From: V Ravi Chandra <ravichandra.v@Maamba.onmicrosoft.com>
Sent: 30 January 2026 16:06

Dear Sir,

Maamba Energy Limited (MEL) invites reputable and qualified consulting firms to submit technical and commercial proposals for the provision of Hydrogeological Consultancy Services for the Kanzinze Block of the Maamba Coal Mine, located in the Southern Province of Zambia.

Note: The final study area may be revised based on operational requirements.

The engagement and scope of work will be subject to technical review and approval by MEL, following which the selected consultant will be formally appointed.

Please find attached details Terms of reference indication the details scope of work and the AOI (Area of Interest) map and the Google Earth files (KMZ) for the Hydrogeological Consultancy Services of Kanzinze Blocks – Maamba Coal Mine.

With regards,

V.Ravi chandra

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Detailed Scope of Hydrogeological Assessment, Groundwater Modelling, and Mine Dewatering Design for Kanzinze Blocks of Maamba Coal Mine.

1. Project Initiation and Planning

❖ **Project Scoping & Data Review**

- Compile and review all available geological, geotechnical, hydrological, and mining design data.
- Review historical and current groundwater monitoring data, pit inflow records, rainfall and evaporation data, and regional hydrogeological information.
- Identify data gaps that may affect the hydrogeological conceptualisation or slope stability modelling.
- Prepare a comprehensive project execution plan outlining timelines, resources, responsibilities, and regulatory requirements.

❖ **Remote Sensing and Hydrogeological Data Management Framework**

- Acquisition of Satellite Imageries and Digital elevation data and generation of base layers and supervised and unsupervised classification of satellite data to delineate geomorphological and hydrogeological features.
- Establish a database for geological logs, borehole construction details, groundwater levels, pumping test results, and water quality information.
- Data collection (rain fall data), storage, and quality assurance.

2. Groundwater Investigation and Aquifer Characterization

❖ **Field Reconnaissance**

- Conduct site walkovers to identify recharge zones, springs, seepage faces, structural features (faults, fractures), and existing groundwater infrastructure.
- Map drainage patterns, topography, and surface water–groundwater interaction features.

❖ **Borehole Siting and Hydrological Assessment**

- Identify optimal locations for new monitoring or dewatering boreholes based on Geophysical survey, geology, pit design, hydrogeological structures, and modelling requirements.
- Prepare borehole siting maps and drilling specifications.

❖ **Drilling & Construction of Monitoring Boreholes**

- Drill No.of 10-12 boreholes (150-180m deep) using DTH drilling and rotary drilling methods with Hole Diameter Range is 6.5"/4.5”, maintaining full lithological logging to target aquifers, geological contacts, and depressurisation zones.
- Install standpipe casings and/or VWPs with correct screen and seal placement to ensure reliable groundwater and pore-pressure monitoring.
- Develop boreholes through cleaning, surging, and air-lifting until clear water is achieved and all piezometers respond correctly.

❖ **Aquifer Testing and Groundwater Monitoring**

- Conduct pumping tests (constant-rate, step-drawdown, recovery tests) to determine aquifer transmissivity, storativity, hydraulic conductivity, and boundary conditions.
- Install data loggers for continuous groundwater level measurement.
- Perform manual water-level measurements to calibrate logger data.
- Update the monitoring network design with recommendations for redundant or additional boreholes.

❖ **Hydrogeochemical Analysis & Water-Quality Monitoring**

- Collect groundwater and Surface water samples both sessions of pre-monsoon and post-monsoon following strict QA/QC protocols.
- The rainwater quality analysis particularly bicarbonate (HCO_3^-) domination
- Analyse for major ions, trace metals, isotopes, and indicators of contamination or mixing if any of harmful element from mining activities.
- Interpret hydrogeochemical signatures to assess recharge sources, flow paths, seepage origins, and potential impacts on mine infrastructure.

❖ **Hydrogeology and Morphometric Analysis**

- Perform morphometric analysis of the catchment and pit area, including slope, drainage patterns, and watershed characteristics.
- Correlate morphometric parameters with groundwater recharge, flow paths, and slope stability.
- Identify areas prone to seepage, landslides, or erosion.
- Surface water - Groundwater Interaction.
- Integrate morphometric insights with hydrogeological and slope stability models to enhance predictive accuracy.

❖ **Hydrogeological Uncertainty and Risk Assessment**

- Evaluate uncertainties in aquifer geometry, hydraulic properties, and recharge estimation.
- Assess risks to slope stability, mine inflow, and surrounding water resources under various scenarios.

3. Groundwater Flow Assessment for Slope Stability

❖ **Integration of Groundwater Flow into Geotechnical Models**

- Characterise pore pressure distribution across slope sectors based on monitoring data and aquifer parameters.
- Identify seepage zones, perched water bodies, and high-pressure intervals that may reduce shear strength.
- Generate groundwater contours, flow nets, and pore-pressure profiles for integration into slope stability analysis software (e.g., Slide2, FLAC, PLAXIS).

❖ **Assessment of Pit Inflows and Seepage Zones**

- Quantify groundwater inflows using analytical equations, pumping test results, and observed seepage points.
- Map seepage zones across pit walls and ramps, identifying areas requiring depressurisation or drainage.
- Assess seasonal fluctuations and impacts of rainfall recharge.

❖ **Pore Pressure Modelling and Stability Implications**

- Estimate pore pressure changes during mining progression.
- Provide pore pressure distributions for multiple mine stages (pre-mining, active mining, and final pit).
- Evaluate the effect of groundwater pressure on Factor of Safety (FoS) in slope models.

4. Groundwater Modelling & Mine-Water Management

❖ **Development of the Conceptual Hydrogeological Model**

- Define aquifer geometry, boundaries, hydraulic properties, recharge mechanisms, and surface water interactions.
- Identify major controls such as faults, dykes, shear zones, and lithological boundaries.

❖ **Numerical Groundwater Flow Modelling**

- Construct a 3D numerical model using MODFLOW, FEFLOW, or equivalent.
- Calibrate model using pumping test results, time-series water levels, and inflow measurements.
- Conduct sensitivity analysis on uncertain parameters (hydraulic conductivity, recharge, boundary conditions).

❖ **Prediction of Mine-Water Inflow**

- Simulate inflows for different mining stages, depths, and pit geometries.
- Forecast dewatering requirements for normal, wet, and extreme climate conditions.
- Estimate long-term inflow for post-mining scenarios and pit lake formation (if relevant).

❖ **Dewatering Assessment & Mine-Water Management Recommendations**

- Evaluate natural and artificial drainage options.
- Develop operational dewatering strategies using pumping wells, horizontal drains, in-pit sumps, and depressurisation wells.
- Assess water storage, reuse, treatment needs, and discharge compliance.
- Prepare a dewatering schedule tied to mine development milestones.

5. Design of Dewatering and Depressurisation Systems

❖ **Dewatering Borehole Design**

- Determine well depths, screen intervals, pump sizes, and expected yields.
- Provide borehole construction diagrams and installation standards.

❖ **Depressurisation Systems for Slope Stability**

- Design horizontal drains, relief wells, and in-pit drainage galleries.

- Model drawdown and pore-pressure reduction required to achieve geotechnical stability.

❖ **Mine-Water Infrastructure Planning**

- Design pipelines, sumps, pump stations, water storage facilities, and energy requirements.
- Assess redundancy and contingency requirements for critical systems.

❖ **Operational Guidance**

- Provide recommended pumping schedules, monitoring triggers, and system maintenance plans.

6. Monitoring, Reporting, and Adaptive Management

❖ **Long-Term Groundwater Monitoring Plan**

- Develop a monitoring program including frequency, parameters, and methods.
- Define thresholds and action levels for groundwater levels and water quality.
- Establish early-warning indicators for slope instability or inflow increases.

❖ **Adaptive Management Framework**

- Integrate real-time monitoring to update models and refine dewatering strategies.
- Recommend periodic model recalibration as mining progresses.

❖ **Environmental Impact & Mitigation Assessment**

- Identify potential drawdown impacts on surrounding users, ecosystems, springs, and wetlands.
- Propose mitigation measures: artificial recharge, controlled pumping, reinjection, or buffer zones.

7. Delivery of Final Hydrogeological Report

The final report will include:

- Detailed methodologies for field investigations, laboratory analyses, and numerical modelling.
- Geological and hydrogeological conceptual models with supporting maps and cross-sections.
- Comprehensive records of monitoring boreholes, drilling logs, and construction details.
- Aquifer test results, interpreted hydraulic properties, and hydrogeochemical assessments.
- Groundwater level maps, flow nets, seepage analyses, and pore-pressure distributions.
- Numerical model setup, calibration results, sensitivity analyses, scenario testing, and predictive simulations.
- Dewatering and depressurization system designs, operational plans, and infrastructure diagrams.

- Environmental impact assessments, mitigation strategies, adaptive management recommendations, and stakeholder consultation records.
- Appendices including raw data, maps, borehole logs, model files, technical calculations, and QA/QC documentation.