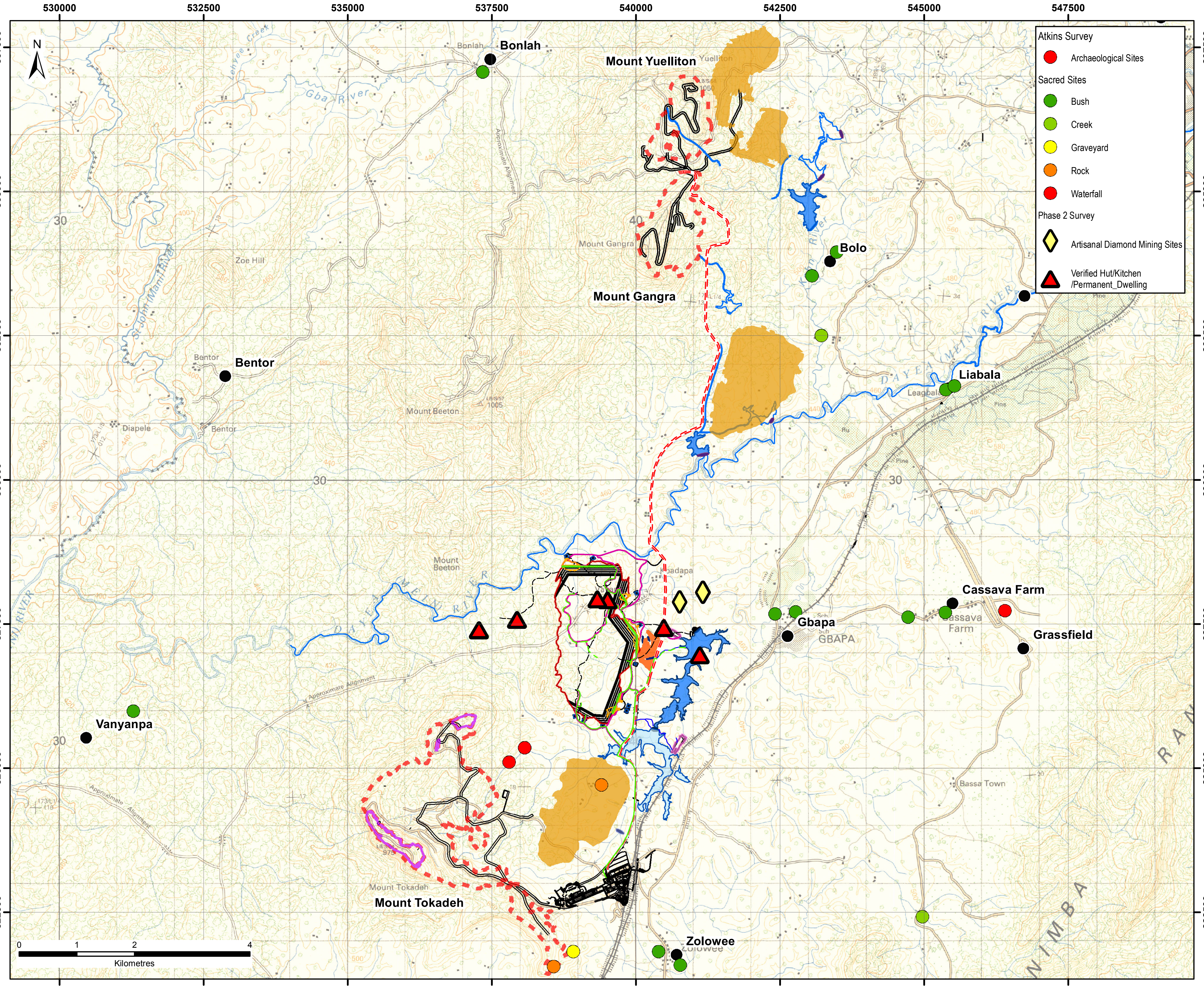
Drawing Number	Rev
DWG 9.5	



NOTES

- Tailings Reclaim Pipeline
- Tailings Pipeline
- Access Roads Embankments
- Proposed Access Roads
- Proposed Roads
- Temporary Tracks
- Haul Road (tentative alignment that needs confirmation)
- Dam
- DSO
- Mine Site
- Overflow Spillway
- Sediment Control Dam
- Sediment Pond
- TMF
- TMF Seepage Pond
- Treatment Pond
- Waste Dump
- Sediment Control Ponds
- Topsoil & Vegetation Stockpile Area

Projection:
UTM Zone 29N; Datum WGS84.

Source
©DigitalGlobe, Inc., All Rights Reserved.
1:50,000 Mapping: LIB50 2840/II (1988),
LIB50 2839/I (1988),
Site Layout based on drawings:
166580-3200-121-PLP-0001 (14/12/2012)
and 166580-6200-121-PLP-0001 (14/12/2012)
Stockpile Sedimentation Control Ponds:
Eastern Storm Water Management Sedimentation Control Pond Stockpile Areas General Arrangment - 7879010023/9040J Rev A (15/11/2012)
Proposed Stockpile Area:
TMF Embankment Proposed Year 0
Borrow Areas Management - 7879010023/9040A Rev A1 (16/10/2012)
TMF Reclaim Pipeline:
166580-3620-165-GAD-1950 (October 2012)
TMF Tailings Pipeline:
166580-3620-165-GAD-1940 (October 2012)
Access Roads:
166580-3620-165-GAD-1801 (September 2012)

Purpose of Issue
FINAL

Client
ArcelorMittal

Project Title
NIMBA WESTERN AREA
IRON ORE CONCENTRATOR
MINING PROJECT
ENVIRONMENTAL AND
SOCIAL IMPACT ASSESSMENT

Drawing Title
SITES OF CULTURAL IMPORTANCE

Drawn	Checked	Approved	Date
JM	TR	TR	18/02/2013

URS Internal Project No.	Scale @ A3:
47059315	1:60,000

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Drawing Number
DWG 9.6

Rev