REPORT

December 2019

MMG LIMITED

Updated Environmental and Social Impact Assessment and Environmental Management Plan for Kinsevere Mine

Submitted to:
Diredtion de Protection de L'Environment Minier (DPEM)
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Report Number: 1790467-320201-8

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Structure of ESIA

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Glossary

- **Environmental Impact Study (EIS):** An assessment of the potential impacts that a project could have on the biophysical and social environment, in comparison with acceptable levels of impact as determined by regulations, standards and guidelines, and including an environmental management plan for the project (EMPP).
- **Environmental and Social Management Plan (ESMP):** A document specifying the mitigation and monitoring measures to be implemented to achieve acceptable levels of impact, subject to the best technology available, at a viable economic cost.
- **Environmental and Social Impact Assessment (ESIA):** Essentially the same as an EIS. The official terminology was changed from EIS in the 2003 Mining Regulations to ESIA in the 2018 Mining Regulations.
- **Mitigation and Rehabilitation Plan (MRP):** Plan required for the operations relating to a mineral or quarry exploration right pursuant to which a holder undertakes to carry out certain mitigation measures of the impact of his activities on the environment, as well as rehabilitation measures where said activities take place, including the holder's undertaking to provide a financial guarantee to cover or guarantee the mitigation and rehabilitation costs of the environment.
- **Mining Regulations:** Set of measures implementing the provisions of the present Code, enacted by Decree of the President of the Republic.
- **Mining Operation:** Any exploration and/or exploitation of mineral substances.
- **Sensitive Environment:** the ambient environment or ecosystem that displays characteristics that make it particularly vulnerable to significant impacts of mining or quarry operations.
- **Environmental Plan:** the environmental document consisting of the Environmental (Risk) Mitigation/ Abatement and Reclamation Plan, the Environmental Impact Study, the Environmental Management Plan for the Project and the Environmental Adjustment Plan.

Acronyms and Abbreviations

Term	Explanation
AIDS	Acquired Immune Deficiency Syndrome
AMD	Acid Mine Drainage
ANC	Acid Neutralising Capacity
AQMP	Air Quality Management Plan
ARD	Acid Rock Drainage
ASCu	Acid Soluble Copper
CACB	Central African Copperbelt
CAMI	Cadastre Minier
CAPEX	Capital Expenditure
CCD	Counter Current Decantation
CEC	Copperbelt Energy Corporation plc
CGEA	Commissariat Général à l'Energie Atomique – General Commissariat for Atomic Energy
CMN	Calcaire á Minerai Noir – Kambove Dolomite
CNV	Carbonate Neutralising Value
CSE	Confined Space Entry
DMR	Department of Mineral Resources
DPEM	Direction de Protection de L'Environnement Minier (Department for the Protection of the Mining Environment)
DRC	Democratic Republic of the Congo
EAF	Electric Arc Furnace
EAP	Environmental Adjustment Plan
EC	Electrical Conductivity
ECP	Environmental Control Pond
EEC	European Economic Community
EHS	Environmental, Health, and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Study
EP	Exploitation Permit
ES	Ecosystem Services
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ERT	Emergency Response Team
EW	Electrowinning
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Gécamines	La Générale des Carrières et des Mines
GIIP	Good International Industry Practice
HDPE	High Density Polyethylene
HIV	Human Immunodeficiency Virus

Term	Explanation
HLP	Heap Leach Pad
HMS	Heavy Media Separation
HR	Human Resources
I&APs	Interested & Affected Parties
ICMM	International Council on Mining and Metals
ITCZ	Inter-tropical Convergence Zone
IUCN	International Union for the Conservation of Nature
KEP	Kinsevere Expansion Project
KOU	Kinsevere Operational Upgrades
kt	Kilo tonnes
LAeq	Equivalent Continuous A-Weighted Sound Pressure Level
LG	Low Grade
LME	London Metal Exchange
LoA	Life of Asset
LOB	Lower Ore Body
LoM	Life-of-Mine
LSA	Local Study Area
mamsl	Metres Above Mean Average Sea Level
MAP	Mean Annual Precipitation
mbgl	Metres Below Ground Level
MCC	Motor Control Centre
MIC	Maximum Instantaneous Charge
ML	Metal Leaching
MMG	Minerals and Metals Group
MPA	Maximum Potential Acidity
MRP	Mitigation and Rehabilitation Plan
µSv	microSievert
mSv	milliSievert
MSDS	Material Safety Data Sheet
Mt	Million tonnes
Mtpa	Million tonnes per annum
NAF	Non-acid Forming
NAG	Net Acid Generation Capacity
NAGpH	Ph of NAG liquor
NAPP	Net Acid Producing Potential
NGO	Non-Governmental Organisation
NORM	Naturally Occurring Radioactive Materials
OHS	Occupational Health and Safety
OHSMS	Occupational Health and Safety Management System
PACs	Project-Affected Communities
PAF	Potentially Acid Forming
PCOC	Potential Constituents of Concern

Term	Explanation
PE	Permis d'Exploitation
PER	Permis d'Exploitation des Rejets des Mines
PLS	Pregnant Leach Solution
PM	Particulate Matter
PM_{10}	Particulate Matter less than 10 microns in diameter
$PM_{2.5}$	Particulate Matter less than 2.5 microns in diameter
PML	Potentially Metal Leaching
PO	Primary Ore
PPE	Personal Protective Equipment
ppm	Parts per Million
QC	Quality Control
RAT	Roches Argilleuses Talceuse
ROM	Run of Mine
RPGI	Residual Pit Groundwater Inflow
RSF	Residue Storage Facility
RSF	Roche Siliceuses Feuilletées – Silicified Dolomite
SAG	Semi-Autogenous Grinding
SAI	Social Area of Influence
SANAS	South African National Accreditation System
SD	Schistes Dolomitique Silicified Dolomite – Carbonaceous Black Shale
SHE	Safety, Health and Environment
SNEL	Société Nationale d'Électricité
SAI	Socio-economic Area of Influence
SSA	Social Study Area
STIs	Sexually Transmitted Infections
SWMP	Surface Water Management Plan
SX	Solvent Extraction
SX/EW	Solvent Extraction / Electrowinning
TDS	Total Dissolved Solids
tpa	Tonnes per Annum
tpd	Tonnes per Day
TMO	Transitional Ore containing transitional copper species and/or a mixture of both oxide and primary copper species
ToR	Terms of Reference
TSF	Tailings Storage Facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
T_{alk}	Total Alkalinity
UC (PAF)	Uncertain, Likely PAF
UC (NAF)	Uncertain, Likely NAF
UOB	Upper Ore Body
USD	United States Dollar

Term	Explanation
v/v	Volume per Volume
VWT	Vibrating Wire Transducers
WHO	World Health Organization
WMP	Water Management Plan
WRB	World Reference Base
WRD	Waste Rock Dump
w/v	Weight per Volume
w/w	Weight per Weight

Executive Summary

Introduction and Legal Framework

This Environmental and Social Impact Assessment (ESIA) was undertaken in accordance with the format and requirements of Annex VIII (*l'annexe VIII du Decret N°18/024 du 08 Juin 2018 modifiant et completant le Decret N° 038/2003 du 26 Mars 2003 portant Reglement Minier) of the DRC Mining Code (la Loi N°18/001/du 09 Mars 2018, Portant Code Minier*).

MMG's Kinsevere copper mine is located in the Kipushi territory in the Haut-Katanga Province of the Democratic Republic of the Congo, approximately 33 km north north-east from Lubumbashi. The oxide ore resource is being depleted and the mine is considering mining and processing sulphide ore, which will extend the life of the mine from approximately 2023 to 2030, increase maximum copper cathode production from 84 000 tpa to 105 000 tpa (or produce up to 250 000 tpa of copper concentrate as an alternative) and recover 13 000 tpa of cobalt hydroxide product on a dry basis.

MMG undertook an EIS (Environment Impact Study) in 2017 for a project to expand the mining and ore processing operations and extend the life of the mine. The project was known as the Kinsevere Primary Copper Project (KCP) but has been renamed the Kinsevere Expansion Project (KEP). The EIS report was submitted to the Department Responsible for the Protection of the Mining Environment (DPEM) (a department of the Ministry of Mines) in August 2017 and approved in December 2017.

MMG subsequently completed a pre-feasibility study to further define the KEP and commenced with an ESIA in February 2018 to include the new information along with other planned operational changes at Kinsevere, and the project is now known as the Kinsevere Operational Upgrades (KOU) project. Current mining-related activities are confined to tenement PE528, but some of the KOU mine waste materials will be deposited on tenement PE7274.

This ESIA deals with the KOU project, which includes the KEP approved in December 2017. The components of the KEP and KOU projects are listed in Section 2.2.2 of this report.

Baseline Environment

Geology

Kinsevere mine is located in the north-eastern section of the Central African Copperbelt (CACB), which is the largest and highest grade sedimentary hosted copper province in the world. It is hosted in Neoproterozoic metasedimentary rocks of the Katangan Supergroup. Most of the significant copper-cobalt deposits in the CACB, including Kinsevere, are confined to the basal sections of the Lower Roan Mines Group.

Deposits of both oxide and sulphide mineralisation are present, with different phases of weathering resulting in localised zones of either transitional copper species and/or a mixture of both oxide and primary copper species.

Topography

The Kinsevere mine site is situated on a plateau at a height of 1 150 - 1 300 metres above sea level, which is incised by streams and rivers that form gently sloping, shallow valleys. The local topography prior to the development of the mine was defined by the drainage system of the Kifumashi River and its tributaries, from west to east. The current topography of the project site is defined by the mine infrastructure, including the Waste Rock Dump (WRD), the open pits and the Tailings Storage Facilities (TSFs).

Soils, Land Capability and Land Use

Major soil types encountered include Shortlands, Clovelly, Avalon, Bainsvlei and Hutton. The terrain is rocky, the soil is shallow and unsuitable for demanding crops, and the average annual soil loss through sheet erosion was estimated as 13 tons/ha.

The main land uses on tenement PE7274 are charcoal making and subsistence farming with maize, cassava, sweet potatoes, beans, groundnuts and vegetables but there are also some wilderness areas.

Air Quality

Ambient concentrations of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and particulate matter (PM_{10}) are monitored at Kinsevere. Existing sources of emissions from Kinsevere mine include drilling and blasting, loading, hauling and deposition of ore and waste rock, and internal combustion engines (vehicles and generators). Regional sources include charcoal production, domestic fuel burning, clay brick making, biomass burning, unpaved roads and exposed areas.

Future ore processing activities will add SO_2 emissions from a new sulphide roaster and sulphuric acid plant, and there will be particulate emissions associated with the expansion of opencast mining and the establishment of a new TSF (TSF3) and stockpiles of waste rock, ore and topsoil.

Dispersion modelling has indicated that the regulated limits for NO_2 and SO_2 would not be exceeded at any of the nearby villages, but that mitigations such as the use of wet suppression or chemical binders in the mine and on the haul roads would be required to ensure that PM_{10} concentrations remain within regulated limits at the mine's clinic and at all the villages.

Water Quality

The Kinsevere mine has an extensive surface and groundwater-monitoring network with an established water quality monitoring programme.

Surface water monitoring includes all process ponds, return water dams, settling ponds and six monitoring points along the Kifumashi River, upstream and downstream of the mine. Monitoring protocols and frequencies are described in the monitoring plan. Acute toxicity tests, comprising 96-hour Daphnia and fish tests, are undertaken quarterly.

Groundwater monitoring points within and around the mine are sampled quarterly for detailed quality analysis. Water abstracted from the dewatering boreholes in excess of processing plant requirements and from the pit sumps, is discharged to the Kifumashi River. Volume and quality are monitored, and the water meets the regulated discharge quality requirements.

Surrounding villages obtain potable water from the river system, dug wells and boreholes fitted with hand pumps provided by the mine. Although this is not a legislative requirement, all potable water points are analysed quarterly for a suite of water quality parameters. Potable water is evaluated against World Health Organization (WHO) 2017 guidelines for drinking water. The chemical analysis is conducted by a South African National Accreditation System (SANAS) accredited laboratory. Bacteriological analysis of all potable points is conducted on site. Two methods, namely Colliert 18 and E*colite, are used to determine the presence and quantity of E. coli and coliforms.

Fauna

Three surveys were conducted over a 10-year period to identify mammals, birds, reptiles and amphibians. These surveys indicated the animal life to be severely depleted. During the 2018 survey only three small mammalian species, mainly rodents, and eight reptile and ten frog species were recorded.

Of the 693 bird species confirmed to occur in the Katanga region, 237 were recorded at Kinsevere in 2006 and 144 in 2018.

Flora

Four biodiversity surveys have been undertaken within the project area since November 2006. The most recent one was in May 2018 and it focused more specifically on tenement PE7274, from which a plant list of 379 species has been compiled. Seven distinct species assemblages or vegetation communities have been recognised, namely:

- Broad-leaved Woodland ('Miombo');

- Dry Evergreen Forest;
- Termitaria Thickets;
- Grassland on Copper/Cobalt Rocky Outcrops (Kinsevere Hill);
- Riparian Grassland/Wetland;
- Riparian Forest ('Muhulu'); and
- Degraded Shrubland.

Aquatic Ecosystems

Aquatic biomonitoring is conducted biannually (wet and dry season), to identify any possible impact of mining activities and the mine dewatering system on the Kifumashi River. The aquatic bio monitoring spans the period of August 2013 to August 2016. Seasonal variation within the Kifumashi River was evident from the last survey, but no direct measurable impact from the mining activities could be detected.

Social Environment

The social baseline aimed to identify the current social and economic conditions within the area of influence of the project. The Social Study Area (SSA) included a total of 26 villages with 4 035 households and an estimated population of 23 815 people. The social surveys covered aspects such as demographics, housing, basic services, communications, transport, education, health, economics, and vulnerable, sensitive or marginalised groups.

Houses consist mostly of one (64%) or two (33%) rooms with an average size of about 15 m^2, which have multiple uses. About 76% of the households own their houses, 20% are leasing, and 4% are provided with free accommodation by friends or church groups.

Infrastructure and basic services such as water and sanitation, electricity, health and emergency services are generally lacking in the region. Much of the available infrastructure and services result from the community development programs administered by MMG's Kinsevere mine.

Educational services and infrastructure within the mine's social area of influence (SAI) are very limited. About 33% of the local population have had no formal education, 45% have primary school education, and less than 2% have completed any form of tertiary education. About 54% of children within the SAI attend school. The majority (61%) of them attend the eleven primary and two secondary schools built by the mine. MMG pays the six principals and 65 teachers at these schools, which serve 2 696 pupils. MMG has also provided scholarships to the value of USD 47 500 to 260 primary school pupils, 28 high school pupils and 21 university students.

Three health facilities, one of which was built and is largely supported by the mine, serve about 23 000 people in the SAI.

Livelihoods are based mainly on agriculture, charcoal and small businesses. Average household income ranges from USD 1.95 to USD 3.45 per day.

Community Development

MMG's Kinsevere mine has developed a Sustainable Development Plan in the form of a Community Investment Program designed to foster resilient and sustainable communities in the mine's area of influence up to and beyond mine closure. The plan focuses on:

- Reduction of poverty;
- Food security;
- Health and wellbeing;
- Quality education;

- Clean water for domestic use; and
- Sanitation.

The plan is in the form of a Cahier des Charges and requires the approval of the authorities. It is implemented, managed and monitored by the mine's Social Development Department.

In addition to its support for education and healthcare, the mine has established several social development programs that have had a major positive impact on the lives of those within the SAI. These include agricultural support projects that assist farmers primarily with the production of maize, beans and groundnuts via training and by providing seed and fertiliser. The farmers who receive assistance repay a portion of their harvest to the mine in the form of produce and seed.

The mine has also established two community aquaculture projects in Mpundu (two ponds) and Mikanga (ten ponds) to breed tilapia, which are sold within the local community.

The planned expansion of mining and ore processing activities will extend the life of the mine, and the associated benefits to the local communities by approximately six years and increase the probability of the support actions maturing towards sustainability.

Alternatives Analysis

An evaluation of alternatives was conducted for key areas of infrastructure expansion within the mining lease:

- Tailings deposition options;
- Process design alternatives;
- Workshop alternatives;
- Surface water management;
- Perimeter security barrier (trench or fence);
- Topsoil and WRD locations and designs; and
- New ROM pad.

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

The impacts can be separated into four key phases.

- **Pre-construction phase:** The pre-construction phase will entail clearing, stripping of vegetation and stockpiling of topsoil. Expected negative impacts include:
  - Loss of conservation-important plant species habitat;
  - Introduction of invasive alien plant species;
  - Loss of threatened and/or sensitive habitats;
  - Stripping of utilisable soil and vegetation – TSF & WRD footprint, ore stockpile footprints;
  - Change in land use;
  - Loss of income from decreased availability of wood for charcoal production; loss of agricultural land; and
  - Physical and economic displacement.

- **Construction phase:** The KEP will involve the extension of the security barrier (trench, fence or other) around the perimeter of tenement PE7274, construction of a new ROM pad and TSF, a sulphide ore processing circuit comprising a semi-autogenous mill, a flotation plant, a tailings thickener, a fluidised bed roaster for sulphide concentrate, a wet gas cleaning plant, a sulphuric acid plant and supporting infrastructure such as roads and bunds.

  The additional activities associated with the KOU project will include modification of existing environmental control ponds, establishment of new sediment ponds, new crushers, a vat leaching system, a cobalt recovery plant, a solvent exchange (SX) fire protection system, new stockpile configurations and associated infrastructure.

  Expected negative impacts include:

  - Noise impacts are expected to range from none to insignificant, as increases in noise levels at sensitive receptors (village residents) are predicted to be negligible;
  - Particulate mobilisation due to site clearing, earth moving and general construction activities will contribute to existing dust fall rates and ambient PM_{10} concentrations;
  - While spillage of hydrocarbons could result in contaminated runoff and erosion of disturbed areas could cause sediment transport, the application of basic good practice methods are expected to prevent are expected to prevent any significant impacts on water quality in the Kifumashi River;
  - The construction activities could lead to soil contamination with hydrocarbons, loss of topsoil through erosion and colonisation of disturbed land by weeds and invasive alien plants; and
  - A positive impact is expected in the form of employment for contractors' employees and cash injection into the local economy via the purchase of local goods and services.
- **Operational phase:** The activities concerned with the operational phase include continued mining of oxide and sulphide material, expansion of the opencast pits, operation of existing facilities, operation of new plant such as the sulphide ore processing circuit, scats crushing, vat leaching, cobalt recovery plant, expanded WRD and TSF3.

  Expected negative impacts include:

  - Low night-time levels of noise intrusion (<5 dBA) at local villages, the highest being 3.4 dBA at Kalianda;
  - Noticeable air blast, albeit not exceeding the DRC limit of 120 dBL, the highest expected level being 118 dBL at Kalianda and Kilongo;
  - Ground vibration levels of 20 - 5 mm/sec at Kalianda and Kilongo, during blasting, lower at other villages. The DRC limit is 12.5 mm/sec;
  - Predicted exceedance of DRC limits for PM_{10} concentrations in ambient air at the Dewatering Outfall, Clinic, Kilongo School and Kilongo Village prior to the implementation of mitigation measures. The impacts are due mainly to the expansion of the Kinsevere Hill Pit, the increased tonnage of materials mined, hauled and deposited, and the increase in ore throughput. No exceedances of the DRC limits for NO_x or SO_x are expected at any of the villages;
  - Lining (high density polyethylene or non-acid forming rock) of the new TSF3 and any WRD stockpiles containing acid forming minerals, and collection of runoff or seepage from these facilities, as per regulatory requirements, together with an integration of the new facilities with the existing surface water management system that prevents the discharge of contaminated water to the environment, is expected to prevent any significant surface water impacts beyond the exploitation perimeter;

- Increased dewatering as the pits become deeper is not expected to affect the availability or quality of the groundwater abstracted by local residents from boreholes and dug wells, but a low risk of sinkhole formation at the plant area and possibly some villages has been identified, which MMG has managed with a karst risk assessment;
- The establishment of TSF3 and new/expanded WRDs will reduce the land currently available for agriculture on tenement PE7274 by at least 127 hectares;
- Expansion of the Kinsevere Hill Pit will result in the loss of some Copper Grassland habitat however, the mine has demonstrated the successful relocation of this species of concern. Establishment of TSF3 and WRDs on PE7274 will result in the loss of some patches of Dry Evergreen Forest, but denial of access to PE7274 will protect the remaining vegetation and its use as faunal habitat from farming and wood harvesting for fuel and charcoal production during the remaining life of the mine; and
- Positive impacts include preservation of jobs, skills development and community benefits flowing from the mine's community investment management plan and more time for the initiatives resulting from this plan to mature towards becoming self-sustainable.

- **Closure phase:** The closure phase will focus on the rehabilitation, decommissioning and closure of the mine. Negative impacts as a result of mine closure include:
  - Formation of an altered vegetation community;
  - Loss of direct and indirect job opportunities;
  - Cessation of social development programmes, which could put the continued existence of the economic activities created during the life of the mine at risk; and
  - The pit lakes will present a danger to local residents and their animals, but the mine will construct access-limiting barriers as required by DRC regulations.

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN FOR THE PROJECT

The Environmental and Social Management Plan (ESMP) lists obligations to manage impacts to acceptable levels. The ESMP is drafted in accordance with the DRC legal requirements.

Environmental Monitoring Programme

The environmental monitoring is performed according to both the DRC legal requirements as well as MMG standards. Monitoring is required to continue throughout the decommissioning phase of the mine until relinquishment.

Emergency Response and Contingency Plan

The MMG Operations Emergency Response Plan contains information on the planning for emergency situations that could occur at the site. The plan is based on a comprehensive approach to emergency management and is designed around the four elements of this approach, namely: prevention, preparedness, response and recovery.

Conceptual Closure Plan

At closure, MMG will apply for relinquishment of the mining leases in line with the DRC legal requirements. Kinsevere mine have compiled a set of closure objectives and potential post-closure land uses. These objectives and the final land use will require expansion and refinement over the life of the asset, in close consultation with key stakeholders.

Public Consultation

The legally required public consultation was undertaken between 6 June and 3 July 2018. It was found that, in general, communities realise the benefits of the Kinsevere mine through employment, increased revenue in the area, improved access to their villages and the investment in social infrastructure. During the final round of consultation, key issues and concerns identified include:

- Employment;
- Community development projects;
- Environmental impacts, such as dust, noise and blast damage;
- Stakeholder relations and involvement;
- Compensation process; and
- Rehabilitation after mine closure.

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FIGURES

APPENDICES

APPENDIX A
Document Limitations

APPENDIX B
Community Consultation Report: Rapport des Consultations Publiques lors de Termes de Référence

APPENDIX C
Mining Permit. Amalgamation Registration of Mining Permits No. 528 and 7274 under No. 528

1.0 TITLE I: COMPLIANCE WITH THE DIRECTIVE ON THE ESIA WHEN ELABORATING THE ENVIRONMENTAL AND SOCIAL IMPACT STUDY AND THE ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN FOR THE PROJECT (PROPOSED KOU ACTIVITIES)

1.1 SINGLE CHAPTER: ESTABLISHING THE ENVIRONMENTAL AND SOCIAL IMPACT STUDY AND THE ENVIRONMENT AND SOCIAL MANAGEMENT PLAN

1.1.1 Examination of the Guidelines on the Environmental and Social Impact Assessment (Article 1)

The project developer, Minerals and Metals Group Limited (MMG) and the Environmental and Social Impact Assessment (ESIA) consultant Golder Associates DRC SARL (Golder) confirm that the Democratic Republic of Congo (DRC) Mining Regulations: Annex VIII of Decree No. 18/024 of 08 June 2018 (Tshibala Nzenzhe, B. et al and Kabila, J. K. et al) have been read and understood in the preparation of this ESIA for the proposed MMG Kinsevere Operational Upgrades (KOU) project, which involves an expansion of MMG's existing activities on Tenement PE528 and the establishment of some new facilities on Tenement PE7274.

1.1.2 Compliance with the Conditions for Drawing up the Environmental and Social Impact Assessment and the Environmental and Social Management Plan for the Project (Article 2)

In developing this ESIA for the proposed KOU project, inclusive of an Environmental and Social Impact Assessment (ESIA) and an Environmental and Social Management Plan for the project (ESMP), all substantive and technical environmental standards as defined in Annex VIII of Decree No. 18/024 of 8 June 2018 have been followed.

1.1.3 Stages in the Development of the Environmental and Social Impact Assessment (Article 3)

The development of this ESIA update begins with the presentation of the mine development project. This presentation of the mine consists of the identification of the exploitation project and the description of the mining operations as stipulated in Annex VIII of the Mining Regulations: Decree No. 18/024 of 8 June 2018.

2.0 TITLE II: PRESENTATION OF THE MINING PROJECT

2.1 CHAPTER I: PROJECT IDENTIFICATION DETAILS (ARTICLE 4)

The applicant for a right to mine or permanent quarry presented next:

1) An analysis of the environmental system affected by the project;
2) An analysis of the impacts of operations on the environment;
3) A program of mitigation and rehabilitation measures; and
4) A budget and a financing plan for the Environmental Mitigation and Rehabilitation Program.

2.1.1 Company Responsible for Exploiting the Mine (Article 5)

The Minerals and Metals Group Limited (MMG) is responsible for developing and exploiting the mine. The MMG Kinsevere Copper Mine is located in the Democratic Republic of the Congo in the Haut-Katanga Province, Kipushi Territory, Group Kasongo, within the Bukanda Community Sector. Lubumbashi is the capital of the Haut-Katanga Province. The Kinsevere Copper Mine is located approximately 33 km north north-east of Lubumbashi. Originally developed by Anvil Mining in 2007, it was acquired by MMG in 2012. MMG is a leading global resources company that explores, develops and mines base metal deposits around the world. The company was founded in 2009, is headquartered in Melbourne, Australia and is listed on the Stock Exchange of Hong Kong Limited under Stock Code HKEx1208.

MMG has offices in the DRC at:

- 7409 Avenue de la Révolution in Lubumbashi, Katanga; and
- 63, Avenue Mondjiba, concession Cotex, Local 10A Kinshasa, Ngaliema.

MMG currently mines and processes oxide copper ore on Tenement PE528, which covers an area of approximately 5.94 km^2. Mining Rights for the exploitation of PE 528 are held under Permis d'Exploitation no. CAMI/CE 363/2003, issued to AMCK Mining sprl on 26 January 2007. The Mining Rights are valid until 3 April 2024 and an application for a 15-year extension will be submitted at least one year and no more than five years before the expiry date.

MMG has entered into a lease agreement with La Générale des Carrières et Mines (Gécamines), to mine the mineralised copper zones, including the Kinsevere deposits: Kinsevere Hill, Central Pit and Mashi Pit.

Table 1~~Table 1~~ below presents the name and contact details of the project developer.

Table 1: Details of Project Developer

Name of Project Developer	MMG Kinsevere SARL
Contact numbers: **Telephone** **Email address** **Website address**	 +243 81 657 3134 drc.administration@mmg.com www.mmg.com/en/Our-Operations/Mining- operations/Kinsevere.aspx
Address	7409 Avenue de la Révolution, Lubumbashi, Katanga Province, Democratic Republic of Congo
Name and Address of Mineral Rights Holder	La Générale des Carrières et des Mines 419 Boulevard Kamanyola Lubumbashi, Haut-Katanga, RDC
Registration Number (RCCM)	CD/L'SHI/RCCM/14-B-1480
National Identification Number	6-118-N43735Y
Tax Identification number	A0800394N
Life of Mine	2007-2030

2.1.2 Identification of the Applicant and of the Consultant Responsible for the Environmental Impact Study (Article 6)

MMG is the applicant, and MMG has appointed Golder Associates DRC SARL (Golder) to undertake the ESIA update for the proposed Kinsevere Operational Upgrades (KOU) project.

Golder is an independent company registered with the DPEM and has no vested interest in the proposed KOU. Golder is an employee-owned, global company specialising in ground engineering and environmental services. From 160 offices worldwide, our nearly 7 000 employees work with clients who want to manage their environmental and engineering activities in a technically sound, economically viable and socially responsible manner. Golder is responsible for updating the ESIA for the proposed KOU. The core team of engineers and scientists for this project are based in Golder's Midrand office in Johannesburg, South Africa – see Table 2~~Table 2~~.

Table 2: Contact Details of Golder

Golder Associates DRC SARL 105/1683, Avenue Kamanyola, Quartier Alilac, Lubumbashi RCCM : CD/TRICOM/L'SHI/RCCM : 14-B-1561 ID.NAT. : 6-83-N 85264 K Numéro Impôt : A1006563
Tel: [243] (81) 904 3399
Haut-Katanga Province
Democratic Republic of Congo

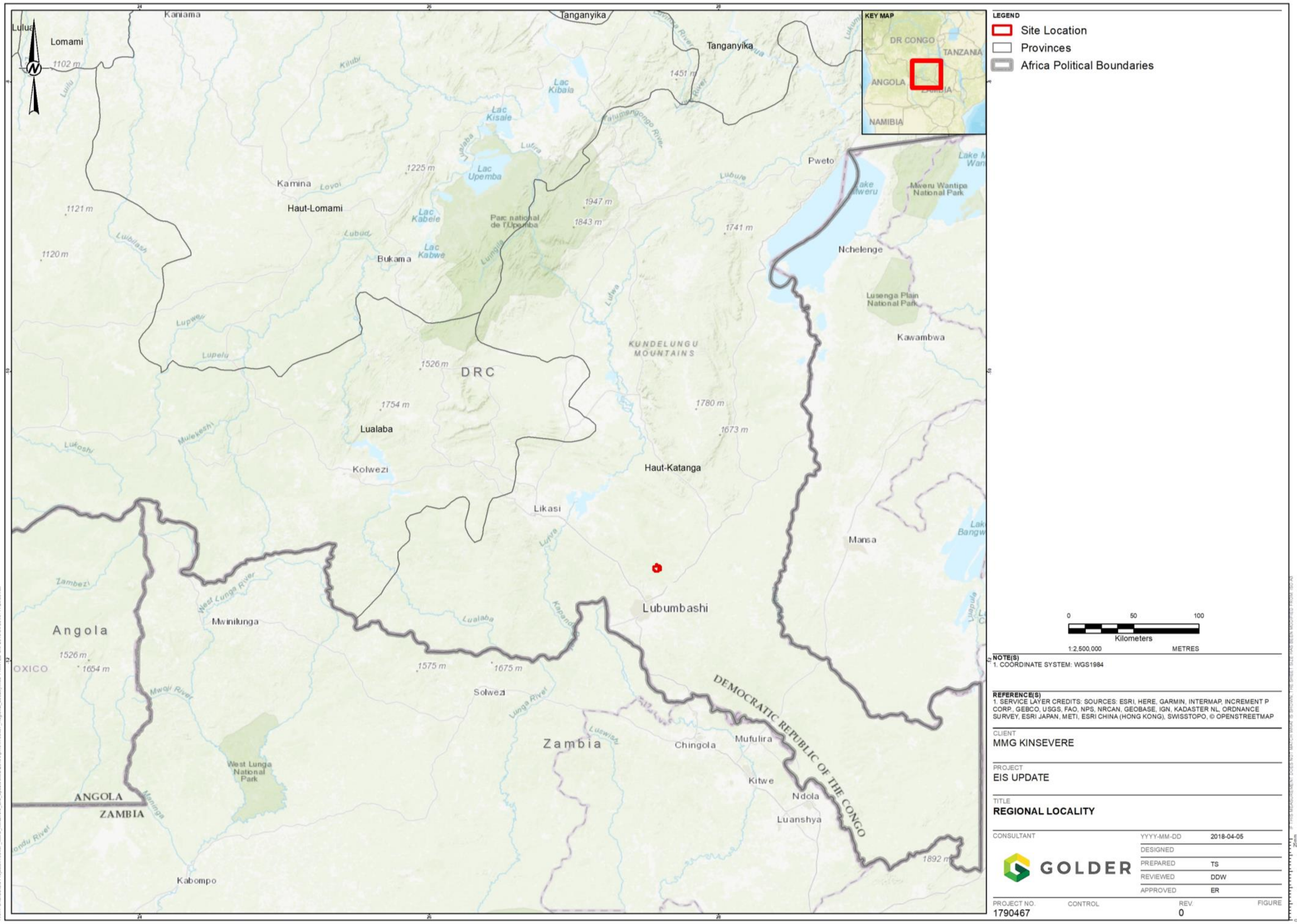


Figure 1: Regional Locality

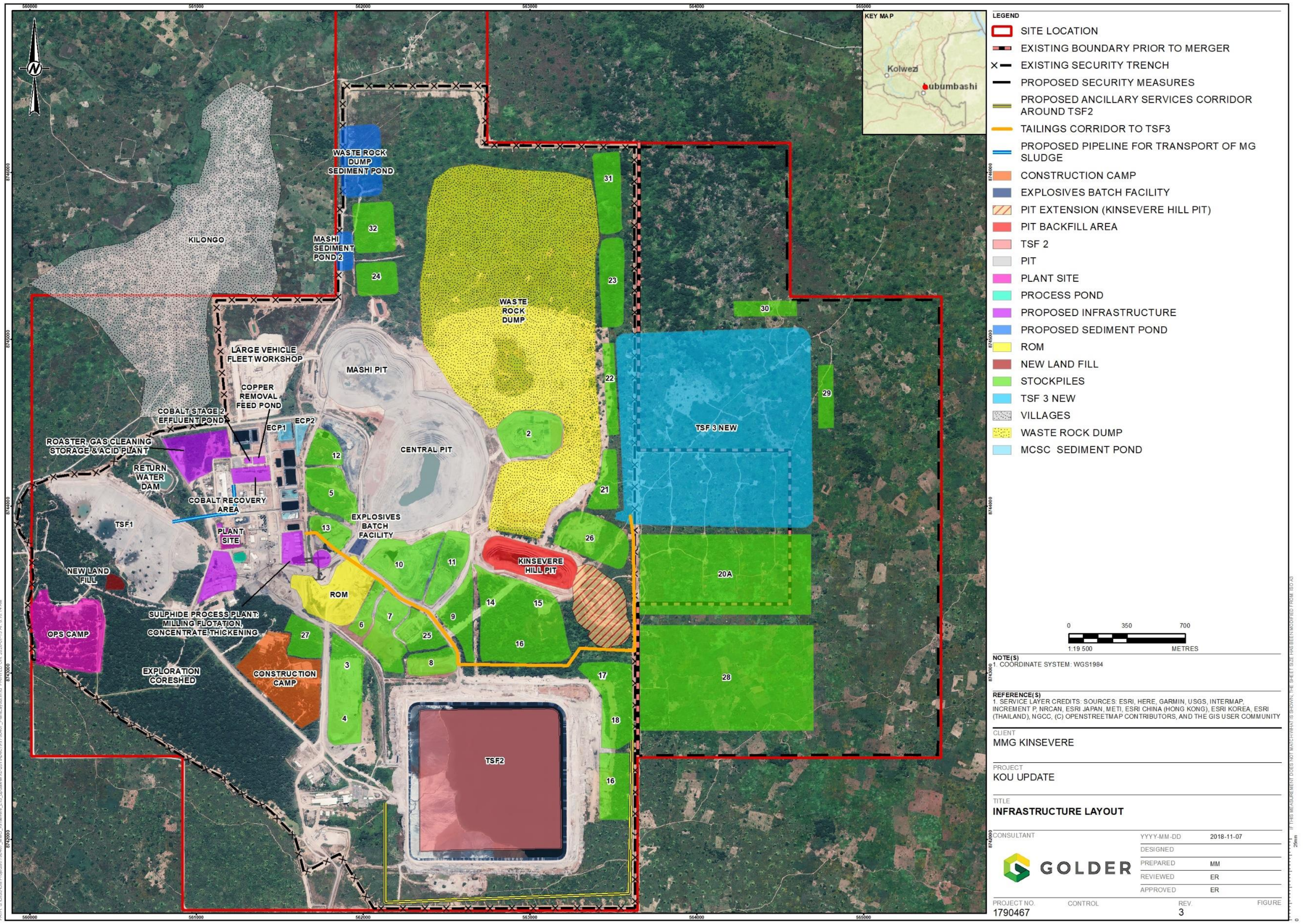

KEY MAP
Kolwezi
Lubumbashi
LEGEND
SITE LOCATION
EXISTING BOUNDARY PRIOR TO MERGER
EXISTING SECURITY TRENCH
PROPOSED SECURITY MEASURES
PROPOSED ANCILLARY SERVICES CORRIDOR AROUND TSF2
TAILINGS CORRIDOR TO TSF3
PROPOSED PIPELINE FOR TRANSPORT OF MG SLUDGE
CONSTRUCTION CAMP
EXPLOSIVES BATCH FACILITY
PIT EXTENSION (KINSEVERE HILL PIT)
PIT BACKFILL AREA
TSF 2
PIT
PLANT SITE
PROCESS POND
PROPOSED INFRASTRUCTURE
PROPOSED SEDIMENT POND
ROM
NEW LAND FILL
STOCKPILES
TSF 3 NEW
VILLAGES
WASTE ROCK DUMP
MCSC SEDIMENT POND
KILONGO
WASTE ROCK DUMP SEDIMENT POND
MASHI SEDIMENT POND 2
WASTE ROCK DUMP
LARGE VEHICLE FLEET WORKSHOP
MASHI PIT
COPPER REMOVAL FEED POND
COBALT STAGE 2 EFFLUENT POND
ECP1
ECP2
CENTRAL PIT
ROASTER, GAS CLEANING STORAGE & ACID PLANT
RETURN WATER DAM
COBALT RECOVERY AREA
TSF1
PLANT SITE
EXPLOSIVES BATCH FACILITY
KINSEVERE HILL PIT
NEW LAND FILL
ROM
SULPHIDE PROCESS PLANT: MILLING FLOTATION, CONCENTRATE THICKENING
OPS CAMP
EXPLORATION CORESHED
CONSTRUCTION CAMP
TSF 3 NEW
TSF2
0 350 700
1:19 500 METRES
NOTE(S)
1. COORDINATE SYSTEM: WGS1984
REFERENCE(S)
1. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, USGS, INTERMAP, INCREMENT P, NRCAN, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), ESRI KOREA, ESRI (THAILAND), NGCC, (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
CLIENT
MMG KINSEVERE
PROJECT
KOU UPDATE
TITLE
INFRASTRUCTURE LAYOUT
CONSULTANT
GOLDER
YYYY-MM-DD 2018-11-07
DESIGNED
PREPARED MM
REVIEWED ER
APPROVED ER
PROJECT NO. 1790467
CONTROL
REV. 3
FIGURE

Figure 2: Locality of Tenement PE7274, Current and Proposed Infrastructure

2.1.3 Exploitation Permit (Article 7)

The Prospecting Right PR7274 was acquired by Anvil Mining in 2007 pursuant to an Option Agreement with Gécamines S.A. The title was subsequently transferred to AMCK Mining sprl. The tenement was renewed in July 2012 for a five-year period with a 50% compulsory relinquishment. MMG acquired Kinsevere in 2012. MMG submitted a request for the conversion of the Exploration Permit PR7274 to an Exploitation Permit on 27 June 2017. The Exploitation Permit was issued by Cadastre Minier (CAMI) on 8 December 2017.

Dates of application, grant and expiry, as well as shareholdings, surface area and permitted substances are presented below in Table 3~~Table 3~~.

Table 3: Licence Tabulation for PE7274

Information Required	Information Provided
Permit Type	Permis d'Exploitation
Permit Number	PE7274
Title Holder	MMG Limited
Holding	100%
Status	Active
Date of Application	6 February 2007
Date Granted	8 December 2017
Expiry Date	7 December 2047
Substances	Cu, Co
Surface Area (squares)	six carrés (cadastral squares)
Surface Area (km^2)	5.027 km^2

PE7274 is in the form of an irregular polygon with 10 corner points and is comprised of six cadastral squares (or "carrés"), each of dimensions of 30 arc seconds of latitude by 30 arc seconds of longitude (approximately 915 m × 915 m). The permit covers an area of approximately 5.027 km^2. The surface area, grant and expiry dates, title holder and holding percentage and permitted substances were confirmed on the website of the DRC Cadastre Minier ("CAMI"), which presents mineral registry data for all mineral permits in the DRC. Corner coordinates were obtained from the CAMI "Carte de Retombe". CAMI information and corner coordinates are presented in Table 4~~Table 4~~ and Figure 3~~Figure 3~~. While the CAMI website is believed to represent up-to-date and official information about mineral title registrations, it is not considered to be the definitive legal record of mineral title, and as such Golder cannot provide any warranty as to the accuracy of these records.

Table 4: Corner Coordinates for PE7274 (Data from DRC CAMI Website – accessed 15 August 2018)

Corner Point	Longitude	Latitude
1	27° 35' 00" E	11° 20' 30" S
2	27° 35' 30" E	11° 20' 30" S
3	27° 35' 30" E	11° 21' 00" S
4	27° 36' 00" E	11° 21' 00" S
5	27° 36' 00" E	11° 22' 30" S
6	27° 35' 00" E	11° 22' 30" S
7	27° 35' 00" E	11° 22' 00" S
8	27° 35' 30" E	11° 22' 00" S
9	27° 35' 30" E	11° 21' 30" S
10	27° 35' 00" E	11° 21' 30" S

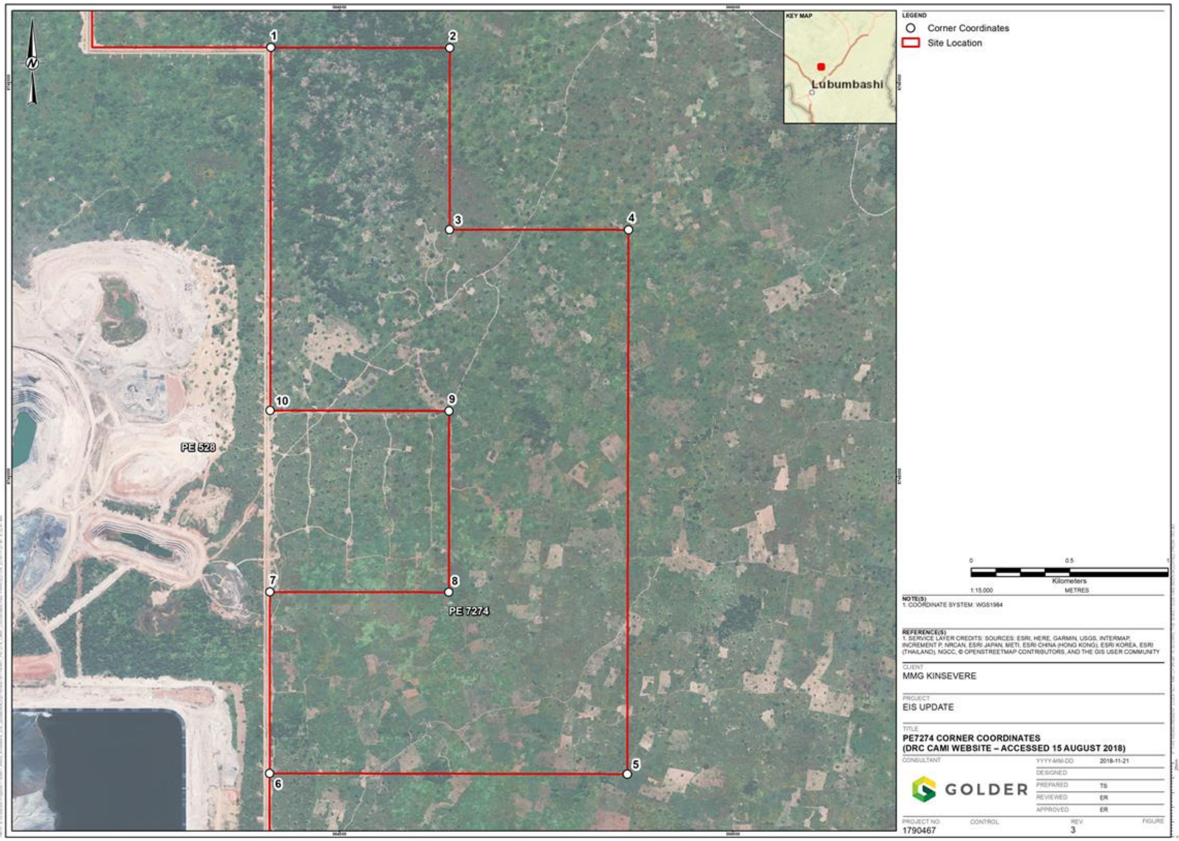


Figure 3: Corner Coordinates for PE7274

A letter was delivered to the Minister of Mines seeking approval for the the amalgamation of the PE528 and PE7274 tenements on 7 February 2019. This was approved by the Minister of Mines on 1 March 2019 and CAMI issued an Appendix to the existing exploitation certificate on 2 April 2019 (see Appendix C) for the PE7274 geographical parameter to be incorporated into the PE528 geographical parameter as shown inFigure 4Figure 4, resulting in the single exploitation tenement referred to as PE528. The list of geographical coordinates is provided in Table 5Table 5. This has resulted in PE528 increasing from 19 to 25 blocks (cadastral squares). The ESIA was largely completed prior to CAMI approval and as such discusses both PE528 and PE7274 tenements. This has no effect on the Project Description, identified Impacts or Mitigations.

Table 5: Corner Coordinates for Tenement PE528 after incorporation of PE7274

Name	X_DMS	Y_DMS
1	27° 33' 30" E	11° 23' 0" S
2	27° 33' 30" E	11° 22' 30" S
3	27° 33' 0" E	11° 22' 30" S
4	27° 33' 0" E	11° 21' 0" S
5	27° 34' 0" E	11° 21' 0" S
6	27° 34' 0" E	11° 20' 0" S
7	27° 34' 30" E	11° 20' 0" S
8	27° 34' 30" E	11° 20' 30" S
9	27° 35' 30" E	11° 20' 30" S
10	27° 35' 30" E	11° 21' 0" S
11	27° 36 00" E	11° 21' 0" S
12	27° 36' 00" E	11° 22' 30" S
13	27° 35' 00" E	11° 22' 30" S
14	27° 35' 00" E	11° 23' 0" S

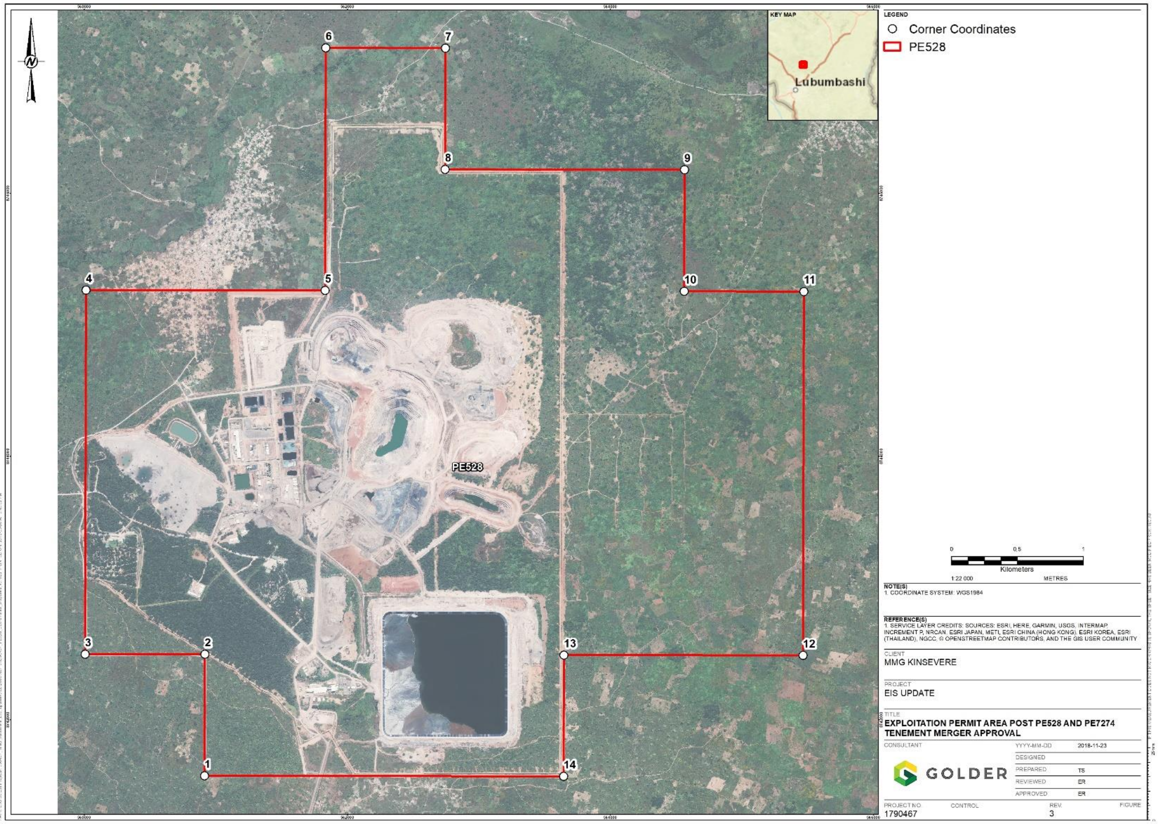


Figure 4: Exploitation Permit Area after approval of amalgamation of Tenements PE528 and PE7274

The amalgamation is described and referenced in this section (2.1.3) and section 2.1.4 of the ESIA report, but references to both tenements, which were correct at the time when the specialist studies were being done and the ESIA report was being compiled, have been retained in the rest of the report.

2.1.4 Title of the Project (Article 8)

The name of the proposed project is the Kinsevere Operational Upgrades (KOU) project.

MMG currently mines and processes oxide copper ore on Tenement PE528, located about 33 km north east of Lubumbashi – see

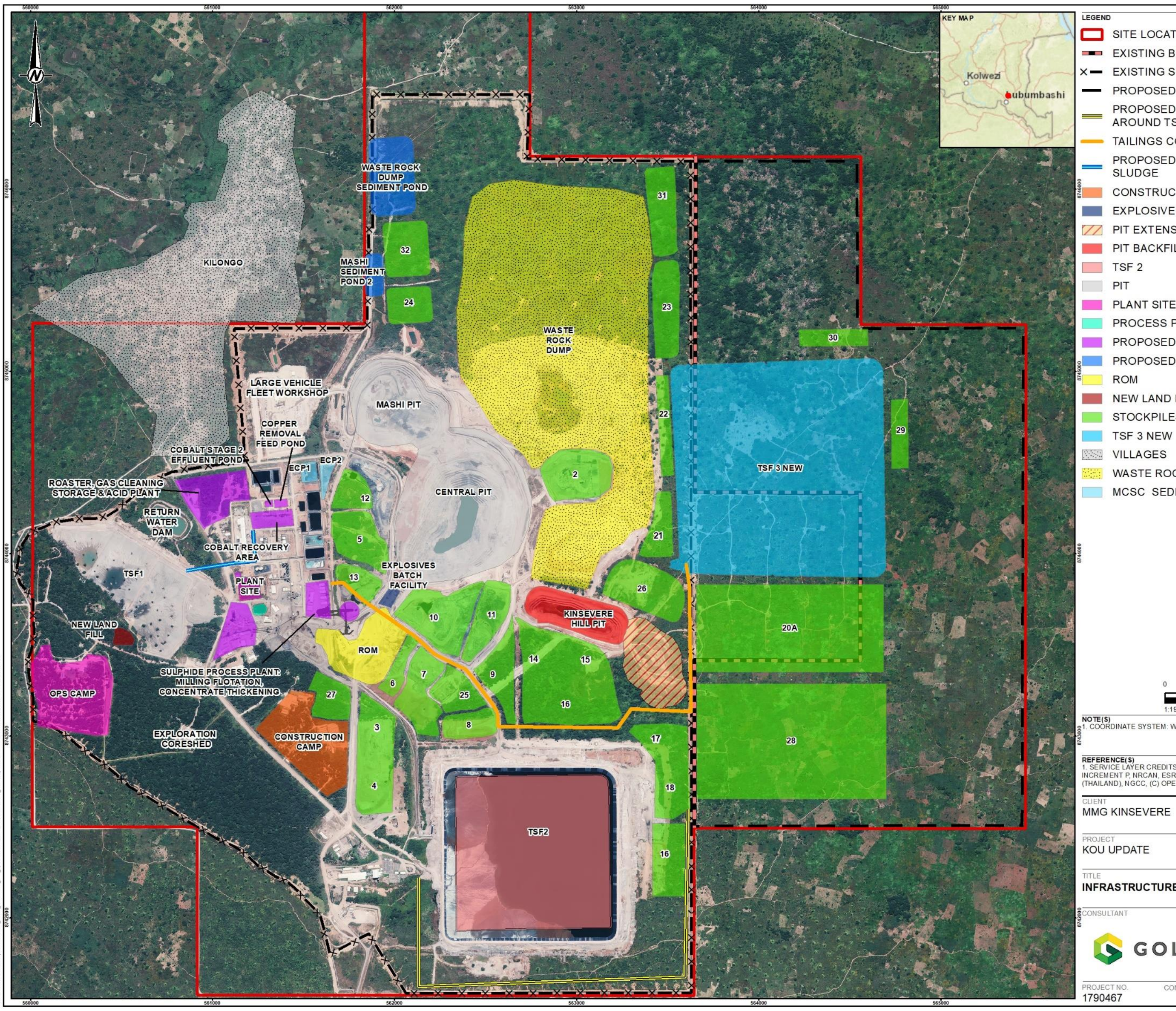

KEY MAP
Kolwezi
Lubumbashi
LEGEND
SITE LOCAT
EXISTING B
EXISTING S
PROPOSED
PROPOSED
AROUND TS
TAILINGS C
PROPOSED
SLUDGE
CONSTRUC
EXPLOSIVE
PIT EXTENS
PIT BACKFIL
TSF 2
PIT
PLANT SITE
PROCESS F
PROPOSED
PROPOSED
ROM
NEW LAND
STOCKPILE
TSF 3 NEW
VILLAGES
WASTE ROC
MCSC SEDI
KILONGO
WASTE ROCK DUMP SEDIMENT POND
MASHI SEDIMENT POND 2
WASTE ROCK DUMP
LARGE VEHICLE FLEET WORKSHOP
MASHI PIT
COPPER REMOVAL FEED POND
COBALT STAGE 2 EFFLUENT POND
ECP1
ECP2
ROASTER, GAS CLEANING STORAGE & ACID PLANT
RETURN WATER DAM
CENTRAL PIT
COBALT RECOVERY AREA
TSF1
PLANT SITE
EXPLOSIVES BATCH FACILITY
TSF 3 NEW
NEW LAND FILL
KINSEVERE HILL PIT
ROM
OPS CAMP
SULPHIDE PROCESS PLANT: MILLING,FLOTATION, CONCENTRATE,THICKENING
EXPLORATION CORESHED
CONSTRUCTION CAMP
TSF2
NOTE(S)
1. COORDINATE SYSTEM: W
REFERENCE(S)
CLIENT
MMG KINSEVERE
PROJECT
KOU UPDATE
TITLE
INFRASTRUCTURE
CONSULTANT
PROJECT NO.
1790467

Figure 2Figure 2. Sulphide copper ore is also mined but is currently stockpiled and not processed. Mining Rights for the exploitation of PE 528 are held under Exploitation Permit no. CAMI/CE 363/2003, issued to AMCK Mining sprl on 26 January 2007. MMG Limited acquired the Kinsevere mine in 2012. The Mining Rights are valid until 3 April 2024 and an application for a 15-year extension will be submitted at least one year and no more than five years before the expiry date.

MMG intends expanding its operations at Kinsevere mine to include the processing of copper sulphide ore and the recovery of cobalt from 2021 onwards. The proposed Kinsevere Operational Upgrades (KOU) project will enable the processing of both oxide and sulphide ore and will increase copper cathode production from 84 000 tpa up to 105 000 tpa (or produce up to 250 000 tpa of copper concentrate as an alternative). It will extend the life of the mine up to approximately 2030 and produce about 13 000 tpa of cobalt hydroxide product (on a dry basis). This will involve the establishment of a new tailings storage facility (TSF3), spanning across the previous boundary that existed between PE528 and PE7274 before the amalgamation – see

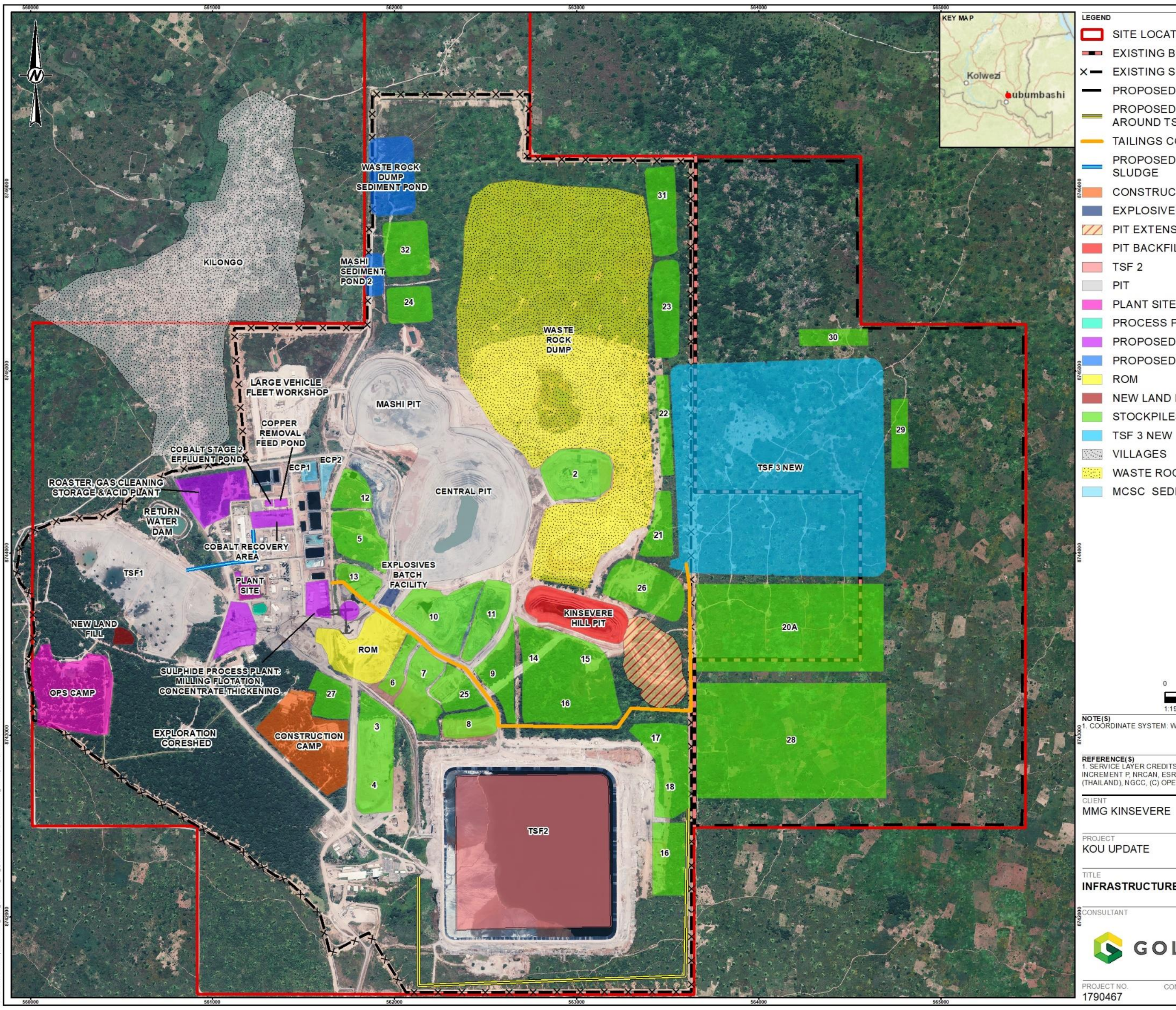


Figure 2~~Figure 2~~.

It should be noted that, while the amalgamation of the two tenements has resulted in there now being only one tenement, namely PE528, references to both tenements, which were correct at the time when the specialist studies were being done and the ESIA report was being compiled, have been retained in the rest of this ESIA report.

2.1.5 Project Location (Article 9)

The proposed KOU project is located approximately 33 km north north-east of the city of Lubumbashi in the Territory of Kipushi, in the Katanga Province of the DRC. See Figure 1~~Figure 1~~.

2.1.6 Land and Mining Rights within the Perimeter of the Exploitation Right (Article 10)

Gécamines holds the mining rights to both tenements and MMG has a lease agreement with Gécamines that allows it to undertake mining and other associated activities on the tenements. There are no private landowners, but the village of Mpundu and part of the village of Kilongo fall within PE528 and the inhabitants have a de facto right of tenure – see

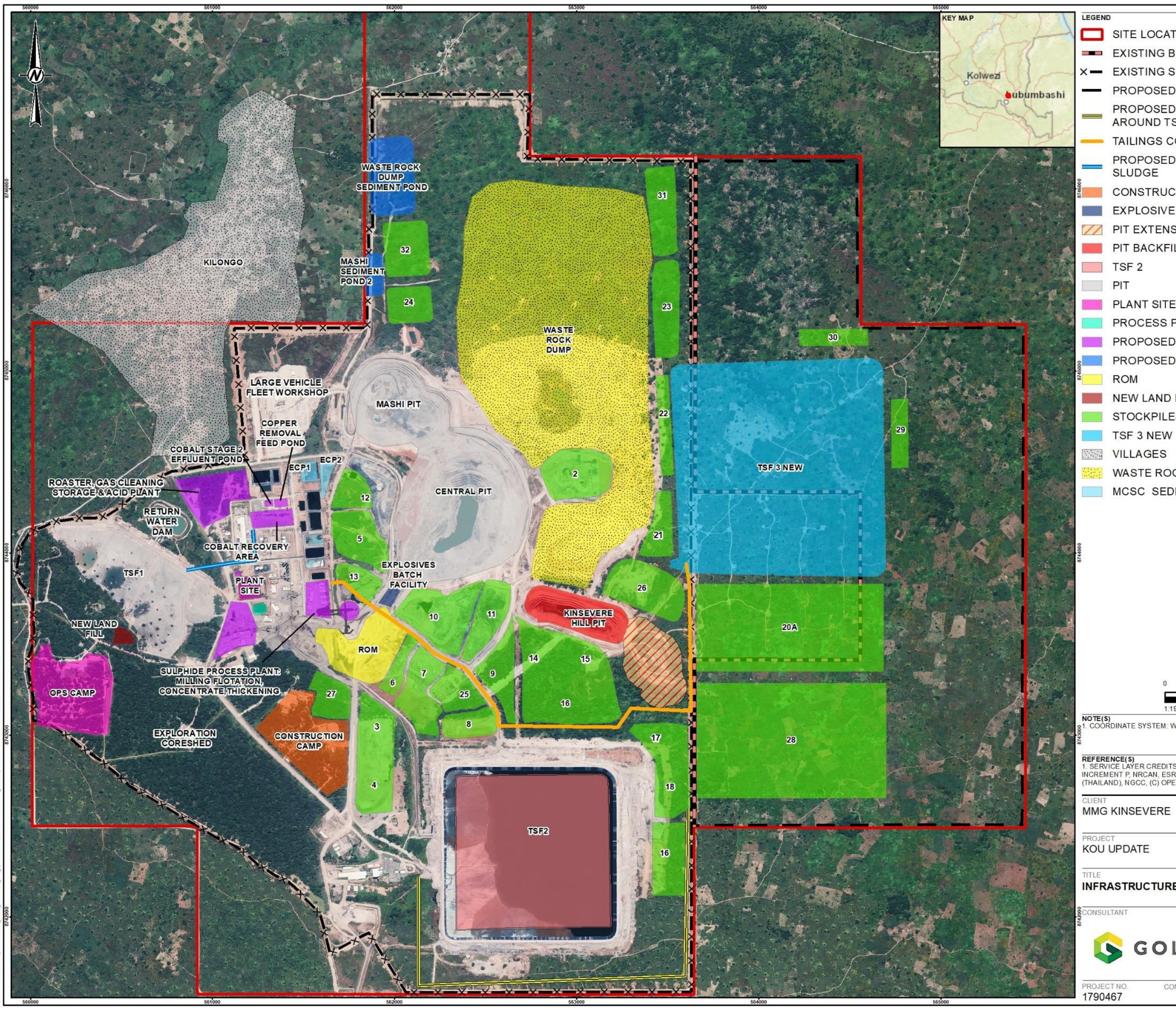


Figure 2~~Figure 2~~. There are prospecting activities, but no mining activities on PE7274. Some 140 farmers who grow crops on PE7274 and live in nearby villages have been identified.

2.2 CHAPTER II: PROJECT DESCRIPTION

2.2.1 Obligation to Describe the Project (Article 11)

This chapter describes the mining methods, processing and project infrastructure according to Articles 11 - 24 of Annex VIII of the Mining Code (2018).

2.2.2 Summary of the Project (Article 12)

2.2.2.1 Summary of Current Operations

Currently, oxide copper ore is mined and processed on PE528. Conventional open pit mining is carried out at Central Pit, Mashi Pit and Kinsevere Hill Pit. The oxide copper ore, containing copper bearing minerals such as malachite and cuprite, was processed in a Heavy Media Separation (HMS/Stage I) plant to produce copper concentrate until mid-2011. The Stage II Solvent Extraction/Electro-winning (SX/EW) plant commenced operation in April 2011. Kinsevere currently processes up to 2.6 million tons per annum (Mtpa) of oxide copper ore to produce up to 84 000 tonnes of copper cathode per annum. The oxide ore resource is being depleted and the current projected life of mine is until 2023 with closure of the operation thereafter.

2.2.2.2 Proposed Expansion Projects

Co-mined material containing sulphide copper minerals has been stockpiled for a number of years. MMG is considering a project to increase the copper production rate and extend the life of the mine by mining and processing of the deeper lying sulphide ore, which contains copper-bearing minerals such as chalcopyrite, bornite and chalcocite. The ore throughput for the new processing facilities will be up to 2.6 Mtpa, which, combined with the processed oxide ore, will produce up to a combined total of up to 105 000 tonnes of copper cathode annually. An alternative case may be implemented where cathode production from oxide ore is maintained (up to 84,000 tonnes annually) but up to 250 000 tonnes of copper concentrate is produced annually from processing the sulphide ore – see Section 2.2.2.2.2 for further detail. The project will increase the life of mine to approximately 2030. This project was previously referred to as the Kinsevere Primary Copper Project (KCP), but it has been renamed and is now referred to as the Kinsevere Expansion Project (KEP).

An Environmental Impact Study (EIS), which covered some aspects of the KEP, was compiled and submitted to the Department Responsible for the Protection of Mining Environment (DPEM) (a department of the Ministry of Mines) (Thierry, B K EMIS CONGO; November 2017) in August 2017 and it was approved in December 2017.

MMG subsequently completed a pre-feasibility study to further define the KEP and commenced with an ESIA in February 2018 to include the new information along with other planned operational changes at Kinsevere. The KEP and the other operational changes are now known as the Kinsevere Operational Upgrades (KOU) project.

The components of the KEP and the additional components defining the KOU are listed in Sections 2.2.2.2.1 and 2.2.2.2.2 respectively.

Figure 5~~Figure 5~~ shows the integration of the KEP and KOU infrastructure with the existing infrastructure.

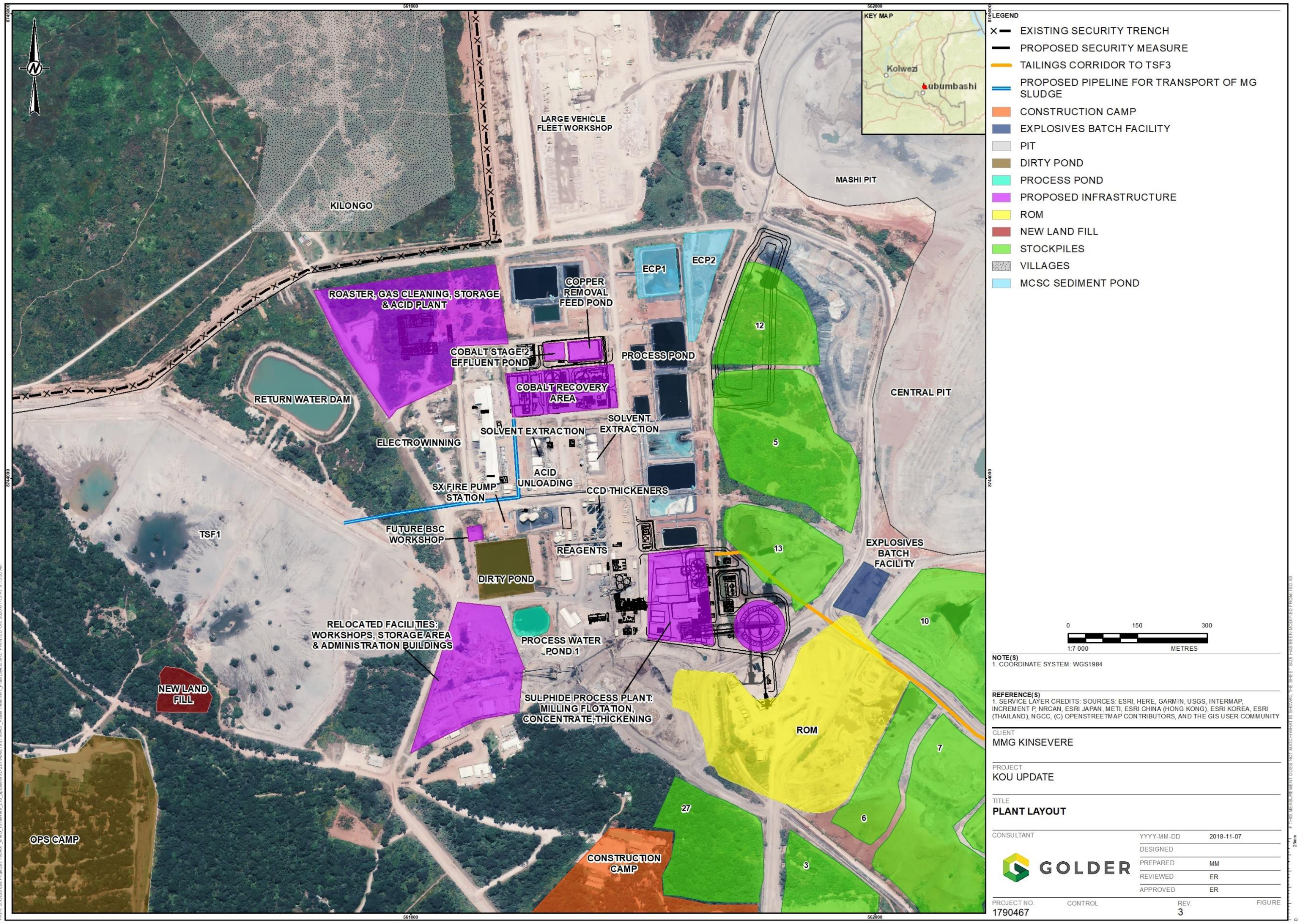


Figure 5: Integration of Proposed KEP and KOU Infrastructure with Existing Infrastructure

This ESIA covers a range of changes to the current operations. Listed below are some of the aspects that were covered in the 2017 EIS submission as well as updates to be described in more detail in this ESIA.

2.2.2.2.1 Kinsevere Operational Upgrades (KOU)

In summary, the KOU will comprise:

- The oxide ore throughput will be up to 2.6 Mtpa as per the 2017 ESIA;
- The Kinsevere Expansion Project (KEP) – see Section 2.2.2.2.2 for further detail;
- Footprint expansion of existing pits;
- Expansion of current waste rock dump (WRD) – (design, location and management) to potentially include non-acid forming (NAF) and potentially acid forming (PAF) waste;
- Progression of dewatering system and rates;
- Update of stockpile design, footprint and locations;
- Reclamation of Tailings Storage Facility 1 (TSF1) materials;
- Expansion of Tailings Storage Facility 2 (TSF2) and relocation of associated infrastructure;
- New large fleet workshop (already built and exists as per 2017 EIS) with Waste Rock Dump Sediment Pond;
- Update of the oxide plant layout to incorporate new process ponds;
- Modification of the existing Environmental Control Ponds 1 and 2 (ECP1 and ECP2). ECP1 is lined and will be extended to the east and the west. Built-up silt will be removed to increase its capacity and any damaged lining will be replaced. The extended ECP1 will encroach onto ECP2, which will be linked to ECP1 by a spillway and will serve as an emergency containment pond;
- Decommissioning of Mashi Sediment Pond 1 and construction of Mashi Sediment Pond 2;
- Implementation of an updated surface water management plan (SWMP);
- Establishment of new groundwater abstraction and monitoring boreholes;
- Processing of third-party ore to maintain production and grade control;
- Processing of third-party pregnant leach solution;
- A crusher and vat leaching system to process ore from existing stockpiles; and
- A cobalt recovery circuit to recover cobalt from the existing low grade raffinate stream in the solvent exchange (SX) plant;
- Reprocessing mill reject material in a scat crushing plant;
- Installing a solvent exchange (SX) fire protection system;
- Waste management changes, including a new landfill;
- Upgrade of the existing accommodation facilities;
- Update of the rehabilitation and closure plan and financial guarantee;
- Filling in of the security trench along the current boundary between PE528 and PE7274;
- Community engagement activities, including determination of compensation for loss of access to farms and structures on PE 7274, if the KEP is implemented; and

- Infrastructure associated with the above.

2.2.2.2.2 Kinsevere Expansion Project (KEP)

In summary, the Kinsevere Expansion Project will comprise:

- Mining and processing of sulphide copper ore from the expanded pits at a rate of up to 2.6 Mtpa and increasing copper production up to 120 000 tpa, potentially requiring an electrowinning plant upgrade;
- Cobalt hydroxide production from oxide and sulphide copper ore with capacity of 13 000 tpa;
- Ability to process satellite ore bodies near Kinsevere and processing of third party concentrates through processing facilities;
- Potential for producing and selling up to 300 000 tpa as an alternative; and
- Mining of sulphide ores is expected to commence in 2021 with Cobalt and Copper production commencing in 2022 and 2023 respectively. The life of mine is expected to be extended to approximately 2035.

Facilities to be established include:

Mining

- Expansion of current opencut pits;
- New ore and topsoil stockpiles;
- Expanded Waste Rock Dumps (WRD);
- Establishing a new Run of Mine (RoM) pad;

Processing

- A sulphide ore processing circuit will be established on PE528. It will include a semi-autogenous mill, a flotation plant, a tailings thickener, a pressure filter, a fluidised bed roaster for sulphide concentrate, a wet gas cleaning plant, a sulphuric acid plant and supporting infrastructure on PE528;
- Upgrade of oxide ore processing circuit to process transitional ore (TMO: oxide and sulphide);
- A Cobalt recovery processing circuit;
- Third party concentrate storage handling facilities;
- Potential Solvent Extraction and Electrowinning circuit expansion to 120 000 tpa Copper;

Infrastructure

- A new tailings storage facility (TSF3) spanning the current boundary between PE528 and PE7274, for deposition of sulphide tailings;
- Relocation and establishment of new workshop and administration buildings, transmission line/tailings line relocation including a temporary construction area (laydown and bond store area) between the processing area and Central Pit;
- Extending the existing security trench from the outer perimeter of PE528 along the outer perimeter of PE7274, or erecting another type of security barrier, e.g. a fence, along the outer perimeter of PE7274 to consolidate the two tenements into a single operational area;
- Establishing associated infrastructure such as utilities, services, roads and bunds; and
- Surface water management infrastructure, including the new Waste Rock Dump Sediment Pond.

2.2.2.3 Need, Desirability and Benefits of the Proposed KOU Project

Undertaking the KOU project will extend the life of the mine from 2023 to approximately 2030, which will:

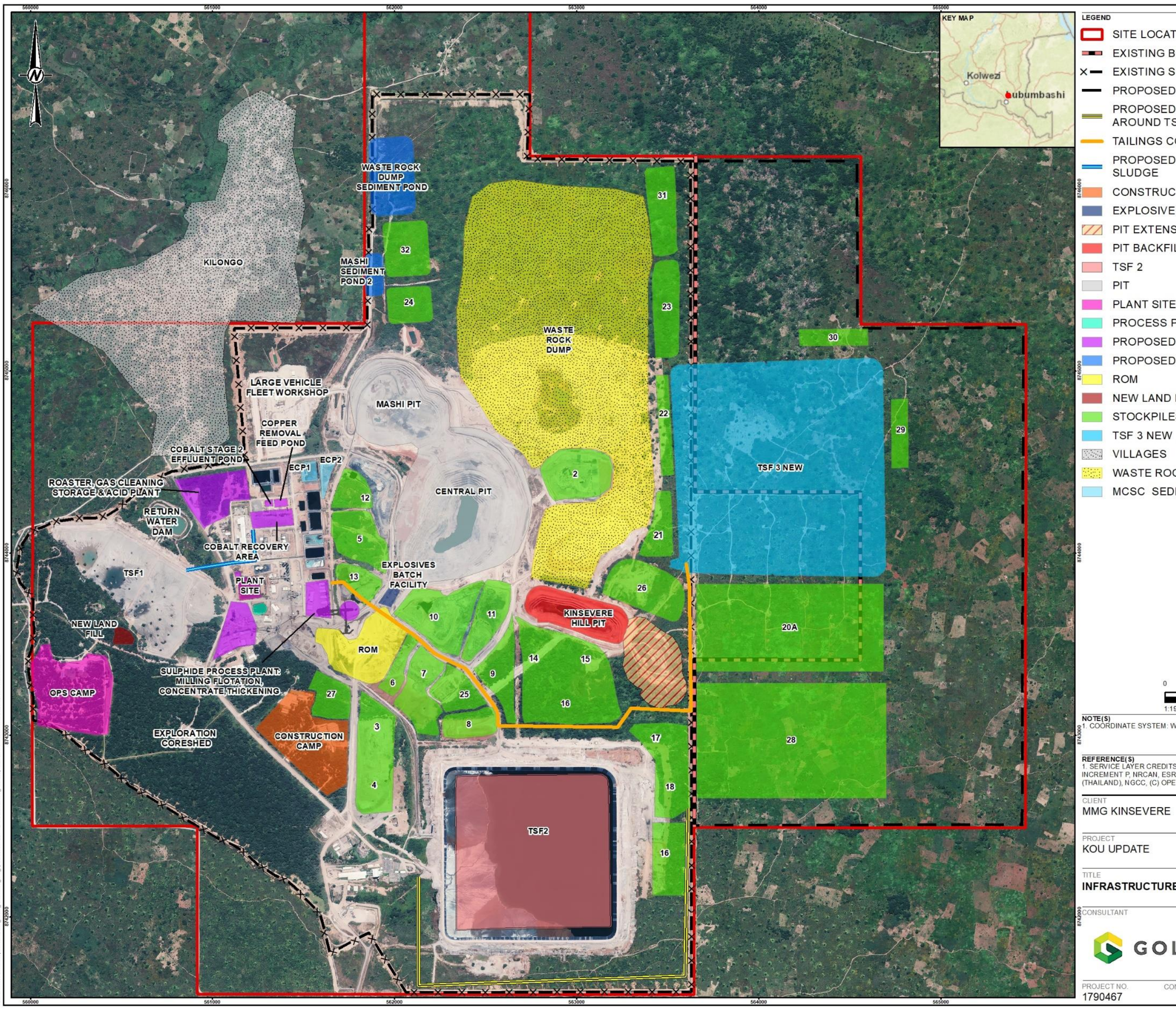
- Create some additional jobs - the number is yet to be established;
- Result in continued contributions to the national economy via the payment of royalties and taxes;
- Continue earning foreign exchange for the DRC;
- Ensure continued cash injection into the local and regional economies in the form of employees' remuneration and the purchase of local and regional goods and services;
- Ensure the continuation of the social development projects described in Section 8.2, which will enhance the probability of them maturing and becoming sustainable; and
- Continue to provide copper and cobalt as much needed materials in the manufacture of electrically powered vehicles, which can contribute to a reduction in air pollution if they are recharged from power generators that do not make use of fossil fuels.

If MMG does not undertake the KOU project, it will not necessarily result in the permanent or long-term avoidance of the adverse environmental impacts described in this ESIA. For as long as there is a demand for copper and/or cobalt, there will be attempts to mine the remaining reserves at Kinsevere and there is no guarantee that such mining will be undertaken with the same or similar degree of environmental responsibility as committed to by Kinsevere in this ESIA and previous EISs.

2.2.3 Mineralogy of the Deposit (Article 13)

The copper mineralisation at Kinsevere occurs in three known deposits namely Central, Mashi and Kinsevere Hill, hosted in the SD (dolomitic shale) and CMN (Kambove dolomite) with minor mineralisation occurring within the RAT (Roches Argileuses Talqueuses) formation along the contact with Silicified Dolomite

(SD) (MMG, 2016) – see Figure 1Figure 1,



Golder Associates

Figure 2~~Figure 2~~, and Figure 27~~Figure 27~~.

Oxide copper minerals occur in the upper weathered zone, to a depth of about 100 m below ground level. The oxide minerals are predominantly malachite and pseudomalachite, with minor portions of azurite and chrysocolla and very small amounts of inter-grown heterogenite (Thierry, B K EMIS CONGO, November 2017). These minerals exist as disseminations or in veins and veinlets. Only oxide ore is currently processed at Kinsevere.

Sulphide mineralisation occurring deeper has been intercepted at the base of the weathered zone, approximately 100 m below surface level. The sulphide ore minerals at Kinsevere consist primarily of chalcopyrite, with minor deposits of pyrite, bornite, chalcocite, cuprite and native copper. The mineralisation occurs in veins and veinlets that crosscut bedding, but it is not clear whether this is primary mineralisation or the product of remobilised stratiform sulphides of late-diagenetic age.

Apatite, which contains small amounts of uranium, occurs in association with the sulphide copper minerals. Uranium concentrations of up to 3 660 mg/kg have been found in drill cores from the deeper exploration boreholes. The majority of the higher values were found in rock outside of the optimal pit shell, where uranium concentrations seldom exceeded 700 mg/kg (see Figure 6 and Figure 7). Uranium concentrations in excess of 100 mg/kg were found in 0.2% of all assayed samples, i.e. the uranium concentration in the ore that will be mined and processed is very low.

As discussed in Section 5.8.6.4, all measured radiation values were below the occupational limit of 20 mSv per annum and no inhalation or ingestion risks in excess of the authorised limits were found during a dosimetry study undertaken at the Kinsevere mine by the General Commissariat for Atomic Energy (CGEA) of the DRC.

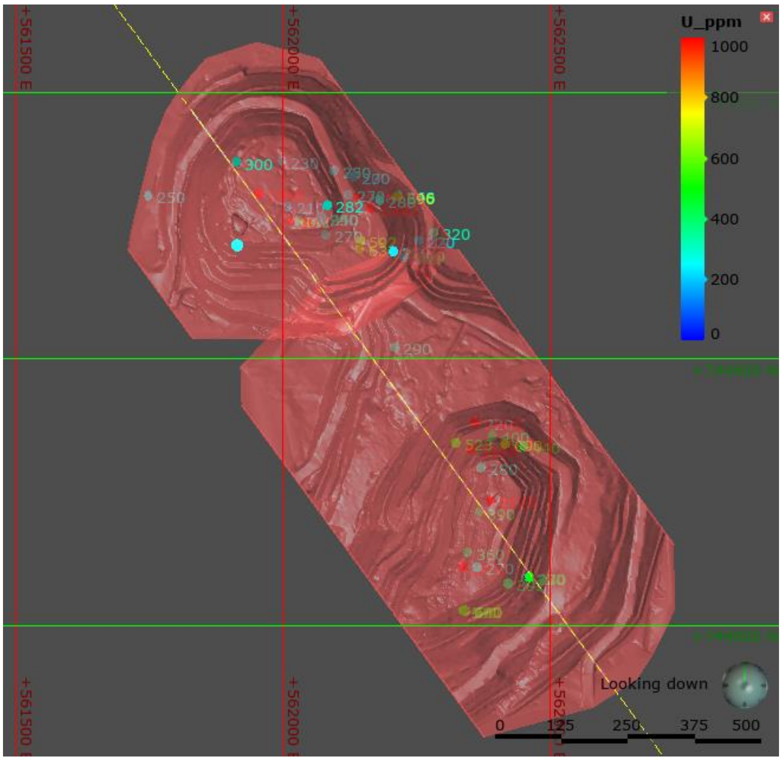


Figure 6: Uranium Concentrations Intersected by Drilling – Plan View

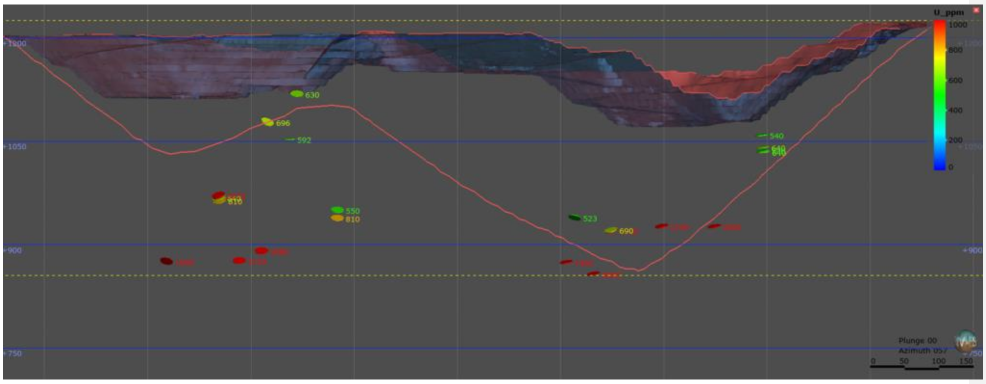


Figure 7: Uranium Concentrations Intersected by Drilling – Side View

2.2.4 Mineralogy of the Parent Rock (Article 13)

The host rock on tenement PE7274 is the same as that on PE528.

2.2.5 Mineral Extraction (Article 14)

The Kinsevere operations currently comprise three pits: Central, Mashi and Kinsevere Hill (a single pit with a North and South mining area). Kinsevere Hill North is all but exhausted and future mining will focus largely on Mashi, until Cutback 4 at Central Pit has been developed to a point where it starts providing the bulk of the ore. Central and Mashi will eventually merge to form a single pit with a “saddle” between the two pits.

Exploration activities are being undertaken south-east of Kinsevere Hill, within the PE7274 mine tenement, which may result in additional mining pit(s).

2.2.5.1 Average and Nominal Extraction Capacity – Article 14 (a)

The existing plant will process up to 2.6 Mtpa of oxide ore. Up to 2.6 Mtpa of sulphide ore will be processed between 2021 and 2030 to substitute for the decline in oxide grades, making a combined (oxide and sulphide) estimated total of approximately 55.5 Mt of mineralised resource to be processed over the life of mine. Transitional ores mined with the sulphide ores will be stockpiled and processed in the oxide plant.

The following approximate tonnages are envisaged inclusive of ore sourced from an external third party:

- 18 Mt oxide and transitional ore zones (TMO);
- 8 Mt oxide and TMO stockpiles;
- 2 Mt of Kalumines (Oxide) ore;
- 19 Mt of sulphide ore; and
- 38 Mt of waste rock.

Additional third-party ore may be processed throughout the life of mine. Third-party ore may be sourced from the same area or other areas within the DRC. The ore will be transported using existing national or secondary roads.

The mining rate for oxide ore was increased from 1.8 Mtpa up to 2.6 Mtpa (the processing capacity of the plant) in 2011 to achieve a copper production rate of up to 84,000 tpa. The oxide ore mining rate will start declining by 2020, and until then co-mined sulphide copper ore will be stockpiled. The rate of sulphide ore production will increase to 2.6 Mtpa, with a copper production rate of up to 105 000 tpa until 2027, by which time a combined (oxide and sulphide) total of about 41 Mt of mineralised resource will have been extracted and processed. An alternative case may be implemented where cathode production from oxide ore is maintained (up to 84 000 tonnes annually) but up to 300 000 tonnes of copper concentrate is produced annually from processing the sulphide ore – see Section 2.4.1.1 for further detail.

The mine commenced purchasing oxide ore from the Iverland Mining Kalumines deposit in 2015. Iverland agreed to supply 60 kt of Cu over a five-year period, but discussions are underway to continue supply of Kalumines ore over the life of the mine.

A modest amount, between 10 and 15 Mt, of potentially acid forming (PAF) material will be mined over the life of the operation. It could either be placed on a liner or NAF base layer, encapsulated in designed cells within the WRD surrounded by NAF material or used as compacted backfill in Kinsevere Hill pit between NAF material.

2.2.5.2 Location of the Extraction Works – Article 14 (b)

The location and layout of the mine and supporting infrastructure are shown in

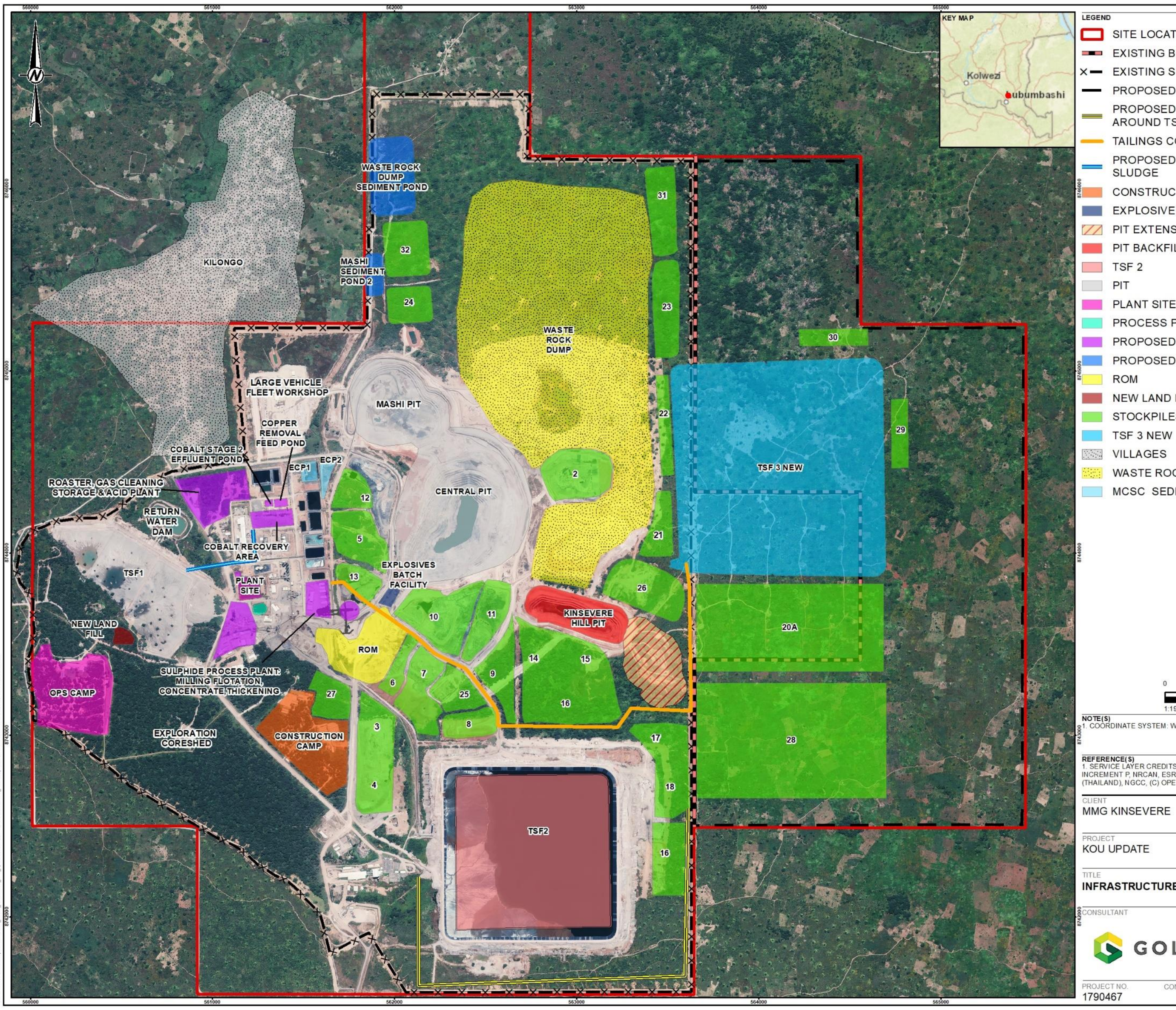


Figure 2Figure 2 and Figure 5Figure 5.

2.2.5.3 Extraction Methods – Article 14 (c)

The current and future mining methods are described in this section.

The mining method is opencast, using the conventional truck and shovel method, with limited blasting on 10 m benches and mining is done in four 3 m flitches. Ore is delineated by grade control drilling. Samples are taken at 2.5 m intervals in mineralised zones and dispatched to the mine laboratory for assaying. The ore zones are marked out by mine surveyors as super high, high, medium and low, grade zones, based on assays taken from grade control drilling.

The mine operates on a 24-hour basis under the supervision of trained geological technicians who are in constant contact with the operators of the excavators via two-way radio. The mined ore is hauled to the run of mine (ROM) pad or long-term stockpiles. At the ROM pad it is dumped on various “fingers” to allow for selective feeding of ore to the mineral sizer via the ROM bin.

Oxide, transitional and sulphide ores are stockpiled and processed separately. The ore is stockpiled for grade control and to ensure correct processing and optimised consumption of reagents and energy during the copper extraction process. Lower-grade ores are blended with higher-grade ores to maintain consistent copper feed grade.

Black shale material has been isolated and stockpiled into grade ranges for a number of years. Most of this material is stockpiled in a designated area for use during the proposed KEP stage of the mine development.

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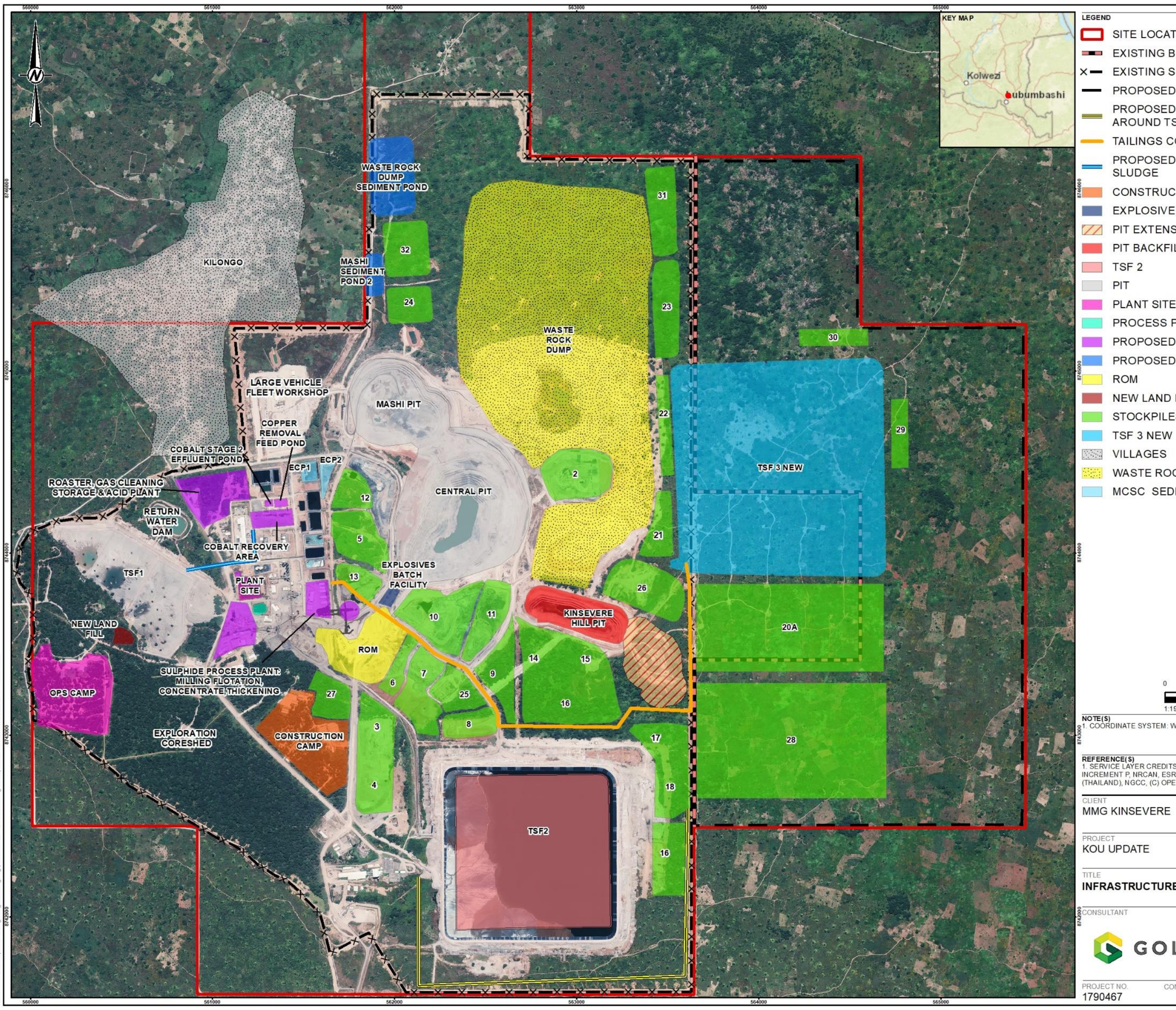
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SULPHIDE PROCESS PLANT:
MILLING FLOTATION,
CONCENTRATE THICKENING
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Figure 2Figure 2 for the locations of all the new stockpiles for the proposed KOU.

2.2.5.4 Types of Mining Equipment – Article 14 (d)

The geological formation is highly weathered to a depth of about 100 m and the mining of oxide ore requires only limited blasting.

Mining of the sulphide ore will be similar to the current operation, but significantly more blasting will be required to provide the correct fragmentation for plant feed, and the haulage lengths will increase with the deeper open pits. Operations will require closer adherence to maintaining regular 10 m drill & blast benches, trim blasting, pit wall depressurisation, and in-pit dewatering, to maintain planned productivity.

MMG makes use of bulk P101 emulsion explosive supplied by an appropriately licensed supplier. The emulsion is stored in an overhead silo equipped with gassing solution tanks, offloading pumps and piping. Storage is expected to increase from 28 tonnes to 56 tonnes in the short term. Blasting accessories include Pentolite Boosters, Benchmasters, Handimasters and Cordtex. These are stored in three timber lined and earth mounded magazine containers that comply with the requirements of the DRC Mining Code. Lightning masts provide lightning protection and the area is fenced off, with access control. The existing explosives magazine may be relocated within the Kinsevere mining tenement area.

A third-party mining contractor has been utilised since mining commenced in 2007. Mining is carried out using trucks and shovels. When sulphide ore mining commences, the fleet will include larger equipment, such as 70 - 120 t excavators and 40 - 100 t trucks (articulated and/or rigid), ADTs to transport ore to the ROM pad for processing or to transport mine waste to the WRD or TSF embankment), water carts, bulldozers and graders.

The mining activities include:

- Blasting and excavating of material;
- Loading and hauling of ore and waste rock from the open pits;
- Earthmoving and clean-up work;
- Haul road maintenance; and
- Equipment maintenance.

Typical equipment used for the mining operations includes but is not limited to what is shown in Table 6Table 6.

Table 6: Estimated KOU mining fleet

Equipment	Make/Model	Number
90 t Excavator	Cat390	4
120 t Excavator	PC1250SP	3
100 t Truck	Komatsu 785-7	22
45 t Truck	Cat745C	76
Dozer	CadD8T	8
Grader	Cat16M	2
Water Cart	Cat745C	3
Front End Loader	Cat 980H	2
Run of Mine Truck	Dump Truck	3
Drill	Tamrock Pantera	5

This equipment list is indicative as the terms of mining contracts can be amended. These terms may change mid-term or upon renewal, if agreed between the parties that alternative equipment is more appropriate to the changing needs.

The haul road design includes:

- 1:9 gradient, 20 m width, or as per safety requirements;
- A safety berm on either side of the haul road;
- A water drainage channel on either side of the haul road;
- The haul road is crowned to shed water; and
- Ramp gradients at 10%.

2.2.5.5 Volume of Sterile Material (Waste Rock, Overburden) to be Removed and its Location – Article 14 (e)

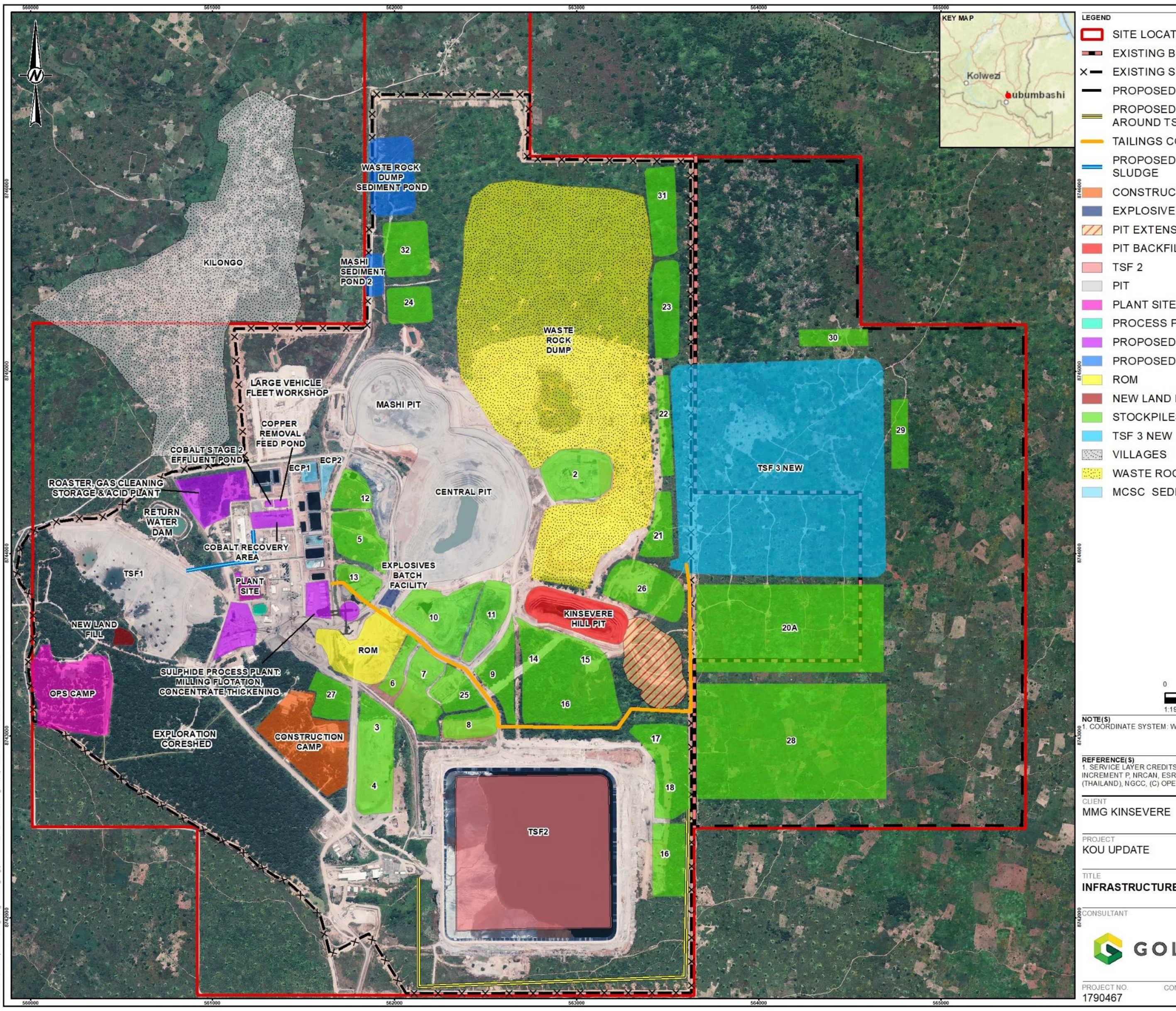
The existing waste rock dump (WRD) footprint was expanded towards the east and south-east of Central Pit and it will continue to expand with the mining of sulphide ore.

Non-acid forming (NAF) oxide waste rock will be placed along the perimeter of the expanded WRD facility. Potentially acid forming (PAF) sulphide and transitional waste rock may be placed inside the "oxide shell" and will ultimately reduce the area to be capped.

Based on the design of the TSF2 and TSF3 mined oxide waste (around 12.5 million cubic metres (Mm^3)) will be required for the construction of the TSF2 and TSF3 embankments. The reprocessing of TSF1 material for the recovery of residual copper and the deposition of the resulting tailings on TSF2, as mentioned in sections 2.2.2.2.1, 0 and 4.3.1.5.2, will result in an increase in the amount of tailings stored in TSF2 and in its final embankment height. Relative to the parameters stated in the approved 2012 EIS, the final crest elevation of TSF2 will increase to 1 300.9m R.L. and the tailings stored will increase to 37 052 000 tons.

The amended TSF2 design is not expected to have any significant environmental or social impacts. There will be an increase in the volume of supernatant water that will have to be managed at the end of the life of this operation, which will be done in accordance with the Closure Plan. Geotechnical and any other design considerations will be dealt with separately from the ESIA.

The expanded WRD will eventually cover an area of up to 171 ha (it could potentially be larger) and will be up to 80 m in height. Refer to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CONCENTRATE THICKENING
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Figure 2~~Figure 2~~ for the proposed expanded WRD. After mining activities have ceased, the facility will be capped to pre-determined standards, with particular attention to areas where PAF material might be present.

During the operational phase, run-off will be managed based on the updated Surface Water Management Plan. Refer to Section 5.4.3.

The options being considered for the storage of PAF waste rock are:

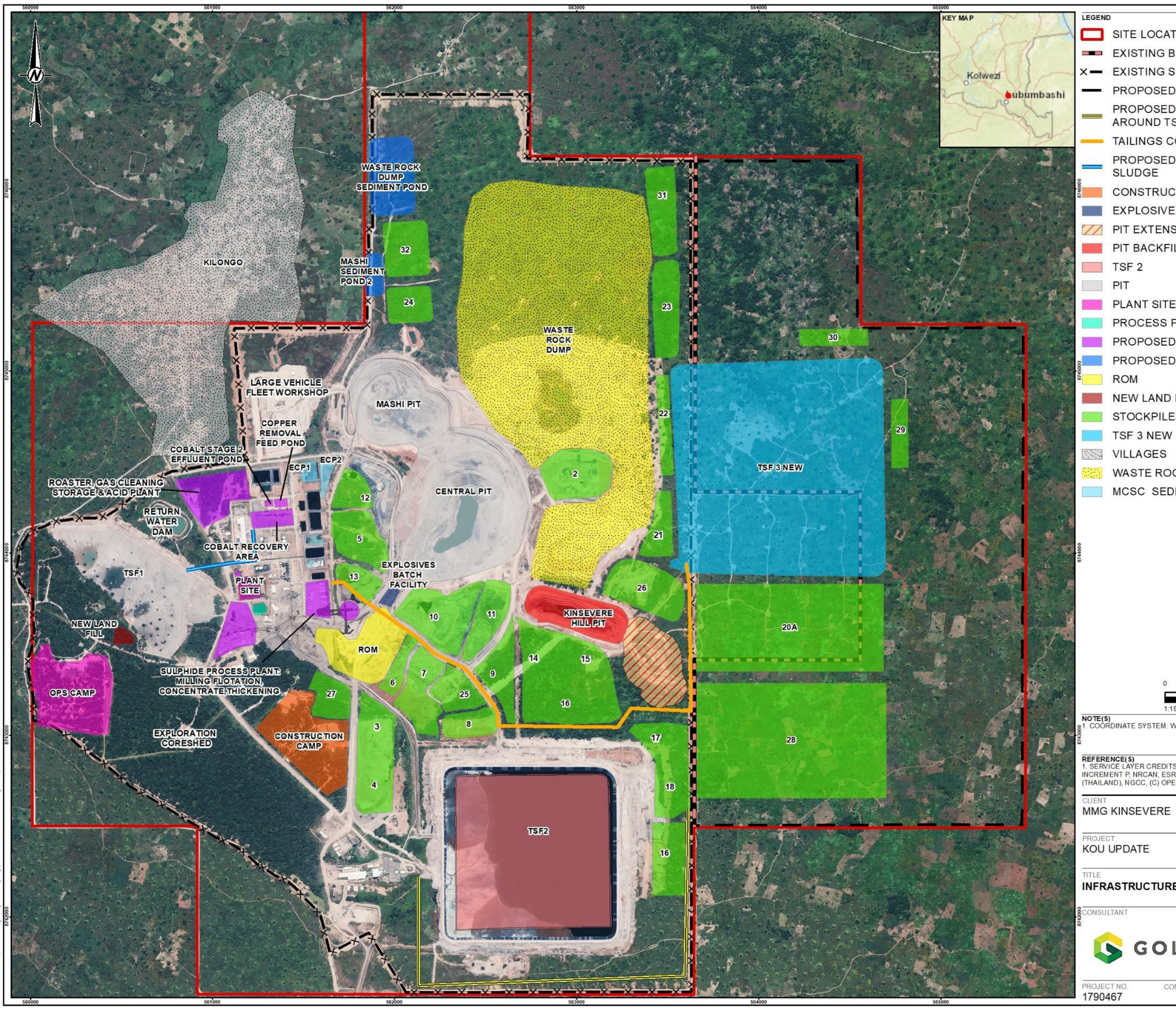
- Cells within the WRD – Lined layers of PAF and NAF completely encapsulated by NAF with drainage to the proposed Waste Rock Dump Sediment Pond (WRDSP);
- Kinsevere Hill Pit – Backfilled with PAF and additional monitoring bores may be required to assess groundwater impacts; and
- Stockpiled – Lined or on a NAF base layer with drainage to a collection pond or sump.

All exposed NAF surfaces used to encapsulate PAF will be capped with 300 mm low permeability soil (laterite) placed in two 150 mm layers followed by 200 mm topsoil at closure. This applies to both horizontal and sloping surfaces.

All PAF storage areas where PAF waste rock is exposed, will be capped with a:

- 500 mm thick capillary break layer consisting of coarse durable NAF rockfill;
- 300 mm layer of low permeability lateritic soil;
- 500 mm coarse durable NAF rockfill layer to facilitate moisture control and reduce root penetration into the soil liner; and
- 300 mm topsoil layer over the NAF surface, sourced from on-site stockpiles.

A review of topsoil stockpiles and management infrastructure associated with the pit extensions and the proposed KOU project identified that the topsoil stockpiles will have to be relocated to make space for the establishment of the components of the new project. In addition, new topsoil stockpiles will also be required as shown in



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TSF 3 NEW
LARGE VEHICLE FLEET WORKSHOP
MASHI PIT
COPPER REMOVAL FEED POND
COBALT STAGE 2 EFFLUENT POND
ECP1
ECP2
ROASTER, GAS CLEANING STORAGE & ACID PLANT
RETURN WATER DAM
12
CENTRAL PIT
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21
COBALT RECOVERY AREA
TSF1
PLANT SITE
EXPLOSIVES BATCH FACILITY
13
26
KINSEVERE HILL PIT
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NEW LAND FILL
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SULPHIDE PROCESS PLANT: MILLING FLOTATION, CONCENTRATE THICKENING
OPS CAMP
27
6
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CONSTRUCTION CAMP
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Figure 2Figure 2. The new topsoil stockpiles will be up to 15 m high.

2.2.6 Ore Processing Methods (Article 15)

The locations of the ore processing areas and plant components are shown in Figure 5Figure 5 and the ore processing flowsheet is shown in Figure 9Figure 9. The ore processing methods are summarised briefly in this section. A complete process description is provided in Section 2.4 (Article 17).

2.2.6.1 Current Ore Processing Methods

The oxide copper ore, which is currently being mined, is stockpiled, crushed, milled and leached with sulphuric acid to bring the copper into solution, from which the copper is recovered by means of solvent extraction and electro-winning to produce copper metal cathodes. Some oxide copper ore is also sourced from Iverland Mining's Kalumines deposit and processed in the same plant but may also be sourced from other locations.

2.2.6.2 Proposed Ore Processing after Upgrade

Sulphide copper ore will be mined from the deeper strata in the same open pits at Kinsevere. The sulphide ore will be stockpiled, crushed and milled. The sulphide copper minerals will be recovered by froth flotation, the flotation concentrate will be thickened, filtered and roasted to oxidise the copper, which will then be recovered by leaching with sulphuric acid, solvent extraction and electro-winning to produce copper metal cathodes.

Cobalt will be recovered from the low-grade raffinate stream in the solvent exchange process by precipitation with magnesium hydroxide and removal of iron, aluminium and manganese. The cobalt will be in the form of a cobalt hydroxide filter cake or crystalline cobalt sulphate heptahydrate.

At present, oxide ore is sourced for grade blending from a third-party supplier. Additional third-party ore will be processed throughout the life of mine. Third-party ore may be sourced from the same area or other areas within the DRC. The ore will be transported using existing national or secondary roads.

Kinsevere are also adding the option to process a pregnant leach solution (PLS) from a third party through the current processing plant.

The mine intends installing a scats crushing plant to reprocess mill reject material through the existing oxide circuit which will require an additional small crusher and a mill and vat leaching system to process low grade ore from certain existing stockpiles – see Section 2.4.1.2.3.

Raw water will be received on site from a series of boreholes and pumped into a fire services water pond that continuously overflows into the adjacent raw water storage pond. It is a safety requirement that the full 90 minutes' deluge is available at all times and for this reason, the fire water pond will be designed with a volume capacity that fulfils the 90 minutes deluge requirement. The fire water system will be equipped with an electric fire water pump and a back-up diesel driven fire water pump, together with dual jockey pumps. Fire water will be reticulated, predominantly below ground, throughout the processing plant.

Potable water will be produced on site by taking a stream of raw water and treated it in multiple filters. Potable water is reticulated to the ablution facilities, buildings, and safety shower/eyewash stations throughout the Processing plant.

Gland seal water will be reticulated throughout the Processing plant to the mechanical and stuffing box seals on centrifugal pumps.

There are different systems of gland seal water for different requirements which include; the high-pressure gland seal water for the tailings disposal pumps; the normal pressure gland seal water for the slurry pumps around the leaching and CCD circuits; and the dual mechanical seal water for the SX circuit.

2.3 Mine Water (Article 16)

The hydrogeology at Kinsevere is complex due to highly deformed formations through faulting and folding. There is significant variability in permeability along structures, causing either increased inflows into the mine excavations or compartmentalisation of depressurisation effects where faults act as barriers (Mabenge, B; Chimhanda, W; van Heerden, M;, August 2017). The current dewatering system has already lowered the groundwater table by 80 m around the mining area to maintain groundwater ingress rates within an acceptable and manageable level.

Mining of the oxide, sulphide and cobalt ore at Kinsevere will continue to a depth in excess of 330 m at Central Pit (~890 m RL), 160 m at Mashi Pit (~1,075 m RL) and 105 m at Kinsevere Hill Pit (~1,115 m RL) and dewatering will have to be extended to maintain a phreatic surface of at least one bench below the pit floor to ensure a safe mining environment.

Water abstracted from the boreholes is pumped to the main raw water holding pond in the utilities area. The water is used as make-up water in the ore processing plant, gland seal water, fire water, a source for potable water, cooling water, reagents and water for heating electrolyte as and when required. The supply of groundwater is continuous and in excess of that required to meet demand.

The plant is designed to be a zero, discharge water circuit. In line with Article 19 of Schedule VIII of the 2018 DRC Mining Code, all supernatant resulting from tailings discharged to each TSF is recycled directly back into the processing plant via a small holding pond. Water from the TSFs is also lost through evaporation or stored as interstitial water within the tailings. The water balance of the combined TSFs and plant circuit is influenced by rainfall onto plant areas and the TSFs.

The Stage II Plant is equipped with a series of process water ponds and two Environmental Control ponds (one lined and one unlined) to collect runoff from the plant area.

2.3.1 Measures to Limit the Pumping of Mine Water – Article 16 (a)

Mine dewatering is limited to that required for operational and safety reasons. Dewatering currently produces on average approximately 477 L/s of groundwater, some of which is pumped to the process plant for use in processing of the ore. The excess is discharged into the Kifumashi River, via a large diameter pipeline at an authorised discharge point. Water is discharged as a constant release with periodic interruptions.

The volume of discharge water is expected to increase to a maximum of 2 190 L/s in 2025 (Table 7~~Table 7~~).

2.3.2 Water Quality – Article 16 (b)

The groundwater quality is summarised in Table 29~~Table 29~~ in Section 3.2.3.9 as part of the baseline information. In general, most groundwater monitoring points meet DRC legal/licence requirements for discharge as listed in Table 83~~Table 83~~. The water currently discharged via the discharge pipeline meets all DRC legal/licence requirements - see Table 26~~Table 26~~.

2.3.3 Volume and Daily Average Outflow of Mine Drainage Water to keep Mine Dry – Article 16 (c)

A numerical regional groundwater model was constructed by SRK (August 2017 and May 2017) and was used to simulate mine dewatering during the LOM. The estimated dewatering pumping rates during the LOM are provided below in Table 7~~Table 7~~.

Table 7: Estimated Progression of Pumping Rate

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Average (L/s)	477	747	1122	1252	1452	1452	1602	1752	1752	1752
Maximum (L/s)	596	934	1403	1565	1815	1815	2003	2190	2190	2190

2.3.4 Components of the System to Keep the Mine Dry – Article 16 (d)

The dewatering system maintains dry conditions for the mining activities and increases the stability of the pit high walls. Additional horizontal drain holes may be required in the future at Mashi Pit and Central Pit to help dewater and depressurise the pit walls. Any groundwater seeping out of these horizontal drain holes will be collected by the in-pit sumps. The current dewatering infrastructure at Kinsevere consists of:

- External and in-pit dewatering wells: The abstracted groundwater is pumped to a main pipeline placed around the perimeter of the final pit shells prior to discharging the water to the Kifumashi River (see Sections 2.3,2.5 and 2.6); and
- In-pit dewatering sumps: Water from the Mashi and Central in-pit sumps is pumped to Mashi Sediment Pond 1 (this pond is due to be decommissioned and replaced by a larger, more efficient pond to handle the increased volumes from the pit expansions). The sumps have been designed to cater for both residual groundwater ingress and direct rainfall into the pits. Design of the sedimentation ponds and water discharge is part of the surface water management system that is described in Section 5.4.3.2.

The current mining operation has a network of seven dewatering boreholes around the pits and six dewatering boreholes within the pits (see Figure 8Figure 8), together with in-pit sumps to manage the residual seepage water and direct rainfall into Mashi pit and Central Pit. Most of the boreholes in use for the dewatering of the current oxide pit will be mined out as the pit expands. New dewatering boreholes will therefore be required as proposed in Figure 8Figure 8.

A network of water level monitoring boreholes is in place in addition to the dewatering boreholes. Water levels in the dewatering boreholes and their pumped discharge are monitored every second day, while weekly monitoring of water levels is undertaken at monitoring boreholes within the vicinity of the excavations. Groundwater points within and around the mine are sampled quarterly for detailed quality analysis, as described in Section 5.4.4.2.

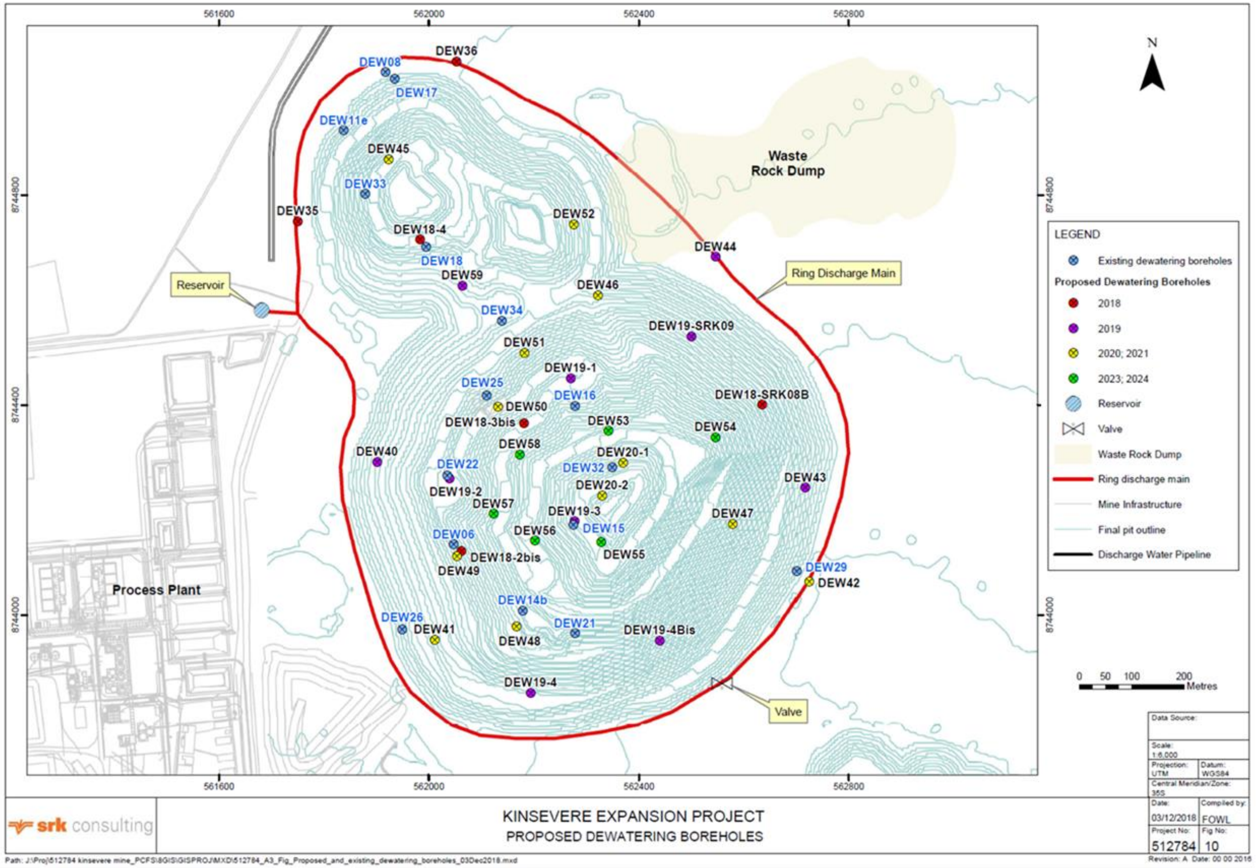


Figure 8: Existing and Proposed (by SRK) Dewatering Boreholes for the LoM Oxide and Sulphide mine from 2018 to 2027

2.3.5 Use of Mine Water – Article 16 (e)

Water abstracted from the dewatering boreholes is used to supply make-up water for the processing plant and associated infrastructure. It is used for gland seal water services, reagent mixing, solvent extraction wash, pressure filter service water, potable water make-up and process water make-up. The excess water is discharged into the Kifumashi River via a discharge pipeline. Most of the abstraction is from the dewatering boreholes drilled within and around the perimeter of the pits.

2.3.6 Location where Mine Water is Discharged – Article 16 (f)

Excess groundwater from the dewatering program is discharged into the Kifumashi River via the existing discharge pipeline located south-west of the Mashi Pit (see Figure 14~~Figure 14~~ and Figure 15~~Figure 15~~). The below ground and aboveground pipelines are monitored and have flow meters and stop valves to enable control of the flow rate of the water from the dewatering boreholes and from the pits to the discharge point into the Kifumashi River.

In order to prevent erosion, the pipe opens onto a concrete spillway at the discharge point. The water at the discharge point is constantly flowing and reeds have accumulated downstream of the discharge point over the life of the operation. The flowing water limits the risk of suitable habitat for malaria mosquitoes.

The water quality and aquatic toxicity of water being discharged is checked monthly, in line with the DRC regulatory requirements.

2.4 Ore Processing Plant (Article 17)

2.4.1 Detailed Description and Location of Plant Components

The Stage I heavy media separation (HMS) plant, electric arc furnace (EAF) and tailings storage facility (TSF1) that were established in 2005 have been decommissioned and remain on site. Although they are unlikely to be used in future operations, the HMS plant could be recommissioned if required. Sale to an off site third party is a possibility that would involve a complete removal of the existing infrastructure, cabling and groundworks.

The current ore processing circuit at Kinsevere mine was designed to process oxide copper ore. It comprises the infrastructure described below and illustrated in Figure 5~~Figure 5~~:

- A jaw crusher station that was part of the original Stage I plant built in 2005. It remains operational as a back-up to the Stage II process plant mineral sizer;
- The Stage II infrastructure for the continued development of the oxide resource, using oxide leach technology, was described in detail in the 2012 EIS. Continued development of the oxide ore resource, using oxide leaching technology, requires additional infrastructure, including the installation and operation of the following:
  - ROM bin and mineral sizer;
  - A 900 mm wide feed conveyor reporting to a single stage grinding mill;
  - Single stage rubber lined 4.5 MW SAG Mill;
  - Three acid leach tanks in series;
  - Thickener, two pin bed clarifiers and five counter current decantation washers (CCDs);
  - Solvent extraction and electro-winning plant;
  - Process water, PLS raffinate and organic ponds;
  - Reagents plant, with sulphuric acid storage;
  - Compressed air plant;

- Pipe racks, piping, cable trays and cabling;
- Tailings storage facility (TSF2); including progressive dam lifts;
- Sediment ponds and drainage systems;
- Heavy vehicle workshop, site buildings and camp; and
- Services, including control room, telecommunication, water reticulation, power distribution, accommodation, ablutions and waste management.

The oxide leach plant can process 2.6 Mt/a at a head grade of about 4.0% acid soluble Cu, resulting in the production of approximately 84,000 Cu metal tonnes per year of London Metal Exchange (LME) “A” grade copper cathode. The overall Cu recovery rate obtained from the SX/EW plant is approximately 92%.

- The increase in copper production, optimisation of the plant and the sequence in which the three deposits were mined, resulted in changes to the original Stage II project description. These changes were described in an Environmental Adjustment Plan submitted in 2015, which was approved by DPEM in 2016. A number of plant improvements have been made in order to optimise the ore processing and improve output. The changes included the following aspects:
  - A Dolomitic Shale (Black Shale) stockpile area, with one medium grade and one high grade stockpile, was constructed for copper ore feed grade control. It consists of a 300 to 600 mm deep compacted clay base surrounded by a lined drainage channel feeding into a sump;
  - Two additional “mineralised waste stockpiles” were created to the south-east of the current WRD to store low grade ore that was not feasible to process;
  - During 2014, Pond 7 (the SX event pond) showed signs of failing. The contents of the pond were removed, and two additional ponds were constructed (a raffinate pond and an organic reclaim pond). The new ponds provide additional capacity in emergency situations;
  - The groundwater discharge channel was replaced with a buried pipeline fed by a header reservoir. A concrete spillway controls erosion at the discharge point;
  - A new settling pond was constructed on top of the WRD to replace the original settling ponds. The pond has subsequently failed and is no longer in use. The revised water management infrastructure is described in Sections 5.4.3.2, 5.4.4 and 5.4.4.2; and
  - The access road from Lubumbashi was tarred in sections to decrease dust, facilitate access to the mine and reduce maintenance of vehicles and the road.

2.4.1.1 Parameters of Proposed Kinsevere Operational Upgrades (KOU) Project and Capacity of the Processing Plant – Article 17 (a)

The primary ore processing plant (sulphide inventory) will be designed to process up to 2.6 Mtpa at approximately 2.3% acid soluble Cu head grade, which will produce a concentrate that will report to the roaster with the subsequent calcine product reporting to the oxide leach plant. The resulting plant production will be increased to approximately 120 000 tons of copper cathode per annum. The ore processing plant will also include a cobalt recovery section designed to produce 13 000 tpa of cobalt hydroxide product (on a dry basis) in the form of a filter cake.

As oxide mining progresses the production of higher grade (>3% ASCu) oxide ore is declining, which is being countered by a combination of blending in lower grade oxide ore and increasing the throughput of the ore processing plant to maximise copper cathode output. Stockpiled material is selectively fed through the processing plant at an average grade of between 2.6 and 4.0% Cu (average 3.15%) to ensure that the processed head grades remain relatively constant and that cathode copper production is maintained at a relatively steady rate.

Further development of the mineral resource requires processing of primary ore (PO), and transitional ore (TMO), which forms a buffer between the primary and oxide ore types.

The following considerations apply:

- Recovery of the copper by direct acidic leaching (as is done with oxide ore in the existing process plant) of the PO and TMO achieved poor results. Several oxidation options were investigated in earlier studies, but roasting was selected for further study due to the high copper extraction efficiency and the successful commercial application of this technology;
- The new primary ore processing plant has been designed to process up to 2.6 Mtpa of sulphide and transitional ore per annum, to compensate for a reduction in grade of the 2.3 Mtpa of oxide ore that will continue to be processed. The existing process plant administration buildings and workshops will be relocated to make space for the proposed sulphide ore treatment plant. This site has been selected for the development of the new process plant due to its proximity to supporting infrastructure, design constraints of the mining ROM pad and associated stockpiles, mine pit boundary and dust reduction. Existing offices and warehouses will be relocated to the existing disturbed areas by relocating existing laydown and maintenance storage areas; and
- The proposed plant location contains the disturbed process plant area within the existing process area drainage system. This location will reduce risk to operations personnel during construction activities by allowing clear demarcation from existing process plant operations.

The general layout of the proposed KOU Project infrastructure is provided in

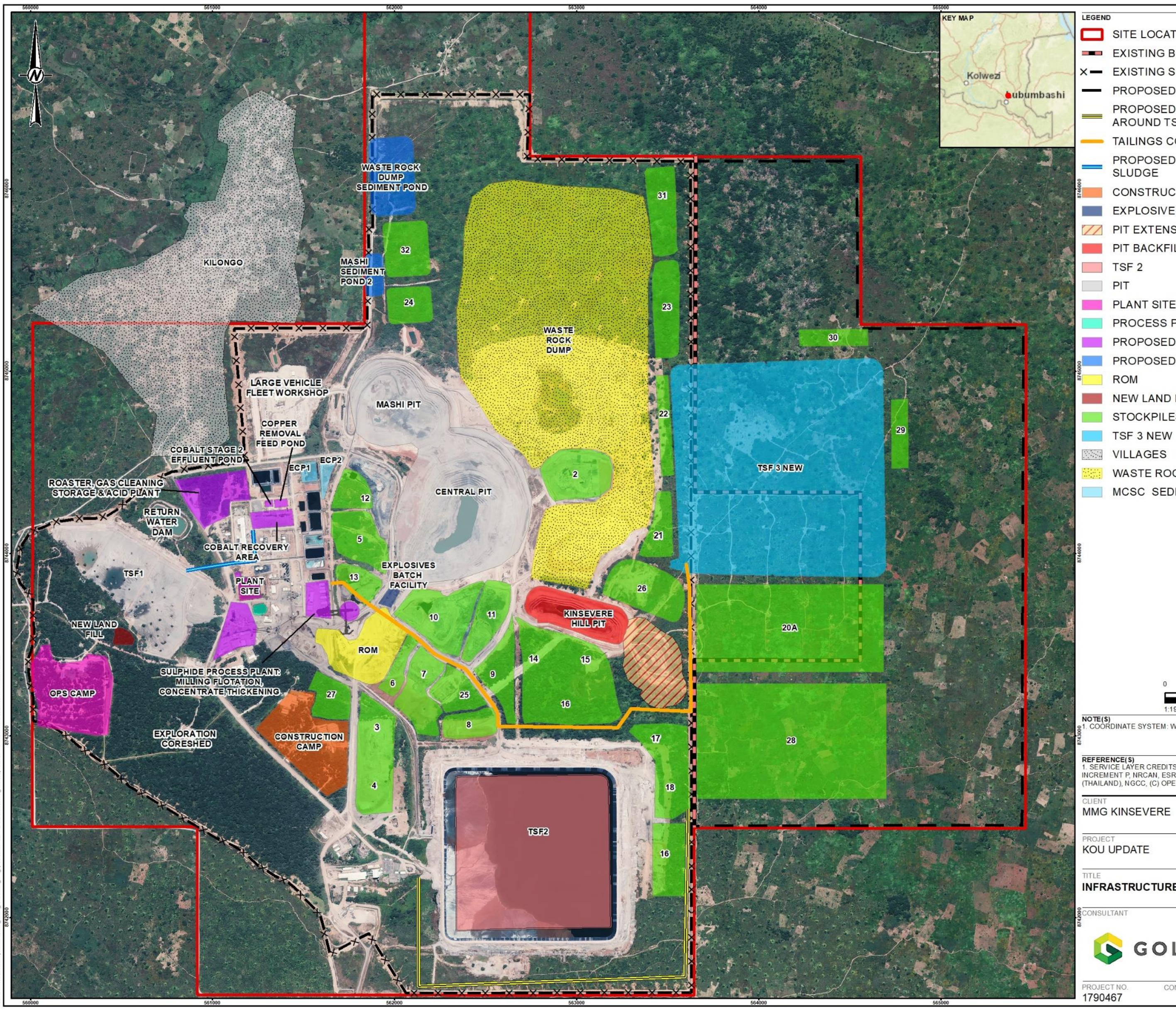


Figure 2Figure 2 and Figure 5Figure 5 and the process flow diagram is illustrated inFigure 9Figure 9.

An alternative case may be implemented where current cathode production from oxide ore is maintained (84,000 tonnes annually), but 300 000 tpa of copper concentrate is produced annually from processing up to 2.6 Mtpa of sulphide ore. The concentrate grade would be approximately 23% copper.

The roaster, wet gas cleaning and sulphuric acid plant as illustrated in Figure 9Figure 9 would not be needed in this case. An additional flotation circuit is required downstream of the oxide ore processing mill, where concentrate would report to the sulphide ore processing flotation circuit and the underflow would report to the oxide ore processing leach tanks. The cobalt recovery section in this case would remain unchanged except for potential sulphur dioxide gas/liquid or sodium metabisulfite addition in the acid leach tanks (Figure 11Figure 11) to enable reductive leaching. The concentrate would be stored in the area designated for sulphide ore processing as shown in Figure 5Figure 5.

Figure 99: Process Flow Diagram

2.4.1.2 Components of Proposed KOU

2.4.1.2.1 Kinsevere Expansion Project (Sulphide Ore Processing)

The new primary copper sulphide ore processing plant and primary ore stockpile will be located on the area vacated by the relocation of the existing workshops and administration building and will include the following:

- New run of mine (ROM) bin/hopper complete with retaining wall, bridge, supporting structures, removable grizzly bars, liners, access walkways, handrails, traffic lights, boom gate and all necessary anchoring;
- Fit for purpose jaw crushing plant;
- Coarse ore stockpile and feed conveyor;
- Reclaim apron feeders and drives, chutes complete with removable liners, mill feed conveyor, complete with weightometer, ball charge system, tramp metal detector, tramp metal magnet;
- Comminution circuit including SAG mill, cyclone feed pumps, launders, primary cyclone cluster, linear screen, pebble crushing equipment and boil box;
- Flotation circuit including flotation cells, aeration blowers, agitators and launders;
- Thickening plant including rakes and rake lifting system, launders, under and overflow pumps, reagent dosing system;
- Fluidised bed roaster plant including tuyere plate, tuyeres and refractory lining, roaster storage and feed system for concentrate and fluidising air blower, heating burner and pre-heat system, roaster cooling system, off-gas cyclones, gas ducts and dampers, roaster seal leg, calcine quench and cooling system for waste heat recovery;
- Wet sulphuric acid plant;
- Concentrate storage shed for 50 000 t of sulphide concentrate;
- Leaching circuit tie-in;
- Gas cleaning plant, including gas quencher tower, venturi scrubber, gas cooler wet electrostatic precipitators, induced draft fan, heat exchangers and air blowers/heaters;
- Pipe, conduit and cable tray supports, including all supporting structures, fasteners and ancillary equipment as required;
- Transfer tanks for process and slurry solutions, complete with pumps, pipework and pipe hangers to support the overall operation including feed/level control and flushing;
- Services infrastructure and associated equipment to support; slurry streams, sump streams, CCD wash, raw water, process water, fire protection, potable water, gland seal water, instrument air, plant air, power, communications and all necessary pipework, valves and control. A water treatment plant is being considered;
- Structural steel and supports including walkways, grid mesh, handrails complete with kick-plates and pipe work;
- Earthworks and civil (concrete) works including drainage, hard-stands, footings, foundations, piling, blast walls, retaining walls and embedded items;
- High voltage and low voltage electrical equipment, instrumentation and control systems required (integrated with existing oxide plant control system) including power reticulation, cabling, ring main units, protection relays, transformers, switch rooms and motor control centres (MCCs), drives, cable supports, instrumentation, wiring, junction boxes, marshalling panels, control panels, PLC, UPS, software, lighting, and earthing;

- Lightning protection for the facility;
- All necessary safety facilities and services including fire protection, eye wash stations, guards, acid protection and drainage;
- Containment of solutions within bunded areas, supported by sump pumps to control spills;
- Laydown area, including temporary undercover storage, ablutions and offices;
- Relocation of the existing workshops and administration buildings to the laydown area south-west of the plant non-contact water pond;
- Removal of the two existing septic tanks supporting the mechanical workshop and administration buildings, fill and compaction with structural fill;
- Electrowinning plant upgrade;
- New tailings storage facility (TSF3); and
- Upgrade of existing accommodation facilities.

The major landforms will consist of:

- Extended open pits;
- New topsoil stockpiles;
- New ore stockpiles – to complement existing stockpiles, both sulphide and oxide, sorted into various grade bins;
- New Run of Mine (ROM) pad for sulphide ore;
- New paddock style TSF3; and
- Extension of the existing waste rock dump consisting of both Non-acid Forming (NAF) and Potentially Acid Forming (PAF) material.

The proposed infrastructure and landforms are illustrated in Figure 5~~Figure 5~~. The engineering design and financial modelling of the proposed KOU project are in the feasibility phase and the information presented in this ESIA may be subject to further optimisation and improvements but is not expected to change in substance.

2.4.1.2.2 Cobalt Recovery

Cobalt will be recovered from the existing low-grade raffinate stream in the solvent exchange (SX) plant. The raffinate will be processed at a rate of 200 to 400 m^3/h to recover up to 13 ktpa of cobalt hydroxide (on a dry basis). Additional plant to convert the cobalt hydroxide to cobalt sulphate is being considered.

The cobalt recovery area will consist of the following processing circuits:

- Iron and Aluminium and removal;
- Copper removal;
- Cobalt precipitation (Stage 1 and 2); and
- Magnesium removal.

The process to recover filtered cobalt hydroxide as a wet filter cake is shown in Figure 10~~Figure 10~~.

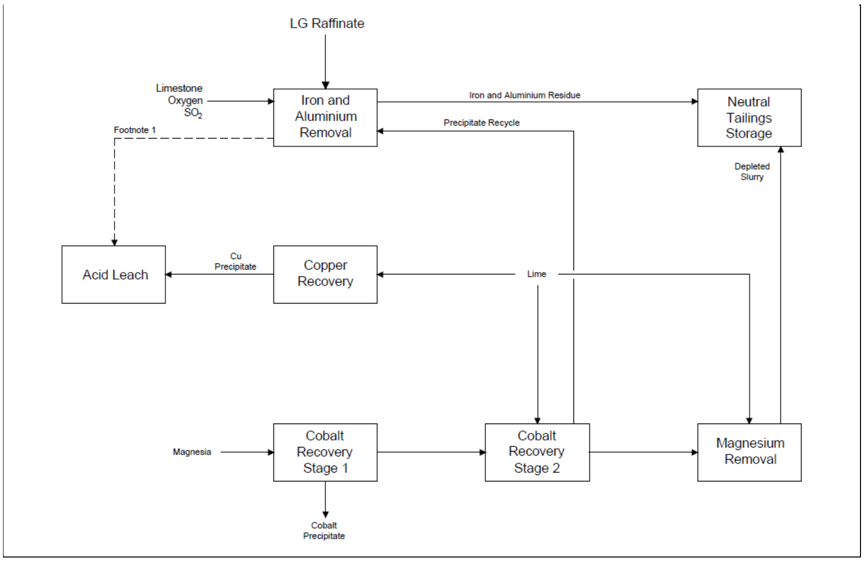


Figure 10: Block Flow Diagram for Cobalt Recovery

Kinsevere is considering integrating cobalt recovery into the existing SX/EW circuit and proposed sulphide ore processing infrastructure as shown in Figure 11~~Figure 11~~.

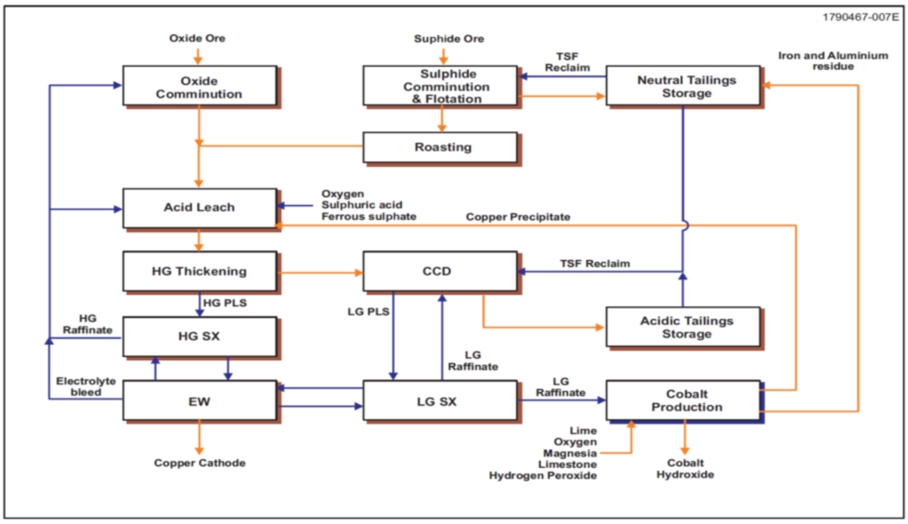


Figure 11: Cobalt Recovery Integration into Existing SX/EW Circuit and Proposed Sulphide Ore Processing Infrastructure[1]

The following are being considered for the cobalt processing option:

- **Ferrous sulphate:** There is an increase in the consumption of ferrous sulphate in the leach caused by the iron precipitated in the cobalt recovery area and directed to tailings. Some iron and aluminium residue will be recycled back to the leach circuit to reduce this;
- **Additional reagents:** The inclusion of the cobalt production area also requires the use of magnesia and possibly sodium hydroxide; and
- **Utilities:** There will be an overall increase in power requirements for operating the cobalt production area.

Any spillage from cobalt processing including iron and aluminium removal reactors and thickener/filter, copper removal circuit, and cobalt recovery circuit will be collected and returned to ECP1.

2.4.1.2.2.1 Iron and Aluminium Removal

The Iron and Aluminium Removal Circuit will receive feed solution from the low grade raffinate storage pond. This circuit is the first stage of impurity removal, where almost all the iron, and the aluminium will be removed. Most of the manganese will be removed in the Cobalt Stage 2 Precipitation Circuit.

The feed to the Iron and Aluminium Removal Circuit will be contacted with limestone slurry in mechanically agitated tanks arranged in a series-cascade-overflow configuration. The iron and aluminium removal reactors will be agitated, and each will cascade down to the next reactor. Each reactor can be by-passed to facilitate maintenance activities with little adverse effect upon plant throughput. A partial recycle stream from the iron and aluminium removal thickener underflow will be used for particle seeding. Limestone will be added for pH control and oxygen and will be added to oxidise iron, thus forming precipitates for removal.

The off-gas from the covered tanks (predominantly carbon dioxide from the acid neutralisation tanks and unutilised oxygen) will be vented to atmosphere. The acid neutralisation process is highly susceptible to scale (gypsum) formation and regular equipment de-scaling will be required.

The Iron and Aluminium Removal Circuit discharge slurry will be pumped to an iron and aluminium removal thickener. Flocculant solution will be added directly to the thickener feed launder and feed well to assist with the settling of fine solid particles. Slurry will be delivered to a filter feed tank. Thickener overflow liquor will gravitate to a feed tank, from where it will be pumped to the Copper Removal Circuit.

Slurry from the filter feed tank will be pumped to the iron and aluminium filter. The filtrate will be pumped back to the iron and aluminium removal thickener. The filter cake will be washed with process water prior to being discharged into the repulping tank where the cake will be mixed with raw water. The resulting slurry will be pumped to the proposed TSF 3 or existing TSF2. Options are being investigated to potentially recycle iron and aluminium residue back to the leach circuit to recover iron used for ferric leaching.

2.4.1.2.2.2 Copper Removal

The Copper Removal Circuit (second stage impurity removal) will remove soluble copper by selective precipitation with lime slurry. This circuit will receive feed liquor from the Iron and Aluminium Removal Circuit in mechanically agitated tanks arranged in a series-cascade-overflow configuration. Each tank can be by-passed to facilitate maintenance activities with little adverse effect upon plant throughput. Reactors allowing for copper removal will be agitated to ensure efficient mixing for precipitation reactions.

Milk of lime slurry will be added to the reactors to precipitate copper and any residual iron. The resulting slurry will be transferred to a thickener where flocculant solution will be added to assist with the settling of

[1] There is the option for a portion of the iron and aluminium residue to be routed to the Acid Leach to recover contained iron and copper.

fine solid particles. The thickened slurry will be returned to the oxide leach circuit distribution box, recovering precipitated copper.

Overflow liquor from the thickener slurry will be returned to the Cobalt Recovery Circuit.

Options are also being reviewed to combine the Iron and Aluminium and Copper removal circuits and to either partially or fully recycle the residue back to the leach circuit.

2.4.1.2.2.3 Cobalt Recovery Stage 1

The Cobalt Recovery Stage 1 Circuit will receive feed liquor from the overflow of the copper removal circuit thickener. The liquor will be fed into mechanically agitated tanks. The Cobalt Recovery Stage 1 reactors will be arranged in a series cascade overflow configuration.

Milk of Magnesia will be added to the reactors to initiate the precipitation of approximately 70% of the cobalt in solution as cobalt hydroxide. The slurry will flow from the reactors to a thickener where flocculant will be added to the thickener feed to assist with the settling of fine solid particles. The thickener overflow liquor will then be pumped to the Cobalt Recovery Stage 2 Circuit. The thickened slurry will be returned to a mechanically agitated filter feed tank.

Cobalt hydroxide slurry from the filter feed tank will be filtered after which the filtrate will flow back to the Cobalt Recovery Stage 1 thickener. The filter cake will be discharged and fed to a spin flash dryer and dried product will be bagged for sale.

2.4.1.2.2.4 Cobalt Recovery Stage 2

The Cobalt Recovery Stage 2 Circuit will receive feed liquor from the overflow of the Cobalt Recovery Stage 1 thickener. The liquor will be fed into mechanically agitated reactors arranged in a series-cascade-overflow configuration.

Milk of lime slurry will be added to the reactors to recover the remaining soluble cobalt and precipitate most of the manganese. The slurry flows from the reactors to a thickener where flocculant solution is added to assist with the settling of fine solid particles. The thickened slurry will be pumped back to the reactors in the Iron and Aluminium Removal Circuit to recover this low-grade cobalt. Most of the thickener overflow liquor will be used as process water in the plant and approximately 50 m3/h may be pumped to a Magnesium Removal Circuit. It is expected that the magnesium circuit will not be required for the first few years of operation.

2.4.1.2.2.5 Magnesium Removal

About three years after the cobalt recovery plant comes into operation, as mentioned in section 0 of this report, process water will be pumped from a tank to a magnesium removal circuit at an average (or nominal) flowrate of approximately 6.4 m^3/hour. The design feed water flow is 50 m^3/h and the circuit is likely to be operated intermittently at this design flow rate rather than the lower nominal flowrate; with it being turned on and off as required.

The nominal flowrate will produce about 6.9m^3/hr of a slurry with a solids content of approximately 3.5%. Table 8 below provides the estimated composition of the solids and the supernatant liquid, as derived from mass balance simulations.

The liquor will be fed into the first of three mechanically agitated reactors arranged in a series-cascade-overflow configuration. Reactors can be by-passed to facilitate maintenance activities, with little adverse effect upon plant throughput.

Milk of lime slurry will be added to the magnesium removal circuit to remove the remaining soluble magnesium. Neutralised liquor will be pumped to the counter-current decantation (CCD) circuit as wash solution.

Table 8: Expected composition of effluent feeding magnesium removal circuit

Component	Units	Value
Feed Mg tenor	g/L	4
Feed Ca tenor	g/L	0.14
Feed Mn tenor	g/L	0.24
Feed Co tenor	mg/L	26
Feed F tenor	mg/L	7
Feed Cl tenor	mg/L	21

Co-disposal of this effluent with tailings from the copper flotation plant onto TSF3 was considered and discarded, because the sludge settles slowly, leading to concerns that it could disrupt the settling and consolidation of the tailings particles. Also, the magnesium readily solubilises back into solution at close to neutral pH, which is expected in TSF3.

As mentioned in section 4.3.1.5.2, TSF1 tailings will be reprocessed through the oxide circuit of the processing plant to recover residual copper. Drilling, sampling and analysis of the TSF1 material confirmed it to be low risk non acid forming (NAF) material.

The TSF1 tailings material will be recovered by front end loader and trucked to the oxide processing plant. After reprocessing, the resulting tailings will be pumped to TSF2 for disposal as per the current practice for oxide plant tailings.

The volume of TSF1 is substantially more than the total volume of slurry to be deposited over the remaining life of the mine. When enough TSF1 material has been removed to enable deposition of the slurry to commence, the condition of the clay liner in that area, as well as side walls and embankments, will be determined by inspection and, if necessary, these components will be refurbished.

After adding flocculant, the slurry will be deposited within the vacated area of TSF1 at a nominal rate of about 6.9 m^3/h and allowed to settle. The supernatant water will be retained in the TSF1 dam, and its pH will be monitored. If required, it will be neutralised and transferred to a sediment pond or discharged to the environment.

The solids, consisting largely of magnesium hydroxide and gypsum, are expected to settle in the rebuilt dam to an ultimate concentration of approximately 40%w/w solids. The dam will be designed to retain 10 years' accumulation of the settled slurry plus 30 days retention of supernatant liquor, to allow maturation and calcium desaturation from the liquor. The required dam volume, including an allowance for 10% free board, is estimated to be 48,500 m^3.

At the end of the life of the mine, as much of the supernatant as practicable will be removed for impoundment in one of the sediment ponds and the disposed Mg-rich solids will be capped in a similar manner as described in section 5.5.7 of this report and illustrated in Figure 79~~Figure 79~~.

2.4.1.2.2.6 Reagent Handling

Limestone will be required for the control of the acid concentration/pH in the iron and aluminium removal reactors. Hydrated lime will be required for the control of the acid concentration/pH in Copper Removal, Cobalt Recovery Stage 2 and Magnesium Removal circuits. Magnesia will be required for the precipitation of cobalt in the first stage Cobalt Recovery Circuit.

In the proposed handling system, limestone and hydrated lime will be delivered in bulk. Limestone may be delivered as crushed rock and milled on site. Magnesia will be delivered in 1 tonne bulk bags.

Finely ground limestone slurry will be pumped to a larger limestone slurry tank from which the reagent will be distributed to the required process areas via a ring main.

Kinsevere is also considering the installation of a limestone milling circuit to produce finely ground limestone as a reagent. The milled material will be cyclone separated to produce a ground limestone product.

Magnesia will be discharged via a bag breaker into a magnesia make-up tank where process water will be added to produce magnesia slurry. The slurry will be pumped to a larger magnesia slurry tank from which the reagent will be distributed to the required process areas.

2.4.1.2.2.7 Modifications to Acid Leach

It is likely that the existing leach tank agitators and electrical drives will be increased in size to manage the slurry mixing application with access gas holdup. SO_2 or Sodium metabisulfite is potentially required for the reductive leaching of cobalt minerals in the acid leach tanks. The addition of gaseous SO_2 will necessitate installation of the tank lids and off-gas scrubber to the existing leach tanks.

2.4.1.2.2.8 Bolt-on Addition to Produce Cobalt Sulphate

MMG Kinsevere is considering adding a 'bolt-on' plant to the above to convert the cobalt hydroxide product to cobalt sulphate.

The cobalt hydroxide product would be redissolved in only a few m^3/h of fairly concentrated sulphuric acid solution in agitated atmospheric tanks, making this a small circuit. After re-dissolution the concentrated cobalt sulphate solution will be treated in a SX circuit using D2EPHA reagent to remove copper, manganese, zinc and any traces of remaining ferric iron not removed in the Iron and Aluminium Removal Circuit. A small bleed of organic from this SX circuit may be needed to be stripped with hydrochloric acid to remove ferric iron. Raffinate from this circuit will advance to a second SX circuit which will utilise Cyanex 272 reagent to extract cobalt, thus separating it from nickel and further concentrating it into a purified stream suitable for crystallisation of the cobalt sulphate heptahydrate product in a crystalliser. The product will be bagged or drummed for sale.

Aqueous sodium hydroxide (caustic solution) will be required for pH control in both of the SX circuits. This may require the nickel raffinate from the D2EPHA to be neutralised and sent to TSF3 to avoid the sodium reporting back to the oxide circuit liquor and causing contamination, if it were sent to TSF2. Sulphuric acid will be required for the re-dissolution step and for stripping metals from the organic in the two SX circuits. Some sulphuric acid will be recovered from the crystalliser and recycled to SX.

2.4.1.2.2.9 Proposed Location of the Cobalt Processing Plant

The proposed cobalt plant and associated infrastructure will be located within the footprint of the existing processing plant area on site – see Figure 5~~Figure 5~~.

2.4.1.2.2.10 Product Drying

A spin flash dryer is being considered for hydroxide product drying down to a target moisture content of between 3 and 10%. The unit will be either electric or diesel powered, (yet to be finalised) and some trace emissions (mainly dust) may be released downstream of a baghouse.

2.4.1.2.3 Vat Leach

MMG Kinsevere mine is also considering the addition of a minor vat leaching system to process low grade ore from certain existing stockpiles. The proposed Fluidised Leach Oxidation Reactor (FleXoR) system has been developed to treat low-grade material at high volume and in a cost-effective manner. The system will be designed to treat three million tons of low, grade ore, containing 1.0 - 1.5% acid soluble copper, at a rate of 1.3 Mtpa, and is expected to achieve a Copper recovery of 93% or higher.

The low-grade ore will be crushed to <2 mm by a mineral sizer and impact crusher before transfer to the FleXoR process with raffinate. The FleXoR system will comprise ten double-lined ponds with a footprint of about 220 m × 100 m. The first pond is the raffinate pond containing make-up, material transfer and recirculation wash solution; the subsequent few ponds are leach ponds where most of the copper extraction will occur with controlled addition of sulphuric acid. Washing of the leached solids will take place in the final few ponds – see Figure 12~~Figure 12~~.

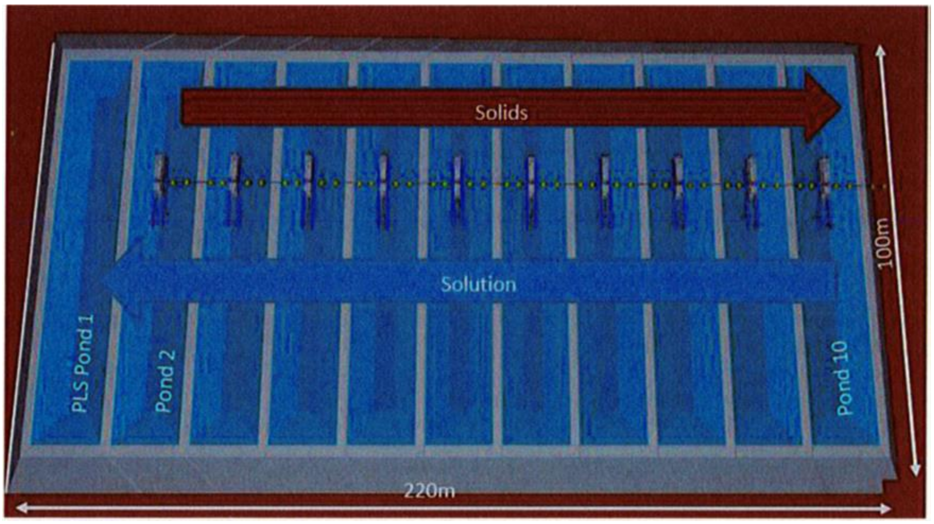


Figure 12: FleXoR Vat Leaching System

After about 48 hours, the leached material is transferred by dredges from pond to pond subjected to counter current washing with the recirculation wash solution to minimise the copper content in the solution reporting to the tailings dam.

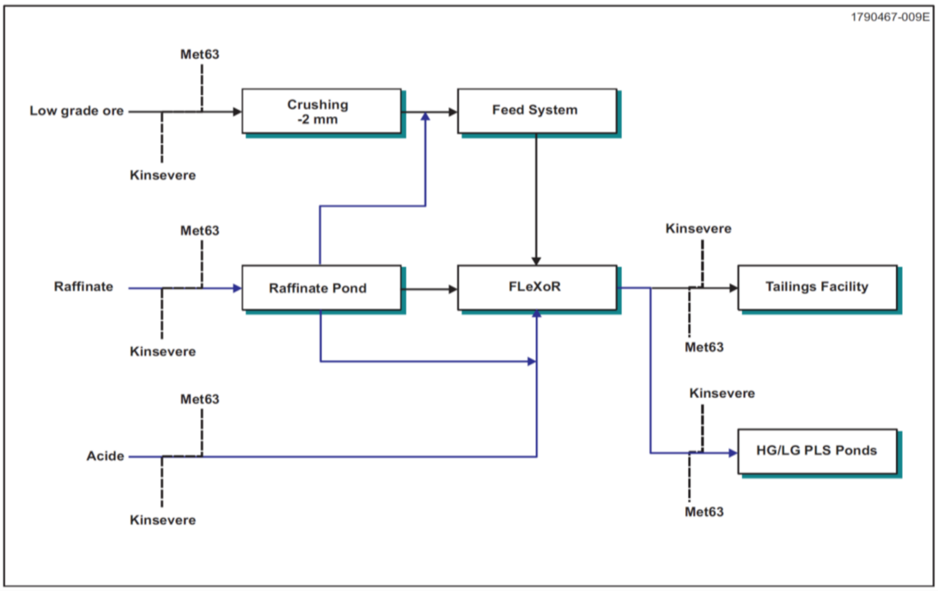


Figure 13: Flow Diagram for FleXoR Vat Leaching Process

The solids in each pond are suspended/fluidised to optimise acid contact and the solution is circulated throughout the pond by means of fluidisation piping located in the base of the pond above the pond liner. The solution containing leached copper is pumped to the existing low/high grade pregnant leach solution (PLS) ponds for further processing in the existing SX/EW circuits and the low grade raffinate is returned to the FleXoR process for solution make-up, material transfer and washing of the acid leached material.

2.4.1.3 Quantitative Routing of the Solid, Liquid and Gaseous Phases – Article 17 (b)

The flow of solids and liquids during the processing of the ore is shown in Figure 9~~Figure 9~~ to Figure 13~~Figure 13~~ as well as Figure 19~~Figure 19~~.

The fluidised bed roaster plant will produce sulphur dioxide (SO_2). The plant will be equipped with a gas cleaning plant comprising a gas quencher tower, venturi scrubber, gas cooler, wet electrostatic precipitators, induced draft fan, heat exchangers and air blowers/heaters. All residual impurities in the roaster gas will be removed in the gas cleaning plant prior to the wet sulphuric acid plant and will not report to the stack. The plant design will meet the relevant statutory regulations for atmospheric emissions and ambient air quality standards.

If at times the sulphur content of the copper concentrate is too low to maintain isothermal operation, sulphur will be added at an appropriate rate to maintain the required sulphur content.

The cleaned gas stream will be routed to the wet sulphuric acid plant, where the sulphur dioxide will be oxidised to sulphur trioxide (SO_3) to produce sulphuric acid via the contact process. The off gas from the sulphuric acid plant will not contain any solid particulate matter, only mechanically entrained acid droplets of micron/sub-micron size, at concentrations typically below 25 mg/Nm^3 expressed as sulphur trioxide, to avoid a visible stack plume and damage from acid droplet fallout in the vicinity of the stack. The acid plant vendor will be required to guarantee the licensed emission. The off gas from the covered tanks in the cobalt recovery section (predominantly unutilised oxygen and carbon dioxide from the acid neutralisation tanks) will be vented to atmosphere.

2.4.1.3.1 Operational Phase

Dispersion simulations were undertaken for a sulphide ore throughput of 2.6 Mtpa and the sulphuric acid plant parameters listed in Table 65.

2.4.2 Chemicals, Hydrocarbons and Lubricants – Article 17 (c)

The chemicals, hydrocarbons and lubricants used in the production of copper cathode and cobalt hydroxide products are described below. The storage facilities, reagent inventory and pollution prevention measures as required in terms of Article 85 are described in Sections 5.5.10, 5.5.11 and 5.8.4.

2.4.2.1 Sulphuric Acid

Sulphuric acid is used in the leaching circuit as a lixiviant to dissolve copper and cobalt. The acid consumption is based on the requirement to dissolve the desired metal and also the gangue material that will dissolve in sulphuric acid conditions. Concentrated sulphuric acid, of greater than 98% (w/w) is imported and transported to site in road tankers.

2.4.2.2 Sulphur

Sulphur will be added to the roaster feed at times when the sulphur content of the ore is too low to maintain isothermal operating conditions. The sulphur will be trucked to the site and stored under cover.

2.4.2.3 Limestone and Lime

Limestone will be delivered to site in 1-tonne bags, discharged via a bag breaker and possibly milled on site prior to feeding into a limestone make-up tank where process water will be added to produce limestone slurry. The slurry will be pumped to a larger limestone slurry tank which will distribute the reagent to the required process areas via a ring main.

Similarly to limestone, lime will be trucked to site in bulk bags and stored in the lime storage facility. Milk of lime slurry will be used in the cobalt recovery circuit to precipitate residual iron and manganese and to remove magnesium. It will also be used in the treatment of raw water.

2.4.2.4 Flocculant

Flocculant will be used at the Iron and Aluminium Removal Circuit in the cobalt recovery plant and elsewhere. The flocculant solution will be added directly to the thickener feed launder and feed well to accelerate the settling of fine solid particles.

2.4.2.5 Extractant and Diluent

An organic extractant and diluent (for viscosity control) will be used to extract metal from pregnant leach solution in the solvent extraction areas.

2.4.2.6 Magnesia

Magnesia (MgO) will be used in cobalt precipitation to increase pH to 8.3 during the precipitation process. Magnesia is preferred to lime as by-product magnesium sulphate is soluble and does not contaminate the product.

Magnesia will be delivered to site in 1-tonne bags and discharged via a bag breaker into a make-up tank where process water will be added to produce magnesia slurry. The slurry will be pumped to a larger magnesia slurry tank, from which the reagent will be distributed to the required process areas.

2.4.2.7 Ferrous Sulphate

Ferrous sulphate is used as required in the electro-winning plant to control the iron to manganese ratio and to reduce manganese corrosion of the lead anodes.

2.4.2.8 Interfroth 50

A proprietary blend of alcohols and esters that will be used as a frother in the sulphide copper flotation plant.

2.4.2.9 Kerosene

Will be used as a froth stabiliser in the sulphide copper flotation plant.

2.4.2.10 Dextrin

Will be used as a depressant for unwanted minerals (e.g. pyrite) during froth flotation.

2.4.2.11 Sodium Silicate

Used in the gas cleaning circuit at the sulphuric acid plant.

2.4.2.12 Hydrogen Peroxide

Will be used in the cobalt recovery circuit, together with oxygen, to oxidise Fe and Mn, which will be precipitated and removed.

2.4.2.13 Sodium Metabisulfite

Sodium metabisulfite is potentially required for the reductive leaching of cobalt minerals in the acid leach tanks.

Sodium metabisulfite will be delivered to site in 1-tonne bags and discharged via a bag breaker into a make-up tank where process water will be added to produce sodium metabisulfite slurry. The slurry will be pumped to a larger slurry tank from which the reagent will be distributed to the required process areas.

2.4.2.14 Diesel Fuel

Diesel is required primarily for the mining fleet and, to a lesser extent, on-site diesel generation of electrical power for standby emergency power when SNEL power is not available. The demand for diesel is approximately 700,000 litres per month. On-site fuel storage capacity comprises of 2 × 240,000 litre as well as 5 × 22,000 litre tanks in order to ensure a reliable supply.

With the introduction of the new fleet for primary sulphide ore, consumption of diesel will be approximately 3.6 million litres per month with a total diesel storage capacity of approximately 900,000 litres.

Given the large volume of diesel that will be stored on site for the power generation plant (minimum 1.17 million litres), the following technical considerations have been included for the diesel storage area:

- Self-bunded diesel tanks to UL 142 certification, or certified equivalent;
- Fire protection to NFPA 30 certification;
- C/S piping reticulation in accordance with RTR SC8 Piping System;
- Fuel Management System to be iPETRO or equivalent, with web/cloud interface;
- Operation team set up for a 24/24 7/7 operation, including on-site technical support;
- Vendor will have a planned maintenance schedule against which Metalkol can audit;
- Vendor will have a bulk fuel offloading procedure against which Metalkol can audit;
- Main storage facility will be easily expandable, with minimal operational impact; and
- Fuel supplied meets the Aggreko specification.

2.4.2.15 Annual Consumption of Chemicals – Article 17 (d)

The chemicals used at Kinsevere and their average annual consumption are listed in Table 9~~Table 9~~.

Sulphuric acid consumption is expected to increase for the remaining period of oxide processing, i.e. until about 2023. The use of sulphur will commence when the sulphide roaster comes into operation, by about 2023. As mentioned in section 2.4.1.3, it will be added to the roaster feed when the sulphur content of the ore is too low to maintain isothermal operation. All other current reagents are expected to continue within a similar range of consumption (±50%). New reagents such as magnesia may be tested to improve the safety, volume or cost of the operation and may require additional dosing systems and storage to be commissioned to facilitate their delivery.

The existing reagent storage building will be extended to accommodate the expected yearly consumption rates.

Table 9: Reagents and Consumables to be Stored on Site for Processing (Oxide/Sulphide Ores and Cobalt Recovery)

Reagent	Approximate Annual Usage in Tonnes per Annum
Sulphuric acid	80 000
Sulphur	18 000
Kerosene (froth stabiliser)	1 000
InterFroth IF50	2 200
Dextrin	1 400
Flocculant	385
Potassium amyl xanthate (PAX)	1 800
Ferrous sulphate	27 600
Sodium silicate	50
Limestone	64 800
Lime	~51 600 hydrated or 39 100 quicklime

Reagent	Approximate Annual Usage in Tonnes per Annum
Magnesia	2,900
Hydrogen peroxide	1,500
Diluent (Shellsol)	1,376
Extractant (OPT 5510)	330
Sodium metabisulfite	22,000

2.4.2.16 Storing of Chemicals, Hydrocarbons and Lubricants Article 17 (e)

A lightning safe fuelling facility has been established in the workshop area. This includes two fuel tanks of 120 m^3 capacity each. The facility is detached from the workshop and is self-contained with its own bunding (reinforced concrete slab and 1 m high wall), oil separator and hydrocarbon management system. The facility footprint (350 m × 190 m) is larger than the storage system footprint in order to provide flexibility for the safe movement of equipment in the area.

Storage facilities for all chemicals and lubricants, spillages of which could cause pollution of soil, surface runoff and groundwater, are likewise bunded. Such facilities are located close the plant areas where these materials are used.

2.4.2.17 Cyanide Report – Article 17 (f)

Cyanide is not used at Kinsevere.

2.4.2.18 Preventive and Emergency Measures – Article 17 (g)

Site-specific measures and procedures are in place for storage and handling of the chemicals discussed in the above parts of Section 0. These measures and procedures include the following:

- Adequate, properly designed and constructed storage facilities with bunds, barriers, sumps etc. for all materials, taking into consideration also their Safety Data Sheets (SDS);
- Adequate training for persons involved in materials handling and storage;
- Keeping appropriate spillage clean-up kits available at all handling and storage areas; and
- Emergency Response and Contingency plans for each material stored on site.

2.5 Final Effluent (Article 18)

The DRC Mining Code defines final effluent as all water discharged by the mining operations into the receiving environment. Kinsevere does not produce any waste discharge and no waste discharge is envisaged during sulphide and cobalt mining and processing, but other discharges are required.

Water from dewatering boreholes in excess of that required as makeup water is discharged into the Kifumashi River directly, via an underground pipeline. Water from the pit sumps (rainfall and groundwater seepage into the pits) is pumped to Mashi Sediment Pond 2 and the clear supernatant is also discharged to the Kifumashi River via the pipeline. The mine proposes to also route rainfall collected in the security trench system via Mashi Sediment Pond 2 for discharge to the Kifumashi River.

The pipeline ends at natural ground level at the edge of the floodplain of the Kifumashi River, approximately 300 m from the centre of the watercourse.

Water then passes over erosion control structures before reaching the river. The pipeline runs at an angle of approximately 60° to the flow of the river, however, does not extend all the way to the river. Table 7~~Table 7~~ in Section 2.3.3 shows the estimated progression of dewatering.

Additional pipelines will be required that will run within the existing pipeline corridor to the discharge point – one for dewatering boreholes and two for the supernatant from Mashi Sediment Pond 2.

The existing pipeline may be replaced for maintenance or operational reasons, which may require a different pipe diameter to the one currently installed (715 mm).

All runoff will be managed in terms of the updated Surface Water Management Plan described in Section 5.4.3.2. Non-contaminated runoff will bypass the mining areas and will not enter the site water system. Water from other infrastructure areas will be tested for compliance to DRC legal limits prior to discharge. Other waste streams, such as process pond sludge, are managed on site.

Water quality monitoring takes place at the point of discharge in line with legal requirements. Figure 14~~Figure 14~~ below shows the discharge pipe and Figure 15~~Figure 15~~ illustrates the discharge point in relation to aquatic bio-monitoring, surface water, groundwater and potable water monitoring points. The coordinates of the discharge point are: 11°20'17.62" S; 27°34'00.63" E.

Figure 14: Photograph of End of Current Discharge Pipeline

Figure 15: Discharge Point SWK04 in Relation to Monitoring Points

2.5.1 Non-mineral Waste

Non-mineral waste generated at Kinsevere includes hazardous waste, recyclable, organic and solid inert (non-contaminated and contaminated) waste. Such waste is managed in accordance with the Kinsevere Non-Mineral Waste Management Plan (October 2016). Where possible, the principles of the waste hierarchy are applied.

Provision is made for disposal of waste material on site due to the distance and lack of engineered waste disposal infrastructure and facilities in Lubumbashi. As such facilities become available, off-site disposal or removal by contractors is implemented. Kami Metal has been appointed to manage disposal and recycling of Kinsevere's waste in Lubumbashi. The following waste management practices are applicable:

- Reduction of waste: potable water is supplied via water coolers and employees are issued with reusable water containers to refill rather than water in disposable bottles;
- MMG has a contract in place with two contractors for the removal of scrap metal, drums, waste oil, etc.;
- Batteries are currently stored in the environmental yard, but a contract will be established for their removal and disposal;
- Uncontaminated paper, steel and wood is made available for third parties for their beneficial use;
- Waste that cannot be recycled, reused or collected by contractors is separated into general waste and hazardous waste;
- Large tyres from earthmoving equipment are used in the mining operations as beacons, for demarcation of roads and high-risk areas. Rock or soil is placed within the demarcation tyres to control water ponding and mosquito breeding sites. Excess tyres are kept on site, as a contractor has not yet been appointed to remove tyres from site; and
- Domestic wastes are buried on site to control the human health risk of exposure.

Waste is separated in the environmental yard as indicated in Figure 16~~Figure 16~~.

The current landfill has reached capacity and a new landfill site is proposed. It is currently in the design phase, but it will be located close to the south-western border of TSF1, as indicated in Figure 5~~Figure 5~~. The site layout for the proposed new landfill is shown on Figure 17~~Figure 17~~ and the proposed design of the landfill is shown on Figure 18~~Figure 18~~.

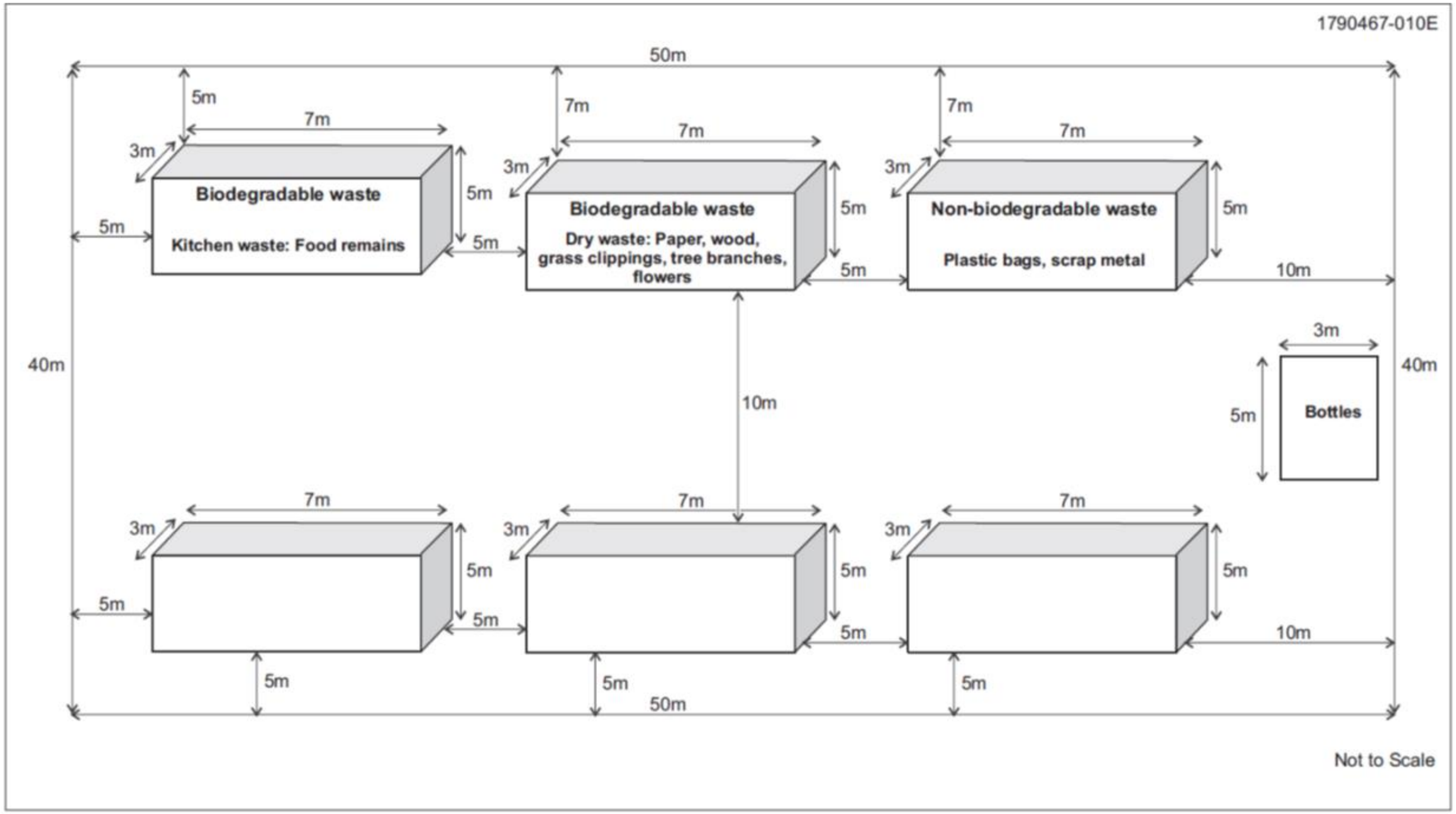


Figure 16: Layout of Environmental Yard

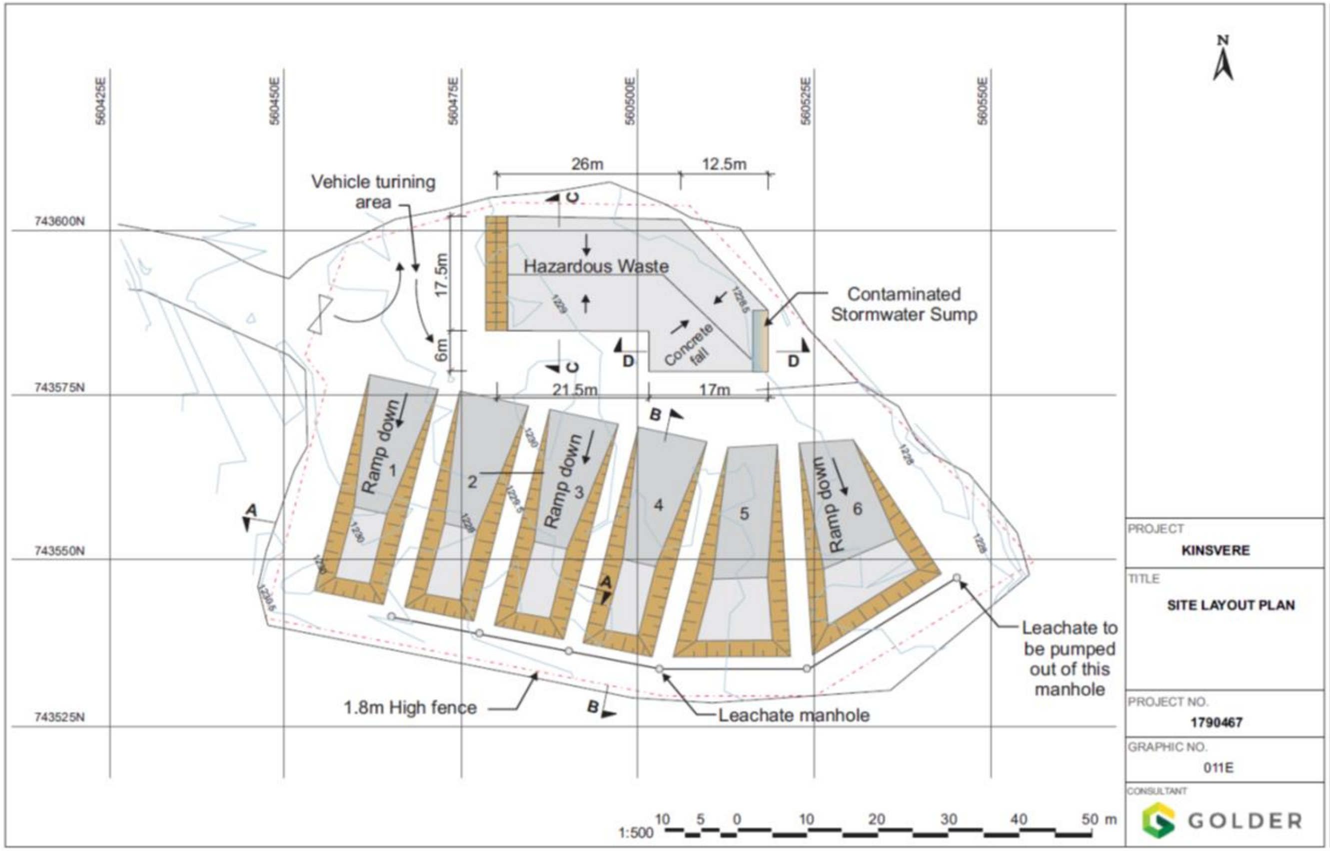


Figure 17: New Landfill Site Layout Plan

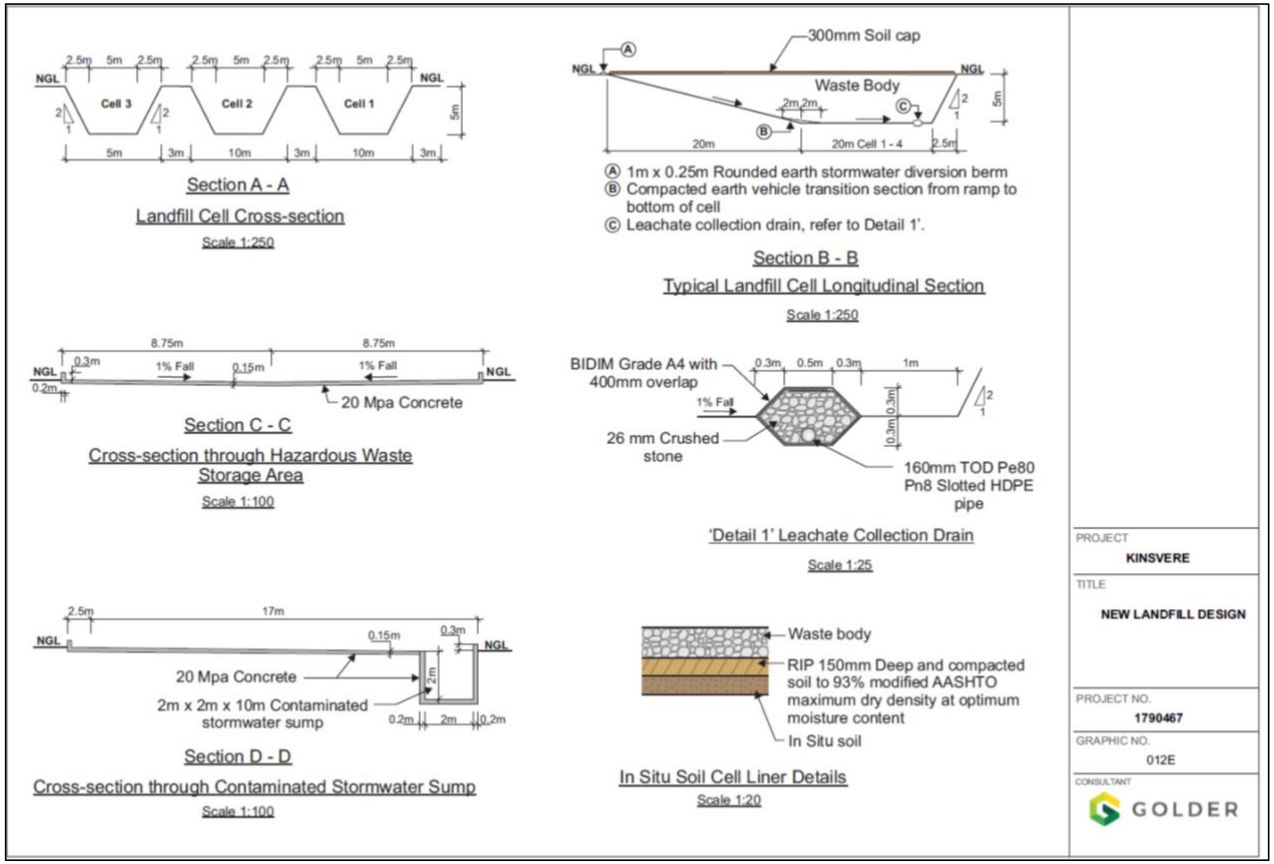


Figure 18: New Landfill Design

2.6 Water Use (Article 19)

2.6.1 Water Balance – Article 19 (a)

The Kinsevere mining area is drained by the Kifumashi River and its tributaries. There are no major drainage lines within the mining area. The Surface Water Management Plan (Anon;, April 2018) is intended to protect the Kifumashi River and its tributaries from contaminated runoff.

The Kinsevere mine's water balance, updated to reflect the proposed KOU Project and showing the activities that use water, and the sources of fresh water and recirculated water supplies is set out in Figure 19~~Figure 19~~. Cut-off berms and channels are in place to divert non-contaminated water away from the mining and processing areas, thereby minimising the volume of contaminated water.

2.6.2 Sources of Water Supply – Article 19 (b & c)

Potable water is supplied by boreholes and is treated before use. An estimate of 50 ℓ per person per day is used.

The process plant is in a closed loop with TSF2 and receives approximately 70% of the water that is sent to TSF2 (about 20 500 m^3/d) back as decanted recycled water. Some water is used to control the density of the tailings pumped to TSF2. The remainder goes into the circuit for re-use.

When decant water is not available, make-up water is supplied to the processing plant by the dewatering boreholes, via the raw water pond, at a rate of about 60 m^3/hour in the wet season), and 120 m^3/hour in the dry season. The expected water demands once the proposed KOU is in operation are provided in Table 10~~Table 10~~.

Table 10: Summary of Future Water Demands at Kinsevere

Demand	Source	Daily average (m^3/d)	Annual average (m^3/a)
Process water – makeup	Groundwater	5 400	1 971 000
Process water – recycled	Recycled	20 500	7 482 500
Process water (total)	Combination groundwater and recycled water	25 900	9 453 500
Raw water (camp, dust and fire suppression)	Groundwater	270	98 550

2.6.3 Uncontaminated Runoff entering the Water Management System – Article 19 (d)

The surface water management system was designed and constructed to protect the Kifumashi River and its tributaries from contaminated runoff. Cut-off berms and channels are in place to divert uncontaminated rainfall runoff away from the mining and processing areas and towards the Kifumashi River, thereby minimising the volume of contaminated water present on the site.

Runoff from some areas within PE528 and, in future PE7274, that is chemically clean enough for discharge, but contains sediment, is directed to sediment settling ponds, from which the clear supernatant is discharged to the environment. In future, uncontaminated runoff that collects in the security trench system will be pumped to the Mashi sediment pond 2 and the clear supernatant will be released to the environment.

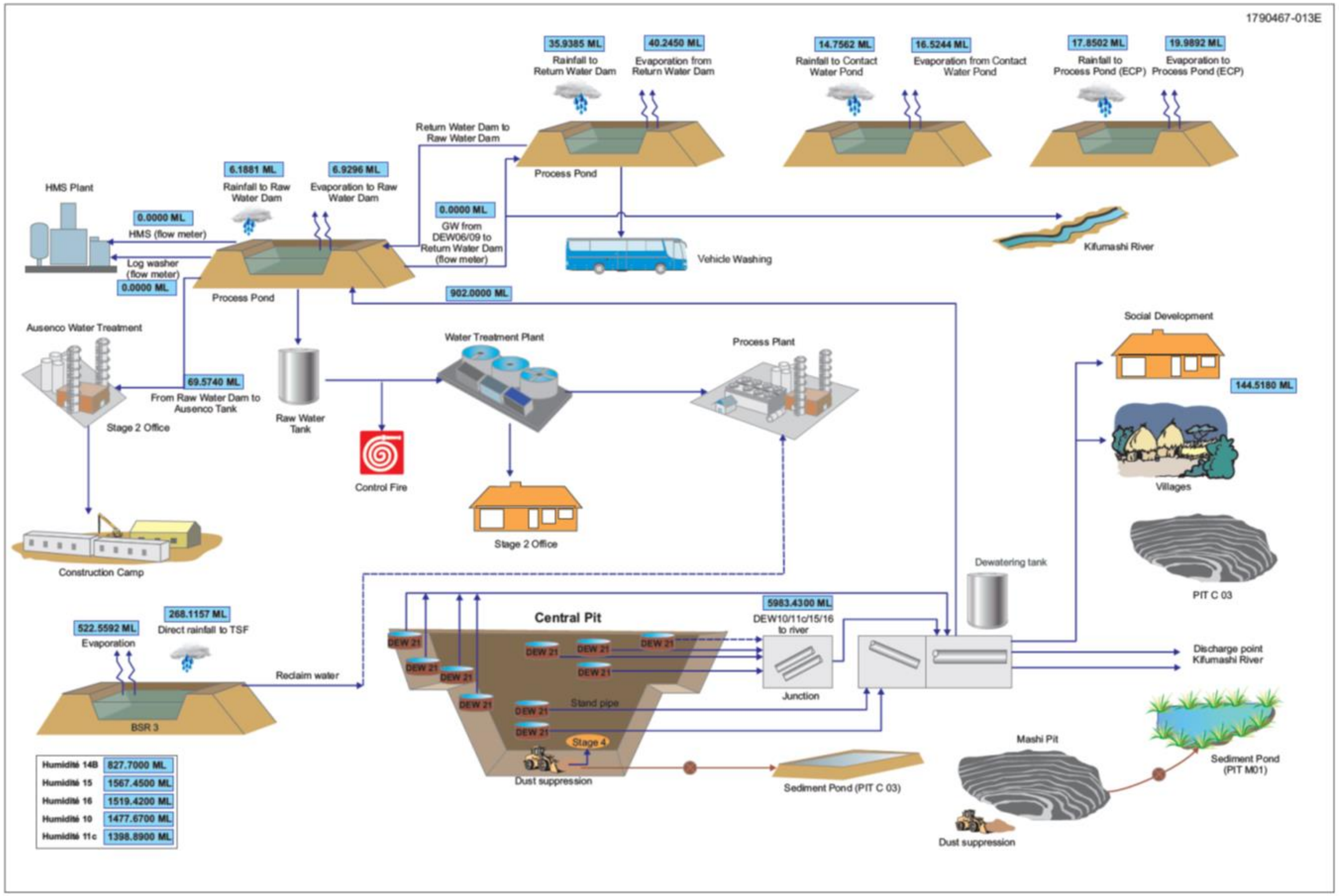


Figure 19: Site Water Balance

2.6.4 Measures to Reduce Use of Fresh Water

Process water is sourced from pit dewatering, internally circulated water, and make up water from the raw water pond, which has an available capacity of approximately 300 m^3. As described in Section 2.3, water from dewatering boreholes in excess of that required as makeup water, is discharged into the Kifumashi River directly. The processing plant is designed to be a zero-discharge water circuit. In line with Article 19 of Schedule VIII of the Mining Code, supernatant resulting from tailings discharged to the TSF2 is recycled directly back into the processing plant via a small holding pond, and the same approach will be implemented for TSF3, but with a process water tank.

Sediment containing runoff from the mining lease area that is otherwise clean, is not used in the process, but is directed towards settling ponds, from which the clear supernatant is discharged to the Kifumashi River.

2.7 Infrastructure and Developments (Article 20)

2.7.1 Early Works – Relocating Site Workshops and Administration Buildings

To make room for the new KEP processing plant in the area east of the oxide mill feed conveyor, the following facilities will be relocated to the south-west of the process plant water pond:

- Warehouse;
- Riggers workshop;
- Mechanical workshop;
- Change house;
- Administration building;
- E&I workshop;
- Metallurgical Laboratory;
- Piping Workshop; and
- Emergency Response Team (ERT) Shed.

The Works will include:

- Disassembly of the above facilities, demolition of unwanted structures and site clearance of the area for the new facility;
- Grubbing, clearing, bulk and detailed earthworks for the new building area, including drainage for water run-off;
- Construction of a new administration building by refurbishing an existing building in the new administration area, and supplying it with services such as electrical and water supply;
- Construction of ablution facilities within the refurbished building, matching the ablution facilities in the existing administration building;
- Prepare earthworks and undertake soil compaction in area for relocated facilities;
- Pour concrete slabs on the compacted areas;
- Design of foundation plinths suitable to support the relocation and use of the existing 12.5 tonne bridge crane for the mechanical workshop;
- Relocation and re-assembly of buildings and facilities;
- Relocation of containers and relevant canopy roofs;

- Design and installation of jib crane foundation at the new piping workshop, utilising the existing jib crane;
- Re-establish container access to relevant buildings;
- Demolition of all remaining concrete slabs and support plinths;
- Concrete footing plinths for all containers;
- Design, construct and commission new septic tanks including design, capacity and elevation and design of the septic tanks. Connecting and commissioning sewer system between toilets and septic tanks; and
- Establish cut-off drains and grid before each workshop to match existing facilities.

2.7.2 Accommodation Camp for Construction Workers

The size of the construction workforce, construction plan and proposed roster for peak manning is still to be finalised, but preliminary requirements include either upgrading of existing site accommodation and amenities buildings for the construction workforce or providing a new accommodation facility. The current camps can accommodate up to 600 people. The site has access to potable water, sewage and electricity to provide for the new accommodation facilities.

2.7.3 Security Measures

The Kinsevere site boundary requires additional physical barriers to prevent illegal and unauthorised incursions onto the tenement to protect MMG property and people.

As part of the proposed KOU project, the security measures (such as a security trench, security fence, or a combination of various security measures and their associated infrastructure such as roads, bunds etc.) may be extended to follow the mining tenement boundary of PE7274. This is necessary, not only to protect infrastructure such as stockpiles, pipelines and power lines that will be placed in this area, but also to prevent members of the public from exposure to safety risks within the mining areas. The existing security trench around PE528 may also be augmented with a fence or other security measure.

2.7.4 Illegal Occupation on Lease: PE7274

The DRC Mining Regulations recognise the right of MMG Kinsevere to clear the lease of any illegal occupation, including both housing and other economic activities such as agriculture. To do so, a full survey of all assets must be undertaken and placed on record, and compensation must be paid at a rate of 1.5 times the valuation of the asset.

MMG has historically elected to compensate the villagers who occupy the mining lease illegally. Any future removal of illegal occupiers on the PE7274 mining tenement or other tenements will follow the same approved and authorised process including assessment of houses and fields, calculation of compensation, approval from the Kipushi authority and payment of compensation.

2.7.5 Laboratory

MMG Kinsevere is equipped with an on-site laboratory. The laboratory undertakes chemical analyses and basic environmental analyses on water samples.

2.7.6 Power Supply

The 2012 EIS described electricity infrastructure. This remains unchanged and is summarised below.

A 120 kV power line supplies Kinsevere from Kasapa power station. The power line follows the access road along a 26 km route to the 33 kV switchyard at the mine.

The overall power demand at Kinsevere is currently about 31 MW, which may increase with the implementation of the KEP and cobalt recovery projects. SNEL power outages and restrictions necessitated the installation of a 25 MW Aggreko base load diesel generating station.

A power import contract was established between MMG and Zambian power trader Copperbelt Energy Corporation (CEC). The contract between CEC, SNEL and MMG led to additional grid power supply of 15 MW from August 2014. The contract was subsequently increased to 18 MW.

The resultant significant improvement in grid supply has reduced the portion of power supplied by the Aggreko generator to just 10% of supply in 2017, down from approximately 60% in 2013.

There are also several initiatives being pursued to access additional power. These include a battery energy storage system in the short term and several new transmission and project options in the medium and long term.

2.7.7 Sanitation

Several hundred people are on site at any one time and a large number of employees are housed in on-site accommodation. Ablution and change-room facilities are provided on-site with appropriate washing facilities. Containerised sewage treatment plants, septic tanks and soakaways are used to dispose of sewage generated at these ablutions.

2.7.8 Housing

Accommodation is provided in the mining contractor’s camp and in the operations camp.

2.7.9 Clinic

The site clinic is managed by MMG Kinsevere. The clinic is staffed by professionals who provide coverage for employees’ medical needs and work-related injuries. The medical personnel are equipped to treat general medical conditions (common illnesses, malaria and similar conditions), and minor accidents and injuries. The clinic also facilitates the stabilisation and transport of serious injuries and illnesses.

2.7.10 Access Road

The access road to Kinsevere is a private road (signposted as such) constructed by the mine for access to both the mine site and the power line. The access road runs parallel to the power line within a 50 m wide servitude which accommodates both these features. Refer to Figure 20~~Figure 20~~ for the access road and power line network.

The access road is used by mine vehicles and employees travelling from Lubumbashi. As currently reviewed and authorised by Mine Management, the access road is used extensively by the communities and local industry around Kinsevere and alongside the access road corridor. This includes minibus taxis, private vehicles, trucks carrying goods and passengers, and bicycles. Heavy vehicles delivering materials or collecting product from the mine are encouraged to travel at night to limit incidents on the access road. A boom gate has been established near the turn-off into the Kinsevere Access Road to control traffic.

Vehicles need to be permitted for access to private land. MMG undertakes alcohol and speed tests on this private road as well as traffic control activities. MMG also requires all vehicles accessing this private road to abide by all other DRC road laws.

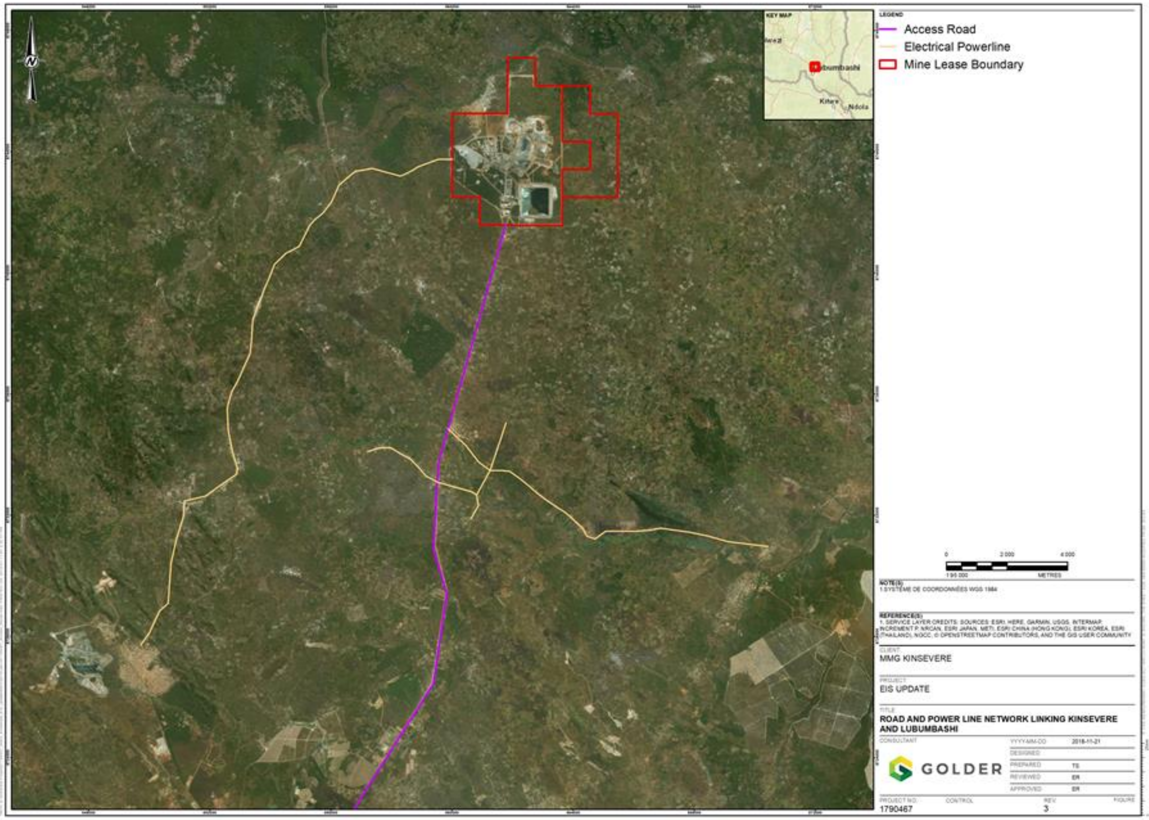


Figure 20: Road and Power Line Network linking Kinsevere and Lubumbashi

2.7.11 Fire Detection and Suppression System for Solvent Extraction (SX)

The Project requires the installation of a supplementary Automatic Fire Detection and Suppression System (water and foam) for the High and Low Grade SX trains. The following will be installed and implemented:

- Subterranean pumphouse:
- Fed from the existing contaminated water pond providing a minimum of eight times (two hours) the required water volume; and
- Diesel pump sets with electric jockey pump.

Fire water distribution network:

- Above and below ground large bore supply main;
- Two valve stations with foam concentrate mixing and deluge valve banks; and
- Distribution system comprising small bore piping, including discharge nozzles, foam generators and sprinklers.

Fire detection and alarm signalling network:

- Infra-red detection devices;
- Heat detection wire; and
- Det-Tronics control connected to existing site PLC.

The system is entirely automated in order to detect and extinguish fire without any human involvement.

2.8 Ores and Concentrates (Article 21)

A geochemical assessment of drill cores representing the sulphide copper ore was undertaken (Jeffery, J;, November 2016). Ore grade samples were classified in accordance with the following criteria:

- PAF – positive NAPP and NAG pH<4.5 Material to acidify if exposed to atmospheric conditions (as well as leach copper);
- PML – positive NAPP and NAG pH>4.5 Material that is unlikely to acidify below pH 4.5 but has the potential to leach significant amounts of copper if exposed to atmospheric conditions; and
- NAF – negative NAPP and NAG pH>4.5 Material that is unlikely to acidify or leach significant copper if exposed to atmospheric conditions.

The results are summarised in Table 13~~Table 13~~.

Overall the ore-grade samples included in the geochemical assessment were fairly evenly split over the three classifications, with approximately one third reporting as NAF, one third as PML and one third as PAF, i.e. about two thirds of the samples tested could represent problematic materials in terms of acid generation and/or metals leaching upon prolonged exposure to atmospheric conditions. This is more likely to be a potential issue for water quality within the pit sumps, rather than drainage from ore stockpiles, which will have limited exposure time and/or generate limited drainage.

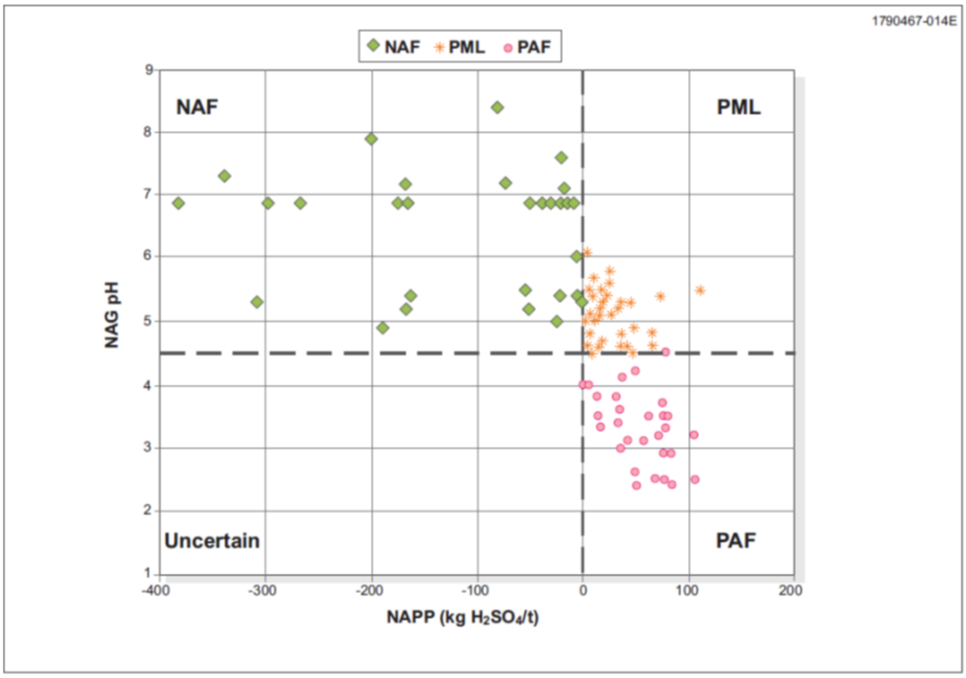


Figure 21: Geochemical Characteristics of Sulphide Copper Ore Samples

2.9 Mine Waste (Article 22)

There have been various geochemical investigations of material at Kinsevere, including analysis of waste rock from the Central and Mashi deposits completed in 2007 (Institute for Groundwater Studies), a study in 2010 by Water Geosciences Consulting, and studies in 2013 by SLR. In 2013, Environmental Geochemistry International Pty Ltd (EGi) was commissioned by MMG to carry out a geochemical assessment of waste rock and ore grade materials that will be mined during development of the Kinsevere Hill copper deposit. Further studies were conducted by EGi during 2016 and 2017 on materials representative of the proposed KOU Project. The final report was issued in May 2018 (Anon, Kinsevere Primary Copper Project. Geochemical and Acid Forming Characteristics of Waste Rock, Ore and Process Tailings, May 2018) and the findings are summarised here.

2.9.1 Black Shale

Geochemical studies during 2014 confirmed that some of the Black Shale samples encountered during the mining of oxide ore had elevated sulphur contents (i.e. 0.9 to 8.15%) and were potentially acid forming (PAF).

Kinetic tests indicated PAF samples to be reactive and that acid generation is likely to occur within a short time of the rock being exposed to atmospheric conditions. Apart from copper, some of the Black Shale material is enriched with selenium, zinc, molybdenum, cobalt and/or bismuth.

Increased concentrations of dissolved metals in drainage may be expected where PAF Black Shale is exposed to atmospheric conditions and acidification occurs. In addition to copper, iron and aluminium, there will likely be significant concentrations of cobalt, manganese, nickel and zinc (EGi, 2014).

EGi (2017) confirmed that Black Shale associated with Kinsevere sulphide copper ore will be PAF. The results of kinetic testing of PAF SD indicate that such material will be highly reactive and has potential to generate low pH, high acidity drainage almost immediately if exposed to leaching under atmospheric conditions. Waste rock consisting of such material must be considered high risk and will require active management.

2.9.2 Current WRD (Oxide Ore Processing)

The samples from the waste rock dump were essentially devoid of sulphur (0.01 or 0.02%) and were classified as NAF. Elevated concentrations of copper and cobalt were seen in the waste rock solids; however, there was no evidence of mobilisation of copper, cobalt or any other environmentally important elements when the solids were leached with deionised water (EGi, 2014).

The test samples indicated that the waste material should be benign with respect to acid generation. Additionally, the drainage from such material should be pH neutral and relatively free of metals and metalloids. The solubilities of metals such as copper are highly pH-sensitive, and any action that might lower pH even slightly (i.e. inadvertent inclusion of some PAF waste) could increase in the mobilisation of copper from NAF material with elevated copper content (EGi, 2014).

2.9.3 TSF2 (Oxide Ore Processing)

The three tailings samples analysed had sulphur concentrations between 0.15 and 0.21%. One of the samples had a negative Net Acid Producing Potential (NAPP) and was classified as NAF. The other two samples had positive NAPPs but the ARD classifications were "uncertain (UC)". Elemental analysis of one of the uncertain samples indicated that there was enrichment of the solids with arsenic, cobalt, copper and selenium. Results from the water and peroxide extractions indicated potential for significant leaching of copper, cobalt and manganese under neutral and slightly acidic conditions (EGi, 2014).

Due to the concentrations of some elements, the TSF2 tailings material was classified as highly hazardous waste in accordance with the procedures in Articles 2 to 8 of Schedule XI. The classification is described in the 2012 EIS.

2.9.4 Tailings and Waste Rock (Sulphide Ore Processing)

EGi was commissioned to undertake various geochemical characterisations for samples associated with the Kinsevere sulphide copper deposit. The acid forming characteristics of the 185 drill core samples representing waste are summarised in Table 11~~Table 11~~ (EGi, 2017).

Table 11: Summary of NAF/PAF Distributions for Waste Rock Samples (EGi, 2017)

Stratigraphy	PAF	NAF	Total
SD	97	19 (1)	116
CMN	13 (2)	18 (3)	31
R1, RRAT, GRAT	1	31	32
DSTR	-	4	4
HBX	-	2	2
Total	**111**	**74**	**185**

Of the 185 waste samples tested all but seven were definitively classified as NAF or PAF based on the NAPP and NAG pH results. The seven samples where there was some uncertainty included one CMN and three SD samples which had small positive NAPPs but the samples did not acidify under NAG test conditions. These samples were classified UC (NAF), signifying some uncertainty but considered more likely NAF.

There were also two CMN samples and one RAT sample that had small negative NAPPs but the samples did acidify to less than pH 4.5 under NAG test conditions.

These samples were classified UC (PAF), again signifying some uncertainty but considered more likely PAF (EGi, 2017).

The geochemical testing program also assessed flotation tailings that would be produced during the processing of sulphide ore. The program tested true composite samples and variability samples. True composite samples were formed from several sections of primary drill core that are not contiguous and came from different areas of the ore body, Primary HH, HL and LL, PC1, PC3, TMO low ASCu Float Tailings and TMO Cu (EGi, 2017 and Mintek, 2016) – see Table 12~~Table 12~~.

Variability samples are continuous sections of drill core, containing between 10 and 25 m of core, selected to represent a particular ore characteristic – such as mineralogy, grade, and stratigraphy/lithology. The variability program tested 62 samples against a standard flowsheet. Samples with low pH pulp forming characteristics were selected for further flotation tests including V1, V5, V9, V44, V57 and V62. A composite sample PC2 (V44: 44%, V43: 43%, and V33: 12%) was created to reflect the blending expected during the plant operation (Mintek, 2016). The results are summarised in Table 13~~Table 13~~.

As shown in Table 13~~Table 13~~, results from the KEP tailings geochemical assessment indicate tailings solids will have low sulphur content and will be NAF. Expected dissolved metals concentrations will be low and below the criteria specified in the DRC Regulations for classification of tailings as Slightly Hazardous. (EGi, 2017).

Results from some variability composite samples exceed the Slightly Hazardous criteria for metals such as copper, iron, nickel and/or zinc. These samples are minor ore types that are not representative of the average processing plant throughput (45% SD, 44% CMN, 2% DIP and 8% RAT ore) and do not trigger DRC environmental regulations. However, Level A watertight measures are triggered (SRK, 2018). Appropriate management of the tailings with respect to their ARD/ML risk will ensure that Level A watertight measures are not required (SRK, 2017). Section 5.10.3 details the Kinsevere mine's approach to managing waste rock ARD/ML risks.

Table 12: Sources and Descriptions of Tailings Tested

Tailings/Source	Sample Names	Description
Primary tailings/Slurry from ALS Amtec	Primary LL	Low clay/Low organic carbon
	Primary HL	High Clay/Low organic carbon
	Primary HH	High Clay/High organic carbon
Production Composite Tailings/Bulk Flotation test samples from ALS Amtec	PC1	Representing years 1 to 3
	PC2	Representing years 4 and 5 tailings
Transition Mixed Ore (TMO) Mintek, Johannesburg	TMO Low ASCu Float Tailings (CT+RT)	Low acid-soluble Cu/total Cu ratio (ASCu:TCu ratio 0.18 to 0.20
	TMO CC Float Tailings	Chalcocite rich sample of TMO (ASCu:TCu ratio of 0.29)
	TMO Cu/Cpr Rougher Tailings (Combined Tests C3,7,8 and 9)	Native copper and cuprite rich sample of TMO (ASCu:TCu ratio of 0.43)
Variability Composite Tailings/ALS Amtec	Composite v1 – RT and CT	Flotation tailings samples from metallurgical program examining the variability of ore characteristics, specifically selected by MMG as producing supernatant liquors of low pH during processing. For each composite the rougher (RT) and cleaner (CT) fractions were provided as separate slurries.
	Composite v5 – RT and CT	
	Composite v9 – RT and CT	
	Composite v13 – RT and CT	
	Composite v44 – RT and CT	
	Composite v57 – RT and CT	
	Composite v62 – RT and Ct	

Table 13: Acid Forming Characteristics of Production Composite and Variability Composite Tailings Solids

Parameter	Unit	Production Composite Tailings		Variability Composite Tailings (Low pH Samples)											
		Comp PC1	Comp PC2	Comp V1 CT	Comp V1 Ro Tail	Comp V5 CT	Comp V5 Ro Tail	Comp V9 CT	Comp V9 Ro Tail	Comp V44 CT	Comp V44 Ro Tail	Comp V57 CT	Comp v57 Ro Tail	Comp V62 CT	Comp V62 Ro Tail
pH of tailings liquor	mass%	7.3	7.2	3.3	3.1	5.2	5.6	3.3	4.0	3.2	3.3	5.8	6.0	3.7	4.1
Solids Analyses*															
Total S	%S	0.15	0.31	0.53	0.28	1.37	0.79	1.03	0.57	1.41	0.41	0.95	0.44	1.52	1.08
Total C	%C	7.45	5.95	8.43	4.56	7.59	4.80	6.06	2.49	7.29	5.67	5.34	1.89	8.40	6.09
Organic C	%C	1.60	2.68	8.16	3.84	5.76	2.58	4.65	1.98	5.70	1.92	4.95	1.92	6.90	3.84
Inorganic C	%C	5.85	3.27	0.27	0.72	1.83	2.22	1.41	0.51	1.59	3.75	0.39	-0.03	1.50	2.25
Neutralising Characteristics															
CNV	kg H_2SO_4/t	478	267	22	59	149	181	115	42	130	306	32	-2	123	184
ANC	kg H_2SO_4/t	64	7	0	0	0	5	1	21	0	0	17	54	7	20
Acid Generating Characteristics															
MPA	kg H_2SO_4/t	5	9	16	9	42	24	32	17	43	13	29	13	47	33
ANC/MPA Ratio		14	0.7	0.0	0.0	0.0	0.2	0.0	1.2	0.0	0.0	0.6	4.0	0.2	0.6
NAPP	kg H_2SO_4/t	-59	2	16	9	42	19	31	-4	43	13	12	-41	40	13
NAG	kg H_2SO_4/t	0	0	15	11	11	3	27	2	19	14	19	0	20	6
NAGpH		7.4	7.3	2.8	2.8	3.7	4.2	2.6	4.6	2.8	2.7	3.8	7.2	2.8	3.4
ARD Classification		**NAF**	**UC (NAF)**	**PAF**	**PAF**	**PAF**	**PAF**	**PAF**	**UC**	**PAF**	**PAF**	**PAF**	**NAF**	**PAF**	**PAF**

Notes: * Sulphur and carbon assays provided by MMG

Abbreviations: CNV = Carbonate Neutralising Value NAPP = Net Acid Producing Potential NAF = Non-Acid Forming

ANC = Acid Neutralising Capacity NAG = Net Acid Generation capacity PAF = Potentially Acid Forming

MPA = Maximum Potential Acidity NAGpH = pH of NAG liquor UC = Uncertain

2.10 Mine Waste Storage Areas (Article 23)

This section describes the locations for mine waste storage areas, their surface areas and capacities, and the type of mine waste that will be contained in each mine waste storage area.

2.10.1 Stage I (Oxide Ore) Tailings Storage Facility (TSF1)

During the Stage I operations of Kinsevere the tailings from the oxide ore processing plant were stored in TSF1 to the west of the mining operations. Tailings deposition to TSF1 stopped when the Stage II TSF (TSF2) was commissioned in April 2011, as described in the 2007 and 2012 EIS documents. TSF1 has a footprint area of about 29.1 ha.

2.10.2 Stage II (Oxide Ore) Tailings Storage Facility (TSF2)

The existing Stage II TSF (TSF2), indicated on

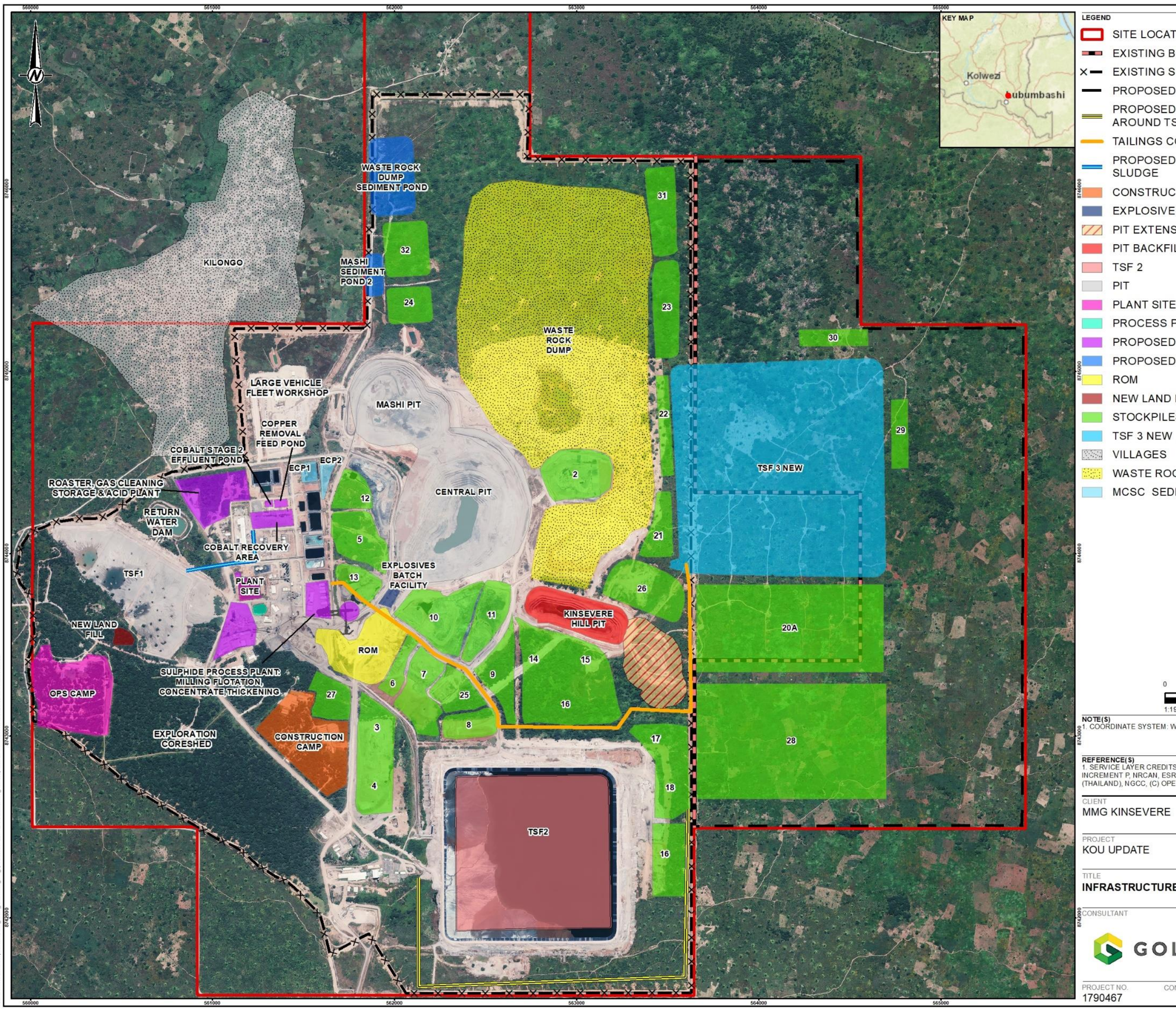

KILONGO
WASTE ROCK DUMP SEDIMENT POND
MASHI SEDIMENT POND 2
WASTE ROCK DUMP
LARGE VEHICLE FLEET WORKSHOP
MASHI PIT
COPPER REMOVAL FEED POND
COBALT STAGE 2 EFFLUENT POND
ECP1
ECP2
ROASTER, GAS CLEANING STORAGE & ACID PLANT
RETURN WATER DAM
CENTRAL PIT
TSF 3 NEW
COBALT RECOVERY AREA
TSF1
PLANT SITE
EXPLOSIVES BATCH FACILITY
KINSEVERE HILL PIT
NEW LAND FILL
ROM
OPS CAMP
SULPHIDE PROCESS PLANT: MILLING FLOTATION, CONCENTRATE THICKENING
EXPLORATION CORESHED
CONSTRUCTION CAMP
TSF2
KEY MAP
Kolwezi
LEGEND
SITE LOCAT
EXISTING B
EXISTING S
PROPOSED
PROPOSED AROUND TS
TAILINGS C
PROPOSED SLUDGE
CONSTRUC
EXPLOSIVE
PIT EXTENS
PIT BACKFIL
TSF 2
PIT
PLANT SITE
PROCESS F
PROPOSED
PROPOSED
ROM
NEW LAND
STOCKPILE
TSF 3 NEW
VILLAGES
WASTE ROC
MCSC SEDI
NOTE(S)
REFERENCE(S)
CLIENT
MMG KINSEVERE
PROJECT
KOU UPDATE
TITLE
INFRASTRUCTURE
CONSULTANT
PROJECT NO.
1790467

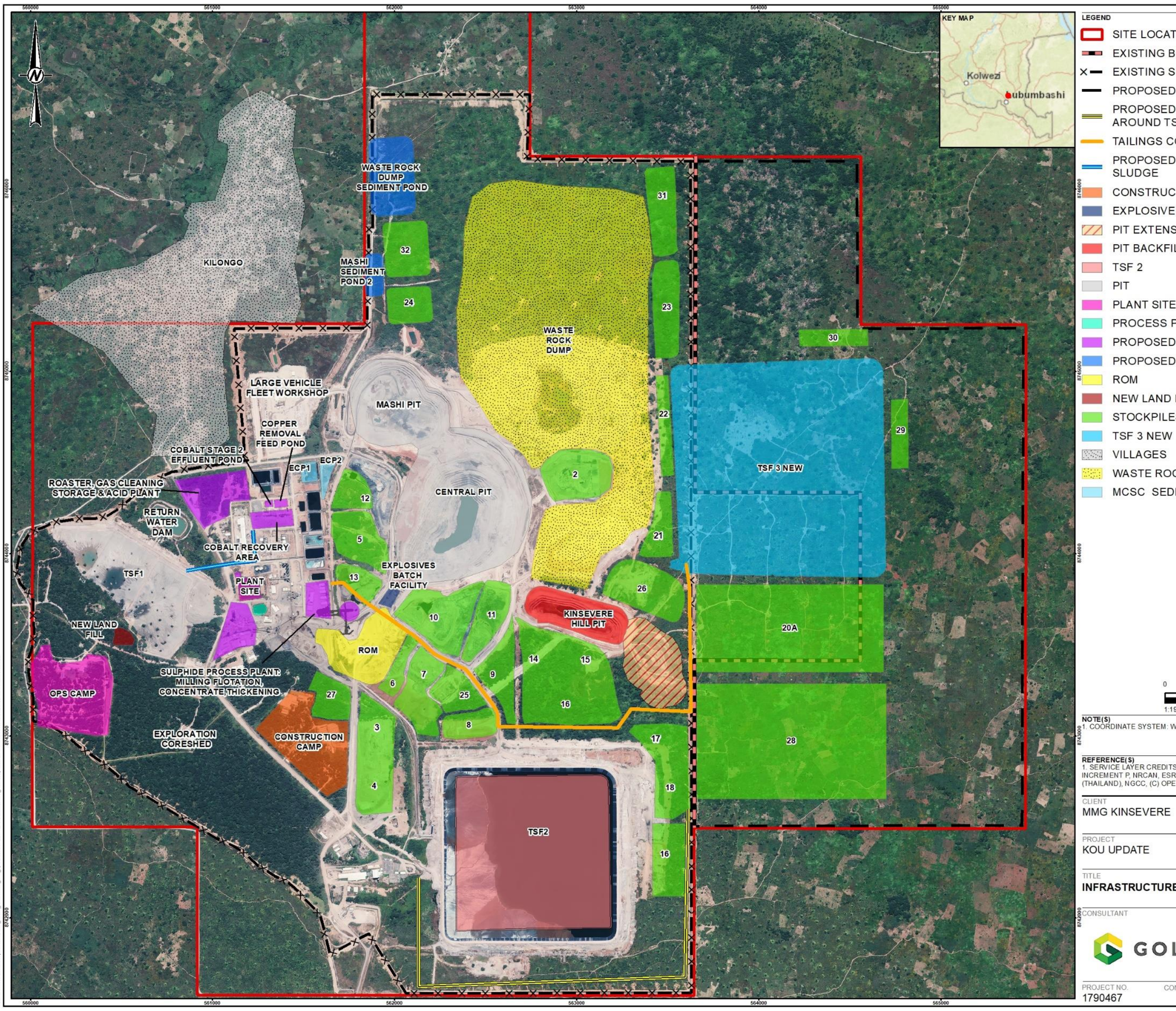
Figure 2Figure 2, is situated approximately 3 km from the Kifumashi River. The construction comprises a high-density polyethylene (HDPE) geomembrane-lined, zoned, downstream constructed paddock embankment. Underdrainage was installed to increase TSF2 tailings densities and reduce seepage into the groundwater. In the event that the underdrainage is not operational, the Closure Plan will be adjusted for any impact this may have on tailings consolidation. Any seepage will be monitored using piezometers and groundwater samples; a mitigation plan will be actioned if required to minimise any impacts.

The design and operation of TSF2 was described in the 2012 ESIA. The facility is managed in line with the design parameters and is audited annually by tailings engineers. Although the quality of water cannot be modelled or predicted, overflows may only occur in extreme rainfall events, when such effluent is diluted. A cut-off trench is located beneath the upstream toe of the embankment. A stormwater collection pond will be constructed at the north-eastern corner and water will be pumped back to the pool of the TSF. Hence the probability of overflow water reaching the river is very low.

2.10.3 New Tailings Storage Facility (TSF3)

A new facility (TSF3) will be required for the storage of tailings arising from the processing of sulphide copper ore. The operation of TSF2 will continue with the processing of oxide ores and with the recirculation of decant water back to the processing plant, as described in Section 2.6.2.

The TSF3 option location is approximately 1.5 km east of the KEP processing plant and it will be constructed as a standalone paddock style facility with a footprint area of about 136.1 ha. The construction will comprise of a compacted clay layer and HDPE liner. The downstream slope (outer face) of the impounding embankment will be constructed with NAF waste rock. A temporary mobile crushing/screening plant may be required to crush NAF material to 20-40 mm for TSF3 construction. Refer to



Golder Associates

Figure 2Figure 2 for the locality, and Figure 22Figure 22, Figure 23Figure 23, and Figure 24Figure 24 for the design of TSF3.

The topography of the proposed location for TSF3 is flat, sloping at 1 to 2% toward low points in the north-east corner of the TSF basin. There are no known significant geological or topographical features in the proposed TSF location and the footprint area will be cleared of all topsoil before construction. The tailings solids settle over time while the released process water is decanted and pumped back to the concentrator for re-use. Section 3.0 of this ESIA describes the soil and biodiversity investigations conducted on PE7274, where the proposed TSF3 will be located.

TSF3 has been designed by a consultant specialising in the design and monitoring of tailings dams.

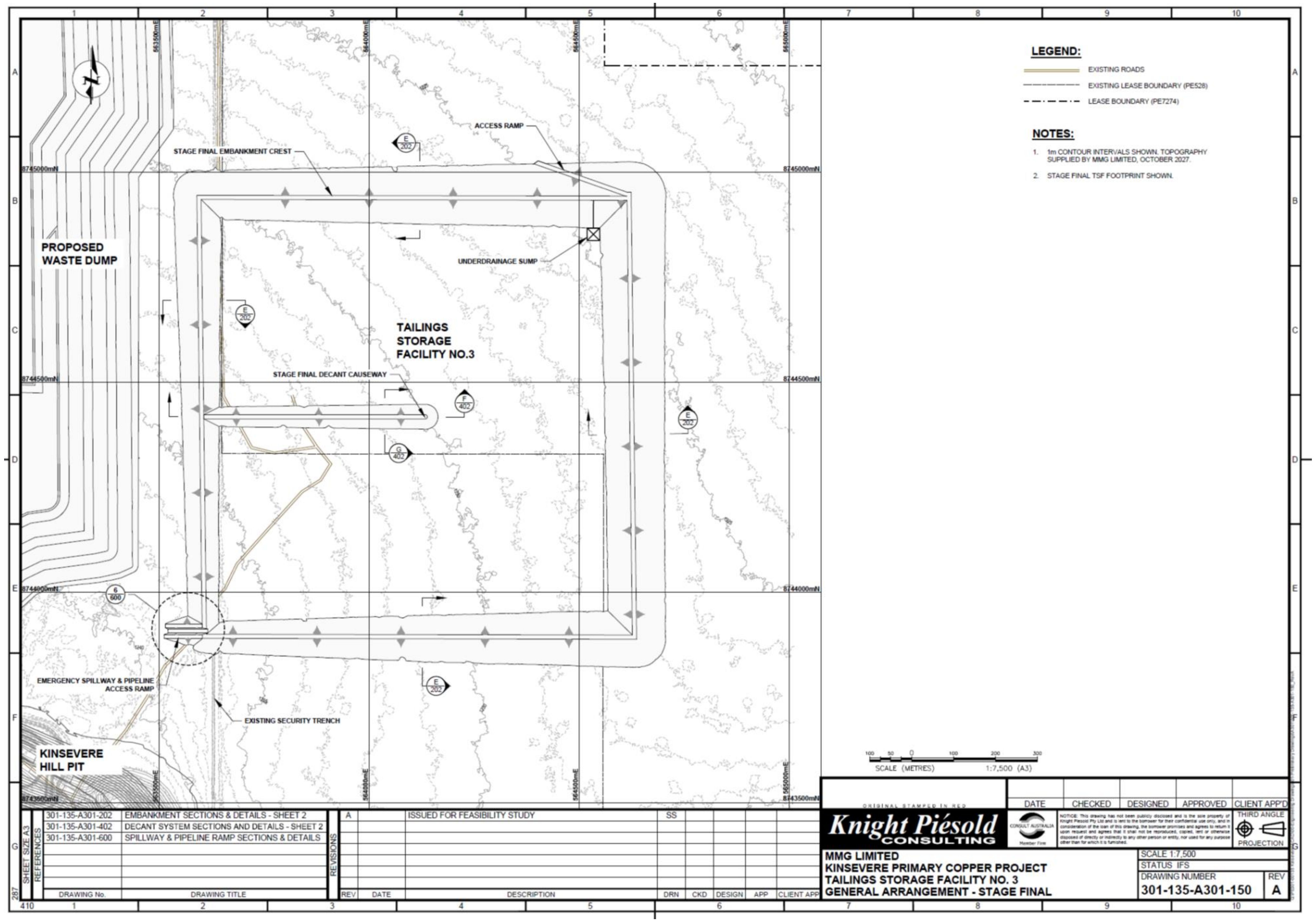


Figure 22: TSF3 General Arrangement

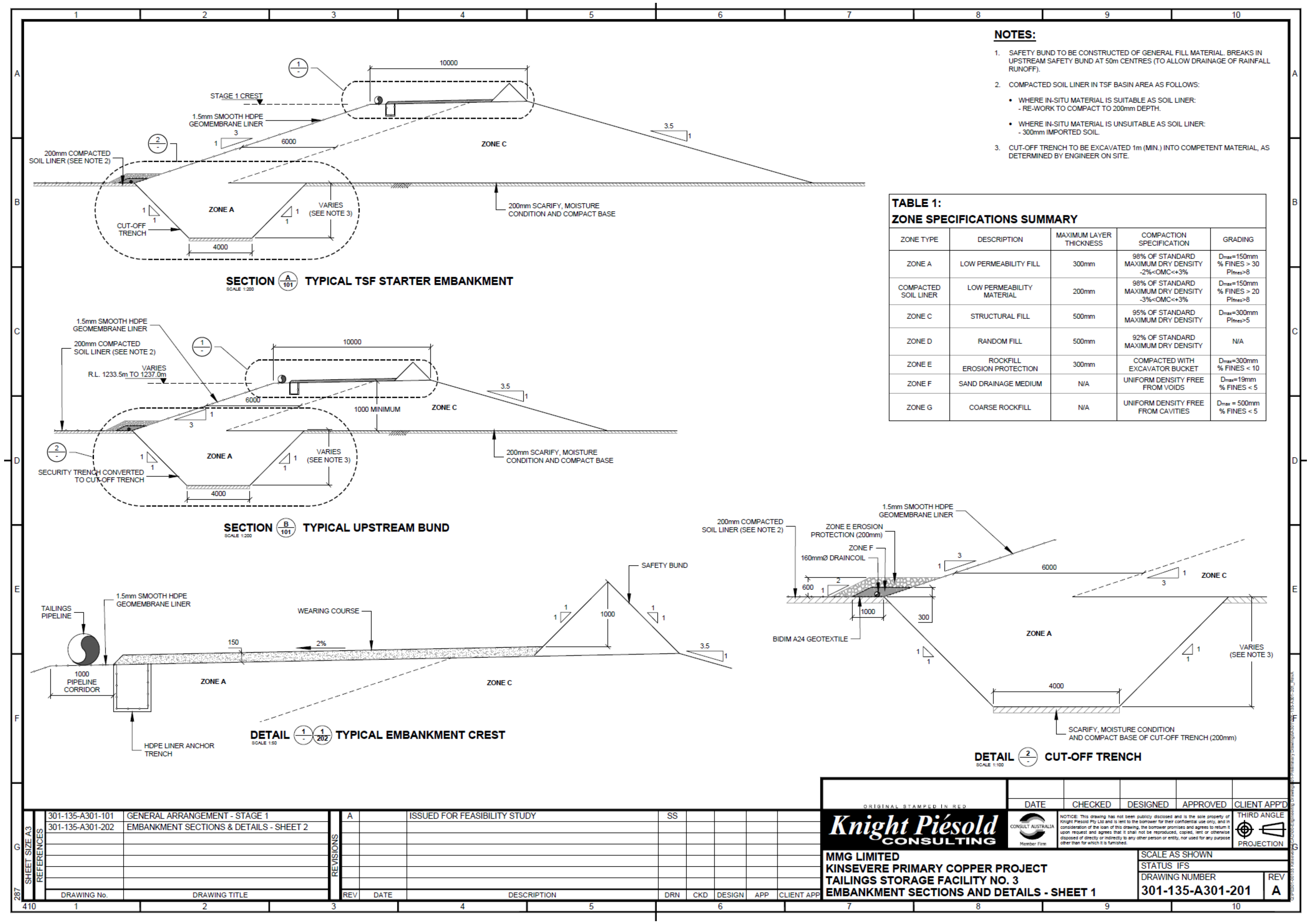


TABLE 1: ZONE SPECIFICATIONS SUMMARY

ZONE TYPE	DESCRIPTION	MAXIMUM LAYER THICKNESS	COMPACTION SPECIFICATION	GRADING
ZONE A	LOW PERMEABILITY FILL	300mm	98% OF STANDARD MAXIMUM DRY DENSITY -2%<OMC<+3%	D_{max}=150mm % FINES > 30 PI_{fines}>8
COMPACTED SOIL LINER	LOW PERMEABILITY MATERIAL	200mm	98% OF STANDARD MAXIMUM DRY DENSITY -3%<OMC<+3%	D_{max}=150mm % FINES > 20 PI_{fines}>8
ZONE C	STRUCTURAL FILL	500mm	95% OF STANDARD MAXIMUM DRY DENSITY	D_{max}=300mm PI_{fines}>5
ZONE D	RANDOM FILL	500mm	92% OF STANDARD MAXIMUM DRY DENSITY	N/A
ZONE E	ROCKFILL EROSION PROTECTION	300mm	COMPACTED WITH EXCAVATOR BUCKET	D_{max}=300mm % FINES < 10
ZONE F	SAND DRAINAGE MEDIUM	N/A	UNIFORM DENSITY FREE FROM VOIDS	D_{max}=19mm % FINES < 5
ZONE G	COARSE ROCKFILL	N/A	UNIFORM DENSITY FREE FROM CAVITIES	D_{max} = 500mm % FINES < 5

Figure 23: Design of TSF3 – Starter Embankment, Bund and Cut-off Trench

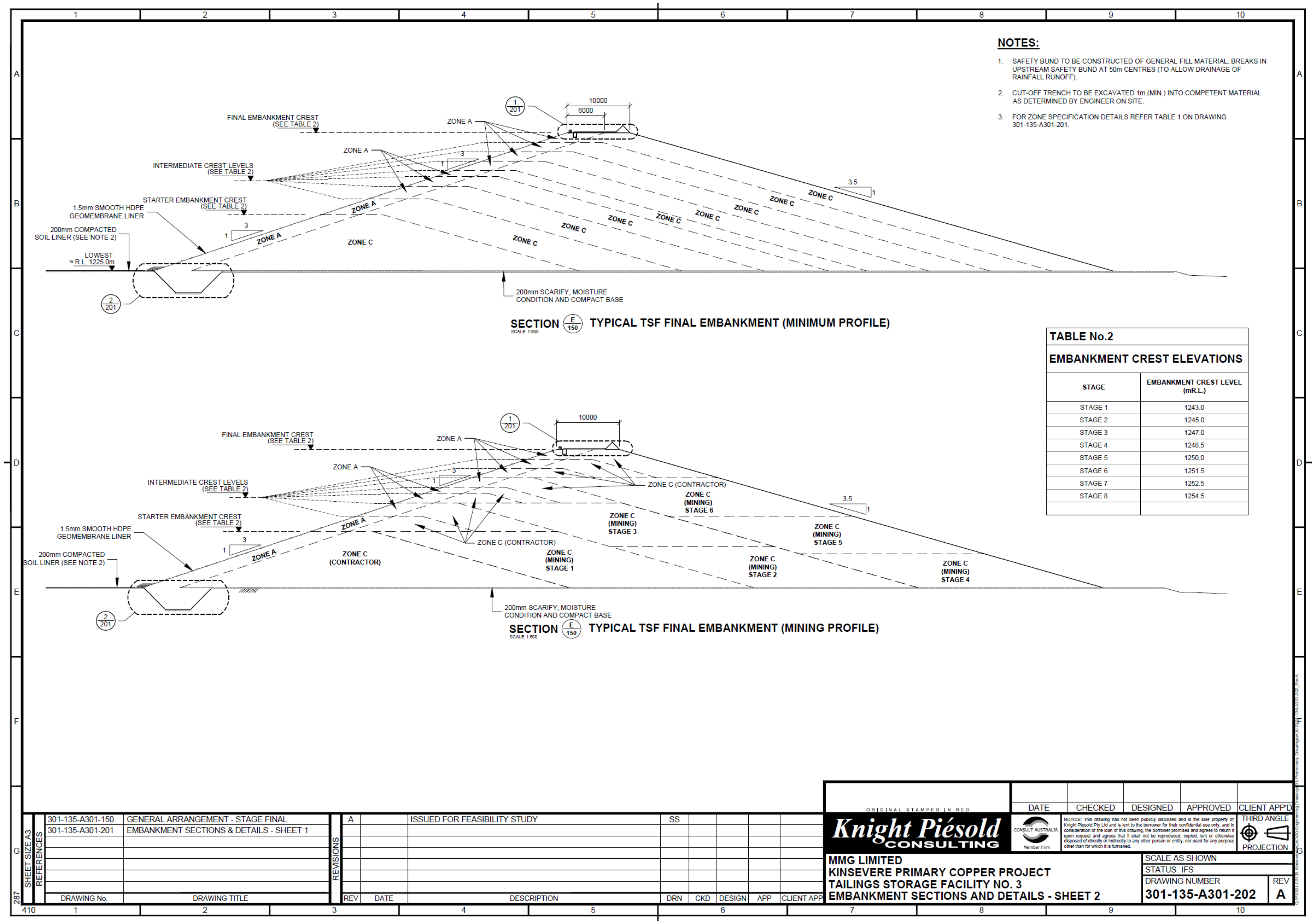


TABLE No.2

EMBANKMENT CREST ELEVATIONS

STAGE	EMBANKMENT CREST LEVEL (mR.L.)
STAGE 1	1243.0
STAGE 2	1245.0
STAGE 3	1247.0
STAGE 4	1248.5
STAGE 5	1250.0
STAGE 6	1251.5
STAGE 7	1252.5
STAGE 8	1254.5

Figure 24: Design of TSF3 – Final Embankment

2.11 Transport (Article 24)

The copper cathodes are transported via the Kinsevere access road to the Likasi – Lubumbashi road junction and then onwards via Lubumbashi to the Kasumbalesa border post to be exported. The transportation route is illustrated in Figure 25~~Figure 25~~.

Currently, an average of nine 34 tonne trucks per day are utilised to transport the copper from site. When the proposed KOU Project reaches full output, the number of trucks will increase to an average of 11 per day.

Processing reagents are transported to site on a daily basis with a combination of 28 tonne and 34 tonne trucks as required. When the proposed KOU Project reaches full output, the number of trucks required for delivering reagents to site will be an average of 18 per day. These trucks are likely to take various routes to reach Kinsevere.

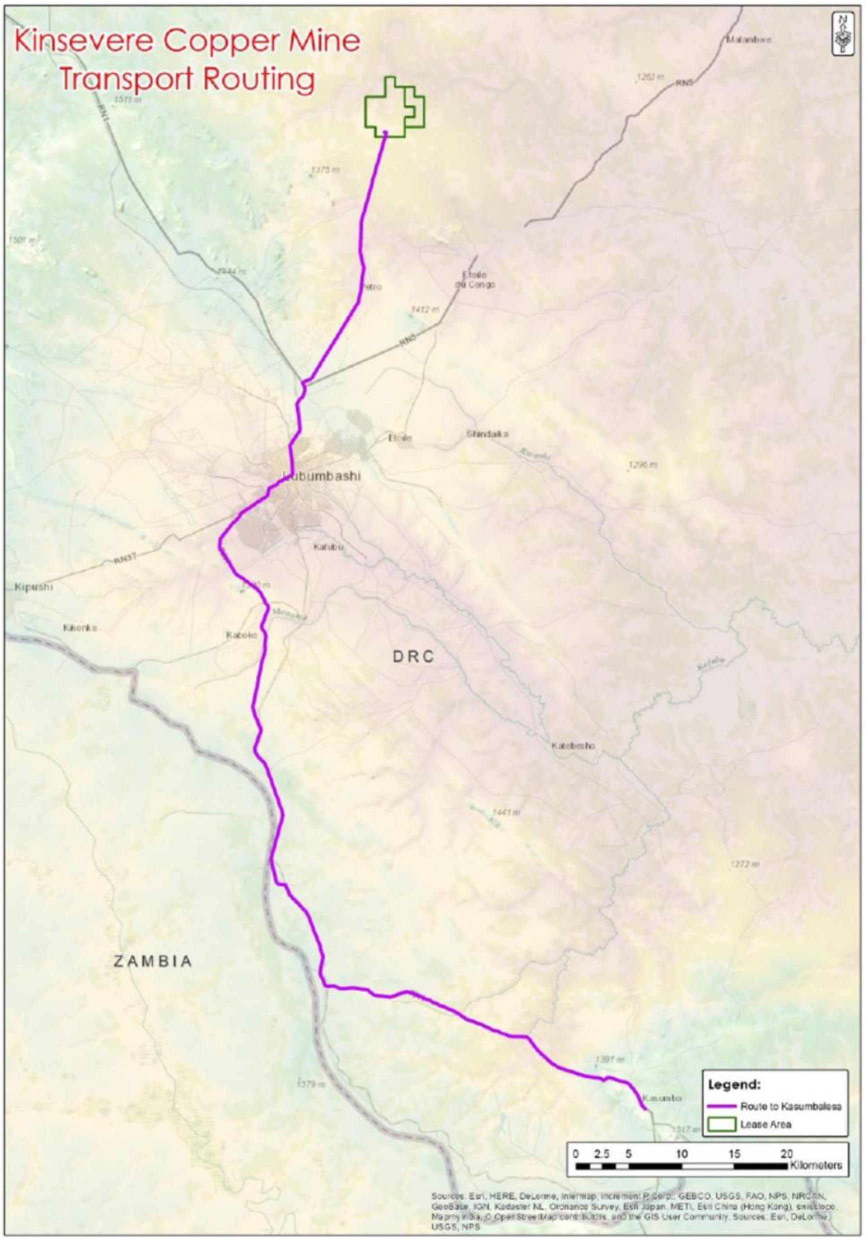


Figure 25: Copper Cathode Transport Route from Kinsevere to Kasumbalesa

3.0 TITLE III: ANALYSIS OF THE ENVIRONMENTAL SYSTEM AFFECTED BY THE PROJECT

3.1 CHAPTER I: COMPONENT PARTS OF THE ENVIRONMENTAL SYSTEM

3.1.1 Obligation to Analyse the Components of the Environmental System (Article 25)

The applicant for a mining or quarry right analyses the biophysical resources and sociological components of the environmental system affected by the project as it existed prior to its implementation.

In the environmental system, the following three components may be affected by KOU project activities:

- The physical component;
- The biological component; and
- The sociological component.

3.1.2 Reference Documents (Article 26)

This section is informed by a number of specialist studies and reports produced in recent years. For a full list of the references used see Section 1.0 of this report.

In undertaking these studies and the ESIA process, cognisance was taken of the amendments to the DRC Mining Code Law No. 007 of 2002 in the form of the bill passed by the Congolese senate on 24 January 2018 and the Mining Regulations Decree No. 038 of 26 March 2003 as amended by Decree No. 18/024 of 08 June 2018.

3.2 CHAPTER II: DESCRIPTION OF THE PHYSICAL ENVIRONMENT

3.2.1 Description of the Components (Article 27)

This section provides a description of the components of the physical environment in their current state, prior to the commencement of any physical activities associated with the proposed Kinsevere Operational Upgrades (KOU) Project.

3.2.1.1 Topography, Geology and Land Use (Article 28)

3.2.1.1.1 Topography

The Kinsevere mine site is situated on a plateau at a height of 1 150-1 300 masl (metres above sea level), which is incised by streams and rivers that form gently sloping, shallow valleys. The plateau is incised by the Luapula River, located 91 km east of Kinsevere and flowing in a northerly direction via Lake Moero, the Luvua River and the Lualaba River towards its confluence with the Congo River. Its watershed extends to include the Kinsevere Copper Mine area and beyond.

Prior to the development of the mine, the local topography was defined by the drainage system of the Kifumashi River and its tributaries, i.e. from west to east. The drainage gradient of the Kifumashi River is 2% and the surrounding topography is generally slightly undulating and gently rolling.

The current topography of the tenement PE528 is defined by the mine infrastructure, including the Waste Rock Dump (WRD), the open pits and the Tailings Storage Facilities as shown in Figure 26~~Figure 26~~.

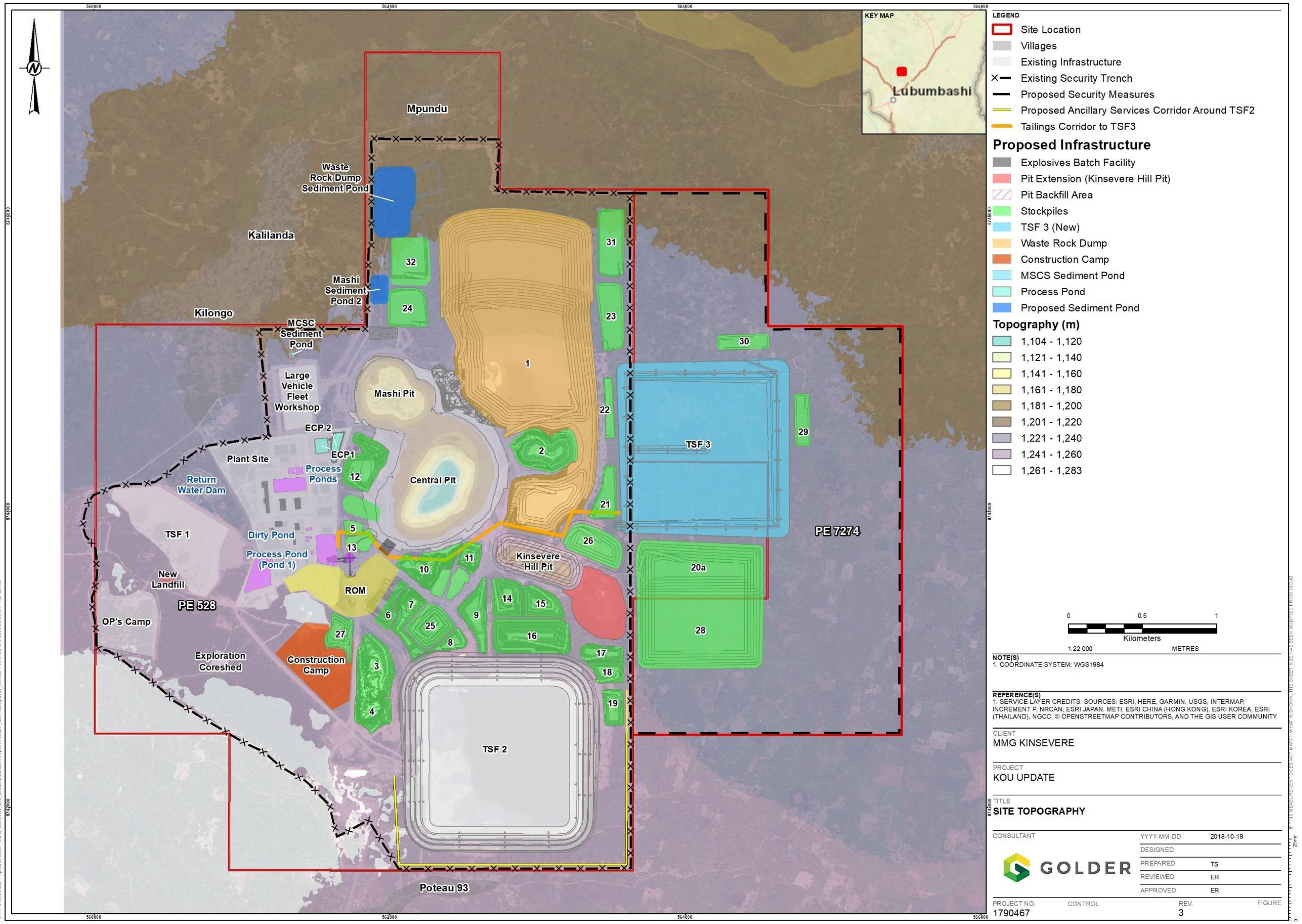


Figure 26: Topography of Proposed KOU Project Area

3.2.1.1.2 Regional Topography

Tenement PE7274 has a gentle slope of about 1% from the south-west to the north-east. The topography of the proposed location for TSF3 is flat, sloping at 1 to 2% towards low points in the north-eastern corner of the TSF basin. There are no known significant geological or topographical features within the proposed TSF footprint, which will be cleared of topsoil before construction.

3.2.1.1.3 Regional Geology

Kinsevere is located in the north-eastern section of the Central African Copperbelt (CACB), which is the largest and highest grade sedimentary hosted copper province in the world. It is hosted in Neoproterozoic metasedimentary rocks of the Katangan Supergroup. Most of the significant copper-cobalt deposits in the CACB, including Kinsevere, are confined to the basal sections of the Lower Roan Mines Group.

Most of the mineralisation within the Katangan section of the Central African Copperbelt is hosted within two stratigraphic zones, namely the Lower Ore Body (LOB) and the Upper Ore Body (UOB). The LOB is hosted within the Grey Roches Argilleuses Talceuse (RAT), DStrat and RSF units of the Kamoto Dolomite Formation, whereas the UOB is hosted by the Silicified Dolomite (SD) unit comprised mostly of dolomitic shales. There is no barren zone between the Lower and the Upper Orebodies at Kinsevere mine. A Third Ore Body (TOB) is present in the lower part of the CMN unit of the Kambove Dolomite Formation, in regions where it hosts significant mineralisation within some deposits. The mineralisation in all three of these zones is well developed at Kinsevere deposits.

3.2.1.1.4 Local Geology

The geology at Kinsevere Copper Mine consists of the RAT, Mines Series and Dipeta. Kinsevere hosts deposits of both oxide and sulphide mineralisation, with different phases of weathering resulting in localised zones of either transitional copper species and/or a mixture of both oxide and primary copper species (TMO).

The following stratigraphies were identified in drill cores:

- SD (Schistes Dolomitique) – Carbonaceous black shale;
- CMN (Calcaire á Minerai Noir) – Dolomite;
- DSTR (Dolomie stratifiées) – Stratified dolomite;
- RAT (Roches Argilo-Talqueuses) – Dolomitic siltstone (includes GRAT, RRAT, R1);
- RSF (Roche Siliceuses Feuilletées) – Silicified dolomite; and
- HBX – Breccia.

The local geology is illustrated in Figure 27~~Figure 27~~.

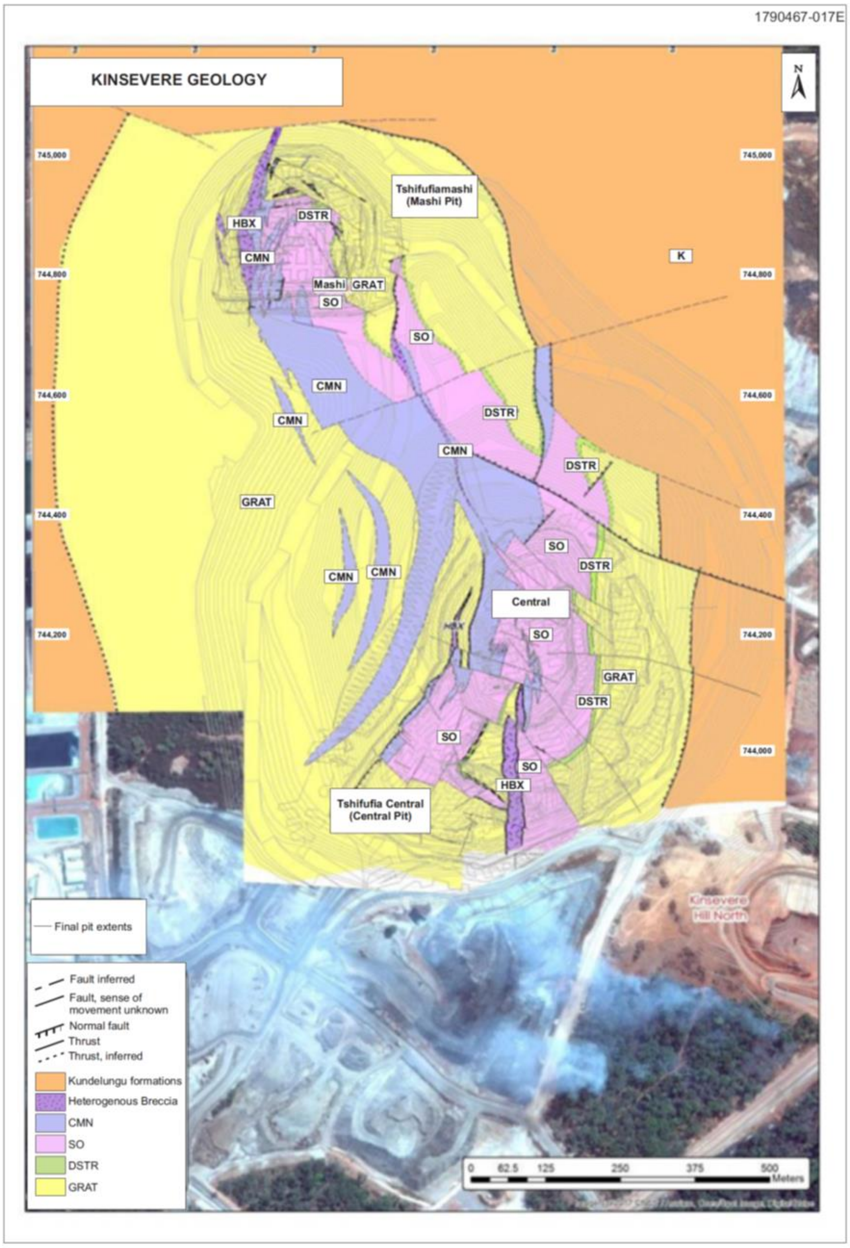


Figure 27: Geology at Kinsevere

3.2.1.2 Soil, Land Capability, and Land Use

Earth Science Solutions undertook a field survey during March 2016 and April 2017 of areas not previously assessed and the data was combined with existing data from surveys done during 2008-2011 (Jones, I; Briel, A;, April 2017).

Pursuant to a review by Golder Associates in March 2018 (Snyman, I; Herselman E;, March 2018), an additional survey was undertaken to provide more information on the soil characteristics, land capability and land use for the proposed development and infrastructural areas, and to undertake soil erosion modelling, impact assessment and formulation of mitigation measures (Snyman, Mukalay, Maake, & Herselman, 28 August 2018).

3.2.1.2.1 Soil Sampling and Classification

After completing a desktop review of available information, soil samples were taken by hand auger at the locations shown on Figure 28~~Figure 28~~, to depths ranging from 25 cm to 120 cm, depending on the soil type. Samples from locations with similar morphological features were grouped into the same soil unit, resulting in seven representative soil profiles.

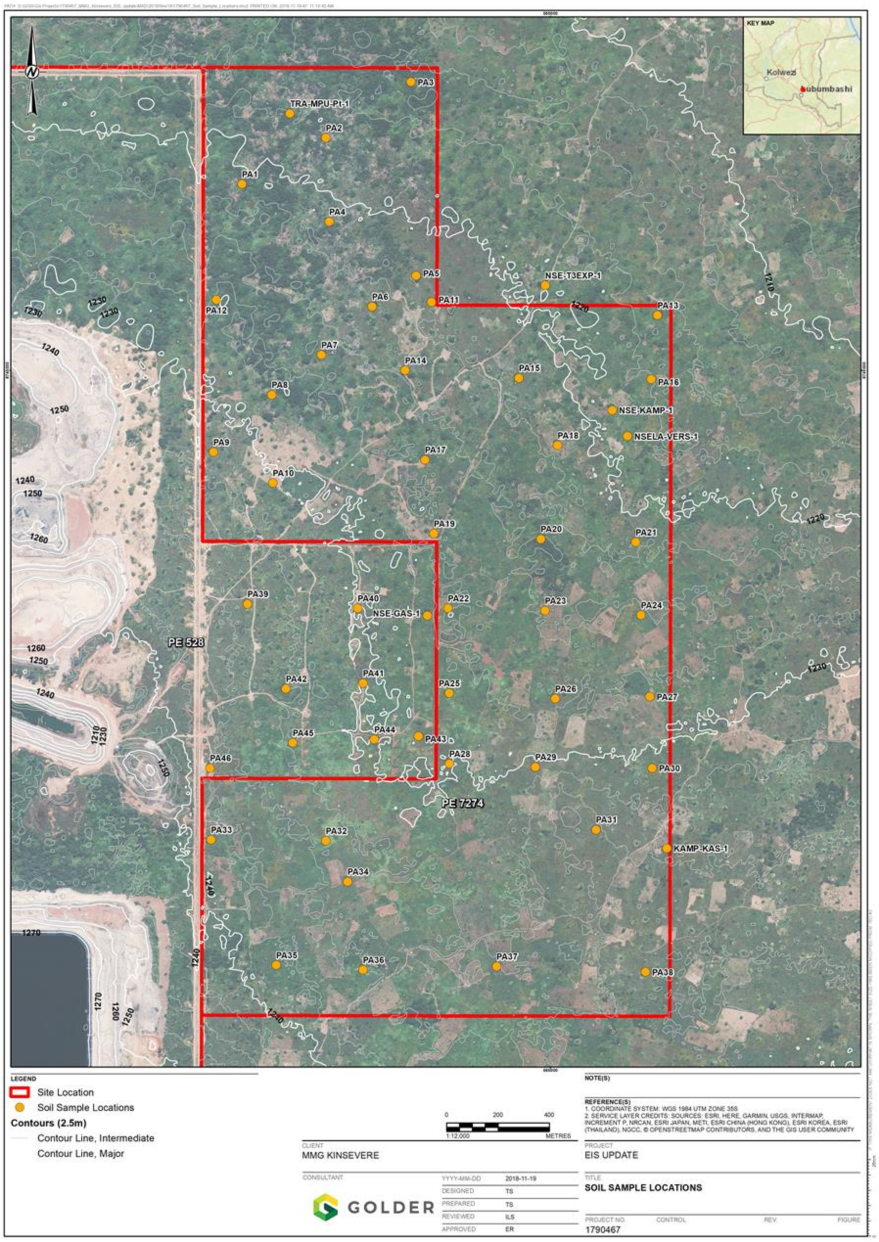


Figure 28: Locations of Soil Sampling and Observation Points within Study Area

Soil capability indices were determined as listed in Table 14Table 14, based on soil profile development, texture, depth, colour/drainage conditions, pH/base saturation and development of the A horizon.

Table 14: Suitability Classes for Different Groups of Crops

Suitability Classes	Soil Index		
	Exacting Crops	Moderately Exacting Crops	Less Exacting Crops
Excellent suitability	>90	>85	>75
Very suitable	70-90	65-85	50-75
Suitable	50-70	45-65	35-50
Moderately suitable	35-50	30-45	25-35
Slightly suitable	25-35	15-30	10-25
Unsuitable	<25	<15	<10

The land suitability ratings outlined above are only qualitative, without regard for economic or social analysis. The ratings are based on the dominant soils found and on a limited number of sampled and analysed soils.

The soil index was used to define the land capability classes with regard to their suitability for various crops as follows:

- **Class I:** Soil index >90. Excellent for all crops;
- **Class II:** Soil index between 70 and 90. Very suitable for exacting crops, excellent to very suitable for moderately exacting crops and excellent for less exacting crops;
- **Class III:** Soil index between 50 and 70. Suitable for exacting crops, suitable to very suitable for moderately exacting crops and very suitable for less exacting crops;
- **Class IV:** Soil index between 35 and 50. Moderately suitable for exacting crops, moderately suitable to suitable for moderately exacting crops and suitable for less exacting crops;
- **Class V:** Soil index between 20 and 35. Only slightly suitable for exacting crops, slightly to moderately suitable for moderately exacting crops and moderately suitable for less exacting crops; and
- **Class VI:** Soil index <20. Unsuitable for exacting crops, unsuitable to slightly suitable for moderately exacting crops and less exacting crops.

Table 15Table 15 summarises the various soil types and their extent within the study area, classified in terms of the WRB 2014 international soil classification system (World Reference Base – WRB: FAO; UISS, 2014), and correlated with the Congolese classification by INEAC (Sys, 1960; after Ngongo et al, 2009) and the Taxonomic System for South Africa (Soil Classification Working Group 1991).

Table 15: Soils Classified according to WRB (2014), correlated with DR-Congo and RSA Soil Classification Systems

Profile No.	WRB	Extent (ha, Approx. % Coverage)	Effective Depth for Representative Soil Profiles (cm)	DR-Congo	RSA
1	Haplic Ferralsol (Alumic, Endoclayic)	47.7 ha ~ 8%	80	Ferralsol typique	Clovelly (Oxidic, dystric, Deep haplic, clay)
2	Plinthic Ferralsol (Alumic, Endoclayic)	68.5 ha ~ 11%	80	Ferralsol typique	Clovelly form/ Avalon form (Oxidic, dystrophic, clay)
3	Rhodic Alisol (Alumic, Endoclayic) for soil profile 6	50.6 ha ~ 8%	65-100	Ferrisols	Hutton form (Oxidic, rhodic, dystrophic, Clayey)
3	Rhodic Alisol (Alumic, Endoclayic) for soil profile 2 and Sondage 4	291.5 ha ~ 49%	75-110	Ferrisols	Shortlands form (Oxidic, pedorhodic, dystrophic, clayey)
4	Endoplinthic Alisol (Alumic, endoclayic)	56.8 ha ~ 9%	90-110	Ferralsol intergrade Ferrisol	Bainsvlei form (Oxidic, rhodic, dystrophic, clayey),
4	Endoskeletic Cambisol (Alumic, Endoloamic)	4.9 ha ~ 0.8%	40-50	Sols tropicaux recents	Clovelly form (Oxidic, dystrophic, sandy clay loam)
6	Haplic Plinthosols (Alumic)	77.8 ha ~ 13%	45-70	Ferralsol typique	Avalon form (Plinthic, Soft-Xanthic, dystrophic, haplic)
7	Anthropogenic soil	0.08 ha ~ 0.01%	Not determined	*-not included in local classification system*	Witbank form

Figure 29~~Figure 29~~ shows the distribution of the soil types within the study area.

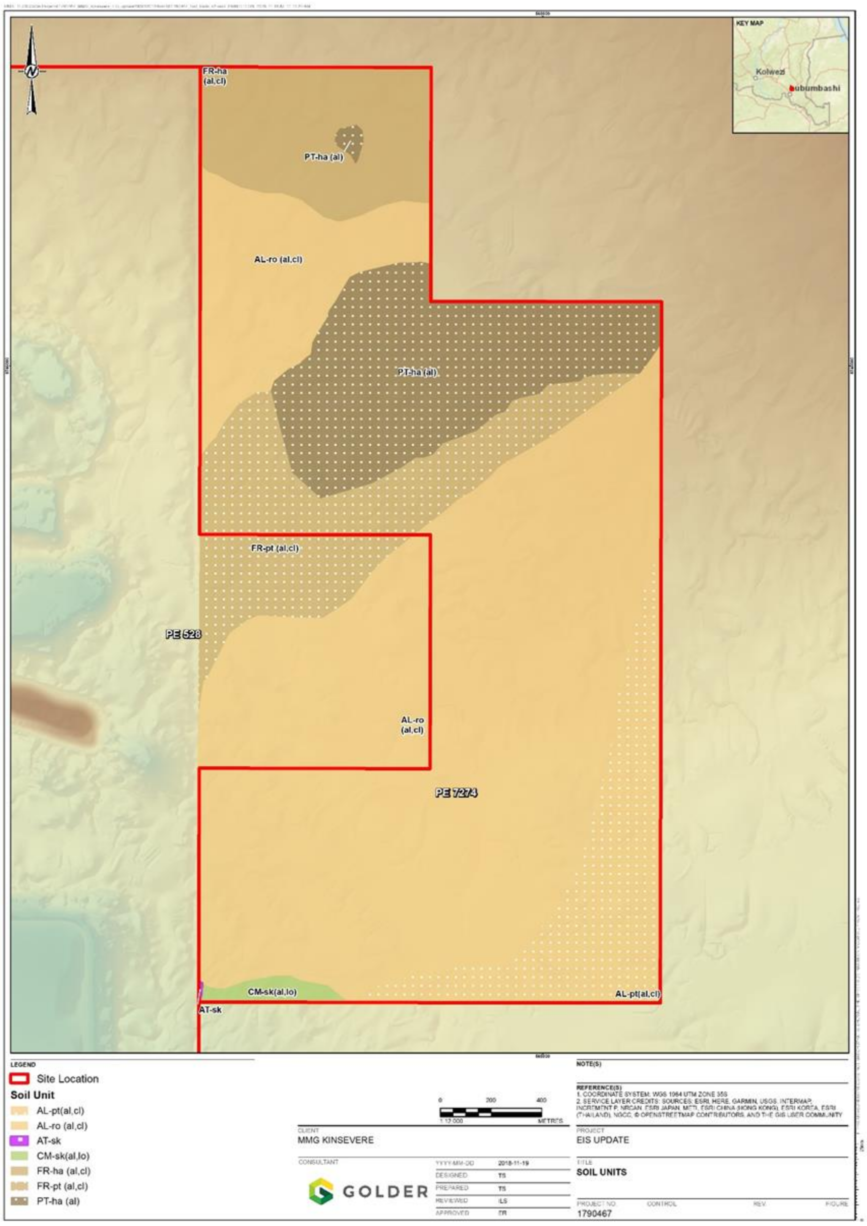


Figure 29: Soil Types within KEP Project Area on PE7274

3.2.1.2.2 Land Capability

The land capability classification (LCC) for annual crops of different soils within the KEP project area of PE7274 is summarised in Table 16Table 16. The distribution of the various land capability classes within the project area is illustrated on Figure 30Figure 30.

Table 16: Land Capability Index for Annual Crops of Different Soils within KEP Project Area of PE7274

RGS	Soil Group	A	B	C	D	E	F	CS	Class
Ferralsols	FR-ha(cl)	75	97	100	90	75	60	29	V
Ferralsols	FR-pt(cl)	75	90	100	90	75	40	20	VI
Alisols	AL-ro(cl)	100	93	100	100	75	40	28	V
Cambisols	CM-sk(lo)	100	81	85	90	75	40	19	VI
Alisols	AL-pt(cl)	100	62	100	75	75	60	21	VI
Plinthosols	PT-ha	75	75	85	60	75	40	9	VI

Legend: **CS**: capability index; **A**: rating for profile development; **B**: rating for texture; **C**: rating for depth; **D**: rating for colour/drainage conditions; **E**: rating for pH/base saturation; **F**: rating for the development of the A horizon

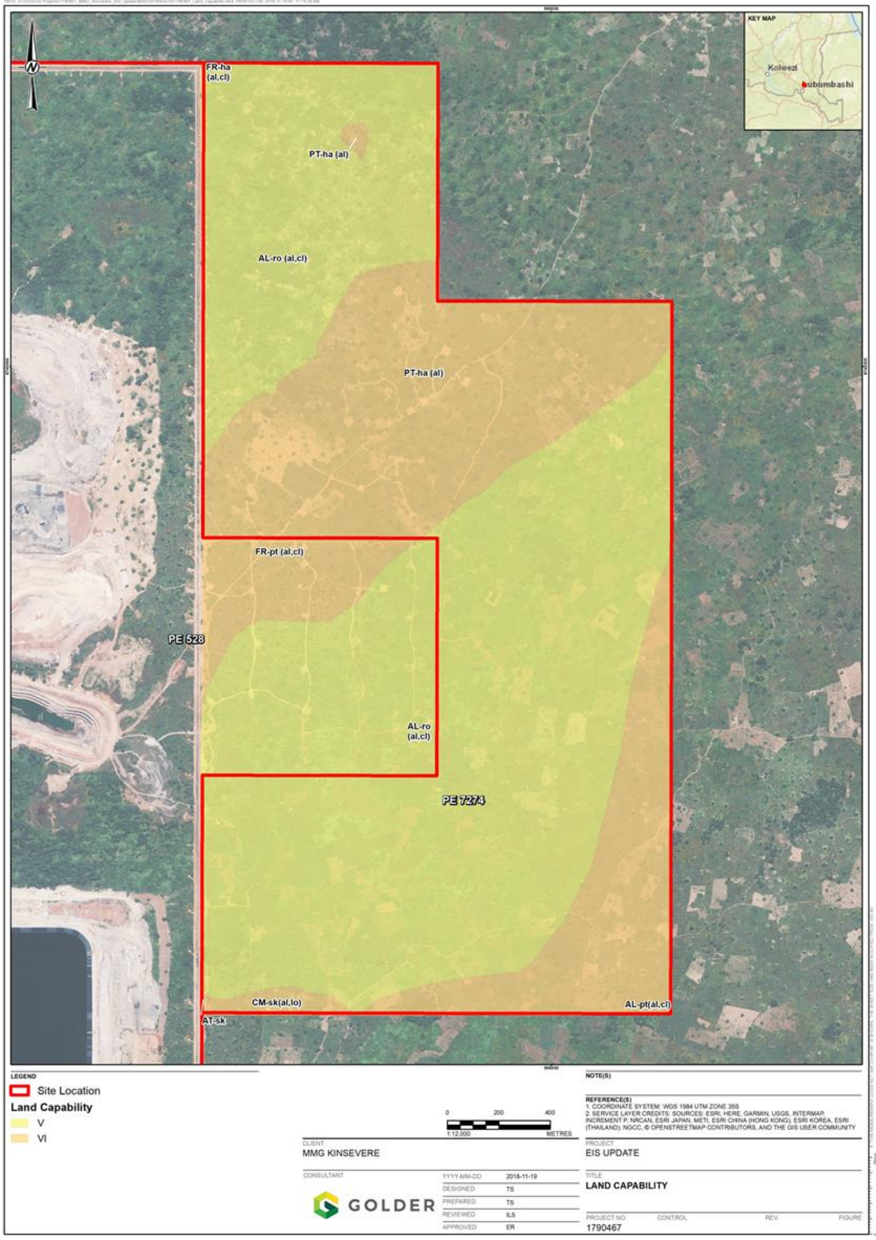


Figure 30: Land Capability within Study Area

3.2.1.2.3 Land Use

The land use in the project area was assessed from satellite imagery, drone survey and direct observation in the field. Current land use is shown on Figure 31~~Figure 31~~. It includes cropping (57.2%), wood cutting and charcoal making (30.8%) and forest (12%). Some exploration drilling was also observed. Vegetation clearing by burning is commonly practiced by farmers and the charcoal makers strip topsoil to cover their kilns. Cropping, wood cutting and charcoal making activities are undertaken by local communities and farmers seasonally.

3.2.1.2.4 Estimation of Soil Loss

The potential annual soil loss through sheet erosion was estimated using the Revised Universal Soil Loss Equation (R/USLE), which takes rainfall, topography, vegetation cover, land use and soil characteristics (particle size distribution, organic matter content structure and permeability) into account.

Figure 32~~Figure 32~~ illustrates the estimated potential for soil loss from various parts of the Kinsevere project area. The average soil loss was calculated as 13 ton.ha-1.yr-1 from the whole project area, and 14 ton.ha-1.yr-1 from the area where it is proposed to place the KEP project components on PE7274. Although these values exceed the FAO tolerance level (>12 ton.ha-1.yr-1), it is not unusual given that the Plinthosols, Cambisols and Anthropogenic soils are more prone to erosion than the other soil types occurring in the project area. Wildfires and the practice of burning vegetation to clear an area for farming results in bare areas with increased erodibility since the vegetation cover is removed and the organic matter content of the soil is reduced.

Soil loss can increase dramatically if the vegetation cover is removed or the soil is not stripped and stockpiled correctly (see mitigation measures in Section 5.5).

Figure 33~~Figure 33~~ illustrates the potential soil loss from bare, unvegetated soil within the areas where it is proposed to place the new TSF3, WRDs and other stockpiles. Under such conditions, the average soil loss would be about 96 ton.ha-1.yr-1.

As described in Sections 2.2.5.5, 5.5.7, and 5.9.2, the TSFs and WRDs will be covered with a 200 mm layer of topsoil and any exposed PAF waste rock will be covered with a 300 mm layer of topsoil. Taking into account that the surface area of a raised structure such as a TSF or a WRD is larger than its footprint area, the soil stripped from its footprint area will not be enough to cover its surface area with a layer of the same thickness. It is therefore important to minimise soil losses by the application of the mitigation measures described in Section 5.5.

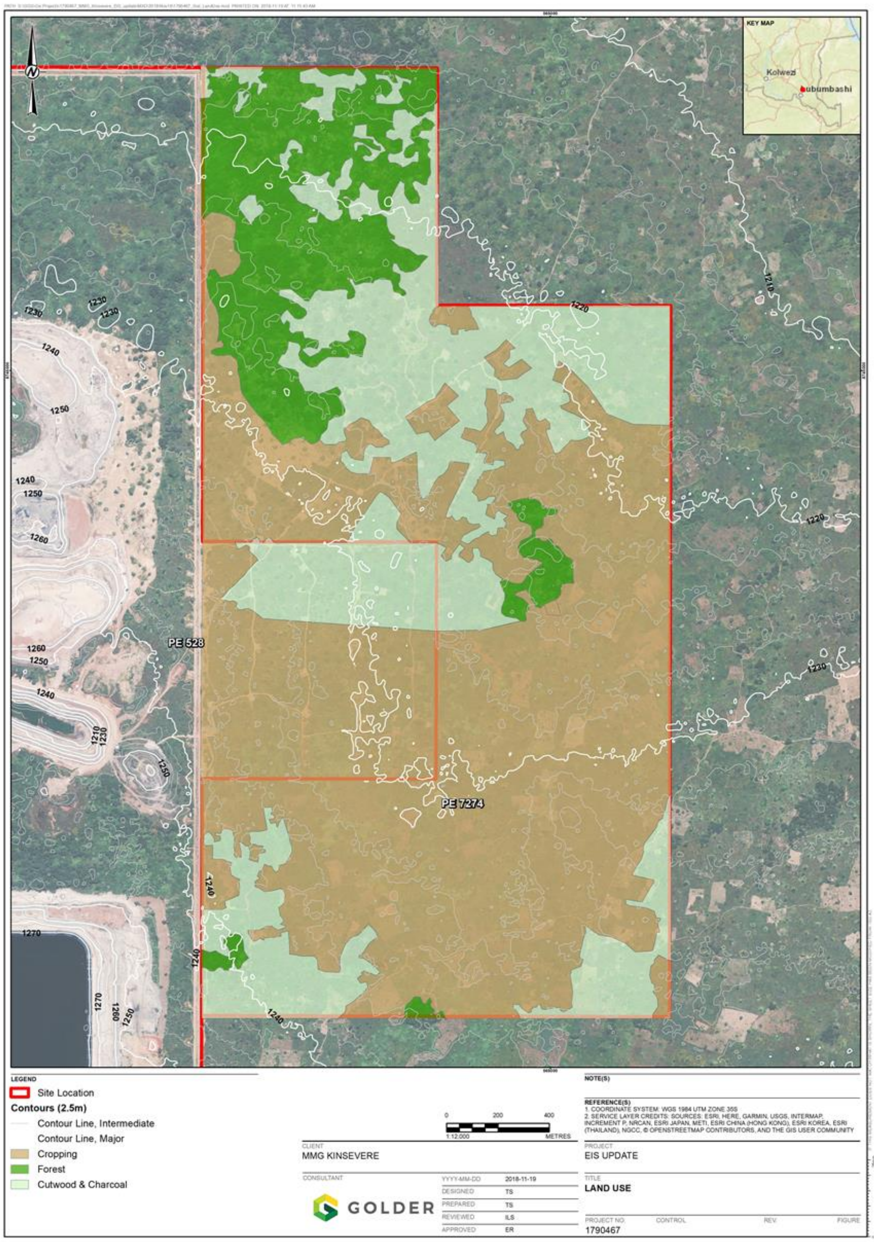


Figure 31: Land Use within Study Area

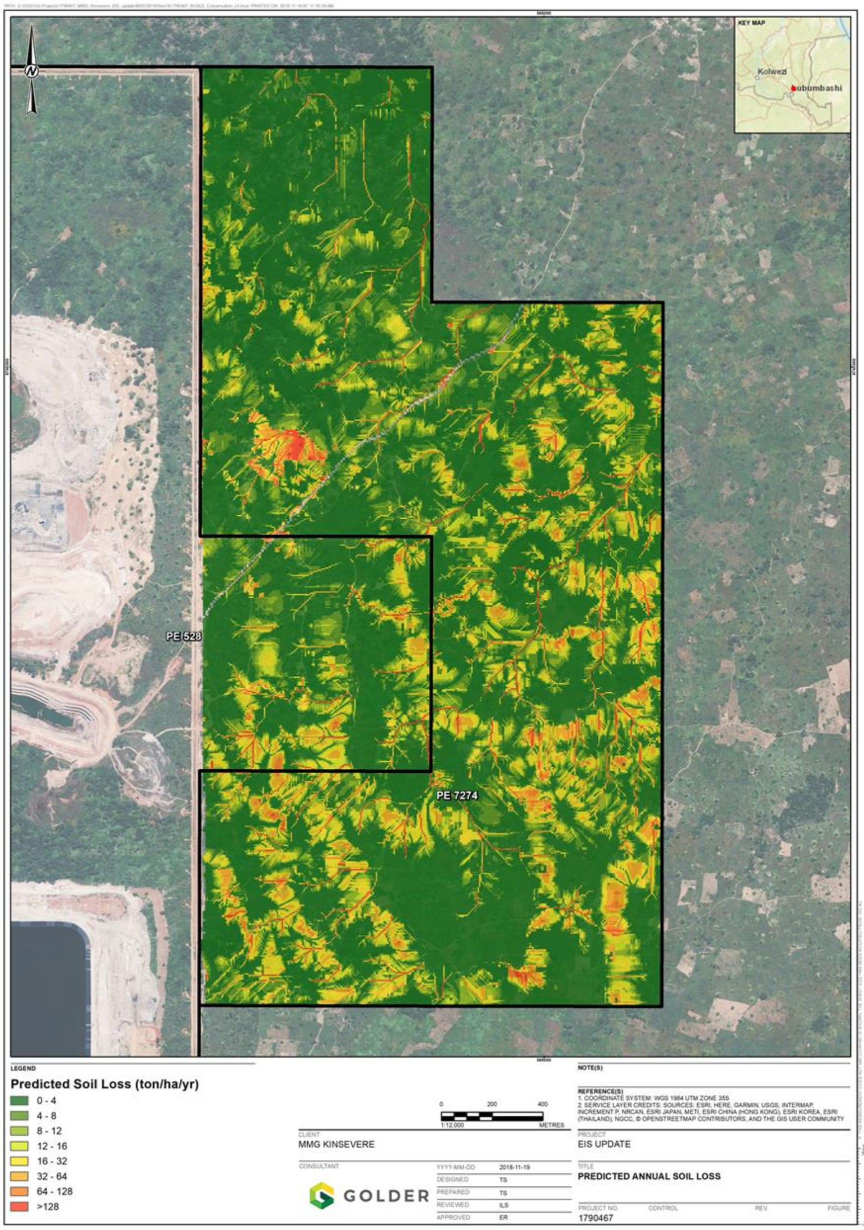


Figure 32: Estimated Potential for Soil Loss within KEP Project Area on PE7274 prior to Development

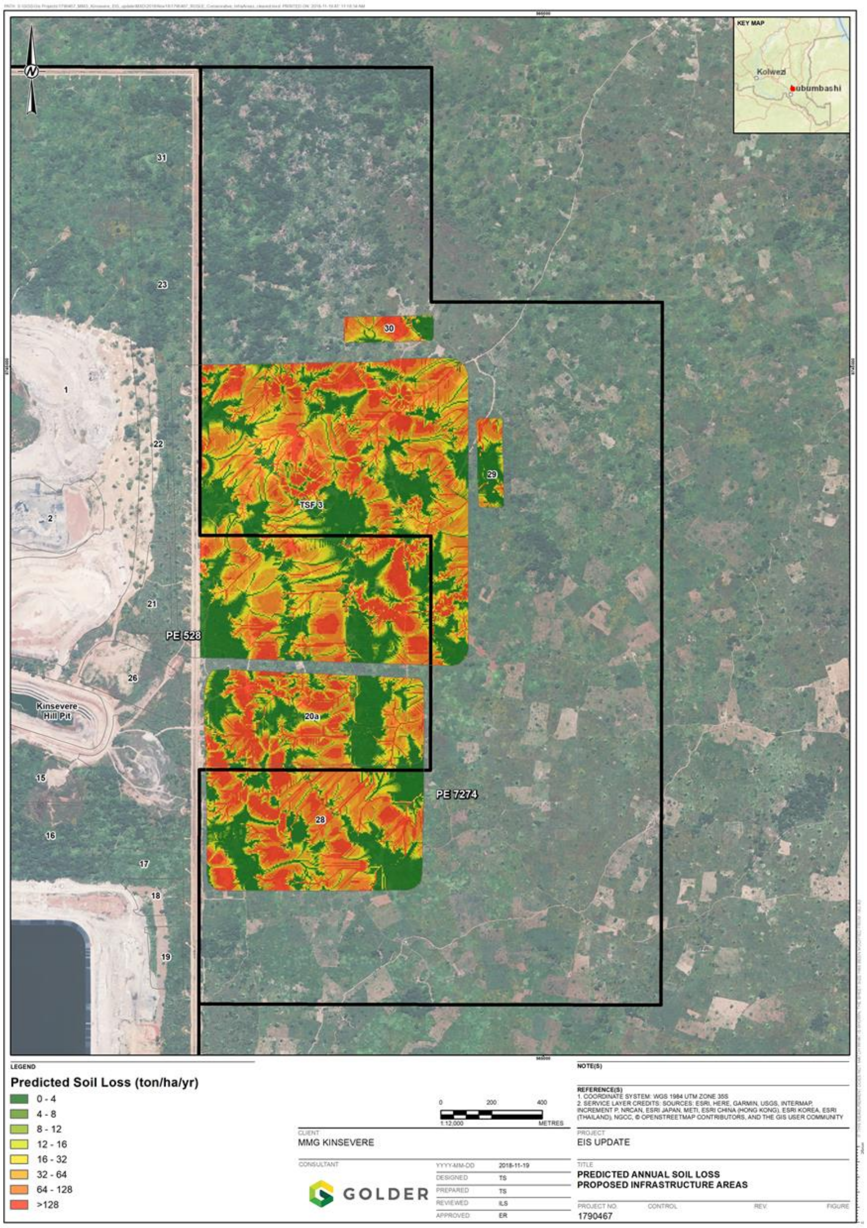


Figure 33: Estimated Soil Loss for Proposed Infrastructure Areas Following Removal of Vegetation

3.2.1.2.5 Availability of Soil

Table 17Table 17 indicates the estimated volumes and tonnages of topsoil and subsoil that could be stripped from each facility footprint and stockpiled to be available for rehabilitation.

Table 17: Estimated Topsoil (A-horizon) and Subsoil (B-horizon) Volumes and Tonnage

Soil Type	Soil Code	Facility	Facility Footprint Area	A Horizon	B Horizon	A Horizon	B Horizon
Unit			m^2	m	m	m^3	m^3
Alisols	AL-ro (al,cl)	Stockpiles 20a	307167	0.14	0.56	43003	172013
Alisols	AL-ro (al,cl)	Stockpiles 28	422291	0.14	0.56	59121	236483
Alisols	AL-ro (al,cl)	Stockpiles 29	12312	0.14	0.56	1724	6895
Alisols	AL-ro (al,cl)	TSF 3	305050	0.14	0.56	42707	170828
Plinthosols	PT-ha (al)		323405	0.14	0.31	45277	100256
Alisols	AL-ro (al,cl)		60088	0.14	0.56	8412	33649
Ferralsols	FR-pt (al,cl)		556029	0.08	0.72	44482	400341
Average horizon depth				0.13	0.52		
Total volume (m^3)						251726	1147788
Estimated Total tonnage[1]						352 416 to 390 175	1 606 903 to 1 779 071

Notes: [1] Tonnage calculated from estimated moist bulk density values by texture (USDA)

3.2.1.3 Geochemistry – Sulphide Mine Waste

Previous geochemical investigations on drill cores (Thierry, B K M;, November 2017) found that:

- The Black Shale associated with the sulphide ore is decidedly PAF and likely to produce ARD almost immediately upon exposure to leaching under atmospheric conditions;
- About 60% of the samples of waste rock associated with sulphide ore were PAF; and
- Pilot plant tailings samples based on a composition (50% SD ore and 50% CMN ore), representative of the average processing plant throughput, were classified as NAF.

More information on the geochemistry of the ore and waste rock is provided in Sections 2.9 and 3.2.1.3.

3.2.1.4 Climate and Air Quality (Article 29)

3.2.1.4.1 Regional Climate

Most of DRC is situated within the Inter-Tropical Convergence Zone (ITCZ), a region characterised by high convective activity with well-defined regions of ascent and associated regional subsidence, typically resulting in high rainfall conditions (Golder, 2017g). The ITCZ band migrates between the northern and southern hemispheres (within approximately 10° on either side of the equator) between the months of January and July (Preston-Whyte and Tyson, 1997).

The mean circulation patterns in this area are dominated by tropical easterly flows that converge around the equator (Preston-Whyte and Tyson, 1997).

When the easterly flows cross the equator from north to south, the Coriolis effect causes the flows to deflect from left to right (Note: When crossing south to north the effect is reversed and deflection is right to left), resulting in an immediate re-curvature of the flow such that the winds acquire a westerly component.

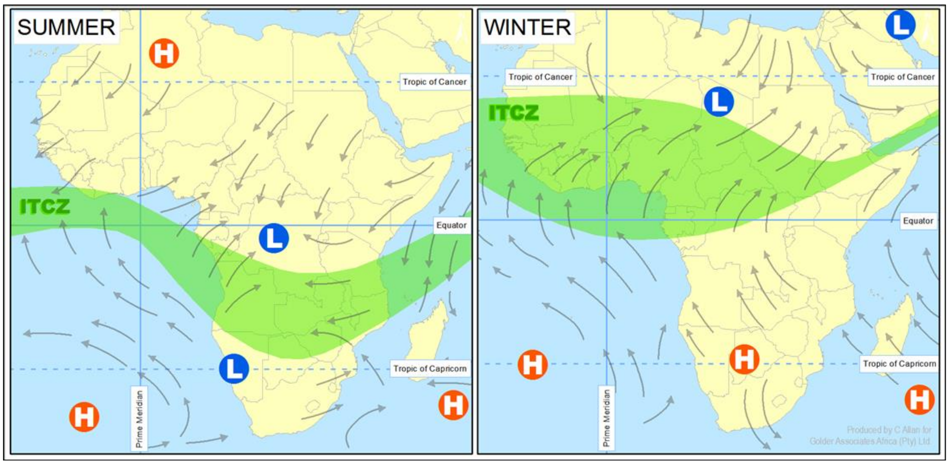


Figure 34: Intertropical Convergence Zone (ITCZ) Variation across Southern Africa Throughout Year

3.2.1.4.2 Local Climate and Meteorology

MMG's Kinsevere mine has a weather station that records hourly precipitation, temperature, atmospheric pressure, wind speed and direction, humidity and solar radiation. Data is available for the period 2013-2017.

3.2.1.4.2.1 Temperature

Temperature data was sourced from the ClimaTemps website and the Kinsevere weather station. The climate is very similar in the two areas, with humid, hot summers and mild, dry winters (see Table 18~~Table 18~~ and Figure 35~~Figure 35~~).

Table 18: 2017 Kinsevere and Lubumbashi Weather Station Monthly Temperatures

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Kin_Ave Max 2017 (highest daily temp) (°C)	26.6 (28.9)	28.8 (32.5)	32.1 (34.5)	32.4 (36.4)	30.4 (36.4)	28.4 (31.6)	28.2 (31.2)	28.2 (32.9)	27.7 (30.4)	27.9 (31.6)	28.1 (30.5)	26.9 (28.2)
Kin_Ave 2017 (°C)	18.1	20.3	23.2	24.5	22.9	21.8	21.4	21.2	21.3	21.0	20.7	18.6
Kin_Ave Min 2017 (lowest daily temp) (°C)	10.1 (7.7)	12.3 (9.5)	14.0 (9.3)	17.8 (12.9)	18.3 (16.5)	18.1 (17.1)	18.0 (17)	18.0 (17)	17.6 (15.5)	16.9 (13.7)	14.8 (12.4)	11.1 (7.8)
Kin_Ave Max 2013-2017 (°C)	27.24	29.75	32.83	33.40	31.65	29.70	22.52	23.04	23.72	22.86	28.61	27.31
Kin_Ave 2013-2017 (°C)	17.82	20.62	23.26	24.74	24.83	22.01	17.18	17.10	17.64	16.91	19.90	18.03
Kin_Ave Min 2013-2017 (°C)	8.86	11.28	14.20	16.99	18.02	17.96	14.38	14.23	14.19	13.20	12.61	9.71
Lub_Ave Max Temp (°C)	25	28	31	32	29	27	27	27	27	28	27	25
Lub_Average Temp (°C)	17	19.5	22.5	24	23	22	22	22	22	21.5	19.5	17

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Lub_Ave Min Temp (°C)	9	11	14	16	17	17	17	17	17	15	12	9

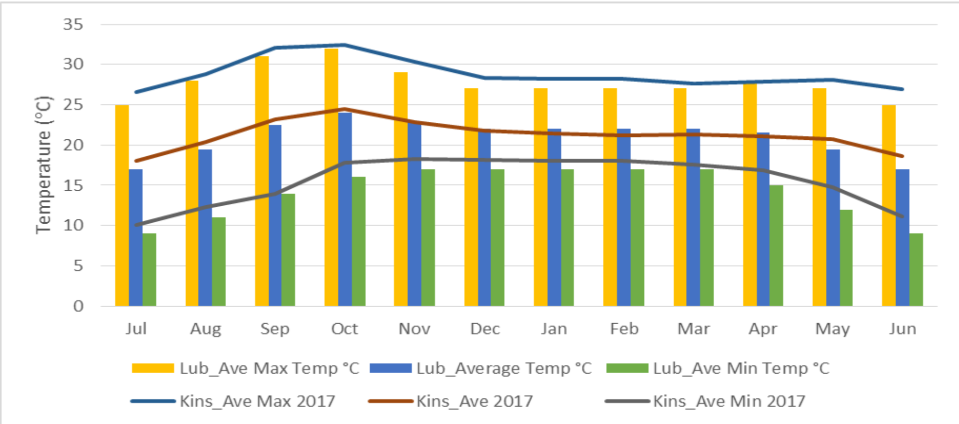


Figure 35: 2017 Kinsevere and Lubumbashi Weather Station Average Minimum and Maximum Temperatures

3.2.1.4.2.2 Rainfall and Evaporation

Historical monthly rainfall data for the period October 1927 to January 2018 was obtained for the town of Kipushi, approximately 50 km south-east of the mine – see Table 19~~Table 19~~ and Figure 36~~Figure 36~~.

Table 19: Monthly Rainfall and Evaporation Data for Kinsevere 2017 and Kipushi (average for 1927 to 2017)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Annual
2017 Kinsevere rainfall (mm)	0	0	0	82	85	282	262	138	227	112	0	0	**1 190**
Average Kipushi rainfall (mm)	0	1	5	35	151	256	257	240	205	56	6	1	**1 213**
2013-2017 Kinsevere Evap. data	109	121	137	131	140	119	110	101	121	108	123	107	**1426**
Relative humidity (%)	56	48	36	52	70	80	82	84	81	80	69	61	

The mean monthly evaporation exceeded the mean montly rainfall for the period May – November, peaking during November.

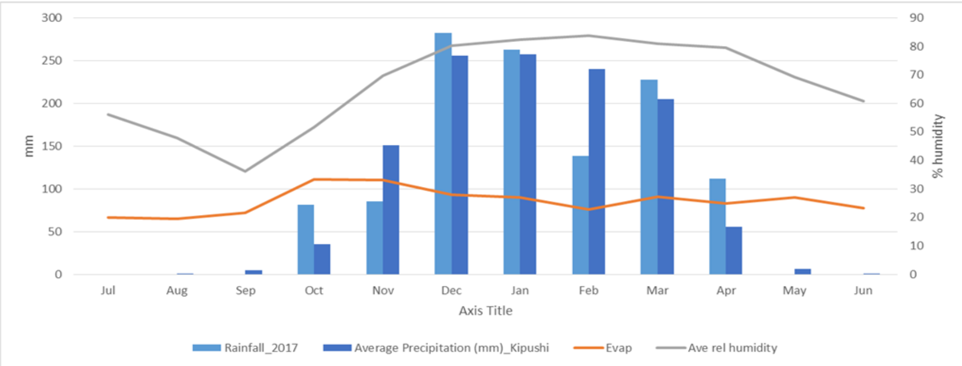


Figure 36: Average Historical Rainfall Measured at Town of Kipushi (1927 to 2018) Compared to 2017 Rainfall and Relative Humidity Data Recorded at Kinsevere

Annual rainfall for the Kipushi station is shown in Figure 37~~Figure 37~~. The plot shows that the annual rainfall depths are highly variable with periods where annual rainfall is well below the average rainfall (indicated by the orange line). The overall trend on the graph shows annual rainfall decreasing over the years, with the years from 1980 being lower than the average.

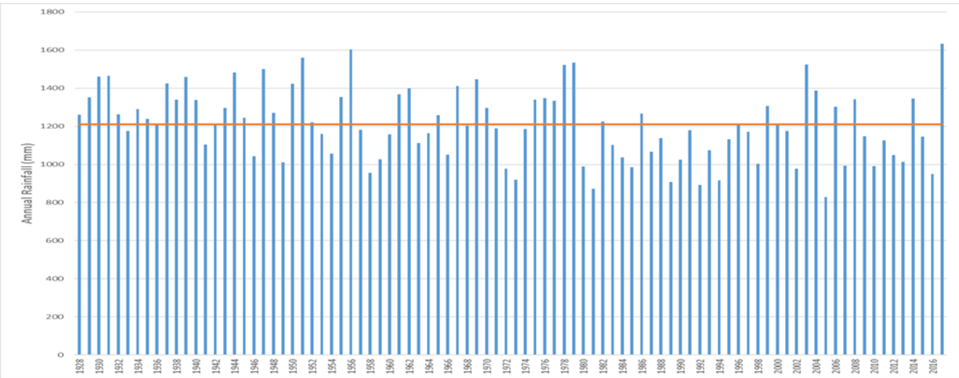


Figure 37: Annual Rainfall at Kipushi Rain Gauge from October 1927 to January 2018

3.2.1.4.2.3 Relative Humidity

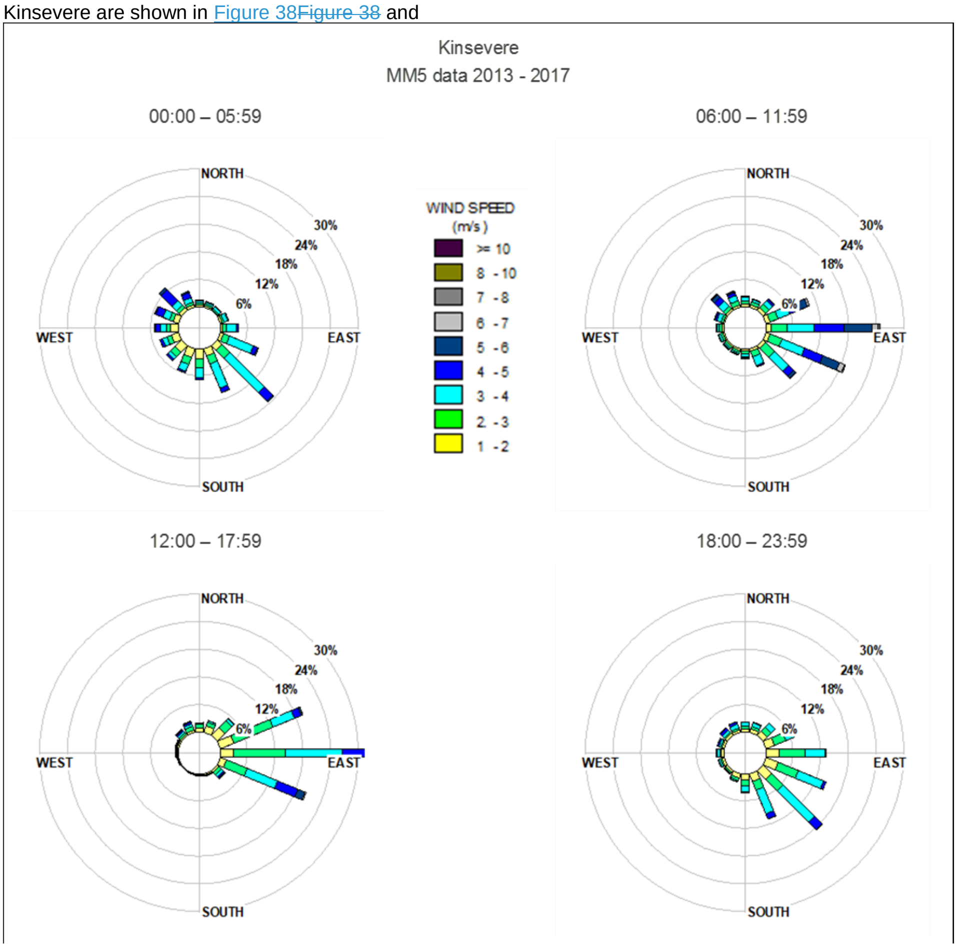
The average monthly relative humidity, ranging from 36% in September to 84% in February, taken from the data measured at the meteorological station at Kinsevere for 2017 has been compared to the average monthly relative humidity recorded at Lubumbashi (Table 20~~Table 20~~).

Table 20: Average Humidity at Lubumbashi and Kinsevere (2017)

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Relative Humidity_Lub (%)	56	46	43	48	70	81	82	84	81	75	65	61
Relative Humidity_Kins (%)	56	48	36	52	70	80	82	84	81	80	69	61
Ave Dew Point Temp °C	8.2	7.6	9.3	12.3	17.2	18.6	18.8	19.2	18.6	16.9	12.8	9.4

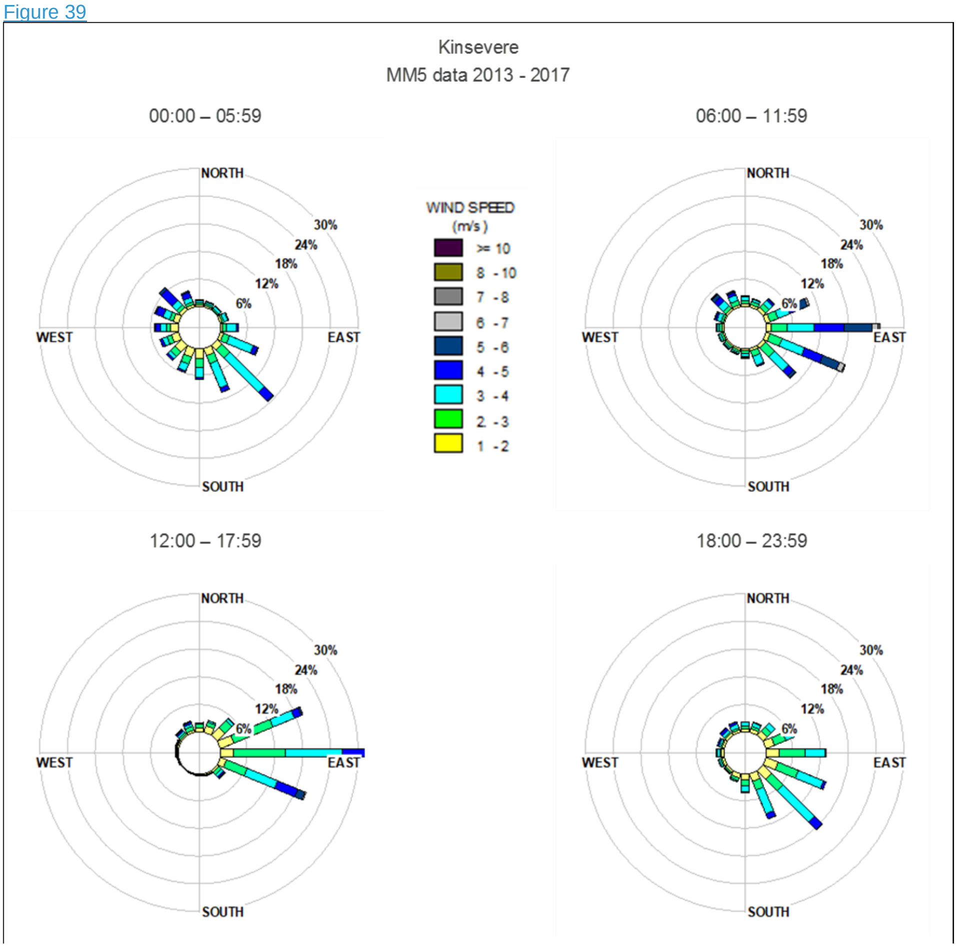
3.2.1.4.2.4 Wind Roses

Wind roses summarise the occurrence of winds at a specified location by representing their strength, direction and frequency. Calm conditions are defined as wind speeds of less than 1 m/s, which are represented as a percentage of the total winds in the centre circle. Each directional branch on a wind rose represents wind originating from that specific cardinal direction (16 cardinal directions). Each cardinal branch is divided into segments of different colours which represent different wind speed classes. The wind roses for Kinsevere are shown in Figure 38~~Figure 38~~ and



Month	Wind Speed	Dominant Sector		Dominant Sector		Calms	Missing
00-05	2.6 m/s	ESE-SSW	55%	NW	8%	11%	0%
06-11	3.4 m/s	ENE-SE	67%	0	0%	6%	0%
12-17	2.7 m/s	ENE-ESE	79%	0	0%	7%	0%
18-23	2.3 m/s	ENE-SSE	72%	0	0%	13%	0%

Figure 39

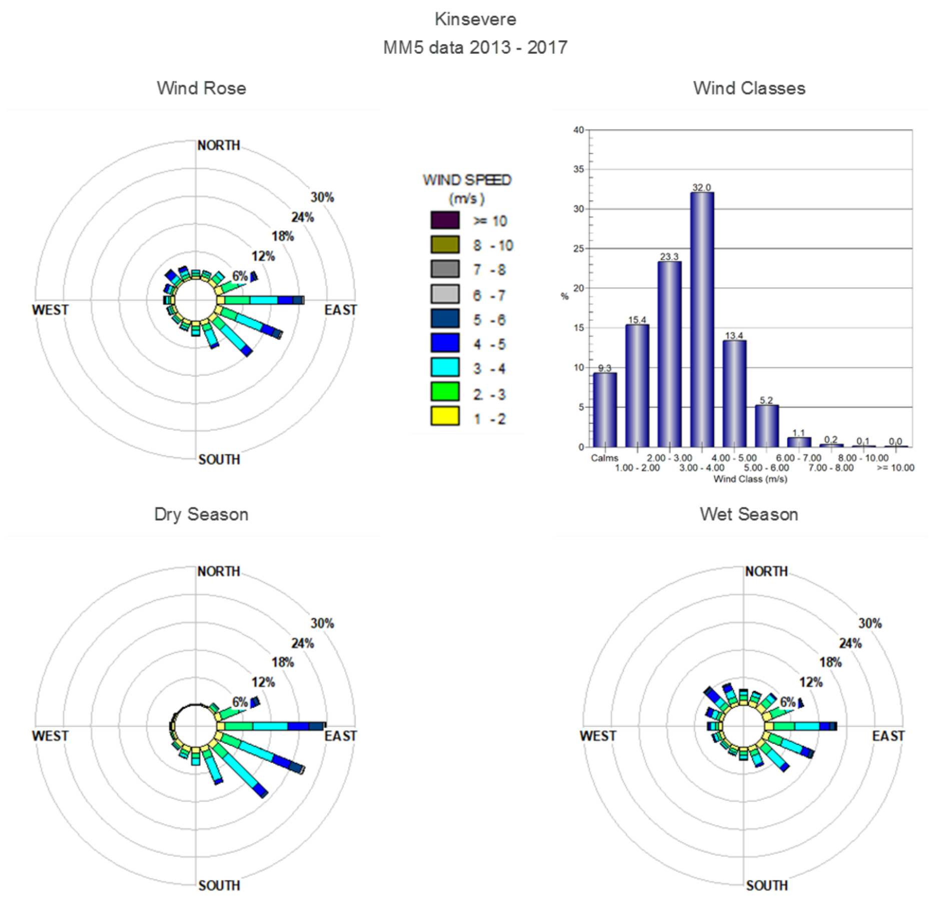


Month	Wind Speed	Dominant Sector		Dominant Sector		Calms	Missing
00-05	2.6 m/s	ESE-SSW	55%	NW	8%	11%	0%
06-11	3.4 m/s	ENE-SE	67%	0	0%	6%	0%
12-17	2.7 m/s	ENE-ESE	79%	0	0%	7%	0%
18-23	2.3 m/s	ENE-SSE	72%	0	0%	13%	0%

Figure 39.

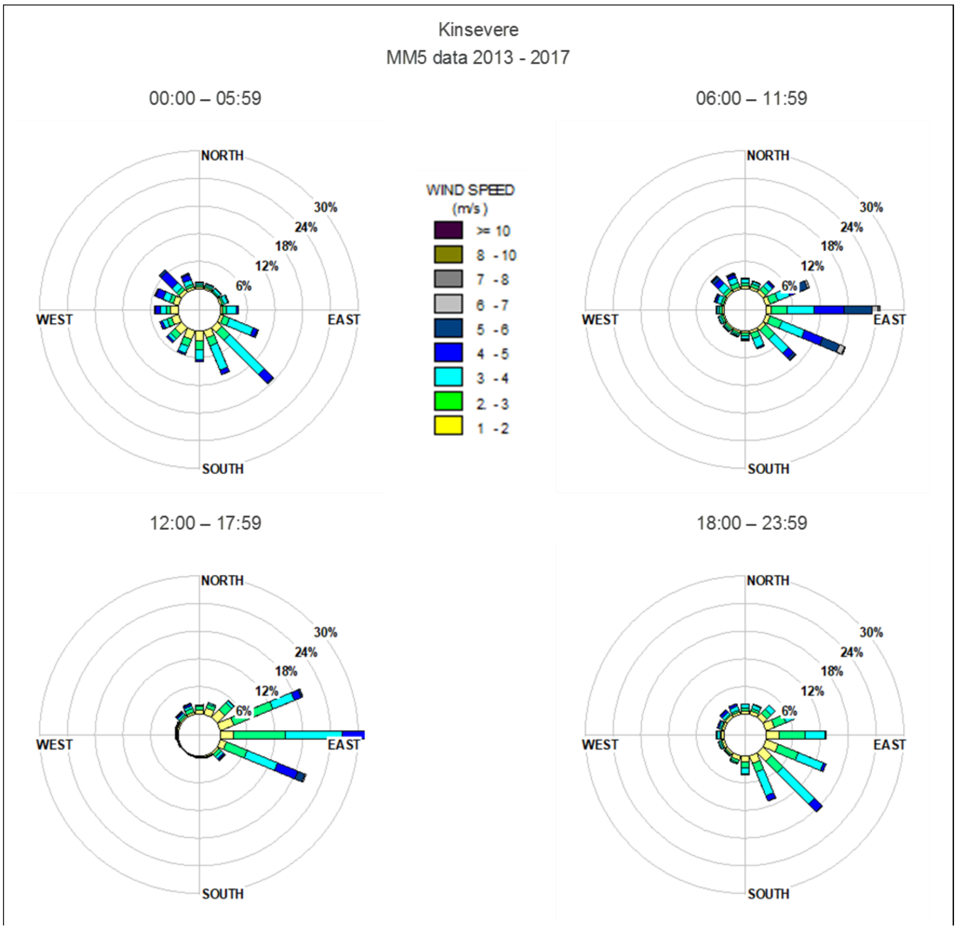
3.2.1.4.2.5 Risk of Meteorological Disasters

Based on available weather records for Kinsevere and Lubumbashi, and a literature search for severe weather events in the south-eastern region of the DRC, it may be concluded that the risk of disastrous meteorological events at Kinsevere is low.



Month	Wind Speed	Dominant Sector		Dominant Sector		Calms	Missing
2013-2017	2.8 m/s	ENE-SE	50%	NW	7%	11%	0%
Dry (May-Sep)	3.0 m/s	ENE-SSE	85%	-	-	6%	0%
Wet (Oct-Apr)	2.6 m/s	ENE-SE	50%	NW	7%	11%	0%

Figure 38: Kinsevere Period and Seasonal Wind Roses



Month	Wind Speed	Dominant Sector		Dominant Sector		Calms	Missing
00-05	2.6 m/s	ESE-SSW	55%	NW	8%	11%	0%
06-11	3.4 m/s	ENE-SE	67%	0	0%	6%	0%
12-17	2.7 m/s	ENE-ESE	79%	0	0%	7%	0%
18-23	2.3 m/s	ENE-SSE	72%	0	0%	13%	0%

Figure 39: Kinsevere Diurnal Wind Roses

3.2.1.4.3 Local Ambient Air Quality

The current air pollution sources in the region include:

- Mining and processing activities;
- Combustion engines (vehicles);

- Unpaved roads and exposed areas;
- Domestic fuel burning;
- Clay brick manufacturing;
- Charcoal production; and
- Biomass burning.

Measuring of pollutants associated with mining operations that are regulated within the DRC, namely SO_2, NO_2 and PM_{10}, was undertaken in the vicinity of the Kinsevere mine concession area and surrounds – see Table 21~~Table 21~~ and Figure 40~~Figure 40~~.

Table 21: Monitoring Program

#	Name	UTM 35 L X (m)	UTM 35 L Y (m)	Elevation Z (mamsl)	Parameters
DT3/DM3	Expat Camp	560222	8743160	1267	NO_2, SO_2, PM_{10}
DT4/DM1	Kinsevere Hill	563446	8743437	1254	NO_2, SO_2, PM_{10}
DT5	South End Tailings Dam	563194	8742062	1261	NO_2, SO_2
DT6/DM4	Main Gate Entrance	561668	8741996	1265	NO_2, SO_2, PM_{10}
DT7/DM2	Dewatering Outfall	561854	8745630	1223	NO_2, SO_2, PM_{10}
DT8	Clinic/Kilongo School	560890	8744576	1233	NO_2, SO_2
DT11/DM5	Kilongo Village	561024	8745437	1219	NO_2, SO_2, PM_{10}
DT12/DM6	Mpundu Village	562239	8746722	1208	NO_2, SO_2, PM_{10}
DT13/DM7	Mumba Village	556313	8743828	1236	NO_2, SO_2
DT14	New Tenement SE	565027	8741786	1247	NO_2, SO_2
DT15	New Tenement NE	564976	8744971	1230	NO_2, SO_2

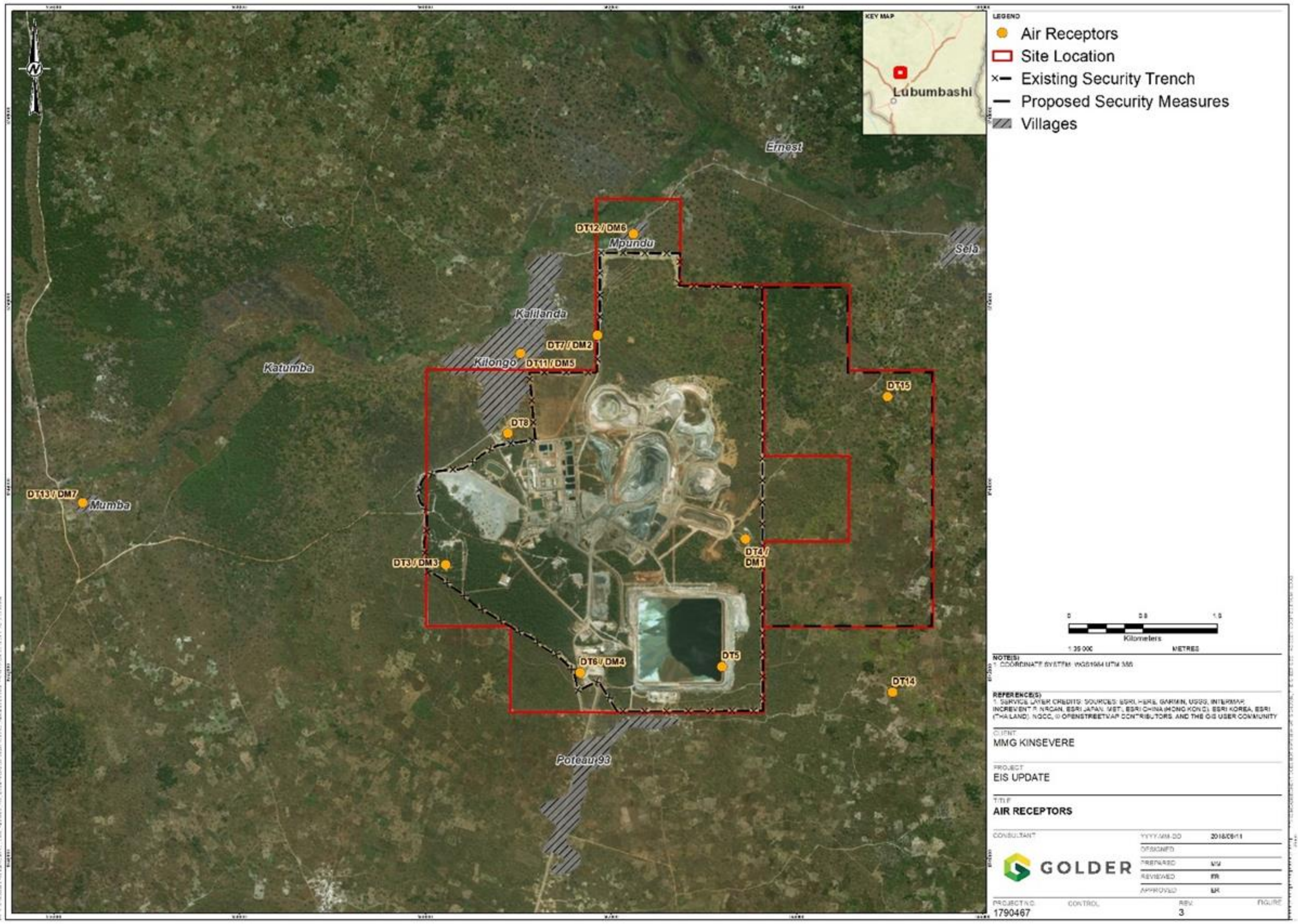


Figure 40: Air Quality Sampling Locations

The baseline data presented here incorporates historical and current data from the ongoing wet and dry season ambient air quality monitoring programme that was established as part of the original Kinsevere Copper Mine EIS (Meyer, A;, September 2016).

The monitoring results for NO_2 and SO_2 are shown in Figure 41Figure 41 and Figure 42Figure 42.

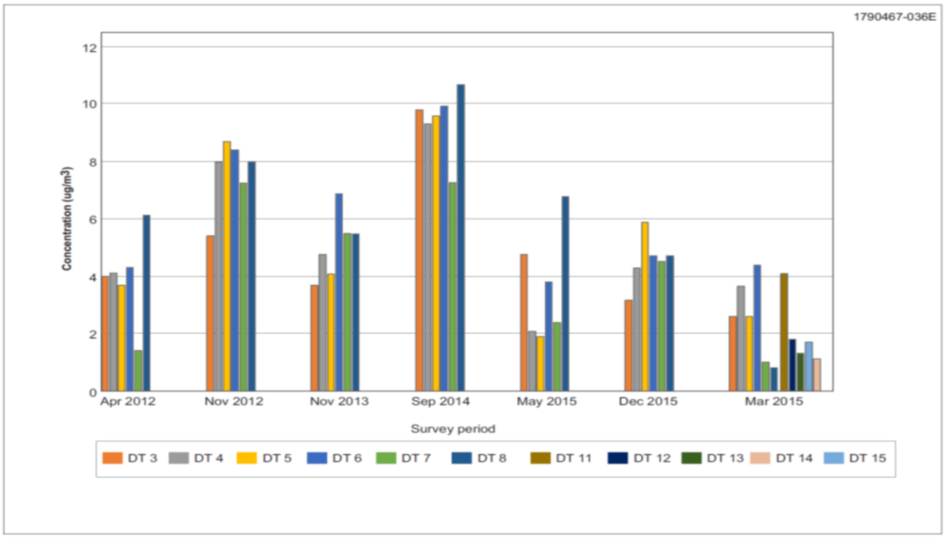


Figure 41: Results of NO_2 Monitoring Campaigns (WKC, 2016)

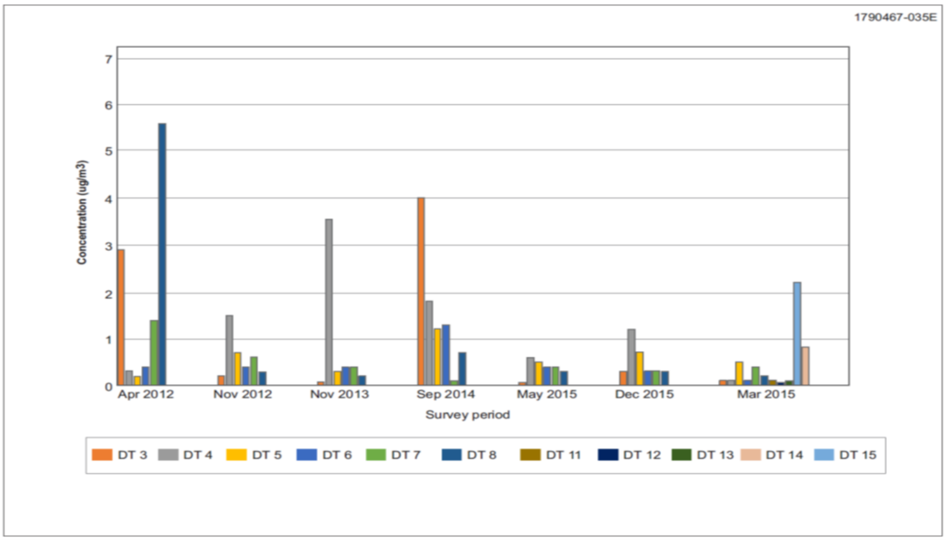


Figure 42: Results of SO_2 Monitoring Campaigns (WKC, 2016)

The PM_{10} monitoring results are shown in Figure 43Figure 43.

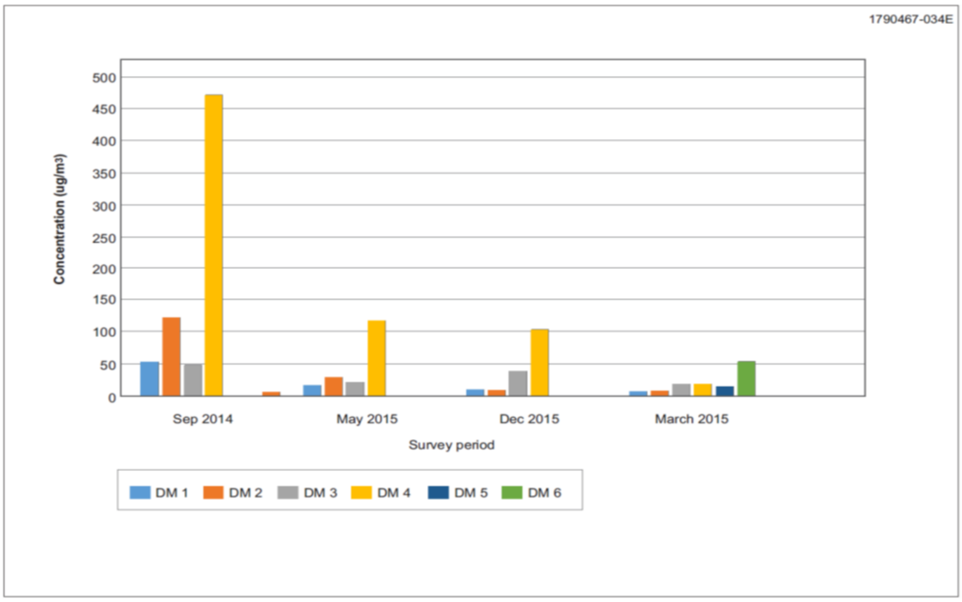


Figure 43: Results of PM_{10} Monitoring Campaigns (WKC, 2016)

The monitoring results indicate that the ambient concentrations of NO_2 and SO_2 were below the relevant DRC ambient air quality standards in all areas that were sampled. The low results are to be expected as NO_2 and SO_2 are products of combustion, and there are no significant sources of NO_2 and SO_2 within the concession area, apart from the mining vehicles, periodic waste burning and power generators (when in use). The PM_{10} results show that ambient concentrations were also below the relevant standard at the monitoring locations at concession boundaries and surrounding areas during the survey periods.

3.2.2 Description of Water Sources and Watercourses (Article 30)

3.2.2.1 Regional Watercourses

The Kinsevere Copper mine is located in the upper reaches of the Luiswishi River Basin, a tributary of the Luapula River. The Luapula River forms part of the Lake Mweru Catchment, within the Congo River Basin. The Kifumashi River and its tributaries drain the project area in a northerly direction towards the Luiswishi River running from west to east. The Kifumashi is a perennial, first order tributary of the Luiswishi River (Thierry, B K M;, November 2017). A number of streams and drainage lines run across the two tenements – see Figure 19.

The Kifumashi River runs 1.8 km north of the plant area at its nearest point and 1.3 km north of the settling dam. The river is characterised by a low gradient and an extensive sedge-dominated (*Cyperus* sp.) marshland (dambo) about 300 m wide.

These marshes and riparian margins have been impacted significantly by dryland irrigation activities, but there is a relic patch of swamp forest (mushitu) located approximately 9 km downstream of the mine (Nepid, 2008a). There are no dams or weirs in this part of the river and stream flow patterns are likely to be close to natural, reflecting seasonal precipitation.

Rural communities near the mine rely heavily on groundwater. Most of their potable water is sourced from boreholes and wells, but drinking water is also sourced directly from the Kifumashi River. Yields from groundwater sources are generally quite high and are of sufficient quality for basic domestic purposes, with monitoring indicating that the groundwater is generally of good quality.

Groundwater from dedicated water supply boreholes is abstracted to supply potable water to the Mine's residential camps and offices. The largest abstraction occurs within and around the perimeter of the pits.

Raw water abstracted by the mine dewatering boreholes is pumped to the main raw water holding tank in the utilities area. It is used as make-up water in the ore processing circuit, fire water, cooling water, preparing reagents and for heating electrolyte when required. It is also treated and used as potable water.

MMG Kinsevere has invested considerably in the social environment surrounding the mine. Potable water points supplied by MMG Kinsevere and the river system are important to surrounding villages and are included in the monitoring program. In addition to community hand pumps there are also numerous potable water points in and around the mining concession. All potable points are analysed quarterly for a suite of potable water quality parameters. Potable water is evaluated against World Health Organization (WHO) guidelines for drinking water, which satisfy DRC effluent discharge criteria. The chemical analysis is conducted by a South African National Accreditation System (SANAS) accredited laboratory in South Africa. Bacteriological analysis of all potable points is conducted on site. Two methods, namely Colliert 18 and E*colite, are used to determine the presence and quantity of E. coli and coliforms.

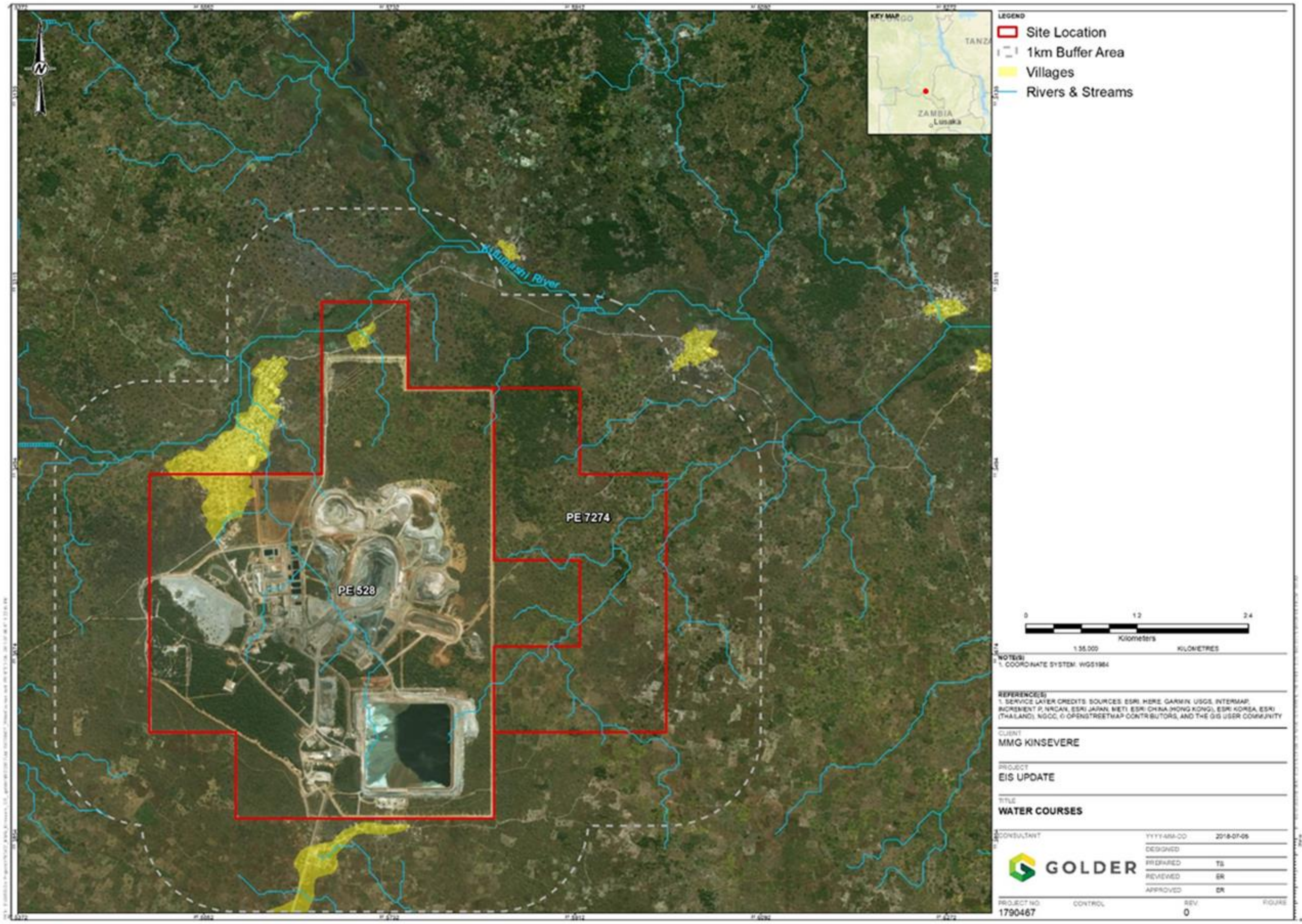


Figure 44: Watercourses at Kinsevere

3.2.2.2 Water at Kinsevere Mine

Surface water within the Kinsevere mining and ore processing complex is classified as either contact or non-contact water as defined in Table 22~~Table 22~~ and illustrated in Figure 45~~Figure 45~~ (Knight Piésold Report PE301-00135/51, Rev A). The Water Balance is shown in Section 2.6.1.

Table 22: Types of Water on Site

Water Type	Characteristics
Non- *contact water* and *non-contact water* (clean water)	■ Water from undisturbed areas of the site; ■ Diverted off site or reports to existing ponds; ■ Considered to meet DRC release water quality guidelines; or ■ Contaminated water that has been treated to a level that meets DRC release guideline limit values.
Contact water: Sediment water	■ Water from cleared or disturbed areas likely to have a high sediment load, in excess of the DRC Total Suspended Solids (TSS) limit value of 100 mg/L; and ■ Water quality may be close to pH limits at times but not consistently enough to warrant active treatment.
Contact water: Acid Water	■ Water that is consistently highly acidic due to the nature of the process or the source of the runoff; and ■ This water should be the highest priority process water source to ensure that treatment and release is not required.

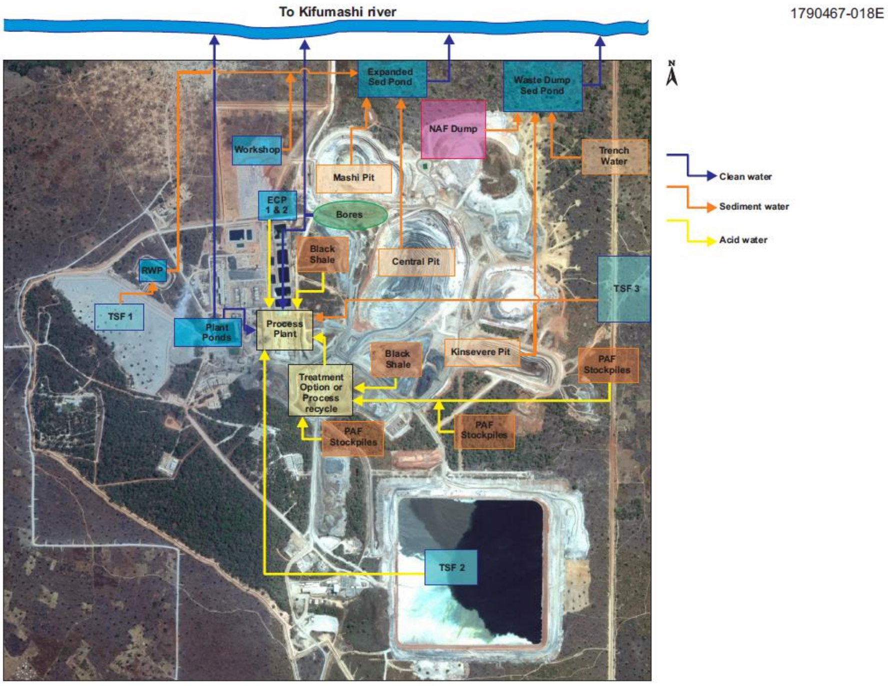


Figure 45: Three Types of Water at Kinsevere Mine Site

3.2.2.3 Water Quality

A Golder hydrologist visited surface and groundwater monitoring sites on the mine, within the plant area and along the Kifumashi River during the week of 16 - 20 April 2018. Water quality samples and field readings were taken and information generated by the Mine's water quality monitoring program was reviewed (Boyd, L; Coleman, T;, July 2018).

The average water quality data for the Kifumashi River/receiving environment samples are set out in Table 25Table 25. The concentrations of total dissolved solids and some metals at the discharge point SWK04 are higher than the average concentrations in the Kifumashi River – see Figure 46Figure 46. Further upstream, at SWK01, total suspended solids are elevated, very likely due to community activities, such as washing of motorbikes and clothes at the bridge.

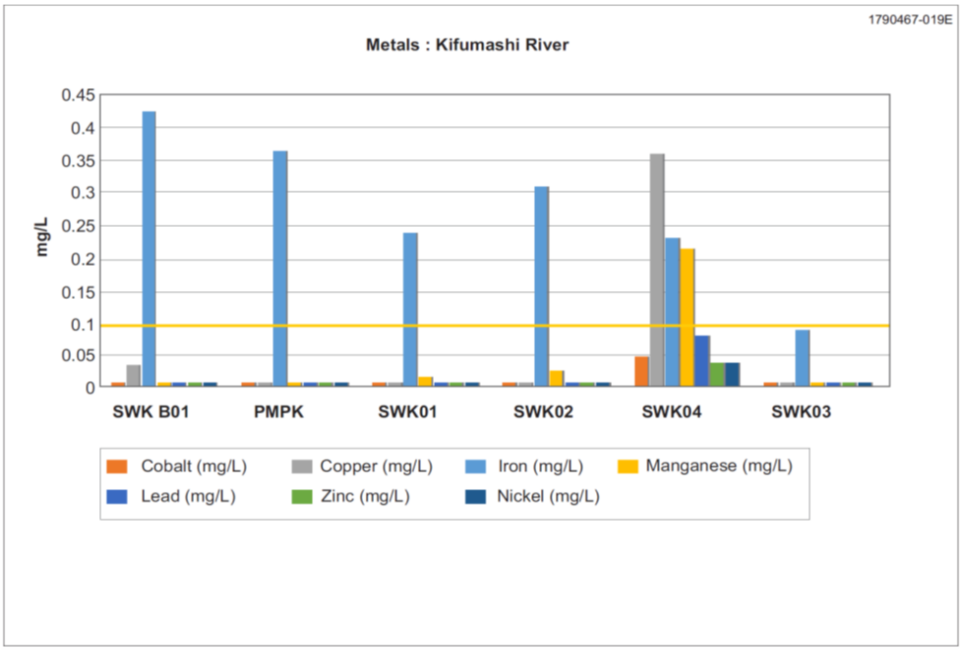


Figure 46: Average Metal Concentrations at Kifumashi River/Receiving Environment Monitoring Sites

The average water quality data for the pit water samples in 2017 is shown in Table 23Table 23. Manganese was elevated in Pit C, Pit CB, Pit C 03 and Pit M02 (Table 23Table 23) and cobalt in PIT M02 (sedimentation pond). Manganese becomes noticeable at concentrations >0.05 mg/L by imparting colour, odour, or taste to the water and people would naturally avoid drinking it. Health effects are not a concern until concentrations are about 10 times higher.

The quality of the abstracted groundwater (Table 31Table 31), which is co-discharged with the water pumped out of the pit sumps (Table 23Table 23), is good and the water discharged to the Kifumashi River at the point SWK04 meets all the legal and licence requirements for discharge (Figure 46Figure 46).

Table 23: Average Water Quality Data for Pit Water Samples (monthly data 2017)

Parameter	Units	DRC Effluent Discharge Limits	PIT C	PIT CB	PIT C 03 (Sediment Pond)	PIT M	PIT M02 (Sediment Pond)
Total Dissolved Solids	mg/L	-	224	195	198.5	153	274
Total Suspended solids	mg/L	100	10	19.5	12	10	13
Chlorides	mg/L	-	5	5	5	5	5
Bicarbonate Alkalinity	mg/L	-	198	192	204	No data	No data
Sulphate	mg/L	-	60.9	49.2	32.7	No data	No data
Calcium	mg/L	-	35.8	31.3	20.9	No data	No data
Magnesium	mg/L	-	42.2	39.8	41.6	No data	No data
Sodium	mg/L	-	9.14	8.64	9.07	No data	No data
Potassium	mg/L	-	1	1.255	1.02	No data	No data
Iron	mg/L	6	0.2	0.1	0.1	0.05	0.1
Manganese	mg/L	-	0.11	0.125	0.11	0.04	0.36
Conductivity	mS/m	-	40.15	42.45	41.9	32.8	46.2
pH	pH units	6-9	7.1	7.6	7.7	7.4	7.1
Copper	mg/L	1.5	0.04	0.04	0.04	0.015	0.39
Cobalt	mg/L	-	0.13	0.05	0.05	0.01	1.69
Lead	mg/L	-	0.05	0.05	0.05	0.02	0.05
Zinc	mg/L	10	0.04	0.04	0.04	0.01	0.04
Nickel	mg/L	1	No data	0.01	0.01	0.01	0.01
Arsenic	mg/L	0.4	No data	0.01	0.01	0.01	0.01

Average water quality data in Table 24Table 24 shows that the ECP1 and black shale ponds are, as expected, acidic with high concentrations of TDS and metals. The pH values at the other sites fall within the acceptable limits of 6 to 9. Most samples were slightly alkaline.

The Process Pond, Dirty Water Dam and Return Water Dam (RWD) at TSF1 all have fairly good water quality, with only manganese being elevated in the RWD.

Table 24: Average Water Quality Data for Contact Water Samples

Parameter	Units	ECP1	Process Pond	Dirty Water Dam	Black Shale Pond 01	Black Shale Pond 02	RWD
Total dissolved solids	mg/L	8 168	292	203	12 200	450	76
Total suspended solids	mg/L	2 612.5	9.2	180.8	739	306.7	22
Chlorides	mg/L	7.84	7.33	7.875	4.095	3.98	3.04
Bicarbonate Alkalinity	mg/L	0	256	173	2.5	No data	15
Sulphate	mg/L	6 616	16.4	21	13 212	3 868.5	37.2
Calcium	mg/L	188.2	60.4	34.3	282.6	41.7	11.6
Magnesium	mg/L	813.5	24	22.8	1360	175	4.3
Sodium	mg/L	24.32	11.5	11.645	7.19	6.48	4.33
Potassium	mg/L	22.145	1.07	1.415	1.57	2.56	0.88
Iron	mg/L	37.22	0.01	0.05	4.37	22.67	0.01
Manganese	mg/L	692.95	0.01	0.02	33.3	20.1	0.61
Conductivity	mS/m	764	49	38.6	327.67	474.5	13.1
pH	pH units	2.79	8.16	8.015	2.85	3	7.23

Parameter	Units	ECP1	Process Pond	Dirty Water Dam	Black Shale Pond 01	Black Shale Pond 02	RWD
Copper	mg/L	1415	0.06	0.01	0.57	0.655	0.01
Cobalt	mg/L	293.05	0.01	0.01	511.8	318.5	0.76
Lead	mg/L	0.02	0.01	0.01	0.03	0.01	0.01
Zinc	mg/L	7.67	0.01	0.01	2.335	1.165	0.01
Nickel	mg/L	8.05	0.01	0.01	0.71	7.71	0.01
Arsenic	mg/L	0.015	0.01	0.01	0.01	0.01	0.01

Contact water is not discharged to the environment. It is returned to the processing plant and used as process water. High levels of manganese, cobalt, nickel and copper in water can cause health effects. Limit concentrations in drinking water, such as those imposed by the DRC legislation (see Table 96~~Table 96~~ and Table 83~~Table 83~~) are designed to be protective of human health.

Adverse health effects due to manganese may be expected at levels >0.4 mg/L (WHO, 2017), but aesthetic effects limit the acceptability of manganese-containing water for domestic use to concentrations not exceeding 0.15 mg/L. At the levels detected at SWK 04 and Pit M02 it is likely that the manganese may cause staining and taste problems, but no health effects. Regarding aquatic ecosystems, the values measured are below the target water quality guideline of 0.37 mg/L (DWAF, 1996), the concentration at which there is expected to be a significant probability of measurable chronic effects on up to 5% of the species in the aquatic community.

In humans, adequate dietary intake of cobalt is important to prevent anaemia and metabolic interaction occurs with iron. The limit value of 1 mg/L for cobalt is in relation to livestock, where continuous intake of water at concentrations >1 mg/L may cause adverse chronic effects. The elevated levels occasionally recorded in Pit M02 and SWK 04 are mostly <2 mg/L, which can be tolerated for short periods of time. It is noted that levels at the downstream point, SWK 03, are <0.01 mg/L, so the impact from the discharge at SWK 04 is limited.

The current surface water monitoring points are shown on Figure 15~~Figure 15~~. These points are sampled monthly by the mine personnel and analyses are undertaken by the Mine laboratory and an external laboratory in South Africa. The average water quality in the Kifumashi River/receiving environment samples is indicated in Table 25~~Table 25~~ The discharge at SWK04 does have higher concentrations of total dissolved solids and dissolved metals than the Kifumashi River. Total suspended solids are higher upstream in the Kifumashi, probably due to community activities, such as washing of clothes and motorbikes at the bridge.

As the major water uses along the Kifumashi are domestic, including human consumption, livestock watering and subsistence agriculture, the in-stream data has also been compared against the most conservative of the three guideline values for domestic use (WHO, 2017 of SANS 241: 20172 in the absence of a WHO guideline value).

The summarised data in Table 26~~Table 26~~ indicates that for those parameters measured, the water is fit for the traditional water uses in the catchment. Microbiological contamination due to livestock using the river and the poor sanitation facilities in the area is an area of concern but this is beyond the control of Kinsevere mine.

Table 25: Average Water Quality Data for Kifumashi River/Receiving Environment Samples (Quarterly Samples) compared to DRC and WHO Guidelines

Parameter	Units	DRC Effluent Discharge Limits	WHO for Drinking*	SWK B 01	PMPK – US	SWK01-US	SWK02-US	SWK04 – Discharge Point	SWK03_DS
Total Dissolved Solids	mg/L	-	ng	198	126	215	207	243	380
Total Suspended Solids	mg/L	100	ng	8.4	24	22.6	6.6	10	5.2
Chloride	mg/L	-	ng	9.1	6.2	7.6	8.7	6	59.2
Bicarbonate Alkalinity as $CaCO_3$	mg/L	-	ng	164	96.5	180.5	167.5	265	161
Sulphate	mg/L	-	ng	9.8	4.9	7.0	8.3	32.1	33.2
Calcium	mg/L	-	ng	42.1	20.9	44.0	37.6	61.1	55.1
Magnesium	mg/L	-	ng	11.5	6.3	12.2	11.6	29.5	17.2
Sodium	mg/L	-	ng	14	13.1	15.1	12.6	12.9	40.4
Potassium	mg/L	-	ng	1.5	1.9	1.9	1.3	1	1.6
Iron	mg/L	6	ng	0.15	0.14	0.04	0.26	0.10	0.01
Manganese	mg/L	-	ng	0.01	0.01	0.01	0.01	0.05	0.01
Conductivity	mS/m	-	ng	30.7	20.2	34.5	34.9	55.9	63.1
pH	pH units	6-9	ng	8.0	7.8	7.9	8.2	8.3	8.2
Copper	mg/L	1.5	2	0.02	0.01	0.01	0.01	0.04	0.01
Cobalt	mg/L	-	ng	0.01	0.01	0.01	0.01	0.05	0.01
Lead	mg/L	-	0.01	0.01	0.01	0.01	0.01	0.05	0.01
Zinc	mg/L	10	ng	0.01	0.01	0.01	0.01	0.04	0.01
Nickel	mg/L	1	0.07	0.01	0.01	0.01	0.01	0.01	0.01
Arsenic	mg/L	0.4	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Notes:

* health-based guidelines

US – Upstream of discharge point

DS – Downstream of discharge point

Table 26: Average Water Quality Data for Biannual Samples

	Total Suspended Solids (mg/L)			Iron (mg/L)			pH			Copper (mg/L)			Lead (mg/L)			Nickel (mg/L)		
Percentile	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**
DRC Limit	**100**			**6**			**6-9**			**1.5**			**0.6**			**1**		
SWK B 01	2	7.4	32.12	0.28	0.39	0.66	6.94	7.95	8.5	0.01	0.01	0.03	nd	nd	nd	nd	nd	nd
PMPK	5	27	68	0.24	1.1	4.04	7.35	7.7	8.3	0.01	0.01	0.12	nd	nd	nd	nd	nd	nd
SWK01	3.5	12	66.45	0.23	0.99	4.11	6.9	7.8	8.25	0.01	0.02	0.03	nd	nd	nd	nd	nd	nd
SWK02	1.5	4.7	24.8	0.22	0.37	0.95	6.9	7.9	8.55	0.01	0.01	0.03	nd	nd	nd	nd	nd	nd
SWK03	1	6	69.5	0.17	0.44	0.92	7.45	7.9	8.5	0.01	0.01	0.03	nd	nd	nd	nd	nd	nd
SWK04	1	5	35.5	0.03	0.05	0.24	7.35	8.1	8.5	0.02	0.04	0.05	nd	nd	nd	nd	nd	nd
PIT C 03	11.5	24	148.7	nd	nd	nd	7.12	8.2	8.56	0.03	0.23	1.59	nd	nd	nd	nd	nd	nd
PIT CB	1.25	3.4	88.75	nd	nd	nd	7.86	8.5	8.68	0.01	0.01	2.56	nd	nd	nd	nd	nd	nd
PIT M	1	13.2	970.8	0.03	0.07	0.51	7.2	7.9	8.56	0.04	0.1	0.58	nd	nd	nd	nd	nd	nd
PIT M01	1	12	277.2	0.03	0.159	0.42	7.2	7.9	8.42	0.05	0.11	0.58	nd	nd	nd	nd	nd	nd
ECP1	16.1	313	9 132	0.03	0.6	34.4	1.89	4.15	7.68	0.95	26	960	nd	nd	nd	0.05	0.44	6.84
Process pond	1.35	12.15	50.95	0.03	0.07	0.32	7.575	8.05	8.5	0.09	0.13	0.34	nd	nd	nd	0.03	0.03	0.03
Dirty Water Dam	24.9	89	2 161	0.08	0.28	0.42	7.28	7.9	8.07	0.14	0.18	0.49	nd	nd	nd	0.03	0.03	0.03
RWD	1.595	6.3	65	0.03	0.03	0.21	7.58	8.1	8.47	0.02	0.08	0.19	0.01	0.01	0.02	nd	nd	nd

Notes: nd: no data received

3.2.3 Geohydrology (Article 31)

A geohydrology study was undertaken by SRK for Kinsevere Copper Mine between February and April 2016, with further updates in May 2017 (Mabenge, B; Chimhanda, W; van Heerden, M; Mahomed, I;, May 2017), November 2018 (Mabenge, B;, 6 November 2018) (Mabenge, B;, 26 November 2018) and in December 2018 to include transport modelling of dissolved SO_4 (Mabenge, B;, 28 December 2018).

The study considered both the oxide (current) mining and potential future (sulphide) mining and previous studies. The SRK study was reviewed and its key information was summarised by Golder (Gqweta, M; Demmer, T;, August 2018). Impacts were assessed and recommendations for mitigation measures and further work were made.

Groundwater monitoring data has indicated the average baseline SO_4 concentration to be in the region of 5 mg/L. The geochemical assessment indicated that 2 500 mg/L could leach from the TSF sites and 1 500 mg/L from the WRD.

3.2.3.1 Available Information – Article 31 (a)

Table 27~~Table 27~~ presents an inventory of the information sources consulted.

Table 27: Available Hydrogeological Reports

No.	Authors/Dates/Report Titles
1	Knight Piésold Consulting: (2007-2013). Quarterly and Monthly Dewatering Status and Optimisation Reports.
2	Knight Piésold Consulting. 2010. Hydrogeological Numerical Model: Saturated Zone Model Optimisation, Kinsevere Pit Dewatering (including updates)
3	SRK Consulting. 2015.Kinsevere Primary Copper Project: Phase 1 – Scoping Study
4	SRK Consulting. 2016. Kinsevere Mine – Groundwater Management System Design
5	Solution [H+] Report.2017. Lake Water Balance (Stage 1 Report)
6	Solution [H+] Report.2017. Post Closure Pit Lake Chemistry (Stage 2 Report)
7	Solution [H+] Memo. 2017. Kinsevere Mine: Pit Closure Pit Lake Downstream Impact
8	SRK Consulting Memo, 6 November 2018. Kinsevere Expansion Project_Dewatering Preliminary Memo
9	SRK Consulting Memo, 26 November 2018. Kinsevere Expansion Project - Preliminary Dewatering Memo
10	SRK Consulting Memo, 28 December 2018. Kinsevere Expansion Project_Contaminant Transport Preliminary Memo

A summary of the available key information is provided in the subsections below.

The 2016 SRK study included an updated hydrocensus, the monitoring of borehole installations, slug tests and airlift testing. The hydrocensus was performed to identify the locations of wells, boreholes and springs as well as the users thereof, and to develop a piezometric map to refine the direction of groundwater flow. Nine drill sites were selected to represent preferential groundwater flow pathways, and monitoring boreholes were drilled to depths ranging from 65 to 120 m below ground level (mbgl). Slug tests were performed, during which a 1.5 m long solid slug was inserted to displace the water column, and the rise in water level as well as the rate of return to the undisturbed state were recorded. Three geotechnical boreholes underwent airlift testing in order to determine the hydraulic conductivity values of the dolomitic shale and the black shale lithological units, obtaining intermediate and high hydraulic conductivity values respectively.

3.2.3.2 Topography – Article 31 (b)

See Section 3.2.1.1 and Figure 26~~Figure 26~~.

3.2.3.3 Stratigraphy – Article 31 (c)

The geology of the area is described in Section 3.2.1.1 and illustrated in Figure 27~~Figure 27~~. The geohydrology near the mine is defined by four key hydrostratigraphic units, as identified during field investigations:

- The saprock or transition zone found below the highly weathered saprolite. Monitoring boreholes drilled into the saprock in March 2016 showed these units to be highly permeable and capable of storing groundwater;
- The CMN dolomite aquifer, which is high yielding and the main aquifer within the Copperbelt and the Kinsevere mining area. This aquifer is defined by interconnected pores, cavities, faults, and fractures which act as preferential flow pathways and provide high storage capacity;
- The fractured RAT Breccia which is associated with severely fractured zones within the RAT unit. This unit is locally weak, with irregular to parallel bedding and is a moderately yielding aquifer; and
- The fresh RAT and shales units form a poorly-developed argillitic/shaley aquifer.

3.2.3.4 Hydraulic Properties of Stratigraphic Units – Article 31 (d)

The hydraulic conductivities (K) of the hydrostratigraphic units were determined by airlift testing, focused on the fractured and fresh rock, and slug tests, focused on the saprolite and saprock.

The results are summarised in Table 28~~Table 28~~. Fractures within the different lithologies form water-bearing units of the deeper system. The size and frequency of fracture openings and thus the hydraulic conductivity, are expected to decrease with depth. However, some cavities that act as conduits for the rapid flow of groundwater within the dolomites were encountered at depth.

Table 28: Hydraulic Conductivities, Storage Coefficients (Ss) and Storativity (Sy) (SRK, November 2018)

Lithology	Degree of Weathering	K value (m/day)			Ss	Sy
		Zone 1	Zone 2	Zone 3	(m^{-1})	(-)
Kundelungu	Saprolite	1.58	0.85	0.5	0.0001	0.01
	Moderately weathered	1.05	0.57	50.25	0.0001	0.01
	Competent rock	0.35	0.35	0.1	0.0001	0.001
Dipeta	Saprolite	30	-	-	0.0001	0.01
	Moderately weathered	5.7	-	-	0.0001	0.01
	Competent rock	3	-	-	0.0001	0.001
RAT (RSL, SDOL &RBX)	Saprolite	0.3	0.75	-	0.00001	0.001
	Moderately weathered	0.25	1.5	-	0.0001	0.05
	Breccia	0.25	2.5	-	0.00001	0.05
	Competent rock	0.25	0.9	-	0.0001	0.01
CMN Dolomite (LMU &IDSH)	Saprolite	5.5	2.85	-	0.0001	0.02
	Moderately weathered	5.7	7.5	-	0.0001	0. 1
	Competent rock	3	2.5	-	0.0001	0.05
DSTRAT (LNU)	Saprolite	0.3	0.075	-	0.00001	0.001
	Moderately weathered	0.027	0.15	-	0.0001	0.01
	Competent rock	0.03	0.05	-	0.0001	0.001

Lithology	Degree of Weathering	K value (m/day)			Ss	Sy
		Zone 1	Zone 2	Zone 3	(m^{-1})	(-)
Dolomitic Shale SD (ICSL,LSH)	Saprolite	0.3	0.375	0.375	0.0001	0.01
	Moderately weathered	0.9	0.9	0.9	0.0001	0.01
	Competent rock	0.15	0.15	0.15	0.0001	0.01
Black Shale (LSH)	Saprolite	0.3	0.45	0.45	0.0001	0.01
	Moderately weathered	1.7	0.9	0.9	0.0001	0.01
	Competent rock	0.3	0.3	0.3	0.0001	0.005

3.2.3.5 Structural Components that Influence Groundwater Flow – Article 31 (e)

The lithological formations dip steeply to the west with a thick and variable weathered zone (saprolite) overlying the fractured (saprock) and fresh rock. The geological structures are quite complex, with several faults cutting through the area. The 'Sinistral' fault located between the Central and Mashi Pits, with a NNE-SSE strike direction and dipping steeply to the north-west, has a competent nature and restricts groundwater flow.

3.2.3.6 Hydraulic Properties of Structural Components that Constitute Preferential Groundwater Flow Paths – Article 31 (f)

The 'Sinistral' fault located between the Central and Mashi Pits, with NNE-SSE strike direction and dipping steeply to the north-west has a competent nature and restricts groundwater flow.

3.2.3.7 Groundwater Piezometry and Flow Directions – Article 31 (g)

The groundwater occurrence and flow are predominantly controlled by the geological structures and weathering profiles. The geological structures are complex, with several faults cutting through the area. Lithological formations dip steeply to the west, with saprolite forming a thick and variable weathered zone overlying fresh and fractured rock. These structures show significant variability in permeability, which can result in either increased inflows into the open pits or compartmentalisation of depressurisation effects where faults act as barriers.

The mine has a comprehensive monitoring network and water levels have been monitored monthly since 2009. SRK undertook a site-wide hydrocensus in 2016, measured the water levels in the boreholes across the mine and installed Vibrating Wire Transducers (VWT) in six boreholes. The groundwater levels were recorded to depths of up to 78 m. The regional groundwater flow, albeit disturbed by mine dewatering activities, was determined to be north-easterly towards the Kifumashi River (see Figure 24~~Figure 24~~).

Groundwater piezometric elevations east of the Central Pit and north-east of the Mashi Pit show a limited response to the mine dewatering as there are no dewatering boreholes located in this area. Dewatering on the western side of both the Central and Mashi Pits is significant with drawdowns of up to 60 m.

SRK drilled and slug-tested nine monitoring boreholes during their investigation. These monitoring boreholes were selected taking cognisance of geological structures representing preferential groundwater flow pathways, accessibility for drilling, planned pit pushbacks and mining infrastructure such as waste rock dumps and ore stockpiles.

Most of these monitoring boreholes were drilled within and close to the final pit crest so that the groundwater occurrence and the permeability of the weathered saprolite for the planned pushback could be further characterised. The boreholes were drilled to depths ranging from 65 m to 120 m and blow yields ranged from 0.4 L/s to 15 L/s. Water levels ranged from 15.72 to 59.30 mbgl. All the boreholes intersected essentially the same weathered lithological profile, but a very thin laterite layer is present at surface in some places. It is underlain by a thick saprolite zone (oxide ore), then a fractured zone (saprock), which overlies the competent fresh rock.

Figure 8Figure 8 shows the existing dewatering boreholes (seven around the pit and six in-pit) and additional boreholes recommended by SRK. The existing boreholes can control the influx of water into the mine to manageable levels, but they are unable to maintain the phreatic surface at the desirable level of at least one bench below the current pit floor. There are also in-pit sumps from which the residual groundwater seepage and direct rainfall in Central and Mashi Pits are pumped out.

Dewatering of the mine pits through these large diameter boreholes produces an average of 550 L/s of groundwater, some of which is pumped to the ore processing plant for use as process water, some is pumped into settlement ponds and the rest is discharged into the Kifumashi River.

Groundwater recharge is due mainly to rainfall, but seepage from the settlement ponds contribute locally. Groundwater levels fluctuate by up to 2 m in response to seasonal precipitation and evaporation cycles and range from 10 to 13.5% of MAP on a monthly basis on different geological formations across the area.

Most of the in-pit dewatering boreholes will be mined out as the pit expands, and SRK has proposed 20 additional dewatering boreholes to continue targeting the CMN dolomite (main contributor of groundwater into the pits), RAT siltstone and the RAT breccia. The dewatering strategy proposed by SRK includes the installation of large diameter boreholes drilled into the main water bearing strata within the pit and on the perimeter, and the installation of horizontal drain holes in the north-western wall of Mashi Pit. The following phased approach was proposed:

- 2017-2018: 250 m deep perimeter boreholes and horizontal drain holes at Mashi Pit;
- 2019-2019: 250 m deep boreholes at the crest between Mashi and Central Pits;
- 2020-2021: 150 m deep in-pit boreholes; and
- 2023-2024: 150 m deep in-pit boreholes.

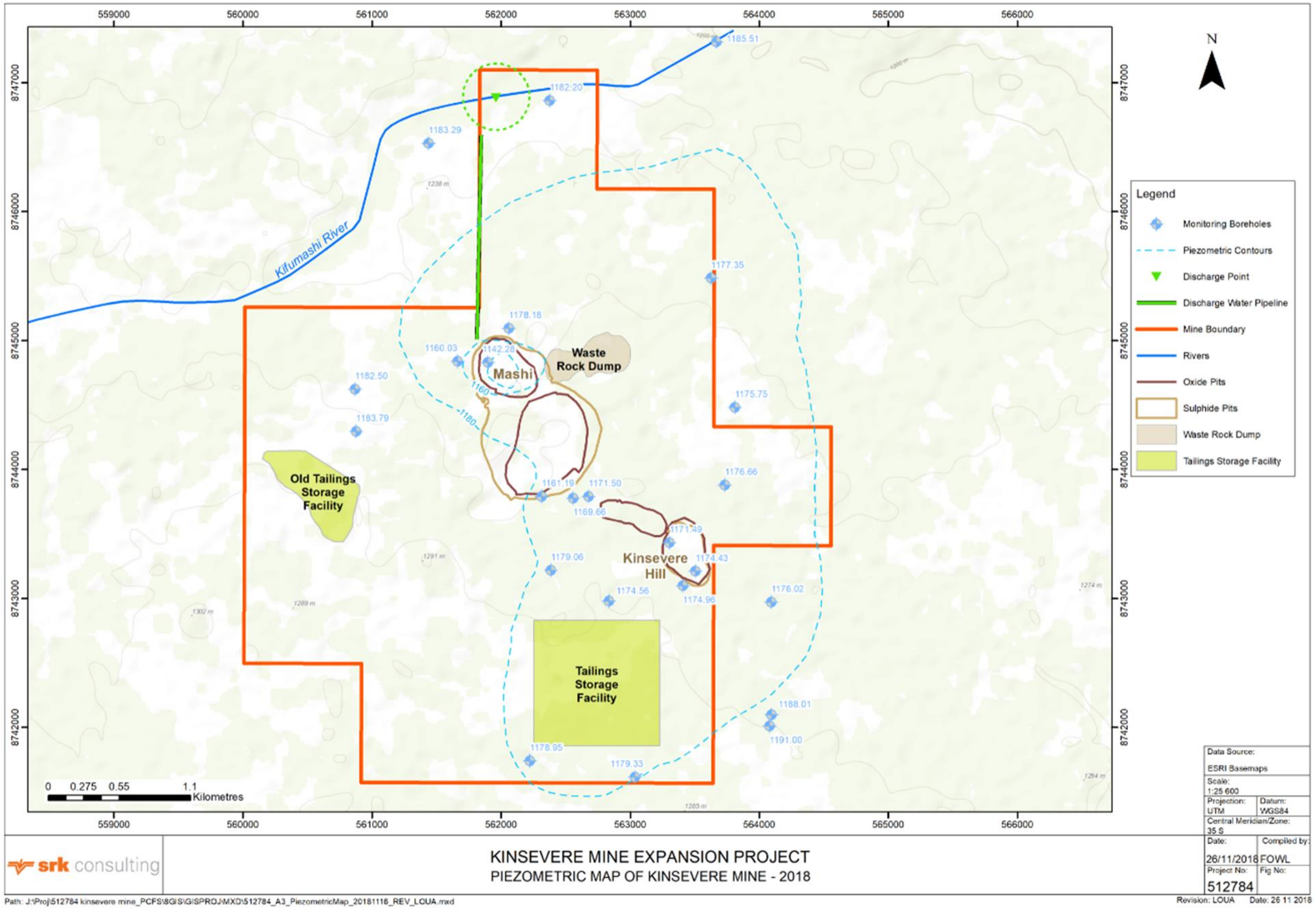


Figure 47: Current Piezometric Elevations at Kinsevere Mine due to Dewatering

3.2.3.8 Groundwater Users and Receptors – Article 31 (h)

The communities in the vicinity of the mine make use of both surface water and groundwater, but their potable water supply is mainly from boreholes drilled into the saprolite and saprock, and wells dug into the shallow saprolite.

The SRK Report (Mabenge, B; Chimhanda, W; van Heerden, M; Mahomed, I;, May 2017) mentions an expanded hydrocensus undertaken in 2016, during which all accessible boreholes within a 5 km radius of the mine were visited. Basic information was collected at approximately 90-100 groundwater observation points, of which:

- Six are Kinsevere mine water supply wells; and
- 36 are village water supply wells.

Even if some of the boreholes surveyed are no longer in use and/or new boreholes have been constructed, the SRK information would probably be sufficiently representative of current receptors. As the mining progresses to greater depth, the cone of depression will widen and borehole yields may be affected in some villages, such as Kilongo and Poto 93. In such event, MMG will take corrective action such as drilling the existing boreholes deeper or drilling new boreholes. After mine closure, the receptors will experience a gradual recovery of the groundwater levels in their boreholes, but it will be decades before dissolved contaminants might show up in the boreholes.

Water supply wells are located in the following communities and their villages surrounding the mine:

- Kilongo Village;
- Village 4 Coins;
- Village 75;
- Village 93;
- Chikwesa Village;
- Ntentema Village;
- Denis Village;
- Emmanuel Village;
- Ernest Village;
- Kalundwe Village;
- Kampetembe Village;
- Kilongo Village/School;
- Kifta Village;
- Kanduluwe Village;
- Kiswishi Village;
- Kalianda Village;
- Muombe Village;
- Mashini Village;
- Mutwale Village;

- Mumanga Village;
- Mumba Village;
- Ngongo Village;
- Pundu Village; and
- Sela Village.

Although this list of villages does not provide direct information regarding the number of human receptors dependent on the groundwater, it does signal a significant dependency of villages on groundwater within the 5 km radius surrounding the Kinsevere Mine.

The SRK report does not expand on these issues and does not provide any information on groundwater levels or borehole depths. No water samples were collected, probably because these wells are equipped with hand pumps which do not provide access for sampling.

3.2.3.9 Local Groundwater Quality – Article 31 (i)

The groundwater monitoring data indicates the groundwater to be of good quality as per the United States Environmental Protection Agency (US EPA), World Health Organization (WHO) and European Economic Community (EEC) standards (Table 29~~Table 29~~).

Water samples collected at selected sites during the SRK investigations were analysed for major ions and metals. The groundwater in the saprolite zone across the mine was found to be slightly acidic to alkaline, with pH ranging from 6.2 to 8.7, and generally low to medium EC values ranging from 7.6 to 51 mS/m.

The highlighted exceedances of guidelines cannot be attributed to metal leaching with certainty, as the results may include metals that were dissolved from sediment by the nitric acid that was added for sample preservation.

Although exceedances of guidelines were recorded in some samples of pit water (Table 23~~Table 23~~) and groundwater (Table 29~~Table 29~~), both of which are discharged to the Kifumash River, it should be noted that:

- The recorded levels of iron, copper, manganese and lead do not pose a risk to human health:
  - The limit concentration for iron in drinking water has been set at 0.3 mg/L because laundry and sanitary ware will stain and the taste of the water may be affected at concentrations above this level (Fawell, J K; *et al*.;, 2003);
  - A provisional guideline value of 2 mg/Lwas established for copper in drinking water to be protective against the adverse effects of copper and to provide an adequate margin of safety in populations with normal copper homeostasis. The guideline value was provisional as a result of uncertainties in the dose–response relationship between copper in drinking-water and acute gastrointestinal effects in humans (Fawell, J K; *et al.*;, 2004);
  - While several studies have determined average levels of manganese in various diets, no quantitative information is available to indicate toxic levels of manganese in the diet of humans and manganese is generally not considered to be very toxic when ingested with the diet. Manganese becomes noticeable at concentrations >0.05 mg/L by imparting colour, odour, or taste to the water and people would naturally avoid drinking it. Health effects are not a concern until concentrations are about 10 times higher (Fawell, J K; *et al.*;, 2011);
  - The World Health Organization has not published a guideline for cobalt concentration in drinking water. Limits of 0.1 mg/L for livestock watering and 0.05 mg/L for long term irrigation have been adopted by Canada, the USA, Australia and Souh Africa (Nagpal, N K;, July 2004); and

  - There is evidence from human studies that adverse effects other than cancer may occur at very low lead levels and that a guideline thus derived would also be protective for carcinogenic effects. A provisional guideline of 0.01 mg/L has been recommended by the WHO (Cotruvo, J; Fawell, J K;, 2011); and

- No exceedances were recorded in the discharge to the Kifumashi River (Table 26~~Table 26~~), which consists of water pumped out of the pit sumps and water abstracted from the dewatering boreholes.

3.2.4 Groundwater Modelling (Article 32)

Kinsevere mine commissioned a groundwater modelling study in order to gain a better understanding of the dynamics of the hydrogeological system in the area, and to predict the future impacts of the current and proposed future mining activities until and beyond the end of the mine's life.

SRK carried out a modelling study as described in the 2017 SRK report (Mabenge, B; Chimhanda, W; van Heerden, M; Mahomed, I;, May 2017).

Table 29: Groundwater Quality

Parameter	Units	SRK01	SRK02	SRK03	SRK04	SRK05	SRK06	SRK07	SRK08	SRK09	KTC-SS-320 (144-219 m)	KTC-SS-320 (219.9-273 m)	KTF-SS-262 (104-197 m)	KSV-SS-51 (72-140 m)	Central Pit Sump	Mashi Pit	Main Discharge to River	Mashi Sump	Rainfall	Limit Value Recommended by EPA, EEC or WHO
pH	-	6.5	6.8	7.3	7.4	8.1	6.5	7.7	7	6.2	8.3	8.7	8.2	8.2	7.3	8	7.8	7.6	6.2	6.5-9
EC	mS/m	7.6	25.8	45	48.9	48.1	9.6	28.7	18.9	10.3	35.1	41.3	37.8	45.8	39	29.9	51.7	30.8	0.9	100
TDS	mg/L	54	164	266	252	256	50	168	90	50	188	236	178	258	278	162	292	168	4	500
Turbidity	NTU	0.7	190	1.2	98	1.2	1.7	2	0.7	7.3	5.7	1.2	2.2	34	51	1.2	1.2	5	0.8	
Ca		9.4	19.4	45	53	58	5.4	27	2.8	8.3	23	19.5	25	39	27	23	54	22	0.34	100
Mg		1.9	12.8	30	23	21	5.4	12.7	21	2.8	23	32	26	42	27	21	25	21	<0.034	50
Na		3.5	6.6	14.1	9.5	6.2	0.99	6.3	1.3	5.2	7.6	14	1.4	3.8	1	1.1	6.3	0.95	0.08	
K		1.1	0.76	1.9	3.6	0.69	3.9	4	0.38	0.38	0.63	0.85	2.6	4.2	0.97	2.3	0.66	2.2	0.11	200
T_{alk} as $CaCO^3$		35	87	178	247	245	39	100	84	29	153	157	188	269	22	147	247	151	9	
HCO_3		43	106	217	301	299	48	122	102	35	106	123	229	328	27	179	301	184	11	
CO_3		0	0	0	0	0	0	0	0	0	40	34	0	0	0	0	0	0	0	250
Cl		2.1	1.9	5.4	1.1	2.5	1	7.1	1.1	0.9	5.3	11.9	1.1	1.6	1.6	1	5.2	1.2	0.6	250
SO_4		<0.2	31	58	5.7	4.3	1.3	20	1.6	10.3	10.1	25	1.7	0.4	173	3.2	21	2.5	1.2	
NO_3		1.8	<0.1	0.5	<0.1	1.4	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	0.1	50
NO_3-N		0.4	<0.1	0.1	<0.1	0.3	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	
F		0.1	0.4	0.3	0.4	0.2	0.1	0.4	0.3	0.1	0.2	0.3	0.3	0.2	0.4	0.3	0.3	0.2	<0.022	1.5
PO_4			<0.12		<0.12	<0.12	<0.12	<0.12	1.16	<0.12	<0.12	<0.12	<0.12		<0.12	<0.12	<0.12	0.36	<0.12	
Al		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.029	<0.003	<0.003	<0.003	0.098	0.02
B	mg/L	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.034	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	0.117	0.091	0.073	0.053	0.106	0.5
Ba		0.073	0.038	0.049	0.081	0.084	0.105	0.197	0.011	0.024	0.148	0.15	0.386	2.369	0.078	0.396	0.079	0.372	0.001	0.5
Co		0.28	0.87	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	0.054	<0.001	<0.001	0.077	<0.001	1.181	<0.001	<0.001	<0.001	<0.001	
Cr		<0.003	0.05	<0.003	0.051	0.055	0.054	0.039	0.047	0.051	0.054	0.023	0.042	<0.003	0.044	0.045	0.049	0.06	0.042	0.1
Cu		0.003	1.412	0.026	1.442	1.909	1.775	1.233	1.344	1.883	1.815	0.561	1.136	<0.002	1.488	1.558	1.863	2.691	1.289	2
Fe		<0.001	0.342	<0.001	0.271	0.264	0.252	0.172	0.224	0.247	0.265	0.139	0.205	<0.001	0.224	0.215	0.241	0.29	0.217	0.3
Mn		0.499	0.839	0.293	0.026	0.009	0.165	0.011	0.011	0.315	0.028	0.009	0.097	0.028	0.702	0.021	0.024	0.048	0.006	0.05
Mo		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.073	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.07
Ni		0.004	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	
P		0.057	0.131	0.173	0.095	0.086	0.089	0.076	0.377	0.068	0.066	0.045	0.048	0.2	0.044	0.135	0.067	0.118	<0.040	
Si		6.986	14.38	2.296	3.513	8.793	9.862	15.98	5.105	3.359	5.56	7.486	9.9998	8.803	1.556	11.16	7.857	9.714	<0.007	
Sr		0.011	0.022	0.054	0.079	0.088	0.012	0.285	0.004	0.012	0.044	0.172	0.046	0.135	0.037	0.057	0.08	0.051	<0.001	
Ti		<0.001	0.003	<0.001	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
V		0.002	<0.002	0.006	0.002	0.002	<0.002	0.01	<0.002	<0.002	0.014	<0.002	0.002	0.008	0.004	<0.002	<0.002	<0.002	<0.002	
Zn		0.031	0.046	0.11	0.053	0.057	0.057	0.041	0.048	0.051	0.054	0.024	0.043	<0.005	0.045	0.047	0.05	0.061	0.046	3
Pb		<0.001	0.01	0.001	0.01	0.02	0.007	0.003	0.003	0.003	0.009	<0.001	0.001	<0.001	0.005	<0.001	0.007	0.005	0.01	0.01
Error Charge Balance		0.501	-2.6	4.504	-0.5	-1.6	0.6	2.7	5.1	3.3	-0.8	2.8	-4.3	2.044	-5.6	-1.095	-5.178	-3.243	-79.2	

Note: Numbers in blue indicate exceedance of guidelines/limits

3.2.5 Modelling Study (Article 33)

The Kinsevere mine commissioned a groundwater modeling study to better understand the dynamics of the hydrogeological system in the area and to predict the future impacts of current and future mining activities until the end of mine life. SRK conducted a modeling study as described in the 2017 SRK report (Mabenge, B, Chimhanda, W, van Heerden, M, Mahomed, I, May 2017).

Content of the Modelling Study

3.2.5.1 Type of Modelling – Article 33 (a)

The 2017 SRK report represents an update of an initial numerical model completed in June 2016 (SRK Report No. 476655). Three-dimensional finite element saturated groundwater flow modelling was undertaken to calculate the residual groundwater inflow to the Kinsevere Mine pits. Particle tracking was used to trace the flow paths and ultimate fate of potential contaminant particles introduced into the groundwater model in order to determine the likely areas of influence of existing and proposed permanent mine waste storage facilities. Further groundwater modelling updates were undertaken in 2018 extending model boundaries, enhancing particle tracking capability and including SO_4 transport modelling.

Solution [H+] undertook a pit lake water balance and hydro-geochemical assessment in 2017, incorporating outputs from the SRK modelling.

3.2.5.2 Aims and Objectives of the Modelling – Article 33 (b)

The main purpose of the 2017 model update was to inform operational mine dewatering over the life of the mine by incorporating the revised mining plans to include the sulphide mining activities. The updated model also included additional dewatering information from recently drilled dewatering boreholes, revised hydraulic parameters from fieldwork carried out in 2016, pit sump dewatering information, and additional recharge zones associated with unlined ponds and canals as well as seepage from the Waste Rock Dump (WRD).

The updated numerical groundwater model was re-calibrated to the new data and used to simulate the scenarios listed in Table 30~~Table 30~~.

The importance of the groundwater modelling done for the Kinsevere mine can be summed up as follows:

- It provides valuable guidance on the rate of groundwater influx into the pits to be expected as the mining progresses towards a larger and deeper pit. Such information is essential for the planning of additional boreholes (timing, location, depth, pump size, abstraction rate) and the installation of additional pumping capacity at the pit sumps to maintain acceptable operating conditions in the mine;
- Modelling provides information on the rate and nature of contamination of the groundwater due to the ingress of runoff from the waste rock dumps, tailings storage facilities and areas of soil contamination, and the ingress of seepage from unlined ponds, which in turn provides information on the quality of the groundwater that will seep into the pit and that will be abstracted from the various boreholes;
- It provides information about the rate at which the groundwater levels are expected to rebound after the cessation of mining and the expected quality of the groundwater during and for many years after the rebound process has been completed; and
- The above information is also needed to plan appropriate safety measures in the vicinity of the pits after closure.

3.2.5.3 Hydrogeological Context – Article 33 (c)

The geology of the area hosting the Kinsevere mine is discussed in Section 3.2.1.1.4, the stratigraphy in Section 3.2.3.3, their hydraulic properties in Section 3.2.3.4, the groundwater flow directions in Section 3.2.3.7, and the surface water management systems in Section 5.4.3.2.

3.2.5.4 Conceptual Model – Article 33 (d)

SRK developed a conceptual hydrogeological model, based on the geological structures and stratigraphy as described in Sections 3.2.1.1.4 and 3.2.3.3, to describe the identified mine drainage sources in terms of aspects that affect drainage quality, including the distribution of major geochemical units, assumed geochemical conditions and indications of water flow in the mine components.

The mine's October 2016 monitoring datasets were used in the setting up of the groundwater model; datasets from 2017 and 2018 have been used to calibrate the updated groundwater models.

3.2.5.5 Digital Code – Article 33 (e)

The 2017 numerical groundwater model made use of the MINEDW (ver. 3.03) code which is used primarily for operational pit dewatering modelling. The advantage of the MINEDW code lies primarily in its ability to incorporate complex pit geology and progressive pit mining advances. The complexity of the geological model is, however, restricted to the pit areas and this level of information does not extend to the model boundaries.

The numerical model is well refined at the pit area, with element sizes in the order of 10 m - 25 m, enabling the geology of the pit to be represented in detail and allowing sufficient numerical resolution in the pit area. Vertical discretisation was achieved through 15 m thick layers in the pit area. A significant advantage for simulating pit dewatering and mining is the ability of MINEDW to 'collapse' the finite-element grid to represent the changing configuration of the pit over time.

Since the main purpose of a numerical model is to inform operational mine dewatering, model boundaries have been assigned at the river drainage line to the north and at approximately 5 km distance from the pits, to the east, south and west. This demonstrates that the main purpose of the model is to examine residual pit groundwater inflows (RPGI) and pit wall pressure conditions related to the detailed geological differentiation provided by the mine geological model in the near pit environment. It makes a correctly conservative assumption, with respect to mine inflows, that the risk of overestimating pit inflows is preferred to an underestimation.

The latest groundwater modelling update was done by SRK in December 2018 using FEFLOW 7.1 software to evaluate various additional dewatering designs and to assess impacts. The mine boundaries and boundary conditions previously described for the operational 2017 MINEDW numerical model remained unchanged, as did the calibration against pre-mining and 2018 groundwater level data,

The Solution [H+] modelling undertaken in 2017 used the GoldSim model code to undertake the pit lake water balance and PHREEQC hydro-geochemical model code to simulate post-closure water quality.

3.2.5.6 Model Calibration and Validation – Article 33 (f)

Steady state calibration of the 2017 MINEDW model under the assumed pre-mining conditions was achieved by varying recharge and hydraulic conductivity (K) in the numerical model to obtain reasonable groundwater elevations throughout the model domain, based on the assumed model boundary conditions. Most of the model's calculated heads were within 5 m of the pre-mining groundwater level data, which was considered adequate for estimating pit in-flows.

A recharge value of 10% of the MAP was assigned across the entire model for the steady state calibration. For transient calibration and model validation purposes the current dewatering boreholes were considered as active and the historically available pumping rates were applied. The transient calibration process also applied with a monthly variable recharge of 10 - 13.5% of MAP on different geological formations across the model domain. In addition, storage values were varied in an attempt to match the simulated water levels with observed water levels in the long-term water level monitoring data set.

The 2018 FEFLOW groundwater model was calibrated using the distribution of water levels from 29 boreholes while varying the recharge rate between 7.5 and 30% of MAP across the model domain. Standard steady state and transient calibration processes, similar to those described above for the MINEDW model were followed to generate the updated aquifer parameters provided in Table 28~~Table 28~~.

3.2.5.7 Results and Predictions – Article 33 (g)

The five scenarios listed in Table 30~~Table 30~~ were modelled for the LOM and residual passive groundwater inflow (RPGI), phreatic surfaces and pit pore pressures for the Central, Mashi and Kinsevere Hill opencast pits.

Table 30: Summary of Scenarios for Predictive Simulation by SRK (2017) using MINEDW Code

Scenario	Description
1	Dewatering with current boreholes: ■ Pumping rates equal to current rates measured during March 2016 hydrocensus review.
2	Dewatering with additional perimeter boreholes: ■ Located along the perimeter of expanded pit; ■ 250 m deep; and ■ Pumping at 60 L/s with a 5 m pumping freeboard.
3	Dewatering with perimeter boreholes as above and additional in-pit boreholes: ■ Located in the expanded pit; ■ 150 m deep; and ■ Pumping at 60 L/s with a 5 m pumping freeboard.
4	Post closure – pit lake rebound.
5	Dewatering with perimeter boreholes and in-pit boreholes as above (Scenario 3): ■ Drain holes in north-west wall of Mashi Pit.

The current and proposed dewatering borehole layout in the Central and Mashi open pits is shown in Figure 8~~Figure 8~~.

Groundwater level drawdown of at least 80 m by 2028 (near end of LOM) in the vicinity of the processing plant was predicted, resulting in an increased risk of sinkhole formation in that area, which has been considered in a Karst review, but may be subjected to additional geotechnical investigations.

SRK concluded that dewatering may affect the water levels in nearby villages. MMG monitors the potentially affected boreholes and takes corrective action if the water supply is affected adversely.

Post-closure pit water level rebound estimations would tend to be conservative and estimates of the time taken to reach pre-mining or near pre-mining groundwater levels could be shorter if different boundaries were chosen. A terminal pit lake was predicted for the Central/Mashi Pits whereas the Kinsevere Hill Pit was predicted to be a flow-through pit lake once water levels have stabilised in the pits.

As expected, particles introduced from the footprints of the existing and planned TSFs surrounding the pits during the operational phase, will travel towards the pits and the various pit dewatering boreholes and exit via the mine's groundwater discharge system into the Kifumashi River. During the initial stages of post-closure or until pre- or near pre-mining conditions return, estimated by SRK to be *circa* 2080, such contaminants are likely to continue to migrate predominantly towards the pits, although less so with time, as the groundwater levels rebound.

After *circa* 2080 contaminants from existing and planned waste storage facilities will begin to migrate towards the east, north-east and south-east.

The results of two 2018 FEFLOW model update scenarios (modelled for the LOM) listed in Table 31~~Table 31~~ are discussed below.

Table 31: Summary of Scenarios for Predictive Simulation by SRK (2018) using FEFLOW code

Scenario	Description
1	Current proposed mine development schedule with existing dewatering boreholes only. This simulation will provide an indication of the total inflows into the pits without active dewatering.
2	Implementation of existing and proposed dewatering boreholes with the assumed abstraction volumes based on locality in relation to lithological units.

1) Scenario 1 (FEFLOW)

The current boreholes can pump approximately 41 000 m^3/day. Assuming the majority of the current dewatering boreholes will remain in use, with the exception of a few replacement boreholes shown on Figure 8Figure 8. The FEFLOW model predicts that the RPGI at the end of the LOM will be approximately 4 000 m^3/day, 34 000 m^3/day and 15 500 m^3/day for the Kinsevere Hill, Central and Mashi pits respectively (Figure 48Figure 48).

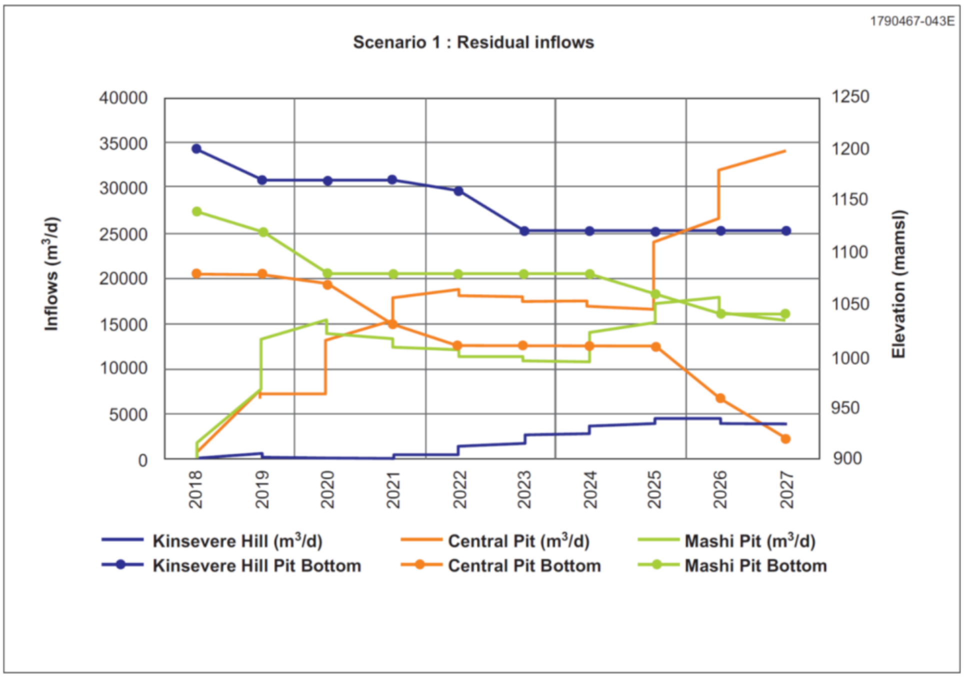


Figure 48: Simulated RPGI with Current Applied Abstraction Volumes (SRK 2018)

2) Scenario 2 (FEFLOW)

The mine schedule (Table 32Table 32) indicates that the pit bottom will be at an elevation of 1 120 m above mean sea level (mamsl) at Kinsevere Hill by 2023, at 920 mamsl in the Cetral Pit by 2027 and at 1 040 mamsl in the Mashi Pit by 2026. The simulation indicates that additional abstraction boreholes will be required to adequately lower the water table in advance of the mine development. The calibrated model was used to assess the proposed borehole locations.

Table 32: Mine Schedule (SRK 2018)

	Elevation of Pit Bottom (mamsl)		
Year	**Kinsevere Hill Pit Bottom**	**Central Pit Bottom**	**Mashi Pit Bottom**
2018	1 200	1 080	1 140
2019	1 170	1 080	1 120
2020	1 170	1 070	1 080
2021	1 170	1 030	1 080
2022	1 160	1 010	1 080
2023	1 120	1 010	1 080
2024	1 120	1 010	1 080
2025	1 120	1 010	1 060
2026	1 120	960	1 040
2027	1 120	920	1 040

Scenario 2 shows that additional pumping capacity is required to adequately lower the water levels in each respective pit in advance of mining. Proposed dewatering borehole positions were assessed in this scenario, assuming a 30 L/s pumping capacity for each proposed borehole and a total dewatering capacity of 24 387 m^3/day from the existing dewatering boreholes. The modelled SO_4 migration results during the operating phase are shown on Figure 49~~Figure 49~~ and Figure 50~~Figure 50~~.

The simulation indicated that:

- Additional dewatering capacity will be required for the Kinsevere Hill Pit in 2024 and 2026. Residual inflows of between 658 m^3/day (7.6 L/s) and 1 293 m^3/day (15 L/s) are predicted to report to the Kinsevere Hill open pit with the additional dewatering implemented. Dewatering of Central Pit and the elevation of the Kinsevere Hill Pit floor will assist the dewatering process;
- A large volume of RPGI will report to the Central Pit from 2019 to 2021 (a maximum of approximately 18 000 m^3/day, which is lower than the abstraction rate of 24 000 m^3/day from the high yielding boreholes DEW14b, DEW22, DEW25, DEW26, and DEW32 that will be replaced with new boreholes;
- Based on the simulated predictions, a total of 35 additional dewatering boreholes will be required for the Central Pit from 2026 to address residual inflows;
- The Mashi Pit is also expected to experience increased residual inflows from 2019 to the end of 2020 due to the replacement boreholes abstracting less than the existing abstraction boreholes. Replacement boreholes should be in similar locations and target the same lithologies to obtain dewatering rates similar to those of the existing boreholes;
- From 2025 onwards, an increased risk of pore pressure build-up in the pit walls is expected, which must be monitored on an ongoing basis. Additional horizontal drain holes targeting selected high wall areas will be required as and when stability analysis indicates a need; and
- The hydraulic gradient caused by mine dewatering acts as a sink for soluble contaminants originating from the TSFs, WRDs and other stockpiles.

  The post operational contaminant transport after 100 years was simulated to assess the potential migration of SO_4 from the TSFs, open pits and WRD/stockpiles. The results of the post-closure mass transport simulation are provided in Figure 49~~Figure 49~~ to Figure 52~~Figure 52~~, which show that:

- Solute migration from the TSF, WRD/stockpiles and open pits remains localised at the mine and does not reach the Kifumashi River to the north; and

- The groundwater levels at the open pits will rebound to levels between 1 190 and 1 210 mamsl within about 10 years. Due to the water levels stabilising at 20 to 40 m below the topographical surfaces surrounding the open pits, decanting is not expected.

As mentioned in Section 2.2.5.1, potentially acid forming (PAF) material may be used as compacted backfill between layers of NAF material in the Kinsevere Hill pit. A layer of NAF material would be placed in the bottom of the pit, followed by most of the PAF material in-pit, followed by a layer of NAF material extending above the ground level, followed by the remainder of the PAF material, a further layer of NAF material and a final 300 mm thick cover layer of topsoil.

With this design, most of the PAF will be submerged and cut off from contact with air, effectively preventing acid formation. The remainder of the PAF material will be encapsulated within adequate NAF material to neutralise all acid resulting from this PAF material. This design is expected to produce significantly less leachate than a stand-alone PAF dump on a NAF base layer or PAF encapsulated within a NAF dump.

With reference to Figure 50~~Figure 50~~ and Figure 52~~Figure 52~~, backfilling of PAF material into the Kinsevere Hill pit would result in solutes emanating from the PAF material migrating into the Kinsevere Hill pit instead of the Central pit, but the solute would still be confined to the mining area and the impacts on existing groundwater users would not be significantly different.

The main purpose of the SRK hydrogeological investigations was to advise the mine on a dewatering strategy for the KEP. Broad impact statements relating to ground stability and overall dewatering impacts were provided as well as illustrations of the lateral extent of the area that may be impacted by groundwater quality deterioration over time, based on solute transport modelling. This information has been considered in the qualified groundwater impact assessment undertaken by Golder during this ESIA process. Such impacts are listed in Table 75~~Table 75~~. No impacts were identified that cannot be mitigated to low or moderate levels.

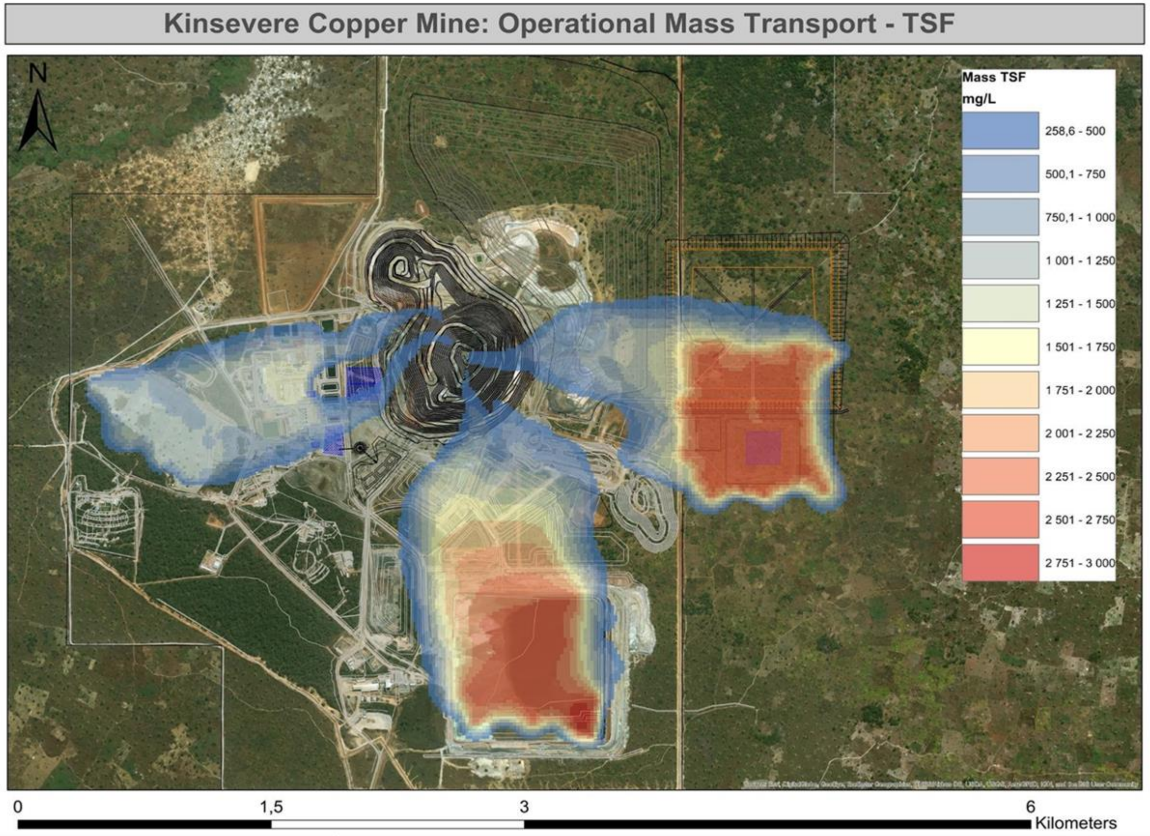


Figure 49: SO_4 Mass Transport from TSFs during Operating Phase

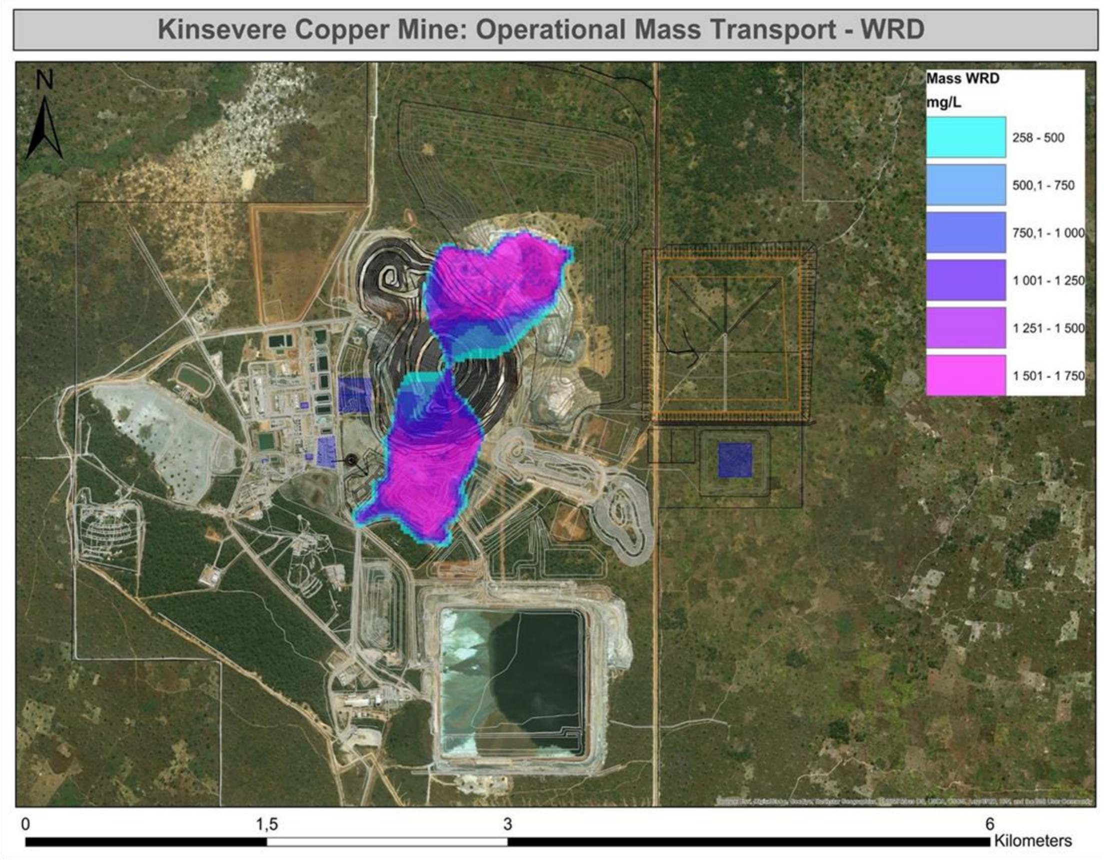


Figure 50: SO_4 Mass Transport from WRD and other Stockpiles during Operating Phase

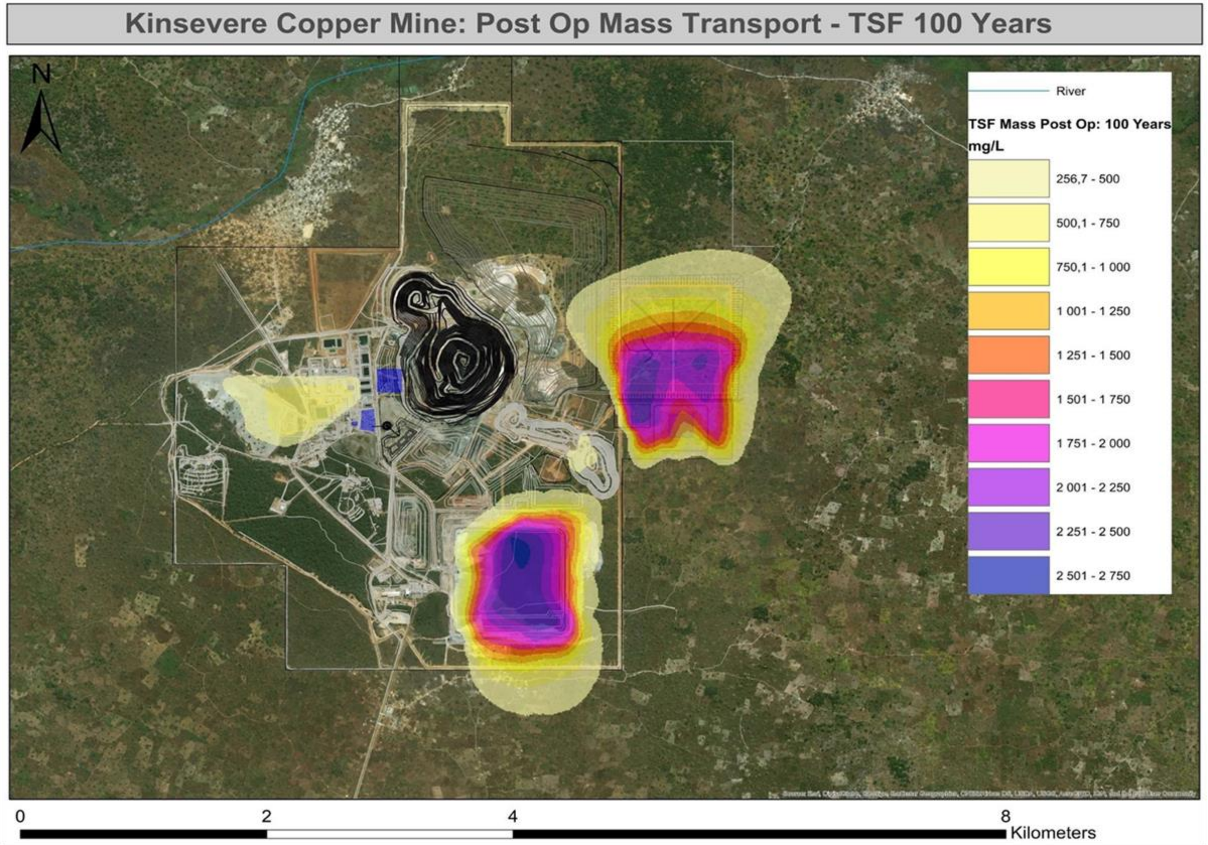


Figure 51: SO_4 Mass Transport from TSFs 100 Years after Closure

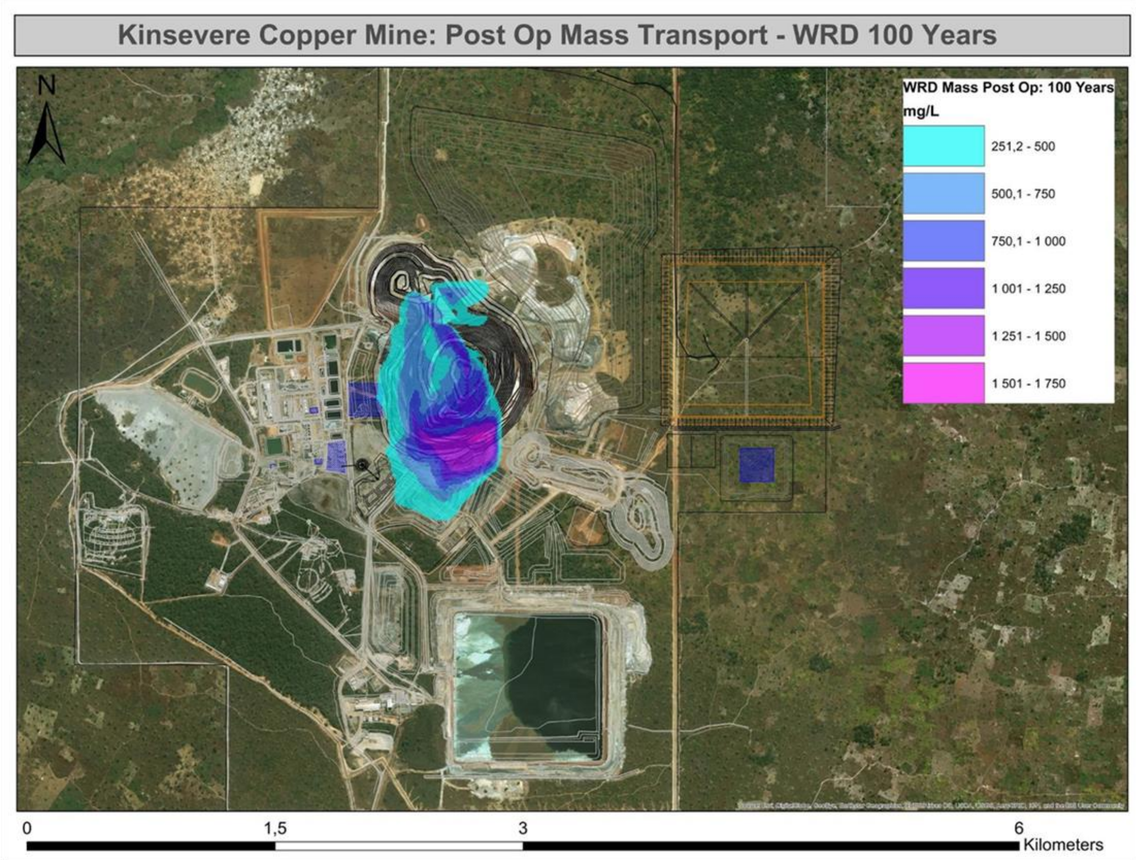


Figure 52: SO_4 Mass Transport from WRD and other Stockpiles 100 Years after Closure

The post-closure water balance model was developed for the combined Central, Mashi and Kinsevere Hill Pits to calculate the changes in storage at a daily time step for 1 000 years, considering scenarios that included pit backfill with tailings and no backfill. The model indicated that the tailings level would reach an elevation of 1 005 mamsl in the combined Central and Mashi Pit and 1 191 mamsl in the Kinsevere Hill Pit.

The GoldSim modelling undertaken by Solution[H+] predicted that the pit water level will fluctuate seasonally by about 1 m after it has rebounded to the regional groundwater level, with evaporation losses during the dry season reducing the pit water levels to below the surrounding groundwater level and causing groundwater flow towards the pits. It was concluded that the water level in the Main pit lake will be approximately 20 m below the decant level at the Main pit and 40 m below the decant level at the Kinsevere Hill Pit.

The preliminary pit lake chemistry modelling predicts that the combined Central and Mashi Pit lake water, without backfill will:

- Unlikely become acidic;
- Be influenced mainly by the groundwater quality;
- Experience exceedance of Cu concentrations with respect to DRC mining regulations, 2018;
- Have Cu concentrations increase over time and no prediction of Cu precipitation; and
- Develop increased salinity over time. Guideline exceedances of Cu, Fe and Zn concentrations are predicted to potentially occur about 500 years after closure.

The combined Central and Mashi Pit lake with tailings backfill will:

- Unlikely become acidic;
- Experience exceedance of Cu concentrations with respect to DRC mining regulations, 2018;
- Experience increased Cu concentrations over time but no precipitation of Cu; and
- Develop increased salinity over time, which will be higher than in the “no backfill” scenario. Guideline exceedances of Cu, Fe and Zn concentrations are predicted to potentially occur about 500 years after closure.

The Kinsevere Hill Pit lake with no backfill will:

- Unlikely become acidic;
- Experience significant variation in water quality as the lake volume responds to seasonal changes in runoff and evaporation;
- Experience exceedance of Cu concentrations with respect to DRC mining regulations, 2018; and
- Develop increased salinity over time, leading to exceedances of guideline Cu, Fe, Zn and Mn concentrations.

The Kinsevere Hill Pit lake with backfill tailings will:

- Unlikely become acidic;
- The water quality will be subject to significant variation as the lake volume responds to seasonal changes in runoff and evaporation. Of all the scenarios modelled, this scenario indicates the poorest water quality and the greatest variation in water quality; and
- Pit lake water will be characterised by exceedance of the tds, mn, and Cu water quality guidelines. Occasional exceedances of the Fe and Zn guidelines will be related to periods of reduced rainfall and increased evaporation.

The Solution [H+] downstream impact assessment indicated that the pit lake level dynamics will require numerical groundwater modelling to quantify the difference between the groundwater and pit lake levels. It also concluded that:

- Once rebound has occurred, it may take a further 75 years for groundwater affected by pit lake water to move approximately 1 000 m north-east of the pits, which is still on the mine lease. The closest existing community with potentially affected water sources is Mpundu Village, approximately 1.5 km north of Mashi Pit;
- The above estimate of the impact zone is uncertain due to a lack of data characterising the Kundelungu aquifers and the expected seasonal changes in hydraulic gradient, and
- Mixing of pit lake water and groundwater indicates that Cu concentrations downstream of the pits may exceed the DRC guideline of 1.5 mg/L. However, this conservatively ignores the potential for sorption of trace elements on clay and oxyhydroxide minerals in the Kundelungu aquifer.

3.2.5.7.1 Limitations of Model – Article 33 (h)

The modelled predictions of pit lake chemistry are based on a number of assumptions about the post-mining physical and geochemical characteristics of the materials in contact with the pit water and are likely to be accurate within one order of magnitude.

3.2.5.7.2 Summary and Conclusions – Article 33 (i)

The SRK work mainly deals with the operational dewatering predictions for the planned pit expansions on tenement PE528 and residual passive inflows under different dewatering scenarios. A maximum RPGI of 63 400 m^3/day is predicted for the Central Pit at the end of the operational phase if all current and recommended perimeter and in-pit dewatering boreholes are installed.

Pore pressures are expected to build up after 2024 and may range from 30-60 m head behind the Central Pit wall in the deepest sections of the mine.

Additional drain holes will be required in the Mashi Pit to depressurise the RAT siltstone, which will reduce inflows by 6 000 m^3/day in 2019 and, due to ongoing dewatering of the Central Pit, there should be no further RPGI at Mashi Pit by 2022.

SRK concluded that dewatering may affect the water levels in nearby villages, and there may be an increased risk of sinkhole formation around the processing plant, where the water level drop could be as much as 80 m.

A rebound of the water level to 1 190 mamsl in the Central and Mashi Pits and to 1 210 mamsl in the Kinservere Hill pit by 2080 was predicted, based on the assignment of infinite and homogeneous aquifer and boundary conditions.

The particle tracking undertaken by SRK suggested that all contaminants entering the saturated aquifer zone will flow to the pits during the operational phase and to the north-east and south-east after 2080.

3.2.6 Noise – Article 42 (a)

A noise and vibration impact study was undertaken for the proposed KOU project (van der Merwe, B;, July 2018). The mine monitors noise and vibration associated with current operations on PE528, at locations where sensitive receptors may experience impacts, but not at all locations that might be affected by the proposed future activities on PE7274. Accordingly, the noise specialist took a series of measurements at such points on 16, 17 and 18 April 2018.

Leq, Maximum (dB LAmax) and minimum (dB LAmin) noise levels were measured during the daytime at points in the vicinity of the villages and PE7274, as indicated on Figure 53~~Figure 53~~ and Figure 54~~Figure 54~~. Leq is the average noise level for the specific measuring point over a period of time, the Lmax is the maximum noise level and the Lmin is the minimum noise level registered during the noise survey for the specific area, expressed in dBA.

The results are presented in Table 33~~Table 33~~.

Table 33: Baseline Noise Levels in Villages and Rural Areas that may be affected by Proposed KOU Project

Point	Coordinates (Universal Transverse Mercator - Zone 35L)		Daytime – dBA			Description
	Easting	Northing	Leq	Lmax	Lmin	
1	562267.16	8746649.03	45.6	74.1	31.1	Noise level in Mpundu Village along the gravel feeder road.
2	562622.68	8747090.65	38.4	62.6	25.4	Noise level west of Mpundu Village along the gravel road.
3	563652.55	8747320.82	39.0	62.7	29.3	Along the gravel road to Sela Village.
4	565131.86	8746752.03	34.9	61.4	24.0	Along the gravel road to Sela Village.
5	565863.02	8746767.11	43.5	66.6	31.0	Northern side of Sela Village.
6	565760.62	8746585.52	56.9	79.0	38.2	At the central business area of Sela village.
7	565433.66	8746301.34	38.1	63.5	28.2	Southern side of Sela Village.
8	565121.00	8745746.00	37.2	62.2	25.3	Western side of PE7274.
9	565026.00	8744940.00	33.8	57.9	24.8	Northern boundary of PE7274.
10	563607.36	8743828.46	40.2	60.8	35.3	Western boundary of PE528 and inside PE7274.
11	563705.53	8742904.93	39.5	62.5	28.5	Western boundary of PE528 and inside PE7274.
12	564658.92	8743148.12	32.6	66.6	21.7	Inside PE7274 along a gravel road.
13	568819.54	8743898.68	35.8	56.2	25.2	Along a gravel road west of PE7274.
14	568007.84	8745314.00	34.1	59.5	23.9	Along the gravel road to Denis village.
15	568766.81	8746314.57	36.6	61.9	26.6	East of Denis at the school.
16	568017.94	8746877.16	36.2	56.0	22.8	East of Mlkanga Village.
17	560883.18	8744783.59	44.1	63.3	37.2	Noise level in the vicinity of the school in Kilongo Village.
18	559849.08	8743656.82	37.5	61.1	22.9	Western boundary of PE 528 along gravel road.
19	561425.43	8740248.17	53.7	78.0	24.5	Along the main feeder road between Lubumbashi and Kinsevere Mine.
20	562659.31	8739856.88	35.3	62.1	23.5	South of the mine along a gravel road.
21	562446.82	8740907.80	38.8	56.1	27.1	At Poto 93 along an internal gravel road.

A noise survey was also done along the perimeter of PE528 during the day and night time periods at the points shown in Figure 54~~Figure 54~~. The results are shown in Table 34~~Table 34~~.

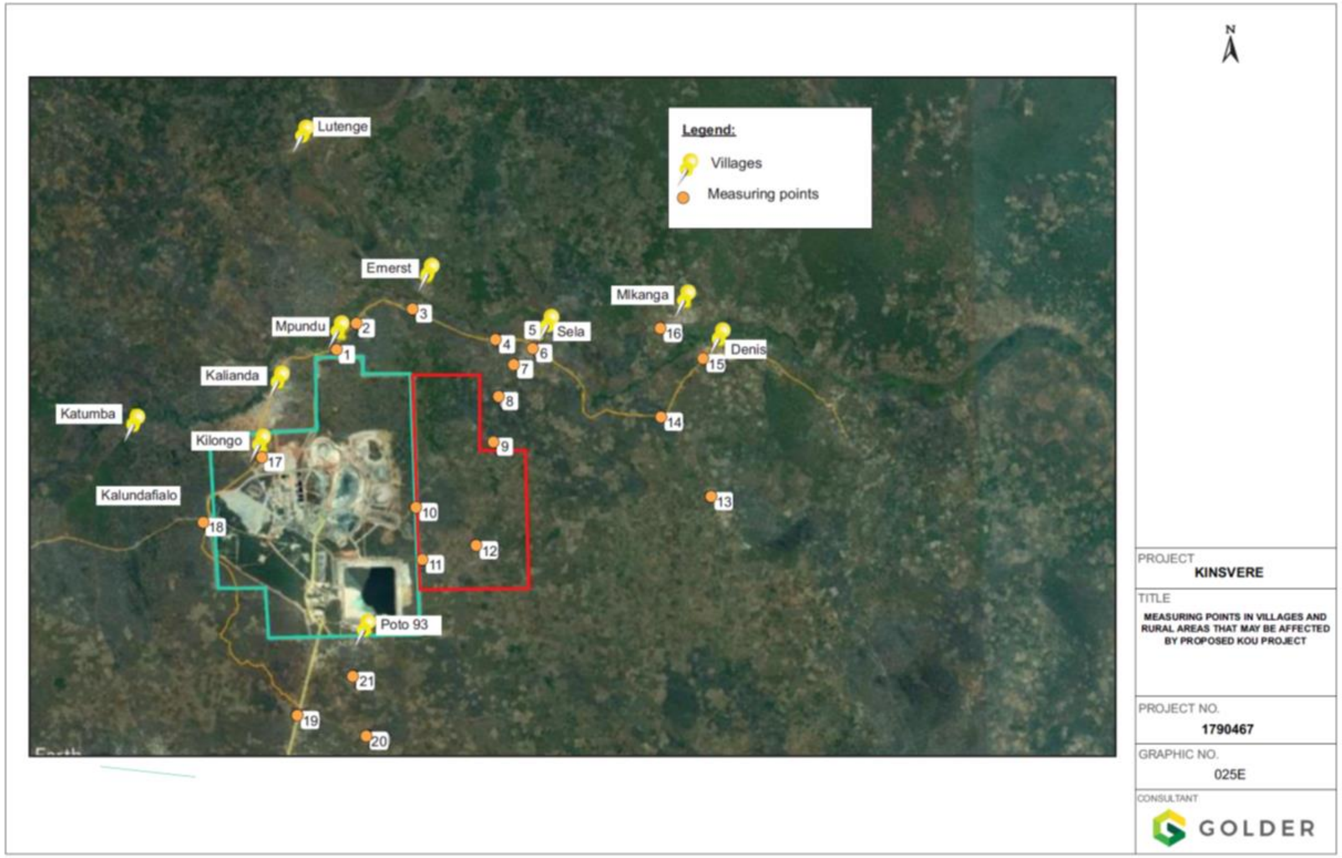


Figure 53: Measuring Points in Villages and Rural Areas that may be affected by Proposed KOU Project

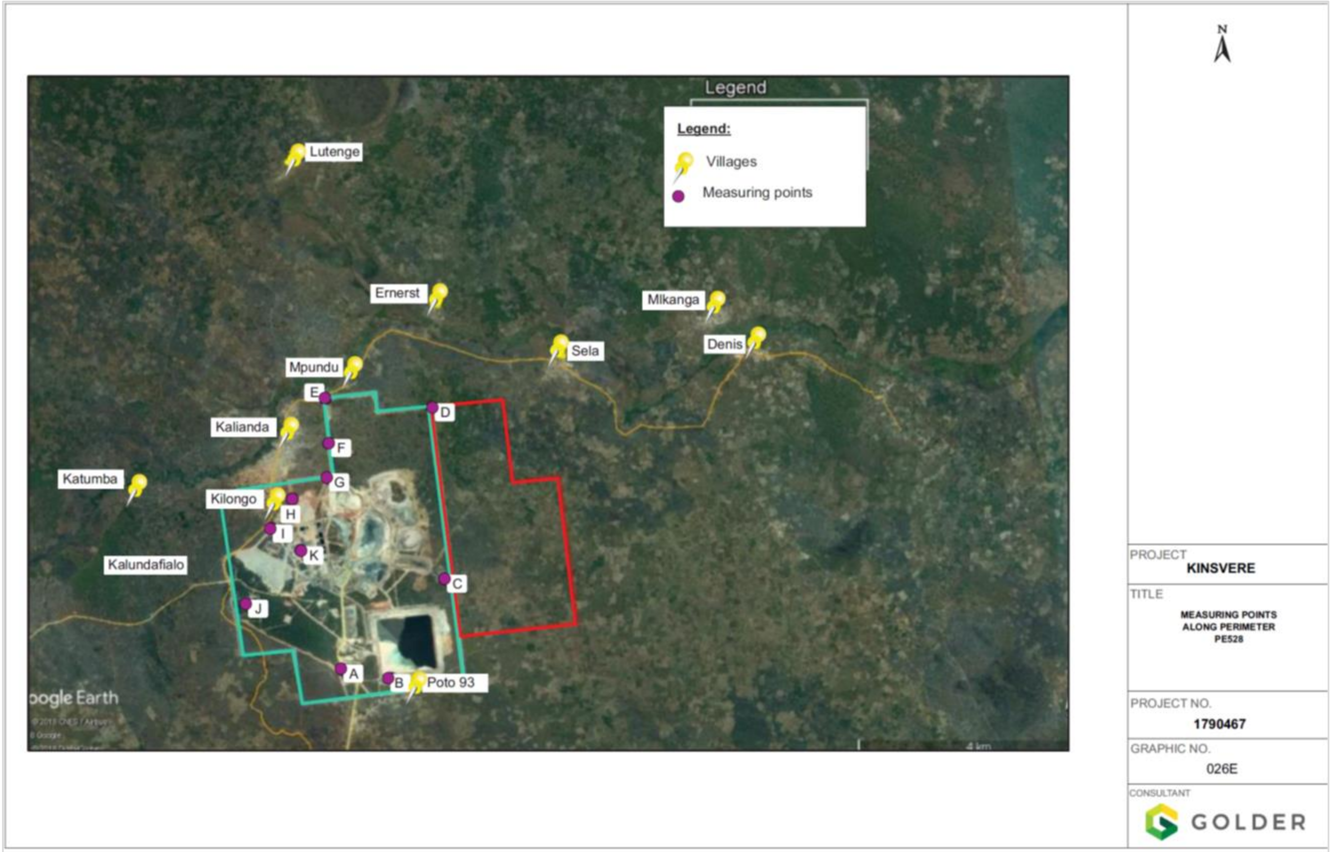


Figure 54: Measuring Points along Perimeter of PE528

Table 34: Current Noise Levels along Perimeter of PE528

Point	Coordinates (Universal Transverse Mercator - Zone 35L)		Daytime – dBA			Night time – dBA			Description
	Easting	Northing	Leq	Lmax	Lmin	Leq	Lmax	Lmin	
A	561665.36	8742070.41	56.1	77.6	36.0	53.7	82.2	37.3	Main entrance gate of the mine.
B	562434.12	8741842.22	30.9	51.2	19.9	33.9	47.7	28.4	At the TSF to the south of the mining area.
C	563508.19	8743343.96	39.2	62.1	29.6	32.0	61.2	28.0	Western boundary of the mine (PE528).
D	563632.01	8746145.04	35.4	57.6	23.1	40.0	58.9	34.3	North-western corner of PE528.
E	561899.50	8746506.00	39.4	65.9	26.0	43.2	58.9	39.1	Northern boundary of PE528.
F	561874.42	8745768.86	38.9	61.8	33.4	45.9	59.4	41.3	Eastern boundary of PE528 in the vicinity of Kalianda Village.
G	561793.32	8745212.43	44.6	62.5	30.3	53.0	59.3	45.7	Mine boundary on the northern side of Mashi Pit.
H	561167.18	8744937.20	42.9	63.1	35.5	48.5	64.1	44.3	Northern boundary in the vicinity of Kilongo Village.
I	560775.11	8744507.46	46.0	66.0	37.4	52.5	66.5	49.2	Social and Development buildings opposite Kilongo Village.
J	560228.61	8743329.70	44.7	62.9	35.5	40.2	60.8	35.3	Mine village residential area along the eastern boundary of the mining area.
K	561211.28	8744092.58	No noise reading			75.3	82.0	67.3	Along the boundary of the electro-winning plant.

The noise levels recorded during this survey are in broad agreement with noise levels recorded at the same locations between April 2012 and November 2017. Noise levels at the locations that are more distant from the noise sources associated with the mining and ore processing activities are typical of rural areas and are generally lower than the levels measured close to the mining and ore processing activities.

The current ambient noise levels at the potentially affected villages are listed in Table 35~~Table 35~~.

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Table 35: Current Ambient Noise Levels at Villages

Village	Noise Level Daytime – dBA	Noise Level Night Time – dBA
Mlkanda	36.2	33.2
Denis	36.6	33.6
Sela	46.2	43.2
Ernest	39.0	36.0
Mpundu	38.4	34.4
Kalianda	39.0	36.0
Katumba	39.0	36.0
Lutenge	38.4	35.4
Kilongo	44.1	41.1
Poto 93	36.2	33.2

3.2.7 Vibration

Ground vibration levels were measured at the same locations as for the noise survey (Figure 53Figure 53 and Figure 54Figure 54).

There was no blasting at any of the pits during the time of the survey and the levels measured represent the natural ground vibration levels that prevail within the study area.

The results of the measurements are shown in Table 36Table 36. Ground vibration is expressed as peak particle velocity (PPV) in mm per second. Humans are quite sensitive to ground vibration and most people can detect PPV levels in the 0.3 to 0.5 mm/sec range.

Table 36: Natural Ground Vibration Levels on Study Area

Point	Coordinates (Universal Transverse Mercator - Zone 35L)		Transverse Peak mm/s	Vertical Peak mm/s	Longitudinal Peak mm/s	PPV mm/s
	Easting	Northing				
1	562267.16	8746649.03	0.127	0.127	0.254	0.284
2	562622.68	8747090.65	0.254	0.127	0.254	0.284
3	563652.55	8747320.82	0.127	0.127	0.127	0.220
4	565131.86	8746752.03	0.127	0.254	0.127	0.254
5	565863.02	8746767.11	0.254	0.127	0.254	0.311
6	565760.62	8746585.52	0.127	0.127	0.127	0.220
7	565433.66	8746301.34	1.127	0.254	0.254	0.254
8	565121.00	8745746.00	0.127	0.127	0.127	0.220
9	565026.00	8744940.00	0.381	0.254	0.254	0.402
10	563607.36	8743828.46	0.127	0.127	0.254	0.284
11	563705.53	8742904.93	0.127	0.127	0.127	0.220
12	564658.92	8743148.12	0.127	0.127	0.127	0.220
13	568819.54	8743898.68	0.127	0.127	0.127	0.220
14	568007.84	8745314.00	0.127	0.127	0.127	0.220
15	568766.81	8746314.57	0.127	0.254	0.127	0.254
16	568017.94	8746877.16	0.127	0.254	0.127	0.284
17	560883.18	8744783.59	0.127	0.127	0.127	0.220
18	559849.08	8743656.82	0.254	0.254	0.254	0.311
19	561425.43	8740248.17	0.127	0.127	0.127	0.220
20	562659.31	8739856.88	0.127	0.127	0.127	0.220
21	562446.82	8740907.80	0.254	0.127	0.254	0.311
A	561665.36	8742070.41	0.381	0.254	0.254	0.402
B	562434.12	8741842.22	0.254	0.127	0.254	0.311
C	563508.19	8743343.96	0.127	0.127	0.254	0.284
D	563632.01	8746145.04	0.127	0.127	0.254	0.284
E	561899.50	8746506.00	0.127	0.127	0.254	0.284
F	561874.42	8745768.86	0.127	0.127	0.254	0.284
G	561793.32	8745212.43	0.127	0.127	0.254	0.284
H	561167.18	8744937.20	0.127	0.127	0.254	0.284
I	560775.11	8744507.46	0.127	0.127	0.254	0.284
J	560228.61	8743329.70	0.127	0.127	0.254	0.284
K	561211.28	8744092.58	0.254	0.254	0.254	0.311

3.3 CHAPTER III: DESCRIPTION OF THE BIOLOGICAL ENVIRONMENT

3.3.1 Components of the Description of the Biological Environment (Article 34)

The applicant for a permanent mining or quarrying right must describe the elements of the biological environment as required in terms of sections 34 to 36 of Schedule VIII of the Mining Regulations.

An ecological specialist study was undertaken on the PE7274 tenement during May-June 2018 (McCleland, W; Dower, A; Mason, M;, August 2018).

3.3.2 Terrestrial and Avian Fauna (Article 35)

The applicant for a permanent mining or quarrying right must describe the terrestrial and avian wildlife species whose habitat is within the perimeter or whose migration route passes through the perimeter. Habitats, as well as migration routes, must be indicated on a topographic map. For each species, the the breeding and calving periods must be specified, and it must be indicated whether the species is one of the rare species, fully or partially protected species as identified in the tables in Articles 4 and 5 of Appendix. XII of the Mining Regulations on Sensitive Environments.

The faunal assemblages in both the PE528 and the PE7274 tenement areas were found to be depauperate during a previous survey (McCleland, W; McKenzie, D;, February 2017), particularly with regard to mammal and herpetofaunal assemblages. Fieldwork was thus focused on a current assessment of the bird assemblages present, using the same transects that were walked for the vegetation assessment. Birds were searched for by walking slowly through vegetation and recording all species seen or heard. Care was taken to remain at any point of bird activity and record all the species present, particularly flocks comprising mixed species. All species seen or heard were listed in chronological order as each was encountered in the field.

The breeding season coincides with the beginning of the rainy season, between October and March.

3.3.2.1 Mammals

Only nine mammal species have been confirmed to occur within both tenement areas, with no evidence for the presence of large mammals (McCleland, W; McKenzie, D;, February 2017) see Table 37~~Table 37~~. However, none of the previous studies has incorporated trapping of rodents or nocturnal recording of bats and it is likely that these groups are under-represented. Only three mammals were recorded in PE7274 during this (2018) study, although no nocturnal fieldwork was conducted. A single Gambian Sun Squirrel was seen in a patch of Dry Evergreen Forest, while a Slender Mongoose was seen crossing a road in Degraded Shrubland and dung of Scrub Hare was found in Degraded Shrubland. Several snare lines were located along tracks in Degraded Shrubland, although the size of the snares indicated that the target species are likely to be rodents.

Table 37: Mammals observed within the project area between 2006 and 2018

Scientific name	Common Name
Heliosciurus gambianus	Gambian Sun Squirrel
Petrodromus tetradactylus	Four-toed Sengi
Lepus saxatilis	Scrub Hare
Atilax paludinosus	Marsh Mongoose
Paracynictis selousi	Selous Mongoose
Herpestes sanguinea	Slender Mongoose
Sylvicapra grimmia	Common Duiker
Orycteropus afer	Aardvark
Otolemur crassicaudatus	Greater Galago

3.3.2.2 Birds

Kinsevere mine is situated in a region of high avifaunal diversity, with 693 species confirmed to occur in the Katanga region (Louette & Hasson, 2012). Bird surveys conducted at Kinsevere in between 2006 and 2016 recorded 237 species, which is high considering the relatively low habitat diversity and lack of wetland habitat (McCleland, W; McKenzie, D;, February 2017). A significant number of these species are woodland habitat specialists that have not been recorded in either tenement since 2010, when the rate of woodland destruction accelerated. Bird surveys of PE7274 took place in March 2016 (McCleland, W; McKenzie, D;, February 2017) and during the current (2018) study, recording a total of 144 species – see Table 39~~Table 39~~.

Table 38: Potentially Occurring and Confirmed Bird Species of Conservation Concern in Project Area

Scientific Name	Common Name	Red List Data Status	
Balearica regulorum	Royal crane	EN	u
Bucorvus leadbeateri	Southern ground hornbill	VU	x
Bugeranus carunculatus	Wattled crane	VU	u
Circus macrourus	Pale harrier	NT	p
Gallinago media	Great snipe	NT	x
Gyps africanus	White-backed vulture	CR	u
Necrosyrtes monachus	Hooded vulture	CR	u
Ploceus ruweti	Lufira masked weaver	DD	u
Polemaetus bellicosus	Martial eagle	VU	u
Stephanoaetus coronatus	Crowned eagle	NT	p
Terathopius ecaudatus	Bateleur eagle	NT	x

Notes: X = confirmed ; P = possible ; U = unlikely

Table 39: Bird Species Recorded within PE 7274 in 2018

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
ORDER: ACCIPITRIFORMES					
Family Accipitridae (kites, hawks & eagles)					
Black-shouldered Kite	*Elanus caeruleus*				x
Western Banded Snake Eagle	*Circaetus cinerascens*				x
Wahlberg's Eagle	*Hieraaetus wahlbergi*		x		x
Lizard Buzzard	*Kaupifalco monogrammicus*		x		x
Common Buzzard	*Buteo buteo*		x		x
ORDER: COLUMBIFORMES					
Family Columbidae (pigeons, doves)					
Red-eyed Dove	*Streptopelia semitorquata*		x	x	x
Cape Turtle Dove	*Streptopelia capicola*		x		x
Emerald-spotted Wood Dove	*Turtur chalcospilos*		x		
African Green Pigeon	*Treron calvus*		x	x	
ORDER: MUSOPHAGIFORMES					
Family Musophagidae (turacos)					
Schalow's Turaco	*Tauraco schalowi*			x	

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
Ross's Turaco	*Musophaga rossae*			x	
ORDER: CUCULIFORMES					
Family Cuculidae (cuckoos & coucals)					
Senegal Coucal	*Centropus senegalensis*				x
African Cuckoo	*Cuculus gularis*		x		
Red-chested Cuckoo	*Cuculus solitarius*		x	x	
Diederik Cuckoo	*Chrysococcyx caprius*				x
Klaas's Cuckoo	*Chrysococcyx klaas*		x		
ORDER: APODIFORMES					
Family Apodidae (swifts)					
African Palm Swift	*Cypsiurus parvus*				x
Böhm's Spinetail	*Neafrapus boehmi*		x		
ORDER: COLIIFORMES					
Family Coliidae (mousebirds)					
Red-faced Mousebird	*Urocolius indicus*				x
ORDER: TROGONIFORMES					
Family Trogonidae (trogons)					
Narina Trogon	*Apaloderma narina*			x	
ORDER: CORACIIFORMES					
Family Coraciidae (rollers)					
Lilac-breasted Roller	*Coracias caudatus*				x
Family Alcedinidae (kingfishers)					
Brown-hooded Kingfisher	*Halcyon albiventris*		x		x
Striped Kingfisher	*Halcyon chelicuti*		x		
Family Meropidae (bee-eaters)					
Little Bee-eater	*Merops pusillus*				x
Blue-cheeked Bee-eater	*Merops persicus*				x
Swallow-tailed Bee-eater	*Merops hirundineus*		x		
European Bee-eater	*Merops apiaster*		x		x
Southern Carmine Bee-eater	*Merops nubicoides*				x
ORDER: BUCEROTIFORMES					
Family Upupidae					
African Hoopoe	*Upupa africana*		x		
Family Phoeniculidae (woodhoopoes)					
Green Woodhoopoe	*Phoeniculus purpureus*		x	x	
Common Scimitarbill	*Rhinopomastus cyanomelas*		x		
Family Bucerotidae (hornbills)					
Crowned Hornbill	*Lophoceros alboterminatus*		x	x	
Trumpeter Hornbill	*Bycanistes bucinator*		x	x	
Pale-billed Hornbill	*Tockus pallidirostris*	x	x		
ORDER: PICIFORMES					
Family Lybiidae (African barbets)					

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
Yellow-fronted Tinkerbird	*Pogoniulus chrysoconus*		x		
Yellow-rumped Tinkerbird	*Pogoniulus bilineatus*			x	
Black-collared Barbet	*Lybius torquatus*		x		
Family Indicatoridae (honeyguides)					
Lesser Honeyguide	*Indicator minor*		x		
Family Picidae (woodpeckers)					
Bearded Woodpecker	*Dendropicos namaquus*		x		
Golden-tailed Woodpecker	*Campethera abingoni*		x	x	
Cardinal Woodpecker	*Dendropicos fuscescens*		x		x
ORDER: FALCONIFORMES					
Family Falconidae (falcons)					
Eurasian Hobby	*Falco subbuteo*				x
ORDER: PSITTACIFORMES					
Family Psittacidae (parrots)					
Meyer's Parrot	*Poicephalus meyeri*		x		x
ORDER: PASSERIFORMES					
Family Eurylaimidae (broadbills)					
African Broadbill	*Smithornis capensis*			x	
Family Platysteiridae (wattle-eyes & batises)					
Chinspot Batis	*Batis molitor*		x		
Black-throated Wattle-eye	*Platysteira peltata*			x	
Family Prionopidae (helmetshrikes)					
White-crested Helmetshrike	*Prionops plumatus*		x		
Retz's Helmetshrike	*Prionops retzii*		x	x	
Family Malaconotidae (bushshrikes)					
Grey-headed Bushshrike	*Malaconotus blanchoti*		x	x	
Black-fronted Bushshrike	*Chlorophoneus nigrifrons*			x	
Orange-breasted Bushshrike	*Chlorophoneus sulfureopectus*		x		
Black-crowned Tchagra	*Tchagra senegalus*				x
Brown-crowned Tchagra	*Tchagra australis*				x
Black-backed Puffback	*Dryoscopus cubla*		x	x	x
Brubru	*Nilaus afer*		x		x
Tropical Boubou	*Laniarius major*		x	x	x
Family Campephagidae (cuckooshrikes)					
White-breasted Cuckooshrike	*Coracina pectoralis*		x		
Black Cuckooshrike	*Campephaga flava*		x		
Purple-throated Cuckooshrike	*Campephaga quiscalina*			x	
Family Laniidae (shrikes)					
Northern Fiscal	*Lanius humeralis*				x
Red-backed Shrike	*Lanius collurio*				x

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
Family Oriolidae (orioles)					
Black-headed Oriole	*Oriolus larvatus*		x		x
African Golden Oriole	*Oriolus auratus*		x		
Family Dicruridae (drongos)					
Square-tailed Drongo	*Dicrurus ludwigii*			x	
Fork-tailed Drongo	*Dicrurus adsimilis*		x		
Family Stenostiridae (fairy flycatchers)					
White-tailed Blue Flycatcher	*Elminia albicauda*			x	
Family Monarchidae (monarchs)					
African Paradise Flycatcher	*Terpsiphone viridis*			x	
Family Corvidae (crows)					
Pied Crow	*Corvus albus*				x
Family Paridae (tits)					
Miombo Tit	*Melaniparus griseiventris*	x	x		
Rufous-bellied Tit	*Melaniparus rufiventris*	x	x		
Family Remizidae (penduline tits)					
Grey Penduline Tit	*Anthoscopus caroli*		x		
Family Alaudidae (larks)					
Flappet Lark	*Mirafra rufocinnamomea*				x
Family Pycnonotidae (bulbuls)					
Dark-capped Bulbul	*Pycnonotus tricolor*		x		x
Cabanis's Greenbul	*Phyllastrephus cabanisi*			x	
Yellow-bellied Greenbul	*Chlorocichla flaviventris*			x	
Family Hirundinidae (swallows & martins)					
Black Saw-wing	*Psalidoprocne pristoptera*		x		x
Barn Swallow	*Hirundo rustica*				x
Mosque Swallow	*Hirundo senegalensis*				x
Lesser Striped Swallow	*Cecropis abyssinica*				x
Family Macrosphenidae (crombecs & African warblers)					
Red-capped Crombec	*Sylvietta ruficapilla*	x	x		
Family Phylloscopidae (leaf warblers & allies)					
Willow Warbler	*Phylloscopus trochilus*		x		
Family Acrocephalidae (reed warblers & allies)					
Great Reed Warbler	*Acrocephalus arundinaceus*				x
Family Cisticolidae (cisticolas & allies)					
Red-faced Cisticola	*Cisticola erythrops*				x
Trilling Cisticola	*Cisticola woosnami*		x		x
Rattling Cisticola	*Cisticola chiniana*				x
Short-winged Cisticola	*Cisticola brachypterus*				x
Tawny-flanked Prinia	*Prinia subflava*		x		x

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
Yellow-breasted Apalis	*Apalis flavida*		x	x	
Green-capped Eremomela	*Eremomela scotops*		x		
Miombo Wren-Warbler	*Calamonastes undosus*	x	x		
Grey-backed Camaroptera	*Camaroptera brevicaudata*			x	x
Family Zosteropidae (white-eyes)					
African Yellow White-eye	*Zosterops senegalensis*		x	x	
Family Hyliotidae (hyliotas)					
Yellow-bellied Hyliota	*Hyliota flavigaster*		x		
Southern Hyliota	*Hyliota australis*		x		
Family Sturnidae (starlings)					
Sharp-tailed Starling	*Lamprotornis acuticaudus*	x	x		
Violet-backed Starling	*Cinnyricinclus leucogaster*		x		
Family Turdidae (thrushes)					
African Thrush	*Turdus pelios*			x	
Kurrichane Thrush	*Turdus libonyanus*	x	x		
Groundscraper Thrush	*Psophocichla litsitsirup a*				x
Family Muscicapidae (chats & Old World flycatchers)					
White-browed Scrub Robin	*Cercotrichas leucophrys*				x
Grey Tit-Flycatcher	*Myioparus plumbeus*		x		
Spotted Flycatcher	*Muscicapa striata*		x		
Ashy Flycatcher	*Muscicapa caerulescens*		x	x	
Pale Flycatcher	*Bradornis pallidus*		x		
Southern Black Flycatcher	*Melaenornis pammelaina*		x		
African Stonechat	*Saxicola torquata*				x
White-browed Robin-Chat	*Cossypha heuglini*			x	
Red-capped Robin-Chat	*Cossypha natalensis*			x	
Family Nectariniidae (sunbirds)					
Collared Sunbird	*Hedydipna collaris*		x	x	
Amethyst Sunbird	*Chalcomitra amethystina*		x		x
Scarlet-chested Sunbird	*Chalcomitra senegalensis*		x		x
Olive Sunbird	*Cyanomitra olivacea*			x	
Family Passeridae (Old World sparrows)					
Northern Grey-headed Sparrow	*Passer griseus*		x		x
Yellow-throated Petronia	*Gymnoris superciliaris*		x		
Family Ploceidae (weavers & widowbirds)					

Common Name	Scientific Name	Zambezian Biome Endemics	Broad-leaved Woodland	Dry Evergreen Forest	Degraded Woodland / Transformed
Dark-backed Weaver	*Ploceus bicolor*			x	
Holub's Golden Weaver	*Ploceus xanthops*				x
Village Weaver	*Ploceus cucullatus*				x
Red-headed Weaver	*Anaplectes rubriceps*		x		
Black-winged Bishop	*Euplectes hordeaceus*				x
Yellow Bishop	*Euplectes capensis*				x
Red-collared Widowbird	*Euplectes ardens*				x
White-winged Widowbird	*Euplectes albonotatus*				x
Family Estrildidae (waxbills, mannikins, whydahs)					
Red-throated Twinspot	*Hypargos niveoguttatus*			x	
Green Twinspot	*Mandingoa nitidula*			x	
Jameson's Firefinch	*Lagonosticta rhodopareia*				x
African Firefinch	*Lagonosticta rubricata*		x		x
Orange-winged Pytilia	*Pytilia afra*		x		
Blue Waxbill	*Uraeginthus angolensis*				x
Common Waxbill	*Estrilda astrild*				x
Bronze Mannikin	*Lonchura cucullata*		x		x
Red-backed Mannikin	*Lonchura nigriceps*				x
Magpie Mannikin	*Lonchura fringilloides*			x	
Family Viduidae (indigobirds & whydahs)					
Purple Indigobird	*Vidua purpurascens*				x
Dusky Indigobird	*Vidua funerea*		x		x
Pin-tailed Whydah	*Vidua macroura*				x
Long-tailed Paradise-whydah	*Vidua paradisaea*				x
Broad-tailed Paradise-whydah	*Vidua obtusa*		x		x
Cuckoo Finch	*Anomalospiza imberbis*				x
Family Motacillidae (wagtails & pipits)					
African Pipit	*Anthus cinnamomeus*				x
Family Fringillidae (finches, canaries & allies)					
Black-faced Canary	*Serinus capistratus*				x
Black-eared Seedeater	*Serinus mennelli*	x	x		
Yellow-fronted Canary	*Crithagra mozambica*		x		x
Family Emberizidae (buntings)					
Golden-breasted Bunting	*Emberiza flaviventris*		x		x
Cabanis's Bunting	*Emberiza cabanisi*		x		
TOTAL	**144**	**8**	**79**	**37**	**70**

3.3.2.2.1 Broad-leaved Woodland

McCleland (2017) documented the occurrence of 18 biome-restricted endemic bird species in broad-leaved woodland habitat on PE528 and PE7274 between 2006 and 2016. The original woodland bird assemblage in PE7274 may have included most of these range-restricted habitat specialists, such as Miombo Pied Barbet, Anchieta's Barbet, Black-necked Eremomela and Chestnut-mantled Sparrowweaver. However, the impacts on broad-leaved woodland in the tenement area have resulted in a reduced woodland bird assemblage that is dominated by generalist species such as Dark-capped Bulbul, Black-headed Oriole, Black backed Puffback and Cape Turtle Dove. While 79 bird species were recorded on PE7274 in March 2016 and during this current (2018) survey, the only biome-restricted endemics were Miombo and Rufous bellied Tits, Miombo Wren-Warbler, Pale-billed Hornbill, Red-capped Crombec and Sharp-tailed Starling, all of which require closed-canopy woodland.

3.3.2.2.2 Dry Forest/Thicket Assemblage

This is a small, fragmented assemblage confined to the patches of Dry Evergreen Forest that remain on PE7274 and is mostly absent from PE528. 37 species, which include Narina Trogon, African Broadbill, Black fronted Bush-shrike, Purple-throated Cuckooshrike, Cabanis' Greenbul and Red-throated Twinspot, were recorded in this assemblage between March 2016 and the study undertaken in May-June 2018. Most of them are habitat specialists that are unlikely to occur away from forest or thicket habitat and thus have extremely restricted occurrence in the tenement area. It is likely that the closed woodland habitat still evident in the northern part of PE7274 allows for some of these species to move between thickets, but this may not be the case in the near future if the woodland destruction continues.

3.3.2.2.3 Degraded Shrubland Assemblage

This has become the dominant host assemblage for birds on PE7274, occurring on most of the tenement area, although it was almost entirely absent in 2006 when biodiversity surveys commenced. It is a modified assemblage associated with degraded or secondary woodland habitat that now resembles low, open to closed shrubland.

McCleland (2017) recorded 58 species within this assemblage, although data collected during the current study has increased this total to 70 species. One of the features of this assemblage is the lack of habitat specialists. Habitat generalist species are dominant, particularly species that are most common in degraded, scrubby habitats, such as Black-crowned Tchagra, Northern Fiscal, Tawny-flanked Prinia, White browed Scrub Robin, African Stonechat and Yellow-fronted Canary. Another feature of the Degraded Shrubland Assemblage is the high proportion of seed-eating birds as a result of the increased grass abundance. Species such as Black-winged Bishop, Red-collared Widowbird, Pin-tailed Whydah and Common Waxbill, which are absent from closed-canopy woodland, are now prominent.

3.3.2.3 Herpetofauna

Broadley & Cotterill (2004) consider miombo (broad-leaved) woodland and riparian grasslands or 'dambos' to be the most important habitats for reptiles of conservation importance in the Katanga region of the DRC, neither of which are prominent habitats within PE7274.

Only eight reptile and 10 frog species were recorded during surveys on both tenements (McCleland 2017), although most frog species were recorded along the Kifumashi stream to the north of the study area and are unlikely to occur in PE7274. The reptile species are listed in Table 40~~Table 40~~.

Table 40: Reptiles Encountered during Surveys

Scientific Name	Common Name
ORDER: SQUAMATA	
Family Chamaeleonidae (chameleons)	
Chamaeleo dilepis	Flap-necked Chameleon

Scientific Name	Common Name
Family Scincidae (skinks)	
Trachylepis varia	Variable Skink
Family Viperidae (adders & vipers)	
Bitis gabonica	Gaboon Adder
Bitis arietans	Puffadder
Family Elapidae (cobras & mambas)	
Dendroaspis polylepis	Black Mamba
Naja melanoleuca	Forest Cobra
Naja nigricollis	Black-necked Spitting Cobra
Family Colubridae (colubrid snakes)	
Thelotornis capensis oatesii	Savannah Vine Snake

A dedicated trapping exercise using drift fences and pitfall traps would have produced significantly more reptile species but is unlikely to have added any species of conservation concern. Most of the confirmed reptiles are widespread habitat generalists such as Puffadder, Black Mamba, Flap necked Chameleon and Variable Skink, which are likely to still be present on PE7274.

The DRC is host to 232 known species of amphibian fauna, of which 78 occur in southern DRC (Poyton, 1998). Many of these species are restricted to high-altitude habitats, such as that of the Upemba and Kundelungu National Parks and would not occur within the project area. The amphibian population in the project area is concentrated in the wetlands which occur in the vicinity of the Kifumashi River.

Ten species were recorded during fieldwork, but the true species richness may be much higher. Terrestrial amphibians, such as the Plain Squeaker, Gutteral Toad and Flat-backed Toad were observed outside of the wetland areas, while the Bubbling Kassina and Marginated Reedfrog were recorded within the swamp forest and along the Kifumashi River during a nocturnal survey in March 2016. Three Zambezian biome endemic species were recorded, namely the Plain Squeaker, Pointed Long Reed Frog and Lemaire's White-lipped Frog. The amphibians observed are listed in Table 41~~Table 41~~.

Table 41: Amphibians Encountered during Surveys

Scientific Name	Common Name
ORDER: ANURA	
Family Pipidae	
Xenopus cf. *muelleri*	Müller's Platanna
Family Arthroleptidae	
Schoutedenella xenochirus	Plain Squeaker
Family Bufonidae	
Amietophrynus maculatus	Flat-backed Toad
Amietophrynus gutturalis	Guttural Toad
Family Phrynobatrachidae	
Phrynobatrachus sp.	Puddle Frog sp.
Family Ptychadenidae	
Ptychadena anchietae	Plain Grass Frog
Family Hyperoliidae	
Kassina senegalensis	Bubbling Kassina

Scientific Name	Common Name
Hyperolius marginatus	Marginated Reed Frog
Hyperolius nasicus	Pointed Long Reed Frog
Family Ranidae	
Hylarana lemairei	Lemaire's White-lipped Frog

3.3.2.4 Protected Fauna in DRC

Fully protected animals (Article 4 of Annex XI: "SENSITIVE ENVIRONMENTS" of the Mining Regulations) are totally protected by the DRC Mining Regulations and are listed in Table 42~~Table 42~~ below. The most significant threats to wildlife in the project area are the destruction of habitats through the development of mines and associated infrastructure, and the conversion of habitat from wooded areas to cultivated fields.

Table 42: Fully Protected Animal Species

A. Mammalia	A. Mammals	Present at Kinsevere
A.1. Primates	**A.1. Primates**	
Gorilla gorilla spp.	Mountain and plains gorilla	N
Pan troglodytes	Clear-faced chimpanzee	N
Pan paniscus	Dwarf chimpanzee	N
A.2. Proboscidea	**A.2. Proboscidiens**	
Loxodonta africana africana	Savanna elephant	N
Loxodonta africana cylotis	Forest elephant	N
Loxodonta africana purillis	Dwarf elephant	N
A.3. Perissodactyla	**A.3. Perissodactyla**	
Equus burchelli hippotigris	Burchell's zebra	N
Ceratotherium simum cottoni	White rhinoceros	N
Diceros bicornis	Black rhinoceros	N
A.4. Artiodactyla	**A.4. Artiodactyla**	
Giraffa camelopardalis	Giraffe	N
Okapia johnstoni	Okapi	N
Oreotragus oreotragus	Klipspringer	N
Taurotragus oryx	Common eland	N
Taurotragus derbianus	Derby eland	N
Onotragus smithemani	Cobe lechwe	N
Tragelaphus strepsiceros	Greater kudu	N
Aepyceros melampus	Katanga impala	N
Hyemoschus aquaticus	Water chevrotain	N
A.5. Carnivora	**A.5. Carnivores**	
Felis (Profelis) aurata	Golden cat	N
Osbornictis piscivora	Water civet	N
Acinonyx jubatum	Cheetah	N
Felis caracal	Caracal	N
A.6. Sirenia	**A.6. Siréniens**	
Trichechus senegalensis	Aquatic manatee	N
A.7. Tubulidente	**A.7. Tubulidentés**	

A. Mammalia	A. Mammals	Present at Kinsevere
Orycteropus afer	Aardvark	N
B. PHOLIDOTA	**B. PHOLIDOTES**	
Manis gigantea	Giant pangolin	N
C. REPTILA	**C. REPTILES**	
C.1. Crocodyla	**C.1. Crocodiles**	
Crocodylus niloticus	Nile crocodile (L <1,50 m)	N
Crocodylus cataphractus	African slender-snouted Crocodile <1,50 m)	N
Osteolaemus tetraspis	African dwarf crocodile (L <0,50 m)	N
C.2. Testudinata	**C.2. Turtles**	
Curetta curetta	Snapping turtle	N
Dermochelys coriacca	Leatherback turtle	N
Eretmochelys imbricata	Hawksbill turtle	N
Chelonia mydas	Green sea turtle	N
D. AVES	**D. BIRDS**	
Afropavo congensis	Zairian peacock	N
Balaeniceps rex	Shoebill	N
Ciconia ciconia	White stork	N
Pseudochelidon cuvrystominus	Yellow-billed swallow	N
Sagittarius serpentarices	Secretary bird	N
Vulturidae	All vultures	N
Leptoptolus crumeniferus	Marabou stork	N
Bucorvus abyssinicus	Abyssinian ground hornbill	N
Bugeranus carunculatus	Wattled crane	N
Balearica pavonina	black crowned crane	N
Psittacus erithacus	African grey parrot	N
Prionops alberti	Yellow-crested helmetshrike	N
Pseudocalyptemena granueri	Pseudocalyptemena	N
E. PISCES	**E. FISH**	
Caecobarbus	Congo blind barb	N

Partially Protected Animals in terms of (Article 5 of Annex XI: "SENSITIVE ENVIRONMENTS" of the Mining Regulations) are listed in Table 43~~Table 43~~ below.

Table 43: Partially Protected Animals

Scientific Name	Common Name	Present at Kinsevere
A. MAMMALIA	**A. MAMMALS**	
A.1. Primates	**A.1. Primates**	
Cercopithecus mitis spp	Blue monkey	N
Cercopithecus kandti	Golden monkey	N
Colobus spp	Colobus monkey	N
Galago crassicaudatus	Greater long-tailed Katanga lemur	N

Scientific Name	Common Name	Present at Kinsevere
A.2. Carnivora	**A.2. Carnivores**	
Felis serval	Serval	N
Panthera pardus	Leopard	N
Panthera leo	Lion	N
Lycaon pictus	African wild dog	N
A.3. Artiodactyla	**A.3. Artiodactyles**	
Syncerus caffer caffer	Cape buffalo	N
Syncerus caffer nanus	Dwarf buffalo	N
Syncerus caffer Cequinoctialia	Nile buffalo	N
Kobus defassa	Waterbuck	N
Redunca redunca	Bohor reedbuck	N
Damaliscus korrigum	Tsessebe	N
Damaliscus sp	Sassaby	N
Sigmoceros lichtensteinii	Lichtenstein's hartebeest	N
Alcephalus lewali	Leweley bubale	N
Ourebia ourebi	Oribi	N
Tragelaphus neriptus	Harnessed antelope	N
Tragelaphus eurycerus	Bongo	N
Hippotragus equinus	Roan antelope	N
Hippotragus niger	Sable antelope	N
Cephalophus silvicultor	Yellow-backed duiker	N
Onotragus lechwe	Nile lechwe	N
Kobus megaceros	Mrs Gray's lechwe	N
Kobus kob kob	Buffons kob	N
Redunca arundinum	Common reedbuck	N
Tragelaphus spekei	Sitatunga	N
Hylochoerus meinertzhageni	giant forest hog	N
Potamochoerus porcus	Red river hog	N
Hippopotamidae	Hippopotamus	N
Phacochoerus aethiopicus	Desert warthog	N
A.4. Hydracoides	**A.4. Damans**	
Procavia capensis	Rock hyrax	N
B. REPTILIA	**B. REPTILES**	
B.1. Crocodyla	**B.1. Crocodiles**	**N**
Crocodylus niloticus	Nile crocodile (L <1,50 m)	N
Osteolaemus tetraspis	African dwarf crocodile (L >1,50 m)	N
Crocodylus cataphractus	African slender-snouted crocodile	N
B.2. Pholidota	**B.2. Pholidotes**	
*Manis temininck*i	Ground pangolin	N
C. AVES	**C. OISEAUX**	
Tytonidae	Owls (22 species)	N

Scientific Name	Common Name	Present at Kinsevere
Cuprimulgidae	Nighthawks (13 espèces)	N
Alcedinidae	Kingfishers (17 espèces)	N
Casmerodius albus	Great egret	N
Melanophoys ardesiata	Black heron	N
Bubulcus ibis	Cattle egret	N
Buphagus africana	Yellow-billed oxpecker	N
Threskiornis aethiopica	Sacred ibis	N
Phoenicopterus antiquorum	Greater flamingo	N
Bucorvus cafer	Southern ground hornbill	N
Erismatura maccoa	Maccoa duck	N
Habraetus spp	Eagles (13 species)	N

Protected plant species in terms of Article 6 of Annex XI: "SENSITIVE ENVIRONMENTS" of the Mining Regulations are listed in Table 44~~Table 44~~ below.

Table 44: Protected Plant Species

Scientific Name	Common Name	Present at Kinsevere
Encephalartos laurentianus	Kwango giant cycad	N
Encephalartos septentrionalis	Nile cycad	N
Strophantus kombe	Kombe arrow poison	N
Pericopsis elata	African teak	N
Diospyros grex	Common persimmon	N
Diospyros canaliculata	De Wild persimmon	N
Eremospatha	Rattan palms	N
Encephalartos ituriense (Cycadoceae)	Ituri Forest Cycad	N
Juniperus procera	African Juniper	N
Diospyros wagemansii	-	N
Millettia laurentii (Fabaceae)	African rosewood	N
Julbernardia breynei (Caesalpiniaceae)	Wieringa	N
Gnetum africanum (Gnetaceae)	African Jointfir	N
Morinda morindoides (Rubiaceae)	Brimstone tree	N
Entandrophragma angolense	Mountain mahogany	N
Entandrophragma candollei	West African Cedar	N
Entandrophragma cylindricum	Sapele Mahogany	N
Entandrophragma utile (Meliaceae)	Sipo Mahogany	N
Terminalia superba (Combrelaceae)	White afara	N
Milicia excelsa (Moraceae)	African Teak	N
Megaphrynium macrostachyum (Marantaceae)	Yoruba soft cane	N

3.3.3 Flora (Article 36)

McCleland (2017) described and mapped six distinct vegetation communities within PE528 and PE7274, as well as one Riparian Forest community located to the north of PE7274. Four of these vegetation communities are present in PE7274 and are described below. Three of these represent natural habitat, namely Dry Evergreen Forest, Broad-leaved Woodland and Termitaria Thickets, while Degraded Shrubland represents modified habitat. Completely transformed habitat is also present in the form of cultivated fields.

Figure 53 indicates the spatial distribution of three of the vegetation communities within PE7274. Termitaria Thickets, which are embedded in the Broad-leaved Woodland community, are too small to show on the map.

See Figure 56~~Figure 56~~ for photos of the four vegetation communities on PE7274.

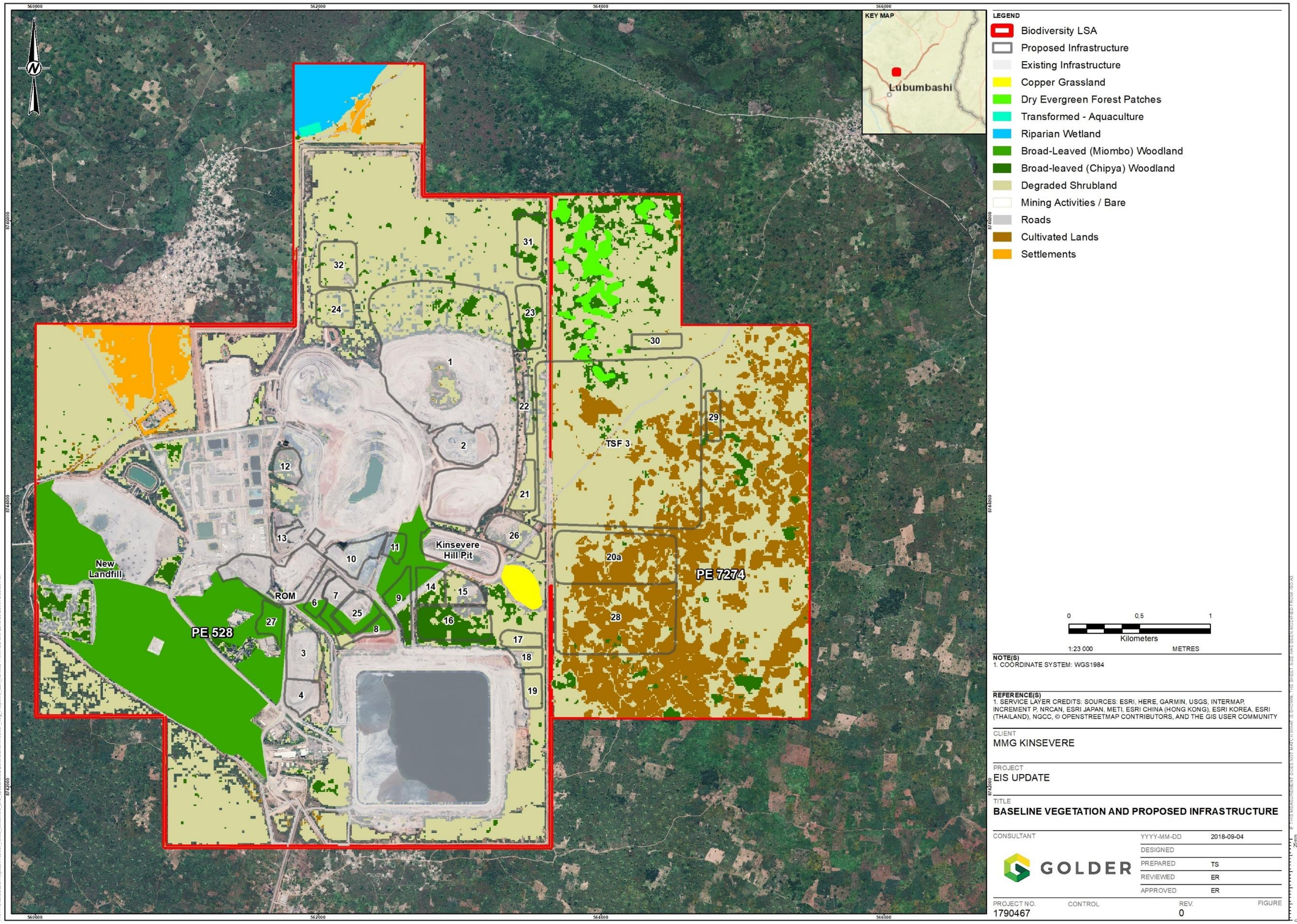

Figure 55: Current Vegetation and Proposed Location of Infrastructure

A,B - Broad-leaved Woodland; C,D - Dry Evergreen Forest; E - Termitarium Thicket; F,G,H - Degraded Shrubland

Figure 56: Photos of Vegetation Communities in PE7274 Study Area

3.3.3.1 Dry Evergreen Forest

This forest community is almost entirely confined to PE7274 within the project area and consists of numerous small, fragmented patches embedded within Broad-leaved Woodland (Figure 56~~Figure 56~~). Evergreen trees, woody shrubs and lianes are predominant. The most prominent canopy trees include Erythrophloeum *suaveolens*, Marquesia *macroura*, Albizia *adianthifolia*, Parinari *curatellifolia* and Anthocleista *schweinfurthii*. A different suite of species dominates the sub-canopy strata, with common small trees and shrubs including Diospyros *hoyleana*, Rutidea *fuscescens*, Sorindeia *katangensis*, Tabernaemontana *pachysiphon* and Psorospermum *baumii*. Lianes are most often found at edges of forest patches, with some of the common species being Adenia *gummifera*, Paullinia *pinnata*, Cissampelos *owariensis*, Strychnos *lucens*, Landolphia *kirkii* and Combretum *gossweileri*.

Data collected during this study showed the presence of 75 species, exhibiting very high species fidelity, with 53 species (71% of the community list) occurring nowhere else on PE7274. Geophila *erythrocarpa*, a threatened species, is also confined to this vegetation community.

The ecological integrity of the Dry Evergreen Forest is high as a result of a low level of transformation, presence of viable populations of the highly threatened Geophila *erythrocarpa*, high species diversity, which includes a large proportion of habitat specialists, and a species composition that represents what is expected in an undisturbed climax community.

3.3.3.2 Broad-leaved Woodland

Broad-leaved Woodland was the dominant vegetation community in PE7274 in 2006 when the first biodiversity surveys were conducted, but most of this community has been heavily impacted by the production of charcoal, harvesting of fuelwood and slash-and-burn agriculture, with the remaining woodland being confined to about 243 ha in the northernmost part of PE7274 (Figure 55~~Figure 55~~).

McCleland (2017) reported 182 plant species in this vegetation community in both tenements, of which only 51 species were recorded within PE7274. McCleland (2017) showed that the Broad-leaved Woodland community had been reduced by 86% in PE528 and PE7274 between 2006 and 2016.

The woodland remnant on PE7274 has been impacted by regular, hot fires and is now what is referred to as 'chipya' woodland. Typical climax woodland genera such as Brachystegia, Julbernardia and Isoberlinia, which are relatively sensitive to hot fires, are mostly absent, while fire-hardy tree species such as Burkea *africana*, Parinari *curatellifolia*, Pericopsis *angolensis*, Hymenocardia *acida* and Lannea *discolor* are common. Aframomum *alboviolaceum* is noticeably dominant in patches as well as the indigenous bamboo Oxytenanthera *abyssinica*. Both these species are usually uncommon in typical climax woodland but common in chipya woodland.

The ecological integrity of Broad-leaved Woodland on PE7274 is moderate as a result of habitat degradation, absence of threatened species, moderate species diversity and floristic composition that indicates a disturbed secondary habitat.

Table 45: Flora Species List 2018

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
PTERIDOPHYTA - FERNS AND FERN ALLIES									
Dennstaedtiaceae									
Pteridium aquilinum (L.) Kuhn subsp. *centrali-africanum* Hieron. ex R.E.Fr.	Fern					x		x	
Nephrolepidaceae									
Nephrolepis undulata (Afzel.) J. Sm.	Fern							x	
Polypodiaceae									
Lepisorus excavatus (Bory ex Willd.) Ching	Fern				x				
Platycerium elephantotis Schweinf.	Fern				x				
SPERMATOPHYTA: SEED-BEARING PLANTS (DICOTS)									
Acanthaceae									
Barleria descampsii Lindau	Forb					x			
Blepharis buchneri Lindau	Forb					x			
Blepharis katangensis De Wild.	Forb					x			
Blepharis glumacea S. Moore	Forb							x	
Blepharis maderaspatensis (L.) B. Heyne ex Roth	Forb						x		
Dicliptera capitata Milne-Redh.	Forb				x		x		
Dicliptera carvalhoi Lindau subsp. *nemorum* (Milne-Redh.) I. Darbysh.	Forb						x		
Duosperma clarae Champl.	Forb		x			x		x	
Justicia lenticellata Champl.	Dwarf shrub		x		x				
Phaulopsis sp.	Forb						x		
Strobilanthopsis linifolia (T. Anderson ex C.B. Clarke) Milne-Redh.	Dwarf shrub					x			
Thunbergia lancifolia T. Anderson	Suffrutex					x			
Achariaceae									
Rawsonia lucida Harv. & Sond.	Tree				x				

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Amaranthaceae									
Achyranthes aspera L. *	Forb					x			
Amaranthus sp. *	Forb								x
Celosia trigyna L.	Forb					x			
Anacardiaceae									
Sorindeia africana (Engl.) Van der Veken	Tree				x				
Anisophylleaceae									
Anisophyllaea boehmii Engl.	Tree					x		x	
Annonaceae									
Annona senegalensis Pers.	Shrub					x			
Monanthotaxis poggei Engl. & Diels	Shrub				x				
Uvaria angolensis Oliv.	Shrub				x				
Uvariastrum hexalobioides (R.E.Fr.) R.E.Fr.	Shrub						x		
Apiaceae									
Steganotaenia araliacea Hochst.	Tree						x		
Apocynaceae									
Ancylobotrys amoena Hua	Climber				x				
Cryptolepis cf. *oblongifolia* Schltr.	Suffrutex					x			
Dictyophleba lucida (K. Schum.) Pierre	Climber				x				
Diplorhynchus condylocarpon (Müll. Arg.) Pichon	Tree					x		x	
Landolphia parvifolia K. Schum.	Climber				x	x	x		
Secamone erythradenia K. Schum.	Climber				x				
Saba comorensis (Bojer) Pichon	Climber				x				
Strophanthus welwitschii (Baill.) K. Schum.	Climber				x				
Tabernaemontana pachysiphon Stapf	Tree				x				
Asteraceae									
Ageratum conyzoides L. *	Forb					x			x

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Baccharoides adoensis (Sch. Bip. ex Walp.) H. Rob. var. *kotschyana* (Sch. Bip. ex Walp.) Isawumi, El-Ghazaly & B. Nord.	Shrub					x			
Bidens pilosa L. *	Forb								x
Bidens schimperi Sch. Bip. ex Walp.	Forb					x			x
Acanthospermum australe (Loefl.) Kuntze *	Forb					x			x
Acmella radicans (Jacq.) R. K. Jansen *	Forb					x			x
Anisopappus chinensis Hook. & Arn.	Forb							x	
Crassocephalum crepidioides (Benth.) S. Moore	Forb					x			
Crassocephalum rubens (Jacq.) S. Moore var. *rubens*	Forb					x			
Elephantopus scaber L.	Forb					x		x	
Erigeron pyrrhopappus (Sch. Bip. ex A. Rich.) Sch. Bip. ex Schweinf.	Forb					x			
Hypericophyllum compositarum Steetz	Forb					x			
Laggera crispata (Vahl) Hepper & J.R.I. Wood	Forb					x			
Pleiotaxis rogersii S.Moore	Forb					x			
Polydora poskeana (Vatke & Hildebr.) H. Rob.	Forb					x			
Tithonia diversifolia (Hemsl.) A. Gray *	Shrub								x
Vernonia polysphaera Baker	Forb					x			
Balanitaceae									
Balanites aegyptiaca var. *quarrei* (De Wild.) G.C.C. Gilbert	Tree		x				x		
Begoniaceae									
Begonia princeae Gilg	Forb						x		
Bignoniaceae									
Markhamia obtusifolia (Baker) Sprague	Tree						x		

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Capparaceae									
Boscia angustifolia A. Rich. var. corymbosa (Gilg) DeWolf	Tree						x		
Maerua triphylla A. Rich. subsp. *pubescens* (Klotzsch) DeWolf	Shrub						x		
Celastraceae									
Gymnosporia sp.	Shrub						x		
Chrysobalanaceae									
Maranthes floribunda (Baker) F. White	Tree					x		x	
Parinari curatellifolia Planch. ex Benth.	Tree					x		x	
Clusiaceae									
cf. Vismia sp. (no flowers / fruit)	Shrub				x				
Garcinia volkensii Engl.	Shrub				x				
Harungana madagascariensis Lam. ex Poir.	Shrub					x			
Psorospermum febrifugum Spach	Tree					x		x	
Combretaceae									
Combretum adenogonium Steud. ex A. Rich.	Tree					x		x	
Combretum celastroides Welw. ex M. A. Lawson	Shrub				x				
Combretum gossweileri Exell	Climber				x				
Connaraceae									
Rourea orientalis Baill.	Shrub						x		
Convolvulaceae									
Ipomoea batatas (L.) Lam. *	Creeper								x
Crassulaceae									
Kalanchoe lanceolata (Forssk.) Pers.	Succulent						x		
Cucurbitaceae									
Cucumis maderaspatanus L.	Creeper					x			

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Dipterocarpaceae									
Marquesia macroura Gilg	Tree				x	x		x	
Monotes katangensis (De Wild.) De Wild.	Tree							x	
Ebenaceae									
Diospyros batocana Hiern	Tree							x	
Diospyros hoyleana F. White subsp. *angustifolia* F. White	Shrub				x				
Euphorbiaceae									
Erythrococca trichogyne (Müll.Arg.) Prain	Shrub						x		
Euphorbia ingens E. Mey. ex Boiss.	Tree						x		
Manihot esculenta Crantz *	Shrub								x
Fabaceae: Caesalpinioideae									
Brachystegia floribunda Benth.	Tree							x	
Brachystegia spiciformis Benth.	Tree				x	x		x	
Brachystegia tamarindoides Benth. subsp. *microphylla* (Harms) Chikuni	Tree				x			x	
Brachystegia wangermeeana De Wild.	Tree							x	
Burkea africana Hook.	Tree							x	
Cryptosepalum exfoliatum De Wild.	Shrub				x				
Cryptosepalum maraviense Oliv.	Suffrutex							x	
Erythrophleum africanum (Welw. ex Benth.) Harms	Tree							x	
Erythrophleum suaveolens (Guill. & Perr.) Brenan	Tree				x				
Julbernardia globiflora (Benth.) Troupin	Tree					x		x	
Julbernardia paniculata (Benth.) Troupin	Tree							x	
Fabaceae: Faboideae									
Abrus melanospermus (Hassk.) D.K.Harder	Climber				x				
Baphia bequaertii De Wild.	Shrub				x	x		x	

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Bobgunnia madagascariensis (Desv.) J.H. Kirkbr. & Wiersama	Tree							x	
Cajanus cajan (L.) Millsp. *	Shrub								x
Eriosema psoraloides (Lam.) G. Don	Shrub					x			
Humularia sp.	Dwarf shrub					x			
Indigofera podocarpa Baker f. & Martin	Shrub					x			
Indigofera sutherlandoides Baker	Shrub					x		x	
Kotschya carsonii (Baker) Dewit & P.A. Duvign.	Dwarf shrub					x			
Kotschya strigosa (Benth.) Dewit & P.A. Duvign.	Dwarf shrub					x			
Leptoderris goetzei (Harms) Dunn	Climber				x				
Pericopsis angolensis (Baker) Meeuwen	Tree							x	
Pterocarpus angolensis DC.	Tree	NT				x		x	
Pterocarpus tinctorius Welw.	Tree				x		x	x	
Rhynchosia resinosa (Hochst. ex A. Rich.) Baker	Dwarf shrub					x			
Vigna sp.	Climber					x			
Fabaceae: Mimosoideae									
Albizia adianthifolia (Schumach.) W. Wight	Tree				x	x		x	
Albizia antunesiana Harms	Tree							x	
Dichrostachys cinerea (L.) Wight & Arn.	Shrub					x			
Gentianaceae									
Anthocleista schweinfurthii Gilg	Tree				x				
Ixonanthaceae									
Phyllocosmus lemaireanus (De Wild. & T. Durand) T. Durand & H. Durand	Tree					x		x	
Lamiaceae									
Clerodendrum buchneri Gürke	Suffrutex						x		

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Clerodendrum frutectorum S. Moore	Suffrutex						x		
Clerodendrum tanganyikense Baker	Suffrutex						x		
Ocimum obovatum Benth.	Suffrutex					x			
Plectranthus sp.	Succulent						x		
Tinnea aethiopica Kotschy ex Hook. f.	Shrub				x				
Vitex fischeri Gürke	Tree				x		x		
Malvaceae									
Grewia flavescens Juss.	Shrub						x		
Hibiscus ovalifolius (Forssk.) Vahl	Dwarf shrub						x		
Thespesia garckeana F. Hoffm.	Shrub						x		
Triumfetta pedunculata De Wild.	Dwarf shrub				x				
Melastomataceae									
Antherotoma sp.	Forb					x		x	
Menispermaceae									
Cissampelos owariensis DC.	Climber				x		x		
Moraceae									
Ficus natalensis Hochst. subsp. *leprieurii* (Miq.) C. C. Berg	Tree				x				
Ficus fischeri Mildbr. & Burret	Tree				x	x	x		
Ficus persicifolia Welw. ex Warb.	Tree						x		
Ficus sansibarica Warb. subsp. *macrosperma* (Mildbr. & Burret) C. C. Berg	Tree						x		
Ficus stuhlmannii Warb.	Tree						x		
Ficus wakefieldii Hutch.	Tree						x		
Myrtaceae									
Syzygium guineense (Willd.) DC. subsp. *afromontanum* F.White	Tree					x		x	
Syzygium guineense (Willd.) DC. subsp. *macrocarpum* (Engl.) F.White	Tree								

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Ochnaceae									
Ochna holstii Engl.	Shrub				x		x		
Ochna schweinfurthiana F.Hoffm.	Tree					x		x	
Passifloraceae									
Adenia gummifera (Harv.) Harms	Climber				x	x	x		
Phyllanthaceae									
Bridelia duvigneaudii J. Léonard	Shrub				x			x	
Hymenocardia acida Tul.	Tree							x	
Margaritaria discoidea (Baill.) G.L. Webster	Shrub					x	x		
Phyllanthus muellerianus (Kuntze) Exell	Shrub					x			
Pseudolachnostylis maprouneifolia Pax	Tree					x		x	
Uapaca nitida Müll. Arg.	Tree							x	
Uapaca pilosa Hutch.	Tree							x	
Polygalaceae									
Securidaca longipedunculata Fresen.	Shrub					x			
Rhamnaceae									
Ziziphus mucronata Willd. subsp. *rhodesica* R.B. Drumm.	Tree						x		
Rhizophoraceae									
Cassipourea gummiflua Tul.					x				
Rubiaceae									
Afrocanthium lactescens (Hiern) Lantz	Shrub							x	
Agathisanthemum bojeri Klotzsch	Forb					x			
Pauridiantha paucinervis (Hiern) Bremek.	Shrub				x				
Crossopteryx febrifuga (Afzel. ex G. Don) Benth.	Tree					x			
Fadogia triphylla Baker	Suffrutex							x	
Feretia aeruginescens Stapf	Shrub						x		

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Geophila erythrocarpa Vanthournout & Dessein	Forb	EN			x				
Geophila obvallata (Schumach.) Didr. subsp. *ioides* (K. Schum.) Verdc.	Forb					x			
Keetia gueinzii (Sond.) Bridson	Climber				x				
Keetia venosa (Oliv.) Bridson	Climber				x				
Keetia zanzibarica (Klotzsch) Bridson	Climber				x				
Pauridiantha paucinervis (Hiern) Bremek.	Shrub				x				
Pavetta gardeniifolia Hochst. ex A. Rich.	Shrub						x		
Pentanisia renifolia Verdc.	Forb					x			
Psychotria butayei De Wild.	Suffrutex				x		x		
Psychotria peduncularis (Salisb.) Steyerm.	Shrub				x				
Rothmannia engleriana (K. Schum.) Keay	Tree							x	
Rothmannia manganjae (Hiern) Keay	Tree				x				
Rothmannia whitfieldii (Lindl.) Dandy	Tree				x				
Rutidea fuscescens Hiern	Climber				x				
Spermacoce dibrachiata Oliv.	Forb					x			
Tarenna pavettoides (Harv.) Sim	Shrub				x				
Tricalysia niamniamensis Hiern	Shrub				x				
Vangueriopsis lanciflora (Hiern) Robyns	Shrub				x				
Rutaceae									
Zanthoxylum chalybeum Engl.	Tree						x		
Salicaceae									
Flacourtia indica (Burm. f.) Merr.	Shrub						x		
Sapindaceae									
Allophylus africanus P. Beauv.	Shrub				x		x		
Haplocoelon foliosum (Hiern) Bullock	Tree				x		x		
Paullinia pinnata L.	Climber				x				

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Sapotaceae									
Englerophytum magalismontanum (Sond.) T. D. Penn.	Shrub				x				
Strychnaceae									
Strychnos angolensis Gilg	Climber				x				
Strychnos cocculoides Baker	Shrub					x		x	
Strychnos innocua Delile	Tree						x	x	
Strychnos lucens Baker	Climber				x				
Strychnos potatorum L.f.	Tree						x		
Thymelaeaceae									
Craterosiphon quarrei Staner	Shrub				x				
Vitaceae									
Rhoicissus tridentata (L.f.) Wild & R.B. Drumm.	Shrub						x		
SPERMATOPHYTA: SEED-BEARING PLANTS (MONOCOTS)									
Amaryllidaceae									
Scadoxus multiflorus (Martyn) Raf.	Geophyte						x		
Colchicaceae									
Gloriosa superba L.	Climber				x				
Commelinaceae									
Commelina africana L.	Forb					x			
Commelina schweinfurthii C.B. Clarke	Forb					x			
Cyperaceae									
Ascolepis leariglumis Lye	Sedge					x			
Dioscoreaceae									
Dioscorea bulbifera L.	Climber					x	x		
Dioscorea quartiniana Hochst. ex A. Rich.	Climber								

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Dracaenaceae									
Sansevieria cylindrica Bojer ex Hook.	Succulent						x		
Sansevieria kirkii Baker	Succulent						x		
Flagellariaceae									
Flagellaria guineensis Schumach.	Climber				x				
Hyacinthaceae									
Drimiopsis sp.	Geophyte						x		
Iridaceae									
Gladiolus verdickii De Wild. & T. Durand	Geophyte		x			x			
Orchidaceae									
Acampe pachyglossa Rchb. f.	Epiphyte				x				
Bulbophyllum sp.	Epiphyte				x				
Calyptrochilum christyanum (Rchb. f.) Summerh.	Epiphyte				x			x	
Cyrtorchis arcuata Lindl.	Epiphyte				x			x	
Diaphananthe fragrantissima (Rchb. f.) Schltr.	Epiphyte				x			x	
Liparis sp. (no flowers)	Geophyte							x	
Nervilia sp.	Geophyte				x				
Poaceae									
Andropogon sp.	Grass					x			
Cenchrus purpureus (Schumach.) Morrone	Grass					x			
Cymbopogon densiflorus (Steud.) Stapf	Grass					x			
Hyparrhenia sp. A	Grass					x			
Hyparrhenia sp. B	Grass					x			
Imperata cylindrica (L.) Raeusch.	Grass					x			
Melinis repens (Willd.) Zizka	Grass					x			x
Oplismenus burmannii (Retz.) P. Beauv.	Grass				x				
Orthoclada africana C.E. Hubb.	Grass				x				

Taxa	Growth Form	Red List	Endemic	Protected	Dry Evergreen Forest	Degraded Shrubland	Termitaria Thickets	Broad-leaved Woodland	Cultivated Areas
Oxytenanthera abyssinica (A. Rich.) Munro	Grass					x	x		
Paspalum sp.	Grass					x			
Setaria lindenbergiana (Nees) Stapf	Grass				x		x	x	
Sorghum bicolor (L.) Moench *	Grass								x
Zea mays L. *	Grass								x
Zonotriche inamoena (K. Schum.) Clayton	Grass					x			
Smilacaceae									
Smilax anceps Willd.	Climber				x	x			
Zingiberaceae									
Aframomum alboviolaceum (Ridl.) K. Schum.	Geophyte				x	x			
Costus spectabilis (Fenzl) K. Schum.	Geophyte						x		
Siphonochilus aethiopicus (Schweinf.) B.L. Burtt	Geophyte				x				
Siphonochilus kirkii (Hook. f.) B.L. Burtt	Geophyte				x				
TOTAL	**220**	**3**	**4**	**0**	**75**	**83**	**54**	**51**	**13**

Notes: EN = Endangered;
NT = Near Threatened

3.3.3.3 Termitaria Thickets

Numerous large termite mounds are scattered throughout the Broad-leaved Woodland community and occasionally in larger patches of Dry Evergreen Forest in the project area. The termitaria support a unique association of plants that are not found elsewhere in the project area. Vegetation structure is low to tall thicket on the crest of the mounds, with steep slopes of the mounds usually covered in a dense grass sward dominated by Setaria *lindenbergiana*. This vegetation community comprises small, highly fragmented thicket patches that could not be mapped at the scale used in this report.

Trees and woody shrubs are dominant and include diagnostic species such as Balanites *aegyptiaca*, Euphorbia *ingens*, Zanthoxylon *chalybeum*, Haplocoelum *foliolosum*, Boscia *angustifolia* var. *corymbosa* and Markhamia *obtusifolia*. Large ficus trees are a prominent feature of many of the termitaria, with the most common species being Ficus *fischeri*, F. *sansibarica* and F. *ovata*. Another feature of some of the thickets is dense clumps of Mother-in-law's Tongue (Sansevieria *pearsonii* and S. *kirkii*). 88 plant species were recorded in Termitaria Thickets on both tenements by McCleland (2017), of which 54 species were recorded on PE7274 during this study.

Species fidelity, which is closely linked to community uniqueness, is remarkably high, with 37 species (69% of the community list) occurring nowhere else on PE7274. Termitaria Thickets have high ecological integrity as they show limited signs of habitat degradation, support moderate diversity with a high proportion of habitat specialists, and have a floristic composition reflecting what is expected in an undisturbed climax community.

3.3.3.4 Degraded Shrubland

Degraded Shrubland is the dominant vegetation community on PE7274, covering 748.76 ha, or 36.1% of the tenement area (Figure 55~~Figure 55~~). This is a modified habitat occurring in areas where woodland has been cleared for charcoal production, fuelwood collection, or cultivation. Vegetation structure varies from low shrubland to open woodland, depending on how much time the vegetation has had to recover.

Prominent small trees or shrubs in this community include widespread woodland species such as Combretum *adenogonium*, Diplorhynchus *condylocarpon*, Dichrostachys *cinerea*, Annona *senegalensis*, Parinari *curatellifolia*, Harungana *madagascariensis* and Burkea *africana*. The herbaceous understory is dominated by tall grass species such as Hyparrhenia species, Pennisetum *purpureum* and Panicum *maximum*. Forbs and dwarf shrubs are also diverse, including Barleria *descampsii*, several Duosperma species, Crassocephalum *rubens*, Chamaecrista *mimosoides*, Eriosema *psoralioides* and Spermacoce *dibrachiata*. Pioneer species are common on recently disturbed ground, such as Ageratum *conyzoides*, Bidens *pilosa* and Acmella *radicans* which are invasive alien species.

Eighty-three species were recorded in Degraded Shrubland on PE7274, which is the highest total for any vegetation community in the tenement area. This is to be expected given the large area covered by Degraded Shrubland and the range of habitat types present, from low shrubland to open woodland.

The ecological integrity of the Degraded Shrubland is low, given the high level of habitat degradation, compromised ecological functionality and capacity to provide the ecological services that woodland would have provided, lack of threatened species, and species composition that has few habitat specialists but a high proportion of pioneer species.

3.3.3.5 Species of Conservation Concern

Six plant species of conservation concern were recorded within PE528 and PE7274 between 2006 and 2016, as well as an additional species in riparian forest to the north of the tenements (McCleland, 2017). Four species are copper grassland endemics that are confined to Kinsevere Hill and are not relevant to PE7274, which has no copper grassland habitat. Two plant species of conservation concern have been confirmed to be present in PE7274: Geophila *erythrocarpa* (EN) and Pterocarpus *angolensis* (NT). Geophila occurs only in dry evergreen forest in PE7274, whereas Pterocarpus is an uncommon tree scattered throughout the area, in broad-leaved woodland and degraded shrubland.

No mammal, reptile or amphibian species of conservation concern have been recorded at Kinsevere. Three bird species of conservation concern have been confirmed, but only one species is likely to be present on PE7274, namely Bateleur (NT). This species is highly likely to forage over the degraded shrubland habitat, but is unlikely to breed, given the lack of undisturbed broad-leaved woodland and the high density of people in the area. No wetland habitat is present for Great Snipe (NT) and insufficient woodland habitat is present to support any populations of Southern Ground Hornbill (VU), and neither of these species is likely to be present.

3.3.4 Ecosystem Services

3.3.4.1 Definition of Ecosystem Services

Ecosystem services are the benefits that people and/or a project obtain from ecosystems, consisting of all the natural products and processes that contribute directly and indirectly to human well-being, as well as the personal and social enjoyment derived from nature (Landsberg, et al., 2013).

Ecosystem services include products and services obtained from ecosystems, such as fresh water, wild foods, timber, flood control, erosion protection, climate regulation, recreational and aesthetic enjoyment.

The DRC's forests are very important to the well-being of the Congolese people, with an estimated 70% of the population directly dependent on the ecosystem services provided by the forests (World Bank, 2002), to varying degrees.

3.3.4.2 Local Ecosystem Services

The Kinsevere mine is located within the Zambezian Phytoregion (phytochorion) of the Savanna Biome This phytoregion comprises several broad vegetation types, namely: dry forest, swamp and riparian forest, Mopane woodland and scrub, Munga woodland and scrub, Chipya woodland, Miombo woodland, thickets and grassland.

The conservation status of Miombo woodland is Vulnerable – largely due to population growth and associated demand for natural resources, such as harvesting of wood and hunting for bush meat.

The ecosystem services that could be impacted by the Project (Type I) and those that the Project depends upon for operational performance (Type II) were identified from the findings of the biodiversity, surface water, ground water, socio-economic, heritage and soil studies, and land cover mapping undertaken for Kinsevere mine. The results are summarised in Section 4.3.1.7 and the assessed impacts of the Project on the ecosystem services, together with the recommended mitigation measures, are listed in Table 77~~Table 77~~.

Table 46: Ecosystem Services that the Project could Potentially Impact and Beneficiaries of those Services

Ecosystem Service	Ecosystem Type	Definition of Service	Beneficiaries
Provisioning			
Food	Degraded Shrubland Riparian and wetland systems	Subsistence food crops	Site-based subsistence farmers
	Degraded Shrubland	Foraging/grazing resources for Livestock (chickens, ducks, goats)	Site-based subsistence farmers
	Broad-leaved miombo woodland Broad-leaved chipya woodland Dry Evergreen Forest	Subsistence hunting of wild animals for meat Gathering of wild foods e.g. honey, edible plants	Site-based subsistence farmers Local communities
	Riparian and wetland systems	Capture fisheries and fish farming – both are conducted on a subsistence basis within the LSA	Site-based subsistence farmers Local communities Regional downstream water users
Biomass Fuel	Broad-leaved miombo woodland Broad-leaved chipya woodland Dry Evergreen Forest	Fuelwood and charcoal	Site-based subsistence farmers Local communities
Biological raw materials	Termitaria thickets	Materials for making clay bricks for traditionally built homes	Site-based subsistence farmers Local communities
Fresh water	Riparian and wetland systems	Water for domestic use is taken from groundwater wells and boreholes. Surface water systems are used for bathing, laundry and washing of vehicles.	Site-based subsistence farmers Local communities Regional downstream water users
	Riparian and wetland systems	The Project relies on groundwater arising from dewatering of pits for use as make-up water and potable water. The Project discharges excess water to the Kifumashi River at an authorised discharge point	The Project Downstream users

Ecosystem Service	Ecosystem Type	Definition of Service	Beneficiaries
Regulating			
Regulation of air quality	Broad-leaved miombo woodland Broad-leaved chipya woodland Dry Evergreen Forest	Leaves of trees, shrubs and forbs trap air pollutants, especially near industrial and urban areas, and along roads	Site-based subsistence farmers Local communities Kinsevere mine personnel
Regulation of water flow patterns	Riparian and wetland systems	Sandy soils facilitate aquifer recharge. Reeds and sedges contribute to reduced flooding frequency	Local communities Regional downstream water users
Water purification and waste treatment	Riparian and wetland systems	The Kifumashi River and associated wetlands have a role in dilution, decomposition and partial water purification.	Local communities Regional downstream water users
Erosion control	Broad-leaved miombo woodland Broad-leaved chipya woodland Dry Evergreen Forest	Vegetation cover within the study area reduces soil loss and prevents erosion	Site-based subsistence farmers Local communities Regional downstream water users
Pollination	Broad-leaved miombo woodland Broad-leaved chipya woodland Dry Evergreen Forest	Subsistence agriculture is reliant on pollination by bees for fruit and vegetable growth.	Site-based subsistence farmers
Cultural			
Ethical and spiritual values	Copper Grassland	Kinsevere Hill is the subject of local myth and legend	Site-based subsistence farmers Local communities Botanists world-wide

3.3.5 Ecosystem Integrity

Ecological integrity refers to the abundance and distribution of species and the ecological patterns and processes that maintain biological diversity and ensure ecosystem resilience (Woodley *et al*. 1993). The major ecosystems and habitat types within the LSA and RSA were initially identified at the desktop level based on previous studies (McCleland & Burrows, 2008; Palmer & McCleland, 2010; McCleland, 2017 REF); as well as a land cover assessment undertaken based on remote sensing of satellite imagery. Thereafter, those ecosystems and habitats were confirmed by field verification undertaken during the field studies (see Sections 3.3.2 and 3.3.3).

The area of each ecosystem and habitat was determined based on the land cover assessment data, and the mapping of communities done during the terrestrial ecology field surveys. A quantitative and qualitative assessment of the integrity of each of the identified ecosystems and habitats was determined from field data.

3.3.6 Presence of Sensitive Environments within or near Permit Area (Article 37)

Six plant species of conservation concern were recorded within PE528 and PE7274 between 2006 and 2016, as well as an additional species in riparian forest to the north of the tenements (McCleland, W; McKenzie, D;, February 2017). Four species are copper grassland endemics that are confined to Kinsevere Hill and are not relevant to PE7274, which has no copper grassland habitat. Relocation trials of copper grassland have been successful, and re-establishment will be done during post-closure rehabilitation.

Two plant species of conservation concern have been confirmed to be present on PE7274: Geophila *erythrocarpa* (EN) and Pterocarpus *angolensis* (NT). Geophila occurs only in dry evergreen forest in PE7274, whereas Pterocarpus is an uncommon tree scattered throughout the area, in broad-leaved woodland and degraded shrubland.

No mammal, reptile or amphibian species of conservation concern have been recorded at Kinsevere.

Three bird species of conservation concern have been confirmed, but only one species is likely to be present on PE7274, namely Bateleur (NT). This species is highly likely to forage over the degraded shrubland habitat, but is unlikely to breed, given the lack of undisturbed broad-leaved woodland and the high density of people in the area. No wetland habitat is present for Great Snipe (NT) and insufficient woodland habitat is present to support any populations of Southern Ground Hornbill (VU), and neither of these species is likely to be present.

3.4 CHAPTER IV: DESCRIPTION OF THE SOCIO-ECONOMIC ENVIRONMENT (ARTICLE 38)

The socio-economic study for the KOU project (Ntila, S; de Waal, D;, August 2018) concentrated on assessing the socio-economic impacts of the project on the people living within the project's socio-economic area of influence (SAI), with specific focus on the people making use of Tenement PE7274, which is currently used almost exclusively for agricultural activities, but where some of the proposed project components will be established.

Knight Piésold undertook a baseline socio-economic assessment in 2016 (Anon;, November 2016) that concentrated largely on the socio-economic impacts of the KEP activities that would be undertaken on tenement PE528. The information in this chapter IV was sourced from both the Knight Piésold report and the aforementioned socio-economic study for the KOU project.

The Kinsevere Mine is located in the province of Haut Katanga, Kipushi territory, in the Kasongo group within the Bukanda area, about 30 km away from Lubumbashi.

3.4.1 Kinsevere Mine's Socio-economic Area of Influence

The socio-economic environment in the vicinity of Kinsevere mine is characterised by 35 villages, each under the leadership of a traditional chief. The area has a mixture of ethnic groups, including Bemba, Lamba, Luba, Kaonde and Tshokwe, who predominately speak the Kiswahili language.

The in-migration of people to the area as well as the illegal occupancy of the MMG concession and the illegal artisanal mining activities have led to an increase in pressure on the natural and social resources and to heightened security concerns.

The Kinsevere mine employs 2 615 people, of which 753 are fulltime MMG employees and 1 862 are contractor employees, as of 2017. More than 95% of the workforce is made up of Congolese Nationals (2017 MMG Sustainability Report). The community considers the mine as a stable employer. The mine has developed positive stakeholder relationships with local communities and has contributed towards improving the social development of the community – see Section 8.2.

The SAI straddles the Kipushi and Lubumbashi Territories and the Bokanda and Lubumbashi Sectors.

The Bokanda Sector includes two groupements, namely:

- Shindaika Groupement, which includes the villages of Ntentema, Kandulwe, Kiswishi, Kulunda, Kampelembe, Ngongo and Muombe, and
- The Kasongo Groupement, which includes the villages of Kifita, Mumanga, Mumba, Petro, Kilongo, Katumba, Kalianda, Poteau 93, Mpundu, Mikanga and Denis.

Figure 57~~Figure 57~~ shows the geographic extent of potential socio-economic impacts related to the current operations and the proposed KOU project at Kinsevere mine and the extent of the area where social baseline data was collected (Social Study Area). The socio-economic area of influence (SAI) comprises both rural and peri urban villages and settlements located on the existing Likasi Road from Kawama to MMG Kinsevere; the road and powerline route from Kiswishi to MMG Kinsevere; and the northern villages along the Kifumashi River between Petro and Denis. A total of 26 villages were included in the SAI, which was based on updated information provided by MMG Kinsevere Social Development Department and confirmed in the field.

The leader of the area of influence is Grand Chef Kasongo Kolonganya Mabumba Jean Marie; Bukanda Sector Chief is Mr Jean Marie Ngombe Kazadi who reports to the Kipushi Territory Administrator, Mr Christian Mushota Kiwele.

3.4.1.1 Villages

The SAI includes 26 villages with an estimated population of 23 815 people and a total of 4 035 households, with an average of 5.7 people per household. Some villages surrounding the Kinsevere Mine site have experienced an exponential increase in population size over the last ten years. Kilongo, which is located directly to the north of the Kinsevere Mine site, experienced an annual growth rate of 44.7% between 2007 and 2016. Kifita, which is located along the new asphalt road between Kiswishi and Kinsevere, experienced an annual growth rate of 60.9%.

Table 49~~Table 49~~ provides a summary of the population distribution across the villages within the socio-economic area of influence (SAI).

3.4.1.2 Housing

The more permanent houses in the villages are constructed from a combination of rammed earth/mudbricks (90%) and thatching grass roofs (86%), or corrugated iron roofs (9%). Many of the houses also include a combination of tarpaulins and High-Density Polyethylene (HDPE) liners on top of the thatch roofs. The HDPE lining, which is typically used for industrial tailings ponds, is not available locally but is sourced from the Kinsevere mine site. The more temporary structures were associated with scattered and isolated dwellings to the North and East of the Kinsevere Mine site. Due to the price and availability of cement, the vast majority of houses either utilise clay, or a mixture of clay and organic waste from the local “lutuku” alcohol distillation process for binding walls and floors. Most (93%) of the floors are compacted earth with only 7% being cement floors. One church within the SAI was made entirely from HDPE lining.

Houses consist mostly of one (64%) or two (33%) rooms with an average size of about 15 m^2, which have multiple uses. About 76% of the households own their houses, 20% are leasing, and 4% are provided with free accommodation by friends or church groups.

In addition to the more established villages there are a number of scattered and isolated informal dwellings to the East of the Kinsevere Mine site in areas no served by formal transport routes. These dwellings are typically constructed as timber frames with thatch and tarpaulin/HDPE coverings for walls and roofs and are largely used seasonally by colliers, subsistence farmers and artisanal miners for than six months in the year.

3.4.1.3 Income and Expenditure

Household income varied across the villages surveyed by Knight Piésold (Anon;, November 2016). In a good month the average was CDF 100 670 (USD 103.79), but in a bad month it was CDF 56 747 (USD 58.50). This means on average, household income in a good month is USD 3.45 per day and in a bad month less than UDD 1.95 per day. Most households (47.9%) felt that their income had decreased over the past two years, 7.3% felt it had increased and 44% said it had stayed the same.

The observed decline in income may be attributed to a decrease in land productivity, availability of trees for charcoal production, or rising inflation due to the rapid population growth in the SAI.

The farmers on PE7274 reported monthly household incomes ranging from about CDF 100 000 to 1 292 000 (Ntila, S; de Waal, D;, August 2018).

The predominant monthly household expenses are food (65%), school fees (19%), medical care (7%), clothing (4%) and other general household items. Very little income is channelled towards savings or recreational activities. The survey found that 99.5% of households have no access to credit or loans and 98.5% have no access to any form of savings.

3.4.1.4 Education

The formal education system in the DRC comprises primary, secondary and tertiary education, but government investment in educational services and infrastructure within the SAI is very limited.

The Knight Piésold survey found that only 54% of children within the SAI attended school. The majority (61%) of these children attended schools built by MMG Kinsevere mine, 9% attended public schools and 30% attended private schools. The mine has built and rehabilitated 11 primary schools and two secondary schools across the SAI and pays the six principals and 65 teachers at these schools, which serve a total of 2 696 students. In addition, the mine has provided scholarships to the value of USD 47 500 to 260 primary school students, 28 high school students and 21 university students.

The survey also found that 33% of respondents had no formal education, for 45% the highest level of education was primary school, and less than 2% had completed any form of tertiary education.

The top six limitations/issues with the successful management of schools at the local level were identified by the principals and teachers as being:

1) Insufficient classrooms to accommodate students;
2) Lack of toilets for teachers and pupils;
3) Abandonment of posts by teachers in the private schools;
4) Interference by village leaders in educational affairs;
5) Late registration and re-registration of pupils at the beginning of the year; and
6) Lack of textbooks and other teaching materials.

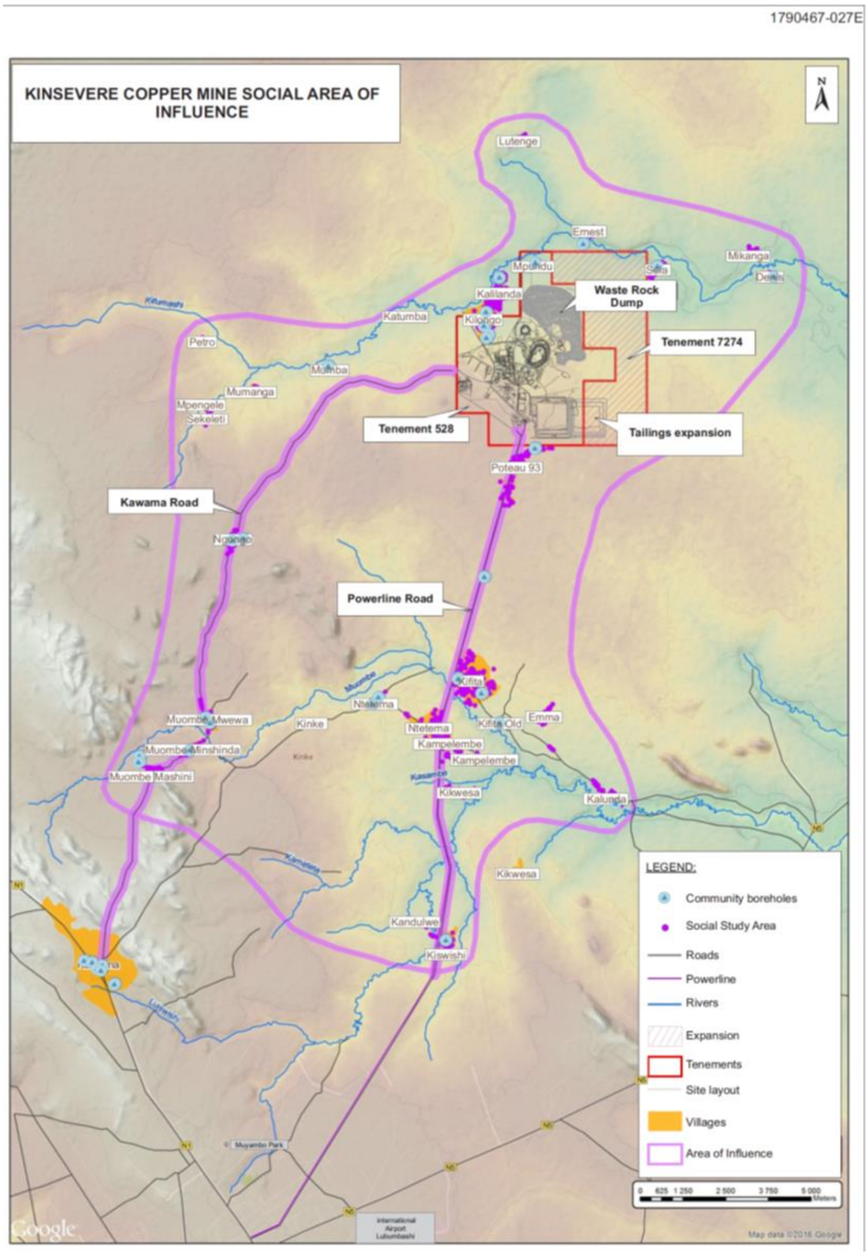

Figure 57: Kinsevere Mine's Socio-economic Area of Influence

3.4.1.4.1 Health

Table 47Table 47 and Figure 58Figure 58 show available health profile data for the Kipushi and Kinsevere areas.

Table 47: Frequently Reported Illnesses in the Kipushi Health Zone – 2018 Data

Month	Diarrhea	Number of Severe Malaria Cases	Pregnant Women with Severe Malaria	Severe Pneumonia	New STI Cases	Contact Cases Among New STI Cases
January	259	382	128	38	116	45
February	238	510	82	120	134	68
March	293	643	185	119	161	69
April	300	512	207	96	142	85
May	375	385	175	124	135	63
June	290	177	9	11	128	75
July	235	239	100	105	153	81
August	223	184	88	13	94	42
September	248	217	92	55	133	76
October	354	357	109	87	188	97
November	305	320	143	19	135	56

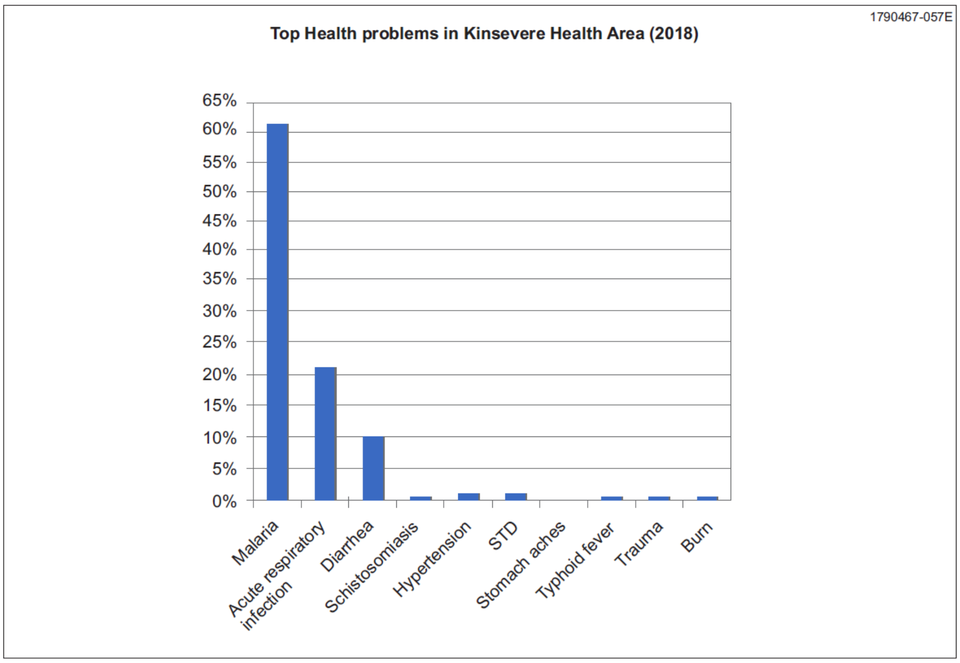

Figure 58: Top Health Problems Reported by Respondents in 2018

The Kipushi Health Zone has 43 health facilities, located in 16 health areas, five of which are in urban areas and 11 in rural areas. It was reported in June 2016 that these facilities serve a population of more than 200 000 people.

The following three facilities, serving about 23 000 people, are located within the SAI:

- Kinsevere Health Centre – A public facility with one doctor and three nursing staff that has been in operation since 2012. Although administered by the Health Zone, it was built and is largely supported by Kinsevere mine. The farmers on PE7274 make use of this facility;
- King Medical Centre – A private primary healthcare facility with one doctor, two nurses and a pharmacist, located in Kilongo; and
- Wantanshi Clinic – A private facility with one doctor and one nurse located in Kifita and providing basic outpatient services.

There are no ambulance services within the SAI and most of the local villages do not have frequent access to transport. As a result, only about 70% of the population make use of these facilities, with about 20% resorting to self-medication and 2.7% to traditional healers. Vaccination coverage and follow-up are poor.

Health care professionals reported the top five limitations/issues with the management of local healthcare facilities as:

1) Lack of equipped examination and operating rooms to perform even basic procedures;
2) Lack of ambulances;
3) Lack of birthing facilities;
4) Lack of funding as patients do not have the financial means to pay for treatment; and
5) Incomplete construction of facilities.

3.4.1.4.2 Water and Sanitation

Access to water within PE7274 was stated to be a challenge, with farmers often relying on bicycles to fetch water (Figure 66Figure 66). The water is used mainly for domestic purposes such as cooking, washing, cleaning and bathing. The farmers also indicated that they do not have access to modern human waste disposal facilities, and pit latrines are the most common type in the area.

There are no hospital facilities within PE7274. The farmers stated that they go to the Kinsevere Health Center, which was built by MMG. There are several health posts in Sela and Poteau 93 and also pharmacies where people get their medicines.

3.4.1.4.3 Livelihoods

According to the Knight Piésold survey (Anon;, November 2016), the primary occupations within the SAI include agriculture (56.7%), charcoal production (9.6%), and small businesses (4.8%), but there are few wage earners. All households engage in a multitude of secondary activities to augment their income. A total of 25% of respondents reported that they were unemployed and/or not otherwise economically active.

While there are a number of permanent fields within the SAI, slash and burn methods are often used to clear areas in order to establish fields and grow crops. The primary crops include maize (37%) and cassava (24%), and secondary crops include sweet potatoes (13%); beans (11%); groundnuts (9%) and vegetables. Agriculture is undertaken mainly at a subsistence level, with more than 73% of cultivated plots being smaller than 1 ha, 19% are 2 to 3 ha and 7% are larger than 3 ha in size. Less than 40% of produce is taken to market. About 78% of households live more than 1 km from their plots. Households rely on their immediate family for agricultural activities with the division of labour being fairly equal between males and females, with men doing most of the manual labour.

Animal husbandry is not an important livelihood activity within the SAI, but chickens, ducks and goats are bred both for consumption and for market.

Charcoal production is an important source of income for households within the SAI, particularly for newcomers without other sources of income, because it is not an activity that requires significant permanent access to land or capital but relies on the availability of suitable trees that can be felled and carbonised. About 9% of the households within the SAI produce charcoal as a primary activity. Charcoal production is not sustainable and limited resources remain within the broader SAI.

Although not disclosed by many of the households, artisanal and small-scale mining (ASM) is most definitely practiced to some extent within the SAI, but it is difficult to quantify as this activity is mostly associated with illegal access to MMG's tenements, particularly Kinsevere Hill, Waste Rock Dump facilities and the edge of the tailings dam.

Less than 3% of the SAI residents are employed as wage earners, only 0.9% of them by the mine, and mostly on a temporary basis. There are several small commercial and trading activities, including food, building materials, clothes and the brewing of alcoholic drinks.

According to Kinsevere mine's Social Development department, there are no permanent residents on the PE7274 tenement, but there are 140 known farmers (at the time of writing) who cultivate plots of 1 to 4 ha. Some of them commute to their plots, from nearby villages, mainly Poteau and Sela, but also from Denis, Petro and Kifika. During meetings held with 99 of the farmers from 6 to 7 June 2018, it transpired that 92 farmers have erected structures on PE7274 in which they live for several weeks during the planting (March-April and October-December) and the harvesting (January-February and May-September) seasons. About half of these farmers have erected mud brick houses, which they indicated are occupied on a daily basis. The rest of the structures are made mainly from thatch grass and are occupied occasionally. HDPE liners from the mine are commonly used for roofing.

The farmers grow maize, cassava, sweet potato, groundnuts, beans, okra, cabbage, egg plant and tomatoes on PE7274 as seasonal crops, but some of them also produce fruit (banana, mango and paw-paw) and some keep chickens, goats and pigs.

About 70% of the farmers are male and the majority (about 41%) are older than 45 years and married (83%).

3.4.1.5 Livelihood Activities of Farmers on PE7274

3.4.1.5.1 Land-use Duration and Options

According to the survey results, 72.7% of the farmers use 2 to 4 hectares of land on PE7274 (Figure 59~~Figure 59~~) and 48.5% of farmers indicated that they have been using land on PE7274 over a period of more than 6 years Figure 60~~Figure 60~~. The main livelihood activities as reported by the farmers include agriculture, charcoal production and the making of baked mudbrick. None of the farmers indicated any engagement in artisanal mining within PE7274.

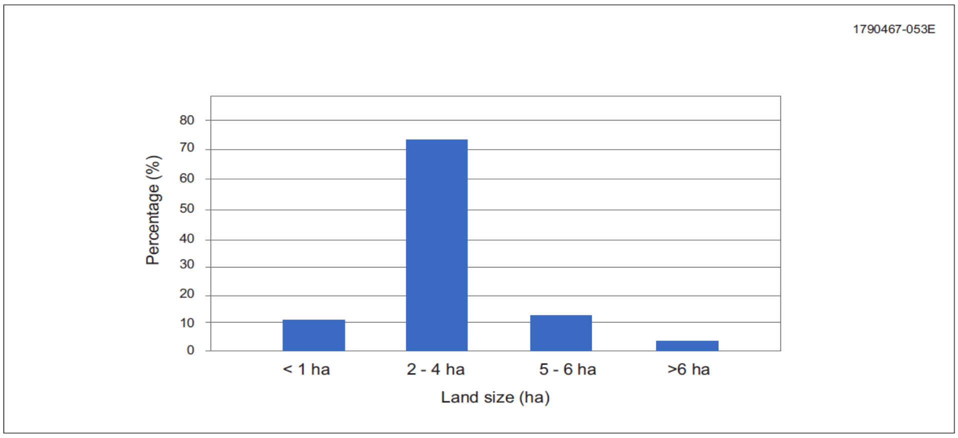

Figure 59: Size of Land used by Farmers

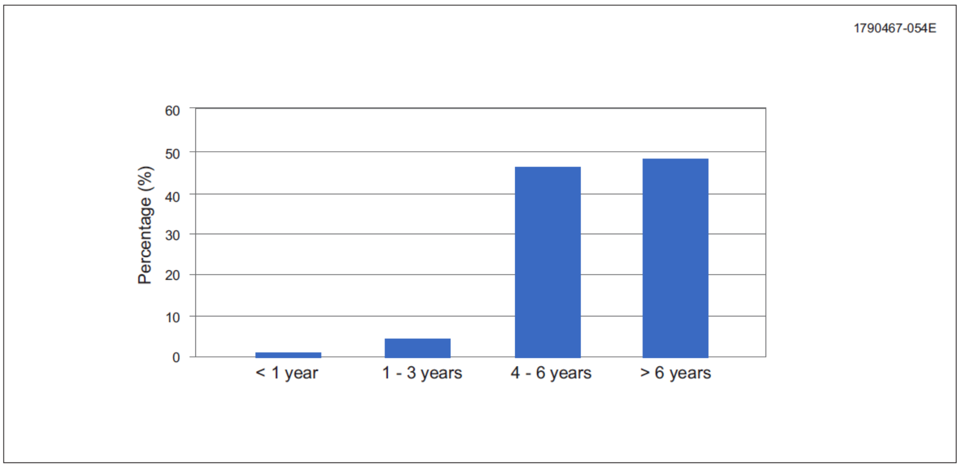

Figure 60: Land-use Duration

3.4.1.5.2 Agriculture on PE7274

Rain-fed crop production on smallholdings, with reliance on family labour, was reported as the main agricultural activity, but some farmers also keep livestock – see Figure 61~~Figure 61~~. Planting is done during the wet season (Late October to mid-April) and harvesting during the dry season (May to mid-October). The crops include maize, cassava, sweet potato, groundnuts, beans, okra, cabbage, tomatoes and eggplant, but maize is the main staple crop. Some farmers also produce fruit, mainly banana, mango and paw-paw.

Chickens were reported to be the main livestock, but some farmers also keep goats and pigs. Livestock is viewed more as a capital asset than food for household consumption.

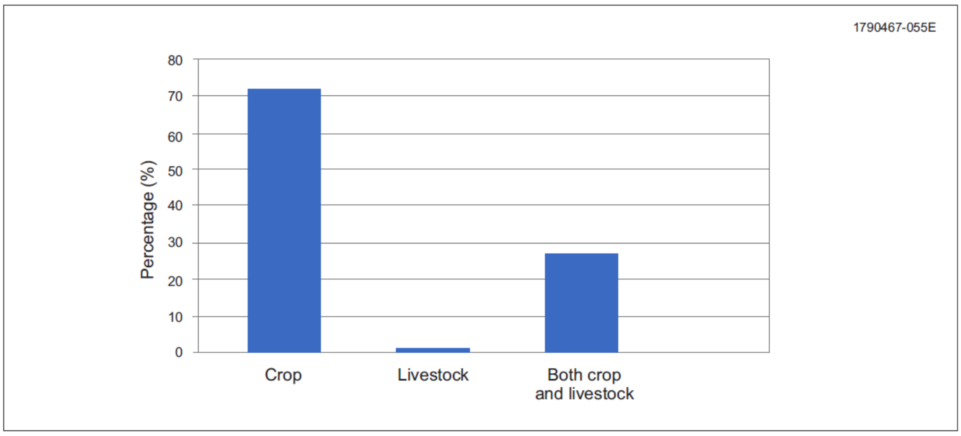

Figure 61: Agricultural Production on PE7274

The farmers indicated that agricultural productivity is constrained mainly by:

- Crop and livestock diseases;
- Lack of effective produce storage facilities;
- Vermin and predators *viz.,* rats and dogs;
- Limited access to agricultural inputs such as farming equipment, seeds and water; and
- Access to markets.

Maize, beans, pumpkins and cabbages were reported as the major crops which are affected by crop diseases. Figure 62~~Figure 62~~ shows a maize cob and pumpkins which were affected by disease.

Figure 62: Maize Cob and Pumpkins Affected by Disease

Nevertheless, farmers confirmed to have adopted several coping strategies in relation to the challenges associated with crop production (Table 48~~Table 48~~).

Table 48: Coping Strategies used by Farmers

Challenge	Coping Strategy
Expensive seeds	Harvesting and storage of seeds for future use.
Water availability	Plant during the wet season as rain water will usually be sufficient, no need for irrigation.
Pests	Improving produce storage techniques. For instance, not removing the leaves when harvesting maize to restrict exposure of maize cob to insects.
No produce to harvest in the wet season	Store produces for future use.

The sale of agricultural produce at Lubumbashi markets is a major source of income for the farmers (Figure 63Figure 63), but market access is constrained by:

- Lack of effective transportation systems and storage facilities;
- Lack of knowledge about adding value to produce; and
- Inability to meet market standards *viz.,* quality and quantity of produce.

Depending on the quality, quantity and sale of the harvested produce, the farmers reported that they make an average of US$2 462 per annum. Cassava tubers and cassava leaves were reported to be in high demand at Lubumbashi.

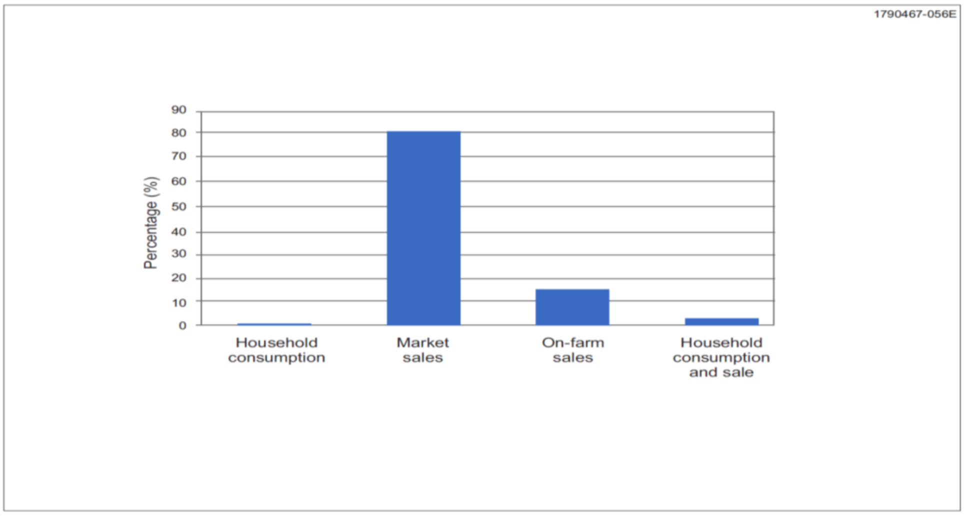

Figure 63: Consumption and Sale of Agricultural Produce

Selling of charcoal is a minor source of income for the farmers. They use the charcoal produced as a source of energy for cooking and during the process of brick making, and the surplus is sold in the surrounding villages and at Lubumbashi market. Charcoal sales are constrained by:

- Lack of effective wood cutting equipment and protective gloves; and
- Access to markets.

Farmers indicated that it is difficult to transport charcoal to the markets because they lack appropriate modern transportation systems. They mostly rely on bicycles or motorbikes to transport charcoal to the market (Figure 64~~Figure 64~~), as it is expensive to hire trucks for charcoal transportation.

Figure 64: Farmer on PE7274 Transporting Charcoal to Lubumbashi Market

Brick making was reported to be the least important income generating activity because bricks are only sold to the locals when needed. Farmers use clay from anthills to make bricks, an oven is built with mud bricks and the bricks are baked with wood or charcoal for 3 to 5 days. Availability of water is a major constraint during this process. Figure 65~~Figure 65~~ shows a brick making site within PE7274.

Figure 65: Brick-making Site within PE7274

3.4.1.5.3 Infrastructure and Services

Infrastructure and basic services such as water and sanitation, electricity, health and emergency services are generally lacking in the region. Much of the infrastructure and services currently available within the SAI are as a result of the community development programmes administered by Kinsevere mine.

None of the 26 villages within the SAI are connected to the national power grid. About 2% of households were recorded as using electricity (from a generator, solar panels or an offtake from the mine).

Wood is the predominant cooking fuel (87%) with some households using a combination of wood and charcoal (13%). Interior lighting is predominantly by means of a torch (82%), candles (10%) or by local lamps "katoritori" that can burn any kind of oil, even diesel.

About 71% of households have access to potable water, which is well above the national average of 31% for rural areas. Most of the households obtain water from community wells (55%), hand dug wells (22%), communal taps (16%) or from rivers or wetlands (7%). The mine has established at least 40 boreholes with pumps, installed ten standpipe taps and four 5 000 litre water tanks within the SAI. About 55% of households have access to water within 100 m and 84% within 500 m of their homes.

Access to water within PE7274 is a major challenge for farmers. During the focus group discussions, farmers indicated that they travel to Kilongo village to fetch water, using bicycles to transport water in plastic containers (Ntila, S; de Waal , D;, August 2018).

There are no formal waste disposal facilities or services in any of the villages and dumping of waste in open spaces or into makeshift pits is the predominant form of disposal. About 74% of households have access to toilet facilities, most of which (70%) are pit latrines located approximately 10-50 m from their dwellings, some 17% are located within 50 to 100 m, and 16% are more than 100 m away.

Mobile phones are used to some extent, but network coverage is temperamental and it does not cover the entire SAI. Radio was reported to be the primary source of communication for 73.5% of households, followed by communications from the chief (9%), neighbours (7%), community meetings (5%), telephone (3.3%) and television (2%). Word of mouth is a popular mode of communication in the villages.

There are two main routes that provide access to the Kinsevere mine site, namely the N1 from Lumbubashi to the Likasi junction and along the Kawama Road to Kinsevere, and the much shorter new powerline road that runs past Kifita to the mine site. These roads were built by and are maintained by the mine.

3.4.1.5.4 Routes and Transport

For transport, residents in the SAI use minibus taxis, motorbikes and bicycles or catch lifts on trucks travelling along the main roads. A number of tracks across the SAI are utilised to access isolated settlements, agricultural fields, and timber for charcoal.

There are no formal roads within PE7274, only a few vehicle tracks, but the demarcation boundaries created by the mine on the south and west side of the PE528 area are also used as access roads.The farmers usually hire trucks to transport their produce to markets in Lubumbashi, but they also use bicycles and motorbikes for local transport of smaller quantities of produce and to fetch water (Ntila, S; de Waal, D;, August 2018).

Figure 66: Water Containers used to Collect Water

Figure 67: Vehicle Track within PE7274

Table 49: Population Distribution across SAI

Village	2007 Social Survey			2010 Social Survey			2016 Social Survey		
	Household Units	Average Size of Household	Estimated Population 2007	Household Units	Average Size of Household	Estimated Population 2010	Household Units	Average Size of Household	Estimated Population 2016
Denis							78	5.7	445
Emma							123	5.3	652
Ernest							87	5.1	444
Kalianda	52	6.8	332				155	6.1	946
Kalunda							141	4.5	635
Kampelembe				20	4.7	94	26	6.0	156
Kandulwe				39	4.5	176	68	5.1	347
Kifita				243	5.7	1 390	807	6.3	5 084
Kikwesa							73	5.8	423
Kilongo	204	6.3	1 293				802	6.5	5 213
Kiswishi				57	5.6	323	97	5.7	553
Lutenge							102	5.4	551
Mikanga							113	5.5	622
Mpengele							13	5.5	72
Mpundu	17	6	102				22	7.1	156
Mumanga							85	4.6	391
Mumba	31	7.8	243				68	6.1	415
Muombe Mashini							72	5.5	396
Muombe Mishinda							88	6.0	528
Muombe Mwewa							133	5.8	771
Ngongo							132	6.1	805
Ntetema				85	5.5	468	294	5.1	1 499

Village	2007 Social Survey			2010 Social Survey			2016 Social Survey		
	Household Units	Average Size of Household	Estimated Population 2007	Household Units	Average Size of Household	Estimated Population 2010	Household Units	Average Size of Household	Estimated Population 2016
Petro							21	4.3	90
Poteau 93							323	6.0	1 938
Sekeleti							24	4.7	113
Sela							88	6.5	572
Totals	**304**		**1 970**	**444**		**4 902**	**4 035**		**23 815**

3.4.1.5.5 Law Enforcement

There is a police station managed by a police commander and an administrative office that was built by MMG Kinsevere in 2014 and that has been functioning since 2015.

The administrative office and the police station depend on the Bukanda sector. The day-to-day management of social relations is the responsibility of the local chief, who settles disputes in terms of customary law. The 2016 household survey found that 60% of respondents were suspicious of public services.

3.4.1.5.6 Cultural and Heritage

A review by a specialist in archaeology (Huffman, December 2006) concluded that:

- Stone tools are common in the Congo basin, but the Lubumbashi region is not known for important Stone Age sites. The Kinsevere project area, in particular, is unlikely to contain important deposits because the terrain is rocky, and the soil is shallow. The areas around the dambos are an exception, but here stone tools would probably be buried out of sight;
- During the last two to three thousand years farming of millet, oil palms and sorghum developed in the region. Archaeologists have recorded one important Iron Age pottery find, known as Naviundu and dating to about AD 300 near Lubumbashi (Anciaux de Faveaux & de Maret 1984). It represents the first farmers in the region, who located their villages near the best agricultural land;
- The land in the vicinity of the Kinsevere mine is characterised by rocky terrain and shallow soil with fairly poor agricultural potential, and the villages currently surrounding the mine were only established in the 1990s. If the project area were good for subsistence farming, these villages would have a much longer history, and there is no reason to believe that Iron Age people were living here earlier;
- The Copper Belt of Zambia and the DRC is well known for pre-colonial mining (e.g. Phillipson 1977). Typical 'ancient workings' include stopes, ventilation shafts, talus slopes and various stone and iron artefacts, and the copper metal was often used to make X-shaped ingots that might have been used as currency (Bisson 1975);
- Such obvious signs of pre-colonial mining are not on record in the project area, but if such mining had taken place, subsequent artisanal mining could have destroyed evidence of earlier mining;
- Due to the occurrence of artisanal mining, combined with the low agricultural potential of the project area, it is unlikely, but not impossible, that the KOU project will have any impact on heritage resources; and
- The only known heritage site near the mine lease area is a modern graveyard.

In response to a question about local cultural and heritage sites at a focus group meeting early in June 2018, one chief indicated the presence of a spiritual site but declined to divulge its location. This was not corroborated by any other attendees. If any archaeological material or signs of pre-colonial mining are uncovered, the finds will be reported to the relevant authorities in Lubumbashi.

MMG has developed a Cultural and Heritage Management Plan (Anon;, 30 Nov 2015) that will be followed if any cultural/heritage resources are discovered on PE528 or PE7274. In terms of this plan:

- All earth disturbance works in the general vicinity of the find will stop immediately and the site will be protected to prevent disturbance of the cultural/heritage resources. A protective 25 m × 25 m buffer zone (50 m × 50 m in the case of skeletal remains) will be established around the site and unauthorised entry will be prevented. The local administrative authority and the authority in charge of Culture, Arts and Museums will be informed;
- Items listed on the National Cultural Heritage List as per Article 275 of the DRC Mining Code and the DRC's Mining Laws and Regulations Handbook will be secured and protected;
- A heritage management plan for each identified heritage site will be developed in discussion with local communities and relevant authorities;

- If cultural finds have not been removed by the authorities within 60 days from notification of discovery, the mine will safely store and protect these items;
- Unauthorised interaction with the site(s) will be recorded in a register;
- Community/stakeholder approval to clear and disturb significant cultural heritage resources in a register;
- Sites of cultural and/or historical significance will be recorded in a cultural heritage register and mapped in a GIS system;
- Any complaints or grievances lodged will be investigated and acted upon;
- The Site Induction includes an overview of the historical and cultural heritage of the Kinsevere area and villages neighbouring the MMG Lease;
- The Site Induction includes the land clearance and disturbance requirements for preserving heritage sites; and
- Protected heritage sites will be inspected annually to ensure they are still appropriately demarcated and have not been damaged.

3.4.1.6 Social Setting for PE7274

Two survey sessions were facilitated as focus group meetings with the farmers utilising PE7274. Information gathered during two focus group meetings held at the church in Kilongo are presented in this section. The meetings were held on 6 and 7 June 2018 and were attended by 49 and 50 farmers respectively.

3.4.1.6.1 Demographics

The demographic characteristics of the farmers who attended the focus group meetings are listed in Table 50~~Table 50~~.

Table 50: Demographic Profile of Farmers

Variables	n (99)	(%)
Gender		
Female	30	30.3
Male	69	69.7
Age range		
Younger than 18	1	1.0
18-25 years	10	10.1
26-35 years	21	21.2
36-45 years	26	26.3
Older than 45	41	41.4
Marital status		
Single	5	5.1
Married	82	82.8
Widowed	7	7.1
Divorced	5	5.1
Level of education		
No formal education	6	6.1
Primary	37	37.4
Secondary	43	43.4
Tertiary	6	6.06

Variables	n (99)	(%)
Employment status		
Employed full-time	0	0.0
Employed part-time	2	2.0
Unemployed	0	0.0
Self employed	97	98.0
Household income per month		
Less than US$63	3	3.03
US$64-US$122	12	12.1
Above US$122	84	84.9

Household income, as reported during the focus group discussions, ranged from $295 to $786 and agriculture was stated to be the main source of income.

3.4.1.6.2 Residential Status

According to the survey results, most of the farmers using PE7274 have permanent residence in Poteau 93, Sela, Denis, Petro and Kifita villages - see Figure 68~~Figure 68~~.

Survey responses indicated that that 33.4% of the farmers sleep in the PE7274 area regularly and 33.1% do so occasionally, during planting and harvesting seasons in order to reduce travel time. Most of the farmers (66.4%) indicated that they have residential structures on PE7274. Residential structures were built using a combination of mud bricks and thatch grass. Tarpaulins were observed being used on some roofs as liners.

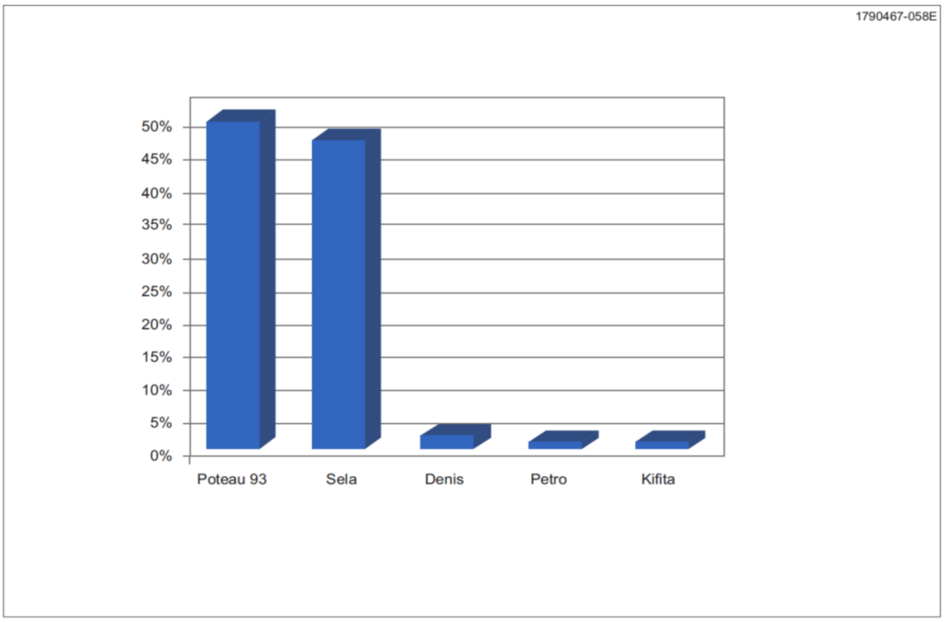

Figure 68: PE7274 Farmers' Areas of Permanent Residence

Figure 69~~Figure 69~~ shows occasional and full-time residential structures. Some structures include toilet facilities, produce storage and livestock pens. Figure 70~~Figure 70~~ shows a chicken coop.

Figure 69: Structures on PE7274

Figure 70: Chicken Coop

3.4.1.6.3 Electricity

There is no electricity supply infrastructure on PE7274. Charcoal was reported as the predominant energy source for cooking and candles as the main source of lighting.

4.0 TITLE IV: ANALYSIS OF THE ENVIRONMENTAL AND SOCIAL IMPACTS OF THE PROJECT

4.1 Methodology for Environmental and Social Impact Evaluation (ESIA)

The significance of the impacts identified during the impact assessment phase were determined in accordance with the methodology described below. This approach is based on the requirements of the DRC Mining Code.

As per Annex VIII of the DRC Mining Code the following is required:

4.1.1 Identification of Impact (Article 39)

The applicant identifies the positive and negative, direct or indirect impact or risk of impact of the exploitation operations on the environment within the perimeter and in the area neighbouring the perimeter that will be affected by the exploitation operations. Each impact is assessed considering:

- The physical environment;
- The biological environment; and
- The sociological environment.

4.1.2 Features of Impact (Article 40)

When quantitatively evaluating each impact caused by the exploitation operations, the applicant must specify the following features:

a) The intensity or size of the impact from the point of view of the degree of disturbance of the environment under consideration, and the degree of sensitivity, vulnerability, uniqueness or rarity of the component under consideration;

b) The extent of the impact, i.e. its spatial dimension;

c) The duration of the impact and its degree of reversibility;

d) The frequency of the impact and the probability as to whether the impact will occur intermittently or occasionally;

e) The level of uncertainty of the impact in relation to the reliability of the estimates;

f) The value of the component for the human populations who are potentially affected and the risks for the safety and well-being of those populations; and

g) The cumulative effect, i.e. the link between the component affected and other components.

For each impact assessed, the applicant determines all the Project operations that are likely to cause such an impact.

The analysis of the negative impacts of the Project on the perimeter and the area neighbouring the perimeter determines the nature of the following types of impact:

a) Noise and vibrations evaluated in accordance with Annex III on noise measurement methods;

b) The risk of degradation and pollution of the air, surface and underground water and soils;

c) The risk to the health and well-being of the local populations and the employees; and

d) The risk of accidents.

This list is not exhaustive, and any other impact or disturbance caused by the Project with regard to the physical, biological and sociological components of the environment must be described accurately.

4.1.3 Impact Assessment Matrix

To assess impacts an Impact Assessment Matrix (Table 51~~Table 51~~) is used that provides a quantitative indication of the severity of an impact prior to and following mitigation. The matrix is based on the requirements outlined by the DRC Mining Code and good international industry practice (GIIP).

Table 51: Impact Assessment Matrix

Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Probability	Frequency	Certainty of Assessment
Positive – impact is positive or beneficial to the environment	5 – Very high/do not know	5 – International	5 – Permanent	5 – Very high/ do not know	5 – Very high/ do not know	5 – Definite/ do not know	5 – Continuous	5 – Very high/ do not know
	4 – High	4 – National	4 – Long-term	4 – High	4 – High	4 – Highly probable	4 – Frequent (daily)	4 – High
Negative – impact is negative or causes adverse damage to the environment	3 – Moderate	3 – Regional	3 – Medium-term (8-15 years)	3 – Moderate	3 – Moderate	3 – Medium probability	3 – Medium-Frequency (once per week)	3 – Moderate
	2 – Low	2 – Local	2 – Short-term (0-5 years) (impact ceases after the operational life of the activity)	2 – Low	2 – Low	2 – Low probability	2 – Infrequent (once per Month)	2 – Low
	1 – Minor	1 – Site only	1 – Immediate	1 – Minor	1 – Minor	1 – Improbable	1 – Infrequent (once per year	1 – Minor

Once these factors are ranked for each impact, the significance of impact is defined using the following formula that is based on the overall magnitude of an impact multiplied by the probability of occurrence:

- **SP (significance points) = (Average of Intensity, Extent, Duration, Value of affected component and Risk to the human population) * (Probability)**

The maximum value is 25 significance points (SP). The impact significance was then rated as follows:

Significance Points	Level of Significance/Risk	Description
SP >20	Indicates **severe** environmental significance/risk	An impact that could influence the decision about whether to proceed with the Project regardless of any possible mitigation.
SP 16-20	Indicates a **major** environmental significance/risk	An impact or benefit that is sufficiently important to require management, and which could have an influence on the decision unless it is mitigated.
SP 9-16	Indicates **moderate** environmental significance/risk	An impact or benefit that is sufficiently important to require management, and which could have an influence on the decision unless it is mitigated.
SP 4-9	Indicates **low** environmental significance/risk	Impacts with little effect and that can be mitigated easily and would be easily absorbed by the environment or human population.
SP <4	Indicates a **negligible** impact/risk	Impacts with little real effect and that should not have an influence on or require modification of the Project design.

Impacts are re-rated following mitigation to determine residual impacts.

4.1.4 Definitions

For the methodology outlined above the following definitions were used:

- Intensity is a measure of the degree of change in a measurement or analysis (e.g. the concentration of a metal in water compared to the water quality guideline value for the metal), and is classified as none/negligible, low, moderate or high. The categorisation of the impact magnitude may be based on a set of criteria (e.g. health risk levels, ecological concepts and/or professional judgement) pertinent to each of the discipline areas and key questions analysed. The specialist study must attempt to quantify the magnitude and outline the rationale used. Appropriate, widely-recognised standards are to be used as a measure of the level of impact;
- Extent (Scale/Geographic) refers to the area that could be affected by the impact and is classified as site, local, regional, national, or international;
- Duration refers to the length of time over which an environmental impact may occur: i.e. transient (less than one year), short-term (0 - 5 years), medium term (5 - 15 years), long-term (greater than 15 years with impact ceasing after closure of the Project), or permanent;
- Value of affected component (Sensitivity) is a measure of the uniqueness and value of the potentially affected component (i.e. regionally unique habitats);
- Human Value Risk – is a measure of the value of an affected component to local communities, and/or the risk of the impact to them;
- Frequency describes how often the impact may occur within a given time period and is classified as low, medium or high frequency. Seasonal considerations are discussed where these are important in the evaluation of the impact;

- Uncertainty – defines the level of certainty in the prediction of the impact; and
- Probability of occurrence is a description of the probability of the impact occurring as improbable (less than 5% chance), low probability (5% to 40% chance), medium probability (40% to 60% chance), highly probable (most likely, 60% to 90% chance) or definite (impact will definitely occur).

In addition to the above-mentioned variables addressed in the impact assessment matrix, for each respective impact that is identified the following was determined:

- The direction of an impact, which may be positive (+), neutral ([]) or negative (-) with respect to the particular impact (e.g. a habitat gain for a key species would be classed as positive, whereas a habitat loss would be considered negative);
- Reversibility is an indicator of the potential for recovery of the end-point from the impact. In some cases, reversibility can occur relatively quickly (e.g. in the case of a temporary loss of habitat). In other cases, the effect may extend over a longer period. This is rated as irreversible (I), easily reversible (ER) or potentially reversible (PR); and
- Timing – indicates at what stage the impact would occur, i.e. construction, operation, decommissioning and/or post closure.

4.1.5 Cumulative and Transboundary Impacts

The cumulative effects assessment will be conducted once all residual impacts have been identified for the physical, biological and socioeconomic components. It will build on past, present and reasonably foreseeable Projects and land uses within the cumulative effects study area, which typically encompasses all study areas for the above components.

4.2 Determining the Operations that will have an Impact on the Environment (Article 41)

The operations that are expected to have an impact on the environment are listed in Table 52~~Table 52~~.

Table 52: Operations and Expected Impact on Environment

Impact	Operations Likely to Cause Impact
Deterioration in air quality	Drilling and blasting
	Loading, hauling and stockpiling of ore and waste rock
	Earthworks and landscaping during construction, operation, decommissioning and rehabilitation
	Ore processing
	Sulphide ore roasting and sulphuric acid production
Deterioration in quality of water discharged to Kifumashi River due to inadequate separation of contact and non-contact water, spillage of organic and inorganic substances on open ground outside of the area for management of contact and non-contact water, inadequate containment of sediment in ponds	Drilling and blasting
	Loading, hauling and stockpiling of ore and waste rock
	Earthworks and landscaping during construction, operation, decommissioning and rehabilitation
	Ore processing
	Maintenance of vehicles an equipment
Reduced availability of groundwater to customary users	Mine dewatering by boreholes and pumping out of water from pit sumps

Impact	Operations Likely to Cause Impact
Deterioration in quality of groundwater abstracted by customary users – may manifest only after groundwater levels have rebounded, up to 50 years after closure	Mining and ore processing – contamination of soil within operational areas and deposition of waste rock and tailings on unlined areas
Degradation of soil quality and land capability	Expansion of open pits and clearing of land within footprints of pit expansion, construction areas and areas for deposition of mining waste
Change in land use	Restriction of access to tenements PE528 and PE7274 (temporary until after mine closure) and making areas occupied by open pits, TSFs and WRDs unsuitable for agriculture (permanent)
Nuisance noise experienced by public	Drilling and blasting
	Loading, hauling and stockpiling of ore and waste rock
	Earthworks and landscaping during construction, operation, decommissioning and rehabilitation
	Ore processing
	Sulphide ore roasting and sulphuric acid production
Ground vibration – nuisance and structural damage	Blasting
Socio-economic benefits as described in Section 8.2.	Undertaking and maintaining the mine's Community Investment Management Plan
Loss of jobs and support of Community Investment Management Plan	Closure of mine

4.3 Nature of Environmental and Social Impacts (Article 42)

The impacts as determined by the relevant specialist studies are described in this section.

4.3.1 Impacts on the Physical Environment

4.3.1.1 Noise and Vibration – Article 42 (a)

4.3.1.1.1 Standards and Guidelines for Noise

Permitted noise levels due to mining are set out in Articles 46 and 47 of the 2018 DRC Mining Regulations. The threshold noise levels for three categories of land use are shown in Table 53~~Table 53~~.

Table 53: Maximum Permitted Sound Level According to Land Use Category, dB $L_{Aeq,1hr}$

Land Use Category	Period	
	Daytime (07:00 – 19:00)	Night-time (19:00 – 07:00)
A – Land on which there are several residential dwellings forming a community or village, a school or a hospital or any other educational, health or convalescence service establishment.	45	40
B – Land on which permanent commercial hunting or fishing activities or recreational activities take place. However, the noise level provided for night-time applies only within the limits of ownership of residential dwellings. Elsewhere, the maximum noise level provided for day-time also applies at night-time.	55	50

Land Use Category	Period	
	Daytime (07:00 – 19:00)	Night-time (19:00 – 07:00)
C – Land on which mainly industrial or agricultural activities take place. However, where an existing residential dwelling is located in this land type, the thresholds are 50.0 dB (A) at night-time and 55.0 dB (A) in day-time.	70	70

The DRC standards are more stringent than some widely used international guidelines such as the World Health Organization guideline values (WHO 1999). The guideline values are specified as either a fixed noise limit or an increase of 3.0 dB over ambient noise levels.

The DRC regulations make no reference to baseline noise levels. A potential result of any assessment which does not reference baseline conditions is over-conservative where baseline levels are high or, conversely, does not offer sufficient protection to receptors where baseline levels are low. This assessment has therefore adopted the WHO's 3.0 dB change as a metric for defining significance in addition to the DRC's fixed limit approach. The criteria for assessing the magnitude of a noise impact are illustrated in Table 54~~Table 54~~.

Table 54: Noise Intrusion Level Criteria

Increase Δ-dBA	Assessment of Impact Magnitude	Colour Code
0 <Δ≤ 1	Not audible	
1 <Δ≤ 3	Very low	
3 <Δ≤ 5	Low	
5 <Δ≤ 10	Moderate	
10 <Δ≤ 15	High	
15 <Δ	Very high	

4.3.1.1.2 Modelled Noise Levels at Sensitive Receptors

Noise levels at the receptors indicated on Figure 53~~Figure 53~~ and Figure 54~~Figure 54~~, that can be ascribed to the proposed KOU Project, were calculated for the construction, operational and closure/rehabilitation phases.

Current open pit mining, hauling and processing activities could possibly continue to 2030, i.e. they will contribute to the noise regime during the construction and operational phases.

Some of the mining vehicles will contribute noise associated with earthmoving, landscaping and the reshaping of WRDs and TSFs during the closure phase and into the rehabilitation phase.

4.3.1.1.2.1 Construction Phase

Calculated intrusion levels are very low. The highest Δ-dBA value is 0.3, at Kalianda Village. The Δ-dBA values at all the other villages are between 0 and 0.2. With reference to the noise intrusion level criteria (Table 55~~Table 55~~), it is seen that these intrusion levels are rated as not audible.

4.3.1.1.2.2 Operational Phase

The following noise sources and associated noise levels were used in the noise calculations:

- Open pit activities – 90.0 dBA;
- Blast hole drilling – 100.0 dBA;
- Cobalt recovery – 70.0 dBA;

- TSF3 – 85.0 dBA;
- VAT leach process – 80.0 dBA;
- Electro-winning – 85.0 dBA;
- Primary jaw crushing – 95.0 dBA;
- Wet ball mill – 95.5 dBA; and
- Solvent extraction – 85.0 dBA.

The expected noise impact on the environment and the residents living near Kinsevere mine concession area was modelled. The cumulative noise levels are the noise levels that the noise receptors will experience as a result of the activities at the pits, the TSF and the ore processing plant. The noise intrusion levels for the different combinations are indicated in Table 55~~Table 55~~.

With reference to the noise intrusion level criteria (Table 54~~Table 54~~), it is seen that:

- Residents of Kalianda Village can expect to experience a noise intrusion level of Δ-dBA = 3.3, which is rated as low, during the night time when mining occurs in Mashi Pit (Table 55~~Table 55~~); and
- For all other combinations of mining with the other operations, the noise intrusion levels at all villages are expected to be either very low (Δ-dBA between 1 and 3) or not audible (Δ-dBA ≤1).

4.3.1.1.2.3 Closure and Rehabilitation Phase

The noise levels during the closure and rehabilitation phase, when mining and ore processing activities have ceased, will be lower than those experienced during the construction phase, i.e. the intrusion levels at the villages are expected to be rated as not audible.

Table 55: Noise Intrusion Levels at Villages due to Pits and Other Noise Sources

Residential Property	Noise Intrusion Levels at the Different Villages (dBA)															
	Open Pit Activities	Blast Hole Drilling	Cobalt Recovery	TSF3	Heap Leach Activities	Vat Leaching & Scats Crushing Processes	Electro-Winning	Primary Crusher	Secondary Crusher	Tertiary Crusher	Sulphide Ore Process	Cumulative Levels	Cumulative Noise Level – Daytime	Cumulative Noise Level – Night Time	Intrusion Noise Level – Daytime	Intrusion Noise Level – Night Time
Mashi Pit																
Mlkanda	9.3	18.8	2.7	5.3	-2.6	-2.6	2.7	12.1	7.1	2.1	12.7	21.3	36.3	33.5	0.1	0.3
Denis	8.8	18.3	2.3	4.9	-3.0	-3.0	2.3	11.7	6.7	7.5	12.3	20.8	36.7	33.8	0.1	0.2
Sela	14.0	23.5	6.5	10.1	0.8	0.8	6.5	15.6	10.6	11.3	16.4	25.7	46.2	43.3	0.0	0.1
Ernest	15.3	24.8	7.4	8.4	1.1	1.1	7.4	16.3	11.3	11.6	16.9	26.7	39.2	36.5	0.2	0.5
Mpundu	20.4	29.9	11.4	8.6	4.0	4.0	11.4	19.8	14.8	14.5	20.3	31.4	39.2	36.2	0.8	1.8
Kalianda	26.0	35.5	17.9	9.7	8.1	8.1	17.9	24.9	19.9	18.6	24.3	36.8	41.0	39.4	2.0	3.4
Katumba	14.7	24.2	10.4	4.9	4.0	4.0	10.4	20.3	15.3	14.5	15.4	27.1	39.3	36.5	0.3	0.5
Lutenge	11.0	20.5	4.3	3.4	-1.8	-1.8	4.3	13.5	8.5	8.7	11.1	22.5	38.5	35.6	0.1	0.2
Kilongo	26.2	35.7	23.7	8.9	11.5	11.5	23.7	28.5	23.5	22.0	28.9	38.0	45.1	42.8	1.0	1.7
Poto 93	15.0	24.5	11.0	11.1	8.9	8.9	11.0	22.7	17.7	19.4	22.6	29.1	37.0	34.6	0.8	1.4
Central Pit																
Mlkanda	9.4	18.9	-2.3	5.3	-2.6	-2.6	2.7	12.1	7.1	2.1	12.7	21.3	36.3	33.5	0.1	0.3
Denis	9.0	18.5	-2.7	4.9	-3.0	-3.0	2.3	11.7	6.7	7.5	12.3	20.9	36.7	33.8	0.1	0.2
Sela	14.0	23.5	1.5	10.1	0.8	0.8	6.5	15.6	10.6	11.3	16.4	25.6	46.2	43.3	0.0	0.1
Ernest	14.2	23.7	2.4	8.4	1.1	1.1	7.4	16.3	11.3	11.6	16.9	25.9	39.2	36.4	0.2	0.4
Mpundu	17.8	27.3	6.4	8.6	4.0	4.0	11.4	19.8	14.8	14.5	20.3	29.4	38.9	35.6	0.5	1.2
Kalianda	21.2	30.7	12.9	9.7	8.1	8.1	17.9	24.9	19.9	18.6	24.3	33.2	40.0	37.8	1.0	1.8
Katumba	13.6	23.1	5.4	4.9	4.0	4.0	10.4	20.3	15.3	14.5	15.4	26.4	39.2	36.5	0.2	0.5

Residential Property	Noise Intrusion Levels at the Different Villages (dBA)															
	Open Pit Activities	Blast Hole Drilling	Cobalt Recovery	TSF3	Heap Leach Activities	Vat Leaching & Scats Crushing Processes	Electro-Winning	Primary Crusher	Secondary Crusher	Tertiary Crusher	Sulphide Ore Process	Cumulative Levels	Cumulative Noise Level – Daytime	Cumulative Noise Level – Night Time	Intrusion Noise Level – Daytime	Intrusion Noise Level – Night Time
Lutenge	9.9	19.4	-0.7	3.4	-1.8	-1.8	4.3	13.5	8.5	8.7	11.1	21.7	38.5	35.6	0.1	0.2
Kilongo	22.4	31.9	18.7	8.9	11.5	11.5	23.7	28.5	23.5	22.0	28.9	35.8	44.7	42.2	0.6	1.1
Poto 93	17.1	26.6	6.0	11.1	8.9	8.9	11.0	22.7	17.7	19.4	22.6	30.0	37.1	34.9	0.9	1.7
Kinsevere Hill Pit																
Mlkanda	9.9	19.4	-2.3	5.3	-2.6	-2.6	2.7	12.1	7.1	2.1	12.7	21.6	36.3	33.5	0.1	0.3
Denis	9.6	19.1	-2.7	4.9	-3.0	-3.0	2.3	11.7	6.7	7.5	12.3	21.3	36.7	33.8	0.1	0.2
Sela	14.3	23.8	1.5	10.1	0.8	0.8	6.5	15.6	10.6	11.3	16.4	25.8	46.2	43.3	0.0	0.1
Ernest	13.6	23.1	2.4	8.4	1.1	1.1	7.4	16.3	11.3	11.6	16.9	25.5	39.2	36.4	0.2	0.4
Mpundu	15.8	25.3	6.4	8.6	4.0	4.0	11.4	19.8	14.8	14.5	20.3	28.1	38.8	35.3	0.4	0.9
Kalianda	17.6	27.1	12.9	9.7	8.1	8.1	17.9	24.9	19.9	18.6	24.3	31.4	39.7	37.3	0.7	1.3
Katumba	12.0	21.5	5.4	4.9	4.0	4.0	10.4	20.3	15.3	14.5	15.4	25.6	39.2	36.4	0.2	0.4
Lutenge	9.1	18.6	-0.7	3.4	-1.8	-1.8	4.3	13.5	8.5	8.7	11.1	21.2	38.5	35.6	0.1	0.2
Kilongo	18.5	28.0	18.7	8.9	11.5	11.5	23.7	28.5	23.5	22.0	28.9	34.5	44.6	42.0	0.5	0.9
Poto 93	18.9	28.4	6.0	11.1	8.9	8.9	11.0	22.7	17.7	19.4	22.6	31.0	37.4	35.3	1.2	2.1

4.3.1.2 Vibration

Current open pit blasting could continue to 2027, i.e. there will be blasting during the construction and operational phases of the proposed KOU Project, but blasting is unlikely to take place during the closure and rehabilitation phases.

4.3.1.2.1 Standards and Guidelines for Ground Vibration

The DRC Mining Code (Article 48 Annex VIII of Decree No 18/024 of 8 June 2018) sets out limits for airborne and ground-borne vibration levels at sensitive receptors:

"Mine or quarry exploitation operations must not emit vibrations whose speed assessed at ground level at any residential dwelling, school or hospital or any artesian bore is greater than 1.25 cm/s and air pressures greater than 120 linear decibels. In cases where extraction activities are taking place less than 600 m from a structure or building mentioned in the Article 46 (except for a dwelling belonging to the mine operator), the applicant must carry out self-monitoring of the contaminants each time dynamiting takes place, and the data must be recorded and must be accessible for at least two years".

The effects of vibration on structures is related to both the amplitude and the dominant frequency of the vibration, as well as the type and configuration of the structure. The peak particle velocity (PPV) is the most commonly-used measure of the intensity of the ground vibration due to blasts. Two of the most important variables that affect the PPV from a blast are the distance from the source and the maximum explosive charge weight per delay period.

Table 56~~Table 56~~ lists the effects of increasing levels of ground vibration and is used to assess the impacts of vibration.

Table 56: Effects of Different Levels of Ground Vibration

Ground Vibration Intensity (mm/s)	Ground Vibration Effect
0.3-0.5	Becomes perceptible to humans.
2.0	Ghana national regulatory limit to prevent damage to weakest of building materials in residential structures in study area.
12.5	DRC limit for ground-borne vibration at sensitive receptors, USBM recommended limit to prevent damage to weakest of building materials in well-built wood-frame structures (e.g., plaster-on-lath).
19.1	Recommended limit to prevent damage to drywall/sheetrock construction.
50.0	Recommended limit for construction blasting and quarry blasting at high frequencies.
75-25	Hairline cracks may start developing in plaster.
300-600	Micro-cracks may start developing in rock.

Peak ground vibration limits generally established for blasting operations to prevent damage to adjacent facilities or structures typically range from 12.5 mm/s to 50.0 mm/s, depending on the dominant frequency of the ground vibration. The DRC vibration limit for sensitive receptors is aligned to international guidelines.

This assessment assumes that most of the houses in the nearby villages are of traditional construction and may be more sensitive to ground vibrations than structures using modern materials and technology and a ground vibration limit of 12.5 mm/s is recommended.

The human body is an excellent detector of vibration and ground vibration is felt at levels far below those that can cause structural damage. Most people can detect a PPV in the region of 0.2 mm/s, find a level of 1.0 mm/s to be clearly perceptible, levels in excess of 2 to be annoying and levels exceeding 5 to be alarming. The criteria used in this study for the assessment of the significance of vibration levels are listed in Table 57Table 57.

Table 57: Criteria for Assessment of Ground Vibration

Period	Vibration PPV (mm/s)			
	Low	Moderate	High	Very High
Daytime	<2	2-5	5-10	>10
Night time	<1	1-2	2-5	>5

No blasting is done at night and the night time threshold levels are not considered in the assessment.

4.3.1.2.2 Modelled Ground Vibration Levels at Sensitive Receptors

Ground vibration levels at the receptors indicated on Figure 53Figure 53 and Figure 54Figure 54, that can be ascribed to the proposed KOU Project, were calculated for the mining activities taking place at the Mashi, Central and Kinsevere Hill pits for blasting slurry charge weights of 300, 500, 750 and 1 000 kg per delay.

The calculated ground vibration levels during blasting at the opencast pits are listed in Table 58Table 58.

Table 58: Modelled Ground Vibration Levels in mm/s at Different Noise Receptors during Blast

Noise receptor village	Distance in metres	Calculated vibration levels for 300 kg site mixed slurry explosives	Calculated vibration levels for 500 kg site mixed slurry explosives	Calculated vibration levels for 750 kg site mixed slurry explosives	Calculated vibration levels for 1 000 kg site mixed slurry explosives
Mashi Pit					
Mlkanda	6420	0.09	0.13	0.18	0.23
Denis	6846	0.08	0.12	0.17	0.21
Sela	3746	0.21	0.32	0.44	0.55
Ernest	3240	0.26	0.40	0.55	0.69
Mpundu	1789	0.68	1.03	1.42	1.79
Kalianda	947	1.89	2.84	3.93	4.95
Katumba	3480	0.24	0.35	0.49	0.62
Lutenge	5284	0.12	0.18	0.25	0.32
Kilongo	927	1.96	2.94	4.07	5.12
Poto 93	3345	0.25	0.38	0.52	0.66
Central Pit					
Mlkanda	6348	0.09	0.14	0.19	0.24
Denis	6686	0.08	0.12	0.17	0.22
Sela	3780	0.21	0.31	0.43	0.54
Ernest	3665	0.22	0.33	0.45	0.57
Mpundu	2426	0.42	0.63	0.87	1.10
Kalianda	1650	0.78	1.17	1.62	2.04
Katumba	3941	0.19	0.29	0.40	0.51
Lutenge	5995	0.10	0.15	0.21	0.26

Noise receptor village	Distance in metres	Calculated vibration levels for 300 kg site mixed slurry explosives	Calculated vibration levels for 500 kg site mixed slurry explosives	Calculated vibration levels for 750 kg site mixed slurry explosives	Calculated vibration levels for 1 000 kg site mixed slurry explosives
Kilongo	1429	0.98	1.47	2.04	2.56
Poto 93	2637	0.37	0.55	0.76	0.96
Kinsevere Hill Pit					
Mlkanda	6034	0.10	0.15	0.20	0.26
Denis	6259	0.09	0.14	0.19	0.24
Sela	3623	0.22	0.33	0.46	0.58
Ernest	3948	0.19	0.29	0.40	0.50
Mpundu	3040	0.29	0.44	0.61	0.77
Kalianda	2484	0.40	0.61	0.84	1.06
Katumba	4736	0.14	0.22	0.30	0.38
Lutenge	6622	0.08	0.13	0.18	0.22
Kilongo	2239	0.48	0.72	0.99	1.25
Poto 93	2131	0.52	0.78	1.07	1.35

The modelled ground vibration levels were assessed in terms of the criteria listed in Table 57Table 57.

From Table 58Table 58 it can be seen that the predicted ground vibration levels for daytime blasts are low (PPV <2 mm/s) at all villages excepting Kalianda and Kilongo, where moderate (PPV = 2-5 mm/s) to high (PPV = 5-10 mm/s) effects may be expected, depending on charge weight per delay – see Table 59Table 59.

Table 59: Assessment of Ground Vibration Levels at Sensitive Receptors

Village	Blast in Mashi Pit	Blast in Central Pit
	Charge Weight & Effect	**Charge Weight & Effect**
Kilongo	300-750 kg: Moderate	300-750 kg: Moderate
	1 000 kg: High	
Kalianda	Up to 1 000 kg: Moderate	Up to 1 000 kg: Moderate

4.3.1.2.3 Standards and Guidelines for Air Blast Overpressure and Vibration

Blast induced air vibration effects are primarily influenced by the prevailing weather conditions at the time of the blast and less so by the factors influencing ground vibrations.

Windows are typically the first structural components to show signs of distress from excessive air vibrations as they are the least able to withstand high external air pressures. Air pressure limits commonly used for surface mining operations where blasting can be expected to occur over many years typically fall in the range of 120.0 to 134.0 dBL measured at the nearest sensitive receptor.

The effects of increasing levels of air vibration are listed in Table 60Table 60.

Table 60: Effects of Different Intensities of Air Pressure Levels

Air Vibration Intensity (dBL)	Effect
95	Equivalent to a wind gust of 5 km/hr.
110	Equivalent to a wind gust of 11 km/hr.
120	DRC limit and USBM cautionary limit set for quarries and open pit mines.
133	Recommended limit for large scale surface mine blasting. Equivalent to a wind gust of 43 km/hr.
140	May result in window breakage.
171	General causes window breakage.

Air blast is experienced as air over-pressure by a receptor and is due to the propagation of the shock wave through the air. It is normally associated with frequency levels less than 20 Hz, which is the threshold for human hearing. It is measured in pascals, but the pressure range is very wide, and the pressure levels are converted to dB for reporting purposes.

The level experienced at a given point is influenced by meteorological conditions such as wind speed and direction, temperature, cloud cover and humidity, blast layout, timing, stemming, accessories used, and the topography and distance between the blast and the receptor.

Under calm atmospheric conditions over flat terrain a doubling of the distance from the blast will result in the air overpressure level (experienced as a shock wave) being attenuated by 6 dB. The human response of annoyance to blast vibrations is aggravated by secondary noises such as the rattling of crockery, windows and walls.

The criteria listed in Table 61~~Table 61~~ are based on international standards and are designed to avoid unacceptable air blast levels at sensitive receptors while permitting the operations to be conducted in a practical manner. The criteria are presented as 95 percentile limits for human comfort in occupied buildings while avoiding cosmetic and structural damage due to long term effects of air blast vibration. An air blast noise level of 140.0 dBL is generally accepted as the safe threshold for human hearing protection.

Table 61: Criteria for Assessment of Air Blast Vibration

Period	Air Blast dBL			
	Low	Moderate	High	Very High
Daytime	<115	115 - 125	125 - 140	>140
Night time	<105	105 - 115	115 - 140	>140

No blasting is done at night and the night time threshold levels are not considered in the assessment.

4.3.1.2.4 Modelled Air Blast Levels at Sensitive Receptors

Air blast overpressure levels at the receptors indicated on Table 62~~Table 62~~ and Figure 54~~Figure 54~~, that can be ascribed to the proposed KOU Project, were calculated for the mining activities taking place at the Mashi, Central and Kinsevere Hill pits for blasting slurry charge weights of 300, 500, 750 and 1 000 kg per delay. Air blast noise and vibration are typically experienced for up to three seconds per blast.

The calculated air blast levels during blasting at the opencast pits are listed in Table 62~~Table 62~~.

Table 62: Modelled Air Pressure Levels at Different Receptor Locations during Blast

Noise receptors	Distance in metres	Calculated dBL value (dB) at the receptor for 300 kg site mixed slurry explosives	Calculated dBL value (dB) at the receptor for 500 kg site mixed slurry explosives	Calculated dBL value (dB) at the receptor for 750 kg site mixed slurry explosives	Calculated dBL value (dB) at the receptor for 1 000 kg site mixed slurry explosives
Mashi Pit					
Mlkanga	6420	93.7	95.5	96.9	97.9
Denis	6846	93.1	94.8	96.3	97.2
Sela	3746	99.4	101.1	102.5	103.5
Ernest	3240	100.9	102.6	104.0	105.0
Mpundu	1789	107.1	108.8	110.2	111.2
Kalianda	947	113.7	115.5	116.9	117.9
Katumba	3480	100.1	101.9	103.3	104.3
Lutenge	5284	95.8	97.5	98.9	99.9
Kilongo	927	113.9	115.7	117.1	118.1
Poto 93	3345	100.5	102.3	103.7	104.7
Central Pit					
Mlkanga	6348	93.9	95.6	97.0	98.0
Denis	6686	93.3	95.1	96.5	97.5
Sela	3780	99.3	101.0	102.4	103.4
Ernest	3665	99.6	101.4	102.8	103.8
Mpundu	2426	103.9	105.7	107.1	108.1
Kalianda	1650	107.9	109.7	111.1	112.1
Katumba	3941	98.8	100.6	102.0	103.0
Lutenge	5995	94.5	96.2	97.6	98.6
Kilongo	1429	109.4	111.2	112.6	113.6
Poto 93	2637	103.0	104.8	106.2	107.2
Kinsevere Pit					
Mlkanga	6034	94.4	96.2	97.6	98.6
Denis	6259	94.0	95.8	97.2	98.2
Sela	3623	99.7	101.5	102.9	103.9
Ernest	3948	98.8	100.6	102.0	103.0
Mpundu	3040	101.5	103.3	104.7	105.7
Kalianda	2484	103.6	105.4	106.8	107.8
Katumba	4736	96.9	98.7	100.1	101.1
Lutenge	6622	93.4	95.2	96.6	97.6
Kilongo	2239	104.7	106.5	107.9	108.9
Poto 93	2131	105.2	107.0	108.4	109.4

The modelled air blast levels were assessed in terms of the criteria listed in Table 61~~Table 61~~. From Table 62~~Table 62~~ it can be seen that the predicted air blast levels for daytime blasts are low (<115 dB) at all villages excepting Kalianda and Kilongo, where moderate (dB = 115 - 125) effects may be expected for blasts at Mashi Pit with charge weights per delay exceeding 500 kg.

4.3.1.2.5 Impact Assessment

A summary of impacts before and after mitigation is presented in Table 63~~Table 63~~.

Table 63: Noise and Vibration Impact Assessment

Phase/Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	▪ Change in land use; and ▪ Establishment of infrastructure (including for cobalt recovery and sulphide ore processing).	Neg	3	1	2	4	3	2.6	5	13	Mod	Neg	2	1	2	3	2	2	5	10	Mod
Operations	▪ Mechanised ore crushing and grinding processes for scat material, sulphide ore and vat leaching; ▪ Limestone mill to grind limestone for cobalt recovery plant; and ▪ Mining.	Neg	3	1	3	4	3	2.8	5	14	Mod	Neg	2	1	3	3	2	2.2	5	11	Mod
Decommissioning	Demolition and disposal of site infrastructure (processing plant, buildings, conveyors, pipelines etc.).	Neg	3	1	2	3	3	2.4	5	12	Mod	Neg	2	1	2	3	2	2	5	10	Mod
Closure	Placement and spreading of sub-soil and topsoil, profiling and contouring of the area as part of rehabilitation works, revegetation.	Neg	2	1	2	4	2	2.2	5	11	Mod	Neg	1	1	2	4	1	1.8	5	9	Mod

4.3.1.3 Air Quality – Article 42 (b)

Determination of the impacts was based on the mining and ore processing methods, as well as infrastructure described in the KEP and KOU Projects – see Section 2.2.2. The United States – Environmental Protection Agency (US-EPA) and Australian Environment – National Pollutant Inventory (EA-NPI) emission estimation methods were used to identify potential pollutants and to quantify emissions.

A steady state Gaussian Plume model is required to gain an understanding of the distribution of the pollutant concentrations in time and space. The approved AERMOD View 9.5.0 modelling software was used to determine the potential impacts. AERMOD View is an air dispersion modelling package that incorporates the following US EPA air dispersion models into one integrated interface:

- AERMOD;
- ISCST3; and
- ISC-PRIME.

These US EPA air dispersion models are used extensively internationally to assess pollution concentrations and deposition from a wide variety of sources. The AERMET View 9.5.0 pre-processor was used to process MM5 modelled regional meteorological data for information on the nature of the receptor grid and emissions input data.

Dispersion models are limited in their ability to account for highly complex, rapidly varying spatial and temporal meteorological systems such as calms, and mountain and valley winds, especially where complex terrain is involved. The US EPA considers the range of uncertainty to be -50% to +200% for models applied to gently rolling terrain. The accuracy improves with strong wind speeds and during neutral atmospheric conditions. Dispersion modelling results can be compared with monitored values to calibrate models and improve their accuracy.

Dispersion modelling was undertaken to estimate the impacts of the KOU Project on the atmospheric concentrations of particulates and the trace gases SO_2 and NO_2 near the Kinsevere mine during the operational phase of the project when the emission rates will be at their highest.

4.3.1.3.1 Standards and Guidelines

Permissible air pollution thresholds within and outside the perimeter of a mining project are specified in Article 50 of the DRC Mining Code: Annexure VIII Environmental Study Guidelines (DRC, 2018). The air pollution thresholds within and outside the perimeter are listed in Table 64~~Table 64~~.

Table 64: Air Pollution Thresholds in Terms of Article 50

Type of Contaminant	Pollution Thresholds
Within Perimeter – Occupational Health and Safety Considerations	
Arsenic	0.5 mg/m³
Carbon monoxide	29 mg/m³
Copper	1 mg/m³
Free silica	5.0 mg/m³
Hydrogen cyanide	11 mg/m³
Hydrogen sulphide	14 mg/m³
Lead: emissions and smoke	0.15 mg/m³
Nitrogen dioxide	6 mg/m³
Solid particles	10 mg/m³
Sulphur dioxide	5 mg/m³

Type of Contaminant	Pollution Thresholds
Outside Perimeter – Environmental and Public Health Considerations, Public Exposure	
Particles of matter (<10 µm): ■ Annual arithmetic mean; and ■ Maximum mean over 24 hours.	100 µg/m^3 500 µg/m^3
Nitrogen oxide as NO_2: ■ Annual arithmetic mean; and ■ Maximum mean over 24 hours.	100 µg/m^3 200 µg/m^3
Sulphur dioxide as SO_2: ■ Annual arithmetic mean; and ■ Maximum mean over 24 hours.	100 µg/m^3 500 µg/m^3

4.3.1.3.2 Construction Phase

4.3.1.3.2.1 Particulates

The main emissions of particulates from mining operations consist of wind-borne dust, vehicle usage and materials handling, also depending on the levels at which they are present, trace metals in mined material as well as the primary metal being mined could be considered. Construction activities that will cause particulate emissions include earthworks, terracing, refurbishing of old, and erection of new surface infrastructure.

The mobilisation of particulates due to construction activities will be transient and the impact is rated as being of low significance.

4.3.1.3.2.2 Trace Gases

Vehicle activity associated with construction activities such as earthworks and terracing would result in trace gas emissions. The trace gas impacts associated with the construction activities will be transient and the impact is rated as being of low significance.

4.3.1.3.3 Operational Phase

Dispersion simulations were undertaken for a sulphide ore throughput of 2.6 Mtpa and the sulphuric acid plant parameters listed in Table 65.

Table 65: Sulphuric Acid Plant Parameters

Item	Value
Stack height (m)	30
Stack diameter (m)	1.4
Area (m^2)	1.5
Temperature (°C)	80
Flow (Nm^3/h)	48 436
Flow (Nm/h)	62 622
Velocity (m/s)	11.3
TSP (tpa)	0
PM_{10} (tpa)	27
NO_2 (tpa)	154
SO_2 (tpa)	668

4.3.1.3.3.1 Particulates

The estimated particulate emissions for maximum operations without mitigation are presented in Table 66~~Table 66~~.

Table 66: Particulate Emissions for Operations (Unmitigated)

Activity	TSP (tpa)	PM_{10} (tpa)
Drilling	22	11
Blasting	220	114
Excavation	500	240
Dozing	310	75
Materials Transfer	864	398
Crushing & Screening	520	52
Hauling on Unpaved Roads	7050	2083
Open Areas	1704	852
Vehicles	0	52
Acid Plant	0	27
Total	**11190**	**3905**

With reference to Table 66~~Table 66~~, the sulphuric acid plant makes a contribution of 0.7% to the total inventory of PM_{10} emissions.

The results of the particulate dispersion simulations when oxide and sulphide ore are mined and processed at a combined rate of 5.2 Mtpa are shown in Table 67~~Table 67~~. The results are shown at the various receptors for the periods during the mine life when air quality is expected to be at its poorest. There is no DRC or international standard for dust-fallout. The results are colour coded according to the air quality index (AQI) shown in Figure 71~~Figure 71~~. The colour scale ranges from blue (indicating a low concentration relative to the standard/guideline), to orange (indicating an exceedance of the standard/guideline).

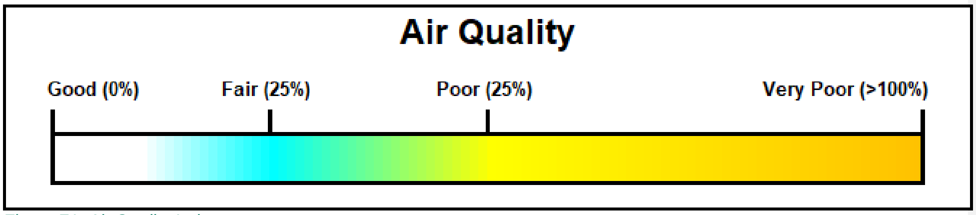

Figure 71: Air Quality Index

The predicted unmitigated PM_{10} impacts, with a sulphuric acid plant stack height of 30 m, are shown in Table 67~~Table 67~~.

Table 67: Impacts of Particulates on Various Points of Interest and Sensitive Receptors (Unmitigated). Stack Height 30 metres

Receptor	Daily Maximum		Annual Maximum		Monthly Maximum
	PM_{10} Concentration (µg/m³)	% of DRC Standard 500 µg/m³)	PM_{10} Concentration (µg/m³)	% of DRC Standard (100 µg/m³)	Dust-fallout (g/m²)
Expat Camp	279	56%	53	53%	0.504
South End Tailings Dam	402	80%	86	86%	0.370
Main Gate Entrance	277	55%	47	47%	0.258
Dewatering Outfall	776	**155%**	217	**159%**	0.582
Clinic / Kilongo School	806	***161%***	192	**133%**	0.581
Kilongo Village	532	***106%***	143	**102%**	0.540
Mpundu Village	468	94%	104	78%	0.263
Mumba Village	77	15%	20	14%	0.098
New Tenement SE	163	33%	40	30%	0.126
New Tenement NE	461	92%	86	66%	0.099
Sela Village	186	37%	35	27%	0.039
Mikanga Village	82	16%	15	12%	0.015
Denis Village	86	17%	14	11%	0.016
Village 01	107	21%	16	12%	0.020
Village 02	98	20%	13	10%	0.076
Village 03	157	31%	22	16%	0.171
Poteau Village 01	197	39%	30	23%	0.142
Poteau Village 02	222	44%	37	30%	0.206
Poteau Village 03	224	45%	40	32%	0.238

The dominant wind sector is from the ENE to SE and particulates will be carried from the proposed waste rock dump, pits, and various stockpiles, plus their associated activities, towards the clinic, Kilongo, Kalianda and Mpundu, especially during the dry season.

Table 68: Wind Field Summary

Period	Wind Speed	Dominant Sector 1		Dominant Sector 2		Calms	Missing
2013-2017	2.8 m/s	ENE-SSE	68%			9%	0%
Dry (May-Sep)	3.0 m/s	ENE-SSE	85%	-	-	6%	0%
Wet (Oct-Apr)	2.6 m/s	ENE-SE	50%	NW	7%	11%	0%

Impacts associated with operations before mitigation are rated as high at the mine dewatering discharge location (due to the prevailing wind), Kilongo School and Kilongo Village, and at the clinic, but moderate after a reduction of 50% by the application of the mitigation measures listed in Section 5.3.

4.3.1.3.3.2 Trace Gases

The unmitigated estimated trace gas emissions for operations at maximum capacity are listed in Table 69~~Table 69~~.

Table 69: Unmitigated Trace Gas Emissions at Maximum Operating Capacity

Activity	NO_2 (tpa)	SO_2 (tpa)
Vehicles	864	24
Acid Plant	154	660
Total	1018	684

The results of the trace gas dispersion simulations when oxide and sulphide ore are mined and processed at a combined rate of 5.2 Mtpa are shown in Figure 41~~Figure 41~~ and Figure 42~~Figure 42~~.

The results are colour coded according to the air quality index (AQI) shown in Figure 71~~Figure 71~~. The colour scale ranges from blue (indicating a low concentration relative to the standard/guideline), to orange (indicating an exceedance of the standard/guideline).

Table 70: Impacts of NO_2 on Various Points of Interest and Sensitive Receptors (Unmitigated). Stack Height 30 m

#	Receptor	Daily Maximum		Annual Maximum	
		NO_2 Concentration (µg/m³)	% of DRC Standard (200 µg/m³)	NO_2 Concentration (µg/m³)	% of DRC Standard (100 µg/m³)
1	Expat Camp	39	19%	8	8%
3	South End Tailings Dam	48	24%	9	9%
4	Main Gate Entrance	39	19%	6	6%
5	Dewatering Outfall	131	66%	41	41%
6	Clinic/Kilongo School	108	54%	32	32%
7	Kilongo Village	88	44%	26	26%
8	Mpundu Village	73	37%	19	19%
9	Mumba Village	14	7%	3	3%
10	New Tenement SE	28	14%	7	7%
11	New Tenement NE	67	34%	13	13%

#	Receptor	Daily Maximum		Annual Maximum	
		NO_2 Concentration (µg/m³)	% of DRC Standard (200 µg/m³)	NO_2 Concentration (µg/m³)	% of DRC Standard (100 µg/m³)
12	Sela Village	28	14%	7	7%
13	Mikanga Village	67	34%	13	13%
14	Denis Village	31	16%	6	6%
15	Village 01	15	8%	3	3%
16	Village 02	15	8%	3	3%
17	Village 03	17	9%	3	3%
18	Poteau Village 01	15	8%	2	2%
19	Poteau Village 02	24	12%	3	3%
20	Poteau Village 03	28	14%	4	4%

Note: The table is colour coded according to the air quality index (AQI) shown in Figure 71~~Figure 71~~.

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As is evident from Table 66~~Table 66~~ and Table 69~~Table 69~~, the sulphuric acid plant will be the main source of SO_2 emissions to the atmosphere, while the mining operatons and vehicles will be the dominant sources of particulate and NO_2 emissions respectively.

The dispersion simulation model was used to explore the relationship between the height of the sulphuric acid plant stack and the dispersion of SO_2. As may be seen from Table 71~~Table 71~~, a stack height of 30 m was found to yield SO_2 concentrations that are well below the DRC standards.

The simulated SO_2 concentrations at various receptor points are indicated in Table 71~~Table 71~~.

Table 71: Impacts of SO_2 on Various Points of Interest and Sensitive Receptors (Unmitigated). Stack Height 30 m

#	Receptor	Daily Maximum		Annual Maximum	
		SO_2 Concentration (µg/m³)	% of DRC Standard (500 µg/m³)	SO_2 Concentration (µg/m³)	% of DRC Standard (100 µg/m³)
1	Expat Camp	10	2%	2	2%
3	South End Tailings Dam	6	1%	1	1%
4	Main Gate Entrance	6	1%	2	2%
5	Dewatering Outfall	7	1%	7	7%
6	Clinic/Kilongo School	33	7%	3	3%
7	Kilongo Village	12	2%	1	1%
8	Mpundu Village	4	1%	1	1%
9	Mumba Village	4	1%	1	1%
10	New Tenement SE	3	1%	1	1%
11	New Tenement NE	3	1%	0	0%
12	Sela Village	2	0%	0	0%
13	Mikanga Village	2	0%	0	0%
14	Denis Village	1	0%	0	0%
15	Village 01	2	0%	0	0%
16	Village 02	2	0%	0	0%
17	Village 03	4	1%	1	1%
18	Poteau Village 01	4	1%	1	1%

#	Receptor	Daily Maximum		Annual Maximum	
		SO_2 Concentration (µg/m³)	% of DRC Standard (500 µg/m³)	SO_2 Concentration (µg/m³)	% of DRC Standard (100 µg/m³)
19	Poteau Village 02	5	1%	1	1%
20	Poteau Village 03	5	1%	1	1%

Note: The table is colour coded according to the air quality index (AQI) shown in Figure 71Figure 71.

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The dominant wind sector is from the ENE to SE and pollutants will be carried from the proposed waste rock dump, pits, various stockpiles and the ore processing plant area towards the clinic, Kilongo, Kalianda and Mpundu. Operational phase impacts are rated as moderate before mitigation and low after a 25% reduction by the implementation of mitigation measures.

4.3.1.3.4 Decommissioning

4.3.1.3.4.1 Particulates

Particulate emissions from activities during decommissioning will be associated with rehabilitation of the TSFs and demolition of surface infrastructure and will be similar to the emissions experienced during the construction phase.

4.3.1.3.4.2 Trace Gases

Trace gas emissions from activities during decommissioning will be similar to those during the construction phase.

4.3.1.3.5 Post Closure

There should be no post closure project-related activities that will generate particulates or trace gas emissions.

4.3.1.3.5.1 Prediction Confidence

See Section 4.3.1.3.

4.3.1.3.6 Impact Assessment

A summary of impacts before and after mitigation is presented in Table 72Table 72.

Table 72: Air Quality Impact Assessment

Phase / Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Impacts of particulates on sensitive receptors.	Neg	4	1	1	5	3	2.8	3	8.4	Low	Neg	2	1	1	5	3	2.4	2	4.8	Low
Operations		Neg	5	1	3	5	4	3.6	4	14.4	Mod	Neg	3	1	3	5	4	3.2	3	9.6	Mod
Decommissioning		Neg	4	1	1	5	3	2.8	3	8.4	Low	Neg	2	1	1	5	3	2.4	2	4.8	Low
Post-Closure		Pos	Air quality will return to baseline conditions post closure.																		
Construction	Impacts of particulates on flora, fauna and aesthetics.	Neg	3	1	1	5	3	2.6	3	7.8	Low	Neg	1	1	1	5	3	2.2	2	4.4	Low
Operations		Neg	4	2	3	5	4	3.6	4	14.4	Mod	Neg	2	2	3	5	4	3.2	3	9.6	Mod
Decommissioning		Neg	3	1	1	5	3	2.6	3	7.8	Low	Neg	1	1	1	5	3	2.2	2	4.4	Low
Post closure		Pos	Air quality will return to baseline conditions post closure.																		
Construction	Impacts of trace gases on sensitive receptors.	Neg	2	1	1	5	3	2.4	3	7.2	Low	Neg	2	1	1	5	3	2.4	2	4.8	Low
Operations		Neg	3	1	3	5	4	3.2	3	9.6	Mod	Neg	3	1	3	5	4	3.2	2	6.4	Low
Decommissioning		Neg	2	1	1	5	3	2.4	3	7.2	Low	Neg	2	1	1	5	3	2.4	2	4.8	Low
Post-Closure		Pos	Air quality will return to baseline conditions post closure.																		
Construction	Impacts of trace gases on flora, fauna and steel structures.	Neg	1	1	1	5	3	2.2	3	6.6	Low	Neg	1	1	1	5	3	2.2	2	4.4	Low
Operations		Neg	2	2	3	5	4	3.2	3	9.6	Mod	Neg	2	2	3	5	4	3.2	2	6.4	Low
Decommissioning		Neg	1	1	1	5	3	2.2	3	6.6	Low	Neg	1	1	1	5	3	2.2	2	4.4	Low
Post-Closure		Pos	Air quality will return to baseline conditions post closure.																		

4.3.1.3.7 Cumulative Effects Assessment (CEA)

Sources identified as having potential to contribute additional air pollutants to the existing air quality in the vicinity of the Kinsevere mine are:

- Expansion of the opencast pits;
- Gaseous emissions from larger vehicle fleet to cope with increased mining rate;
- Increased particulate mobilisation from unpaved roads and exposed areas; and
- Operation of the sulphide concentrate roaster and sulphuric acid plant.

While the overall air quality impact was not rated as higher than moderate even before mitigation, it should be noted that the impact of elevated PM_{10} concentrations at the water discharge point, clinic, Kilongo, Kalianda and Mpundu will be high, especially in the dry season, and will require mitigation to reduce it to the moderate level.

4.3.1.4 Soils, Land Use and Land Capability – Article 42 (b)

Issues and impacts were identified by means of professional experience, community consultation and referencing previous environmental assessments and DRC standards and guidelines.

Key potential impacts on soils, land use and land capability that have been identified for detailed assessment include:

- Changes to land use;
- Physical degradation and disturbance of soils:
  - Loss of topsoil – as a result of land clearance;
  - Increased erosion of soils in exposed cleared areas;
  - Covering of soils by mine waste infrastructure; and
  - Loss of soil fertility in stockpiled areas.
- Contamination of soils due to pollution; and
- Soil erosion.

4.3.1.4.1 Construction

The activities undertaken during the construction phase of the KOU project will result in:

- Temporary, largely reversible changes in land use in areas where infrastructure will be removed after mine closure, e.g. cobalt recovery plant, access barriers, new sedimentation ponds etc.;
- Permanent changes in land use where vegetation will be cleared for components such as TSF3 and new waste rock dumps;
- Soil erosion in cleared areas; and
- Possible contamination of soil with hydrocarbons, cement, paint and solvents.

4.3.1.4.2 Operational Phase

The following impacts may be expected as a result of the operational activities:

- Permanent loss of agricultural land where expansion of the open pits takes place and where TSF3 and new waste rock dumps are developed;
- Potential loss of fertility of stockpiled topsoil;

- Erosion of bare, unvegetated areas and stockpiled topsoil; and
- Possible contamination of soil with hydrocarbons, chemicals used in the ore processing plant and leachate from the TSFs and WRDs.

4.3.1.4.3 Decommissioning, Closure and Rehabilitation Phase

The activities undertaken after the mining and ore processing operations have ceased may be expected to result in:

- Loss of soil fertility and agricultural potential to an extent determined by how well the rehabilitation is done with regard to the preparation of the disturbed areas and the spreading, conditioning and fertilisation of stockpiled topsoil;
- Erosion by wind and water until disturbed areas have been properly landscaped and revegetated; and
- Possible contamination of soil with hydrocarbons.

Table 73: Assessment of Impacts on Soil, Land Use and Land Capability

Phase/Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Changes in land use	Neg	4	1	5	4	3	3.4	5	17	Maj	Neg	4	1	4	3	2	2.8	5	14	Mod
Operations		Neg	4	1	5	4	3	3.4	5	17	Maj	Neg	4	1	4	3	2	2.8	5	14	Mod
Decommissioning		Pos	1	1	5	2	1	2	2	4	Low	Pos	1	1	5	2	1	2	2	4	Low
Post-Closure		Pos	1					1		0	Non	Pos	1					1		0	Non
Construction	Physical Soil degradation and disturbance	Neg	4	1	5	3	3	3.2	5	16	Maj	Neg	3	1	4	2	3	2.6	5	13	Mod
Operations		Neg	4	1	5	3	3	3.2	5	16	Maj	Neg	3	1	4	2	3	2.6	5	13	Mod
Decommissioning		Pos	1					1		0	Non		1					1		0	Non
Post-Closure		Pos	1					1		0	Non		1					1		0	Non
Construction	Contamination of soils due to pollution	Neg	3	1	4	4	4	3.2	4	12.8	Mod	Neg	3	1	3	4	4	3	3	9	Low
Operations		Neg	3	1	4	4	4	3.2	4	12.8	Mod	Neg	3	1	3	4	4	3	3	9	Low
Decommissioning		Neg	3	1	4	4	4	3.2	4	12.8	Mod	Neg	2	1	1	1	1	1.2	2	2.4	Non
Post-Closure		Pos	1					1		0	Non	Pos	1					1		0	Non
Construction	Soil erosion	Neg	3	1	2	2	2	2	3	6	Low	Neg	2	1	2	1	1	1.4	2	2.8	Non
Operations		Neg	3	1	2	2	2	2	3	6	Low	Neg	2	1	2	1	1	1.4	2	2.8	Non
Decommissioning		Neg	3	1	1	1	1	1.4	2	2.8	Non	Pos	2	1	1	1	1	1.2	2	2.4	Non
Post-Closure		Pos	1					1		0	Non	Pos	1					1		0	Non

4.3.1.5 Surface Water – Article 42 (b)

Potential impacts on the Kifumashi River and the people who utilise the river are related to the contact and non-contact water associated with the proposed extensions and upgrades illustrated in

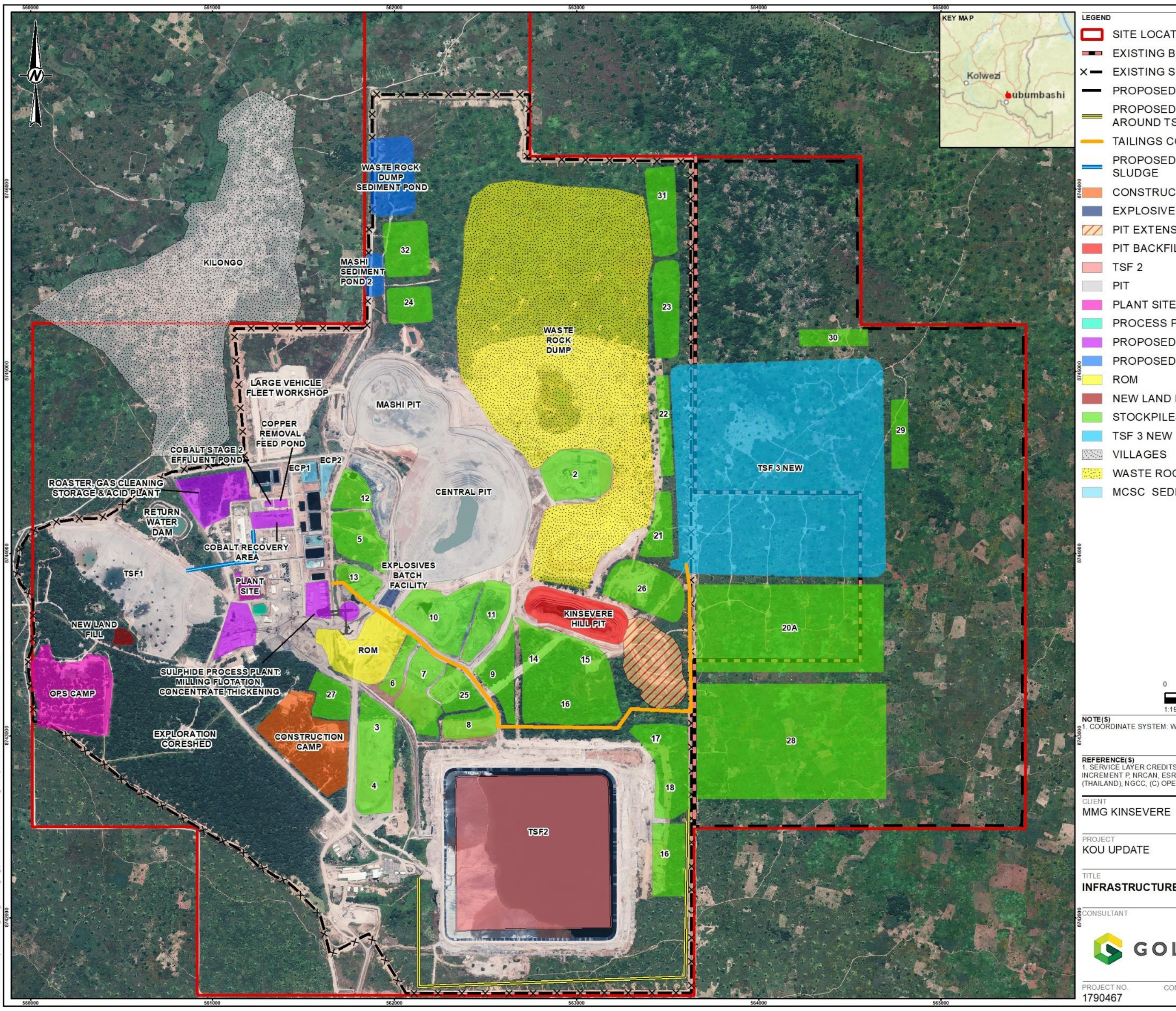

Figure 2Figure 2 and Figure 5Figure 5.

The impacts on the surface water regime were assessed for each phase (construction, operation and closure/ rehabilitation). The predicted impacts are summarised in Table 74~~Table 74~~

4.3.1.5.1 Construction

Because the construction activities associated with the KOU Project will take place against the backdrop of the ongoing operational phase of the existing Kinsevere mine, current surface water impacts will be applicable to the construction phase, as indicated in Table 74~~Table 74~~. Potential additional impacts on surface water during the construction phase, such as contamination with hydrocarbons, cement, solvents and sediment will be confined to the mining permit area by the existing water management system.

4.3.1.5.2 Operational Phase

The potential surface water impacts during the operational phase of the proposed KOU Project can be summarised as follows:

1) Pit dewatering

Pit dewatering by abstracting groundwater from boreholes near the pits and by pumping out the water that collects in the pit sumps is essential to opencast mining and cannot be avoided but monitoring of the water quality in the pit sumps and boreholes must continue.

The dewatering process creates a cone of depression with around the pit that causes groundwater to flow towards the pit and prevents it from contributing towards the flow in the Kifumashi River. Prior to any mitigation, the overall impact risk during the construction and operational phases is predicted to be moderate.

Upon the cessation of mining and dewatering, the pits will fill be backfilled or pit lakes will form as groundwater seeps in. Water levels in the surrounding groundwater will recover and the impact on the river will change from moderate to low at closure and negligible after closure. For the safety of the community members and their livestock, measures must be put in place to prevent access to the lakes.

2) Discharge of pit water and borehole water to Kifumashi River

As described in Sections 2.3, 2.5 and 2.6, water removed from the open pit sumps and by the dewatering boreholes, in excess of that required for process water makeup, is discharged to the Kifumashi River at point SWK04 (Figure 15~~Figure 15~~) and the rate of pumping will increase from the current average of approximately 477 L/s to an estimated maximum of 2 190 L/s in 2025 (Table 7~~Table 7~~). As discussed in Sections 2.3.2, 3.2.2.3 and 5.4.1.3, the discharge meets all the legal and licence requirements.

If the quality of the water discharged to the Kifumashi River fails to meet the DRC standards (see Table 83~~Table 83~~) and Kinsevere mine's licence conditions, there may be adverse impacts on aquatic life and the water users (community members and their livestock). As dewatering is continuous and not new, and the quality of the discharge has consistently met the standards in the past, the overall impact risk during the construction and operational phases is predicted to be moderate and to remain moderate even with mitigation, as the mitigation will be post event detection, so there is likely still to be an impact, although the intensity and extent of the impact would be reduced.

Community engagement, with respect to volume changes and potential increased community impacts, will be important at closure.

3) Contaminated run-off from plant area due to use of chemicals in the process

The relocation of the existing workshops and administration facilities as well as the construction and operation of the new plant area could potentially result in contaminated run-off.

The new plant will require makeup raw water, will discharge tailings at set percentage solids to TSF3 and will be able to accept a maximum decant return to allow the plant to maintain a workable water balance – see Figure 19~~Figure 19~~.

Spillages of process chemicals, fuels, lubricants and hydraulic fluids could contribute to the contamination of water impounded in the plant's water management system depicted in Figure 45~~Figure 45~~.

As there is already a storm water management system in place and considering that the Stage II plant will be constructed within the existing plant area, the overall impact risk during the construction, operational and closure phases is expected to be low.

4) Overflow from contaminated storage ponds within the plant area

If the ECP 1 and 2 ponds and/or any one of the series of process liquor solution ponds are not adequately sized, overflow could occur during the construction and operating phases, which could cause contamination of the soil and the groundwater, and which could be carried to the Kifumashi River along local drainage lines by stormwater during high rainfall events.

Because of the storm water management system and closed loop recycle system that is already in place, the predicted impacts of overflow from contact water ponds during construction and operation is expected to be low.

Removal of pond linings during decommissioning could result in exposure of contaminated soil and the transport of contaminants by stormwater during high rainfall events.

5) Run-off from stockpiles and waste rock dumps

During the construction phase there will be an increased potential for sediment-laden runoff from the preparation of the footprint areas for the new waste rock dumps and other stockpiles by the clearing of vegetation.

During the operational phase there will be contaminated runoff from the waste rock dumps and other stockpiles.

During the closure/decommissioning phase there may be runoff from contaminated soil after the ponds have been emptied and the liners have been removed.

The overall impact and risk during the construction and operational phases is expected to be moderate without mitigation. The main impacts are linked to contaminated run-off reaching the environment and seepage into the groundwater. Once mitigation is in place, the risk will be reduced to low, by reducing the intensity, extent and duration of the impact. The predicted impacts during decommissioning/closure and post closure have been assessed as low.

6) Run-off from tailings storage facilities

TSF1 tailings will be reprocessed through the processing plant. Runoff from TSF1 will be collected in the Return Water Dam, pumped to Mashi Sediment Pond 2 and discharged to the Kifumashi River provided that the water quality meets the regulated discharge limits.

The tailings in TSF2 are potentially acid forming (PAF) and the facility comprises a high-density polyethylene (HDPE) geomembrane-lined, zoned, downstream constructed paddock embankment. Underdrainage was installed to increase TSF2 tailings densities and reduce seepage into the groundwater. In the event that the underdrainage is not operational, the Closure Plan will be adjusted for any impact this may have on tailings consolidation. Any seepage will be monitored using piezometers and groundwater samples; a mitigation plan will be actioned if required to minimise any impacts.

Supernatant is removed from TSF2 via the decant system located in the north-east corner of the TSF and recycled back to the plant for re-use in the ore processing circuits.

The HDPE pipeline runs from the plant site to the TSF embankment crest within a corridor delineated by earthen bunds. A decant riser pipe abstraction system is used throughout the operation of the TSF for the return water system.

TSF2 is comprised of one paddock located approximately 1.5 km south-east of the Plant site. The cell is approximately 850 m × 850 m (inside crest to inside crest) with a decant in the north-eastern corner and a spillway on the east embankment. A heap leach pad consisting of 10 cells was constructed at the southern end of the TSF to recover residual copper remaining in the HMS tailings.

The proposed Kinsevere Operational Upgrades (KOU) Project TSF3 design will be similar to that of TSF2. The main impacts can be summarised as follows:

- During the construction phase there will be an increased potential for sediment-laden runoff from the preparation of the footprint area for the new TSF by the clearing of vegetation;
- During the operational phase there will be an increased potential for contaminated run-off from TSF2 and TSF3 and for seepage of contaminants into the soil and the groundwater;
- During the decommissioning/closure phase there may be erosion of the capping material, resulting in contaminated run-off and seepage of contaminants into the soil and the groundwater;
- Without mitigation, the overall impact risk during the construction and operational phases is expected to be moderate. The main impacts are linked to potential overflow, excessive run-off and groundwater seepage. Implementation of the mitigation measures discussed in Section 5.4 are expected to reduce the risk to a low rating; and
- During and after closure the risk to the surface water environment will remain moderate, but with adequate mitigation it can be reduced to low to negligible.

7) Recycling of contaminated water:

The processing plant is designed to be a zero-discharge water circuit. In compliance with Article 19 of Schedule VIII of the DRC Mining Code, all supernatant resulting from tailings discharged to the TSF2 is recycled directly back into the processing plant via a small holding pond.

The process plant is in a closed loop with the TSF2 and receives approximately 70% of the water that is sent to TSF2 (in the order of 20 500 m^3/d) as recycled water. Some water is used to control the density of the tailings returning to TSF2. The remainder goes into the circuit for re-use.

Recycling of contaminated water during the construction and operational stages of the proposed KOU Project will prevent the release of contaminated water to the environment and reduce the need for fresh water, thereby reducing the adverse impact on the environment. Such recycling will cease when the Project enters the closure and rehabilitation phase.

When decant water is not available, approximately 60 m^3/h (wet season) and 120 m^3/h (dry-season) of makeup water is supplied to the process facility via the raw water pond, sourced from the dewatering boreholes. See Table 7~~Table 7~~ for the expected water demands once the proposed KOU is in operation.

8) Overflow of poor, quality water from sedimentation ponds

Water originating from Mashi and Central pits (runoff and seepage not prevented by the dewatering boreholes) is currently pumped to Mashi Sediment Pond 1. This sediment pond is too small to accommodate Central Pit flows and future predicted increases in passive pit wall seepage.

It will be decommissioned and replaced with the larger, more efficient Mashi Sediment Pond 2, which will also accept water from the Kinsevere Hill Pit, TSF1 Return Water Dam, MCSC Sediment Pond and from the low point of the security trench system.

This water is typically sediment laden and there is a risk of low pH. The discharge to the Kifumashi River must meet the DRC requirements, e.g. the pH must be between 6 and 9 and the total suspended solids (TSS) must be less than 100 mg/L.

During the construction phase, increased sediment from the cleared areas will add to the load of sediment reporting to the sediment ponds.

If the capacity of the sediment ponds is inadequate, or they are not properly maintained, overflow could occur during high rainfall events, resulting in poor quality water migrating to the Kifumashi River along the local drainage lines during the operational phase.

Inadequate rehabilitation could lead to contamination entering the Kifumashi River during and after the closure/decommissioning phase.

9) Hydrological impacts from the security trench

Currently, runoff flows into the security trench where the trench intersects drainage lines. This water, which can be sediment laden, is not removed, either by gravity or pumping. There is significant sediment accumulation in the north-western corner of the Western trench closest to the Kifumashi River and there is a ponding point in the existing Eastern trench that also shows considerable sediment build-up.

If the New Eastern Trench around the perimeter of PE7274 (one of the security barrier options under consideration) is constructed, it will expand the upstream catchment that reports to the network and cause sediment to collect in the new trench.

High rainfall events during the operational phase could result in sediment-laden water overtopping the trenches and migrating to the Kifumashi River.

Inadequate maintenance of the trench system once the mine has been decommissioned could also lead to overtopping and sediment migration before rehabilitation has been completed.

10) Radioactivity in surface water or abstracted groundwater

As discussed in Section 5.8.6.4, Kinsevere mine makes use of instruments containing radioactive sources and the ore contains low concentrations of uranium minerals, but sufficient to require monitoring as recommended by the General Commissariat for Atomic Energy (CGEA) of the DRC (Kazadi, F; Kaka, P; Hongo, R; Kabamba , E; Ndiku, S; Mwamba, V;, July 2015).

According to the World Health Organization, the health risks associated with the presence of naturally occurring radionuclides in drinking water should be taken into consideration (WHO, 2017), although the contribution of drinking water to total exposure is normally very small.

Particles containing radionuclides can become mobilised into the air, soil and water (surface and underground) during mining and ore processing operations. Impact assessment will be possible once a monitoring programme has been implemented and adequate data has been collected. Kinsevere Mine is looking to engage a third party to undertake further monitoring.

4.3.1.5.3 Decommissioning, Closure and Rehabilitation Phase

The impacts that may occur during and after this phase include:

- Contaminated run-off from plant area until rehabilitation has been completed;
- Overflow from contaminated storage ponds, during high rainfall events, until these ponds have been emptied and the relevant areas have been rehabilitated; and

- Contamination of run-off from tailings storage facilities and waste rock dump until rehabilitation, including the establishment of a self-sustaining vegetation cover, has been completed.

Table 74: Surface Water Impact Assessment

Phase/Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Pit dewatering	Neg	3	2	3	3	2	2.6	5	13	Mod	Neg	3	2	3	3	2	2.6	5	13	Mod
Operations		Neg	3	2	3	3	2	2.6	5	13	Mod	Neg	3	2	3	3	2	2.6	5	13	Mod
Decommissioning		Neg	1	1	5	2	1	2	2	4	Low	Neg	3	1	1	1	3	1.8	2	3.6	Non
Post-Closure		Neg	1	1	5	2	1	2	2	4	Low	Neg	3	1	1	1	3	1.8	2	3.6	Non
Construction	Discharge of pit water to Kifumashi River	Neg	4	3	3	5	3	2.8	5	14	Mod	Neg	1	2	3	5	1	2.6	5	12	Mod
Operations		Neg	4	3	3	5	3	2.8	5	15	Mod	Neg	1	2	3	5	1	2.6	5	12	Mod
Closure/ Post closure		Pos	No such discharge into the Kifumashi River post cessation of operations.																		
Construction	Contaminated run-off from plant area due to use of chemicals in the process	Neg	4	1	1	3	2	2.2	4	8.8	Low	Neg	2	1	1	2	2	1.6	3	4.8	Low
Operations		Neg	4	1	1	3	2	2.2	4	8.8	Low	Neg	2	1	1	2	2	1.6	3	4.8	Low
Decommissioning		Neg	3	1	1	1	1	1.4	2	2.8	Non	Neg	2	1	1	1	1	1.2	2	2.4	Non
Post-Closure		Pos	No such runoff post cessation of operations.																		
Construction	Overflow from contaminated storage ponds within the plant area	Neg	3	1	2	2	2	2	3	6	Low	Neg	2	1	2	1	1	1.4	2	2.8	Non
Operations		Neg	3	1	2	2	2	2	3	6	Low	Neg	2	1	2	1	1	1.4	2	2.8	Non
Decommissioning		Neg	3	1	1	1	1	1.4	2	2.8	Non	Neg	2	1	1	1	1	1.2	2	2.4	Non
Post-Closure		Pos	No such overflow post cessation of operations.																		
Construction	Run-off from stockpiles and Waste Rock Dump.	Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Operations			3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Decommissioning		Neg	2	2	2	3	2	2.2	3	6.6	Low	Neg	1	1	2	3	2	1.8	3	5.4	Low
Post-Closure		Neg	2	1	2	3	2	2	3	6	Low	Neg	1	1	2	3	2	1.8	3	5.4	Low
Construction	Run-off from tailings storage facilities	Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Operations		Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Decommissioning		Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	1	1	2	3	2	1.8	3	5.4	Low
Post-Closure		Neg	2	1	2	3	2	2	3	6	Low	Neg	1	1	2	3	2	1.8	3	5.4	Low
Construction	Recycle of contaminated water	Pos																			
Operations		Pos																			
Decommissioning		Pos																			
Post-Closure		Pos																			
Construction	Overflow of poor, quality water from sedimentation ponds	Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Operations		Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Decommissioning		Neg	3	1	1	1	1	1.4	2	2.8	Non	Neg	2	1	1	1	1	1.2	2	2.4	Non
Post-Closure		Pos	Sediment ponds will not be required for particle setting post cessation of operations.																		
Construction	Hydrology changes due to the security trench	Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Operations		Neg	3	2	3	3	3	2.8	4	11.2	Mod	Neg	2	1	2	3	2	2	3	6	Low
Decommissioning		Neg	3	1	1	1	1	1.4	2	2.8	Non	Neg	2	1	1	1	1	1.2	2	2.4	Non

4.3.1.6 Groundwater – Article 42 (b)

The impacts of the mining operations at Kinsevere on the groundwater regime were identified and assessed based on the modelling results described in Sections 3.2.4 and 3.2.5. The impacts were assessed for the construction, operation and closure/ rehabilitation phases of the KOU Project.

The impacts and proposed mitigation measures are listed in Sections 4.3.1.6 and 5.4 respectively.

4.3.1.6.1 Construction Phase

Because the construction activities associated with the KOU Project will take place against the backdrop of the ongoing operational phase of the existing Kinsevere mine, current groundwater impacts will be applicable to the construction phase, as indicated in Section 4.3.1.6. Potential additional impacts on the groundwater migrating towards the mining voids include contamination with hydrocarbons and solvents.

4.3.1.6.2 Operational Phase

The potential groundwater impacts during the operational phase of the proposed KOU Project can be summarised as follows:

- Lowering of groundwater levels within the cone of depression around the mine pits can result in:
  - Reduced yields from boreholes and wells supplying water to the mine and local residents;
  - Increased drought stress on trees and their associated ecosystems; and
  - A risk of subsidence and sinkhole formation in some areas.
- Deterioration in groundwater quality, migrating towards the mining voids, caused by spillages of contaminants can result in the following impacts in areas between the pits and the sources of contamination:
  - Borehole water becoming unfit for use as potable water at the mine; and
  - Subterranean water becoming less fit for use by trees and their associated ecosystems.

4.3.1.6.3 Decommissioning, Closure and Rehabilitation Phase

The impacts that may occur during and after this phase include:

- Continuation of contamination of groundwater by ingress of run-off from plant area until rehabilitation has been completed;
- Contamination of groundwater by ingress of overflow from contaminated storage ponds, during high rainfall events, until these ponds have been emptied and the relevant areas have been rehabilitated;
- Continuation of contamination of groundwater by ingress of run-off from tailings storage facilities and waste rock dump until rehabilitation, including the establishment of a self-sustaining vegetation cover, has been completed; and
- Gradual rebound of groundwater levels.

Table 75: Groundwater Impact Assessment

Phase / Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Groundwater depletion physical impact: yield of boreholes and wells used by mine and community members	Neg	3	2	3	4	3	3	4	12	Mod	Neg	3	2	3	4	3	4	4	12	Mod
Operations		Neg	5	2	4	4	4	3.8	4	15	Mod	Neg	4	2	4	4	4	3.6	4	14.4	Mod
Decommissioning		Neg	5	2	4	4	4	3.8	4	15	Mod	Neg	4	2	4	4	4	3.6	4	14.4	Mod
Post-Closure		Neg	3	1	4	4	1	2.6	3	8	Low	Neg	3	1	4	4	1	2.4	2	4.8	Non
Construction	Groundwater depletion – physical impact: subsidence and sinkhole formation	Neg	3	2	5	4	2	3.2	3	10	Mod	Neg	3	2	5	3	1	2.8	3	8.4	Low
Operations		Neg	3	2	5	4	2	3.2	3	10	Mod	Neg	3	2	5	3	1	2.8	3	8.4	Mod
Closure/ Post Closure		Neg	3	2	5	4	2	3.2	3	10	Mod	Neg	3	2	5	3	1	2.8	3	8.4	Mod
Construction	Groundwater depletion – less water available to trees and associated biological ecosystems	Neg	4	1	3	3	1	2.4	3	7.2	Low	Neg	4	1	3	3	1	2.4	3	7.2	Low
Operations		Neg	4	2	4	4	3	3.4	3	9.6	Mod	Neg	3	1	3	3	1	2.2	3	6.6	Low
Decommissioning		Neg	4	1	3	3	1	2.4	3	7.2	Low	Neg	3	1	3	3	1	2.2	3	6.6	Low
Post-Closure		Neg	4	1	3	3	1	2.4	3	7.2	Low	Neg	3	1	3	3	1	2.2	3	6.6	Low
Construction	Groundwater depletion – biological ecosystems- springs and habitats	Neg	3	2	2	2	3	2.4	3	7.2	Low	Neg	3	1	3	3	1	2.2	3	6.6	Low
Operations		Neg	4	2	4	4	4	3.6	3	10.8	Mod	Neg	3	1	3	3	1	2.2	3	6.6	Low
Decommissioning		Neg	4	2	4	4	4	3.6	3	10.8	Mod	Neg	3	1	3	3	1	2.2	3	6.6	Low
Post-Closure		Neg	4	2	4	4	4	3.6	3	10.8	Mod	Neg	3	1	3	3	1	2.2	3	6.6	Low
Construction	Groundwater depletion – biological ecosystems- impact from infrastructure damage caused by subsidence and sinkholes	Neg	3	2	3	3	2	2.6	2	5.2	Non	Neg	3	2	3	3	2	2.6	2	5.2	Low
Operations		Neg	4	2	4	3	2	3	2	6	Low	Neg	4	2	4	3	2	3	2	6	Low
Decommissioning		Neg	3	2	3	3	2	2.6	2	5.2	Non	Neg	3	2	3	3	2	2.6	2	5.2	Non
Post-Closure		Neg	3	2	3	3	2	2.6	2	5.2	Non	Neg	3	2	3	3	2	2.6	2	5.2	Non
Construction	Groundwater depletion – sociological: shallow wells for domestic supplies	Neg	4	1	3	4	3	3	3	9	Mod	Neg	3	2	2	3	2	2.4	3	7.2	Low
Operations		Neg	4	2	4	4	3	3.4	3	10.2	Mod	Neg	3	2	2	3	2	2.4	3	7.2	Low
Decommissioning		Neg	4	2	4	4	3	3.4	3	10.2	Mod	Neg	4	2	4	4	3	3.4	3	10.2	Mod
Post-Closure		Neg	4	2	4	4	3	3.4	3	10.2	Mod	Neg	4	2	4	4	3	3.4	3	10.2	Mod
Construction	Groundwater depletion – groundwater abstraction schemes for communities	Pos	Dewatering will cease post cessation of operations.																		
Operations		Pos																			
Decommissioning		Pos																			
Post-Closure		Pos																			
Construction	Groundwater quality deterioration- physical	Neg	4	1	4	4	3	3.2	3	9.6	Mod	Neg	3	1	4	4	2	2.8	3	8.4	Low
Operations		Neg	5	2	5	4	3	3.8	4	15.2	Mod	Neg	3	1	5	4	2	3	3	9	Low
Decommissioning		Neg	5	2	5	4	3	3.8	4	15.2	Mod	Neg	2	1	5	4	2	2.8	3	8.4	Low
Post-Closure		Neg	5	2	5	4	3	3.8	5	19	Mod	Neg	2	1	5	4	2	2.8	3	8.4	Low
Construction	Groundwater quality deterioration- biological	Neg	4	1	4	3	2	2.8	4	14.4	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Operations		Neg	5	2	5	4	2	3.6	4	14.4	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Decommissioning		Neg	5	2	5	4	2	3.6	4	14.4	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Post-Closure		Neg	5	2	5	4	2	3.6	5	18	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Construction	Groundwater quality deterioration- sociological	Neg	4	1	4	3	2	2.8	3	8.4	Low	Neg	3	1	3	3	2	2.4	3	7.2	Low
Operations		Neg	5	2	5	4	3	3.8	4	15.2	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Decommissioning		Neg	5	2	5	4	2	3.6	4	14.4	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low
Post-Closure		Neg	5	3	5	4	3	4	5	20	Mod	Neg	3	1	3	3	2	2.4	3	7.2	Low

4.3.1.7 Biological Environment

Calculated losses of the various mapped vegetation communities in the local study area (LSA) due to the placement of the proposed infrastructure are summarised in Table 76Table 76.

Table 76: Vegetation Communities within LSA and Loss to Proposed Infrastructure or Activities

Vegetation Type	Annex IX Article 36 Ecosystem Classification	Extent in LSA (ha)	Loss to infrastructure (ha)	% loss in LSA
Transformed – Aquaculture	n/a	1.04	-	-
Riparian Grassland/Wetland	Grassy fresh water vegetation and water plants	20.75	-	-
Dry Evergreen Forest	Closed sempervirent (evergreen) forest	18.10	1.07	5.9%
Broad-Leaved (Miombo) Woodland	Deciduous forest (Sudanese and Zambesi type)	166.01	18.60	11.2%
Broad-Leaved (Chipya) Woodland	Deciduous forest (Sudanese and Zambesi type)	76.73	28.21	36.8%
Degraded Shrubland	n/a	748.76	270.14	36.1%
Copper Grassland	Grassy formations (various savannah types	5.88	5.88	100.0%
Bare – mining activities	n/a	698.77	183.29	26.2%
Bare – roads	n/a	15.65	1.85	11.8%
Cultivated land	n/a	190.07	67.19	35.4%
Settlements	n/a	29.94	-	-

The predicted impacts to species and ecosystems include: direct loss of habitat due to land take for the KOU Project infrastructure and activities (Table 77Table 77); sensory disturbances (from noise, vibration, light, and odour); air emissions and the associated potential for pollution; and direct mortality of species of concern as a result of vehicle movements, linear infrastructure (trenches, fencing and powerlines) and site preparation.

Project components with the potential to interact with species and ecosystems of concern at all phases of the Project are listed in Sections 4.2 and 4.3.1.7.

4.3.1.7.1 Construction Phase

The activities that will result in impacts to species and ecosystems of concern include clearing of existing vegetation to make way for the expansion of waste rock dumps and opencast pits, placement of new topsoil stockpiles, construction of TSF3 on PE7274, construction of the Waste Rock Dump sediment pond, and extension of the existing security trench or construction of a security fence.

4.3.1.7.1.1 Loss of Plant Species of Conservation Importance

Plant species of conservation importance in the LSA occur on the remaining portion of Kinsevere Hill's Copper Grassland (G. *robiliartianus*, C. *peschiana*, O. *ericoides*, C. *kibweanus*), in Broad-leaved Chipya Woodland (P. *angolensis*) and in patches of Dry Evergreen Forest in the northern extent of PE 7274 (G. *erythrocarpa*).

The expansion of Kinsevere Hill Pit, approved by the DPEM in December 2017 (2017 EIS submission) will result in the loss of the remaining Copper Grassland habitat, however translocation to a protected conservation area has been successful and the remaining species that are endemic and/or considered threatened will be translocated. Please refer to Section 12, Chapter III of the 2017 ESIA for further details of this impact.

The extent of the P. *angolensis* loss is limited to the Broad-leaved Chipya Woodland in the LSA, and in the context of the RSA, a loss of 0.2% of this species is predicted.

The intensity of the *G. erythrocarpa* species loss during construction is rated as moderate (see Table 77~~Table 77~~) prior to any mitigation. The extent of the impact is limited to the LSA (1.07 ha of Dry Evergreen Forest) and in the context of the RSA (135.4 ha of Dry Evergreen Forest), a loss of 0.78% of this species is predicted. A 'minor' risk to the human population score was applied for the purposes of the impact assessment since no adverse impact on the local community or individuals is predicted. The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity of loss of plant species of concern can be reduced through implementation of effective search, rescue, and translocation programmes.

4.3.1.7.1.2 Introduction and Spread of Invasive Alien Plant Species

Transformed habitats in the vicinity of existing and active mining areas have already been colonised by invasive alien plant species, forming dense stands in some places. Vegetation clearance and construction activities in the LSA are likely to promote the spread of these species.

The intensity of the potential impacts is considered high, as the aggressive nature of the invasive species has the potential to transform indigenous habitats completely. The extent of impacts could be local along the road network within the LSA (spread by vehicles) and/or regional (spread wind and birds). The duration of the impact will be permanent, and irreversible without mitigation. Potentially affected vegetation communities, particularly Dry Evergreen Forest, which is an ecosystem of concern, are thought to be of Very High value. A low risk to local communities is predicted since although natural habitats that are currently unaffected by alien vegetation species are used for the provision of ecosystem services, most notably charcoal production, the incursion of alien vegetation is unlikely to affect the harvest of timber for charcoal or exceed the rate at which the native tree species are removed for charcoal production. The significance prior to mitigation is considered Major, but it can be reduced to Low significance through the implementation of the specified mitigation measures (Table 77~~Table 77~~).

4.3.1.7.1.3 Loss of Ecosystems of Concern

1) Dry Evergreen Forest

Vegetation clearance activities prior to the development of the proposed infrastructure will result in the loss of 1.07 ha of Dry Evergreen Forest in the LSA and in the context of the RSA (135.4 ha of Dry Evergreen Forest) a loss of 0.78% of this species is predicted.

The intensity of this loss considered moderate. The extent of the impact will be limited to the LSA and, without mitigation, the duration of the loss will be permanent. The value of the Dry Evergreen Forest is considered Very High, given that it supports the endangered plant species *G. erythrocarpa.* A minor risk to the human population score was applied for the purposes of the impact assessment since no adverse impact on the local community or individuals is predicted. The overall impact significance is considered Moderate prior to mitigation (see Table 77~~Table 77~~). The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity of the impact can be reduced through avoidance and minimisation of loss of this ecosystem.

2) Copper Grassland

The expansion of Kinsevere Hill Pit, approved by the DPEM in December 2017 (2017 EIS submission) will result in the loss of the remaining Copper Grassland habitat; however, translocation to a protected conservation area has been successful and the remaining species that are endemic and/or considered threatened will be translocated. Please refer to Section 12, Chapter III of the 2017 EIS for further details of this impact.

4.3.1.7.1.4 Loss and Fragmentation of Fauna Habitat

Most of the LSA consists of degraded habitat because of cultivation, charcoal manufacture and mining-related activities, but some tracts of broad-leaved woodland and Dry Evergreen Forest in relatively good condition remain in the northern extent of PE7274. Further loss and fragmentation of these habitats is likely impact negatively on the faunal communities currently utilising these habitats, particularly the bird assemblage associated with the Dry Evergreen Forest habitat. The extension of the security trench or erection of a fence around the perimeter of PE7274 could present a barrier to movement for some mammals that have been recorded in the LSA including Gambian Sun Squirrel, Slender Mongoose, and Scrub Hare, and reptiles including Black Mamba, Flap-necked Chameleon and Variable Skink.

Considering the amount of woodland/forest vegetation loss (5.9% of Dry Evergreen Forest and 36.8% of the Broad-Leaved Chipya Woodland in the LSA), the intensity of loss of faunal habitat within the LSA is considered High. The value of the habitat for unprotected faunal species is considered Moderate, resulting in an overall impact of Moderate significance prior to mitigation. The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity of the impact can be reduced through minimisation of loss of faunal habitat, and implementation of restoration recommendations to preserve movement corridors.

4.3.1.7.1.5 Loss and Disturbance of Fauna Species of Concern

Although no mammal species of concern have been recorded at Kinsevere since baseline studies commenced in 2006, three bat species of concern may use the woodland/forest vegetation of the LSA for foraging purposes, and there is a low likelihood of two pangolin species (P. *tricuspis* and S. *temminckii*) occurring in the remaining stands of broad-leaved woodland/Dry Evergreen Forest in the northernmost part of PE7274. The bird species of concern, namely Bateleur and Southern Ground Hornbill, may hold territories which overlap with the LSA, but there is no important breeding habitat for these species within the LSA. Nevertheless, the construction phase of the Project presents risks of loss and/or disturbance of these species.

The intensity of the predicted impact is considered Moderate, occurring at a local scale on a permanent basis. The value of the affected species of concern is considered High, but the probability of occurrence is considered Low, since these species are unlikely to occur in significant numbers within the LSA, resulting in an overall impact of Low significance prior to mitigation. The application of the required mitigation measures would further reduce the magnitude of consequences, and the impact significance remains Low.

4.3.1.7.2 Operational Phase

4.3.1.7.2.1 Smothering of Vegetation with Dust

Particulate mobilisation by vehicles and wind erosion of the TSF, could result in smothering of vegetation in a layer of dust-impairing photosynthesis, and reducing plant productivity and survival.

The intensity of the impact on affected vegetation communities in the LSA is considered moderate. The extent of the impact is limited to the LSA, and the duration of the impact will be long-term. The value of the vegetation communities most likely to be affected is rated high, as they include the ecosystem of concern Dry Evergreen Forest, as well as the Kinsevere Translocation Project where the critically endangered and endangered cuprophytic plant species will be located. A low risk to the human population score was applied for the purposes of the impact assessment since there may be adverse impacts on local communities that utilise the affected vegetation. The overall impact significance is considered Major prior to mitigation (see Table 77~~Table 77~~), as there is a risk that the Kinsevere Translocation Project, which is located adjacent to an active opencast pit, could fail as a result of excessive dust deposition.

The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity of the impact should be reduced to Minor through the application of the recommended dust control measures.

4.3.1.7.2.2 Loss and Degradation of Ecosystems of Concern

Increased human use of the land within PE7274 would result in the loss/degradation of the 17.24 ha of Dry Evergreen Forest that will remain in the LSA once construction is complete, but the extension of security measures to surround PE7274 will assist in minimising such use during the operational phase.

The intensity of the predicted impact on this ecosystem during the operational phase is considered moderate. The extent of the impact is limited to the LSA, and the duration of the effects will be permanent. The value of the Dry Evergreen Forest is considered Very High, given that it supports the endangered plant species *G. erythrocarpa.* A minor risk to the human population score was applied for the purposes of the impact assessment since no adverse impacts on the local community or individuals is predicted. The probability of the impact occurring is high, as it is uncertain how effective the perimeter security measures will be. The overall impact significance is considered Moderate prior to mitigation (see Table 77~~Table 77~~). The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity, and probability of the impact occurring can both be reduced through the successful implementation of the recommended mitigation measures.

4.3.1.7.2.3 Loss and Disturbance of Fauna Species of Concern

There is a risk of disturbance and/or loss of faunal species of concern. The intensity of the predicted impact is considered moderate, occurring at a local scale on a long-term basis. The value of the affected species of concern is considered high, but the probability of occurrence is considered low, since these species are unlikely to occur in significant numbers within the LSA, resulting in an overall impact of Low significance prior to mitigation. The application of the recommended mitigation measures would reduce the magnitude of the consequences, and the impact significance remains Low.

4.3.1.7.3 Decommissioning Phase

4.3.1.7.3.1 Introduction/Spread of Invasive Alien Plant Species

Site closure/rehabilitation activities in the LSA are likely to facilitate the spread of invasive plant species such as Mexican Sunflower (T. *diversifolia*).

The intensity of the potential impacts is considered moderate, given that the areas most likely to be affected will consist of modified habitats. The extent of impacts could be local along the road network within the LSA (spread by vehicles) and/or regional (spread wind and birds). The duration of the impact is considered permanent, and irreversible without mitigation.

Potentially affected vegetation communities, particularly Dry Evergreen Forest, are considered very high value. A low risk to local communities is predicted since although woodland and forest habitats are used for the provision of ecosystem services, most notably charcoal production, the incursion of alien vegetation is unlikely to affect the harvest of timber for charcoal or exceed the rate at which the native tree species are removed for charcoal production. The impact significance prior to mitigation is considered Moderate, but it can be reduced to Low significance with the implementation of the specified mitigation measures (Table 77~~Table 77~~).

4.3.1.7.3.2 Loss of Plant Species of Conservation Importance

The decommissioning of the Kinsevere mining operation will ultimately end in site closure and withdrawal of Kinsevere from the site. Without proper stewardship, the future viability of the translocated cupriferous grasslands and threatened species at the Kinsevere Translocation Project is uncertain, as is the conservation of the Dry Evergreen Forest and associated *G. erythrocarpa*.

The intensity of the potential impacts could be very high, given that the critically endangered and endangered flora species of concern could be lost. The extent of the impact must be considered at the international scale, and the duration of the loss would be permanent. The value of the affected plant species of concern is Very High, as they are highly endemic and threatened at the global scale (IUCN, 2018). A 'minor' risk to the human population score was applied for the purposes of the impact assessment since no adverse impacts on the local community or individuals is predicted. The probability of the impact occurring as predicted is ranked as medium, resulting in a Moderate overall impact prior to mitigation (see Table 77Table 77).

The successful implementation of the required mitigation measures will need to be confirmed to reduce the intensity of potential impacts, and the probability of occurrence, which could result in an overall impact of Low significance.

4.3.1.7.3.3 Smothering of Vegetation with Dust

Particulate mobilisation by vehicles during rehabilitation activities could result in smothering of vegetation in a layer of dust, impairing photosynthesis and reducing plant productivity and survival.

The intensity of the impact on affected vegetation communities in the LSA is considered moderate. The extent of the impact is limited to the LSA, and the duration of the impact will be short-term. The value of the vegetation communities most likely to be affected is rated high, as they include Dry Evergreen Forest, as well as the Kinsevere Translocation Project where the critically endangered and endangered cuprophytic plant species will be located. A low 'risk to the human population' score was applied for the purposes of the impact assessment. The overall impact significance is considered Moderate prior to mitigation (see Table 77Table 77). The residual impact significance after successful implementation of the specified mitigation measures is Low, as the intensity of the impact should be reduced to minor, and the probability of occurrence reduced to low, through the application of the recommended dust control measures.

Impacts are re-rated following mitigation to determine residual impacts.

Table 77: Ecological Impact Assessment

Phase/Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Loss of plant species of concern – G. erythrocarpa.	Neg	3	1	5	5	1	3	5	15	Mod	Neg	2	1	5	5	1	2.8	3	8.4	Low
Decommissioning		Neg	5	5	5	5	1	4.2	3	12.6	Mod	Neg	1	1	5	5	1	2.6	2	5.2	Low
Construction	Introduction/spread of invasive alien plant species	Neg	4	2	5	5	2	3.6	5	18	Maj	Neg	3	1	4	5	2	3	3	9	Low
Decommissioning		Neg	3	2	5	5	2	3.4	4	13.6	Mod	Neg	2	1	2	4	1	2	3	6	Low
Construction	Loss of and degradation of ecosystems of concern - Dry Evergreen Forest	Neg	3	1	5	5	1	3	5	15	Mod	Neg	2	1	4	5	1	2.6	3	7.8	Low
Operation		Neg	3	2	5	5	1	3.2	4	12.8	Mod	Neg	2	2	5	5	1	3	3	9	Low
Construction	Loss and fragmentation of fauna habitat (loss to infrastructure)	Neg	3	1	4	3	1	2.4	5	12	Mod	Neg	3	2	4	3	1	2.6	3	7.8	Low
Construction	Loss/disturbance of fauna species of concern	Neg	3	2	5	4	1	3	2	6	Low	Neg	1	2	4	4	1	2.4	1	2.4	Non
Construction	Smothering of vegetation with dust	Neg	3	1	4	4	1	2.6	2	5.2	Low	Neg	2	1	4	4	1	2.4	1	2.4	Non
Operation		Neg	3	2	4	5	2	3.2	5	16	Maj	Neg	1	1	4	5	1	2.4	2	4.8	Low
Decommissioning		Neg	3	2	2	5	3	3	4	12	Mod	Neg	1	1	2	5	2	2.2	2	4.4	Low

4.3.1.8 Socio-economics

The identified socio-economic impacts associated with the proposed KOU during the construction, operation and closure phases are as described below.

4.3.1.8.1 Construction Phase

The expected construction phase impacts include:

- Two positive impacts, namely limited employment opportunities and increased cash injection into the local economy in the form of remuneration and the purchase of goods and services. The farmers on PE7274 did not indicate much interest in mining-related employment, but the construction phase might represent employment opportunities for the youth, who face a high level of unemployment, many of whom do not view farming as a desirable career. Considering the criteria for employment in heavy industrial construction, the local youth are likely to qualify for low-skilled short-term jobs only; and
- One negative impact, namely physical and economic displacement of the people currently farming on PE7274.

4.3.1.8.2 Operational Phase

The KEP Project will extend the life of the mine from approximately 2023 to 2030 and result in the following expected operational phase impacts:

- Three positive impacts, namely job preservation/creation, community development and economic development:
  - The KOU Project may create some new jobs, the number yet to be established;
  - The social development projects described in Section 8.2 will receive continued support from the mine, which will enhance the probability of them maturing and becoming sustainable;
  - There will be continued cash injection into the local and regional economies in the form of employees' remuneration and the purchase of local and regional goods and services;
  - Contributions to the national economy *via* the payment of royalties and taxes will continue; and
  - Foreign exchange earnings for the DRC will continue.
- Permanent loss of about 79.7 ha of agricultural land associated with the footprints of TSF 3 and at least temporary loss of a further 47.5 ha of land covered by new stockpiles and/or waste rock dumps on PE7274, which will impact negatively on:
  - The livelihoods of the PE7274 farmers;
  - Local food production; and
  - Food supply at the local and Lubumbashi markets.

4.3.1.8.3 Decommissioning and Closure Phase

The expected decommissioning and closure phase impacts include:

- Two positive impacts, namely:
  - The potential for short-term employment opportunities during rehabilitation activities; and
  - Resumption of farming on PE7274. Although 79.7 ha of agricultural land will be permanently sterilised by the TSF3 footprint, the use of the stockpiles/waste rock dumps for landscaping and/or backfill of the opencast voids could free up 47.5 ha of land in addition to the remaining unaffected 502.5 ha of land on PE7274 that would become accessible again after the removal of the security trench or fence.
- Two negative impacts, namely loss of employment when the mining operations cease and again when the rehabilitation work has been completed, and cessation of the national, regional and local socio-economic benefits listed in Section 4.3.1.8.

A summary of impacts before and after mitigation is presented in Table 78~~Table 78~~.

Table 78: Socio-economic Impact Assessment

Phase/Timing	Impact Summary	Impact Characterisation (without mitigation)										Impact Characterisation (with mitigation in place)									
		Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (Magnitude x Likelihood)	Overall Impact Risk Score	Direction	Intensity	Extent	Duration	Value of Affected Component	Risk to Human Population	Magnitude of Consequence	Probability of Occurrence	Overall Risk (magnitude x Likelihood)	Overall Impact Risk Score
Construction	Employment opportunities	Pos	3	3	2	2	1	2.2	4	8.8	Low	Pos	3	5	2	3	1	2.8	4	11.2	Mod
	Increased economic revenue	Pos	3	4	2	3	1	2.6	3	7.8	Low	Pos	3	5	2	4	1	3	4	12	Mod
	Physical and economic displacement	Neg	5	2	5	5	5	4.4	5	22	Sev	Neg	3	2	5	3	2	3	4	12	Mod
	Risk to community health and safety	Neg	4	5	2	3	3	3.4	4	13.6	Mod	Neg	3	2	2	2	2	2.2	3	6.6	Low
Operation	Job creation	Pos	2	4	3	2	1	2.4	3	7.2	Low	Pos	3	5	3	3	1	3	4	12	Mod
	Community development	Pos	3	1	3	3	1	2.2	3	6.6	Low	Pos	4	2	3	4	1	2.8	4	11.2	Mod
	Economic development	Pos	3	3	3	3	1	2.6	4	10.4	Mod	Pos	4	4	3	4	1	3.2	5	16	Mod
	Loss of agricultural land	Neg	5	2	5	5	5	4.4	5	22	Sev	Neg	4	1	5	4	4	3.4	4	13.6	Mod
	Population influx	Neg	3	5	3	3	3	3.4	3	10.2	Mod	Neg	3	4	3	2	2	2.8	3	8.4	Low
Decommissioning/Post Closure	Temporary employment	Pos	2	4	2	3	1	2.4	3	7.2	Low	Pos	3	5	2	3	1	2.8	4	11.2	Mod
	Land rehabilitation	Pos	3	3	5	3	1	3	3	9	Low	Pos	4	4	5	4	1	3.8	5	15.2	Mod
	Transfer of onsite infrastructure	Pos	3	2	5	3	2	3	3	9	Low	Pos	3	4	5	4	1	3.4	4	13.6	Mod
	Risk to community health and safety	Neg	4	2	3	4	4	3.4	5	17	Major	Neg	3	3	5	3	1	3	3	9	Mod
	Loss of employment	Neg	4	4	5	4	4	4.2	5	21	Sev	Neg	3	3	5	4	4	3.8	5	19	Major
	Reduced economic contributions	Neg	4	4	5	4	2	3.8	5	19	Major	Neg	3	3	5	3	2	2.6	4	12.8	Mod
	Reduced community investment	Neg	5	2	5	5	5	4.4	5	22	Sev	Neg	3	2	5	2	1	1.6	3	7.8	Low

5.0 TITLE V: PROGRAM OF MITIGATION AND REHABILITATION MEASURES

5.1 CHAPTER I: PRESENTATION OF THE PROGRAM OF MITIGATION AND REHABILITATION MEASURES

5.1.1 Obligation to present a Program of Mitigation and Rehabilitation Measures (Article 43)

The mitigation and rehabilitation measures to reduce or eliminate any negative impacts of the KOU Project on the environment as per Articles 39 to 42 of Annex VIII to the 2018 DRC Mining Code are described in the sections below. Where possible, alternative measures are also described.

The Environmental Management Plan, which details the implementation and monitoring of the mitigation and rehabilitation measures and the cost of rehabilitation, is also described in this section. The residual negative impacts after applying the mitigation and rehabilitation measures are also described.

5.1.2 Mitigation and Rehabilitation Measures (Article 44)

Explanations of how the proposed mitigation and rehabilitation measures will effectively reduce the negative impact of the project to below the environmental protection thresholds stipulated in the DRC legislation are also described in the sections below.

5.2 CHAPTER II: MITIGATION MEASURES RELATING TO NOISE AND VIBRATION

5.2.1 Mitigation Measures Relating to Noise (Article 45)

The predicted noise impacts at sensitive receptors are described in Section 4.3.1.1. It is expected that residents in the village of Kalianda may experience low levels of intrusive noise from operational phase activities at Mashi pit during the night-time. At all other sensitive receptors, the intrusive noise levels will be either inaudible or very low, for all activities, regardless of which phase is being considered.

The allowable noise limits are shown in Table 79~~Table 79~~.

Table 79: Noise Limits

Category of Land	Day dB(A) (7am – 7pm)	Night dB(A) (7am – 7pm)
Class A: Residential	40	45
Class B: Commercial	50	55
Class C: Industrial	70	70

The following mitigation measures are recommended:

- Avoidance/Prevention:
  - Personnel working in areas where the noise level exceeds 85.0 dBA are required to wear hearing protection.
- Reduction:
  - Noise generated by any mining activity may not exceed the noise limits as shown in Table 79~~Table 79~~.
  - If environmental noise levels increase, the noise levels at the receptor points shown on Figure 53~~Figure 53~~ should be measured monthly until:
    - Measured noise levels are within the noise limits; or

  - MMG Kinsevere mine investigates unacceptable noise levels and implements appropriate mitigation measures such as acoustic screening, change of equipment or change of roads, where practical. Once acceptable noise levels have been achieved, the frequency of measurement can be reduced to biannually or annually, but all complaints should be investigated.

- Blasting to be done during daytime periods only, applying 500 m blasting zone limits;
- Earthmoving machinery and hauling vehicles to comply with the manufacturers' recommended operating conditions;
- Annual review of effectiveness of noise mitigation and blasting procedures; and
- Update Noise and Vibration Management Plan to reflect changes in project design and management measures.

5.2.2 Continuous Noise (Article 46)

The processing plant components described in Sections 2.2.2 and 2.4 and the activities at the new tailings storage facility, TSF3, as described in Section 2.10.3, will constitute relatively constant fixed noise sources during the remaining life of the mine, until about 2030.

The activities associated with mining will vary over the remaining life of the mine, but the contribution of activities undertaken in the open pits to the noise levels experienced at the sensitive receptor points will decrease as the depth of mining increases.

The intrusive noise levels at the sensitive receptor points reflect the expected levels during the early years of the KOU project and the contribution from activities in the pits will decrease over time.

The contribution from the haulage and deposition of ore and waste rock to noise levels experienced at individual receptor points will vary with changes in the timing and quantities of materials hauled from each of the pits.

5.2.3 Land Categories (Article 47)

The current mining and ore processing activities take place on tenement PE528, i.e. the land can be categorised as industrial. The village of Mpundu is located on tenement PE528, near the northern perimeter, but not within the security perimeter – see

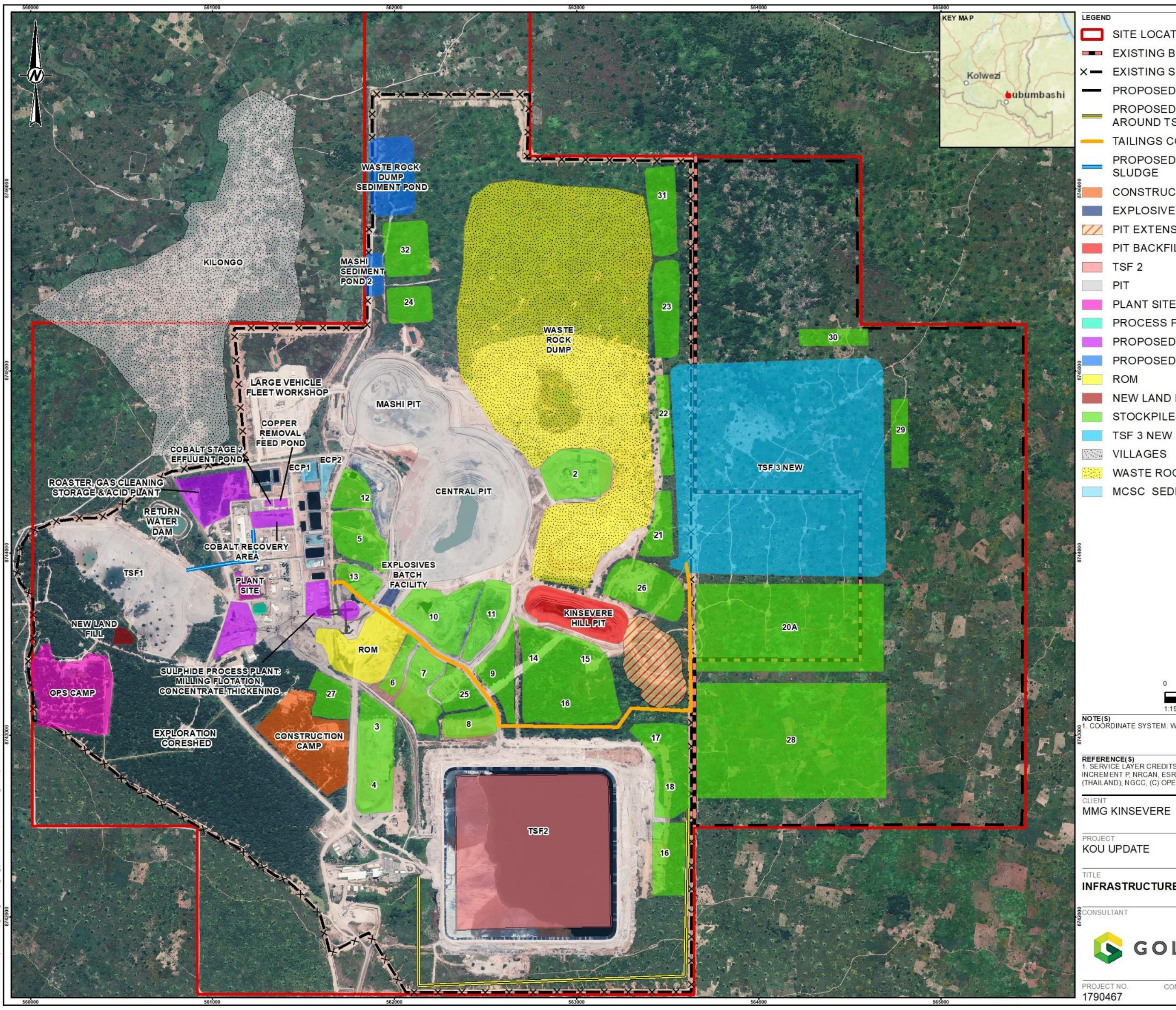

Figure 2~~Figure 2~~. There are no villages on tenement PE7274. The land is used for farming, hunting and charcoal production. The farmers have erected structures which they occupy during the planting and harvesting seasons, but they will no longer have access to their farms once the mine commences with the planned activities on PE7274. Sensitive receptors are indicated on Figure 53~~Figure 53~~.

5.2.4 Vibrations and Noise during Blasting (Article 48)

The expected ground vibration and air blast effects are described in Section 4.3.1.2. Low vibration levels are predicted at all sensitive receptor locations, except Kalianda and Kilongo, where residents could experience moderate vibration levels at charge weights exceeding 300 kg per delay period when blasting takes place in Central and Mashi pits.

Low air blast effects are predicted at all sensitive receptor locations, except Kalianda and Kilongo, where residents could experience moderate air blast effects at charge weights exceeding 300 kg per delay period when blasting is undertaken in Mashi Pit.

The following mitigation measures should be applied to maintain acceptable vibration and air blast impacts at all sensitive receptors:

- Ground vibration and air blast monitoring should be done as necessary, especially after receiving complaints. If the air blast level exceeds 120 dB(L) or the ground vibration level exceeds 12.5 mm/second, reduce charge weight in subsequent blasts, when possible;
- Blasting should be done during daytime periods only, and by using safe blasting techniques;
- The maximum instantaneous charge (MIC) weight should not exceed 300 kg when blasting in Mashi and Central pits until actual measurements have demonstrated that acceptable vibration and air blast levels are achieved at all receptors at higher MIC weights;
- When conducting monitoring of compliance requirements for air blast overpressure and ground vibration (including when investigating community complaints about noise or vibration impacts), the following information should be collected and documented:
  - Maximum instantaneous charge (MIC) weight in kilograms (kg);
  - Location of the blast at the open cast pit, including the bench level;
  - Air blast overpressure level (LdB);
  - Peak particle velocity (mm/s);
  - Location, date and time of measurement;
  - Meteorological conditions such as temperature, relative humidity, temperature gradient, cloud cover, wind speed and wind direction; and
  - Distance from the blast location to the measuring point.
- Monitoring must be done with calibrated Class 1 type instruments and in accordance with approved monitoring methods;
- Environmental auditing to verify contractor compliance with regulated environmental noise and vibration levels;
- The operators who will be doing the monitoring must be properly trained; and
- Records must be kept for at least five years before such information is discarded.

5.3 CHAPTER III: MITIGATION MEASURES FOR ATMOSPHERIC EMISSIONS

5.3.1 Content of the Mitigation Measures for Atmospheric Emissions (Article 49)

The key objective of the air quality management plan is to avoid, prevent or reduce harmful impacts on human health and the environment by the application of suitable mitigation measures to avoid exceedances of the allowable concentrations of air pollutants in terms of DRC legislation and guidelines – see Table 64~~Table 64~~ and Table 80~~Table 80~~.

The following processes were identified as significant sources of air pollutants that must be properly managed:

- Drilling and blasting;
- Loading, hauling and deposition of ore and waste rock;
- Materials transfer;
- Crushing and screening;
- Tailings storage facilities, waste rock dumps and stockpiles of topsoil and subsoil;
- Exhaust emissions from vehicles;
- Backup power generation;
- Wind erosion of bare surfaces; and
- Stack emissions from the roaster and sulphuric acid plant.

  The roaster off-gas will pass through a series of cyclones, venturi scrubbers and electrostatic precipitators to remove 99% of the PM_{10} before it enters the sulphuric acid plant. The captured particulates will be reintroduced into the SX circuit to maximise copper recovery and minimise waste disposal.

  Ninety-nine percent of the SO_2 in the roaster off-gas will be captured and converted to SO_3 before being hydrated to produce H_2SO_4 in the acid plant. This H_2SO_4 will used as a reagent in the leaching tanks.

  The off-gas will be released via a stack downstream of the sulphuric acid plant. The average flow rate through the emissions stack will be 92 715 m^3/h at a temperature of 80^oC (or 62 777 Nm^3/h). The expected contaminant concentrations and quantities are:

  - PM_{10}: 27 tons/year, concentration 50 mg/ Nm^3;
  - SO_2: 660 tons/year, concentration 1 200 mg/ Nm^3; and
  - NO_2: 154 tons/year, concentration 280 mg/ Nm^3.

Roaster start-up will involve the use of diesel burners to bring the fluidised bed up to operating temperature. To avoid poisoning of the catalyst in the sulphuric acid plant, the combustion gases will be diverted away from the acid plant and released via a small, separate stack. The operational availability of the roaster will be in excess of 90%, i.e. the diesel burners will seldom be used, and then for short periods only. Their contribution to the average ambient air quality will be negligible.

The proposed air quality mitigation measures are as follows:

- Avoidance/Prevention:
  - Keeping stockpile heights as low as practicable to reduce their exposure to wind erosion and thus dust generation;

- Progressive rehabilitation and revegetation of areas when they become operationally available; and
- Minimise burning of waste.

■ Reduction:

- Wet suppression or wet misting during materials handling activities, where practical;
- Routine inspections to identify areas of unpaved roads that are increasingly dusty. Maintenance work to be undertaken on these areas including watering, application of dust suppressants, compaction, dust removal and/or utilisation of soil aggregate;
- Implementation of a Traffic Management Plan, including setting speed limits and the institution of traffic calming measures where practical;
- Maintain and service internal combustion engines on all mining vehicles and other equipment regularly to ensure that tailpipe emissions are kept to a minimum;
- Regular monitoring of trace gas emissions and air quality, and maintenance of the acid plant and gas cleaning system, which is expected to remove 99% of the PM_{10} and SO_2 emissions; and
- Use demister balls in the electrowinning plant.

The air quality monitoring program is described in Sections 5.3 and 5.8.1, and further detailed in MMG Kinsevere's existing Air Quality, Noise and Vibration Management Plan.

5.3.2 Tolerated Air Pollution Thresholds (Article 50)

The thresholds for air pollution within and outside the perimeter are indicated in Table 80Table 80.

Table 80: Air Pollution Thresholds Within and Outside the Perimeter

Type of Contaminant	Pollution Thresholds
Within Perimeter – occupational health	
Arsenic	0.5 mg/m³
Carbon monoxide	29 mg/m³
Copper	1 mg/m³
Free silica	5.0 mg/m³
Hydrogen cyanide	11 mg/m³
Hydrogen sulphide	14 mg/m³
Lead: emissions and smoke	0.15 mg/m³
Nitrogen dioxide	6 mg/m³
Solid particles	10 mg/m³
Sulphur dioxide	5 mg/m³
Outside Perimeter – ambient air quality	
Particles of matter (<10:m): Annual arithmetic mean Maximum mean over 24 hours	 100 µg/m³ 500 µg/m³
Nitrogen oxide as NO_2: Annual arithmetic mean Maximum mean over 24 hours	 100 µg/m³ 200 µg/m³
Sulphur dioxide: Annual arithmetic mean Maximum mean over 24 hours	 100 µg/m³ 500 µg/m³

5.3.3 Installation of Air Pollution Control Devices (Article 51)

The fluidised bed roaster/wet sulphuric acid plant complex will be fitted with off-gas cyclones, a venturi scrubber and wet electrostatic precipitators, which are expected to capture 99% of of the PM_{10} particulate emissions indicated in Section 5.3.1 and Table 66Table 66, and recycle them back into the process. The acid plant will also remove an estimated 99% of the SO_2 emissions indicated in Section 5.3.1 and Table 69Table 69.

5.3.4 Pollution Tests (Article 52)

As required, Kinsevere mine carries out air pollution tests as follows to determine the levels of the contaminants listed in Table 64Table 64:

- The tests are undertaken inside and outside of the tenement perimeter in January, March, July and October;
- Test locations outside the perimeter are 5 m away from the boundary on the northern, southern, eastern and western sides of the tenement; and
- The testing methods used, the results of the tests and any corrective measures to be taken are recorded in a register.

5.4 CHAPTER IV: MITIGATION MEASURES FOR WATER DEGRADATION AND POLLUTION RISKS

5.4.1 Section I: Water Protection Measures

5.4.1.1 Description of Measures to Mitigate Water Degradation and Pollution Risks (Article 53)

As described in Section 3.2.2 and illustrated in Figure 45~~Figure 45~~, the existing water management system at Kinsevere mine has been designed to keep acidic water, sediment water and clean, non-contact water separate and to ensure zero discharge of contact water from the plant area.

5.4.1.1.1 Surface Water

The following measures will be implemented to minimise the risk of water exceeding the discharge limits listed in Table 83~~Table 83~~ entering the Kifumashi River from tenements PE528 and PE7274:

- Avoidance/Prevention:
  - Dewatering cannot be avoided, as mining would cease if dewatering does not occur. Ongoing measurement of dewatering volumes must take place and borehole levels must be monitored and recorded weekly;
  - Ensure safety of communities by undertaking adequate community engagement to make communities aware of the dangers of the open pits;
  - Ensure that discharge is done within DRC legislative limits;
  - Store containers of chemicals, fuel and oil in well bunded areas;
  - Ongoing monitoring of water quality and flow to enable timeous intervention;
  - Lining of ponds containing contaminated water;
  - Inspect integrity of pollution containment structures and barriers regularly and maintain in good condition;
  - Clean up spillages immediately, remove and dispose of contaminated soil, or remediate in situ;
  - Store PAF material on a liner or NAF base layer, encapsulate in designed cells within the WRD surrounded by NAF material or use as compacted backfill in Kinsevere Hill pit between NAF material.;
  - Proper operation and maintenance (as required) of the TSF3 underdrainage system;
  - Maintenance of the water balance to ensure adequate recycle for reuse in the plant;
  - Upgrade of Mashi Pit Sediment Pond 1 to accept additional flows;
  - Review the requirement for the Waste Rock Dump Sediment Pond and construct as needed;
  - Operation of sediment ponds to ensure adequate capacity;
  - Proper disposal of any remaining chemicals at closure; and
  - Undertake contaminated land assessment during decommissioning and closure phase, remove and dispose of contaminated soils, or remediate in situ.

- Reduction:
  - Design the pits so that minimal water enters, and that clean water is diverted away from the pit area;
  - Well-designed storm water management in place to prevent contaminated run-off reaching clean areas/clean storm water system;
  - Maintain minimum freeboard in pollution control ponds at 1 m, 1.5 m if there are sensitive areas down-gradient;
  - Regular monitoring of pond levels;
  - Vegetation clearing will be minimised to limit erosion from the site;
  - Berms and sediment traps will be constructed to collect sediment;
  - Water quality monitoring and treatment as necessary prior to discharge if not compliant with DRC limits; and
  - Pumping of accumulated sediment laden water from the trench to a sediment pond on site. This will allow sediment to drop out in a controlled manner and water can then be discharged directly to Kifumashi River.
- Rehabilitation:
  - Groundwater levels will rebound, the pits will be allowed to fill up and groundwater levels will return to normal over time;
  - Create a final landform that meets all legislative requirements, is physically stable and does not contaminate the surrounding environment;
  - Keep adequate spill kits on site for immediate clean-up of any spills;
  - Remediation and rehabilitation of all chemical storage areas during decommissioning and closure phase;
  - Monitoring of surface water and groundwater quality to detect any contamination from the mine area and implement remediation actions timeously;
  - Rehabilitation of areas that may have been contaminated due to overflows from ponds;
  - During decommissioning and closure phase, rehabilitate ponds that may have been contaminated;
  - Any ARD arising from the waste rock dump will be managed prior to revegetation;
  - Identify and encapsulate any PAF material;
  - Rehabilitate stockpile areas during decommissioning and closure phase;
  - The post closure land-use objective for the TSFs (2 and 3) is to establish vegetation and to restrict access for agriculture, brick making or habitation because of the risk of soil erosion;
  - Monitoring of the quality of any water that is not recycled for processing until it can be shown to be suitable for release to the environment;
  - Decommissioning of Kinsevere Hill sediment ponds and rehabilitation of areas as necessary;
  - Backfilling and stabilising the security trench; and
  - Revegetating the affected areas to protect them from erosion.

5.4.1.1.2 Groundwater

The following measures will be implemented to monitor and minimise impacts on the local groundwater regime:

- Avoidance/Prevention:
  - Dewatering cannot be avoided, as mining would cease if dewatering does not occur. Ongoing measurement of dewatering volumes must take place and borehole levels must be monitored and recorded weekly;
  - Undertake Karst Risk Study where appropriate, avoid placement of mine infrastructure on high risk lithology and zones;
  - Identify high risk zones where possible or undertake detailed assessments;
  - Minimise dewatering requirements, develop understanding of dewatering impacts;
  - Store PAF material on a liner or NAF base layer, encapsulate in designed cells within the WRD surrounded by NAF material or use as compacted backfill in Kinsevere Hill pit between NAF material.;
  - TSF3 to be constructed with a clay and HDPE liner; and
  - Operate separate contact and non-contact water systems.
- Reduction:
  - Minimise potential for ingress of potentially contaminated water from pit floor into groundwater by placing berms to prevent contaminated runoff from entering the pits and maintain groundwater level below pit floor by dewatering appropriately;
  - Build infrastructure that cannot avoid high risk zones in such a way that it can withstand subsidence;
  - Build according to karst zone building recommendations;
  - Water quality monitoring and mitigation as necessary if not compliant with DRC legislation;
  - Water quality monitoring and treatment before discharge as necessary if not compliant with DRC limits;
  - Discharge clean water to specific locations to protect biosphere and provide for social needs. If water quality monitoring indicates the ecosystem has been impacted, MMG will develop and implement plans to rehabilitate ecosystems;
  - Monitor groundwater levels to determine any potential impacts on community water supplies from dewatering activities. If groundwater table drawdown has a measurable impact on the availability of community water supplies, suitable mitigation actions will be discussed with those communities; and
  - MMG has commissioned a number of community wells as a social development initiative; water quality is tested on a monthly basis and water levels are measured during maintenance activities. New wells have and will be drilled where the existing ones being used by the community have run dry or are deemed unhealthy. MMG has and will take remedial action on the back of poor water quality results.
- Rehabilitation:
  - Pits will fill up and groundwater levels will return to normal or near normal levels over time (up to 50 years), pit lakes will form and will be allowed to fill up;

- Create a final landform that meets all legislative requirements, is physically stable and does not contaminate the surrounding environment;
- Repair sinkholes where possible after formation;
- Rehabilitate by reintroduction of suitable species under the guidance of a rehabilitation botanist; and
- Water supply boreholes provided by the mine for domestic use will be left in place for community use after mine closure.

5.4.1.2 Water Management System (Article 54)

The Articles in Annex VIII to the DRC Mining Code 2018 that are relevant to Kinsevere mine's surface water management system are summarised in Table 81~~Table 81~~.

Table 81: Articles in DRC Mining Regulations Relevant to Surface Water Management

Item	Topic	Notes
Article 19	Wastewater/used water	Assessment of water used and discharged in m^3/day and per annum in respect to mining operations. Reduction of the total use of fresh water
Article 20	Infrastructure and development	Describe in detail surface structures such as pits, process plants, tailings, pipelines and, drainage
Article 53	Description of mitigation measures in respect of pollution and deterioration of water	Description of mitigation measures in respect of pollution and deterioration of water
Article 54	Water Management System	Establish a water management system to maintain and protect the quality of water until completion of the mining operations
Article 55	Separation of Waste Water or Contaminated Water	Provide drainage system for waste water to be captured and treated prior to release and allow non-contaminated water to release into the environment. It is forbidden to mix waste water from mining with other water. Water from the plant shall be captured and recycled
Article 57	Optimum Reduction of the Use of Fresh Water	Re-use waste water as water supply or reduce need for water in certain processes
Article 66	Maximum Concentration of Contaminants in Water	Provides maximum concentrations of contaminants in water at point of discharge. Specifically of note is pH between 6 and 9 with TSS less than 100 mg/Litre
Article 68	Contents of the Water Management Plan	A water management plan consisting of the hydrological system, catchment delineation, drainage, sediment ponds, typical flows, water balance and treatment systems
Article 69	Description of the Measures for the Monitoring of the Quality of Water	Operating manual for both operation and closure in respect of the quality of surface water
Article 70	Contents of the Program in respect of the Frequency and Quality Control of Water	The operator to set up a monitoring network following rehabilitation
Article 72	Recordings Measurement System of pH and Flow/ Discharge Rate	The operator to set up a sampling and measurement system to record water just upstream of the point of discharge

Item	Topic	Notes
Article 73	Frequency and Sampling Methods at the Final Effluent	The operator to report annually a summary of all test results recorded based on the provided frequency
Article 74	Regularisation of the Flow/ Discharge Rate of the Final Effluent	To discharge as a uniform flow as possible throughout the year
Article 82	Building Water Retention Structures	Constructed with good engineering practice with minimum freeboard of 1 m or 1.5 m if the downstream environment is sensitive to spill overflow. The freeboard must be permanently integrated into the structure by using a visible ruler. If the structure contains acid/highly hazardous, the freeboard must take into account a design flood of a return period of 1 000 years or 100 years for all others. The design flood shall be based on a 6 or 24 hour event, whichever is more critical
Article 83	Inspection of the Stability of the Structures	The operator must make at least one inspection per season or after exceptional climatic events and register the outcomes of the visits and corrective measures
Article 111	Measures in respect of Mine Drainage Water Basins/Ponds	In general, unless demonstrated otherwise, basin/ponds must be rehabilitated at closure by sludge removal, breaching of the wall and re-vegetation
Article 115	Measures in respect of Mine Waste/Tailings Sites (Ponds) and Settling Basins	Structures should no deteriorate, erode or subside due to natural conditions
Article 118	Measures in respect of Water Collection Structures	Discharge by culverts or spillways are recommended while decant towers shall not be acceptable unless justified

In summary, the design objectives for the Kinsevere Surface Water Management System (SWMS) are:

- Utilise or upgrade existing systems where possible;
- Keep contact and non-contact separate as far as possible;
- Contain contact water to be used within the system or treated and released;
- Prevent the pollution of water resources;
- Reduce environmental impact with rapid and effective rehabilitation; and
- Provide ease of operation.

The water management processes associated with the main areas of the mine are summarised in Table 82: Summary of Specific Water Management per AreaTable 82: Summary of Specific Water Management per Area.

Table 82: Summary of Specific Water Management per Area

Mine Area	Brief Description	Surface Water Management Facilities
Oxide Process Plant	Accepts ore of nominal moisture content from the pit and uses a mix of raw and recycled water, with a minimum quantity of clean raw water required. Tailings are pumped to TSF2. To prevent discharge of acidic water, the plant accepts rainfall runoff water from both Blackshale North and Blackshale South, as well as ECP1. A series of process liquor solution ponds are located around the plant that both capture rainfall and evaporate water. Decant is returned from TSF2. If necessary, a final makeup quantity is sourced from pit dewatering (via the Raw Water Pond).	■ ECP1; ■ ECP 2; ■ Raw Water Pond; ■ Blackshale Ponds; and ■ Series of other process liquor solution ponds.
TSF2	Approximately 90 ha, 4-sided paddock facility located to the south-east of the Oxide Process Plant. No external catchment other than the embankment crest reports to the facility, which is HDPE lined due to the acidic process water. The supernatant pond is in the north-western corner. Decant is returned to the process plant via a series of ponds and tanks.	■ ECP1; ■ ECP 2; and ■ Series of process liquor solution ponds.
TSF3 (proposed)	Proposed new TSF (lined) to the east of the current site and located partly on tenement PE 7274.	■ Process/plant ponds.
TSF1	Overflow water from TSF1 (no longer operational) is collected in the Return Water Dam (RWD) to settle out the suspended solids, from where it is discharged to the Kifumashi River via Mashi Sediment Pond 2.	■ Return Water Dam; and ■ Mashi Sediment Pond 2.
Pits	Pit water from Mashi Pit and Central Pit (and in future Kinsevere Pit) is pumped to Mashi Sediment Pond 2, to settle out the suspended solids before being released to the Kifumashi River.	■ Process ponds; and ■ Sedimentation ponds (See Section 5.4.3.2).
	Water pumped from the dewatering boreholes is discharged directly to the Kifumashi River or used within the process plant (Sections 2.3, 2.5 and 2.6).	■ Dewatering boreholes; and ■ Raw Water Pond.

Figure 72: Example of Sediment Ponds

5.4.1.3 Destination of Waste Water, Mining Waste and Other Contaminants (Article 55)

Mining waste materials are disposed of in WRDs and TSFs – see Sections 2.9 and 2.10. Runoff from the NAF WRDs will be recycled or discharged via sediment ponds, and runoff from PAF material and plant areas will be recycled or impounded in environmental control ponds – see Sections 2.3 and 2.6. Any industrial, office and domestic waste that cannot be sold or recycled, will be disposed of in the new landfill – see Section 2.5.1.

Water is pumped out of the pit sumps into sedimentation ponds and dosed with lime to remove metals if required. The water quality is monitored and discharged when it meets the legislated standards. Water in excess of process requirements is discharged to the Kifumashi River as described in Sections 2.3, 2.5, and 2.6.

5.4.1.4 Separation of Waste or Contaminated Water (Article 56)

The Kinsevere mine's water management system has been designed and is operated to prevent the release of contaminated water and contact between contaminated water and clean water – see Section 5.4.3.2.

5.4.1.5 Maximum Reduction in the Use of Fresh Water (Article 57)

No water is abstracted from the Kifumashi River or any other natural surface water resource. As described in Sections 2.3, 2.5 and 2.6, water from dewatering boreholes in excess of that required as makeup water, is discharged into the Kifumashi River directly. As described in Section 2.6.4 process water is sourced from pit dewatering, internally circulated water, and makeup water from the raw water dam.

Sediment-containing runoff from the mining lease area that is otherwise clean and not used in the process, is naturally released to the environment.

To prevent discharge of acidic water, the plant accepts rainfall runoff water from both Blackshale Ponds and ECP1. A series of process liquor solution ponds are located around the plant that both capture rainfall and evaporate water. Decant is returned from TSF2. If necessary, a final makeup quantity is sourced from pit dewatering (via the Raw Water Pond).

In line with Article 19 of Schedule VIII of the Mining Code, all supernatant resulting from tailings discharged to the TSF2 is recycled directly back into the processing plant via a small holding pond. The same approach will be implemented for TSF3, but with a process water tank.

5.4.1.6 Protection of Underground Water (Article 58)

The new tailings storage facility (TSF3) will be constructed as a standalone paddock style facility with a HDPE liner on top of a compacted clay layer, and an underdrainage system. Refer to

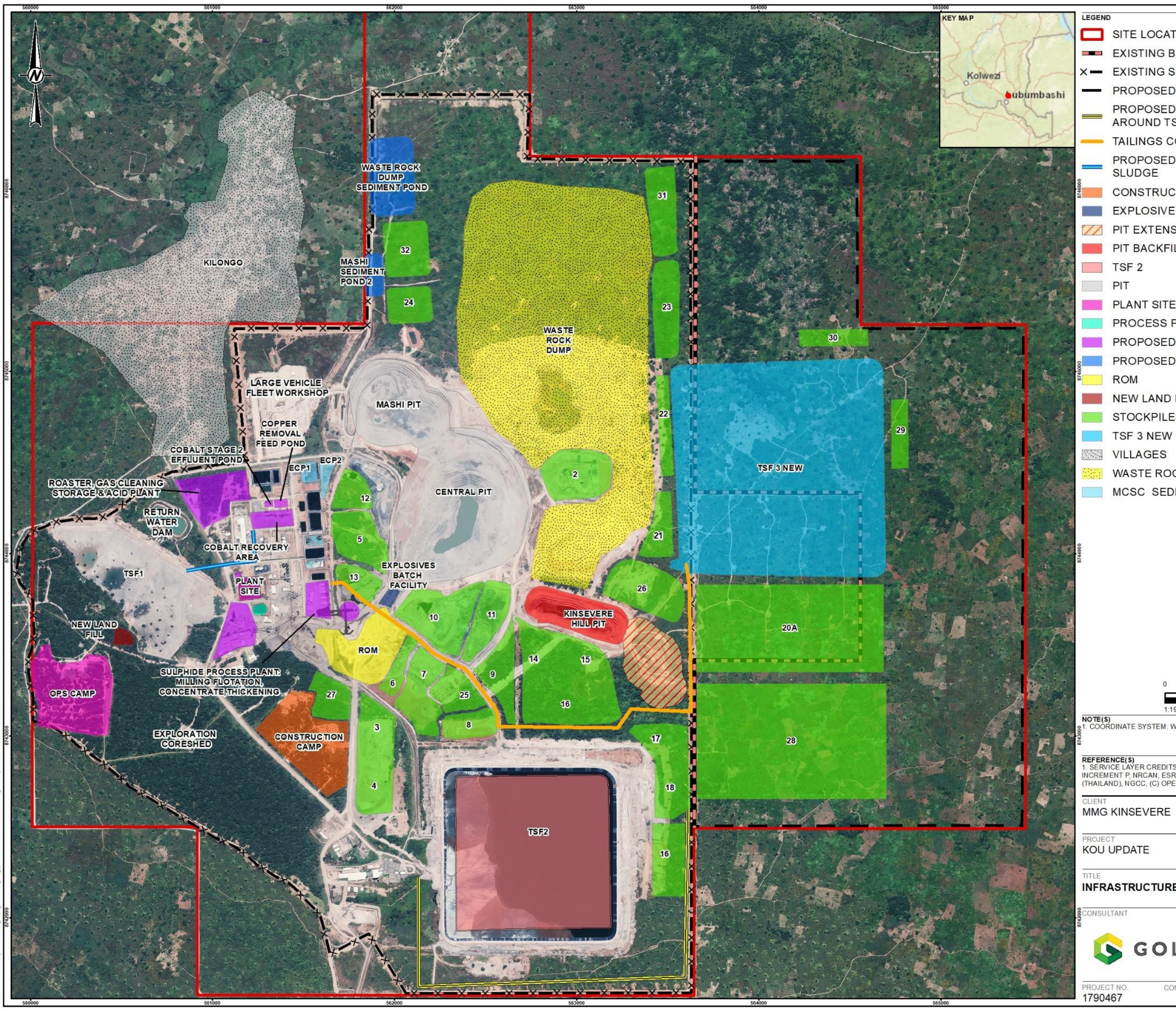
KEY MAP
Kolwezi
Lubumbashi
LEGEND
SITE LOCAT
EXISTING B
EXISTING S
PROPOSED
PROPOSED AROUND TS
TAILINGS C
PROPOSED SLUDGE
CONSTRUC
EXPLOSIVE
PIT EXTENS
PIT BACKFIL
TSF 2
PIT
PLANT SITE
PROCESS F
PROPOSED
PROPOSED
ROM
NEW LAND
STOCKPILE
TSF 3 NEW
VILLAGES
WASTE ROC
MCSC SEDI
KILONGO
WASTE ROCK DUMP SEDIMENT POND
MASHI SEDIMENT POND 2
WASTE ROCK DUMP
LARGE VEHICLE FLEET WORKSHOP
MASHI PIT
COPPER REMOVAL FEED POND
COBALT STAGE 2 EFFLUENT POND
ECP1
ECP2
ROASTER, GAS CLEANING STORAGE & ACID PLANT
RETURN WATER DAM
CENTRAL PIT
COBALT RECOVERY AREA
TSF1
PLANT SITE
EXPLOSIVES BATCH FACILITY
KINSEVERE HILL PIT
NEW LAND FILL
ROM
OPS CAMP
SULPHIDE PROCESS PLANT: MILLING FLOTATION, CONCENTRATE THICKENING
EXPLORATION CORESHED
CONSTRUCTION CAMP
TSF 3 NEW
TSF2
NOTE(S)
1. COORDINATE SYSTEM: W
REFERENCE(S)
CLIENT
MMG KINSEVERE
PROJECT
KOU UPDATE
TITLE
INFRASTRUCTURE
CONSULTANT
PROJECT NO.
1790467

Figure 2Figure 2 for the locality, and Figure 5Figure 5 for the layout and general arrangement and Figure 22Figure 22, Figure 23Figure 23 and Figure 24Figure 24 for the design of TSF3.

About 10 - 15 Mt of potentially acid forming (PAF) material will be mined over the life of the operation. It could either be placed on a liner or NAF base layer, encapsulated in designed cells within the WRD surrounded by NAF material or used as backfill in Kinsevere Hill pit between NAF material.

All impoundments of acidic water, such as ECP1, the Black Shale ponds and TSF2 are HDPE lined.

The groundwater monitoring network is described in Section 5.4.4 and illustrated in Figure 74Figure 74.

5.4.1.7 Mine Tailings Level A Impermeability Measures (Article 59)

Static and kinetic testing of several sulphide ore tailings samples indicated that TSF3 would require Level A impermeability measures.

5.4.1.8 Management of Mine Tailings (Article 60)

The management of mine waste that has at least one of the characteristics mentioned for Level A impermeability measures is permitted on unaltered soil at least 3 m thick and with a hydraulic conductivity equal to or less than 1×10^{-6} cm/s.

Knight Piésold Consulting undertook a feasibility design study (Drew, L; Sawyer, D, September 2018), including a geotechnical evaluation (Jupp, R; Luo, J;, August 2018) for TSF3 and concluded that:

- The TSF3 embankment will be supported on unconsolidated deposits of shallow colluvium to a depth of around 0.5 m overlaying residual siltstone to a depth of around 5.0 m; and
- The foundation permeability is about 5×10^{-7} m/s.

5.4.1.9 Mine Tailings Level B Impermeability Measures (Article 61)

Level B impermeability measures do not apply for the tailings to be deposited in TSF3, but TSF3 will still be built with a HDPE liner.

5.4.1.10 Management of High-risk Mine Tailings (Article 62)

As discussed in the preceding sub-sections of Section 5.4.4.1, and as indicated by the Knight Piésold studies referenced in Section 5.4.1.8, the geotechnical conditions are suitable for the storage of sulphide tailings at the proposed TSF3 footprint, which would require Level A impermeability measures.

5.4.1.11 Installation of Monitoring Wells (Article 63)

The locations of the monitoring boreholes as described in Section 5.4.4.1 and illustrated in Figure 74Figure 74, meet the requirement that there must be such boreholes up-gradient and down-gradient of each facility that could cause contamination of the groundwater.

5.4.1.12 Frequency of Water Analysis (Article 64)

Groundwater sampling and analysis is typically done in February, late May-early June, August and late November for the major ions, electrical conductivity and pH. Analysis for the other parameters is done in late May-early June and August.

5.4.1.13 Monitoring Piezometry (Article 65)

During the first two years of operation of a new facility or activity associated with the KOU, the groundwater levels will be measured monthly, in order to establish the annual variation cycle. Thereafter, the groundwater levels will be measured twice per year when the groundwater is being sampled for analysis.

5.4.2 Section II: Pollution Thresholds

5.4.2.1 Maximum Concentration of Contaminants in the Water (Article 66)

The requirements for discharge of effluent as set out in Article 66 are listed in Table 83Table 83.

Table 83: Limits for Effluent Discharge – Article 66

Parameters	Maximum Acceptable Concentration in Instantaneous Sample
Arsenic (As)	0.40 mg/L
Copper (Cu)	1.5 mg/L
Iron (Fe)	6 mg/L
Nickel (Ni)	1 mg/L
Lead (Pb)	0.5 mg/L
Zinc (Zn)	10 mg/L
Total cyanides (Total CN)	2 mg/L
Hydrocarbons	10 mg/L
Mercury (Hg)	0.002 mg/L
Matter in suspension (TSS)	100 mg/L
pH	6 to 9
BOD_5	50 mg/L
Oil and grease	20 mg/L
Temperature (°C) at the edge of an area of mixture	Maximum of 5°C from the ambient temperature level of the receiving water and maximum of 3° if the receiving water is >28°C.
Acute toxicity	> the acute lethality level according to testing of (river fish) and (river crustaceans).

5.4.3 Section III: Water Management Plan

5.4.3.1 Calculating the Monthly Arithmetic Mean of Final Effluent Development (Article 67)

As described in Sections 2.3, 2.5, 2.6, 3.2.2 and 3.2.3, the only discharge from the Kinsevere mine consists of water abstracted from the dewatering boreholes and water pumped from the pit sumps. In future, TSF1 runoff that is collected in the Return Water Dam, MCSC Sediment Pond and water that collects at the low point of the existing security trench will also be discharged via the expanded Mashi Sediment Pond 2. The flow rate and quality of the discharge water and the water quality of the Kifumashi River downstream of the discharge point shown as SWK04 in Figure 15~~Figure 15~~ is monitored by means of weekly sampling and chemical analysis. Monthly and quarterly arithmetic mean values are calculated from these results for reporting purposes – see Table 26~~Table 26~~ and Figure 46~~Figure 46~~ for quarterly values.

The mean value for a time period is calculated by dividing the sum of the values recorded for the particular parameter by the number of samples analysed or measured during that period. If a value is below the detection limit, a value equivalent to one half of the detection limit is assigned to it. If the arithmetic mean falls below the detection limit, but at least one value for that period is above the detection limit, the arithmetic mean is recorded as the detection limit.

5.4.3.2 Content of the Water Management Plan (Article 68)

To comply with the DRC Mining Regulations, surface water runoff must be managed in such a way that contaminated runoff is contained and sediment loadings from disturbed catchments do not exceed the DRC limit value of 100 mg/L for Total Suspended Solids (TSS). The basic principles/design philosophy of the surface water management strategy include:

- Keeping contaminated and non-contaminated water separate to prevent them from mixing;
- Reuse and recycling of contaminated water;
- Preventing the pollution of water resources; and

- Treatment of contaminated water prior to release.

5.4.3.2.1 Separating Water Types and Minimising Contamination of Water

Cut-off berms and channels have been constructed up-gradient of the existing mining, WRD, TSF and ore processing areas to divert clean, non-contact water around such areas. Runoff from the process plant and ROM pad areas, contact water as defined in Section 3.2.2, is channelled towards and impounded in environmental control ponds by structures designed and engineered to accommodate high rainfall events as stipulated in Article 82 and referenced in Table 22Table 22. These areas are kept as small as practically possible in order to minimise the volume of contact water.

The same approach will be followed with the establishment of the various components of the KOU project and their water management structures will be integrated with the existing structures. The locations of such impoundments, current and planned, are shown on

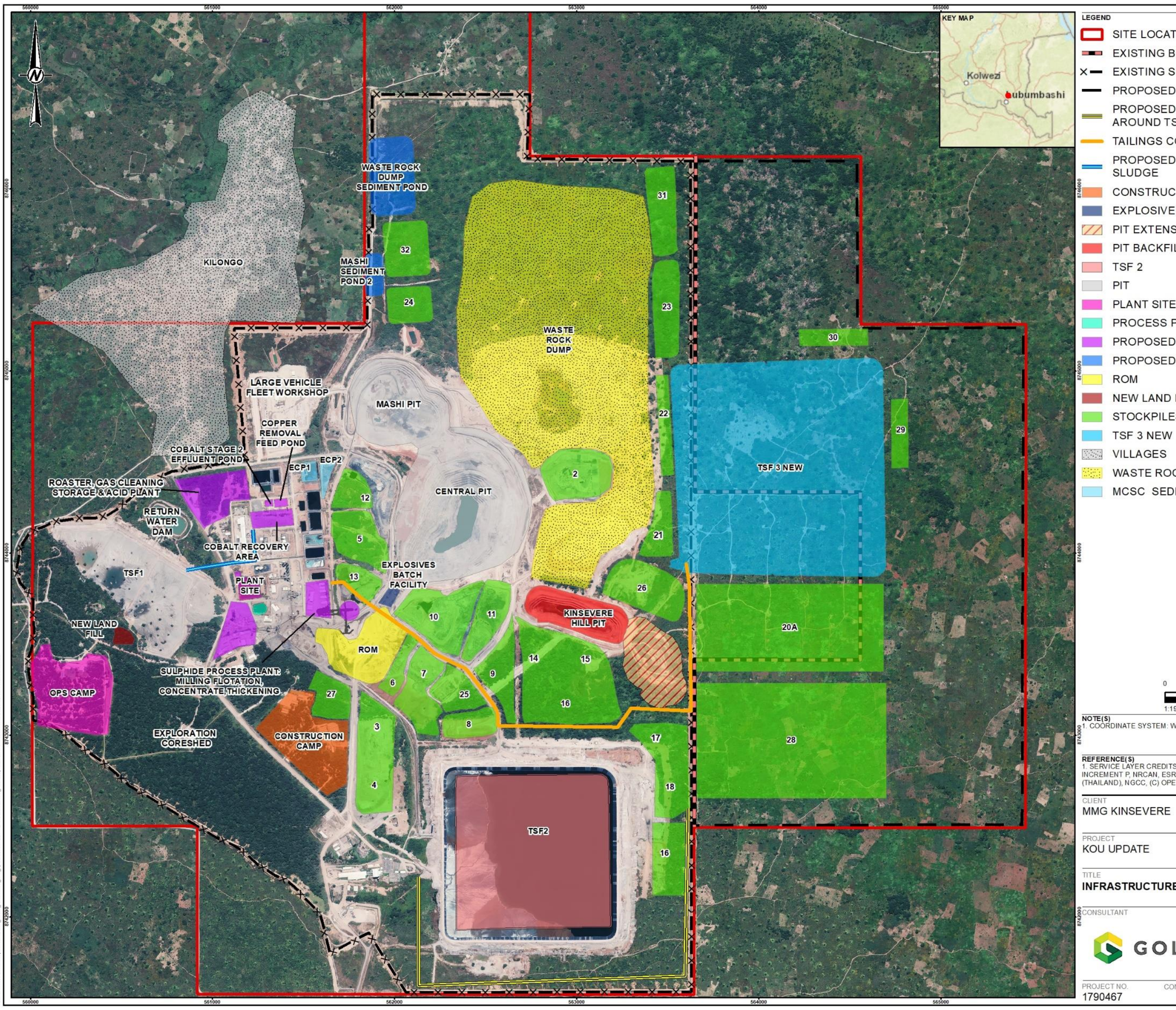

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Figure 2~~Figure 2~~, Figure 5~~Figure 5~~ and Figure 45~~Figure 45~~.

Runoff from the NAF WRD is contact water by definition but will generally contain sediment only and may be discharged via the Waste Rock Dump Sediment Pond. Acidic water will be impounded and may potentially be recycled to the process plant via TSF2.

Runoff from the TSF2 and TSF3 embankments is clean and can be released to the environment within the tenement boundaries.

5.4.3.2.2 Sedimentation Ponds for Water from Pits

Water that collects in Mashi and Central pits (direct rainfall and ingress of groundwater not captured by the dewatering boreholes) is currently pumped to Mashi Sediment Pond 1. This sediment pond will be decommissioned and replaced with the larger, more efficient Mashi Sediment Pond 2, which will also accept water that migrates to the low point of the security trench, MCSC Sediment Pond water and TSF1 runoff via the Return Water Dam. Currently, water in the Kinsevere Hill Pit remains there, but if the KOU project roceeds, this water will be pumped to the proposed new Waste Rock Dump Sediment Pond – see

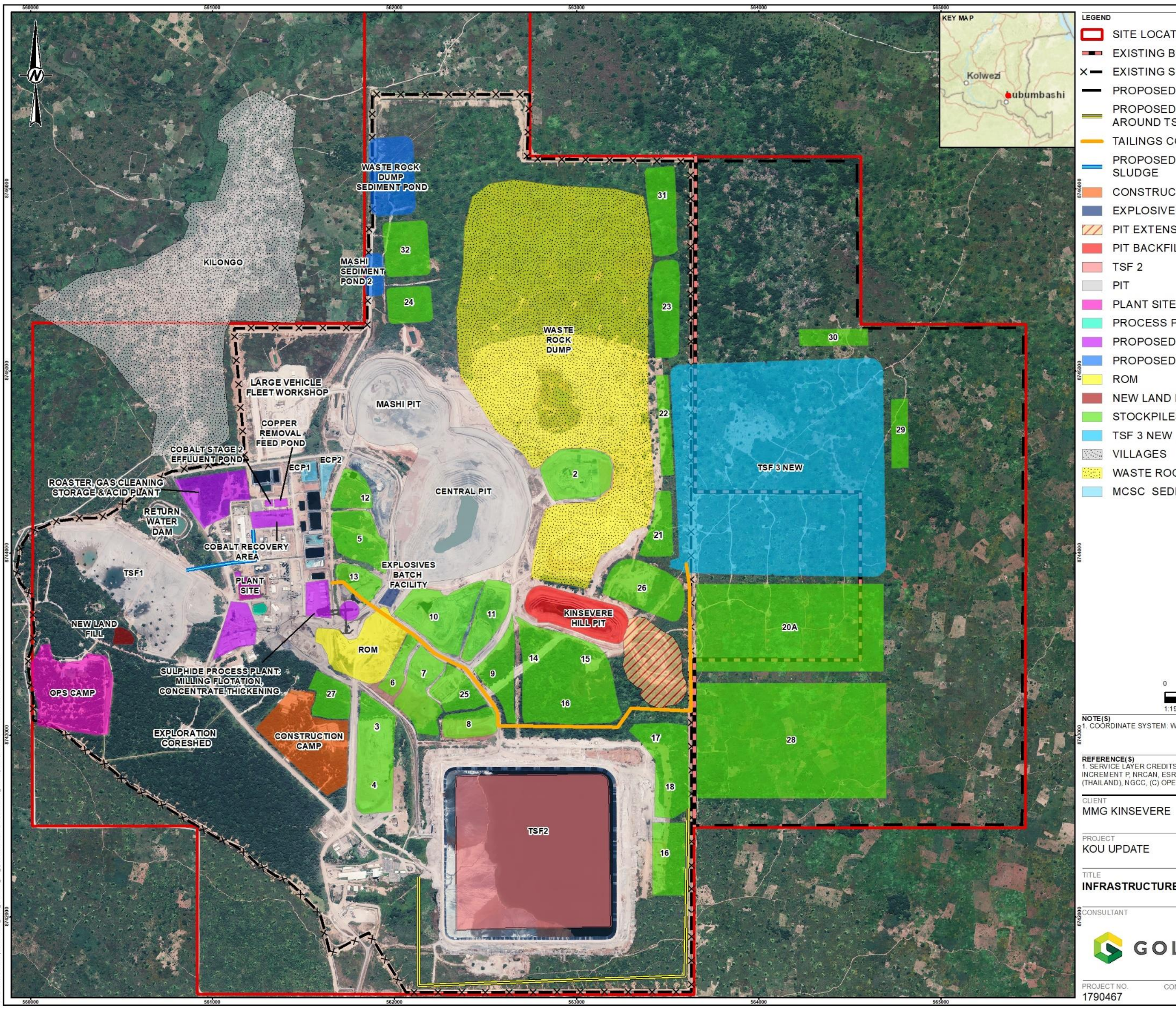

Figure 2Figure 2 and Figure 45Figure 45.

Absorbent pads will be installed in the Mashi Sediment Pond 2 for hydrocarbon control. Pit water containing elevated levels of metals will be treated with lime in-pit.

The Kinsevere Hill Sediment Pond is not being used and will be decommissioned.

Water that meets DRC discharge limits (Article 66 of Annex VIII to the DRC Mining Code 2018) will be discharged into the Kifumashi River via a discharge pipeline (Figure 14Figure 14 and Figure 15Figure 15).

5.4.3.2.3 Surface Water Quality Control and Discharge – Oxide and Sulphide Ore Processing

The surface water management plan for oxide and sulphide ore processing and includes additional sediment ponds (Mashi Sediment Pond 2, MCSC Sediment Pond and Waste Rock Dump Sediment Pond).

Several treatment and/or release options are being considered such as lime dosing, mechanical evaporation and any other suitable technology.

The Waste Rock Dump Sediment pond will cater for the runoff from the increased NAF waste rock dump footprint as well as water pumped out of Kinsevere Hill Pit. Water meeting DRC legal limits will be discharged via the authorised discharge point. Water exceeding limits will be lime-dosed in situ and subsequently discharged or directed back to the process water circuit or TSF2, depending on the quality of the water.

Current TSF 2 decant return may not be sufficient to ensure a small supernatant pond during sulphide ore processing. Two options are being considered namely to increase the decant return to the plant and reduce external makeup (subject to water chemistry) or treatment and discharge of the build-up of TSF 2 water. The latter has been identified as the most appropriate option as increasing the decant return to 80% (KP, 2018), from the current maximum of 70%, may not be capable of reducing the supernatant pond over time. The treated water will be discharged via the authorised discharge point.

5.4.3.2.4 Runoff from Area of Ore Processing Plant

All water originating from the ROM pad and plant area will be viewed as contaminated water and will be channelled to the lined ECP1. Excess water will be returned to the process plant or TSF2.

ECP1 will be extended to increase its holding capacity. Built-up silt will be removed to increase its capacity and any damaged lining will be replaced. The extended ECP1 will encroach onto the existing ECP2, which will be linked to ECP1 by a spillway serving as an emergency containment pond.

5.4.3.2.5 Runoff from Stockpiles

Runoff from PAF stockpiles, where DRC legal limits are exceeded, will be channelled via a lined drainage channel, impounded in lined collection ponds or sumps, and pumped back to the process water circuit or TSF2. If sulphide ore is being processed, runoff could also be directed to the water treatment option being considered.

Runoff from NAF stockpiles will be directed to a sedimentation pond for sampling and analysis, potentially via a collection pond or sump. Water meeting DRC legal limits will be discharged. Water exceeding the limits will be either treated with lime in-situ and discharged or directed back to the process water circuit or TSF2.

The black shale stockpile sump will be relocated. The sump at the dump for mineralised waste has already been constructed.

5.4.3.2.6 Runoff from Waste Rock Dump

Run off from the WRD, mainly consisting of NAF material, will be collected in a sediment pond (Waste Rock Dump Sediment Pond). Water exceeding DRC discharge limits will be lime-dosed in situ (prior to discharge) or directed back to the process water circuit or TSF2.

5.4.3.2.7 Runoff from TSF 2 and TSF 3 Embankments

Stormwater from the NAF embankments of TSF 2 and TSF 3 will be released to the environment within the boundaries of tenements PE528 and PE7274.

5.4.3.2.8 Process Pond Slurry to Black Shale Stockpile

An assessment of the storage capacity of process ponds in the SX/EW plant identified a reduced capacity due to slurry sedimentation in the ponds.

The slurry in the process ponds is classified as high risk mineralised waste and requires specific management measures. Kinsevere mine removed and stored the slurry on top of the black shale stockpile.

This will enable the slurry to be processed with black shale material in the future. The black shale stockpile has been designed and constructed so that all runoff collects in a lined runoff pond, from which it is pumped back to the process plant.

5.4.3.2.9 Runoff from Haul Roads

Stormwater from haul roads is managed locally using breakout points every 100 m.

5.4.4 Section IV: Measures to Monitor Water Quality

5.4.4.1 Description of Measures to Monitor Water Quality (Article 69)

The surface water and groundwater monitoring points are shown on Figure 15~~Figure 15~~ and Figure 74~~Figure 74~~ respectively.

The surface water points are sampled monthly. Water levels in the dewatering boreholes and their pumped discharge are monitored every second day, while weekly monitoring of water levels is undertaken at monitoring boreholes within the vicinity of the excavations. Groundwater monitoring points within and around the mine are sampled quarterly for detailed quality analysis.

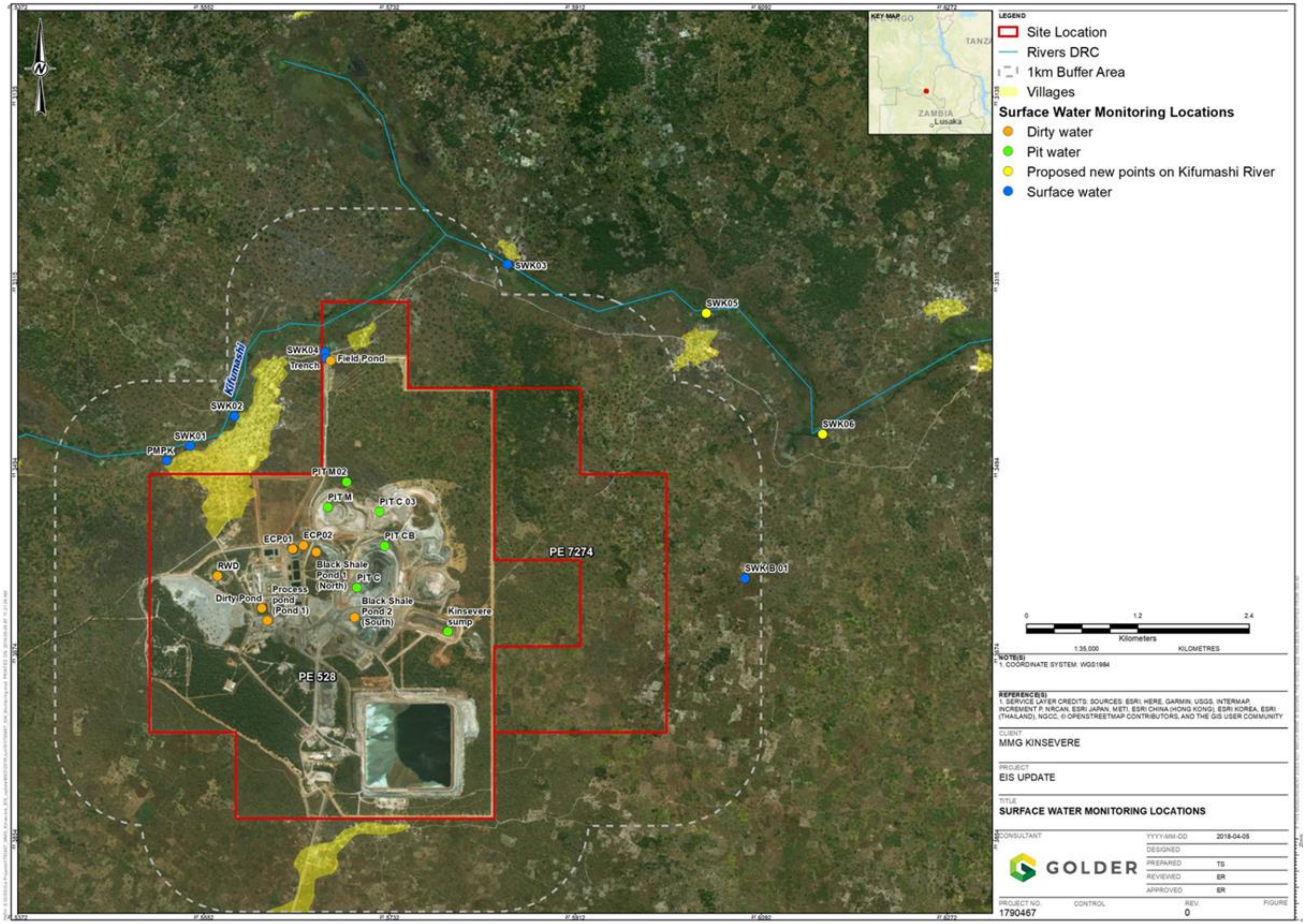

Figure 73: Locations of Surface Water Monitoring Points at Kinsevere Mine

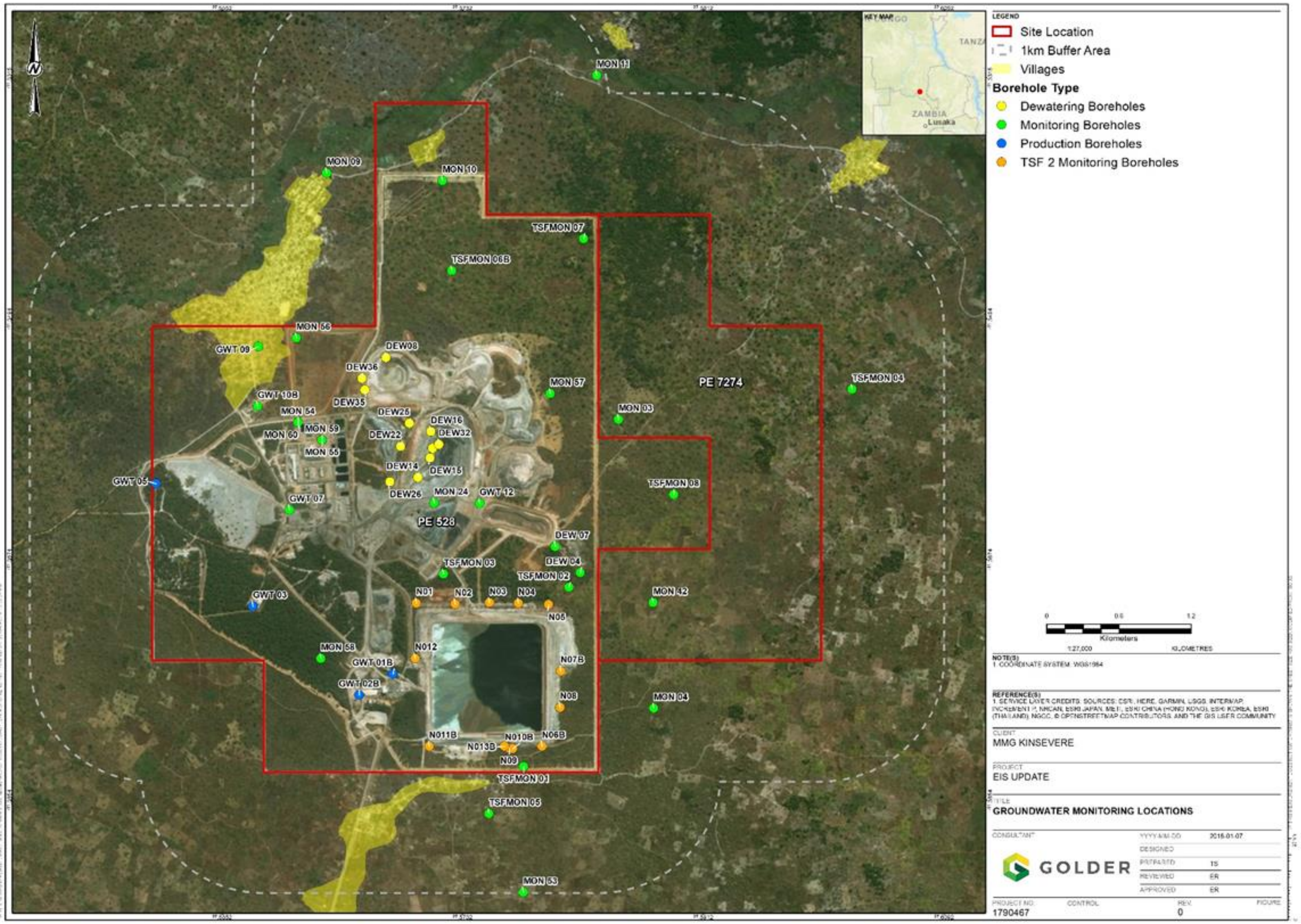

Figure 74: Groundwater Monitoring Points in and around Kinsevere Mine Concession

5.4.4.2 Periodic Verification of Effluent Quality – Article 69 (a)

The quality of the water discharged to the Kifumashi River is monitored as indicated in Table 84Table 84.

Table 84: Monitoring of Water Discharged to Kifumashi River

Site Location	Parameter	Max Threshold	Monitoring Frequency
Discharge Outfall (see Figure 15Figure 1 5)	pH	6 to 9	Weekly
	DB05	50 mg/L	Monthly
	Oil and grease	20 mg/L	Monthly
	Temperate at the boundary of a mixture area	5°C maximum of the ambient temperature of water collected and 3°C maximum if water collecte dis >28°C	Weekly
	Acute toxicity	>lethal level according to tests (river fish and river crustacea)	Monthly
	Arsenic	0.40 mg/L	
	Copper	1.5 mg/L	Weekly
	Iron	6 mg/L	Wekly
	Nickel	1 mg/L	Weekly
	Lead	0.5 mg/L	Weekly
	Zinc	10 mg/L	Weekly
	Cyanides total	2 mg/L	Monthly
	Hydrocarbons	10 mg/L	Monthly
	Mercury	0.002 mg/L	Monthly
	TSS	100 mg/L	Monthly

The quality of groundwater and surface water at Kinsevere is monitored as indicated in Table 85Table 85.

Table 85: Groundwater and Surface Water Monitoring

Sites	Parameters	Frequency
Monitoring boreholes Dewatering boreholes Water supply boreholes Raw water pond Tailings return water dam Settling ponds Environmental control ponds Kifumashi River	Alkalinity	Quarterly
	Chlorides	
	Conductivity	
	BOD5	
	COD	
	Hardness	
	Fluorides	
	Dissolved solids	
	Total solids	
	Phenolic substances	
	Sulphates	
	Ammonia nitrogen	
	Total ammonia	
	Kjeldahl nitrates + nitrites	
	Total phosphorus	
	Aluminium	
	Arsenic	
	Cadmium	
	Calcium	
	Chromium	
	Cobalt	
	Iron	
	Magnesium	
	Manganese	
	Mercury	
	Molybdenum	
	Potassium	
	Silica	
	Sodium	
	Sulphides	
	Thiosulphates	

The following information is recorded:

- Date and time when the sample was taken;
- The monitoring point where the sample was taken;
- The measured or estimated volume of water discharged through the dewatering pumping system;
- The release flow rate (measured or estimated) at the time of sampling at the release point;
- Water levels at the surface water sampling sites downstream of the discharge point using photographic records;

- All monitoring results and details of any exceedances of the applicable limits or thresholds; and
- Any signs of erosion at the discharge point and at downstream surface water quality sampling sites.

5.4.4.3 Organic Contaminants in the Final Effluent – Article 69 (b)

As indicated in Table 85~~Table 85~~, the water discharged to the Kifumashi River is monitored for oil and grease, DB05 and hydrocarbons.

5.4.4.4 Verification of Analytical Results – Article 69 (c)

Surface and groundwater quality monitoring measures include verification of analytical results, by calculating the ionic balance and checking for electroneutrality. The results generally fall within within the acceptable range of error (<5%).

5.4.5 Section V: Frequency and Control of Surface and Underground Water Qualityvolume

5.4.5.1 Contents of the Water Quality Monitoring Frequency and Control Program (Article 70)

Post-closure monitoring of water resources at the Kinsevere mine will involve:

- Monthly sampling and analysis of surface water flowing off-site from rehabilitated areas for at least five years after closure or until such water has met DRC effluent quality guidelines for a 12-month period;
- Biannual biomonitoring at selected downstream sites along the Kifumashi River to demonstrate that runoff from the rehabilitated areas does not meaningfully affect the recorded instream water quality for the maintenance of healthy aquatic life. Such monitoring will be undertaken for at least five years or until site relinquishment criteria have been achieved; and
- Quarterly monitoring of boreholes (water quality and level) for at least five years after closure or until water samples taken from representative groundwater monitoring boreholes are within DRC effluent quality guidelines for a 12-month period.

The results of the groundwater monitoring will be used to:

- Record any changes/trends in groundwater quality following rehabilitation of the mine site;
- Reflect movement and extent of contaminated groundwater plumes, providing data to confirm groundwater models and inform contaminant "source-pathway-receptor" analysis;
- Reflect the effects of the rebounding pit water levels on the surrounding groundwater aquifer;
- Reflect the rebounded in-pit water quality; and
- Determine seasonal fluctuations in the water table post mining to assist with the final determination of pit water rebound.

For groundwater monitoring, the minimum frequency of measurement is the same as that specified in the groundwater protection measures and the minimum monitoring period is as described in Table 86~~Table 86~~ below.

Table 86: Site Categories, Minimum Frequency of Measurement and Minimum Duration of Monitoring of Surface and Groundwater

Locations		Minimum Sampling Frequency	Minimum Duration of Surveillance after Closure of the Site
Locations used for management of mining wastes:			
1.	Mines and pits used for management of mining wastes and cyanide leachate	Twice per year	Every 5 years
2.	Mines and pits used for the management of PAG mine wastes	3 times per year	Every 10 years
3.	Areas ofaccumulation of mining wastes and cyanide leachate	Twice per year	Every 5 years
4.	Areas of accumulation of PAG mine wastes	3 times per year	Every 10 years
5.	Areas of accumulation of high risk mining wastes		
Locations affected or contaminated by the mining activities:			
1.	Presence of sulphides	3 times per year	Every 10 years
2.	Other contaminants	Twice per year	Every 5 years

5.4.5.2 Annual Monitoring Parameters and Calculation of Loads (Article 71)

In terms of this article, MMG's Kinsevere mine must undertake annual monitoring of the parameters listed in Table 87~~Table 87~~ below. The mine does not use any cyanidation processes and Group 2 parameters are not applicable. Group 3 parameters will become applicable within the next three to four years, when Kinsevere will start processing sulphide ore.

Table 87: Groups of Annual Monitoring Parameters

Groups	Group 1			Group 3
	Conventional Parameters	Nutrients	Minerals and Metallic Elements	
Parameters	■ Alkalinity; ■ Chlorides; ■ Conductivity; ■ DBO_5; ■ DCO; ■ Hardness; ■ Fluorides; ■ Dissolved solids; ■ Total solids; ■ Phenol substances; and ■ Sulphates.	■ Ammoniacal nitrogen; ■ Total nitrogen Kjeldahl; ■ Nitrates + nitrites; and ■ Total phosphorus.	■ Aluminium; ■ Arsenic; ■ Cadmium; ■ Calcium; ■ Chrome ■ Cobalt; ■ Iron; ■ Magnesium; ■ Manganese; ■ Mercury; ■ Molybdenum; ■ Potassium; ■ (Radium 226); ■ Silica; and ■ Sodium.	■ Sulphides; and ■ Thiosulphates.

The average monthly loads for the various constituents discharged at SWK04 were calculated from their average concentrations and the measured average monthly flows at SWK04. See Table 88~~Table 88~~, Figure 75~~Figure 75~~, and Figure 76~~Figure 76~~.

Table 88: Average Chemical Loads Calculated vs Loads based on Limit Values (February 2017 – January 2018 data)

Month		Total Dissolved Solids	Total Suspended Solids	Chlorides	Sulphate	Calcium	Magnesium	Sodium	Potassium	Iron	Manganese	Copper	Cobalt	Lead	Zinc	Nickel	Arsenic
January	Actual measured	7 847	48	3	789	1 433	771	325	29	0	1	1	2	0	0	0	0
	Limit	25 926	2 593	75	0	1 944	1 296	0	0	156	3	39	26	16	259	26	10
February	Actual measured	116 844	721	45	11 749	21 336	11 478	4 838	432	4	9	9	27	4	5	4	4
	Limit	386 048	38 605	1117	0	28 954	19 302	0	0	2 316	39	579	386	232	3 860	386	154
March	Actual measured	60 669	374	24	6 100	11 078	5 960	2 512	225	2	5	5	14	2	3	2	2
	Limit	200 447	20 045	580	0	15 034	10 022	0	0	1 203	20	301	200	120	2 004	200	80
April	Actual measured	24 187	149	9	2 432	4 417	2 376	1 002	90	1	2	2	6	1	1	1	1
	Limit	79 914	7 991	231	0	5 994	3 996	0	0	479	8	120	80	48	799	80	32
May	Actual measured	20 990	129	8	2 111	3 833	2 062	869	78	1	2	2	5	1	1	1	1
	Limit	69 350	6 935	201	0	5 201	3 468	0	0	416	7	104	69	42	694	69	28
June	Actual measured	46 902	289	18	4 716	8 564	4 608	1 942	174	2	4	4	11	2	2	2	2
	Limit	154 963	15 496	448	0	11 622	7 748	0	0	930	15	232	155	93	1550	155	62
July	Actual measured	47 212	291	18	4 747	8 621	4 638	1 955	175	2	4	4	11	2	2	2	2
	Limit	155 986	15 599	451	0	11 699	7 799	0	0	936	16	234	156	94	1 560	156	62
August	Actual measured	72 427	447	28	7 283	13 225	7 115	2 999	268	2	6	6	17	2	3	2	2
	Limit	239 296	23 930	692	0	17 947	11 965	0	0	1 436	24	359	239	144	2 393	239	96
September	Actual measured	33 880	209	13	3 407	61 86	3 328	1 403	125	1	3	3	8	1	1	1	1
	Limit	111 938	11 194	324	0	8 395	5 597	0	0	672	11	168	112	67	1 119	112	45
October	Actual measured	28 999	179	11	2 916	5 295	2 849	1 201	107	1	2	2	7	1	1	1	1
	Limit	95 811	9 581	277	0	7 186	4 791	0	0	575	10	144	96	57	958	96	38
November	Actual measured	12 815	79	5	1 289	2 340	1 259	531	47	0	1	1	3	0	1	0	0
	Limit	42 339	4 234	123	0	3 175	2 117	0	0	254	4	64	42	25	423	42	17
December	Actual measured	47 379	292	18	4 764	8 651	4 654	1 962	175	2	4	4	11	2	2	2	2
	Limit	156 537	15 654	453	0	11 740	7 827	0	0	939	16	235	157	94	1 565	157	63

Note: All units are kg/month

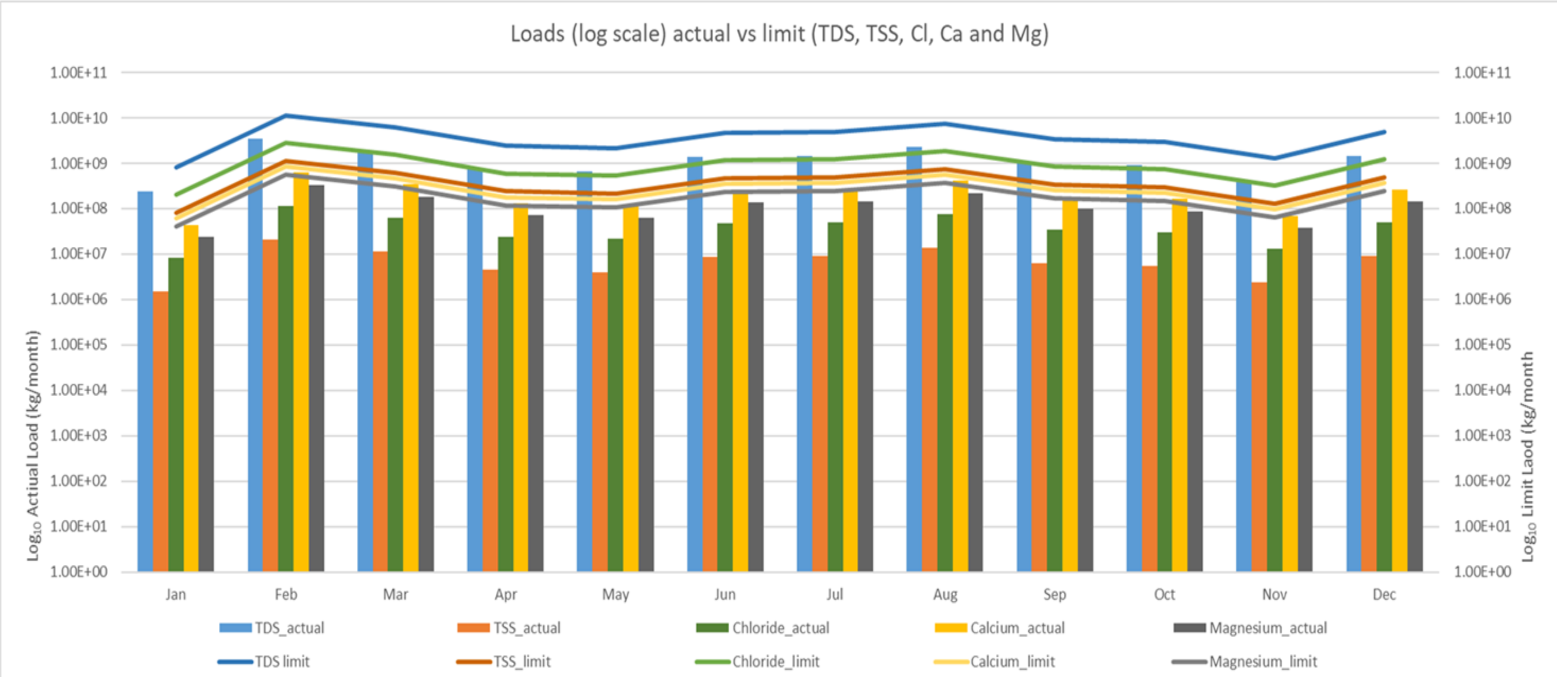

Figure 75: Log10 Scale showing Actual Loads vs Limit Loads (TDS, TSS, Chloride, Calcium, and Magnesium)

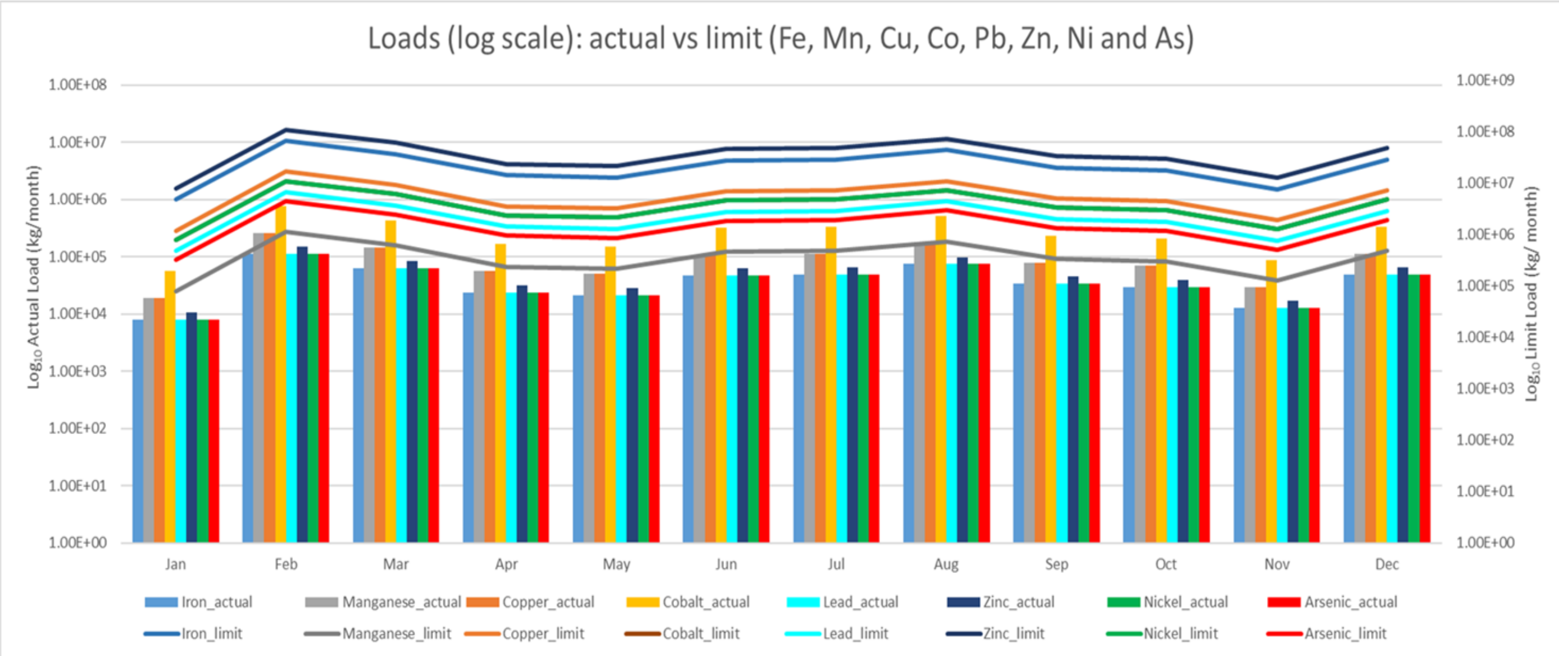

Figure 76: Log10 Scale showing Actual Loads vs Limit Loads (Iron, Manganese, Copper, Cobalt, Lead, Zinc, Nickel, and Arsenic)

5.4.5.3 Measurement System for Recording Flow Rate and pH (Article 72)

Kinsevere mine measures the flow rate and pH upstream from the discharge point, SWK04.

The flow meter is checked annually to ensure that the accuracy remains within the stipulated 7% margin of error and the calibration of the pH measuring system is checked weekly. Records of the measuring results and the maintenance/calibration actions are kept at the mine.

5.4.5.4 Frequency and Methods of Sampling Final Effluent (Article 73)

As required in terms of this article, the Kinsevere mine undertakes sampling, analysis and measurement of final waste as indicated in Table 89~~Table 89~~ below.

Table 89: Frequency of Final Effluent Sampling, Analysis, and Measurements

At least twice per week	Weekly	Monthly	Annually
MES, pH and Flow.	As Cu Fe Ni Pb Zn	Acute toxicity	Parameters of groups 1 to 3

5.4.5.5 Regularising Final Effluent Flow (Article 74)

In terms of this article, the mine is expected to control the flow of discharge so that it remains as uniform as possible over the year. Kinsevere mine has limited storage capacity for surface water. The existing and planned ponds for uncontaminated water are designed primarily for use as sedimentation ponds and the mine's discharge flow varies with seasonal rainfall and groundwater recharge. The monthly discharge volumes for 2017 are listed in Table 90~~Table 90~~ below.

Table 90: Average Monthly Flow at SWK04 (2017)

Month	Dewatering Boreholes (m^3/month)	Sediment Dams less Evaporation (m^3/month)	Total Discharged at SWK04 (m^3/month)
January	760 030	43 680	803 710
February	11 127 900	67 480	11 195 380
March	6 163 540	50 330	6 213 870
April	2 360 010	37 401	2 397 411
May	2 100 970	48 895	2 149 865
June	4 598 850	50 036	4 648 886
July	4 808 560	27 020	4 835 580
August	7 391 150	27 020	7 418 170
September	3 331 120	27 020	3 358 140
October	2 967 610	2 520	2 970 130
November	1 267 650	2 520	1 270 170
December	4 850 140	2 520	4 852 660

5.5 CHAPTER V: MITIGATION AND REHABILITATION MEASURES FOR SOIL DEGRADATION RISKS

5.5.1 Management of Overburden (Article 75)

The overburden that will be removed from the footprint of the proposed pit expansion indicated on

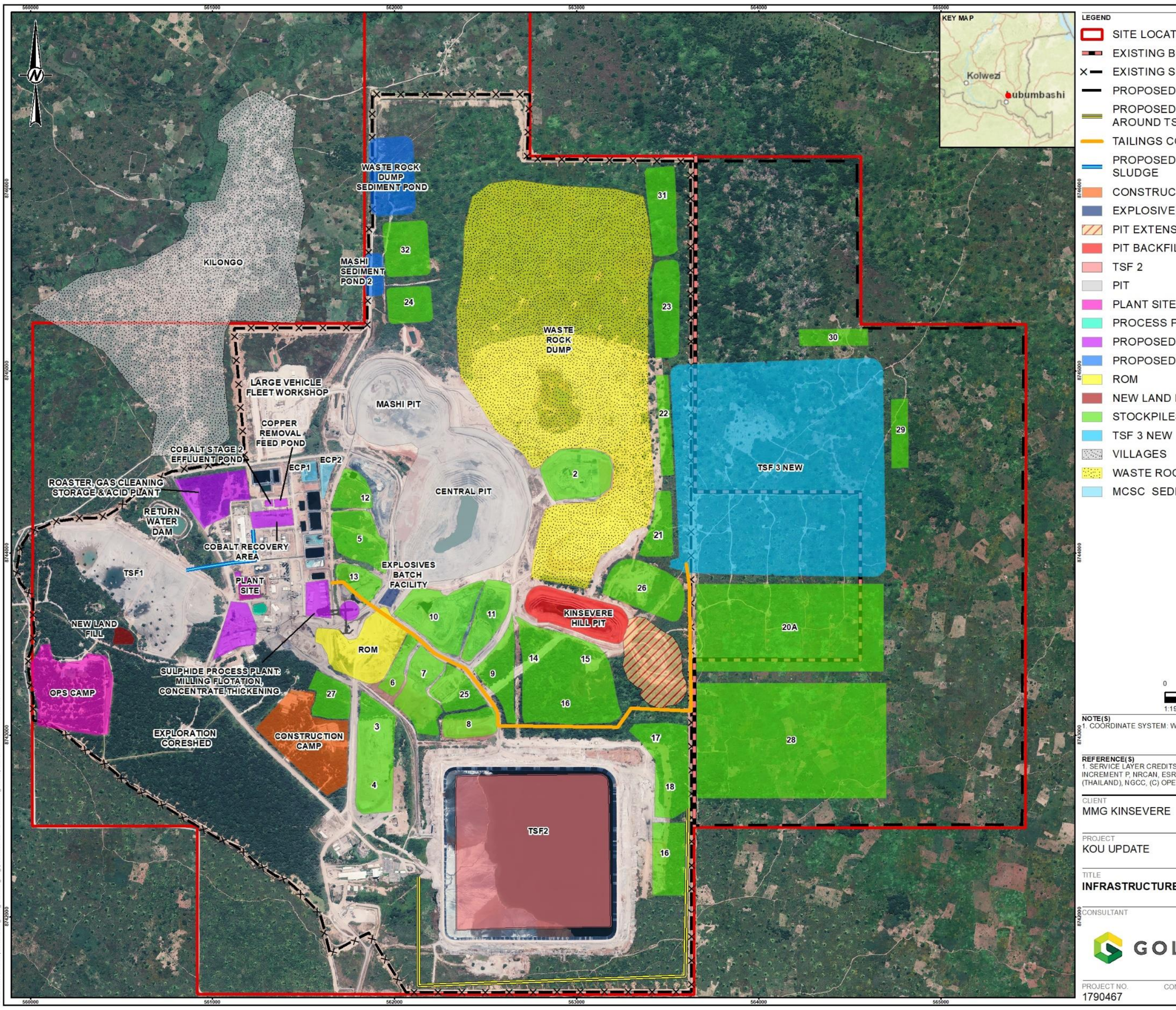

Figure 2Figure 2 is unlikely to be contaminated, but if any contamination has occurred or is suspected, this material will be investigated and, if it is contaminated, it will be either decontaminated or managed as hazardous waste as described in Section 5.5.

The overburden will be stripped in consecutive layers representing topsoil, subsoil and barren material overlaying the ore. As discussed in Section 3.2.1.2.4, the surface area of a raised structure such as a TSF or a WRD is larger than its footprint area, and this stockpiled subsoil and topsoil can be deposited on the TSFs and WRDs in that order, during rehabilitation, to address the shortfall in soils stripped from the footprints of these facilities. The stockpiled barren material could be used as either pit backfill or as an additional lower layer cover on the TSFs and WRDs.

The following measures to minimise the disturbance of the natural soil, to preserve topsoil that must be stripped for use during the closure and rehabilitation phase and for restoring disturbed areas will be implemented:

- Avoidance/Prevention:
  - Minimise the KEP footprint and therefore disturbance to the minimum practicable area;
  - Minimise the extent of the area of access control (by security trench, fence or other barrier) as far as practicable;
  - Ensure proper handling and storage of hazardous chemicals and materials (e.g. fuel, gas, oil, cement, concrete, reagents, etc.) as per their corresponding Material Safety Data Sheets (MSDSs);
  - Maintenance of vehicles and equipment should be carried out in designated appropriate facilities fitted with spills containment barriers, impermeable floors and sumps to capture any fugitive oils and greases;
  - As far as practicable, avoid disturbance of areas with high erosion potential. See Section 3.2.1.2.4, Figure 32Figure 32 and Figure 33Figure 33:
  - Minimise erosion by designing and constructing access roads along gentle slopes and with drainage channels along the roads spaced at intervals dictated by the slope, rainfall pattern and erodibility; and
  - Avoid erosion through proper rehabilitation design and implementation.
- Reduction:
  - Minimise compaction of sensitive/productive soils (see Figure 28Figure 28 and Figure 29Figure 29);
  - Avoid mixing topsoil (A-horizon) with subsoil (B-horizon) during stripping and storing of soil (refer to Section 3.2.1.2.1 for average soil horizon thickness per major soil type mapped);
  - Inform relevant personnel regarding the handling of soils intended for rehabilitation and consider demarcating and indicating areas intended for stockpiling of topsoil and subsoil with signage or noticeboard;
  - Strip and stockpile topsoil together with vegetation to enable continuation of the biogeochemical cycle, thereby preserving fertility;
  - Stockpile side slopes to be assessed by the site geotechnical team to ensure safe slope angles, and rounding of the top edges;
  - Place a runoff containment berm down-gradient of the stockpile to capture runoff, let the transported soil settle and recover it;
  - Keep the stockpile moist to reduce wind erosion and facilitate vegetation growth, until vegetation has established;

- Vegetate topsoil stockpile with locally indigenous grasses and forbs to maintain biological processes, stabilise the soil and reduce soil loss due to erosion;
- Undertake regular weed control;
- Minimise surface footprints of development areas to the extent possible and restrict heavy machinery and heavy truck access to sensitive soil areas (utilise lighter machinery with less potential to compact soils in areas with sensitive soils);
- Minimise soil contamination through suitable measures for containment and handling of potentially polluting materials and implement acid rock drainage and metal leaching mitigation measures. (Refer to recommended management of waste rock and tailings (Geochemical and Acid Forming Characteristics of Waste Rock, Ore and Process Tailings report, Chapters 7 and 8));
- Minimise the use of fire as a site clearing method and establish fire breaks to minimise potential soil contamination and protect site areas;
- Implement suitable measures to control seepage and runoff from mining infrastructure such as the TSFs and WRDs to minimise soil contamination;
- Implement regular site inspections for materials handling and storage as well as pipeline monitoring; and
- Implement soil erosion minimisation techniques such as:
  - scheduling construction and maintenance to avoid heavy rainfall periods (i.e., during the dry season) to the extent practical;
  - mulching to stabilise exposed areas;
  - re-vegetating areas promptly; and
  - designing channels and ditches for post-construction flows.

- Rehabilitation:
  - Implement soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for use in site remediation);
  - Store stripped topsoil and subsoil separately for future site rehabilitation activities;
  - Maintain fertility of stockpiled soils for future rehabilitation;
  - Follow guidance in the Closure Plan and Environment Standard on promoting sustainable land use practices in the project’s area of influence;
  - In case of soil compaction during rehabilitation, ripping is recommended with the addition of fresh organic matter for the improvement of soil structure;
  - Ensure that the overall thickness of the soils utilised for rehabilitation is consistent with surrounding undisturbed areas and future land use;
  - Implement soil conservation measures (e.g. segregation, proper placement and stockpiling of clean soils and overburden material for existing site remediation and maintaining fertility of top soils stored for future rehabilitation);
  - Undertake landscaping of disturbed areas (other than permanent disturbances such as pit voids, WRDs, TSFs etc.) to restore contours and drainage lines as far as practicable;
  - Design slopes to an appropriate gradient for rehabilitation as defined in the Closure Plan;

- Base the soil fertilising programs on the soil chemical, biological and physical status after topsoil replacement;
- Develop detailed procedures for spills containment and clean-up of contaminated soils;
- Rehabilitation of areas to take into consideration erosion aspects; and
- Implement measures to minimise soil erosion from rehabilitated areas.

5.5.2 Backfilling (Article 76)

This ESIA deals with the KOU project, the subject of this ESIA, involves opencast mining only, with no backfilling involved, although the Kinsevere Hill pit may be backfilled with PAF and compacted with layers of NAF material. MMG has indicated that a new underground copper mine could be developed at the NW Mashi copper deposit discovery which is located about 1 km north-west of Kinsevere. If the viability of such a mine is confirmed by a feasibility study, a separate ESIA process or amendment will be undertaken.

5.5.3 Management of Mine Waste (Article 77)

The systems for management and monitoring of mine waste to minimise the impact on soils within the perimeter of tenements PE528 and PE7274 are described in Sections 5.4 and 5.5.

5.5.4 General Conditions relating to Mine Waste (Article 78)

To minimise the potential for wind erosion of mining waste:

- The active areas of the TSF are kept moist as far as practicable; and
- The permanently inactive surface areas of the TSF are covered with layers of laterite, subsoil and topsoil and vegetated with locally indigenous grasses and forbs.

The waste rock is coarse and not prone to wind erosion. Berms are constructed down-gradient of mine waste deposits to trap sediment transported by runoff. The berms are inspected regularly, and the trapped sediment is recovered and returned to the facility.

As part of its community development program described in Section 9.0, Kinsevere mine has helped to establish small businesses to crush inert, not potentially acid forming (NAF) waste rock from the mining operations and sell it as aggregate for use in road building and concrete mixing.

5.5.5 Conditions Specific to each Type of Waste (Article 79)

The currently proposed method of distinguishing between non-acid forming (NAF) and potentially acid forming and metal leaching (PAF and ML) materials is to apply a cut-off sulphur content of 0.3% to all materials.

Geochemical characterisation tests performed by EGI on samples of the various ore and waste rock types occurring at Kinsevere, and on samples of the expected tailings, indicated that the CMN and RAT materials are inherently NAF due to their high neutralising capacity, and would be unnecessarily classified as PAF. Accordingly, a new classification system has been proposed, in terms of which all the CMN and RAT material will be classified as NAF and a cut-of sulphur content of 0.2% will be applied to SD rock. (Burdett, M; Crosbie, J; Verano Garcia, S;, 2018). See Table 91~~Table 91~~.

More of the SD material would be classified as PAF and would have to be managed as such, which would be conservative and more protective of the environment, but it would also result in an overall reduction in the amount of PAF material that must be managed. See Table 92~~Table 92~~.

Table 91: Proposed PAF/NAF Classification System

Strat/Rock Unit	Sulphur cut-off	Classification	Potentially Metal Leaching (PML)
CMN	none	NAF	No
SD	<0.2%	NAF	No

	≥0.2%	PAF	Yes
RAT	none	NAF	No

Notes: CMN; *Calcaire á Minerai Noir* – Dolomite
RAT: *Roches Argilo -Talqueuses* – Dolomitic siltstone
SD: *Schistes Dolomitique* – Carbonaceous black shale

Table 92: PAF and NAF Classification in Terms of Proposed Criteria

Scenario	NAF WRD Volume (M m^3)	Volume of PAF in NAF WRD (M m^3)	% of NAF WRD that is PAF (%)	PAF WRD Volume (M m^3)
Proposed new site criteria: PAF>0.3%S in all waste	55.80	0.13	0.24	12.06
Proposed Study Criteria: PAF>=0.2%S in SD	63.48	2.48	3.84	4.38

The geochemical study concluded that:

- About 0.24% of the waste rock material would be PAF;
- Placing the PAF and NAF material on the WRDs as it is mined is not recommended, as it could affect the overall dump ARD and ML risk adversely. This strategy could have more onerous barrier and capping requirements and contact water management implications than other placement strategies described below:
  - Placing the PAF material in the middle of the waste rock facility for encapsulation by the RAT or CMN materials would limit the exposure of the PAF materials to oxygen and water, which would reduce the performance requirements of the engineered barriers and covers. The NAF material would also act as a cover over the PAF materials during the post closure phase;
  - Placing the NAF and PAF materials separately, the NAF WRD having significantly lower contact water management, barrier and cover requirements than the much smaller PAF WRD; and
  - Depending on the mine planning, in-pit placement of waste rock materials could be considered. PAF materials could be placed under the long-term pit lake water level, effectively creating an oxygen-limiting water barrier. Seepage with low metal content generated from NAF material would report to the pit lakes and only migrate from the pit area in diluted form over the long term.

It is recommended that the above three alternatives be considered in a trade-off assessment, including criteria for cost, mine planning and environmental implications, to decide on an optimal disposal strategy:

- Currently, groundwater seeps through the pit walls and is pumped out from the pit sumps. This water is in contact with sulphide ore and waste rock and as a worst case its quality can be approximated by combining the qualities of seepage from the PAF SD waste rock materials and the water in the black shale pond. Additional dewatering boreholes to maintain the groundwater level at one bench height below the pit floor would reduce such contact significantly; and
- Allowing the development of a pit lake after closure is an effective ARD and ML mitigation strategy.

The Kinsevere mine does not produce any mine waste that is cyanided, high-risk, flammable or contaminated with organic compounds. As discussed in Sections 4.3.1.5.2 and 5.8.4, the ore at the Kinsevere mine contains low concentrations of uranium minerals, but sufficient to require monitoring as recommended by the General Commissariat for Atomic Energy (CGEA) of the DRC after an investigation at the mine (Kazadi, F; Kaka, P; Hongo, R; Kabamba , E; Ndiku, S; Mwamba, V;, July 2015).

The levels of radioactivity in the mining wastes were not quantified during the investigation, but measurements in the pits and at the RoM pad ranged from 0.13 to 2.5 mSv per annum, well below the annual occupational limit of 20 mSv. The mine is developing a program that will monitor worker exposure and radiation levels at various points on the mining lease area.

5.5.6 Mine Waste Storage Areas (Article 80)

The storage areas for mine wastes are indicated on

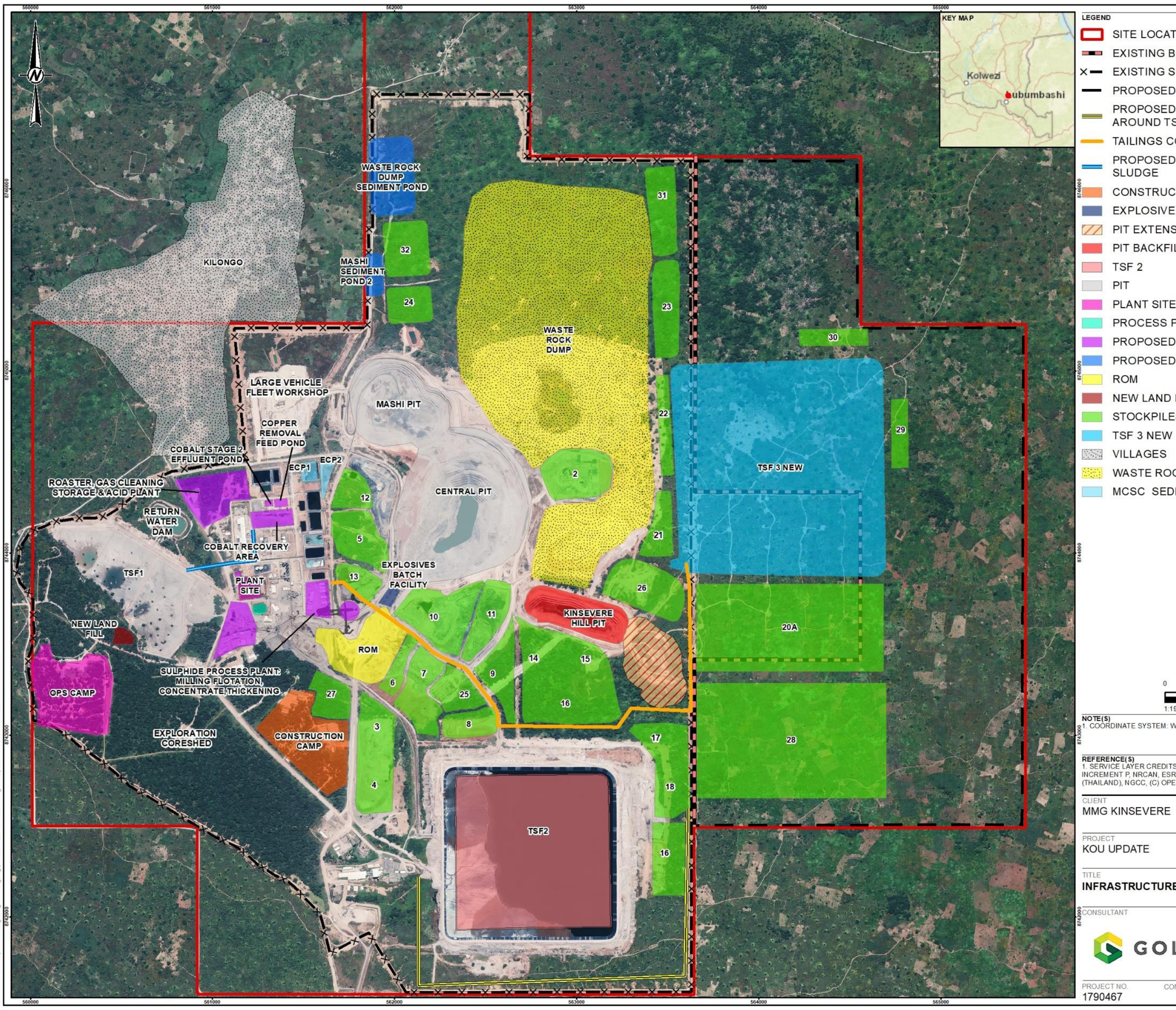

Figure 2Figure 2 and all of them are more than 2 km away from the highwater line of the Kifumashi River.

About 0.24% of the waste rock is PAF and the mine is considering the option of disposing of it within the rest of the waste rock, so that it is surrounded by an encapsulated within NAF rock.

The footprints of the waste rock dumps are determined by the natural angle of repose of the waste rock, which is 1v:1.4h (approximately 36°). This results in the smallest possible footprint for a naturally stable facility.

The design of TSF3 is shown on Figure 22Figure 22, Figure 23Figure 23 and Figure 24Figure 24. The conceptual closure design is shown in Figure 77Figure 77. The tailings are deposited at a slope of 1v:3h on the upstream (inside), and 1v:3.5h on the downstream (outside) during the operational life of the TSFs in order to minimise the footprint, but the slopes will be re-profiled to 1v:3.5h (16°) in order to facilitate topsoiling and re-vegetation and to reduce their susceptibility to erosion.

The final downstream profile will be inherently stable under both normal and seismic loading conditions and will allow for vegetation growth. The downstream slope (outer face) of the impounding embankment will be constructed with NAF waste rock.

Please refer to section 2.2.5.5 for a description of how TSF2 will be affected by the reprocessing of TSF1 material for the recovery of residual copper and the deposition of the resulting tailings on TSF2.

The proposed water management system is shown in Figure 45Figure 45. After closure, runoff from the PAF and NAF WRD stockpiles will continue to drain into the same ponds and runoff from the TSFs, which are also NAF, will drain to the embankment drainage. After the WRDs and TSFs have been properly rehabilitated and revegetated as described in Section 2.2.5.5, their runoff will be allowed to drain into the surrounding environment, and the ponds will be removed, once post-closure monitoring has confirmed the runoff to be clean.

There will be a lined runoff collection channel and pond at the toe of each PAF mine waste repository. The runoff will be monitored and, if not suitable for discharge (Table 83Table 83) it will be treated as a temporary measure, until an economically and technically viable mitigation and rehabilitation measure can be devised and implemented during the closure phase.

The manner in which the mine waste facilities will be covered (Section 2.2.5.5) will result in most of the precipitation that seeps into the cover being returned to the atmosphere by evapo-transpiration, i.e. the vegetation will abstract the water and return it to atmosphere via the stomata on the leaves. Production of a significant volume of runoff, particularly shortly after a rainfall event, would be indicative of an area of degraded vegetation cover. In such event, the area of inadequate cover will be located, the cause will be identified and addressed (e.g. repairing erosion damage, adding topsoil, fertilising, planting appropriate varieties of grass under the guidance of a specialist in rehabilitation).

5.5.7 Measures Required for Rehabilitation of Mine Waste Deposits and Dependent Infrastructure (Article 81)

The current slope angle on the rockfill impounding embankments is 1v:1.4h (approximately 36°), as this is the natural angle of repose of the material used for embankment construction. By the end of the mining operation, the TSF embankments will have been flattened to a downstream slope of 1v:3.5h (16°). The outer slopes are planned to be profiled to have 5 m horizontal benches every 10 vertical metres for erosion control. Landform studies will be conducted to validate this design, as closure approaches. The benches will be constructed to provide a stable drainage system for the embankment.

All exposed NAF surfaces used to encapsulate PAF will be capped with 300 mm low permeability soil (laterite) placed in two 150 mm layers followed by 200 mm topsoil at closure. This applies to both horizontal and sloping surfaces.

All PAF storage areas where PAF waste rock is exposed, are planned to be capped with a:

- 500 mm thick capillary break layer consisting of coarse durable NAF rockfill;

- 300 mm layer of low permeability lateritic soil;
- 500 mm coarse, durable NAF rockfill layer to facilitate moisture control and reduce root penetration into the soil liner; and
- 300 mm topsoil layer over the NAF surface, sourced from on-site stockpiles.

Rehabilitation of the TSF upper surface will commence as soon as practicable upon termination of tailings deposition. After removal of the TSF water inventory drying and consolidation of the tailings is expected to take at least several months and might possibly require completion of the capping in the following dry season.

The TSF underdrainage systems may need to continue to operate for some time after completion of capping and re-vegetation to drain excess water from the tailings deposit and to monitor the collected runoff volume and quality (see Section 5.5.6 above). In the event that the underdrainage is not operational, the Closure Plan will be adjusted for any impact this may have on tailings consolidation. Any seepage will be monitored using piezometers and groundwater sampling, and a mitigation plan will be actioned if required to minimise any impacts that may develop.

To improve long-term erosion resistance, the external embankments are typically flattened through a combination of cut and fill (embankment crests and freeboards are no longer required once the tailings surface has been capped). Depending on soils and climate, a batter slope of around 1:6 (V:H) is normally sufficient. The final profile of the tailings surface will therefore slope gently from the embankments towards the final spillway and the low spot on the tailings surface will be adjacent to the spillway. The figures below show this closure concept.

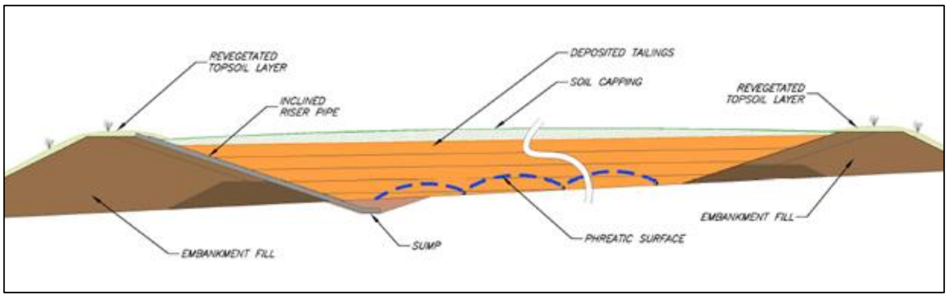

Figure 77: Cross-Section through Tailings Dam indicating Conceptual Closure Design

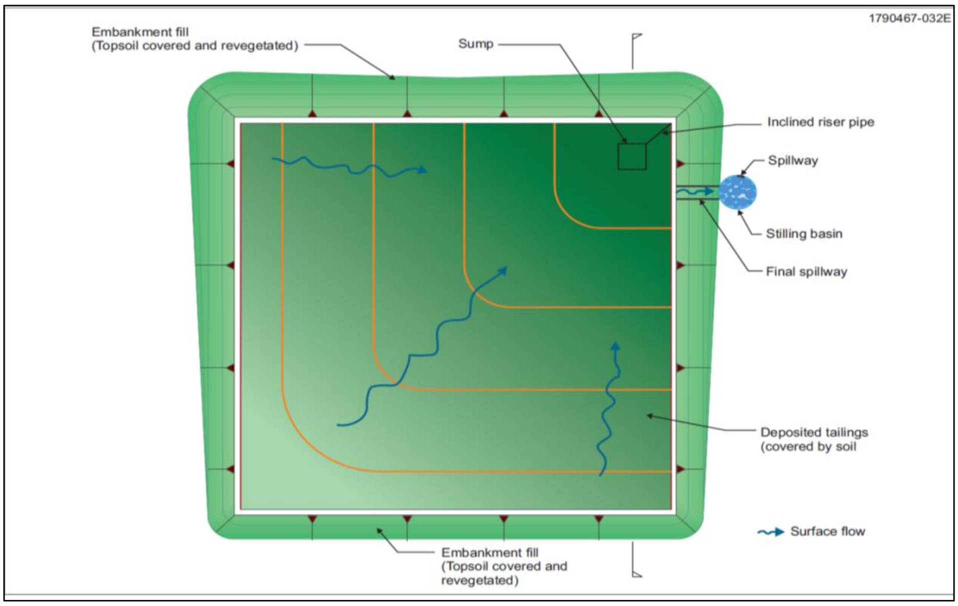

Figure 78: Stage II TSF Closure Concept

The proposed capping configuration for the TSFs is illustrated in Figure 79~~Figure 79~~. It is designed to reduce water infiltration into the underlying tailings, shed any rainfall runoff off the landform and promote vegetation growth:

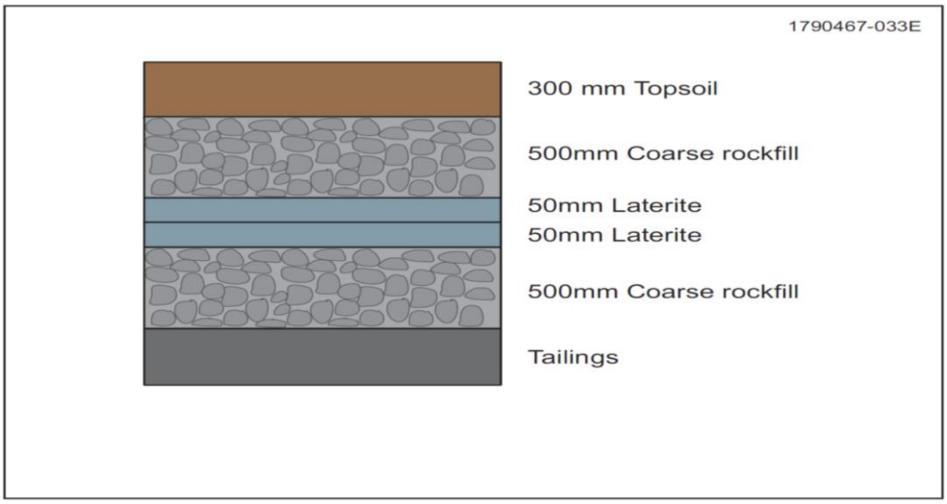

Figure 79: Proposed Capping Configuration

The water management system around the mine waste repositories is discussed in Section 5.5.6 above. The final downstream profiles of the mining waste repositories will be inherently stable under both normal and seismic loading conditions and will allow for vegetation growth. Due to the downstream construction method adopted, the embankment face can only be rehabilitated at closure. The downstream slope (outer face) of the impounding embankment will be constructed with NAF waste rock. The rehabilitated repositories will not be suitable for agriculture and must be left as wilderness areas.

5.5.8 Erection of Water Retention Structures (Article 82)

All water retention facilities associated with the KOU will be designed by qualified civil engineers to meet DRC requirements and will be constructed in terms of good engineering practice.

A minimum freeboard of 1 m will be maintained at all times, or 1.5 m where the downstream environment is sensitive to impacts from spillage. The freeboard will be permanently integrated into the structure by means of a visible ruler. The design will allow for the freeboard to be maintained during rainfall events with a return period of at least 100 years, and 1 000 years if the contents of the facility are acidic or otherwise highly hazardous. Such facilities will have at the same linings as the mining waste deposits or better and no water will be discharged from them until prior treatment to meet the DRC discharge standards (Article 66, Table 83~~Table 83~~).

The design flood shall be based on a 6- or 24-hour event, whichever is more critical, the floodwater evacuation capability must be adequate to meet dam safety requirements, and all retention structures must be well beyond the floodlines of nearby watercourses.

5.5.9 Monitoring Stability of Structures (Article 83)

The water retention facilities will be inspected for physical stability at least once per season and after each exceptional rainfall event. Maintenance/repairs will be undertaken as and when necessary to ensure proper functioning of the facilities and records of inspections and repairs will be kept.

5.5.10 Management of Chemical Products, Solid Waste and Dangerous Waste (Article 84)

All bulk chemicals used in the ore processing plant are stored in bunded areas with impermeable floors and walls, and with a volume equal to at least 110% of the volume of the largest vessel within the bund.

Smaller quantities of consumable chemicals will be stored in secure, well ventilated lockable areas under the control of a designated responsible person.

Hazardous wastes and other solid wastes will be handled and disposed of as described in Section 2.5.1 and illustrated on Figure 16~~Figure 16~~, Figure 17~~Figure 17~~ and Figure 18~~Figure 18~~.

5.5.11 Mitigation Measures relating to Chemical Products (Article 85)

MMG makes use of bulk P101 emulsion supplied by an appropriately licensed supplier. The emulsion is stored in an overhead silo equipped with gassing solution tanks, offloading pumps and piping. Storage is expected to increase from 28 tonnes to 56 tonnes in the short term. Blasting accessories such as Pentolite Boosters, Benchmasters, Handimasters and Cordtex are stored in three magazine containers which are timber lined and earth mounded magazines as required in terms of the DRC Mining Code. Lightning masts provide lightning protection and the area is fenced off with access control.

All hazardous substances, including the toxic, corrosive and flammable reagents listed in Table 9~~Table 9~~, are stored in properly bunded and signposted storage facilities. Other potentially hazardous substances, such as solvents, cleaning chemicals, laboratory reagents, pesticides, etc. are stored in correctly labelled containers, in appropriately secured and signposted facilities, with signage displaying the responsible person and numbers to call in case of emergency. MSDSs for all chemicals are kept at the storage areas. The transport, storage, use and disposal of such products takes place under the supervision of appropriately trained and experienced personnel, and in accordance with relevant DRC Regulations.

Process chemicals are stored within the ore processing area, generally close to where they are used. Storage areas are shown on Figure 5~~Figure 5~~.

5.5.12 Measures relating to Solid Waste (Article 86)

The management of non-mineral solid waste is described in Section 2.5.1. The layout of the environmental yard, showing the types of solid waste handled there is shown on Figure 16~~Figure 16~~. The layout and design of the planned new landfill is shown on Figure 17~~Figure 17~~ and Figure 18~~Figure 18~~, and its location is shown on Figure 5~~Figure 5~~. Kami Metal has been appointed to manage disposal and recycling of Kinsevere's waste in Lubumbashi.

5.5.13 Measures relating to Dangerous Waste (Article 87)

The management of non-mineral solid waste, including hazardous waste, is described in Section 5.2. The layout and design of the planned new landfill, which will be able to accept hazardous waste, is shown on Figure 17~~Figure 17~~ and Figure 18~~Figure 18~~.

5.6 Mitigation Measures Relating to Socio-Economic Impacts

The following measures are proposed to minimise the negative and enhance the positive impacts of the proposed KOU project during all the project phases:

- Avoidance/Prevention:
  - Implement dust-suppression measures as per Section 5.3 dealing with air quality, with the focus being on improving health in the local communities;
  - MMG's community health and safety plan should be maintained and reviewed regularly;
  - Engage with relevant stakeholders to ensure that the recruitment process is fairly and evenly distributed;
  - Demolish all infrastructure which will not be handed over for re-use; and
  - Ensure that adequate handover is done for all local economic development projects.
- Reduction:
  - Directly affected communities should be given special consideration in terms of the benefits arising from the KEP and cobalt recovery project;
  - The local resident status of applicants should be verified in consultation with community representatives;
  - Local businesses should be given preference during the procurement of required goods and suitably skilled and available services;
  - Plan and implement sustainable exit strategies for all projects;
  - Engage socio-economic development institutions in the area to gauge whether they can collaborate on or contribute to some of the development initiatives planned for the communities;
  - The selection of project beneficiaries should be fair and directly affected parties should be given preference;
  - The mine will continue paying direct and indirect taxes and give preference to local procurement;
  - Develop/update a comprehensive influx management plan, authorities and other relevant stakeholders should be engaged during this process;

- Timely and adequate consultation with employees who are dependent on the mine several years before closure;
- Education and training of employees to equip them with skills that could benefit them in other industries after mine closure;
- Engage with local and regional government with respect to the closure of the mine; and
- Manage the community investment plan during the operational phase in a manner designed to transition programs to other providers to promote sustainability after closure.

- Rehabilitation:
  - Develop a compensation plan in consultation with the affected farmers and the authorities (chef secteur Bukanda, chef de groupement Kasongo, administrator of the Kipushi territory, chiefs and community representatives of the local communities) to specify which assets or livelihood resources will be affected by the KOU project, and how these will be compensated for;
  - Support directly affected farmers, who have lost access to land, *via* MMG's farmer support programs;
  - Land should be rehabilitated and seeded with local vegetation, using temporary labour as appropriate. Rehabilitation should include shaping/stabilisation of the side slopes, earthworks to ensure appropriate drainage and the application of topsoil and fertiliser for vegetation establishment as described in Chapter VII; and
  - Identify, together with relevant authorities, economically sustainable, socially acceptable uses for infrastructure where possible and develop handover plans for those assets with local stakeholders.

5.7 Mitigation Measures Relating to Ecological Impacts

The following measures are proposed to minimise the adverse impact of the KOU Project on the ecology within the PE528 and PE7274 tenements:

- Avoidance/Prevention:
  - As far as practicable, infrastructure and mining activities should not be sited on Dry Evergreen Forest areas;
  - An on-site team trained in the identification of invasive plant species and the use of herbicides to be deployed;
  - Quarterly audits of invasive plant species in controlled areas to be undertaken;
  - Limit vegetation clearing to only those areas that are utilised for infrastructure construction, mining operations and waste dumping activities;
  - Adherence to existing Traffic Management Plan, e.g. enforcement of speed limits;
  - Provide driver training and environmental awareness training for employees;
  - Apply mitigation measures in Air Quality section aimed at minimising particulate mobilisation; and
  - Shade netting to be used as dust screens around areas to which plants have been translocated.
- Reduction:
  - Unauthorised activities in any areas of Dry Evergreen Forest will be controlled and minimised through the application of the Kinsevere Land Disturbance and Clearance Procedure;
  - Maintain invasive species eradication program; and

- Restrict access to remaining woodland areas and, where possible, prevent harvesting of firewood.

- Rehabilitation:
  - Seeds of indigenous trees and shrubs should be collected and propagated in the on-site nursery and in cooperation with the University of Lubumbashi to obtain seedlings for rehabilitation;
  - Appropriate stewardship agreements should be put in place with suitable stakeholders to ensure that the translocation receiving areas remain under the care of botanical experts into the future, to ensure their viability;
  - Bare areas to be re-vegetated with indigenous vegetation; and
  - Progressive rehabilitation of waste rock dumps and disturbed land surfaces with indigenous vegetation will be undertaken.

5.8 CHAPTER VI: SAFETY MEASURES

The management and personnel of Kinsevere mine recognise and are fully aware of the potential safety issues associated with mining activities in general and with the specific safety risks associated with the current and future activities at the mine. Accordingly, the mine has implemented and maintains a number of measures to minimise safety risks to its personnel, visitors and the general public (see Table 93~~Table 93~~).

Table 93: Safety Measures

Description	Risk Control Measures	Responsibility
Health and Safety Measures		
All mining activities.	■ All mining related work shall comply with MMG's Safe Task Management Standard, Fatal Risk Standard and Occupational Health and Hygiene Standards and include the legal requirements as described in Article 92 – the *"traditional safety measures"*; ■ Develop an emergency plan in case of accidents or natural disasters (Article 94); and ■ Provide injury treatment for employees at the medical centre on site.	All
Chemicals Management		
■ Storage, use and disposal of chemicals on an industrial scale; and ■ Production of acid in the acid plant.	■ Implement appropriate management practices for chemicals used to ensure the minimisation and mitigation of adverse impacts (Articles 84, 85 and 87) including: ▪ Maintaining an inventory of the stored chemicals; ▪ Documenting locations and descriptions of the storage sites; ▪ Documenting the type of subsoil at the storage sites; and ▪ Establishing disposal procedures for waste chemicals, including used oils. ■ Incorporate safety measures for the management of hazardous products in operational procedures or similar, including (Article 91): ▪ Storing all hazardous products in correctly labelled containers; ▪ Maintaining Material Safety Data Sheets (MSDS) for all chemicals used on site at the point of use; ▪ When transporting chemicals, ensure that the MSDS is available in the vehicle transporting the substance; and ▪ The Emergency Response Plan should include response actions in the event of chemical spills. ■ Implement the Emergency Response Plan for incidents related to acid production on site and transportation off site; ■ Contain the spillage of all flammable and combustible liquids within the on-site containment systems and clean up spillages in a manner that prevents adverse impacts; ■ Ensure that safety measures and procedures for transportation of hazardous materials include (Article 91): ▪ Ensuring that the volume, nature, integrity and protection of packaging and containers used for transportation are appropriate for the type and quantity of hazardous material and modes of transportation involved: – Ensuring adequate vehicle specifications; and – Training employees participating in the transportation of hazardous materials regarding proper shipping procedures and emergency procedures.	Processing Department

Description	Risk Control Measures	Responsibility
Fires on site.	■ Undertake all necessary operational and management measures to maintain the fire prevention and protection system (Article 91); ■ Maintain an Emergency and Contingency Response Plan that includes fire related emergencies; and ■ Manage vegetation on and surrounding the site to limit the build-up of flammable biomass.	Fires on site
Non-Mineral/Non-Hazardous Waste Management		
■ Disposal of waste from Mining and processing activities; ■ Use of products and consumables on site; and ■ Camp and catering facilities.	■ Implement waste management practices and procedures to minimise or mitigate adverse impacts (Article 86) including: Proper management of solid and liquid waste; ▪ Non-hazardous waste will be managed in a designated waste disposal location; ▪ Enforce proper housekeeping measures to ensure that solid wastes are dumped in dedicated areas designed for this purpose and covered to prevent access by animals and flies; ▪ Waste disposal bins should be made available; ▪ Minimise the generation of waste on site by using products that contain less packaging material, and by reusing and recycling waste; and ▪ Separate wastes at source into different waste streams to facilitate ease of recycling and disposal.	Environmental
Social		
■ Responding to complaints.	■ When requested, disclose any significant water quality impacts to the Community Development Committees (CDCs) and explain implications and management approach to mitigate impacts; ■ Record all complaints received about the mining activities, together with details of the complainant and reasons for the complaint; and ■ All complaints must include: ▪ Description of the complaint; ▪ Investigations undertaken; ▪ Conclusions; ▪ Actions taken to resolve the complaint; ▪ Any abatement measures implemented; and ▪ The person responsible for resolving the complaint.	Social Development

Description	Risk Control Measures	Responsibility
■ Transport of goods, equipment and materials to site; and ■ Mobilisation and use of equipment at site.	■ Implement and maintain all necessary measures to ensure safety on the main access road, including: ▪ Undertake regular road maintenance; ▪ Maintain signage along the access road for speed control, vehicle interactions, and pedestrians; ▪ Identify potential high-risk areas to integrate these into construction hazard analysis with community; ▪ Conduct safety and awareness campaigns in villages and schools regarding safety on and near the road during the construction period, including other road users such as motorcycles, taxis, trucks and other private vehicles; and ▪ Work with the Office des Routes to arrange to marshal the Likasi road intersection. ■ Conduct training sessions for employees and for the social development team to use in the community about hazards on the site access road such as: ▪ Traffic density and vehicle speeds; ▪ Visibility in dusty conditions or at night for drivers and pedestrians; ▪ Taking wet weather and eroded surfaces into consideration when driving; ▪ Health hazards from stagnant water along the road; and ▪ Emergency response actions in the event of injury, accident, damage or spillages of dangerous goods. ■ Implement integrated traffic management measures, including: ▪ Dust control measures along the access road (e.g. water carts, increasing watering frequency during the dry season); ▪ Use headlights when driving on the access road; ▪ Oversize and/or over-mass vehicles will require having a lead escort vehicle; and ▪ Schedule oversize and/or over-mass vehicles for off-peak times.	SHE

Description	Risk Control Measures	Responsibility
Socio-economics		
■ General mining operations; and ■ Influx of people due to job opportunities.	■ Actively involve traditional leaders, women and the youth in consultation processes in a culturally appropriate manner; ■ During mining operations economic develop and implement programs and measures that build capacity and encourage community self-reliance, which may include: ▪ Agricultural and economic development activities; and ▪ Community infrastructure. ■ Implement health-related measures regarding the prevention of diseases and epidemics (Article 93) including: ▪ Educate employees and villages on good sanitary practices; ▪ Maintain adequate sanitation facilities for security workers on the boundary of the mining lease area; ▪ Implement malaria control measures if water ponds or collects in the security trench system; ▪ Implement a HIV & AIDS policy; ▪ Raise awareness with employees and villages near to the site for personal protection against malaria and bilharzia; and ▪ Implement and maintain effective control of malaria programs at Kinsevere mine. ■ Where appropriate and feasible, employ local people to reduce influx from other communities; ■ Cooperate with law enforcement authorities; and ■ Maintain employee environmental awareness and management by: ▪ Education on importance of protecting native species in the Kifumashi River and encouraging them to use the river without depleting fish stocks below recoverable levels; ▪ Providing environmental awareness and reforestation initiatives; and ▪ Supporting and contributing to clean-up campaigns.	Social Development

5.8.1 Monitoring and Control of Air Quality and Temperature (Article 88)

The thresholds for air pollution within and outside the perimeter are indicated in Section 5.3.2.

The mine undertakes monthly dust fall measurements at the locations shown in Figure 80~~Figure 80~~ in terms of the MMG Air Quality, Noise and Vibration Management Plan (Anon) and regular monitoring of the air quality in the various operational areas.

Figure 80: Dust Fallout Monitoring Locations

Protective breathing equipment will be located at strategic locations in the sulphide roaster, sulphuric acid plant and solvent extraction areas.

High temperature combined with high humidity may at times be experienced in the milling, flotation, solvent extraction, electrowinning and cobalt recovery plants. When the combination of temperature and humidity results in a poor “comfort index”, workers take frequent breaks outside of such areas.

5.8.2 Monitoring and Control of Noise (Article 89)

The impact of Kinsevere mine’s activities on sensitive receptors will be monitored as indicated in Table 94Table 94 and monitoring results will be recorded and submitted to the mine management in hard copy.

Table 94: Noise and Vibration Monitoring Program

Aspect	Monitoring Requirements	Locations	Parameters	Frequency
Environmental noise	Taking acoustic measurements at noise sources such as the sulphide ore processing plant, electro-winning plant, cobalt recovery plant, vat leaching plant, crushers, haul routes and opencast pits. Physical sampling as per sampling monitoring plan at the noise receptors. Analysis and reporting.	All areas where mine infrastructure has been developed on surface, at the PE528 & PE7274 tenement boundaries and at the noise receptors within a radius of 4 km from the mine.	Noise limits shown in Table 79Table 79.	If noise levels increase, the noise levels should be measured monthly until levels are within the noise limits or Kinsevere mine investigates unacceptable noise levels and implements appropriate mitigation measures.
Ground vibration and air blast	Physical measurement at ground vibration and air blast sources such as the processing plant, haul routes, opencast pits and at the sensitive receptors. Analysis and reporting.	At the opencast pits during each blast and at sensitive receptors nearest to the pits such as in Kilongo, Kalianda and Mpundu Villages.	The ground vibration levels and air blast levels as provided in Table 53Table 53 and Table 57Table 57.	As required basis.

Noise levels will also be monitored quarterly at noisy areas in the workplace. In areas where continuous noise levels exceed 85 dBA, workers will be required to wear hearing protection.

5.8.3 Work in a Confined Space (Article 90)

MMG’s has a comprehensive and detailed Confined Space Entry (CSE) procedure, which contains the following key provisions:

- The SHE department at Kinsevere mine must conduct a hazard assessment for all confined spaces and record the details in a Confined Space Register;
- Identified confined spaces must be permanently signposted “*DANGER – CONFINED SPACE, ENTER BY PERMIT ONLY*”;

- A Rescue Procedure must be developed as part of the confined space program and it must include the following:
  - Procedure for notification and assembly of emergency response teams including the procedure for making the emergency response team available and on standby;
  - Identification, location, and access to equipment necessary for rescue in each type of confined space;
  - Location, use and availability of hazard assessments for each confined space;
  - Where available, documented agreements with external rescue services; and
  - Plans for each type of confined space rescue operation at the location. The emergency response team will be required to practice making confined space rescues at least once every 12 months.
- A trained and competent person authorised as atmospheric tester must test the atmosphere in the confined space before entry;
- A trained and competent CSE sentry will remain outside of and near the confined space;
- Only trained and authorised personnel may enter confined spaces and perform atmospheric testing and sentry duties;
- Records will be kept of all training;
- Breaches in the Confined Space Entry procedure must be investigated through MMG's Incident Reporting process;
- A competent person authorised by the SHE department manager must issue a permit to work in a confined space;
- The Workgroup Supervisor:
  - Reviews the hazard assessment, and assists in identifying permit controls that must be implemented by the Permit Holder; and
  - Gives authorisation to the Permit Holder for work to proceed using specific permits that are identified as required for a given task.
- Smoking, matches, lighters and other similar items are prohibited in confined spaces;
- Prior to performing any hot work within a confined space, a risk assessment must be conducted on following;
  - Fire hazards from welding and burning gases, residual chemicals and metal chips and fines;
  - Health hazards from the generation of toxic gases from the base metal, electrode or shielding gases; and
  - Electrical hazards.
- Where there is hot work within a confined space, continuous monitoring is required, and a Hot Work Permit will be raised;
- Grounding and isolation procedures shall be implemented prior to electrical welding in the confined space;
- No cylinder of liquefied or compressed gas, except for self-contained breathing apparatus (SCBA) cylinders, is to be taken into a confined space. All cylinders must be turned off immediately after use

and removed from the confined space, with their hoses, when the confined space is left unattended for extended time periods. All hoses will be fitted with flame arrest non-return valve systems;

- Personal protective equipment to be worn in a confined space shall protect against foreseeable hazards;
- Either double insulated or Residual Current Device-protected electrical tools, and lighting systems that are low current – low voltage, with a maximum of 32 volts, will be used in damp or metallic confined spaces. Primary and emergency lighting will be provided to enable work to proceed safely and to facilitate an emergency exit;
- Electric and pneumatic tools shall be selected to eliminate sparks and other hazards as required by the conditions in the confined space. Portable tools shall be cleaned and visually inspected for defects that may affect safe operation before use in any confined space;
- Only electrical, pneumatic or gas operated tools that have been inspected, certified and tagged in accordance with the inspection and tagging policy may be used in CSE tasks;
- Nobody shall enter a confined space until:
    - The Permit Holder has been provided with a completed CSE Permit and Permit to Work by the Permit Issuer;
    - The Permit Issuer has advised the Permit Holder of the required isolations that are in place;
    - The Permit Holder understands and complies with the requirements of the CSE Permit;
    - A record of the work team's presence in the confined space is established; and
    - All other Permit to Work procedures are followed, i.e. isolations completed and placement of personal danger lock and tag by anyone working on the equipment.
- All the permit documentation, the Hazard Assessment and the Rescue Plan together with the lockbox will be at the entry point to a confined space for the duration of entry. These shall be displayed in a prominent place, usually adjacent to the confined space entry point;
- When the open-entry point to a confined space is left unattended, signage indicating *NO ENTRY* shall be displayed, and the opening sealed with danger tape. These will remain in place at the entry point for the duration that the space is unattended, or until the CSE Permit is closed;
- Where there is more than one entry to the confined space, the other entry points shall be sign posted *NO ENTRY, EMERGENCY EGRESS and KEEP CLEAR* and barricaded in a way that shall prevent involuntary entry, but will allow for emergency egress;
- A communication system must be agreed upon before any work begins in a confined space;
- Before the space is entered, the CSE Sentries must also confirm their ability to contact emergency services;
- Where persons entering a confined space are not wearing SCBA, the confined space must be ventilated by natural, forced or mechanical means in order to establish and maintain a safe environment;
- Isolation locks, tags, blanks and other protective lock-out systems must only be removed after the Permit Holder has signed off and handed back the CSE Permit and Permit to Work to the Permit Issuer; and
- The Permit Issuer must sign off on the Isolation Registration Sheet to allow the Authorised Isolator to de-isolate.

5.8.4 Dangerous Products and Mine Waste (Article 91)

All hazardous substances, including the toxic, corrosive and flammable reagents listed in Table 9Table 9, are stored in properly bunded and signposted storage facilities.

Other potentially hazardous substances, such as solvents, cleaning chemicals, laboratory reagents, pesticides, etc. are stored in correctly labelled containers, in appropriately secured and signposted facilities, with signage displaying the responsible person and numbers to call in case of emergency. MSDSs for all chemicals are kept at the storage areas. The transport, storage, use and disposal of such products takes place under the supervision of appropriately trained and experienced personnel, and in accordance with relevant DRC Regulations.

The transport and processing of ore and the management of mining wastes (waste rock and tailings) is undertaken by appropriately trained and experienced personnel, and in accordance with applicable DRC Regulations. The physical properties, phreatic surfaces, underlying ground conditions and 50-year rainfall recurrence intervals are considered in the design and operation of mining waste management facilities, to ensure the stability of such facilities.

In particular:

- Tailings storage facilities and any other water retention structures are designed by and constructed under the supervision of a suitably qualified and experienced engineer;
- The base areas of dams and other retention structures are protected from floods by berms and drainage channels (Article 83);
- Water retention structures are operated with a minimum freeboard of 1 m. When the failure of the retention structure could cause a negative impact to a drinking water catchment/intake, a neighbouring community, fauna, a protected on sensitive area the minimum freeboard shall be 1.5 m minimum (Article 82);
- The freeboard level is marked to ensure that it is clearly visible during inspections of the structure (Article 83); and
- The physical stability of the structure and adjoining structures is inspected once per season and after exceptional climatic events (Article 83).

5.8.5 Classical Safety Measures (Article 92)

The following standard safety measures are standard in the mining industry and are applied at MMG's Kinsevere mine:

- All machines with movable parts that could cause injuries, e.g. conveyor systems, crushers, mills, mixers, flotation cells, drill rigs, generators etc. are equipped with an emergency stoppage mechanism. During maintenance, a lockout procedure that prevents the machinery from being started accidentally, is applied by the maintenance personnel;
- Guard rails have been fitted to all stairways and raised areas such as platforms and walkways;
- All electrical equipment is insulated, earthed, protected and installed in compliance with the applicable DRC installation standards;
- Each employee is provided with personal protective equipment (PPE), such as a helmet, boots, safety glasses and gloves and employees are required to wear them when entering designated safety areas;
- Employees exposed to high levels of dust are required to wear dust masks and suitable protective clothing, as provided by the mine;
- Employees exposed to noise levels of 85 dBA and higher are required to wear hearing protection equipment, as provided by the mine;

- Blasting operations are carried out only by workers who are competent and certified to use explosives in accordance with the relevant regulations;
- Blasting is done during daylight hours only and the person in control of the blast takes all necessary measures to ensure prior evacuation of all people within a radius of 500 m from the blast; and
- Employees and contractors who contravene the safety measures are subjected to disciplinary measures and appropriate sanctions in terms of MMG Kinsevere's procedures applicable to personnel and service providers.

5.8.6 Section II: Safety Measures Concerning Local Communities, Visitors and Personnel

5.8.6.1 Local Communities

- MMG's Kinsevere mine takes all necessary measures to ensure that its impacts on the surrounding environment remain within the DRC's guidelines and legislated standards, which are designed to be protective of human health and safety during the construction, operational and decommissioning/closure/rehabilitation phases of the mine;
- The efficacy of such measures is monitored on a regular basis and corrective measures are developed when necessary;
- The mine maintains a grievance procedure and all complaints are investigated and resolved a soon as practicable; and
- The mine has placed security barriers, which have been designed and constructed not only to protect the mine's assets, but also to prevent people from exposure to potential health and safety risks, around the perimeter of its operational area.

5.8.6.2 Visitors

- All visitors undergo safety induction prior to entering any of the mine's operational areas; and
- Visitors are always accompanied by competent and experienced mine personnel when in operational areas.

5.8.6.3 Personnel

- MMG's Kinsevere mine takes all reasonable measures to ensure a safe working environment and adherence to safe working procedures;
- All personnel receive training in the mine's general safety policy and procedures, augmented by on-the-job training in safety measures and procedures applicable to specific areas with higher safety risks, such as the opencast mines, haul roads, TSFs and ore processing plant;
- All personnel and visitors are subjected to a breathalyser test for alcohol upon entering and leaving the mine's premises; and
- Safety committees have been set up for the various work areas. They have regular meetings in which safety matters are discussed, especially recent incidents and new safety procedures.

5.8.6.4 Article 404 bis: Measures to Prevent Exposure to and Contamination by Radioactive Materials

Kinsevere mine is responsible for radiation protection for all its activities in accordance with the Law on the Protection against the Hazards of Ionizing Radiation and the Physical Protection of Nuclear Materials and Installations and the Decree on the Regulation of Protection against the dangers of ionising radiation.

Kinsevere mine must ensure the radiological protection of its workers and take all necessary measures to prevent its mining activities from being sources of radiological contamination of the environment to prevent exposure of the public to ionising radiation. A dosimetry study was undertaken at the Kinsevere mine by the

General Commissariat for Atomic Energy (CGEA) of the DRC in July 2015 (Kazadi, F; Kaka, P; Hongo, R; Kabamba , E; Ndiku, S; Mwamba, V;, July 2015). The key findings were:

- Process control instruments with radioactive sources are used at ten locations across the mining and ore processing operations;
- Uranium minerals in the ore emit α, β and γ radiation. Workers in the mine and ore processing plant can be exposed to α radiation by inhalation or ingestion of fine particles suspended in the air, and to β and γ radiation by being in close proximity to the ore, mineral concentrates and mining wastes;
- The background radiation across the mining lease area varied from 0.05 µSv/h to 0.12 µSv/h. An average value of 0.10 µSv/h was taken as the baseline;
- All measured values were below the occupational limit of 20 mSv per annum and no inhalation or ingestion risks in excess of the authorized limits were found. The values measured at various points, after subtracting the baseline value, were as follows:
  - 0.13 µSv/h to 0.65 µSv/h (at the contact), or an annual dose ranging between 0.3 mSv and 1.3 mSv in the Central Pit Tshifufya (Quarry 1);
  - 0.07 µSv/h to 0.30 µSv/h, or an annual dose ranging between 0.14 mSv and 1.3 mSv in the Central Pit Tshifufya (Quarry 2);
  - 0.15 µSv/h to 1.25 µSv/h (on Mashi Pit), i.e. an annual dose of 0.3 mSv to 2.5 mSv at the contact;
  - 0.12 µSv/h (on Kinsevere Hill, under stripping) to 0.17µSv/h, or an annual dose of 0.2 mSv has 0.24 mSv while in contact with the ores;
  - 0.10 µSv/h to 0.15 µSv/h (at the RoM PAD);
  - 0.35 µSv/h to 5 µSv/h on the drill core samples stored in the Geologists/Exploration Office, outside and in the store, representing an annual dose between 0.7 mSv and 10 mSv at the contact;
  - 1.05 µSv/h to 8 µSv/h while in contact with the instruments at the ore processing pond and 0.9 µSv/h to 1µSv/h at ±1 m from the instruments. The highest dose rate measurement, 8 µSv/h, is equivalent to an annual dose of 16 mSv. In the Stage 2 plant, the values of dose rate measured varied from 0.25 µSv/h to 2 µSv/h in contact; and
  - 8 µSv/h while in contact with the instruments at the Cyclones Plant and 1 µSv/h at ±1 m from the instruments.
- The occupational categories likely to receive annual doses ranging between 6 mSv and 13 mSv will be subject to the personal dosimetry monitoring program. These include geologists, operators of mining machinery and vehicles, drilling and blasting personnel, the instrument technicians and maintenance personnel in the controlled areas, and the personnel responsible for radiation protection, etc. These occupational categories are classified as “Category A” and their working areas constitute “Controlled areas”;
- Other personnel who enter the controlled area periodically are classified as “Category B” and their working areas constitute “Monitored Areas”. These designations could change, depending on the collection of personal dosimetry data; and
- The key finding was that Kinsevere mine should establish an operational radioprotection program which would include:
  - Definition and assignment of responsibilities for executing the program;
  - Designation of the work areas and categorisation of the employees;
  - Radiological monitoring and control measures;

- Dosimetry monitoring of employees who are exposed to ionising radiation;
- Formal management of radioactive sources, including assessment of security risks and providing appropriate protection;
- Purchase of detection and measuring equipment;
- Developing procedures for working in the controlled area (work permits) and for transporting radioactive sources;
- Training of personnel exposed to ionizing radiation;
- Monitoring the environmental effects of radioactive particles migrating from the mine into the surrounding environment;
- Installing appropriate signage in the main languages used at the mine;
- Prohibition of eating, drinking and smoking in the controlled areas; and
- Establishing secure storage facilities for radioactive sources that are not in use.

5.8.7 Measures relating to Health (Article 93)

- MMG's Kinsevere mine maintains an on-site clinic staffed by professionals who provide coverage for employees' medical needs and work-related injuries.
- The medical personnel are equipped to treat general medical conditions (common illnesses, malaria and similar conditions), and minor accidents and injuries. The clinic also facilitates the stabilisation and transport of serious injuries and illnesses;
- The concentrations of several hazardous substances such as crystalline silica, acid mist and welding fumes are monitored, and the amount of time spent by individuals in the various work areas is tracked. Noise levels in the workplace are also monitored;
- All personnel are subject to regular medical check-ups for early detection of developing signs of occupational diseases and conditions that could compromise their safety in the workplace; and
- The mine operates a mosquito control program and provides mosquito repellent in the workplace and the visitors' accommodation camp.

5.8.7.1 Emergency Measures (Article 94)

The Emergency Response Plan (ERP) forms part of the Kinsevere Safety and Environmental Management System. It contains information on the planning for emergency situations that could occur at the site. It acknowledges that it is vital for staff members to be suitably trained and to have their skills improved through regular training exercises and mock scenarios.

The plan is based on a comprehensive approach to emergency management and is designed around the four elements of this approach, namely: prevention, preparedness, response and recovery. This approach meets the requirements and principles of *Safety & Health in Mines ILO – Geneva* and the *Australian Mines Safety and Inspection Regulations 1995, Division 3 – Emergency Preparation.*

The chemicals, fuels, gases and explosives stored and used on site are listed in the ERP and typical emergency situations that could arise are described in summarised form.

The ERP identifies the responsibilities of various management members and outlines the personnel requirements for the Emergency Response Team (ERT) that is responsible for various aspects of the plan and the maintenance thereof. It also outlines the communications procedure and the methods of rating the severity of various emergencies. The emergency response plan and the risks are communicated to the local authorities and communities. The ERP is reviewed annually.

The ERP is based on MMG's "*Comprehensive Approach to Emergency Management*" and is designed around the various elements of this approach, namely:

5.8.7.2 Prevention

Prevention covers both regulatory requirements and physical measures to reduce the likelihood of emergencies and lessen their effects. It includes being proactive in identifying possible emergency situations that could arise.

The preventative measures included in the plan involve identifying and preventing:

- Ground and wall failure within the pit;
- Vehicle accidents on and off the mine lease area;
- Injury requiring medical evacuation;
- Structural failure within the plant area;
- Release of hazardous chemicals on and off the mine lease area; and
- Injuries at remote sites during exploration.

The measures also include:

- Snake handling and relocation;
- Fogging and spraying in and around the site; and
- Managing bush fires.

5.8.7.3 Preparedness

Preparation for foreseeable emergencies requires the involvement of all personnel on site with specific responsibilities being undertaken by key personnel. The ERT must have volunteers in every department that can act as first responders during an emergency.

Preparation for emergencies is on-going and includes:

- Regular testing and maintenance of portable and fixed fire suppression systems;
- Annual review and update of existing emergency procedures and plans;
- Supply and maintenance of emergency response equipment; and
- Training of personnel in response procedures and use of equipment.

The systems, infrastructure and procedures in place in preparation for emergencies include:

- Alerting systems including:
  - Two electric sirens;
  - Hand siren at the MMG camp; and
  - Communication system which includes:
    - Mobile phones and emergency phone number list;
    - Security Control Room manned 24/7; and
    - Emergency radio channel.

- Firefighting equipment that includes:
  - Fire detection systems (smoke detectors);
  - Fire extinguishers;
  - Water tanker trucks; and
  - Firewater pumps.
- Emergency response equipment that includes:
  - Rescue and fire truck; and
  - Ambulance.
- Standard Operating Procedures; and
- Training of personnel.

5.8.7.4 Response

Any employee who discovers an emergency shall raise the alarm by activating a siren and/or using a two-way radio or mobile phone to contact the Control Room or to report it to a member of the management. Emergency contact numbers are listed in an appendix to the ERP and displayed at numerous places on the site.

The response actions have been detailed by incident type:

- Accident involving serious injury to any person on site or an employee off site;
- Fire on site or fire off site required to be attended to by the emergency response team;
- An explosion on site;
- A major chemical spillage posing a risk to personnel or the environment, on or off site;
- Overflow of tailings storage facilities;
- Release of a flammable or toxic gas on site;
- Bomb threat on site;
- Vehicle accident on site;
- Failure of the flammable/hazardous substance store; and
- A person becoming trapped on site.

5.8.7.5 Communications

The person who first notices a potential or actual emergency will report it to their immediate supervisor who will notify the Emergency Response Team and Security. The Security Department will notify the relevant Managers who will deal with the incident. Environmental emergencies incidents will be reported to the Environmental Manager, who will be responsible for notifying the relevant authorities.

If an emergency arises that may impact on the communities in the area, MMG will appoint a spokesperson who will liaise with the public, media and other external parties.

5.8.7.6 Recovery

The recovery activities following a major emergency are the responsibility of the site management team and are intended to return the site to normal as soon as possible after an emergency.

5.9 CHAPTER VII: MITIGATION AND REHABILITATION MEASURES AFTER SITE CLOSURE

5.9.1 Description of Mitigation and Rehabilitation Measures after Site Closure (Article 95)

The DRC legislation requires the owner/operator of a mine upon closure to:

- Eliminate the risk of harmful effects on people's health and safety and restore the site to a condition that is acceptable to the community and compatible with future use;
- Limit the production and propagation of substances likely to harm the receiving environment; and
- Monitor the efficacy of the mitigation and rehabilitation measures until acceptable rehabilitation has been achieved.

MMG's vision, in terms of mine closure planning, is as follows:

"We are committed to minimising the legacy impacts on the environment post-closure of our operational activities. We adopt a life-of-asset approach to closure planning which includes technical assessment, forecasting, and consulting with relevant stakeholders. The content and level of detail in our Closure Plans depends on the timeframe to closure and decommissioning of the asset. We focus our business resources on assets within five years of expected closure.

We also aim to manage the impacts of mine closure on employees, host communities and economic development through our workforce transition strategies and the social development programs we implement during operations. By aligning our social development programs with our Life-of-Asset Plans we are focusing on longer-term economic development which is not reliant on mining."
MMG, 2017

MMG's closure planning process for the Kinsevere mine is guided by the requirements of the DRC Mining Code and the MMG Life of Asset Standard (MMG, 2015), which reflects MMG's current approach to closure planning and execution, and alignment with International Council on Mining and Metals (ICMM) principles.

5.9.2 Revegetation (Article 96)

The likely closure scenario related to the KOU, as reflected in Table 95~~Table 95~~ below, is based on the life of mine, mine planning and the battery limits for closure. This closure scenario has largely been adapted from the existing conceptual closure plan for Kinsevere ((Anon;, February 2017)) to ensure closure planning alignment.

Table 95: Closure Scenario for Key Infrastructure/Mining Areas Associated with KOU

Remaining Operational Period	Closure Period
Infrastructural and Plant Areas	
■ All surface infrastructure considered redundant/defunct during operations (i.e. obsolete plant, roads no longer needed to support operations and redundant buildings), will be appropriately decommissioned and rehabilitated; ■ Suitable third-party transfer agreements for infrastructure that is to be transferred for third party beneficial re-use post-closure will be put	**Likely closure option: Wilderness or industrial development** ■ On completion of mining activities, the infrastructure and services will either be decommissioned/demolished and returned to safe and stable landforms, to allow the intended post mining land use, or transferred to a third party for beneficial re-use; ■ Contaminated sediment will be removed and disposed of in the hazardous waste cells of

Remaining Operational Period	Closure Period
in place (e.g. infrastructure, access roads, etc.); and ■ Obvious surface contamination at workshop areas is removed as and when it occurs.	the landfill (Figure 17~~Figure 17~~ and Figure 18~~Figure 18~~); and ■ Infrastructural footprint areas will be shaped to be free-draining with vegetation cover, which will include the removal and appropriate disposal of contaminated.
Waste Rock Dump (WRD)	
■ Non-acid forming (NAF) oxide waste rock will be placed along the perimeter of the expanded WRD facility. Potentially acid forming (PAF) sulphide and transitional waste rock will be placed inside the "oxide shell" and will ultimately reduce the area to be capped; ■ Where possible, concurrent rehabilitation will be undertaken on the inactive sections and slopes of the WRD to increase slope stability and minimise erosion/dust generation during operations, and decrease required rehabilitation works at closure; and ■ Engineering designs for the creation of the chosen landform would have been obtained.	**Likely closure option: Wilderness** ■ The WRD will be rehabilitated and seeded with locally indigenous vegetation to create an area of unused land ("wilderness area"); and ■ Rehabilitation will include shaping/stabilisation of the side slopes, earthworks to ensure appropriate drainage, and capping with a 300 mm low permeability soil (laterite) placed in two 150 mm layers followed by 200 mm topsoil and the application of fertiliser for the establishment of vegetation.
Expanded Opencast Pits	
■ Studies to inform the choice of the final landform option for the open pits will be undertaken, and the final closure option will be selected; and ■ Engineering designs for the creation of the chosen landform will be developed.	**Likely closure option: Pit lakes** ■ After closure, access will be restricted, and pit lakes will be allowed to form from groundwater inflow and rainfall. Use the water will depend on the final in-pit water quality. Pit lake water balance modelling indicates that the pit will not decant to the environment. The lakes are not expected to be acidic; and ■ An abandonment bund of rock will be constructed around the perimeter of the pit.
Tailings Storage Facility 3	
■ Studies to inform the chosen final rehabilitation design/option for TSF3 will be undertaken, and the final closure option will be selected; ■ Excess water inventory from the TSF will be removed; ■ TSF side slopes will be re-shaped and profiled during operations to facilitate capping and revegetation and manage erosion; and ■ Engineering designs for the creation of the chosen rehabilitation design/option will be developed.	**Likely closure option: Wilderness/unused land** ■ The TSF will be capped with a 300 mm low permeability soil (laterite) placed in two 150 mm layers followed by 200 mm topsoil and the application of fertiliser for the establishment of vegetation; and ■ Access to the TSF will be restricted to prevent agriculture, extractive uses (e.g. artisanal mining, brick making) or habitation by the local communities.

The final land uses at the closure of Kinsevere are still to be assessed in more detail and preferred options are to be selected. The most feasible next land use of each area will to a large extent also depend on its current use. For example, TSF3 can only be rehabilitated to wilderness use and will not support agriculture or other intensive activities.

In addition, future beneficial uses would require that agreements be reached with third parties that would take ownership of specific facilities. These agreements have not been developed yet and therefore the potential future uses remain conceptual.

It may be necessary to place restrictions on future land uses such as agriculture, brick making or habitation, to ensure that the integrity of closure landforms is not compromised.

5.9.3 Contaminated Soils (Article 97)

A contaminated land assessment plan will be developed during the final year of the mine life. Records of spills and other incidents during operations will guide the focus of the contaminated land assessment study. After the removal of plant and infrastructure, a contaminated land assessment will be undertaken to identify, characterise and quantify the contaminated soil areas.

Contamination at Kinsevere is likely to include:

- Acid spills;
- Solvent/diluent spills;
- Hydrocarbons; and
- Footprints of Black Shale and other sulphide material stockpiles.

5.9.4 Action relating to Contamination Exceeding Criterion B (Article 98)

In areas where contamination is found that could affect the quality of runoff and/or groundwater, an in-depth analysis will be done to characterise the degree of contamination in terms of DRC and/or international soil screening values.

5.9.5 Mitigation and Rehabilitation Work on Contaminated Soil (Article 99)

Appropriate decontamination action will be taken, depending on approved the post-mining land use and associated risk assessment. Where practicable, in-situ remediation will be done (e.g. digestion of hydrocarbons by bacteria). Other contaminated soil will be excavated and safely disposed – e.g. in the hazardous waste section of the landfill or within the mine waste storage facilities (TSF and/or WRD).

5.9.6 Measures relating to Buildings, Infrastructure and Surface Equipment (Article 100)

All buildings and surface infrastructure, except structures that will be left for beneficial use by formal agreement with the authorities and the local communities, will be dismantled and removed from the site.

The walls of administration and accommodation buildings will be removed, foundations will be excavated to a depth of 1 m covered with topsoil and vegetated.

Recyclable materials (metals, glass, plastic, wood, etc.) will be sold. Other scrap will be disposed of in the pit voids, within the mine waste storage facilities or in the hazardous waste section of the landfill, depending on the results of a risk assessment.

5.9.7 Measures relating to the Headframe, Service Buildings and Processing Plant Buildings (Article 101)

As per Section 5.9.6 above.

5.9.8 Measures relating to Support Infrastructure (Article 102)

Underground infrastructure such as pipework will either be left in place or removed, depending on the site's post-mining use for residential, industrial, tourism, agricultural or forestry purposes.

Openings of and access points to support infrastructure that is to remain in place will be sealed off and the mine will provide the authorities with a map of such infrastructure.

5.9.9 Measures required for Transport Infrastructure (Article 103)

The main access road to the mine and secondary access roads needed for post-closure monitoring will be maintained until monitoring is no longer required. Other mine-related roads used by the local population will be left in place.

Land on which roads have become unnecessary will be restored as follows:

- Road surfaces and shoulders will be ripped, scarified, levelled and revegetated;
- Bridges, culverts and pipes will be removed, and ditches will be filled in; and
- Mine-affected drainage lines will be restored to enable resumption of the natural flow of water and the edges of affected watercourses will be stabilised by the establishment of vegetation or the deposition of rock/establishment of riprap. Similar anti-erosion measures will be applied to steep slopes.

5.9.10 Measures relating to Electrical Equipment and Infrastructure (Article 104)

Mine-related electrical infrastructure will be dismantled and removed if it is not necessary for follow-up maintenance and monitoring or a request for it to remain has been made to the Ministry of Mines by local communities. The soil quality around the transformers will be assessed and it will be rehabilitated if it is contaminated by oil.

5.9.11 Measures relating to Surface Equipment and Heavy Machinery (Article 105)

All heavy machinery that was used in mining operations and all plant equipment that was used to process the ore will be removed from the site, soil will be assessed and treatment/removal measures will be applied in the event of contamination.

5.9.12 Measures relating to Underground Equipment, Heavy Machinery and Infrastructure (Article 106)

Kinsevere is an opencast mine. There are no current plans to undertake underground mining.

5.10 Section III: Measures Relating to Underground and Open-Air Work

5.10.1 Article 107: Measures relating to Excavations and Areas of Stripping

Excavations and stripping areas other than the opencast voids will be backfilled. A 2 m high embankment with a trench (2 m wide and 1 m deep) in front of it will be constructed. The wooded area between the embankment and the trench will be thinned. Signage will be installed at appropriate intervals.

5.10.2 Article 108: Excavations and Open Pits

Excavations will be backfilled, where technically feasible, with material approved by the DPEM. All access roads will be closed, and a fence complying with the requirements of the Mining Regulations will be erected. Embankment barriers and trenches as described in Section 1.10.2 above will be installed. The barriers will be at least 15 m from the pits.

5.10.3 Article 109: Safety of Above-ground Openings

Kinsevere is an opencast mine. There are no openings to underground operations. Safety measures to prevent accidental access to the opencast voids by humans and animals are described in Sections 5.9.11, 5.10.1 and 5.10.2.

5.10.3.1 Article 110: Measures relating to the Stability of the Surface Pillars

Kinsevere is an opencast mine. There are no underground operations.

5.10.3.2 Article 111: Measures relating to Mine Water Ponds

All drainage infrastructure, including settling ponds basins and dykes, will be levelled, rehabilitated and revegetated. Any sludge or sediment present in these ponds will be disposed of within the TSF.

5.10.3.3 Article 112: Measures relating to Waste Dumps

The mining waste repositories will be designed to have long term stability after closure, with low apparent risk of erosion, subsidence or collapse. The shaping and vegetation of the facilities will be done in a manner designed to achieve acceptable visual appearance. Acid generation and the leaching of contaminants will be monitored for compliance with the regulated requirements.

5.10.3.4 Article 113: Measures relating to Physical Stability

The slopes of the facilities will comply with the stability criteria set out in Annexure XIV of the Mining Regulations.

5.10.3.5 Article 114: Measures relating to Wastes that Generate Acid Mine Drainage

As described in Section 2.2.5.1, a modest amount, between 10 and 15 Mt, of potentially acid forming (PAF) material will be mined over the life of the operation. It could either be placed on a liner or NAF base layer, encapsulated in designed cells within the WRD surrounded by NAF material or used as compacted backfill in Kinsevere Hill pit between NAF material.

Structures will be put in place to direct uncontaminated runoff water towards the natural and constructed drainage channels and to collect and impound contaminated runoff. If contaminated runoff continues during the closure phase, temporary water treatment will be undertaken until an economically and technically viable mitigation and rehabilitation measure can be devised and implemented.

5.10.3.6 Article 115: Measures relating to the Tailings Deposits and Sedimentation Ponds

The tailings storage facilities (TSFs) will be designed and built to be resistant to deterioration, erosion or subsidence when subjected to water or wind erosion, anthropogenic actions, frost and thaw cycles, root damage, animal burrows or earthquakes.

5.10.3.7 Article 116: Measures relating to the Physical Stability of Confinement Structures

The confinement structures will be designed and constructed to remain stable after mine closure, when no more mining waste is being added.

5.10.3.8 Article 117: Measures relating to the Chemical Stability of Materials

Structures will be put in place to direct uncontaminated runoff water towards the natural and constructed drainage channels and to collect and impound contaminated runoff from PAF stockpiles. If contaminated runoff continues during the closure phase, temporary water treatment will be undertaken until an economically and technically viable mitigation and rehabilitation measure can be devised and implemented.

5.10.3.9 Article 118: Measures relating to Water Collection Structures

Water collection systems will be established to divert uncontaminated runoff into the natural environment and to collect contaminated runoff, seepage and overflows. The containment and collection structures comply with the physical stability criteria set out in Annexure XIV of the Mining Regulations. Flow channels and spillways will be lined with rock.

5.10.3.10 Article 119: Measures relating to Mine Effluents

The solid and liquid mine wastes and their management measures are described in Sections 2.5.1, 2.9, 2.10, 5.4.1.7, 5.4.1.9, 5.5, 5.8.4, 5.10.3.5 and 5.10.3.6.

5.10.3.11 Article 120: Measures relating to Sanitation Installations

Septic tanks will be emptied and filled with inert material. The sludge in domestic waste treatment ponds will be removed and used as fertiliser or disposed of at other authorised sites and the ponds will be backfilled and vegetated.

5.10.3.12 Article 121: Measures relating to Petroleum Products

Storage sites for petroleum products will be rehabilitated by demolishing and removing the steel and concrete structures, undertaking a contaminated land assessment in the vicinity of such facilities, remediating any contaminated soil as described in Section 1.9.5 vegetating the sites.

5.10.3.13 Article 122: Measures relating to Dangerous Waste

No hazardous waste as defined in Article 122 will be left on site in an exposed manner.

As described in Section 5.10.3.2, sludge or sediment recovered from pollution control ponds will be disposed of within the TSF. Other hazardous waste will be disposed of in the appropriate cells in the landfill.

Waste oils will be sent to a waste transfer centre or to an authorised recycling or reuse site. Oil and equipment contaminated with PCBs at a concentration below 50 ppm will be transported to treatment/disposal site authorised by the DPEM.

Mobile treatment units will be used to reduce the concentration of PCBs, but if the concentration remains above 50 ppm, such oils and equipment will be stored until an adequate method of destruction becomes available.

5.10.3.14 Article 123: Measures relating to Solid Waste

In terms of Article 123 inert general waste may be sent to:

- A landfill site or in-trench disposal site authorised by DPEM;
- A disposal site for dry materials authorised for the mining site; or
- An in-trench disposal site for solid waste especially authorised for the mining site.

Burning of waste in in-trench disposal sites is permitted so long as the smoke and fumes do not cause any environmental damage.

Solid waste that cannot be sold or recycled will be disposed of at the mine's landfill site.

6.0 TITLE VI: BUDGET RELATING TO THE SITE MITIGATION AND REHABILITATION PROGRAM (ARTICLE 124)

The 2017 closure cost estimate prepared by Knight Piésold (Anon;, February 2017) was based on the South African Department of Mineral Resources (DMR) "*Guideline Document for the Evaluation of the Quantum of Closure-Related Financial Provision Provided by a Mine*" (January 2005).

This Guideline Document will be replaced by new financial provisioning regulations, but since the new document has not yet been published, this 2018 closure cost estimate has applied the same methodology as previously, using current general arrangement drawings and photographs.

The closure costs for the changes in the Primary Copper project (now known as the KEP) as part of the Kinsevere Operational Upgrades (KOU) Project, indicated as KOU in Table 96~~Table 96~~ and Table 97~~Table 97~~ have been determined in the same manner.

Closure costs associated with the previous EISs undertaken for the Kinsevere mine are summarised in Section 6.3 below. Implementation costs for the majority of mitigations will be absorbed in Kinsevere mine's operational budget that is review quarterly. The capital expenditure for the TSF3 HDPE liner is estimated to be $US 4 million (excl. VAT).

6.1 Unit Rates

The closure costs were determined according to the DMR Guideline master rates, which were published in 2005. These rates were escalated to 2018 values using the SA Statistics CPI values, as required by the Guideline Document.

As applied in the 2017 Knight Piésold cost determination, a further increase of 15% was added to the master rates, since the average construction rates in the Democratic Republic of the Congo are higher than in the Republic of South Africa.

The adjusted rates in South African Rand (ZAR) were converted to US Dollars (US$) at an exchange rate of 13.19 ZAR = 1 US$.

The following weighting factors, as relevant to MMG Kinsevere, were applied to the costing, as per the DMR Guideline Document:

- Weighting factor 1: Flat terrain = 1.0; and
- Weighting factor 2: Remote area = 1.1.

6.2 Assumptions and Qualifications

The following high-level assumptions were applied to the cost estimation:

- Preliminaries and General (P&Gs) have been included at 12%, and contingencies have been included at 10%, aligned with the DMR Guideline Document;
- The costs have been determined for the KOU only, as per the battery limits identified in Section 2.2.2.2.1;
- Demolition was applied to all infrastructure components, including those that may have a beneficial future use;
- For the purposes of cost calculations, no resale or salvage value was assigned to mobile equipment, plant components, scrap metal or other products of demolition; and
- All waste will remain on site and be managed in such a way as to form part of the post-closure landscape, including general and hazardous waste.

6.3 Summary of Closure Costs

The estimated closure costs for the KOU project, at the end of June 2018, amount to **$ 4.7 million** (excl. VAT) and **$ 5.5 million** (incl. VAT at 16%), as summarised in Table 97~~Table 97~~.

Closure costs associated with the previous ESIAs undertaken for Kinsevere, which have been approved by the local regulatory authority (DPEM), are included as below:

- The closure costs for the Oxide project (Knight Piésold, 2012) amount to **$ 33.97 million** (incl. VAT); and
- The closure costs for the KEP (Knight Piésold, 2017) amount to **$ 7.92 million** (incl. VAT).

The above totals, for the KOU, Primary Copper and Oxide projects, have been summed to provide a total for the financial guarantee required from Kinsevere. The cash flow for the total financial guarantee to be provided by Kinsevere is summarised in Table 96~~Table 96~~.

Table 96: Summary of Kinsevere Total Financial Guarantee for the Oxide, KEP and KOU Components (in US Dollars)

	Oxide		Primary Copper		KOU		Total (USD)
Year	**Rate**	**Guarantee**	**Rate**	**Guarantee**	**Rate**	**Guarantee**	**Guarantee**
2007	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-
2009	0.02	30,579	-	-	-	-	30,579
2010	0.061	93,266	-	-	-	-	93,266
2011	0.102	155,953	-	-	-	-	155,953
2012	0.143	218,640	-	-	-	-	218,640
2013	0.016	535,570	-	-	-	-	535,570
2014	0.047	1,573,237	-	-	-	-	1,573,237
2015	0.078	2,610,905	-	-	-	-	2,610,905
2016	0.109	3,648,572	-	-	-	-	3,648,572
2017	0.141	4,719,712	0.063	499,173	-	-	5,218,885
2018	0.172	5,757,379	0.187	1,481,672	-	-	7,239,051
2019	0.203	6,795,046	0.313	2,480,017	0.250	1,363,576	10,638,639
2020	0.234	7,832,714	0.437	3,462,516	0.750	4,090,727	15,385,957
2021	-	-	-	-	-	-	-
2022	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-
Total	-	**33,971,574**	-	**7,923,378**	-	**5,454, 302**	**47,349,253**

Table 97: Closure Cost Estimate for Kinsevere KOU using DMR Master Rates, as at June 2018

No.	Categories	Quantity	Unit	Rate (USD)	Amount (USD)	Notes
1	Dismantling of process plant and related structures (including overland conveyors and power lines)	3 22 500.00	m^3	$1.23	$397 672.17	Demolition of all plant infrastructure associated with the KOU Project (4.3 ha), assumes an average height of 7.5 m
2A	Demolition of steel buildings and structures	119.57	m^2	$17.18	$2 053.79	Future BCS workshop
2B	Demolition of reinforced concrete buildings and structures	0.00	m^2	$25.31	$-	Not applicable, included in process plant above
3	Rehabilitation of access roads	0.00	m^2	$3.07	$-	Not applicable, existing roads will be used for the KOU Project additions
4A	Demolition and rehabilitation of electrified railway lines	0.00	m	$29.83	$-	Not applicable
4B	Demolition and rehabilitation of non-electrified railway lines	0.00	m	$16.27	$-	Not applicable
5	Demolition of housing and/or administration facilities	0.00	m^2	$34.35	$-	Not applicable
6	Opencast rehabilitation including final voids and ramps	13.90	ha	$17 483.87	$243 025.80	Includes Kinsevere Hill pit expansion only
7	Sealing of shafts, adits and inclines	0.00	m^3	$9.22	$-	Not applicable
8A	Rehabilitation of overburden and spoils stockpiles	50.40	ha	$12 005.47	$605 075.71	WRD expansion associated with the KOU Project
8B	Rehabilitation of processing waste deposits and evaporation ponds (non-polluting potential)	0.000	ha	$14 952.60	$-	Not applicable
8C	Rehabilitation of processing waste deposits and evaporation ponds (polluting potential)	15.70	ha	$43 429.43	$681 842.01	Includes planned Mashi and Waste Rock Dump sediment ponds (15.7 ha), excludes TSF 3 (136.1 ha) which was costed for by Knight Piésold (2017)
9	Rehabilitation of subsided areas	0.00	ha	$10 052.77	$-	Not applicable

No.	Categories	Quantity	Unit	Rate (USD)	Amount (USD)	Notes
10	General surface rehabilitation	175.10	ha	$9 510.36	$1 665 263.62	Includes: planned stockpile areas on undisturbed land, new landfill site and plant footprint areas associated with KOU Project
11	River diversion	0.00	ha	$9 510.36	$-	Not applicable
12	Fencing	0.00	m	$10.85	$-	Fencing around planned TSF 3 excluded, costed for by Knight Piésold (2017)
13	Water management	0.00	ha	$3 616.11	$-	Not applicable
14	2 to 3 years maintenance and after care	175.10	ha	$1 265.64	$221 613.03	To be applied on all areas where general surface rehabilitation has been undertaken
				Subtotal 1	***$3 816 546.13***	Multiply with weighting factor 1
	Preliminary and general			12 % of Subtotal 1	$457 985.54	If Subtotal 1 > 100 000 000 = 6%, If Subtotal 1 < 100 000 000 = 12%
				Subtotal 2	***$503 784.09***	Multiply with weighting factor 2
	Contingencies			10%	$381 654.61	
				Subtotal 3	***$381 654.61***	
				Grand Total (Excluding VAT)	**$4 701 984.83**	
				Grand Total (Including VAT @16%)	**$5 454 302.41**	

This cost estimate represents all the calculated costs, the duration of the mitigation and rehabilitation work that is being contemplated, the labour used, and the overheads and other expenses. The information is updated every six months and also includes the attenuation and rehabilitation measures, and the measures for on-site monitoring after site closure.

The means of financing (Section 7.0 below) will be available even if MMG is unable to undertake the mitigation and rehabilitation measures.

7.0 TITLE VII: DESCRIPTION OF THE FINANCIAL GUARANTEE (ARTICLE 125)

MMG currently holds a bank guarantee as a security for future rehabilitation of the site, based on the cost estimate schedule for the Oxide and Primary Copper projects shown in Table 96~~Table 96~~. This guarantee will be increased to include the KOU Project once this ESIA is approved. Payments are made regularly as per the implemented schedule.

In terms of Article 125 of the DRC Mining Regulations: Annex VIII of Decree No. 18/024 of 8 June 2018, requirements for security may be eased or waived for operators who have an accepted environmental management system such as ISO 14001. This initiative will be investigated by MMG.

8.0 TITLE VIII: CONSULTATION OF THE PUBLIC DURING THE DEVELOPMENT OF THE ESIA AND THE SUSTAINABLE DEVELOPMENT PLAN

8.1 Program of Public Consultation During Development of ESIA (Article 126)

Two rounds of public consultation were undertaken, one between 6 June and 3 July 2018, the other between 8 and 10 October 2018. In general, communities realise the benefits of the Kinsevere mine through employment, increased revenue in the area, improved access to their villages and the investment in social infrastructure. The key issues and concerns identified through public consultation 2018 included:

- Employment;
- Community development projects;
- Environmental impacts, such as dust, noise and blast damage;
- Stakeholder relations and involvement; and
- Compensation process.

The report on the public consultation program undertaken during the Terms of Reference (ToR) stage of the ESIA, detailing; the schedule of meetings, the questions and answers exchanged with the communities affected by the KOU project and the arrived at conclusions (Kayembe, S; Pietersen, A; de Waal, D;, July 2018) is attached as Appendix B.

8.2 Identification of Potential Projects to Contribute to Community Development (Article 127)

The Environmental and Social Management Plan must provide information on the main development projects. The plan (Cahier des Charges) must be signed off by the authorities.

MMG's Kinsevere mine has developed a Community Investment Program in the form of a Sustainable Development Plan that focuses on:

- Reduction of poverty;
- Food security;

- Health and wellbeing;
- Quality education;
- Clean water for domestic use; and
- Sanitation.

The key objectives and actions of the Community Investment and Sustainable Development Plan, together with the 2018, 2019 and 2020 budget, are listed in Table 98~~Table 98~~. The emphasis on training and supporting local farmers with agricultural production, establishing produce storage facilities and local markets will help foster resilient and sustainable communities in the mine's area of influence up to and beyond mine closure, thus mitigating some of the key socio-economic impacts identified in Section 4.3.1.8 including loss of agricultural land, loss of employment and reduced community investment post closure. Any community members directly impacted by physical or economic displacement due to the KOU Project will be compensated in consultation with local authorities as referenced in Section 5.6.

The plan requires the approval of the Cahier des Charges. It is implemented, managed and monitored by the mine's Social Development department.

Table 98: Sustainable Development Plan Objectives, Actions and Cost

Objectives	Actions	2018 Budget (USD)	2019 Budget (USD)	2020 Budget (USD)
Achieve universal and equitable access to safe and affordable drinking water for all by 2030.	■ Establish boreholes, pumps and water committees in communities.	$18 000	$65 000	$115 000
Establishment of and improvements to community infrastructure.	■ Build/rehabilitate roads, bridges, markets and community centres; and ■ Upgrade electricity supply in villages.	$10 000	$80 000	$110 000
Improving food security and income generation.	■ Training of and providing support to local farmers for agricultural production; ■ Establish a pilot animal husbandry program; ■ Improve chicken stock; ■ Support for maize grinding for MMG workforce; ■ Vegetable growing and sales to MMG and others; ■ Train local farmers to establish fishponds to produce fish for consumption and sale; ■ Provide support for group registration, organisation, training and management; ■ Consultant support and training sessions; and ■ Establish produce storage facilities and local markets in villages.	$351 000	$306 000	$386 000
Training of women in sewing and business development.	■ Consultant support and training sessions; and ■ Purchase of PPE produced for MMG.	$170 000	$20 000	$20 000
Reforestation and harvesting program for income generation and sustainability.	■ Small equipment and hand tools provided year on year; and ■ Consultant support and training sessions.	$30 000	$10 000	$10 000
Skills development and capability training for small business development.	■ Consultant support and training sessions.	$15 000	$15 000	$15 000
To achieve universal health coverage, including financial risk protection, access to quality essential health care services, and access to safe, effective, quality, and affordable essential medicines and vaccines for all.	■ Support for and contribution towards Government immunisation and other health programs; and ■ Build a new health centre in Kifita.	$30 000	$390 000	$180 000

Objectives	Actions	2018 Budget (USD)	2019 Budget (USD)	2020 Budget (USD)
Improved hygiene.	■ Install improved latrines in villages.	$15 000	$20 000	$20 000
By 2030, ensure that all girls and boys can complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.	■ Build/upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments; and ■ Work to end all forms of discrimination against women and girls everywhere.	$208 000	$335 000	$401 000
By 2020 expand the number of scholarships for developing countries, in particular LDCs, SIDS and African countries to enrol in higher education, including vocational training, ICT, technical, engineering and scientific programs.	■ Adult literacy program; ■ Teacher's training; ■ Scholarship program; ■ Teacher support; ■ School event sponsor; ■ Soccer tournament; and ■ School prize.	$121 000	$344 000	$318 000
	TOTAL	**$968 000**	**$1 585 000**	**$1 575 500**

9.0 CERTIFICATION OF COMPLIANCE (ARTICLE 128)

Golder Associates Africa (Pty) Ltd certifies that every effort has been made to ensure compliance of this ESIA with the format and requirements of Annex VIII (l'annexe VIII du Decret N°18/024 du 08 Juin 2018 modifiant et completant le Decret N° 038/2003 du 26 Mars 2003 portant Reglement Minier) of the DRC Mining Code (la Loi N°18/001/du 09 Mars 2018, Portant Code Minier).

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APPENDIX A

Document Limitations

APPENDIX B

Community Consultation Report: Rapport des Consultations Publiques lors de Termes de Référence

APPENDIX C

Mining Permit. Amalgamation Registration of Mining Permits No. 528 and 7274 under No. 528

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

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