

JEITA GROTTO

Scope of Work (SOW)

Project: Jeita Grotto – Conservation, Safety & Operations Upgrade (BOT)

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1. Introduction & Background

Jeita Grotto is one of Lebanon's most iconic natural landmarks and an internationally recognized heritage site. Located 18 kilometers north of Beirut in the Valley of Nahr al-Kalb, at the foothills of Mount Lebanon, it is considered a symbol of Lebanon's natural beauty and cultural identity. Jeita was selected among the 28 finalists in the New7Wonders of Nature competition and was notably the only cave or grotto worldwide to reach this stage, highlighting its exceptional global significance.

The grotto extends for nearly 9 kilometers and is regarded as one of the most remarkable karstic cave systems in the Middle East. The Upper Cave features spectacular geological formations including stalactites, stalagmites, draperies, columns, and rimstone pools. It is home to the world's longest known stalactite, measuring 8.2 meters in the White Chamber, and also contains other monumental spaces such as the Red Chamber, rising up to 106 meters, and a third hall exceeding 120 meters in height.

Sixty meters below the Upper Cave lies the Lower Cave, stretching approximately 6,200 meters and traversed by an underground river and the Dark Lake. Visitors experience this section by electric boat, passing through decorated halls such as Thompson's Cavern, the Pantheon, Grand Chaos, and Shangri-La. Together, the two cave levels combine monumental scale, fragile formations, and hydrological importance that distinguish Jeita from other caves worldwide.

Supporting the grotto are a number of surface facilities that provide accessibility and visitor services. These include a cable car system, amphitheater, restaurant, snack areas, parking, administration offices, landscaped gardens, and several small service buildings.

Beyond its touristic and cultural value, Jeita's underground river plays a critical national role, supplying fresh drinking water to more than one million Lebanese, particularly in Beirut and surrounding areas. Recognized as a key component of Lebanon's natural heritage, the grotto contains highly fragile geological formations and a sensitive underground ecosystem. Conservation and environmental protection measures are therefore essential to safeguard its geological and hydrological integrity, preserve its cultural and scientific importance, and ensure its sustainable use for regulated tourism, education, research, and public benefit.

The Jeita Grotto site plan comprises the following main facilities:

- Upper Cave

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- Lower Cave
- Parking areas
- Snack facilities
- Lower Cable Car Building
- Restaurant
- Upper Cable Car Building with Amphitheatre
- Administration Building
- Under-road Basement
- Various smaller constructions



Figure 1- Jeita Grotto Site Plan

1.1. Upper Cave

The Upper Cave has an overall length of 2,130 meters, of which only 750 meters are accessible to visitors via a specially designed walkway. Access to the remainder of the cave is restricted to prevent ecological damage that could result from high visitor traffic. The Upper Cave contains a dense concentration of crystallized formations, including

stalactites, stalagmites, columns, mushrooms, ponds, curtains, and draperies, making it particularly famous for its geological richness.

The visitor-accessible portion consists of three main chambers:

- **White Chamber:** The White Chamber is medium-sized but contains the most striking formations in the grotto. Its white dripstones are pure calcite, while reddish tones are caused by iron oxide. Unlike northern countries where iron oxide appears brown or beige, in Lebanon it takes on a red color due to chemical reactions linked to higher temperatures. The White Chamber is also home to the longest known stalactite in the world, measuring 8.2 meters.
- **Red Chamber:** The Red Chamber rises to a height of up to 106 meters, with a width ranging between 30 and 50 meters.
- **Third Chamber:** The third chamber is the largest of all, reaching more than 120 meters in height.



Figure 2 – Upper Cave



Figure 3 - Upper Cave



Figure 4 - 117 m Concrete Tunnel Entrance to the Upper Grotto

1.2. Lower Cave

The Lower Cave, located 60 meters beneath the Upper Cave, extends for approximately 6,200 meters. It is traversed by an underground river and a lake known as the “Dark Lake,” with the river broken up by several small cataracts and rapids. This cave contains several monumental halls, including Thompson’s Cavern, which features the Eagle Obelisk stalagmite, as well as the Pantheon, Grand Chaos, and Shangri-La.

Visitors explore the Lower Cave by electric boats along a 500-metre route. For safety reasons, the Lower Cave is closed during winter months when water levels are too high.



Figure 5 - Lower Cave



Figure 6 - Lower Cave

2. Objectives

The purpose of the project, undertaken within a Build Operate Transfer (BOT) framework, is for the Operator to design and implement a comprehensive program of upgrades across the Jeita Grotto site. These works shall safeguard the grotto's fragile geology and sensitive underground ecosystem, ensure life safety and compliance with all applicable codes and regulations, and sustain continued operations while respecting the site's seasonal constraints. In parallel, the project shall enhance the visitor experience through improved accessibility, reliability, and comfort, while always preserving the heritage, cultural, and environmental value of the site. The scope is intended to provide durable, low-maintenance, and environmentally responsible solutions that balance conservation priorities with modern operational needs. Certain interiors, including the restaurant and administration buildings, are excluded from the detailed scope to preserve the Operator's flexibility for future adaptation and fit-out.

3. Procurement Mode & Structure

This is a Design and Build Minimum Requirements contract under a Build Operate Transfer (BOT) framework.

This SOW is incorporated as Annex (1) to the Arabic RFP. In case of discrepancy, the Arabic RFP governs administrative/financial matters; for purely technical matters the stricter requirement between RFP and SOW shall apply.

4. General Requirements (All Facilities)

4.1 Standards, Codes & References

The Operator shall comply with the latest international standards applicable to the works, including but not limited to:

- IEC 60502-1, IEC 60228, IEC 60364-6 (electrical installations).
- BS 7671 (wiring), BS 7430 (earthing), IEC 60331 (circuit integrity).
- BS 5266 (emergency lighting), BS 5489 and CIE 115 (outdoor lighting).
- EN 54 (fire detection), NFC 17-102 (early streamer lightning protection where adopted).
- ASTM D2665 (PVC drainage), ASME A112.6.3 and A112.3.1 (garage and channel drains).
- BS EN ISO 12944 (anti-corrosion systems).
- ASTM B221M and B209M (aluminum).
- BS ISO 13006, BS ISO 13007-1, and BS EN 13888 (tiling systems).

The Operator shall also comply with all applicable Lebanese laws and regulations governing solid, liquid, and hazardous waste management, environmental protection, and building services. This includes, but is not limited to:

- Laws: Law 80/2018 on Integrated Solid Waste Management; Law 64/1988 on environmental protection against hazardous waste.

- Decrees: Decree 5606/2019 (hazardous waste management); Decree 5605/2019 (sorting at source); Decree 8735/1974 (protection against solid and liquid waste pollution and assignment of waste collection and sweeping to municipalities).
- Ministry of Environment (MoE) Decisions: 998/1 and 999/1 of 2019; 59/1 of 2020 (hazardous waste handling and storage procedures); 58/2020 (classification of Refuse Derived Fuel “RDF”).
- MoE Memo: Memo 4/1 of 2022 (tender document template for waste collection and sweeping by municipalities and unions).
- Furthermore, the Operator shall integrate the findings and recommendations of:
 - Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25
 - Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection-Jun.25
 - Appendix 8- Geotechnical Assessment Report - Sep. 25,ensuring that all necessary measures for concrete repair, rock stabilization, and erosion protection are incorporated into the design and execution of the works.

4.2 Conservation & Environmental Protection

Given the fragile geology and sensitive underground ecosystem, all interventions shall be non-invasive and, where feasible, reversible. The work must not alter the microclimate, hydrology, or geological formations, and no contact with speleothems shall be permitted.

The Operator shall prepare and implement a Cave Conservation and Environmental Management Plan (CEMP) covering, at minimum: limits on dust, noise, and vibration; spill prevention measures; lampenflora control; approval procedures for all materials and chemicals; waste management protocols; and protection of river water quality.

The Operator shall implement micro-environmental controls for both staff and visitors, including continuous CO₂, temperature, relative humidity and radon monitoring, cloud dashboard, SMS/e-mail alarms, automatic ticketing/dispatch throttling, and staged operational responses based on the CO₂ framework adopted in Appendix 1: 2,800 ppm conservation watch/trend level, 3,200 ppm Amber throttling level, and 3,600 ppm provisional permitted ceiling / Red action level.

At all cave entrances, the Operator shall provide and maintain shoe disinfection mats charged with a biocide solution (1% Virkon S or approved equivalent). Mats shall be inspected during opening hours and replenished or replaced only as needed to maintain

effectiveness, without excess liquid, visible dripping from footwear, or runoff into cave floors, drainage pathways, pools, river, or speleothem areas.

4.3 Health, Safety & Accessibility

The Operator shall prepare and implement a site-wide Construction Health and Safety Plan that specifically addresses confined spaces, slippery surfaces, boat operations, ropeway systems, and emergency evacuation procedures. Accessible routes and features, including appropriate gradients, handrails, and tactile cues, shall be provided wherever practicable, if conservation requirements are not compromised. Emergency lighting and egress illumination shall be designed and installed in full compliance with BS 5266 and Exit signage shall be provided in Arabic, French, and English with a minimum battery autonomy of 1.5 hours.

The Operator shall prepare a comprehensive site-wide Emergency Management Plan covering fire, flood, earthquake, CO₂ exceedance, radon exposure, medical emergencies, boat operations, ropeway/cable-car incidents, evacuation, communication protocols, disabled-visitor assistance, coordination with local rescue services and annual drills. The EMP shall be submitted in draft within 3 months from contract start and approved within 6 months.

➤ **First Aid Facilities**

- The Operator shall establish and operate one site-wide on-site first-aid treatment room within 3 months from contract start, equipped at minimum with AED, oxygen, trauma supplies, stretcher, lockable medical cabinet, handwashing sink, communications, emergency lighting and attendant on duty during opening hours. Distributed first-aid stations inside visitor areas shall supplement, not replace, the treatment room.
- Provision of first-aid stations, lifeguards, and an emergency response team.
 - First aid room area not less than 20 m²
 - Basic Equipment and Furniture:
 - ✓ First aid stretcher,
 - ✓ Lockable medical cabinet (for trauma supplies, AED),
 - ✓ Handwashing sink (with elbow or sensor tap),
 - ✓ Desk and chair for attendant,

- ✓ Sharps disposal container,
- ✓ Refrigerator (medications),
- ✓ Waste bins (biohazard and general),
- ✓ Privacy curtain or screen
- Basic Medical Equipment:
 - ✓ AED,
 - ✓ trauma supplies,
 - ✓ diagnostic set,
 - ✓ exam light.
- Room Fit-Out and Technical Requirements:
 - ✓ Walls: Moisture-resistant gypsum board with PVC cladding up to 1200 mm from F.F.L. Smooth, cleanable, anti-bacterial paint (e.g. epoxy or PU), Optional vinyl corner guards for protection.
 - ✓ Floor: Homogeneous anti-static vinyl sheet with coving; Slip-resistant, seamless, easy to sanitize.
 - ✓ Ceiling: Moisture-resistant gypsum or mineral fiber tiles; Smooth, cleanable, antimicrobial.
 - ✓ HVAC requirement:
 - Mechanical ventilation with adequate air changes (minimum 6 ACH recommended);
 - Split A/C or centralized ducted air with filters
 - Exhaust fan.
 - ✓ Electrical Requirement:
 - Power outlets 4–6 general use (220V),
 - Dedicated outlet for refrigerator.
 - Emergency lighting and backup power (generator).

- UPS is needed for the doctor computer.
- General and task lighting.
- Network/data outlet for doctor desk
- ✓ Internal fit out:
 - Cabinetry,
 - curtains
- ✓ Plumbing requirements:
 - Cold and hot water for sink,
 - Proper drainage,
 - Wall-mounted or under-sink cabinet for storage
- ✓ Signage:
 - Install signage outside the room for easy identification.
- ✓ Environmental:
 - Controlled ventilation (no humidity buildup);
 - Comfortable temperature (22–24°C);
 - Good lighting (500 lux general, 1000 lux task lighting over bed)
- ✓ FLS requirement:
 - Smoke detector,
 - extinguisher,
 - clear exit access,
 - fire rated door
- ✓ Compliance:
 - First aid room shall comply with local and international safety/medical regulations

- First aid room shall comply with local Ministry of Health or Occupational Safety Authority guidelines.

4.4 Quality Management

The Operator shall establish a Design Management Plan, detailed Inspection and Test Plans (ITPs), and a comprehensive Commissioning Plan. All design shall be performance-based, and the Operator shall bear full responsibility for the adequacy, safety, and compliance of the design.

4.5 Site Constraints

Seasonal operations shall apply, as the Lower Cave will be closed during portions of the winter season due to high water levels. The Operator shall prioritize disruptive works during low-season windows. Vibration shall be strictly limited, with no percussive drilling permitted in sensitive zones. Lighting and heat loads shall be always controlled, and the use of fuel-powered plant inside the caves is prohibited; only battery-electric equipment shall be permitted.

4.6 Materials, Surface Protection & Coatings

All new and remedial works shall follow the material and coating systems below, with full manufacturer method statements and ITPs:

- High-build polyurethane protective paint to steelwork to BS EN ISO 12944, durability class H for corrosivity C3; color range as approved by the Engineer; surface preparation to manufacturer's recommendation.
- Cave walkways shall be cleaned using a wet-vac scrubber (pH-neutral biodegradable detergents only) with no effluent discharge inside the cave; minimum frequency monthly in low season and fortnightly in high season or after heavy visitor days."

4.7 Structural Testing & Rehabilitation: Minimum Campaign

Wherever structural defects are suspected or recorded, the Operator shall perform the following minimum investigation campaign and execute repairs accordingly:

- Defects Mapping of all accessible RC surfaces.
- Coring & Lab Tests: compressive strength, depth of carbonation, chloride and sulfate content; half-cell potential; Schmidt hammer.

- Repairs: RC spall/void/delamination repair to slabs/beams/columns; crack injection; RC jacketing or CFRP wrapping where required; soil-scour treatment beneath footings (diversion, safe platforms, pressure grouting/underpinning, new RC ground beam, erosion protection, monitoring of movement and settlement).
- Submit a Final Report with findings, design of repairs, and executed works.

4.8 Electrical Systems: Power, Distribution & Containment

- **Cables**
 - Test all existing circuits:
 - Insulation resistance and dielectric withstand in accordance with (IEC 60502-1).
 - Continuity test in accordance with (IEC 60228).
 - Earth resistance test in accordance with (IEC 60364-6).
 - Voltage drop under load to be within the limits required in BS 7671.
 - Replace all non-compliant runs.
 - Provide minimum cable sizes of 2.5 mm² copper conductors for lighting and 4 mm² for power circuits, in conduits with separate protective earth in each conduit.
- **Panels and Boards**
 - Provide panelboards and distribution panels (DPs) compliant with IEC 61439-1, Form 2b.
 - Use copper busbars with full-size neutral and half-size earth.
 - Provide 20% spare capacity and physical space for extensions.
 - Install surge protection devices (SPDs) in each DP.
 - Provide lockable cabinets with clearances in accordance with NEC requirements.
 - Enclosures to IP41 indoors and IP65 outdoors/humid areas.
- **Protection**
 - Provide MCB/RCBO ratings as follows:
 - 16 A for lighting circuits.

- 20 A for power circuits.
- Protect lighting circuits with 100 mA RCBOs.
- Protect socket circuits with 30 mA RCBOs.
- **Containment**
 - Install heavy-duty hot-dip galvanized trays and ladders.
 - Provide rigid galvanized conduit in exposed risk areas and EMT in plenum and non-hazardous interiors.
 - Use minimum conduit diameters of 20 mm indoors and 50 mm outdoors.
 - Maintain maximum 40% conduit fill.

For Upper and Lower Grotto cave areas, the facility-specific cave requirement shall govern: all lighting and power circuits inside the grotto shall be protected by 10 mA RCBO/RCD protection or an Engineer-approved equivalent configuration suitable for high-humidity conditions, nuisance-trip management and life safety.

For non-cave building areas, lighting circuits shall be protected by 100 mA RCBOs and socket circuits by 30 mA RCBOs unless a stricter facility-specific requirement applies

4.9 Lighting & Emergency Lighting

- **General:** Provide LED luminaires with stainless steel housing in humid areas (IP65 minimum outdoors/parking). Submit IK/CRI/lumen and driver data.
- **Interior design targets (non-cave):**
 - Corridors: 150 lux.
 - Toilets: 100 lux.
 - Offices: 500 lux (uniformity ≥ 0.6).
 - Ticketing Booths: 500 lux (uniformity ≥ 0.6).
 - Stairs: 100 lux.
 - Workshops/technical rooms: 300 lux.
 - Amphitheatre: 200 lux with dimming.
- **Parking:** Average 75 lux, maintained 50 lux, uniformity ≥ 0.4 ; wall-mounted luminaires at uncovered ramp entrances.

- **Emergency:** To BS 5266; 1.5 h battery autonomy; escape routes ≥ 1 lux (max:min $\leq 40:1$). Exit signs trilingual ((Arabic/French/English), single/double faced as required.
- Emergency lighting may be **self-contained** or **central-battery**; where a central-battery system is adopted in caves or tunnels, provide **two redundant sources**, monitored circuits, and addressable supervision. Life-safety circuits shall not be subject to local or theme controls.
- **Documentation:** Submit full product data (IP, IK, CRI, lumen output, optical files, driver data, photometric reports). Emergency lighting dedicated to life safety shall be maintained and not subject to local controls.

4.10 Earthing & Lightning Protection

- Earthing: TN-S system to BS 7430 / BS 7671; building ring earth with multi-rod electrodes; equipotential bonding to all exposed/extraneous conductive parts; combined earth resistance $\leq 5 \Omega$ verified by loop-impedance testing.
- Lightning Protection: Early Streamer Emission (ESE) system to NFC 17-102, including air terminals, down conductors, earth terminations, test links, lightning strike counters, SPDs, and all civil works; provide records of resistance and continuity tests.

4.11 Uninterruptible Power Supplies (UPS)

- Provide rack-mounted UPS units with ≥ 30 minutes autonomy for ICT, CCTV, access control, and security systems.
- Provide desktop UPS units for sensitive AV/office systems as required.
- Include static bypass, maintenance bypass, VRLA batteries, cabinets/racks, and full interconnections.
- Submit autonomy and discharge test results.

4.12 Fire Detection & Alarm (FDA)

- Provide a complete cause-and-effect matrix, smoke detector spacing calculations, audibility/visibility calculations, and loop loading; conduct full integrated tests prior to taking-over.

- Provide an addressable, microprocessor-based FDA system for all buildings and parking levels.
- Design for loop isolation and redundancy, zoning, device-level fault identification, and optional remote monitoring.
- Provide manual call points at exits and corridors (≤ 30 m spacing).
- Synchronize AV devices; audibility ≥ 75 dB at 3 m; visual devices visible in bright areas (1 Hz flash).
- Provide fire-resistant cabling in segregated containment to IEC 60331 with labeling.
- Submit full cause-and-effect matrix, smoke detector spacing calculations, audibility/visibility calculations, and loop loading analysis.
- Conduct full integrated tests prior to handover.

4.13 Security & Operations Systems (Access / Parking Control)

- Parking Control: entry/exit terminals, heavy-duty barriers with loops, LPR at all lanes, pay-on-foot kiosks, and PMS; CAT6A cabling with industrial enclosures and wall rack.

4.14 Mechanical, Plumbing & Drainage (incl. Oil Interceptors / Dry Risers)

- Above-ground storm drainage: PVC to ASTM D2665 with cleanouts; garage drains to ASME A112.6.3; channel drains to ASME A112.3.1; provide oil interceptors sized to duty.
- Dry risers: 65 mm black steel with 65/40 mm outlets per level (parking), and portable firefighting equipment per area classifications.
- Toilets: sensor faucets for public sanitaryware; exhaust systems inspected and rehabilitated (fans/ducts/outlets) as required.
- Drainage/Firefighting: Commission oil interceptors and verify discharge quality; provide dry-riser testing and certificates

4.15 Signage & Wayfinding (incl. Accessibility / Braille)

- Provide a coordinated trilingual signage system (Arabic/French/English) including identification (with Braille for ADA compliance), informational, directional and regulatory signs.
- Ensure iconography is consistent across buildings and open areas.
- Provide pedestrian wayfinding at all decision points and parking stairs.
- Include a height-limit gantry at ramp entrance.

4.16 Geotechnical & Rock-Slope Stabilization

- Implement stabilization works per the Geotechnical Assessment Report, including:
 - Cleaning loose fragments.
 - Anchored high tensile wire mesh.
 - Localized shotcrete with mesh only in specified basements.
 - Double-layer mesh with rock bolts at identified localities.
 - Reconstruction of damaged dry-stacked or mortared walls with drainage, weep holes, and scour-resistant toes.
- Provide monitoring and documentation after storms or seismic events.
- Conduct periodic visual walkthroughs of rock faces; flag and isolate hazard zones; photo-document and re-inspect after rain or seismic activity.

4.17 Roads & Paving: Minimum Renewal Standard

- Provide new markings, arrows, and regulatory/directional signage
- Provide new wayfinding signs indicating entries, exits, drop-off, taxi, and bus/car staging areas.

4.18 Wastewater Treatment

The Operator shall carry out all necessary works to rehabilitate, test, and operate the wastewater treatment plants, ensuring compliance with effluent quality standards and continuous reliable operation. The scope shall include, but not be limited to, the following:

- Inspect, repair, or replace all electromechanical equipment that does not function as required, including full rehabilitation of the three plants with associated mechanical and electrical systems, central control and monitoring, and any other necessary items.

- Identify and provide any additional utility requirements needed for proper WWTP operation prior to commencement of the works.
- Perform hydraulic testing of all three plants using clean water to verify proper operation.
- Complete start-up and testing of the plants to demonstrate that they are fully functional and operational. Treated effluent samples shall be collected and tested in a certified laboratory to confirm compliance with effluent requirements. All start-up costs, including bacteriological seeding, nutrients, and laboratory analyses, shall be borne by the Operator.
- Provide all necessary standby components to guarantee uninterrupted operation. All mechanical equipment shall include standby units with automated changeover from duty to standby in the event of failure. Cyclic operation between duty and standby units shall also be implemented.
- Cover all operational costs during the contract, including chemicals, sludge disposal, spare parts, labor, sampling, and testing.
- Ensure that effluent samples are tested in certified laboratories as per supplier's agreements to demonstrate compliance. If effluent limits are exceeded, penalties shall apply, and if exceedances persist for more than three weeks, the operational contract may be terminated.
- Provide annual maintenance agreements with equipment suppliers to secure the proper operation of the plants.
- Accept that the Ministry of Tourism, or its representative, reserves the right to conduct sampling and testing of treated effluent at any time.

Treated Effluent Quality

The treated effluent shall be suitable for discharge to the river in accordance with Ministry of Environment requirements (MOE) (2001) and shall meet the following minimum standards:

- pH: 6 – 9
- Temperature: $\leq 35^{\circ}\text{C}$
- BOD₅: $\leq 25\text{ mg/L}$
- COD: $\leq 125\text{ mg/L}$
- Total Iron: $\leq 5\text{ mg/L}$
- Mercury: $\leq 0.05\text{ mg/L}$
- Copper: $\leq 1.5\text{ mg/L}$
- Nickel: $\leq 0.5\text{ mg/L}$

- Aluminum: ≤ 10 mg/L
- Ammonia Nitrogen ($\text{NH}_4\text{-N}$): ≤ 10 mg/L
- Total Nitrogen: ≤ 30 mg/L
- Nitrate Nitrogen ($\text{NO}_3\text{-N}$): ≤ 90 mg/L
- Phosphates: ≤ 5 mg/L
- Free Residual Chlorine (in irrigation network): 0.2 – 0.5 mg/L

4.19 Solid Waste Management

The Operator shall assume full responsibility for establishing and operating a comprehensive Solid Waste Management system across the Jeita Grotto site. The system shall include, but not be limited to, the following requirements:

- **Waste Identification and Quantification**
 - Identify all types and sources of solid waste generated across the entire project area (Upper Cave, Lower Cave, snack areas, cable car buildings, restaurant, amphitheater, administration, parking, and tourist gathering areas).
 - Estimate daily waste quantities and volumes by weight and volume, with waste composition profiles defined for each functional area.
 - Provide waste density values used for conversions from weight to volume.
- **Sustainability and Compliance**
 - Incorporate source segregation practices and determine the number of waste streams in compliance with Lebanese laws and regulations.
 - Ensure alignment with Law 80/2018 on Integrated Solid Waste Management and all related regulations.
- **Storage and Containment**
 - Provide adequate two-day solid waste storage capacity for all functional areas.
 - Design and construct properly sized and dedicated waste rooms or enclosures, equipped with:
 1. Four-wheel bins of appropriate capacity
 2. External litter bins integrated with landscape furniture

3. Compactors where high waste volumes are anticipated

- Equip all storage areas with necessary MEP provisions, including:
 - Ventilation and climate control
 - Water supply and drainage for cleaning
 - Electrical connections for lighting and compactors
- **Collection and Routing**
 - Develop a structured collection truck routing plan with adequate access and maneuvering spaces.
 - Ensure efficient and safe collection from all waste storage points.
- **Off-Site Integration**
 - Maintain smooth coordination with approved off-site solid waste handling and disposal facilities.
 - Liaise with relevant authorities to ensure compliance and uninterrupted service.

5. Phasing & Operations Interface

The Operator shall prepare a comprehensive Phasing and Access Plan to ensure safe visitor circulation, uninterrupted business continuity, and protection of the grotto environment throughout the duration of the works. The plan shall clearly define construction zones, pedestrian diversions, and operational interfaces to minimize disruption to tourism activities. All possessions, closures, and restricted access periods shall be closely coordinated with the Employer and the Operator's own teams to avoid conflicts with site operations.

Blackout periods may be mandated during peak tourism seasons, national holidays, or special events when uninterrupted access for visitors must be maintained. During such periods, the Operator shall suspend disruptive activities, and limit works to non-intrusive tasks. Within the caves, works shall be carefully sequenced in short, controlled blocks to avoid excessive exposure of sensitive areas. Each phase shall be preceded by baseline environmental monitoring, with continuous monitoring carried out during the works and follow-up measurements performed after completion to confirm that no adverse impacts have occurred.

The Phasing and Access Plan shall also account for logistics and emergency scenarios. It shall define procedures for escorted movements of materials and equipment through shared access tunnels and visitor pathways, establish working-hour restrictions, and include contingency arrangements for rapid reopening of affected visitor areas in case of unforeseen events. The Operator shall update the plan regularly and submit revisions for approval whenever sequencing, access, or operational requirements change. CO₂ and radon readings shall be integrated into the phasing plan as go/no-go criteria for possessions, with pre-defined responses (e.g., temporary closure, pulse ventilation) and clear role assignments (ticketing, guides, control room).

Seasonal closures and employer-mandated blackout periods are planned constraints (not force majeure). FM events and time-extension procedures shall follow the RFP force-majeure article.

6. General Structural Requirements – All Facilities

In general, regardless of the level of visible damage, the structural detailing of the connections between various structural and façade elements, the cantilevered columns supporting the cable car, and the design and reinforcement of the basement walls must be adequate to resist seismic actions in accordance with the latest Lebanese seismic codes, especially given that the Jeita area is susceptible to severe earthquakes.

However, considering the extensive scope of work required to upgrade the structural systems of the various blocks to meet current seismic standards, this aspect of retrofitting will not be addressed in the current report. Nonetheless, it is strongly recommended that seismic strengthening measures be studied and implemented at the earliest opportunity.

VISUAL INSPECTION

A visual inspection was conducted on 13 June 2025 and was limited to the exploration of the site perimeter, as well as the examination of exposed and accessible structural elements across all blocks, including both the lower and upper grotto areas.

The detailed findings of the Visual Inspection are provided in a separate report.

TESTING SCOPE OF WORK AND METHODOLOGY

- **Testing Campaign:**

Following the visual inspection findings detailed above, the Operator shall engage a testing agency to conduct the required testing campaign.

The Operator shall engage a reputable, independent testing agency that is approved by the Engineer and the Authorities having jurisdiction, to perform a comprehensive inspection of the structural elements. This agency shall provide mapped documentation of observed defects and a detailed report outlining the current condition of construction materials and the extent of deterioration in the structural elements.

The purpose of the testing campaign is to assess the current condition of the existing structures.

Detailed as-built structural drawings are not available for all structures; therefore, an in-situ geometrical and topographical survey was already conducted, and its findings will be made available to the appointed testing agency.

To finalize the assessment, an in-situ detailed survey of the strength of structural members is required to understand the behavior of the existing structures and consequently check their ability to support safely the intended service loads.

The detailed survey will consist generally of:

- Defining the existing conditions of the structures including reviewing available information and assessing/considering the conducted geometric and visual surveys.
- Conducting in-situ and laboratory tests for accurate evaluation.
- Preparing and submitting a comprehensive report that includes description of procedures and findings.
- Identifying any structural defect by performing detailed inspection and testing of the structural elements.
- Checking the integrity and strength of the structural elements by conducting mechanical and chemical tests on them.
- Recommendations for future courses of action.

○ **Extent of Testing Scope:**

For the existing concrete structures, the appointed laboratory or testing agency shall carry out the necessary field and laboratory tests as required. The scope of work shall include, but not be limited to, the following:

- Defects Mapping:
 - Assess the condition of the concrete elements, identifying all signs of distress, including but not limited to the existence of cracks (type, pattern, width),

delamination, deflection, rebars corrosion, concrete spalling, concrete carbonation and the like. Furthermore, steel reinforcement and anchors shall be inspected to determine rate of corrosion and other defects. All findings shall be mapped on the topographical survey drawings that will be handed to the testing agency, and documented in details along with photos and sketches in the initial and final report to be submitted to the Employer.

- The same shall be done for steel structures, mainly the steel columns supporting the cable cars and the steel boat-docking platforms, where the testing agency shall inspect steel members in accordance with ASCE Manual 130 for corrosion (to ISO 9223), rust staining, pitting, deformations (bending, buckling, wrapping), cracking or joint separation, coating failures (to ISO 12944), grating, decking supports, bracing elements, accumulated silt, debris, and vegetation, sections loss due to rust or abrasion, and condition of welds and connections.
- For the steel columns supporting the cable car, a thorough inspection of the isolated footings and their surroundings shall be carried out. The scope shall include a detailed visual survey of the steel columns, base plates and reinforced-concrete footings, checking for cracks, spalling, rust staining, misalignment, loose connections and any visible signs of vibration-related distress. The areas around the footings shall be examined for soil scouring or loss of embedment, and, if needed, local geotechnical checks (trial pits and/or in-situ tests) may be carried out in line with EN 1997-2 or similar accepted practice. The anchor bolts and nuts shall be inspected visually and by simple mechanical checks (hammer sounding and torque verification), and, where justified, non-destructive testing such as magnetic-particle or ultrasonic testing shall be used in accordance with ASTM E709 and ASTM E114 / E213 to detect possible defects. The condition of the concrete foundations shall be assessed similarly to other reinforced concrete elements, using the destructive and nondestructive tests listed below. All findings, including measurements and photos, shall be reported part of the defects mapping report, then used to judge the current safety and serviceability of the footings/columns and to identify any need for remedial or strengthening measures.

➤ Destructive Tests:

- **Concrete Coring:** The concrete coring is the process of drilling or cutting through concrete, shells, walls, slabs, columns, and ceilings for assessment of the compressive strength and chemical composition of concrete, and the extent of deterioration due to weathering during the last decades. The number, size and location of core samples will be selected to permit all necessary laboratory tests.
- Core samples shall be extracted from the walls, columns, suspended slabs, and beams to evaluate the structural integrity and safety of the existing reinforced concrete, and to define the extent of the required rehabilitation measures. A minimum of four (4) sets of cores shall be taken from each block, and one (1) set for the foundation of each steel column supporting the cable car, with each set consisting of three (3) cores, as follows:
 - ✓ One set from external columns and walls
 - ✓ One set from deteriorated slabs and beams
 - ✓ One set from main internal columns and walls
 - ✓ One set from basement walls, foundations, and ground beams (where accessible)

Additional core samples may be taken based on the recommendations of the testing agency, depending on site conditions and findings during the investigation.

Three cores (one set) shall be taken from each isolated foundation for the steel columns supporting the cable car.

- **Reinforcement Samples:** Reinforcement bars will be extracted from selected locations in the structures for testing, especially from the Parking Block. Requirements for specimen length, preparation, testing, and determination of the yield strength shall be as provided in ASTM A370. Samples and site measurements will also be used to determine the level of corrosion and section loss of the bars. The results of tensile strength, elongation, and section measurements will be documented in details with photos in the final report.

➤ **Non-Destructive Tests:**

- **Cover meter survey:** In place test to locate the rebars buried in concrete as well as the corresponding cover and size/spacing of reinforcement in accordance with BS 1881 Part 204. This test is required for base slab, columns, walls, beams and slabs as follows:

- ✓ Suspended Slabs: Top and bottom reinforcement in both directions (including beams' longitudinal and transverse reinforcement, if any).
- ✓ Vertical elements: Vertical and horizontal reinforcement of columns and walls.
- ✓ In case cover meter fails to provide the above-mentioned requirements, Operator shall suggest alternative test methods to the engineer's approval.
- Half-cell potential and linear polarization resistance: Half-cell potential measurement in accordance with ASTM C876 shall be carried out to establish the probability of corrosion of rebar. Results of the potential map will provide base line comparison data and assist in determining most anodic areas for embedded reference electrode placement. Corrosion rates are to be valued using linear polarization resistance (LPR) according to ASTM G59.
- Schmidt hammer (ASTM C805) and/or ultrasonic pulse velocity test (ASTM C597): non-destructive tests used to check the compressive strength of concrete. The testing agency shall plot a graph between compressive strength of concrete cores and results from Schmidt hammer or direct UPV tests (at least 9 samples per block) to minimize the number of cores to be extracted from the structure.
- Select critical steel structural members, especially the columns supporting the cable car, for ultrasonic thickness testing to detect section loss (to ASTM E797 or ISO 16809), magnetic particle (to ASTM E709 or ISO 9934-1) or dye penetrant testing (to ASTM E165 or ISO 3452-1) for surface cracks, ultrasonic testing (UT) or radiography (to ASTM E1030 or ISO 17636) for internal flaws detection, and coating thickness gauge for remaining protection layer (to ISO 2808 or ASTM D7091).
- Laboratory Tests:
 - The following tests shall be conducted on the extracted cores, with rates as recommended by the testing agency:
 - ✓ Compressive Strength as per ASTM C39 or BS EN 12390 on all cores
 - ✓ Depth of Carbonation as per BS EN 14630 or ACI 222.R
 - ✓ Chloride Content Test as per BS 1881-124
 - ✓ Sulfate Content Test as per BS 1881-124

- Tensile strength and elongation of reinforcement steel, according to ASTM A370. All tests shall be performed in accordance with international codes and standards.

Once above testing campaign is completed, the testing agency will prepare and submit for the approval of the Engineer, a detailed report collecting findings, results and interpretation presenting the existing facility structural condition and stability assessment together with the recommendations and way forward.

- Deliverables:
 - ✓ Testing Agency Initial Report: This report shall mainly include the following:
 - Data collection including the structural systems of the existing structures.
 - Defects mapping, as described above.
 - Identification of the tests to be performed and proposing their related location in the existing structures.
 - Works schedule for the tests and inspection works, including the time required for the inspection and testing.
 - ✓ Testing Agency Final Report: This report shall mainly include the following:
 - Presentation of Inspection and testing results.
 - Analysis/assessment on the surveys and testing findings.

REHABILITATION SCOPE OF WORK AND METHODOLOGY

Based on the findings of the Testing Campaign and the recommendations outlined in the Testing Agency's Final Report, the Operator shall proceed with the execution of all necessary reinstatement and retrofitting works required to restore the structural integrity, safety, and long-term durability of the affected structural systems across the various blocks.

The Operator shall engage a specialized and certified Operator, with a proven track record in structural rehabilitation and retrofitting works, to carry out these activities. The Operator shall:

- Submit to the Engineer a detailed methodology statement for the rehabilitation works, including:

- Step-by-step procedures
 - Health, safety, and environmental (HSE) provisions
 - Access and protection measures
 - Monitoring and quality control procedures
-
- Propose suitable materials, products, and technologies for the Engineer's review and approval, including product datasheets, material certifications, and method of application.
 - Ensure that all works are carried out in full compliance with relevant international standards and codes, such as ACI 562, EN 1504, or other applicable national or local standards.
 - The rehabilitation strategy shall be performance-based, addressing not only the restoration of structural capacity but also long-term durability, corrosion protection, and serviceability under future loading and environmental conditions.
-
- **Spalling, Voids, and Delamination:**

In areas where concrete spalling, delamination, or surface deterioration is observed due to carbonation, water ingress, or corrosion of embedded reinforcement and steel elements, the following repair procedures shall be executed:

- Delaminated and unsound concrete shall be removed to sound substrate, with edges saw-cut to a minimum depth to avoid feathering (per EN 1504-10, ACI 562).
- Exposed reinforcement shall be cleaned to bare metal using mechanical tools (grinding, sandblasting) to achieve a SA 2½ finish (as defined in ISO 8501-1).
- Bars with a reduction in diameter beyond acceptable limits (typically >20–25%) shall be replaced or supplemented with new reinforcement bars anchored into the surrounding concrete using approved rebar anchoring systems (per ACI 355.4, EN 1504-6).
- The cleaned and treated reinforcement shall be coated with a corrosion-inhibiting primer.
- Electrochemical treatment methods (e.g., re-alkalization) may be proposed in cases of widespread corrosion, subject to Engineer's approval.
- Rebuilding of the concrete section shall be performed using structural-grade R4 repair mortars or flowable micro-concrete conforming to EN 1504-3 and BS EN 12190.

- Curing shall follow manufacturer specifications and site conditions.
- **Cracks in Reinforced Concrete Elements:**

Cracks in concrete elements, whether due to structural loads, shrinkage, or environmental exposure, shall be addressed as follows:

- Structural cracks shall be injected using low-viscosity epoxy resins, ensuring complete penetration and bonding across the crack width, following EN 1504-5 and ACI 503R.
- Non-structural cracks or those associated with water ingress shall be sealed using flexible polyurethane (PU) resins or elastomeric sealants, depending on site conditions and crack movement.
- Crack monitoring may be required prior to injection to assess whether the crack is active or dormant.
- All products used must meet ISO 11600 for movement capability and EN 14188-2 for sealing performance.
- **Structural Strengthening – RC Jacketing and CFRP Wrapping:**

Where structural elements are deemed inadequate due to loading demands or degradation, the following strengthening options shall be implemented:

- For RC Jacketing:
 - Columns, beams, or walls shall be enlarged using additional layers of reinforced concrete with dowels and connectors to ensure monolithic action.
 - Substrate shall be roughened or scabbled and treated with bonding agents per ACI 364.1R, EN 1504-4, and FIB Model Code 2010.
 - New reinforcement shall be detailed to match the design requirements and tied securely to existing steel.
 - Steel rebar dowels shall be anchored into the substrate concrete using approved rebar anchoring systems (per ACI 355.4, EN 1504-6).
 - Pouring of jacket concrete shall be done using non-shrink, high-strength repair concrete or micro-concrete with minimum shrinkage.
- For CFRP Wrapping:
 - CFRP or other FRP systems shall be applied for confinement, flexural, or shear strengthening as needed.

- Surface preparation includes smoothing, cleaning, and priming using compatible epoxy systems.
 - Application of CFRP sheets or laminates shall follow ACI 440.2R, EN 1504-4, and FIB Bulletin 14, ensuring fiber orientation and anchorage detailing match design intent.
 - Pull-off bond strength tests (in accordance with EN 1542) shall be conducted to verify adhesion.
- **Structural Monitoring of RC Elements Cast into Rock Formation to Support Pedestrian Passages at the Upper Grotto:**

The reinforced-concrete elements cast directly into the rock manmade cavities shall be monitored regularly to detect any movement, cracking, slippage, or signs of distress. The monitoring program shall include a periodical visual inspection of all exposed concrete surfaces and contact interfaces with the rock, looking for new cracks, widening of existing cracks, changes in alignment, spalling, or any signs of detachment.

Reference marks shall be installed on both the concrete and the adjacent rock faces so that any relative displacement or rotation can be measured over time. In areas where access allows, crack gauges or simple tell-tales may be placed to track the development of critical cracks. All observations shall be photographed, recorded, and compared to previous inspection cycles to identify trends. Any sudden movement or progressive deterioration shall be reported immediately, as these elements play a direct role in supporting the pedestrian passages inside the grotto.

- **Soil Scour Under Footings:**

To rectify the scour issue affecting the foundation of the circular retaining wall at the west side of the parking structure, the remediation must address both the loss of soil support and the exposure of the foundation to river flow. The goal is to stabilize the existing foundation, prevent further erosion, and protect against future scouring.

➤ *Site Preparation and Access Control*

- Divert the local river flow using temporary cofferdams, sheet piles, or sandbag walls to create a dry or low-flow work zone around the exposed foundation (as per ACI 350.4R guidelines on working near hydraulic structures).

- Establish safe access platforms and install temporary support or shoring if necessary.
 - Carry out a visual and topographical survey to assess the full extent of scour and exposed areas.
- Geotechnical and Structural Assessment: Perform a detailed inspection of the exposed foundation base and adjacent soil.
- Concrete Injection and Pressure Grouting
- Drill grout holes at selected locations beneath and adjacent to the exposed footing area.
 - Inject non-shrink, cementitious grout or microfine cement slurry under controlled pressure to fill voids left by scouring and Reinststate soil contact with the base of the foundation.
 - Grouting materials shall comply with EN 1504-5 (Injection products and systems) or ASTM C1107 (High-performance, non-shrink grout).
 - Confirm effectiveness by grout take monitoring and use ground-penetrating radar (or sounding) to verify void closure.
- Construction of Reinforced Concrete Ground Beam
- Excavate in front of the existing foundation to prepare for a protective ground beam or toe beam along the base of the wall or column. The depth of the beam shall not be less than 1m below the bottom of the foundation level.
 - Design the beam to act as a protective apron resisting hydraulic erosion and as additional lateral restraint to the base of the wall (refer to EN 1992-1-1 for design).
 - Connect the new beam to the existing wall or column footing using epoxy-bonded dowels (anchorage system compliant with ACI 355.4).
 - Cast the beam using durable, water-resistant concrete (min. Grade C40/50), incorporating waterproofing admixtures and corrosion inhibitors.
 - Ensure proper curing using moisture-retaining blankets or curing compounds in accordance with ACI 308.1.
- Erosion Protection and Riverbank Stabilization:
- Place geotextile separation fabric over the compacted riverbed and backfill areas to prevent soil loss through voids.

- Install riprap, gabion mattresses, or revetment concrete blocks around the foundation and beam to dissipate water energy and resist future erosion.
 - Where higher hydraulic velocities are anticipated, use grouted riprap or reinforced concrete protection pads.
 - All protective works shall follow the guidance of FHWA HEC-18 and EN 13383-1 (for rock materials in hydraulic works).
- Monitoring: Install survey markers or inclinometers to monitor potential wall movement or settlement post-repair.
- Quality Control and Documentation
- The Operator shall:
 - ✓ Submit shop drawings, material datasheets, and grout mix designs for Engineer approval.
 - ✓ Perform trial grout injections if required to calibrate pressure and volume.
 - ✓ Maintain detailed records of grout volumes and pressures, reinforcement and dowel installation, and concrete placement and curing
- A final inspection report shall be prepared summarizing works, test results, and photographic documentation of all stages.
- **Surface Protection – Anti-Carbonation and Waterproofing Coatings:**

Exposed concrete surfaces vulnerable to carbonation or chloride ingress, particularly at facades, podiums, and exposed reinforced concrete surfaces, shall be treated as follows:

- Surfaces shall be cleaned, repaired, and dried before coating application.
- An anti-carbonation coating with a CO₂ diffusion resistance ($S_d \geq 50 \text{ m}$) shall be applied, per EN 1504-2 and EN 1062-6.
- Where water ingress is a concern, liquid-applied waterproofing membranes or elastomeric coatings shall be applied, selected based on crack-bridging performance (EN 1062-7) and UV resistance.
- All coatings shall be applied per the manufacturer's system requirements, including primers, base coats, and topcoats.

○ **Steel Columns Supporting Cable Car Rehabilitation**

Possible rehabilitation measures for the steel columns supporting the cable car may include:

- Tightening or replacing deteriorated anchor bolts and nuts,
 - Repairing or re-welding any cracked or weakened welds,
 - Treating areas showing signs of corrosion through cleaning and protective recoating.
 - Where needed, localized strengthening plates or collars can be added around the base plate or column shaft.
 - Once all repairs are completed, the exposed steel surfaces shall receive a suitable protective coating system designed for outdoor exposure, to guard against UV radiation, moisture, and long-term corrosion.
- **Steel Docking Structures Rehabilitation**
- Remove Marine Growth and Rust using high-pressure water jetting or mechanical brushing or with abrasive blasting to ISO 8504-2 (as needed).
 - Degrease and Clean prior to applying any repair materials. Light to moderate rust shall be treated with mechanical cleaning or water jetting. No need to use abrasive blasting unless deep pitting exists.
 - Cut and replace severely corroded or deformed members with more than 30% section loss, with equivalent or improved steel sections. Reinforce with stiffeners or plates as needed. Weld replacement parts to AWS D1.1.
 - Apply a 3-layer paint system: zinc-rich primer + epoxy intermediate + polyurethane or acrylic topcoat, in accordance with ISO 12944.
 - Re-perform NDT on all critical repairs.
 - Establish a maintenance cycle (e.g., visual inspections every 2 years, full reassessment every 5 years).
- **Execution, Quality Control, and Documentation**
- All rehabilitation works shall be supervised and documented under a comprehensive QA/QC framework. The Operator shall:
- Submit detailed method statements for each intervention, including work sequences, materials, safety measures, and control points.
 - Provide technical datasheets, material certifications, and installation manuals for all proposed products, to be reviewed and approved by the Engineer.
 - Carry out trial applications or mock-ups for surface repairs, coatings, or CFRP systems as required.
 - Conduct all required testing, including:
 - Core testing (per EN 12504-1)

- Pull-off adhesion tests (per EN 1542)
 - Visual inspections and photographic documentation
- Maintain a record of all repairs, materials used, and results in Repair Logbook, forming part of the final handover documentation.

7. Facility-By-Facility Scope

7.1 Upper Grotto

The Upper Cave contains three principal chambers: the White Chamber, which includes the 8.2 m stalactite, the Red Chamber with a height of up to 106 m, and a third chamber exceeding 120 m in height.

ARCHITECTURAL

○ Exterior Painting

- Verify suitability of substrates, including surface conditions and compatibility, with finishes and primers. Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
- Reinforced concrete repairs to be conducted where needed and as per structural requirements with suitable anti corrosion cementitious mortar for protecting steel reinforcement rods and suitable non shrink grout complying to ASTM C1107
- Pure acrylic emulsion, pigmented coating system to achieve desired finish; formulated for alkali, mold, microbial, and water resistance and for use on exterior surfaces, suitable for repeated washing and scrubbing; to concrete, masonry, render and plaster, and primed wood; one acrylic primer coat, suitable filler for each substrate type (number of layers as needed to achieve the desired finish), acrylic top coat (number of coats as needed to cover substrate but not less than 2 coats.); (Color RAL 1000 or as approved by engineer).
- Location: Tunnel; walls and ceilings

○ Pipe & Tube Railings

- **Rectification, maintenance and paint of the existing steel balustrades** to meet the below requirements:
 - Minimum height: 1000 mm from the floor

- Maximum gap between horizontal rails: 180 mm
- Maximum distance from floor to bottom rail: 110 mm
- Solid infill or protective panel required up to: 450 mm from the floor (to prevent climbing or slipping through)
- Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
- Polyurethane Colored Coating: paint system obtained from single supplier consisting of high build polyurethane colored exterior coating over anti-corrosive pigmented primer and barrier coat. Color of polyurethane coating applied on weathering face is to be selected by the Engineer from manufacturer's full range of colors and gloss.
- The Operator shall provide corrosion protection to the steelwork, based on type of substrate which has the following durability and maintenance characteristic: Fully compliant to the pertinent provision of BS EN ISO 12944. Conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3.

Location: Internal balustrades within the Grotto premises

- **Cold Liquid Applied Waterproofing**
 - Verify the suitability of substrates, including surface conditions, moisture content and compatibility. Proper surface preparation and debris removal to be conducted prior to applying waterproofing and to follow manufacturer recommendations.
 - Single-Component, Modified Polyurethane Waterproofing: ASTM C836/C836M; UV resistant; solid content not less than 80%; tensile strength not less than 1.5Mpa; low temperature crack bridging, pass; elongation minimum 500%; complete with surface preparation, grouting and flashings; geotextile 200gr/m2 and 70mm screed protection layer 25Mpa compressive strength.
 - Location: Exterior/Exposed tunnel concrete slab with proper area preparation and termination at interfaces.
- **Metal Lockers**
 - **Remove and disposal of existing wood lockers**
 - Lockers; pressed steel ASTM A1008; polyester powder coated finish; (Mat color RAL 1000 or as approved by engineer); including continuous base, ironmongery, fittings and fixings; box type 6 tier; top , bottom, sides, frames shelves minimum thickness 1.5mm; backs min thickness 1.2mm; doors min thickness 1.9mm; ventilated doors; recessed door handle with single point latching; complete

- Location: Lockers at entrance approximate size 5000 mm x 2000 mm high
- **Door Mats & Frames**
 - Heavy duty, rubber disinfectant mat with edging, Virkon chemical resistant, with non-slip backing.
 - Surface: Flexible rubber bristles/fingers or looped scrubs, as approved by Engineer.
 - Color: As approved by Engineer.
 - Size: As approved by Engineer, but not less than 2500 mm * 2500 mm.
 - including cement-sand screed levelling; complete as specified.
Location : Entrance ; minimum 2500mm x 2500mm
- **Rubber Stair Accessories**
 - Stair treads to ASTM F2169, type TP (rubber, thermoplastic), class 1 (smooth, flat), nosing style round with minimum thickness 6mm and tapered to back edge.
Metal Edge Strips: Extruded aluminum, nominal 50.8 mm wide.
 - Location: Stairs inside grotto

SIGNAGE & WAYFINDING

- **Design and execution of new suspended Identification sign at the grotto access.**
 - Welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 1.40m length and 0.30m height.
 - Located at the main entrance.
- **Design and execution of new YAH map sign at the main entry point.**
 - Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting and Braille).
 - Indicative dimensions: 2.20m height poles supporting a 1.40m length and 1.60m height information plate.
 - Located at main decision point.
- **Design and execution of new general information / restriction sign.**

- Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting and Braille).
- Indicative dimensions: 2.20m height poles supporting a 1.40m length and 1.60m height information plate.
- Located at main decision points.
- Minimum quantity 2 Units or more.
- **Design and execution of new educational sign.**
 - Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting and Braille).
 - Indicative dimensions: 2.20m height poles supporting a 1.40m length and 1.60m height information plate.
 - Located at main decision points.
 - Minimum quantity 3 Units or more.
- **Design and execution of new safety signs.**
 - Powder coated steel pole supporting PVD coated 3mm thick aluminum with message in reflective vinyl.
 - Indicative dimensions: 0.60m height by 0.60m length.
 - Located at main decision points.
 - Minimum quantity 10 Units or more.
- **Design and execution of all education signs.**
 - Floor mounted powder coated steel tub to hang PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 1.20m height tube supporting a 0.60m length and 0.60m height sign plate.
 - Located at main decision points.
 - Minimum quantity 20 Units or more.

STRUCTURAL

- **Testing Campaign**
 - Defects Mapping; minimum area 600 m2 or more;
 - Extraction of Concrete Cores and related works; minimum quantity 12 cores or more;

- Compressive Strength Test on All Cores; minimum quantity 12 tests or more;
 - Depth of Carbonation Test; minimum quantity 12 tests or more;
 - Chloride Content Test; minimum quantity 6 tests or more;
 - Sulfate Content Test on Foundations and Ground Beams Samples; minimum quantity 6 tests or more;
 - Schmidt Hammer Test; minimum quantity 30 tests or more;
 - Final Report
- **Rehabilitation Works**
 - Repair of exposed reinforced concrete slabs surfaces (Spalling, voids, and delamination), given in square meters of structurally repaired surfaces, including all required products, equipment, works, workmanship and experienced labor.
 - Repair of exposed reinforced concrete columns and walls surfaces (RC jacketing or CFRP wrapping), given in square meters of structurally repaired surfaces, including all required products, equipment, works, workmanship and experienced labor.
 - The operator must comply with all requirements set out in the following Reports:
 - Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25
 - Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25

ELECTRICAL

- **Cables and Branch Circuits:**
 - Cable & Branch Circuits to be tested and checked if they are still operational. The necessary tests are Insulation resistance & Dielectric Withstand tests according to IEC 60502-1, Continuity Test according to IEC 60228, Earth resistance test according to IEC 60364-6 and voltage drop test under full load. Cables that fail the tests shall be replaced with proper sizes and types according to electrical load being served and area of installation. All branch circuit wiring shall be single-core copper, PVC insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
 - All cables are to be sized in accordance with BS code and taking into consideration the derating factors and environmental conditions.
 - Wires and cables are deemed to include:

- conduits and fittings, draw wires and the like (except where conduit work is required to be measured separately),
 - cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - spare parts as required for continuity of operation and agreed with Employer".
- **Distribution Panels:**
- Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted, installed in lockable cabinets with warning signs.
 - DPs shall have molded case circuit breakers thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
 - Installation must comply with IEC, NEC, or local electrical standards, with a special focus on low-voltage systems and environmental protection.
 - Lighting and Power Panel Boards will have molded case switches on the incoming and miniature circuit breakers on the outgoing.
 - All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth bus.
 - Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability.
 - Surge Protective devices are to be provided in each distribution panel.
 - All boards shall be lockable, installed in dedicated rooms or closets and away from water pipes according to NEC clearances standards.
 - IP 65 rated enclosures shall be used, with anti-corrosion treatment. All components must be compatible for use in extreme humidity environments.
 - Distribution boards under the passageways shall be IP 65 rated and contain the necessary transformers and lighting control gear, fuses, etc.
 - Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
 - Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.

- All circuits feeding lighting & power inside the grotto to be protected by a 10mA RCBO configuration.
- Panelboards shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - AC or DC power supply for switchgear control and operation.
 - spare parts as required for continuity of operation and agreed with Employer.
- **Cable trays**

Cable Trays will be heavy duty, hot dip galvanized after fabrication and will be installed with central supporting, two-sided hanging system and brackets as required. All components must be compatible for use in extreme humidity environments.

 - Rigid metal hot-dip galvanized conduits will be installed in exposed areas where the conduits may be subject to mechanical damage.
 - Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where the ceiling is used as an air plenum (above false ceiling) installations and in exposed non-hazardous indoor locations.
 - The minimum size of conduits for indoor applications shall be 20 mm diameter and 50 mm diameter for exterior installations. A filling capacity of 40% shall be provided for all conduits. Separate conduits and wire ways shall be used for normal light and power circuits and low current systems wiring.
 - Due to high humidity, cables trays and conduits shall be treated properly for anti-corrosion and to withstand high humidity and coated with PVC jacket.
 - Junction boxes shall be:
 - Ingress Protection (IP): IP66 minimum
 - Impact Resistance: IK10
 - UL Listed
 - Material: Stainless Steel 316L or UV-stabilized Polycarbonate
 - Cable Entry: Glanded entries with IP-rated seals compatible with installed cables
 - Mounting: Surface mount with Polycarbonate or stainless-steel brackets and anchors.
 - All junction boxes shall be filled with sealant gel.
 - Conduits are deemed to include:

- Fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Socket outlets:**
- Electrical outlets and isolators will be provided to serve various fixed and portable equipment and general appliances throughout the facilities. IP 65 rated socket outlets shall be used.
- Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-proof socket outlets shall be used in wet and exposed areas.
 - Any isolated 220 V general-purpose sockets within cave-related areas shall be limited to approved dry, protected, service-only locations, outside visitor reach and outside hazardous wet or splash-exposed spaces. No generic socket outlets shall be installed in wet public cave areas, docks or boat-charging splash zones.
 - Wiring devices are deemed to include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panelboard,
 - Fixing and supporting material.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Lighting Design & Lamp Selection**
- Lighting Design & Lamp Selection will be based on achieving recommended illumination levels taking into consideration daylight effect, proper color rendering and temperature for each task. Glare will be kept to minimum as SLL recommendations issued by CIBSE.
- Lighting fixtures used in each type of space will be determined based on the functional requirements of the space as well as architectural consideration.
 - The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP68 rated lighting fixtures with stainless steel

housing shall be used to withstand the high humidity of the surrounding environment, especially for the submersible lights inside the lake.

- High Efficiency Light Emitting Diode (LED) lamps will be utilized throughout the project.
- Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
- Cave lighting shall minimize lampenflora risk and heat exposure through warm-white, high-efficiency LED luminaires, 2,700–3,000 K unless otherwise approved, CRI ≥90%, maximum 50 W per luminaire, dimmable scene control, shielding, careful beam aiming, limited operating duration, and illumination only of visitor-occupied portions or approved interpretive focal points. Light shall not be directed at speleothems except where specifically approved as part of the lighting and conservation design.
- All components must be compatible for use in extreme humidity environments.
- All hardware, fixtures, and accessories shall be corrosion-resistant and cave-safe.
- Lighting lux levels in the middle of the passageways shall not be less than 5 lux
- Each luminaire in the system has its own built-in control unit.
- The Show cave area is only fitted with an ELV DC lighting system and isolated 220V General Purpose sockets.
- Lighting system shall be controllable via central control unit (main controller). Control is by wire and radio.
- The lighting themes are defined and saved via the central control unit. Lighting themes are switched on via the remote control or manually via buttons on the viewing platforms.
- Lighting points distribution and themes are coordinated with the Architect in charge.
- Suppliers shall have previous proven experience in cave installations.

○ **Lighting Fixtures**

- Type: High lumen output LED lighting suitable for the cave requirements detailed above.
- LEDs shall comply with Photo-biological Safety of lamps and lamp systems in accordance with the requirements of IEC 62471. Provide a test report to prove the fixture is classified as "Exempt" or "Risk Group 1".
- Electronic LED Drivers: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Driver shall have constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the

number and wattage of LEDs connected. Guaranteed rated life of the driver shall be 50,000 hours as a minimum.

- LED drivers have electrical insulation between primary and secondary sides. Secondary cables from the driver to LED modules shall be provided by the LED supplier. The maximum length between driver and LED module shall be as per manufacturer's recommendations.
- LED drivers shall be protected against electric shock, accidental contact with live parts, short circuit, and overload.
- LED luminaires equipped with internal temperature monitoring, the LED driver shall be capable of accepting temperature sensor connection to monitor the LED temperature and protect the LED modules against thermal damage by reducing the output current.
- Dimmable drivers, where required, shall be compatible with the dimming system used.
- Drivers shall be compatible with the lighting control system used such as; 1-10V, DALI, DMX, etc...
- LED driver shall be provided with constant light output function, where required on Drawings, in order to maintain the light output of the LED throughout its lifetime by increasing the LED driving current gradually over the lifetime to compensate for the expected lumen output reduction. Fixture's heat sink design shall consider the maximum additional heat dissipation with no impact on the fixture's guaranteed lifetime and color temperature.
- LED driver shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interference suppression limits defined in BS EN 55015 and immunity requirements of IEC 61547.- Polarity Reversal protection
- Power Consumption: Maximum 50 Watts per luminaire
- Beam Angle: Adjustable or selectable range between 10° and 120°
- Color Rendering Index (CRI): ≥ 90%
- Ingress Protection (IP): IP67 for non-submersible fixtures, IP68 for submersible fixtures
- Casing & Mounting Materials: Non-corrosive body and housing made of: Stainless Steel Grade 316L, Coated Aluminum for heat control, High-impact Polycarbonate. Any combination or interlocking between two different metals (even for screws) shall be insulated with non-ferrous material.
- Operating Temperature: 5°C to 45°C
- Relative Humidity: Up to 98%

- Cable: Built-in cable minimum length: 3 meters, extended lengths must be available by manufacturer upon request"
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panelboard,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.)
 - Suppliers shall have previous proven experience in cave installations
 - Lighting shall be installed to illuminate only the portions of the cave that are occupied by visitors.
- **Illumination of means of egress**

Shall be provided in all passageways, exit corridors, exit stairs, exit discharge lobbies, etc. in compliance with BS 5266. Illumination shall be continuous using Central Battery system for 1.5 hours.

 - For escape routes up to 2 m in width, floor surfaces shall be illuminated with not less than 1 lux and with a ratio (maximum to the minimum illuminance) not greater than 40:1 along the center line of the escape route, with minimum distance every 15m along evacuation routes.
 - Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in trilingual language (Arabic, French and English), illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs battery autonomy.
- **Central emergency battery system**

Will be provided complying with the BS 5266. This system will provide power to lighting fixtures in passageways, escape routes and open areas with minimum required lux levels, as per code requirement.

- The system will employ addressable lighting fixtures which will be monitored by the central control panel as per code requirements.
- Batteries will be sealed lead acid type adequate for 1.5 hours operation. All wiring will be of the fire-resistant type.
- Emergency exit lighting along the walkway is of the maintained non-contained type fed by TWO redundant sources.
- Central battery system shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - All devices housed by the emergency central battery systems such as: chargers, batteries, main incoming and outgoing protective devices,
 - Addressable modules for all normal lighting fixtures fed from central battery system and for exit signs were obtained from a different manufacturer,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - Interconnection control cables and other accessories for interface with other systems such as BMS
 - Connection to central monitoring system and respective wiring system and raceways,
 - Intelligent control gears for monitoring and control of emergency fixtures, changeover modules, control modules and final circuit monitoring modules,
 - Enclosure appropriate for the installation and as specified,
 - Spare parts, tools and instruments, where specified.
- **Central lighting control system**
 - The lighting control system shall be adopted for cave lighting. (utilizing DALI, dmx, KNX system or the like)
 - The lighting system shall be controllable via central control unit (main controller). Control is by wire and radio.
 - The lighting themes are defined and saved via the central control unit. Lighting themes are switched on via the remote control or manually via buttons on the viewing platforms. The lighting system shall be able to integrate with the sound system.
 - Emergency lighting dedicated for life safety purposes (including stairways) shall be maintained and shall not be subject to any control.

- **Complete system of electric service grounding (TN-S)**

- Grounding System shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning. The earth electrode shall consist of multi-earth rods buried in the ground around the building and interconnected by a ring copper earth conductor. Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit. Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to ensure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
- Grounding system shall be:
 - A complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),
 - Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure,
 - Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.

- **Complete removal of all legacy wiring and HID fixtures.**

MECHANICAL

- **First Aid Station:**

Supply and install **first aid station** including an emergency kit and survival blanket with all necessary accessories; minimum quantity 3 stations or more.

- **Fire Extinguisher:**

- Supply and install wall-mounted **6 kg ABC** portable fire extinguishers 1.2m above floor level; minimum quantity 18 Units or more.
- Supply and install wall-mounted **4.5 kg CO2** portable fire extinguishers adjacent to the electrical panel boards and positioned 1.2m above floor level; minimum quantity 2 Units or more.

- **Wet Vacuum Cleaner:**

Supply wet-vacuum cleaner for debris removal without wastewater discharge with biodegradable clean agents.

- **Compliance with SOCOTEC Report**

Operator to follow SOCOTEC reports to implement FLS recommendations for upper grotto in conformity with the applicable safety norms and standards.

GEOTECHNICAL

- **General:**

- The Operator shall provide all equipment, workmanship, and execute the required works to the satisfaction of the Engineer. Works including design, supply of all material, installation, ancillary works, method statement of works, design calculations, shop drawings.

- **Stabilization Measures**

- Above **locality 11** (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) at the entrance of the tunnel, rock displacement has been observed with visible signs of damaged steel mesh. Immediate stabilization measures are required to prevent collapse and restore slope stability.
- It is required to:
 - Establish safe access (e.g., manlift, scaffolding, or rope access) to inspect the wedge geometry and net conditions.
 - Carefully remove loose debris and weathered material around the wedge to reduce additional loading.
 - Remove failed and damaged mesh to prepare for reinstallation.
 - Drill and install rock bolts across the wedge body and into stable surrounding rock to prevent detachment.

- Install new high-tensile steel mesh, fixed with anchor plates and edge ropes, ensuring it is properly tensioned and covers the entire affected area.
 - Secure the area below the work zone during operations.
 - Maintain temporary protective barriers or debris catchment netting until full stabilization is confirmed.
- **Surface Stabilization**
 - The rock formation at **Locality 12** (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) - near the study panel to the right, exhibits significant weathering and fracturing. All loose or detached material shall be carefully removed to prevent uncontrolled detachment and ensure a stable surface for any subsequent stabilization measures.
 - **Surface Stabilization**
 - At the end of grotto in **Locality 14** (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*), the geological formation transitions from limestone to sandy limestone, indicating the presence of softer material. Below the bridge, sliding has been observed, accompanied by extensive fracturing in the more complex rock. It is required to monitor these fractures and fissures over time to assess whether movement is occurring. Monitoring shall be done through applying epoxy (or plaster) or tell-tales across selected cracks. Regular visual inspections monthly and post-rainfall/winter) shall be performed and any signs of crack widening, new fractures, or rock spalling shall be documented, to assess the need for further investigations or stabilization methods.
 - **Safety Surveillance**
 - The Operator is responsible for routine safety surveillance within and around the grotto and shall:
 - Conduct regular safety walkthroughs and visual inspections of the grotto.
 - Monitor key visible cracks using simple methods such as plaster or epoxy tell-tales.
 - Visually inspect and document any significantly tilted stalactites or signs of ceiling distress.
 - Photograph and record all observed changes, deteriorations, or potential hazards.

- Immediately report any signs of instability or unsafe conditions—whether related to rock mass, formations, or environmental shifts—to the supervising team for further action.
- **Compliance with Geotechnical Assessment Report**
 - The Operator must comply with all requirements set out in **Appendix 8 - Geotechnical Assessment Report - Sep. 25.**

WATER & ENVIRONMENTAL

- **Speleothem conservation plan**
 - Submit a speleothem conservation plan within 6 months, including dry-ice / CO₂ snow cleaning protocol, pilot testing, fixed-point photography, condition mapping, and annual specialist survey; complete the first condition survey within 12 months.
 - Dry-ice / CO₂ snow cleaning by qualified specialists or trained staff only under a specialist-approved method statement.
 - Pilot testing on limited representative areas before wider cleaning.
 - Fixed-point photography, condition mapping, and annual specialist survey.
 - Hydrogen peroxide, chemical, abrasive, brushing, or uncontrolled washing methods prohibited unless specifically approved by the conservation specialist.
- **Solid waste**
 - General waste bins shall be removed from visitor cave routes. Food, wrappers and organic waste are prohibited inside the Upper and Lower Grotto visitor areas.
 - If water bottles are permitted, only transparent bottle-only mesh containers may be installed at approved control points, preferably outside cave entries/exits, with signage and staff supervision.
 - No general waste or organic waste bins shall be placed beside speleothems, rimstone pools, cave walkways or the underground river.
- **Walkway Cleaning**
 - Routine removal of litter, sediment, fibers, and bio-film from the concrete walkway is essential to protect adjacent speleothems and to minimize the introduction of pathogens (e.g., white-nose syndrome fungus) carried in by visitors. The recommended method is a wet-vacuum scrubber that washes and immediately extracts the rinse water, preventing contaminated run-off from reaching formations on either side of the walkway.
 - Equipment – commercial disc-scrubber / wet-vac unit, ≈ 60 L recovery tank, ≥ 2 000 m² h⁻¹ capacity; similar to Kärcher BD 50/60 C EP (1 piece) or equivalent.

- Cleaning agents – only biodegradable, pH-neutral products certified for use in sensitive environments; chlorine or strong acids/alkalis are prohibited.
- Wastewater handling – all effluent is collected in the machine's tank and removed from the cave for off-site disposal; no discharge inside the cave is permitted.
- Frequency – minimum monthly during low-season; fortnightly during high-season or after heavy visitor days.

- **Shoe Disinfection Mats**

To prevent the transfer of invasive spores, bacteria, and fine soil into the cave ecosystem, absorbent disinfection mats shall be installed at the main entrance as follows:

- Operation:

- Visitors step on a disinfectant mat on entry.
- Disinfection mats shall be placed in contained trays or an equivalent fully contained arrangement.
- No disinfectant, rinse water, or contaminated runoff shall be allowed to enter the cave floor, drainage pathways, pools, river, or speleothem areas.
- Mats shall be sized and managed so that footwear is disinfected without leaving visible dripping before visitors proceed into the cave.
- Staff shall inspect the mat area during opening hours and remove or contain any excess liquid immediately.
- Used disinfectant and contaminated liquid shall be collected and disposed of outside the cave; no discharge inside the cave is permitted.
- Staff shall inspect mats during opening hours and replenish or replace disinfectant solution only as needed to maintain effectiveness without creating excess liquid or Runoff.
- Mat inserts shall be replaced or cleaned in accordance with the manufacturer's schedule and whenever visibly soiled.

- Disinfectant:

- 1% Virkon S (or equivalent broad-spectrum biocide).
- A 1% solution is effective yet non-hazardous under EU classification.

- Signage & Supervision:

- Clear multilingual signs instructing use.
- A 1 % solution is effective yet non-hazardous under EU classification.

- **Radon Exposure Management**

- Ensure that the weekly average radon concentration remains below 3,000 Bq/m³ to protect staff from long-term exposure.
- If this threshold is exceeded rotate staff assignments to limit exposure and consult the occupational-health authority.
- During the first year of operation, maintain staff occupancy logs and review them with measured radon concentrations to assess annual worker exposure in accordance with applicable national requirements and authority guidance.

○ **MICRO-CLIMATE MONITORING**

Jiita Show-Cave shall continuously measure carbon-dioxide (CO₂), temperature (T), relative humidity (RH) and radon-222 (Rn) at the fixed monitoring layout shown in *Figure 7* below. Temperature and RH shall be monitored at all microclimate stations, while CO₂ sensors shall be installed only at the specified CO₂ monitoring stations. Recommended equipment performance requirements are provided in *Table 1* below.

- Upper Gallery: 10 stations for T and RH (Stations 1 to 10), of which 5 stations shall also include CO₂ monitoring (Stations 1, 2, 5, 8 and 10).
- Radon (continuous): Two electronic loggers per gallery
 - Primary at the highest-radon location found by a 1-week walk-through survey.
 - Secondary near each gallery entrance to verify spatial variability as follows:
 - ✓ Mount the logger 5-10 m past the door so it is out of direct wind but still in the low-radon zone.
 - ✓ Install at 1.5 m above floor level approximately, on a wall bracket, away from water drips.

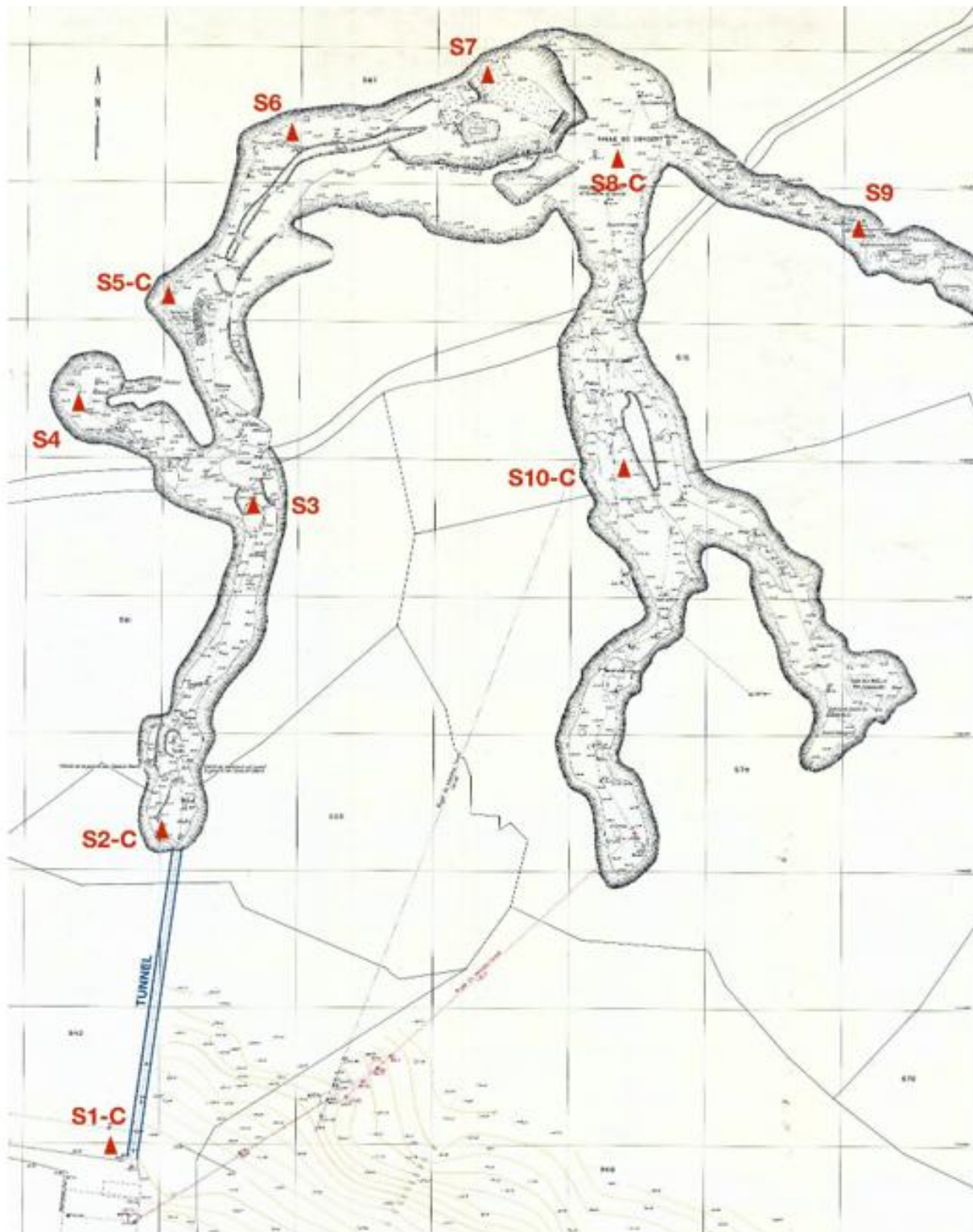


Figure 7- Monitoring Stations for the Upper Grotto (“-C” indicates CO2 monitoring)

Parameter	Minimum Specification	Notes / Examples*
CO₂	- NDIR, 0-10,000 ppm - accuracy $\pm(3\%$ reading + 50 ppm) preferred; $\pm(5\%$ reading + 100 ppm) maximum acceptable - $t_{63} \leq 120$ s - Auto RH/pressure comp	Probe in IP-65 polycarbonate "cave-case" with Gore-Tex® vent. DOL 139* CO ₂ , IP67, iDOL139*, or equivalent
Temperature	- -10 °C to +50 °C - Accuracy ± 0.25 °C	Digital sensor; conformal-coated PCB. HOBO MX2301A* Data Logger, temperature & RH, IP67, or equivalent
Relative Humidity	- 0-100 % RH suitable for condensing or near-condensing cave conditions - Accuracy ± 3 % RH at 40-95% RH, or manufacturer-declared accuracy at >95% RH to be stated in the tender submission	HOBO MX2301A* Data Logger, temperature & RH, IP67, or equivalent
Radon-222	- Pulsed-ion or alpha-spectroscopy logger - 30-45,000 Bq · m⁻³ - Sensitivity ≤ 0.4 cph per Bq · m⁻³	Units equivalent to RAD7* / AlphaGUARD class*, or equivalent
Ingress Protection	IP-65 (IP-67 preferred)	
Power	Lithium battery ≥ 15 Ah for ≥ 12 mo @ 1-min logging or 12 V DC PoE feed with DC-UPS	Field-swappable batteries.
Data Logging	- 1-min samples - $\geq 63,488$ records	Time-stamped CSV.
Communication	• Option 1: Integrated PoE-capable RJ45 Ethernet port (IEEE 802.3af) to support shielded Cat-6 cabling up to 100 m and 10/100 Mbps link for cloud push. • Option 2: Low-power LoRa mesh repeaters with one repeater every 80–100 m and an IP-65 gateway at tunnel mouth. Each node must carry an SD-card buffer that stores at least 30 days of 1-min readings in case of RF outage. • Local USB-C/BLE service port for maintenance.	Each node must buffer ≥ 30 days of 1-min data in non-volatile memory.
Calibration	- CO₂ span check yearly (certified 1,000 ppm gas) - RH/T salt-kit yearly - Radon lab re-calibration every 24 months	Certificates kept on-file.

Table 1 - Monitoring Equipment Performance Requirements

**Brands are examples only; any equipment meeting these numeric specs is acceptable.*

- Draft a full Emergency Management Plan within 3 months of contract start and gain approval by month 6.
- Install permanent CO₂ and radon telemetry (one-minute logging, cloud dashboard, SMS alarms) within 6 months as follows:
 - Upper Gallery: 10 stations for temperature and relative humidity (5 of which including CO₂).
 - Radon: 2 continuous loggers per gallery - one at the highest-radon point, one just inside the entrance.
 - Sensors log T, RH, CO₂, Rn every minute.
 - Data transfer backbone: Install shielded Cat-6 PoE cabling or a LoRa mesh with gateway at the tunnel mouth so sensors can ultimately push data to the cloud every ≤ 5 min.
 - Cloud dashboard with SMS/e-mail alarms using a staged CO₂ response framework: 2,800 ppm as a conservation watch/trend level, 3,200 ppm as the Amber throttling level, and 3,600 ppm as the provisional permitted ceiling / Red action level, with automatic ticketing throttle linked to live CO₂ readings.
- **Alarm & Response Logic**

CO₂ alarms and operational responses shall be based on a 5-minute rolling average from the relevant control sensor(s), except where an obviously abnormal or rapidly rising value requires immediate operational verification. Sensor faults, communication loss, or implausible readings shall trigger manual verification before resuming normal operation.

 - CO₂ Watch / Conservation Trend Level: 2,800 ppm
 - This level is used as an early conservation and trend-review level. Guides and operations staff shall monitor visitor density, group spacing, and CO₂ trends, but automatic suspension of entry is not required solely at this level.
 - CO₂ Amber / Throttling Level: 3,200 ppm
 - Ticketing, group release, or boat dispatch shall be automatically slowed or paused.
 - Guides shall reduce crowding and prevent accumulation at stopping points, stairs, docks, and narrow sections.
 - If CO₂ continues rising, the relevant gallery shall prepare for pulse ventilation.
 - CO₂ Red / Provisional Permitted Ceiling: 3,600 ppm

- New entries, group releases, or boat departures into the affected gallery shall be halted.
- Short pulse ventilation shall be initiated in accordance with the Visitor Management and CO₂ Control protocol in this Section 7.1 and Appendix 1, Section 3.6.
- Operations may resume only after CO₂ falls to ≤3,200 ppm and remains stable for at least 10 minutes.
- CO₂ Critical Escalation: ≥4,000 ppm or repeated exceedance of 3,600 ppm
 - The ≥4,000 ppm level is an emergency escalation trigger and shall not be treated as an operating threshold or permissible excursion. Any ≥4,000 ppm event shall trigger immediate incident reporting, review of sensor validity, suspension of new entries to the affected gallery, investigation of visitor-flow and ventilation controls, and corrective measures before normal capacity resumes
 - The operating capacity, group spacing, dispatch frequency, and pulse-ventilation protocol shall be reassessed.
 - Repeated exceedance shall trigger a reduction in visitor capacity and review of cave-health monitoring results.
- Radon: Weekly average > 3,000 Bq·m⁻³
 - Rotate staff assignments to limit exposure and consult the occupational-health authority.
 - During the first year of operation, maintain staff occupancy logs and review them with measured radon concentrations to assess annual worker exposure in accordance with applicable national requirements and authority guidance.

○ **Recommended VISITOR MANAGEMENT AND CO₂ CONTROL**

All capacities, headways, and pulse-ventilation settings below are preliminary operating assumptions. They shall be confirmed and refined using real operational data and continuous microclimate measurements (CO₂, RH, and temperature). The adopted CO₂ framework uses 2,800 ppm as a conservation watch/trend level, 3,200 ppm as an Amber throttling level, and 3,600 ppm as a provisional permitted ceiling / Red action level. Capacities may be increased only where monitoring demonstrates compliance during peak periods and where speleothem and cave-health monitoring do not indicate deterioration.

➤ Goal

The goal of operation is to run high-capacity guided visits while keeping CO₂ and microclimate within the adopted provisional operating thresholds, using ticket throttling as

the first-line control and short “pulse” door openings only when triggered by live CO₂ readings.

➤ Operating Concept

The operating concept is based on the following:

- Route length: 450 m each way (≈ 900 m total).
- Group format: Guided groups of 20 visitors; this requires hiring and training one guide per group with additional guides on standby to allow for rotating breaks.
- Dwell time: ≈ 30 min per group (walking + interpretation).
- Headway: groups released every 3 min (staggered).

Hourly and daily visitor capacity estimates are summarized in *Table 2*.

Metric	Value	Notes
Theoretical groups on route	30 min ÷ 3 min = 10	Purely by dwell/headway math
Operational groups on route	8 – 9	Allows spacing at stops, buffers, loading/unloading
Instantaneous visitors inside	8 – 9 × 20 = 160 – 180	Recommended cap
Throughput	60 min ÷ 3 min × 20 = 400 vph	At 3-min headway
Daily (8 h)	≈3,200 vpd	If sustained all day

Table 2 - Upper Gallery Visitor Capacity Estimates

- The operational concept starts with a visitor cap of ≤9 concurrent groups (≤180 persons) and only increases beyond this after continuous monitoring confirms that CO₂ remains below the 3,600 ppm provisional permitted ceiling during peak hours, with limited frequency of Amber conditions and no evidence of cave-health deterioration.
- This translates to an hourly capacity of 300-400 visitors (≈ 2,400 - 3,200 visitors per day), which is comparable to the upper end of international practice for large show caves (ranging from 275 to 2,740 vpd), provided continuous monitoring confirms acceptable CO₂, RH, temperature, visitor-flow, and cave-health performance during peak conditions.

➤ CO₂ Control

- To prevent excessive CO₂ rise while minimizing unnecessary disturbance of humidity and natural cave airflow, the Upper Gallery shall use a staged response system based on the Upper Gallery CO₂ monitoring stations specified in *Figure*

7 - Station 1 shall serve primarily as an entrance/reference station; operational control shall be based on the relevant internal CO₂ stations, including Stations 2, 5, 8 and 10, with action taken based on the highest representative reading, as summarized in *Table 3*.

- At 2,800 ppm, CO₂ shall be treated as a conservation watch/trend condition. At 3,200 ppm, ticketing and group releases shall be throttled. At 3,600 ppm, new entries shall be halted and a short pulse-ventilation cycle shall be initiated. The 3,600 ppm value is adopted as a provisional permitted ceiling, not as a fixed cave-health threshold, and shall be reduced if continuous monitoring or speleothem/cave-health monitoring indicates deterioration.
- Pulse frequency shall not exceed one single-door pulse every 2 hours on average (i.e., no more than 4 pulses during an 8-hour period); exceeding this limit shall require reassessment of visitor capacity, group spacing, and ventilation practice. Monitoring data shall be evaluated monthly during the first operating year to assess effectiveness and refine the operational method.

Element	Setting
Live trigger	Highest representative internal Upper Gallery CO ₂ reading ≥3,600 ppm, following Amber throttling at 3,200 ppm
Primary action	Single-door pulse: open the Upper Gallery entrance door for up to 15 min while tours already inside continue toward the exit; no new groups enter during the pulse
Close condition	Close when CO ₂ falls to ≤ 3,200 ppm or after 15 min, whichever occurs first
Escalation (if insufficient)	If CO ₂ remains >3,200 ppm after the Single-Entrance Pulse, initiate a short Dual-Entrance Pulse by opening the Upper and Lower Gallery doors simultaneously for up to 10 min, where feasible and only as an escalation measure
Safety ceiling	Alarm at 3,600 ppm; halt new entries at both ticketing and cave entry until CO ₂ falls to ≤3,200 ppm and remains stable for at least 10 min
Pulse frequency cap	Avg ≤ 1 pulse / 2 h (≤ 4 pulses / 8-h day). If ≥ 2 pulses in any rolling 2-h window, reassess visitor capacity, group spacing, and ventilation practice

Time-weighted target	CO ₂ to remain below 3,600 ppm during opening hours; monthly trend review to evaluate duration and frequency above 2,800 ppm and 3,200 ppm
Ticketing throttle	Link alarms to throttle group releases at 3,200 ppm and pause new entries at 3,600 ppm until recovery conditions are met

Table 3 - Upper Gallery Pulse-Ventilation Protocol

○ **Awareness:**

- Hold awareness sessions or pre-entry briefings to educate visitors about the cave's fragile ecosystem and emphasize the importance of adhering to established rules and guidelines
- Operators must present a sample of the content to be covered during these awareness sessions or entry briefings
- Install clear and educational signage throughout the cave to raise visitor awareness about the cave environment and promote responsible behavior. These signs shall be placed in key areas, be clear, concise, and visually attractive.
- Prevent visitors from throwing coins into the water pool inside the cave to avoid pollution and preserve water quality.
- Prohibit physical contact with cave formations to prevent erosion or structural damage.
- Ensure staff training and qualifications to maintain safety standards and environmental conservation.

○ **Adaptive review**

During the first year of operation, the operator shall prepare monthly monitoring summaries correlating visitor numbers, CO₂ levels, Amber/Red events, pulse-ventilation frequency, RH and temperature trends, and cave-health monitoring observations. If monitoring indicates repeated exceedance of the 3,600 ppm provisional ceiling, frequent Amber conditions, excessive pulse ventilation, declining RH stability, increased lampenflora, adverse drip-water or speleothem condition trends, the operator shall reduce visitor capacity, increase headways, adjust door/pulse protocols, or apply other conservation controls until stable conditions are demonstrated.

○ **Roadmap for Jeita Grotto Conservation**

This section outlines a structured approach to understand, model, and manage elevated CO₂ concentration levels within Jeita Grotto, primarily influenced by visitor activity and limited

natural ventilation, which can alter the cave's delicate microclimatic balance and potentially affect speleothem preservation. To ensure the long-term conservation of the grotto and the safety of visitors, the following roadmap details the steps required to establish baseline conditions, develop predictive CO₂ models, define safe operational thresholds, and test practical mitigation measures through monitored pilot interventions.

➤ Baseline conditions:

Establish a robust baseline by installing CO₂, temperature, and humidity monitoring stations throughout the grotto. These sensors shall operate continuously to capture high-resolution, real-time data under a range of climatic conditions, including peak summer heat and colder winter periods. The data will characterize natural seasonal variability, visitor-related fluctuations, and any site-specific microclimatic features that may influence air quality or ventilation patterns.

➤ CO₂ Modelling:

Develop a comprehensive CO₂ dispersion model tailored to the geometry of the grotto. The modelling shall assess where CO₂ is likely to accumulate and how it disperses over time, considering the gas's density, air stratification, existing natural ventilation pathways, and operational factors such as visitor presence, tour frequency and duration, and door-opening patterns. The model will serve as a predictive tool to understand dynamic conditions and anticipate potential exceedances.

➤ Defining Thresholds, Capacity Limits, and Interventions:

Based on the outputs of the continuous monitoring and modelling activities, establish scientifically informed CO₂ threshold levels that ensure visitor safety and protect the grotto's microclimate. These thresholds shall guide the determination of practical visitor capacity limits for different seasons and operational scenarios. Additionally, identify preferred interventions, such as passive ventilation techniques or controlled ventilation strategies, to maintain CO₂ concentrations within acceptable limits across summer, winter and peak tourist periods.

➤ Scenario Testing and Pilot Operational Measures:

Conduct scenario-based trials to evaluate the effectiveness and practicality of proposed mitigation measures. This includes pilot testing of passive ventilation options, such as pulse ventilation protocols, in parallel with guided tours and controlled capacity limits. Monitoring during these pilots shall track how CO₂ levels respond to varying visitor loads and environmental conditions.

- If CO₂ concentrations remain consistently within the defined thresholds, a full operational implementation plan can be deployed.

- If the pilot measures fail to achieve the required thresholds, more advanced engineering solutions, including feasibility studies and design work for controlled mechanical ventilation systems shall be assessed.
- **Compliance with Inspection & Corrective Actions Report:**
 - The Operator must comply with all requirements relating to Grotto preservation set out in:
 - **Appendix 1- Inspection and Corrective Actions, by Spéléo Club du Liban - 06/06/26.**
 - **Appendix 2- Monitoring Stations for the Lower & Upper Grottoes**

HSE

- **Health Safety & Environmental Protection**
 - Ensure staff training and qualifications to maintain safety standards and environmental conservation
 - Develop emergency response protocols in collaboration with local rescue services
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.)
 - The control system shall have a non-corrosive body and housing, with any combination or interlocking between two different metals (even for screws) insulated with non-ferric material, a minimum ingress protection rating of IP65, a voltage rating between 12 to 48 VDC, an operating temperature range of 5°C to 45°C, relative humidity tolerance up to 98%, support for communication protocols compatible with different system components (DMX, RS232, RS485, CAN, Ethernet, RF for remote controls), and include polarity reversal protection
 - Lighting shall be installed to illuminate only the portions of the cave that are occupied by visitors
 - Implement a visitor-flow system compliant with Environmental and social requirement
 - Provide and install relevant sound proofing system to eliminate echo and sound distraction in all cave areas (where needed) in compliance with international standard ISO, ASTM, EN, UIS, ISTA "
 - Compliance with environmental and heritage protection laws.
 - Adherence to local and international safety, environmental, and tourism standards.
 - Implementation of accessibility standards, including provisions for disabled access.
 - Regular maintenance and inspections to ensure operational safety.
 - Security measures and an emergency response plan for visitor and staff safety.
 - Implementation of safety protocols and hazard mitigation strategies.

- Comprehensive staff training and qualification programs.
 - Enhancement of visitor experience through guided tours and educational programs.
 - Conservation of the grotto's natural and cultural heritage.
 - Control of noise and light pollution to protect the grotto's environment.
 - Provision of first-aid stations, lifeguards, and an emergency response team.
 - Ensure constant internal communication between the guards inside the cave and the team outside.
 - Cave managers shall be competent in both the management of the economics of the show cave and its environmental protection.
 - Any work carried out inside a cave shall avoid disturbing the structure, the deposits, and the formations of the cave.
 - Follow UIS/ISCA Recommended Guidelines for Show Caves.
 - Use non-invasive construction techniques with minimal impact on cave formations.
 - Publish an annual sustainability report (energy, water, visitor load, conservation metrics) starting 12 months after contract award.
- **The operator must comply with all requirements set out in:**
 - *Appendix 3- SOCOTEC - Life & Fire Safety Inspection – Lower Cave - 04/02/16*
 - *Appendix 4- SOCOTEC – Life & Fire Safety Inspection – Lower & Upper Caves -15/03/16*
 - *Appendix 5- SOCOTEC – Life & Fire Safety Inspection – Lower Cave - 02/04/16*

WASTE MANAGEMENT

- The Operator shall provide a designated waste collection point to serve the facilities. Each collection point shall include three (3) colour-coded 1,100 L containers for the temporary storage of segregated waste streams, namely:
 - Organics,
 - Comingled dry recyclables, and
 - Residual/non-recoverable waste.
- The Operator shall ensure containers are positioned, sized, and maintained appropriately, and shall prepare the waste for offsite transportation.

- The operator must comply with all requirements set out in:
Appendix 10- Solid Waste Management Report – Sep. 25

LANDSCAPE

- Raising visitor awareness about the importance of cultural heritage and its role in Lebanon's identity.
- Adhering to cultural prevention methods to preserve heritage sites and reduce damage.
- Establish regulations to limit excessive visitor numbers.
 - Enforce behavioral rules inside caves and natural areas:
 - Walk only on designated paths.
 - Maintain cleanliness and quietness.
 - Do not touch or remove natural elements.
- Cultural mediation programs to be activated.

The present Technical Scope of Work for the preservation of the Upper and Lower Grotto follows the recommendations outlined in *Appendix 1- Inspection and Corrective Actions, by Spéléo Club du Liban -06/06/26*, which was commissioned by the Ministry of Tourism as an expert body in grotto preservation. The collected monitoring data will be evaluated by the various stakeholders namely, the Ministry of Tourism, the Speleo Club du Liban, and the Operator to assess the effectiveness of the grotto preservation measures, particularly the pulse ventilation system, and to adjust the operational methods as necessary.

7.2 Lower Grotto

The Lower Cave extends approximately 6,200 meters, located 60 meters below the Upper Cave. Visitors access around 500 meters of the gallery by electric boats. The cave is subject to seasonal closure in winter when water levels rise.

ARCHITECTURAL

- **PIPE AND TUBE RAILINGS**
 - Rectification, maintenance and paint of the existing steel balustrades to meet the below requirements:

- Minimum height: 1000 mm from the floor
 - Maximum gap between horizontal rails: 180 mm
 - Maximum distance from floor to bottom rail: 110 mm
 - Solid infill or protective panel required up to: 450 mm from the floor (to prevent climbing or slipping through)
 - Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
 - Polyurethane Colored Coating: paint system obtained from single supplier consisting of high build polyurethane colored exterior coating over anti-corrosive pigmented primer and barrier coat. Color of polyurethane coating applied on weathering face is to be selected by the Engineer from manufacturer's full range of colors and gloss.
 - The Operator shall provide corrosion protection to the steelwork, based on type of substrate which has the following durability and maintenance characteristic: Fully compliant to the pertinent provision of BS EN ISO 12944. Conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3.
 - **Internal balustrades within the Grotto premises.**
- **PEDESTRIAN CONTROL DEVICES**
 - Stainless steel grade 316 railings: tubing to ASTM A554; pipe to ASTM A312; plate and sheet to ASTM A240; (180-Grit Polished or as approved by engineer).
 - Safety barriers - they must be clearly marked on the ground refer to high performance coating and enclosed with safety barriers, accompanied by warning signs to prevent visitors from approaching (iron gates that are raised or lowered as needed to control the water level).
 - **Metal Lockers**
 - Remove and disposal of existing wood lockers
 - Lockers; pressed steel ASTM A1008; polyester powder coated finish; (Mat color RAL 1000 or as approved by engineer); including continuous base, ironmongery, fittings and fixings; box type 6 tier; top , bottom, sides, frames shelves minimum thickness 1.5mm; backs min thickness 1.2mm; doors min thickness 1.9mm; ventilated doors; recessed door handle with single point latching; complete
 - Location: Lockers at entrance approximate size 5000 mm x 2000 mm high.
 - **Door Mats And Frames**

- Corrugated rubber mat strips with aluminum slates; including aluminum frame with patent-clip-on polypropylene corner brackets for building in; including cement-sand screed levelling; complete; as specified.
 - The architectural entrance mat is for dirt/moisture control only and shall not replace the shoe-disinfection mat system required under Water & Environmental. Shoe-disinfection mats shall be installed in contained trays and operated in accordance with the cave conservation requirements.
 - Location : Entrance ; minimum size 2500 mm x 2500 mm
- **Rubber Stair Accessories**
 - Stair treads to ASTM F2169, type TP (rubber, thermoplastic), class 1 (smooth, flat), nosing style round with minimum thickness 6mm and tapered to back edge. Metal Edge Strips: Extruded aluminum, nominal 50.8 mm wide.
 - Location: Stairs inside grotto; approximately 38 Steps.

SIGNAGE & WAYFINDING

- **Design and execution of new suspended Identification sign at the grotto access.**
 - Welded steel frame covered by a folded PVD coated 3mm thick aluminium with UV printed message.
 - Indicative dimensions: 1.40m length and 0.30m height
 - To be located at the main access.
- **Design and execution of new YAH map sign at the main entry point.**
 - Floor mounted powder-coated steel structure to hang welded steel frame covered by a folded PVD coated 3 mm thick aluminium with UV printed message (including lighting and Braille).
 - Indicative dimensions: 2.20 m height poles supporting a 1.40 m length and 1.60 m height information plate.
 - To be located at main decision points.
- **Design and execution of new general information / restriction sign.**
 - Floor mounted powder-coated steel structure to hang welded steel frame covered by a folded PVD coated 3 mm thick aluminium with UV printed message (including lighting and Braille).
 - Indicative dimensions: 2.20 m height poles supporting a 1.40 m length and 1.60 m height information plate.

- To be located at main decision points.
- Minimum quantity 2 units or more.
- **Design and execution of new educational sign.**
 - Floor mounted powder-coated steel structure to hang welded steel frame covered by a folded PVD coated 3 mm thick aluminum with UV printed message (including lighting and Braille).
 - Indicative dimensions: 2.20 m height poles supporting a 1.40 m length and 1.60 m height information plate.
 - To be located at main decision points.
- **Design and execution of new safety signs.**
 - Powder-coated steel pole supporting PVD coated 3 mm thick aluminum with message in reflective vinyl.
 - Indicative dimensions: 0.60 m height × 0.60 m length.
 - To be located at main decision points.
 - minimum quantity 4 units or more.

STRUCTURAL

- **Testing Campaign**
 - Defects Mapping; minimum quantity 400 m² or more.
 - Extraction of Concrete Cores and related works; minimum quantity 4 units or more.
 - Compressive Strength Test on All Cores; minimum quantity 4 units or more.
 - Depth of Carbonation Test; minimum quantity 4 units or more.
 - Chloride Content Test; minimum quantity 2 units or more.
 - Sulfate Content Test on Foundations and Ground Beams Samples; minimum quantity 2 units or more.
 - Inspection and testing of steel docking area; minimum quantity 22 m² or more.
 - Schmidt Hammer Test; minimum quantity 15 units or more.
 - Final Report.
- **Rehabilitation Works**
 - Repair of exposed reinforced concrete slab surfaces (spalling, voids, and delamination), given in square meters of structurally repaired surfaces, including all required products, equipment, works, workmanship, and experienced labour; minimum quantity 2 m² or more.

- Reinstatement of steel docking area, including all related works, products, welding or bolting, and all required equipment and post-works testing; minimum quantity 22 m² or more.
- **Compliance Requirement:**

The operator must comply with all requirements set out in:

 - *Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25*
 - *Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25*

Electrical

- **Cables and Branch Circuits**
 - Cables and branch circuits to be tested and checked if they are still operational. The necessary tests are insulation resistance and dielectric withstand tests according to IEC 60502-1, continuity test according to IEC 60228, earth resistance test according to IEC 60364-6, and voltage drop test under full load.

Cables that fail the tests shall be replaced with proper sizes and types according to the electrical load being served and area of installation.
 - All branch circuit wiring shall be single-core copper, PVC-insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
 - Any isolated 220 V general-purpose sockets within cave-related areas shall be limited to approved dry, protected, service-only locations, outside visitor reach and outside hazardous wet or splash-exposed spaces. No generic socket outlets shall be installed in wet public cave areas, docks or boat-charging splash zones.

All cables are to be sized in accordance with BS codes, taking into consideration the derating factors and environmental conditions.
 - Wires and cables are deemed to include:
 - Conduits and fittings, draw wires, and the like (except where conduit work is required to be measured separately).
 - cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints.
 - allowance in cable length for cables entering fittings and accessories, equipment or control gear.
 - Necessary components and accessories for fixing cables on walls, ceilings, and on cable trays/ladders.

- Spare parts as required for continuity of operation and agreed with Employer.
- **Distribution Panels**
 - Distribution panels shall conform to Form 2b to IEC 61439-1, totally enclosed dead-front construction, free-standing or wall-mounted, installed in lockable cabinets with warning signs.
 - DPs shall have molded-case circuit breakers — thermal magnetic for ratings below 250 A and electronic for breakers rated over 250 A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead), and pilot lights. Installation must comply with IEC, NEC, or local electrical standards, focusing on low-voltage systems and environmental protection.
 - Lighting and Power Panel Boards will have molded-case switches on the incoming and miniature circuit breakers on the outgoings.
 - All panels will be fully rated for the available short-circuit current. All bus bars will be copper, with full-size neutral and half-size earth bus.
 - Distribution panels and final branch panels will be sized for a minimum of 20 % future capacity and space availability. Surge protective devices are to be provided in each distribution panel.
 - All boards shall be lockable, installed in dedicated rooms or closets, and away from water pipes according to NEC clearance standards. IP65-rated enclosures shall be used with anti-corrosion treatment.
 - All Components must be compatible for use in extreme humidity environments.
 - Distribution boards under the passageways shall be IP65-rated and contain the necessary transformers and lighting control gear, fuses, etc.
 - A maximum of 8 nos. general single socket outlets can be connected in one circuit.
 - Typical circuit breaker sizes are 16 A for lighting circuits and 20 A for power circuits (MCB/RCBO type).
 - All circuits feeding lighting and power inside the grotto shall be protected by a 10 mA RCBO configuration.
 - Panel boards shall include:
 - Termination of incoming and outgoing cables to equipment including glands, terminations, and accessories.
 - Fixing and support structures and materials for wall- or floor-mounted equipment.
 - AC or DC power supply for switchgear control and operation.
 - Spare parts as required for continuity of operation and agreed with Employer.

○ **Cable Trays and Conduits**

- Cable trays will be heavy-duty, hot-dip galvanized after fabrication and installed with central supporting, two-sided hanging systems, and brackets as required. All components must be compatible for use in extreme humidity environments.
- Rigid metal hot-dip galvanized conduits will be installed in exposed areas subject to mechanical damage.
- Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where ceilings serve as air plenums (above false ceilings) and in exposed, non-hazardous indoor locations.
- The minimum conduit size for indoor applications shall be 20 mm diameter and 50 mm for exterior installations. A filling capacity of 40 % shall be provided. Separate conduits and wireways shall be used for normal light/power circuits and low-current systems wiring
- Due to high humidity, cable trays and conduits shall be treated for anti-corrosion and coated with PVC jackets.
- Junction boxes shall be:
 - Ingress Protection (IP): IP66 minimum,
 - Impact resistance IK 10.
 - UL-listed.
 - Material: Stainless Steel 316L or UV-stabilized Polycarbonate.
 - Cable entries: gland with IP-rated seals, compatible with installed cables
 - Mounting: surface mount with polycarbonate or stainless-steel brackets and anchors.
 - All junction boxes shall be filled with sealant gel.
- Conduits are deemed to include:
 - Fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required for continuity of operation and agreed with Employer.

○ **Socket Outlets, Electrical Outlets and Isolators**

- Socket outlets, electrical outlets, and isolators conforming to IEC standards shall serve fixed and portable equipment and appliances throughout the facilities. IP65-rated socket outlets shall be used.
- Earth-fault protection will be provided for outlets within 0 – 180 cm of a sink edge and other wet locations. Weather-proof socket outlets shall be used in wet/exposed areas.
- Components must be compatible for use in extreme humidity environments. Charging outlets shall be relocated away from hazardous wet spaces and installed in dry areas per BS recommendations.
- Socket outlets, electrical outlets and isolators shall be provided to serve various fixed and portable equipment and general appliances throughout the project.
- Wiring devices are deemed to include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panel board,
 - Fixing and supporting material.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Electrical Boat Charging Station**
 - Supply and installation of charging stations for Electric Boats AC/DC 24 V DC, with rated power of 3KW to 5 KW, supplied from AC input 230V ac, in accordance with IEC standards IEC 61851, IEC 62196, IEC 60364-7-709, IEC 60529, IEC 60664, IEC 60947 / IEC 60898, IEC 60364-5-54.
 - Charging pedestals shall be installed in a protected, splash-controlled and service-accessible position outside the public boarding path. Generic socket outlets shall not be installed in hazardous wet spaces. Each charging station shall have dedicated feeder protection, emergency stop, RCD Type B protection where applicable, DC output protection, ventilation/thermal safeguards and documented SAT results.
 - Charger Electrical Input
 - 1-Supply voltage: 230 V AC $\pm 10\%$, single phase, 50 Hz
 - 2- Input power: 4–6 kVA per unit
 - 3- Power factor: ≥ 0.95 at rated load
 - 4- Efficiency: $\geq 90\%$
 - Charger DC Output:
 - Rated output voltage: 24 V DC

- Output current: Up to 200 A (adjustable / limited as per design)
 - Rated power: 3 – 5 kW continuous
 - Output type: Isolated, regulated DC suitable for marine battery charging
 - Voltage regulation: $\pm 3\%$
 - Charging method: Automatic multi-stage charging curve (IUoU type) consisting of:
 - ✓ Bulk (Constant Current) Phase: Charger delivers constant current until battery voltage rises to the absorption level.
Typical absorption voltage: 28.8 V DC ± 0.2 V (for 24 V nominal system).
 - ✓ Absorption (Constant Voltage) Phase: Charger maintains constant voltage at 28.8 V DC, current gradually decreases until battery reaches ~100% state of charge.
 - ✓ Float (Maintenance) Phase: Voltage reduced to 27 V DC ± 0.5 V to maintain battery at full charge without overcharging.
 - ✓ Equalization / battery charging restrictions:
 - Equalization charging and charging of flooded lead-acid batteries shall not be carried out inside the cave.
 - In-cave charging shall be limited to sealed AGM/GEL or LiFePO₄ battery systems using manufacturer-approved charging profiles, with peak charging voltage not exceeding 29.5 V DC for 24 V nominal systems unless otherwise approved by the boat/battery manufacturer and supported by a site-specific risk assessment.
 - Charging curve transition: Fully automatic, microprocessor-controlled, temperature-compensated (-30 mV/ $^{\circ}$ C per 24 V nominal system).
 - Peak charging voltage limit: Maximum 29.5 V DC for 24 V nominal systems, unless otherwise approved by the boat/battery manufacturer and supported by a site-specific risk assessment.
 - Temperature compensation sensor: Optional, remote-mounted on battery terminal to ensure accurate charging in variable ambient conditions.
 - Battery type compatibility: Compatible with sealed lead-acid (AGM/GEL) and lithium-iron-phosphate (LiFePO₄) batteries provided by the boat manufacturer; selectable via configuration menu or DIP switch.
- Protection Features
- input circuit breaker with residual current device (RCD Type B, 30 mA)
 - Output over-voltage, over-current, and reverse polarity protection
 - Short-circuit and overload automatic shutdown

- Thermal protection with automatic recovery
- Emergency stop push-button (mushroom type, latching) on front panel
- Mechanical and Environmental
 - Enclosure protection: Minimum IP65 (as per IEC 60529)
 - Material: Marine-grade stainless steel (AISI 316L) or powder-coated aluminum alloy
 - Cooling: Natural convection
 - Mounting: Pedestal type, floor-anchored with anti-corrosion fasteners
 - Cable entry: Bottom gland with watertight seals
 - Connectors: Custom marine DC connectors with locking system and watertight caps
 - Enclosure temperature rise: ≤ 10 °C above ambient at full load
- Indicators and Controls
 - Power ON, Charging, Fault LED indicators (visible in low-light cave conditions)
 - Local Start/Stop control pushbuttons
 - Optional communication interface (Modbus RTU / RS-485/Ethernet) for monitoring
- Installation and Cabling
 - All conduits, junction boxes, and cables shall waterproof, and halogen-free.
 - DC cables shall be tinned copper, double-insulated.
 - All metal parts shall be earthed in accordance with IEC 60364.
 - Cable terminations and glands shall be of Min. IP66 rated.
- Testing and Commissioning
 - Each station shall undergo:
 - Site Acceptance Test (SAT): Final verification of operation under site conditions, insulation resistance, earthing continuity, Temperature rise, and communication verification.
 - All test results shall be documented and submitted for approval.
- Documentation and Deliverables
 - The supplier shall provide for the Engineer's approval:
 - Manufacturer's data sheets and IEC test certificates
 - Wiring diagrams (AC & DC sides)
 - Operation and maintenance manual
 - Spare parts list
 - Warranty certificate (minimum 2 years)
- Quality and Warranty

- All materials shall be brand new, of first-class quality, and from approved manufacturers.
- Equipment shall be covered by a minimum two-year warranty from the date of commissioning.
- Supplier shall maintain full compliance with IEC 61851, IEC 62196, and environmental protection standards.
- Quantities
 - The system includes one charging station per boat, each with its own dedicated feeder and DC output circuit.
- **Lighting Fixtures**
 - Supply and installation of lighting fixtures design and lamp selection based on achieving recommended illumination levels considering daylight effect, color rendering, and temperature. Glare shall be minimized per SLL/CIBSE recommendations.
 - Lighting fixtures shall be determined per space function and architectural intent.
 - The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP68 rated lighting fixtures with stainless steel housing shall be used to withstand the high humidity of the surrounding environment, especially for the submersible lights inside the lake.
 - High-efficiency LED lamps throughout the project.
 - Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
 - Cave lighting shall minimize lampenflora risk and heat exposure through warm-white, high-efficiency LED luminaires, 2,700–3,000 K unless otherwise approved, CRI ≥90%, maximum 50 W per luminaire, dimmable scene control, shielding, careful beam aiming, limited operating duration, and illumination only of visitor-occupied portions or approved interpretive focal points. Light shall not be directed at speleothems except where specifically approved as part of the lighting and conservation design.
 - Light sources must not be directed straight at stalactites, stalagmites, or flowstone surfaces, as this can promote unwanted heat and photochemical reactions.
 - All components must be compatible for use in extreme humidity environments.
 - All hardware, fixtures, and accessories must be corrosion-resistant and cave-safe.
 - Lighting lux levels in the middle of the passageways shall not be less than 5 lux
Each luminaire in the system has its own built-in control unit.

- Show cave area is only fitted with ELV DC lighting system and isolated 220V General Purpose sockets.
- Lighting system shall be controllable via central control unit (main controller). Control is by wire and radio.
- The lighting themes are defined and saved via the central control unit. Lighting themes are switched on via the remote control or manually via buttons on the viewing platforms.
- Lighting points' distribution and themes are coordinated with the Architect in charge.
- Technical Requirements:
 - Type: High lumen output LED lighting suitable for the cave requirements detailed above.
 - LEDs shall comply with Photo-biological Safety of lamps and lamp systems in accordance with the requirements of IEC 62471. Provide a test report to prove the fixture is classed as "Exempt" or "Risk Group 1".
 - Electronic LED Drivers: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Driver shall have constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the number and wattage of LEDs connected. Guaranteed rated life of the driver shall be 50,000 hours as a minimum.
 - LED drivers shall have electrical insulation between primary and secondary sides. Secondary cables from the driver to LED modules shall be provided by the LED supplier. Maximum length between driver and LED module shall be as per manufacturer's recommendations.
 - LED driver shall be protected against electric shock, accidental contact with live parts, short circuit, and overload.
 - For LED luminaires equipped with internal temperature monitoring, the LED driver shall be capable of accepting temperature sensor connection to monitor the LED temperature and protect the LED modules against thermal damage by reducing the output current.
 - Dimmable driver, where required, shall be compatible with the dimming system used.
 - Drivers shall be compatible with the lighting control system used such as; 1-10V, DALI, DMX, etc...
 - LED driver shall be provided with constant light output function, where required on Drawings, in order to maintain the light output of the LED throughout its

lifetime by increasing the LED driving current gradually over the lifetime to compensate for the expected lumen output reduction. Fixture's heat sink design shall consider the maximum additional heat dissipation with no impact on the fixture's guaranteed lifetime and color temperature.

- LED driver shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interference suppression limits defined in BS EN 55015 and immunity requirements of IEC 61547.- Polarity Reversal protection
- Power Consumption: Maximum 50 Watts per luminaire
- Beam Angle: Adjustable or selectable range between 10° and 120°+C64:C68.
- Color Rendering Index (CRI): $\geq 90\%$
- Ingress Protection (IP): IP67 for non-submersible fixtures, IP68 for submersible fixtures
- Casing & Mounting Materials: Non-corrosive body and housing made of: Stainless Steel Grade 316L, Coated Aluminum for heat control, High-impact Polycarbonate. Any combination or interlocking between two different metals (even for screws) shall be insulated with non-ferric material.
- Operating Temperature: 5°C to 45°C
- Relative Humidity: Up to 98%
- Cable: Built-in cable minimum length: 3 meters, extended lengths must be available by manufacturer upon request
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panel board,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.)
- Suppliers shall have previous proven experience in cave installations

- Lighting shall be installed to illuminate only the portions of the cave that are occupied by visitors.
- **Emergency and Exit Lighting**
 - Illumination of means of egress shall be provided in all passageways, exit corridors, exit stairs, exit discharge lobbies, etc. in compliance with BS 5266. Illumination shall be continuous using Central Battery system for 1.5 hours.
 - For escape routes up to 2 m in width, floor surfaces shall be illuminated with not less than 1 lux and with a ratio (maximum to the minimum illuminance) not greater than 40:1 along the centre line of the escape route, with minimum distance every 15m along evacuation routes.
 - Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in Arabic, French, and English , illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs battery autonomy.
- **Central Emergency Battery System**
 - Central emergency battery system will be provided complying with the BS 5266. This system will provide power to lighting fixtures in passageways, escape routes and open areas with minimum required lux levels, as per code requirement.
 - The system will employ addressable lighting fixtures which will be monitored by the central control panel as per code requirements.
 - Batteries will be sealed lead acid type adequate for 1.5 hours operation. All wiring will be of the fire-resistant type.
 - Emergency exit lighting along the walkway is of the maintained non-contained type fed by TWO redundant sources.
 - Central battery system shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - All devices housed by the emergency central battery systems such as: chargers, batteries, main incoming and outgoing protective devices,
 - Addressable modules for all normal lighting fixtures fed from central battery system and for exit signs were obtained from a different manufacturer,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,

- Interconnection control cables and other accessories for interface with other systems such as BMS
 - Connection to central monitoring system and respective wiring system and raceways,
 - Intelligent control gears for monitoring and control of emergency fixtures, changeover modules, control modules and final circuit monitoring modules,
 - Enclosure appropriate for the installation,
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Central Lighting Control System**
- Central lighting control system shall be adopted for cave lighting. (utilizing DALI, dmx, KNX system or the like)
 - Lighting system shall be controllable via central control unit (main controller). Control is by wire and radio.
 - The lighting themes are defined and saved via the central control unit. Lighting themes are switched on via the remote control or manually via buttons on the viewing platforms.
 - Emergency lighting dedicated for life safety purposes (including stairways) shall be maintained and shall not be subject to any control.
- **Grounding System**
- Complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning.
 - The earth electrode shall consist of multi earth rods buried in the ground around the building and interconnected by a ring copper earth conductor.
 - Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit.
 - Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to assure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
 - Grounding system shall be:
 - Complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with

branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),

- Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure,
 - Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.
- **Legacy Systems**
 - Complete removal of all legacy wiring and HID fixtures.

MECHANICAL

- **First Aid Station**
 - Supply and install first aid station including an emergency kit and survival blanket with all necessary accessories.
- **Fire Extinguisher**
 - Supply and install wall-mounted 6 kg ABC portable fire extinguishers positioned 1.2 m above floor level: minimum quantity 3 units or more.
 - Supply and install wall-mounted 4.5 kg CO₂ portable fire extinguishers adjacent to the electrical panel boards and positioned 1.2 m above floor level: minimum quantity 1 unit or more.
- **Comply with SOCOTEC Report**

Operator shall comply with:

 - *Appendix 3- SOCOTEC - Life & Fire Safety Inspection – Lower Cave - 04/02/16*

- *Appendix 4- SOCOTEC – Life & Fire Safety Inspection – Lower & Upper Caves - 15/03/16*
- *Appendix 5- SOCOTEC – Life & Fire Safety Inspection – Lower Cave - 02/04/16.*

GEOTECHNICAL

○ **General Scope**

- The Operator shall provide all equipment, workmanship, and execute the required works to the satisfaction of the Engineer.
- Works include the design, supply of all material, installation, ancillary works, method statement of works, design calculations, and shop drawings.

○ **Stabilization Works**

- Stabilize fractured and weathered rock face at locality 7 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) at the entrance of the Grotto. Remove loose overhangs and debris, and install localized protection composed of double mesh with anchors.
- Works are quantified per surface area of the stabilized zone; minimum quantity 625 m² or more.

○ **Stalactites and Stalagmites Safety Scope**

- A number of stalactites and stalagmites within the grotto were found to exhibit fracturing and tilting.
- The scope of the BOT shall include:
 - Preliminary visual inspection and documentation through conducting a visual inspection of all visibly tilted stalactites within accessible zones, documenting each case with photographs and approximate location mapping, and reporting findings to the project authority for further evaluation.
 - Immediate safety measures through temporary isolation of zones located directly beneath or adjacent to significantly tilted formations. Install visible signage to warn visitors and staff of potential overhead hazards and restrict visitor access to affected areas as a precautionary measure.

○ **Routine Surveillance and Monitoring**

- The BOT Operator is responsible for routine safety surveillance within and around the grotto and shall:
 - Conduct regular safety walkthroughs and visual inspections of the grotto.

- Monitor key visible cracks using simple methods such as plaster or epoxy tell-tales.
 - Visually inspect and document any significantly tilted stalactites or signs of ceiling distress.
 - Photograph and record all observed changes, deteriorations, or potential hazards.
 - Immediately report any signs of instability or unsafe conditions—whether related to rock mass, formations, or environmental shifts—to the supervising team for further action.
- **Compliance Requirement**

The operator must comply with all requirements set out in:

 - *Appendix 8- Geotechnical Assessment Report - Sep. 25.*

WATER & ENVIRONMENTAL

- **Speleothem conservation plan**
 - Submit a speleothem conservation plan within 6 months, including dry-ice / CO₂ snow cleaning protocol, pilot testing, fixed-point photography, condition mapping, and annual specialist survey; complete the first condition survey within 12 months.
 - Dry-ice / CO₂ snow cleaning by qualified specialists or trained staff only under a specialist-approved method statement.
 - Pilot testing on limited representative areas before wider cleaning.
 - Fixed-point photography, condition mapping, and annual specialist survey.
 - Hydrogen peroxide, chemical, abrasive, brushing, or uncontrolled washing methods prohibited unless specifically approved by the conservation specialist.
- **Solid waste**
 - Waste bins are currently placed along the concrete passageway in the Upper Gallery, which is highly discouraged in cave environments. Their presence can unintentionally encourage visitors to bring food or wrappers into the cave, increasing the risk of ecological disturbance from organic and putrescible waste.
 - If water bottles are permitted, this shall be clearly indicated through both signage and bin design. In such cases, waste bins shall be limited to transparent, mesh-style containers that visibly restrict disposal to bottles only, preventing misuse for general waste.
- **Walkway Cleaning**

- Routine removal of litter, sediment, fibers, and bio-film from the concrete walkway is essential to protect adjacent speleothems and to minimize the introduction of pathogens (e.g., white-nose syndrome fungus) carried in by visitors. The recommended method is a wet-vacuum scrubber that washes and immediately extracts the rinse water, preventing contaminated run-off from reaching formations on either side of the walkway.
- Equipment – commercial disc-scrubber / wet-vac unit, ≈ 60 L recovery tank, $\geq 2\,000$ $\text{m}^2 \text{h}^{-1}$ capacity; similar to Kärcher BD 50/60 C EP (1 piece) or equivalent.
- Cleaning agents – only biodegradable, pH-neutral products certified for use in sensitive environments; chlorine or strong acids/alkalis are prohibited.
- Wastewater handling – all effluent is collected in the machine's tank and removed from the cave for off-site disposal; no discharge inside the cave is permitted.
- Frequency – minimum monthly during low-season; fortnightly during high-season or after heavy visitor days.

○ **Shoe Disinfection Mats**

To prevent the transfer of invasive spores, bacteria, and fine soil into the cave ecosystem, absorbent disinfection mats shall be installed at the main entrance as follows:

- Operation:
 - Visitors step on a disinfectant mat on entry.
 - Disinfection mats shall be placed in contained trays or an equivalent fully contained arrangement.
 - No disinfectant, rinse water, or contaminated runoff shall be allowed to enter the cave floor, drainage pathways, pools, river, or speleothem areas.
 - Mats shall be sized and managed so that footwear is disinfected without leaving visible dripping before visitors proceed into the cave.
 - Staff shall inspect the mat area during opening hours and remove or contain any excess liquid immediately.
 - Used disinfectant and contaminated liquid shall be collected and disposed of outside the cave; no discharge inside the cave is permitted.
 - Staff shall inspect mats during opening hours and replenish or replace disinfectant solution only as needed to maintain effectiveness without creating excess liquid or Runoff.
 - Mat inserts shall be replaced or cleaned in accordance with the manufacturer's schedule and whenever visibly soiled.

➤ Disinfectant:

- 1% Virkon S (or equivalent broad-spectrum biocide).
- A 1% solution is effective yet non-hazardous under EU classification.

➤ Signage & Supervision:

- Clear multilingual signs instructing use.
- A 1 % solution is effective yet non-hazardous under EU classification.

○ **Radon Exposure Management**

- Ensure that the weekly average radon concentration remains below 3,000 Bq/m³ to protect staff from long-term exposure.
- If this threshold is exceeded rotate staff assignments to limit exposure and consult the occupational-health authority.
- During the first year of operation, maintain staff occupancy logs and review them with measured radon concentrations to assess annual worker exposure in accordance with applicable national requirements and authority guidance.

○ **MICRO-CLIMATE MONITORING**

Jiita Show-Cave shall continuously measure carbon-dioxide (CO₂), temperature (T), relative humidity (RH) and radon-222 (Rn) at the fixed monitoring layout shown in

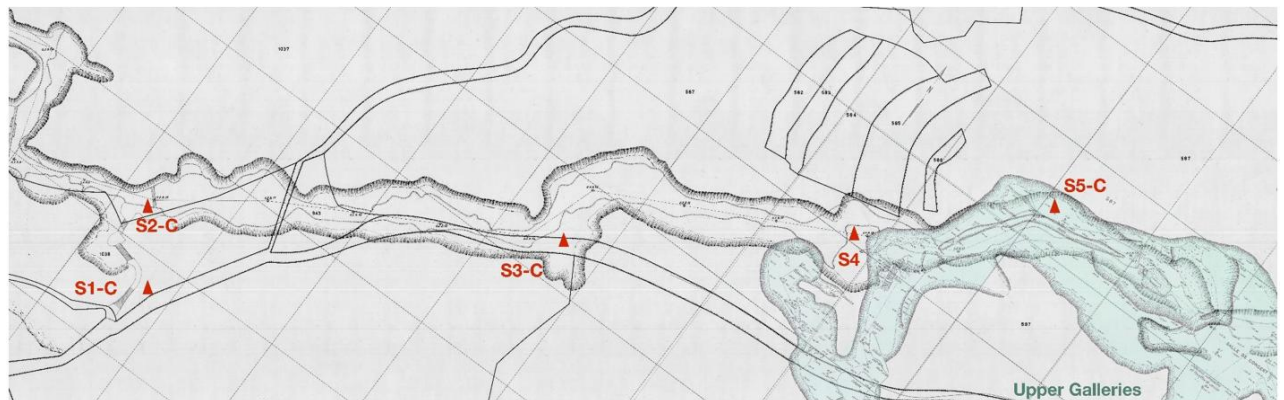


Figure 8 below. Temperature and RH shall be monitored at all microclimate stations, while CO₂ sensors shall be installed only at the specified CO₂ monitoring stations.

Recommended equipment performance requirements are provided in Table 4 below.

- Lower Gallery: 5 stations for T and RH (Stations 1 to 5), of which 4 stations shall also include CO₂ monitoring (Stations 1, 2, 3 and 5).
- Radon (continuous): Two electronic loggers per gallery
 - Primary at the highest-radon location found by a 1-week walk-through survey.
 - Secondary near each gallery entrance to verify spatial variability as follows:
 - ✓ Mount the logger 5-10 m past the door so it is out of direct wind but still in the low-radon zone.

Jeita Grotto – Conservation, Safety & Operations Upgrade

- ✓ Install at 1.5 m above floor level approximately, on a wall bracket, away from water drips.

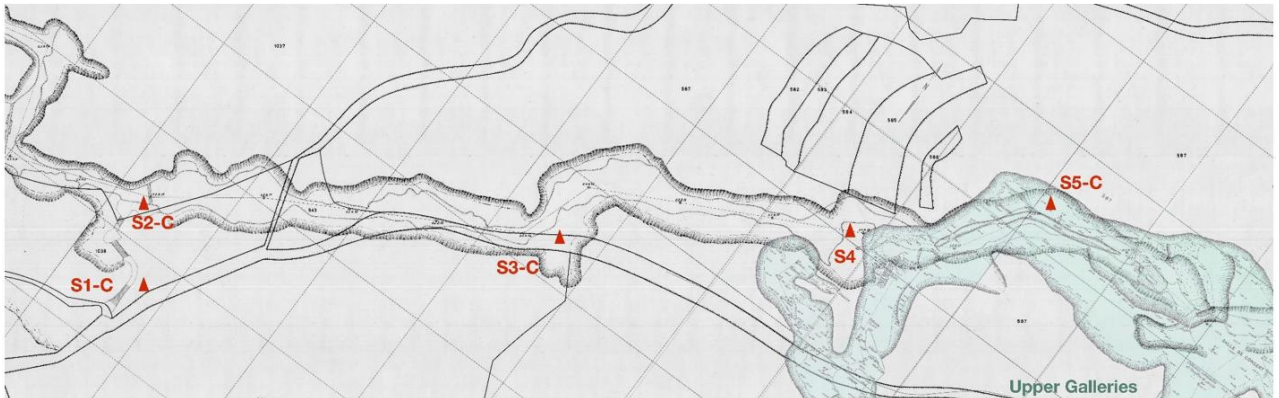


Figure 8 - Monitoring Stations for the Lower Grotto (“-C” indicates CO2 monitoring)

Parameter	Minimum Specification	Notes / Examples*
CO₂	- NDIR, 0-10,000 ppm - accuracy $\pm(3\%$ reading + 50 ppm) preferred; $\pm(5\%$ reading + 100 ppm) maximum acceptable - $t_{63} \leq 120$ s - Auto RH/pressure comp	Probe in IP-65 polycarbonate "cave-case" with Gore-Tex® vent. DOL 139* CO ₂ , IP67, iDOL139*, or equivalent
Temperature	- -10 °C to +50 °C - Accuracy ± 0.25 °C	Digital sensor; conformal-coated PCB. HOBO MX2301A* Data Logger, temperature & RH , IP67, or equivalent
Relative Humidity	- 0-100 % RH suitable for condensing or near-condensing cave conditions - Accuracy ± 3 % RH at 40-95% RH, or manufacturer-declared accuracy at >95% RH to be stated in the tender submission	HOBO MX2301A* Data Logger, temperature & RH , IP67, or equivalent
Radon-222	- Pulsed-ion or alpha-spectroscopy logger - 30-45,000 Bq · m⁻³ - Sensitivity ≤ 0.4 cph per Bq · m⁻³	Units equivalent to RAD7* / AlphaGUARD class*, or equivalent
Ingress Protection	IP-65 (IP-67 preferred)	
Power	Lithium battery ≥ 15 Ah for ≥ 12 mo @ 1-min logging or 12 V DC PoE feed with DC-UPS	Field-swappable batteries.
Data Logging	- 1-min samples - $\geq 63,488$ records	Time-stamped CSV.
Communication	• Option 1: Integrated PoE-capable RJ45 Ethernet port (IEEE 802.3af) to support shielded Cat-6 cabling up to 100 m and 10/100 Mbps link for cloud push. • Option 2: Low-power LoRa mesh repeaters with one repeater every 80–100 m and an IP-65 gateway at tunnel mouth. Each node must carry an SD-card buffer that stores at least 30 days of 1-min readings in case of RF outage. • Local USB-C/BLE service port for maintenance.	Each node must buffer ≥ 30 days of 1-min data in non-volatile memory.
Calibration	- CO₂ span check yearly (certified 1,000 ppm gas) - RH/T salt-kit yearly - Radon lab re-calibration every 24 months	Certificates kept on-file.

Table 4 - Monitoring Equipment Performance Requirements

**Brands are examples only; any equipment meeting these numeric specs is acceptable.*

- Draft a full Emergency Management Plan within 3 months of contract start and gain approval by month 6.
- Install permanent CO₂ and radon telemetry (one-minute logging, cloud dashboard, SMS alarms) within 6 months as follows:
 - Lower Gallery: 5 stations for temperature and relative humidity (4 of which including CO₂).
 - Radon: 2 continuous loggers per gallery - one at the highest-radon point, one just inside the entrance.
 - Sensors log T, RH, CO₂, Rn every minute.
 - Data transfer backbone: Install shielded Cat-6 PoE cabling or a LoRa mesh with gateway at the tunnel mouth so sensors can ultimately push data to the cloud every ≤ 5 min.
 - Cloud dashboard with SMS/e-mail alarms using a staged CO₂ response framework: 2,800 ppm as a conservation watch/trend level, 3,200 ppm as the Amber throttling level, and 3,600 ppm as the provisional permitted ceiling / Red action level, with automatic ticketing throttle linked to live CO₂ readings.
- **Alarm & Response Logic**

CO₂ alarms and operational responses shall be based on a 5-minute rolling average from the relevant control sensor(s), except where an obviously abnormal or rapidly rising value requires immediate operational verification. Sensor faults, communication loss, or implausible readings shall trigger manual verification before resuming normal operation.

 - CO₂ Watch / Conservation Trend Level: 2,800 ppm
 - This level is used as an early conservation and trend-review level. Guides and operations staff shall monitor visitor density, group spacing, and CO₂ trends, but automatic suspension of entry is not required solely at this level.
 - CO₂ Amber / Throttling Level: 3,200 ppm
 - Ticketing, group release, or boat dispatch shall be automatically slowed or paused.
 - Guides shall reduce crowding and prevent accumulation at stopping points, stairs, docks, and narrow sections.
 - If CO₂ continues rising, the relevant gallery shall prepare for pulse ventilation.
 - CO₂ Red / Provisional Permitted Ceiling: 3,600 ppm
 - New entries, group releases, or boat departures into the affected gallery shall be halted.

- Short pulse ventilation shall be initiated in accordance with the Visitor Management and CO₂ Control protocol in this Section 7.2 and Appendix 1, Section 3.6.
- Operations may resume only after CO₂ falls to ≤3,200 ppm and remains stable for at least 10 minutes.
- CO₂ Critical Escalation: ≥4,000 ppm or repeated exceedance of 3,600 ppm
 - The ≥4,000 ppm level is an emergency escalation trigger and shall not be treated as an operating threshold or permissible excursion. Any ≥4,000 ppm event shall trigger immediate incident reporting, review of sensor validity, suspension of new entries to the affected gallery, investigation of visitor-flow and ventilation controls, and corrective measures before normal capacity resumes.
 - The operating capacity, group spacing, dispatch frequency, and pulse-ventilation protocol shall be reassessed.
 - Repeated exceedance shall trigger a reduction in visitor capacity and review of cave-health monitoring results.
- Radon: Weekly average > 3,000 Bq·m⁻³
 - Rotate staff assignments to limit exposure and consult the occupational-health authority.
 - During the first year of operation, maintain staff occupancy logs and review them with measured radon concentrations to assess annual worker exposure in accordance with applicable national requirements and authority guidance.
- **Recommended VISITOR MANAGEMENT AND CO₂ CONTROL**

All capacities, headways, and pulse-ventilation settings below are preliminary operating assumptions. They shall be confirmed and refined using real operational data and continuous microclimate measurements (CO₂, RH, and temperature). The adopted CO₂ framework uses 2,800 ppm as a conservation watch/trend level, 3,200 ppm as an Amber throttling level, and 3,600 ppm as a provisional permitted ceiling / Red action level. Capacities may be increased only where monitoring demonstrates compliance during peak periods and where speleothem and cave-health monitoring do not indicate deterioration.

 - Goal

The goal is to operate high-quality, guided boat visits in the Lower Gallery while maintaining CO₂ and microclimate within the same staged operating framework adopted for the Upper Gallery, using real-time monitoring, automatic dispatch throttling, and short “pulse” door openings only when needed.

➤ Operating Concept

The Lower Gallery visit is managed as discrete, guided boat departures (no free flow). The operating configuration is: 4 boats x 15 passengers = 60 passengers inside the visited river section at any one time (excluding staff). The cycle time is assumed to be 8-10 minutes per boat (8 min return trip + 30 seconds embark/disembark). This translates to an initial dispatch headway of 2.5 minutes (cycle time ÷ 4 boats) to be dynamically adjusted using live CO₂ readings. The dock area shall be managed to avoid crowding; as a rule, keep the dock queue to ≤ 2 boatloads (≤ 30 passengers) at any time to minimize CO₂ buildup and safety risks. Once the first boat departs, the next group of 15 visitors is released to enter the Lower Gallery; given that the walk from the entry point to the docks takes 45 seconds approximately, this group arrives in time to embark and wait for 1-2 minutes before the next departure, and the sequence continues accordingly.

➤ CO₂ Control

The primary operational control point is the mid-route CO₂ sensor at Station 3 (S3-C), supported by the other Lower Gallery CO₂ monitoring stations specified in

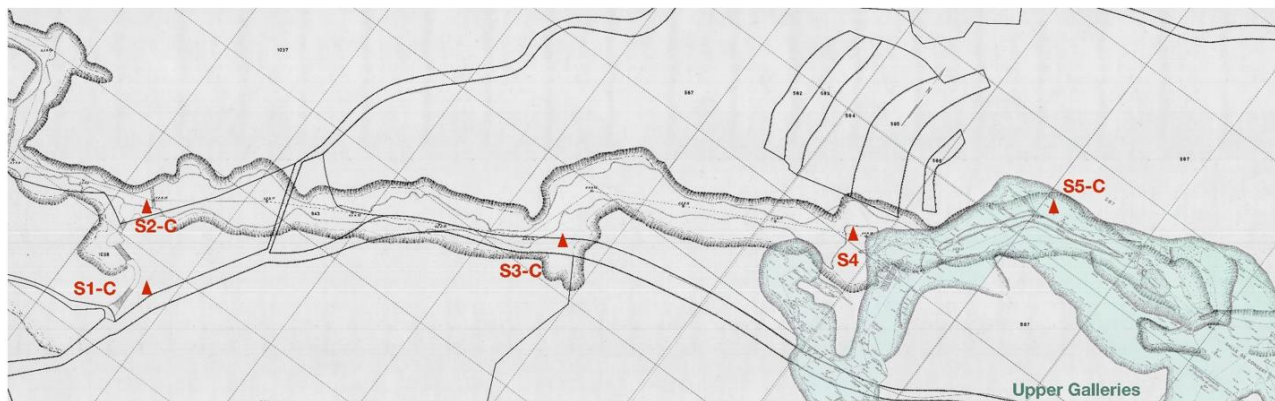


Figure 8. Boat dispatch, ticketing, turnstiles, and boarding release shall be continuously adjusted based on real-time CO₂ values, consistent with the report's approach of linking operations to live telemetry and throttling.

The Lower Gallery shall apply the same staged CO₂ response framework used for the Upper Gallery: 2,800 ppm as a conservation watch/trend level, 3,200 ppm as the Amber throttling level, and 3,600 ppm as the provisional permitted ceiling / Red action level.

- CO₂ Watch / Conservation Trend Level (2,800 ppm at S3-C):
Operations staff shall monitor boat dispatch, dock crowding, and visitor accumulation. No automatic closure is required solely at this level, but continued upward trends shall trigger preparation for dispatch throttling.
- CO₂ Amber / Throttling Level (3,200 ppm at S3-C):

Boat dispatch shall be automatically throttled by increasing headway or pausing discretionary departures. Dock queues shall be actively managed to prevent accumulation, and no additional visitors shall be released toward the docks unless boarding capacity is available.

- CO₂ Red / Provisional Permitted Ceiling (3,600 ppm at S3-C):

All new entries and boat departures shall be halted immediately. Boats already inside the visited river section shall complete the normal exit cycle. Pulse ventilation shall be initiated until CO₂ falls to ≤3,200 ppm and remains stable for at least 10 minutes before departures resume gradually.

➤ Pulse Ventilation Protocol

Doors shall remain closed during normal operation, except for short pulses triggered by CO₂ exceedances, to avoid unnecessary disturbance of cave humidity and microclimate.

- Primary action – Single-Entrance Pulse:

Open the Lower Gallery entrance door for up to 15 minutes when S3-C reaches ≥3,600 ppm. Close earlier if CO₂ falls to ≤3,200 ppm, or at the 15-minute limit, whichever occurs first. No additional boats shall be launched during the pulse.

- Escalation – Dual-Entrance Pulse (use sparingly, if feasible):

If, after the single-door pulse, S3-C remains >3,200 ppm, a short 10-minute dual-door pulse may be applied by opening both relevant gallery doors to increase exchange. This is an escalation measure and shall trigger operational review of dispatch rate, dock crowding, and the need for improved engineered entrance control.

- Pulse frequency cap:

Pulses shall average no more than 1 per 2 hours (i.e., ≤4 pulses over an 8-hour day). Exceeding this indicates that the dispatch rate/cap is not sustainable without revising operations or assessing the feasibility of engineered ventilation or air-control solutions.

➤ Operational performance target (Lower Gallery)

CO₂ shall remain below the 3,600-ppm provisional permitted ceiling during opening hours. Monthly trend review shall evaluate the duration and frequency of conditions above 2,800 ppm and 3,200 ppm, together with RH, temperature, and cave-health observations.

➤ Integration with monitoring layout

The Lower Gallery monitoring system includes CO₂ sensors at selected stations, including Station 3 (S3-C) as the mid-route operational control point, with high-

frequency logging and alarm capability. The Lower Gallery operational logic above shall be implemented directly through that telemetry and alarm framework.

- **Awareness**

- Hold awareness sessions or pre-entry briefings to educate visitors about the cave's fragile ecosystem and emphasize the importance of adhering to established rules and guidelines.
- Operators must present a sample of the content to be covered during these awareness sessions or entry briefings.
- Install clear and educational signage throughout the cave to raise visitor awareness about the cave environment and promote responsible behaviour. These signs shall be placed in key areas, be clear, concise, and visually attractive.
- Prevent visitors from throwing coins into the water inside the cave to avoid pollution and preserve water quality.
- Prevent any leakage on active formations.
- Ensure staff training and qualifications to maintain safety standards and environmental conservation.

- **Adaptive review**

During the first year of operation, the operator shall prepare monthly monitoring summaries correlating visitor numbers, CO₂ levels, Amber/Red events, pulse-ventilation frequency, RH and temperature trends, and cave-health monitoring observations. If monitoring indicates repeated exceedance of the 3,600-ppm provisional ceiling, frequent Amber conditions, excessive pulse ventilation, declining RH stability, increased lampenflora, adverse drip-water or speleothem condition trends, the operator shall reduce visitor capacity, increase headways, adjust door/pulse protocols, or apply other conservation controls until stable conditions are demonstrated.

- **Roadmap for Jeita Grotto Conservation**

This section outlines a structured approach to understand, model, and manage elevated CO₂ concentration levels within Jeita Grotto, primarily influenced by visitor activity and limited natural ventilation, which can alter the cave's delicate microclimatic balance and potentially affect speleothem preservation. To ensure the long-term conservation of the grotto and the safety of visitors, the following roadmap details the steps required to establish baseline conditions, develop predictive CO₂ models, define safe operational thresholds, and test practical mitigation measures through monitored pilot interventions.

➤ Baseline conditions:

Establish a robust baseline by installing CO₂, temperature, and humidity monitoring stations throughout the grotto. These sensors shall operate continuously to capture high-resolution, real-time data under a range of climatic conditions, including peak summer heat and colder winter periods. The data will characterize natural seasonal variability, visitor-related fluctuations, and any site-specific microclimatic features that may influence air quality or ventilation patterns.

➤ CO₂ Modelling:

Develop a comprehensive CO₂ dispersion model tailored to the geometry of the grotto. The modelling shall assess where CO₂ is likely to accumulate and how it disperses over time, considering the gas's density, air stratification, existing natural ventilation pathways, and operational factors such as visitor presence, tour frequency and duration, and door-opening patterns. The model will serve as a predictive tool to understand dynamic conditions and anticipate potential exceedances.

➤ Defining Thresholds, Capacity Limits, and Interventions:

Based on the outputs of the continuous monitoring and modelling activities, establish scientifically informed CO₂ threshold levels that ensure visitor safety and protect the grotto's microclimate. These thresholds shall guide the determination of practical visitor capacity limits for different seasons and operational scenarios. Additionally, identify preferred interventions, such as passive ventilation techniques or controlled ventilation strategies, to maintain CO₂ concentrations within acceptable limits across summer, winter and peak tourist periods.

➤ Scenario Testing and Pilot Operational Measures:

Conduct scenario-based trials to evaluate the effectiveness and practicality of proposed mitigation measures. This includes pilot testing of passive ventilation options, such as pulse ventilation protocols, in parallel with guided tours and controlled capacity limits. Monitoring during these pilots shall track how CO₂ levels respond to varying visitor loads and environmental conditions.

- If CO₂ concentrations remain consistently within the defined thresholds, a full operational implementation plan can be deployed.
- If the pilot measures fail to achieve the required thresholds, more advanced engineering solutions, including feasibility studies and design work for controlled mechanical ventilation systems shall be assessed.

○ **Compliance with Inspection & Corrective Actions Report:**

The Operator must comply with all requirements relating to Grotto preservation set out in:

➤ **Appendix 1- Inspection and Corrective Actions, by Spéléo Club du Liban - 06/06/26.**

➤ **Appendix 2- Monitoring Stations for the Lower & Upper grottoes**

○ **Health, Safety, and Environment (HSE)**

➤ **Emergency Management**

- Draft a full Emergency Management Plan (Fire, flood, earthquake, CO₂, radon, medical. Annual drills (align with ISCA))
- Inspect and assess the condition of boat docking areas to recommend consolidation, maintenance, and preservation measures
- Ensure safe access, navigation, and visitor safety within the Lower Grotto.
- Conduct periodic inspections and maintenance of the boat docking area
- Improve boat safety by installing anti-slip flooring and training operators to ensure safe boarding and disembarking.

➤ **Rescue and Response**

- Develop emergency response protocols in collaboration with local rescue services
- Equip boats (if applicable) with life vests and ropes for emergencies.
- All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.)
- The control system shall have a non-corrosive body and housing, with any combination or interlocking between two different metals (even for screws) insulated with non-ferric material, a minimum ingress protection rating of IP65, a voltage rating between 12 to 48 VDC, an operating temperature range of 5°C to 45°C, relative humidity tolerance up to 98%, support for communication protocols compatible with different system components (DMX, RS232, RS485, CAN, Ethernet, RF for remote controls), and include polarity reversal protection
- Lighting shall be installed to illuminate only the portions of the cave that are occupied by visitors
- provide and install relevant sound proofing system to eliminate echo and sound distraction in all cave areas in compliance with international standard ISO, ASTM, EN, UIS, ISTA.

➤ **Operational and Environmental Compliance**

- Compliance with environmental and heritage protection laws.
- Adherence to local and international safety, environmental, and tourism standards.
- Regular maintenance and inspections to ensure operational safety.
- Security measures and an emergency response plan for visitor and staff safety.
- Implementation of safety protocols and hazard mitigation strategies.
- Comprehensive staff training and qualification programs.
- Enhancement of visitor experience through guided tours and educational programs.
- Conservation of the grotto's natural and cultural heritage.
- Control of noise and light pollution to protect the grotto's environment.
- Visitor flow management, including designated waiting areas for boats.
- Ensure constant internal communication between the guards inside the cave and the team outside.
- Evaluate natural percolation of surface water to avoid disturbance.
- Cave managers shall be competent in both the management of the economics of the show cave and its environmental protection.
- Any work carried out inside a cave shall avoid disturbing the structure, the deposits, and the formations of the cave
- Follow UIS/ISCA Recommended Guidelines for Show Caves.
- Use non-invasive construction techniques with minimal impact on cave formations.
- Publish an annual sustainability report (energy, water, visitor load, conservation metrics) starting 12 months after contract award.

➤ **Visitor Safety**

- All visitors boarding the boats must be provided with life jackets before embarkation.

➤ **Compliance Requirement**

- The operator must comply with:
 - ✓ *Appendix 3- SOCOTEC - Life & Fire Safety Inspection – Lower Cave - 04/02/16*
 - ✓ *Appendix 4- SOCOTEC – Life & Fire Safety Inspection – Lower & Upper Caves -15/03/16*

- ✓ *Appendix 5- SOCOTEC – Life & Fire Safety Inspection – Lower Cave - 02/04/16.*

WASTE MANAGEMENT

- **Waste Collection and Segregation**
 - The Operator shall provide a designated waste collection point to serve the facilities. Each collection point shall include three (3) colour-coded 1,100 L containers for the temporary storage of segregated waste streams, namely:
 - Organics: For biodegradable waste such as food residues and garden waste.
 - Commingled Dry Recyclables: For mixed recyclable materials including paper, plastics, metals, and glass
 - Residual / Non-Recoverable waste: For general waste that cannot be recovered or recycled.
 - The Operator shall ensure containers are positioned, sized, labelled and maintained appropriately, and shall prepare the collect waste for offsite transportation in coordination with approved disposal authorities.
- **Compliance Requirement:**
 - The Operator must comply with all requirements set out in:
Appendix 10- Solid Waste Management Report – Sep. 25.

LANDSCAPE

- Respect archaeological sites and existing heritage materials.
- Raise visitor awareness about the importance of cultural heritage and its role in Lebanon's identity.
- Adhere to cultural preservation methods to protect heritage sites and reduce damage.
- Establish regulations to limit excessive visitor numbers and control overcrowding in sensitive areas.
- Enforce behavioural rules inside caves and natural areas:
 - Walk only on designated paths.
 - Maintain cleanliness and quietness.
 - Do not touch or remove natural elements.

- Activate cultural mediation programs to enhance visitor understanding and promote heritage appreciation.

The present Technical Scope of Work for the preservation of the Upper and Lower Grotto follows the recommendations outlined in the Inspection & Corrective Actions Report prepared by the Speleo Club du Liban, which was commissioned by the Ministry of Tourism as an expert body in grotto preservation. The collected monitoring data will be evaluated by the various stakeholders namely, the Ministry of Tourism, the Speleo Club du Liban, and the Operator to assess the effectiveness of the grotto preservation measures, particularly the pulse ventilation system, and to adjust the operational methods as necessary.

7.3 Lower Cable Car Building

ARCHITECTURAL

- **Steel Protection**
 - Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
 - Polyurethane colored coating: paint system obtained from single supplier consisting of high-build polyurethane colored exterior coating over anti-corrosive pigmented primer and barrier coat. Color of polyurethane coating applied on weathering face to be selected by the Engineer from manufacturer's full range of colors and gloss.
 - The Operator shall provide corrosion protection to the steelwork, based on type of substrate, which has the following durability and maintenance characteristics: fully compliant to BS EN ISO 12944; conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3. (Mat color RAL 1000 or as approved by Engineer).
 - Location: existing and exposed steel elements:
 - Gates, doors and the like (GF).
 - Balustrades (ROOF-MEZ-GF-B1-B2).
 - Roof structure (GF).
 - Fabric canopies structure (B1).
 - Cable car steel structure (B1).
- **Tiling**

- Inspection and removal of existing damaged tiles, substrate and waterproofing condition to be checked and rectified accordingly.
- Full-bodied porcelain tiles and fittings; unglazed anti-slip for exterior and wet areas (R11), glazed polished for interior areas (minimum R9); including cement-sand screed; fill; adhesive/mortar; grout; thin-set adhesive class C2TES1 to BS ISO 13007-1; high-performance grout class CG2AW to BS EN 13888.
- Unglazed/glazed porcelain tiles, minimum 10 mm thick, class Bla rectified to BS ISO 13006 to administrative areas, offices areas flooring and the like (ROOF-MEZ-GF-B1-B2).
- Inspection and removal of existing damaged tiles; unglazed/glazed porcelain tiles, minimum 12 mm thick, class Bla rectified to BS ISO 13006 to circulation areas flooring and the like (ROOF-MEZ).
- Inspection and removal of existing damaged tiles; unglazed/glazed porcelain tiles, minimum 12 mm thick, class Bla rectified to BS ISO 13006 to circulation areas flooring and the like (GF-B1-B2).
- Inspection and removal of existing damaged tiles; unglazed/glazed porcelain tiles, minimum 14 mm thick, class Bla rectified to BS ISO 13006 to large crowds, storage areas flooring and the like (B2).
- **FABRIC**
 - Remove and dispose existing fabric for steel canopies.
 - Acrylic fabric for canopies; solution-dyed 100 % acrylic fibers; UV resistant; fabric weight minimum 300 g/m²; tensile strength: ≥130 daN (warp) / 80 daN (weft); tear resistance: ≥3 daN (both directions); (Color RAL 1000 or as approved by Engineer)
 - Location: Queuing canopies (B1).
- **PIPE AND TUBE RAILINGS**
 - Balustrades to comply with applicable FLS requirements.
 - Balustrades and personnel protective elements to be structurally verified.
 - All fasteners and anchor bolts to be stainless steel 316.
 - Steel railings with protective coating system: tubing to ASTM A500; pipe to ASTM A53; plates and shapes to ASTM A36; refer to High Performance Coatings section for coating systems; (Mat colour RAL 1000 or as approved by Engineer).
 - Minimum height: 1000 mm from floor.
 - Maximum gap between horizontal rails: 180 mm.
 - Maximum distance from floor to bottom rail: 110 mm.

- Solid infill or protective panel required up to 450 mm from floor (to prevent climbing or slipping through).
- Exterior areas, separations/gates between visitors waiting/departure area and cable car routing to comply with FLS or higher requirements (B1).
- **ROOF TILES**
 - Inspect and replace damaged tiles with similar ones to match existing. Substrate condition and waterproofing (where applicable) to be checked and rectified accordingly.
Location: Clay tile at GF.
- **TOILET AND LAUNDRY ACCESSORIES**
 - Miscellaneous fixtures and fittings: soap dispenser, toilet tissue holder, mirror (min 6 mm), polished plate glass, surface-mounted type, with nickel-plated brass clips; including hardboard filler, fittings and fixings, stainless steel, and the like; complete.
Location: Two public toilets and two ablution rooms (B2).
- **TOILETS COMPARTMENT**
 - Dismantle existing toilet compartments and store for reuse, comprising repair and re-installation in location.
 - Toilet and shower compartments: high-pressure laminated factory-finished partitions and doors to match existing; including pilaster shoes and sleeves, brackets, door stop and hook, hardware and ironmongery, fittings and fixings; complete as required.
Location: Replacement of damaged WC cubicles in B2 and maintenance of the others.
- **LINEAR METAL CEILING**
 - Replace the damaged metal ceiling system in the WC areas.
 - Metal pans formed to snap onto carriers securely without separate fasteners; aluminium sheet to ASTM B209, alloy and temper recommended by manufacturer; pan thickness not less than 0.6 mm; powder-coated; same as existing colour and finish; complying with ASTM C635 requirements for indicated applications; carrier system for interior application: HDG cold-rolled sheet steel minimum Z275 to ASTM A653, complete with carriers, splice sections, stabilizing components, connector clips, alignment clips, levelling clips, hangers, molding, trim, retention clips, load-resisting struts, fixture adapters, and other suspension components required to

support ceiling units and other ceiling-supported construction; HDG rods; complete; as required.

- Location: Repair the WC false ceiling in B2 to match the existing one.

- **HOLLOW METAL DOORS AND FRAMES**

- Flush steel doors – 45 mm thick, constructed from steel section frame minimum 1.5 mm thick; galvanized steel (Z275) sheet both skins minimum 1.3 mm thickness; powder-coated finish complying with ANSI A250.3; including fittings and fixings; provide weep holes in bottoms of exterior doors; hardware; fire-rated, infilled with non-combustible thermal insulating material core; including intumescent strip, fittings and fixings; complete.

All storage and ancillary rooms to be free of hazardous materials or high-hazard contents. If hazardous or combustible items are intended to be stored or used in these spaces, additional requirements may apply.

Location:

- Single leaf metal fire-rated door 30 min in room adjacent to ticketing area due to presence of electrical equipment (B1); as per FLS requirements; minimum 1 unit or more.
- Single leaf metal fire-rated door 60 min in shaft and similar locations (B1); as per FLS requirements; minimum 1 unit or more.

SIGNAGE & WAYFINDING

- **Design and execution of new suspended identification sign at stair access**

- Welded steel frame covered by folded PVD-coated 3 mm thick aluminum with UV-printed message.
- Indicative dimensions: 1.0 m length × 0.3 m height identification sign.
- Location: at stair access.

- **Design and execution of new wall-mounted main identification sign including information about destination.**

- PVD-coated 3 mm thick aluminium with UV-printed message.
- Indicative dimensions: 4.5 m length × 1.5 m height information sign.
- Location in the stairs.

- **Design and execution of new general information / restriction sign.**

- PVD-coated 3 mm thick aluminium with UV-printed message (including Braille).
 - Indicative dimensions: 1.2 m length × 2.3 m height information sign.
 - Location: on wall facing the queuing area.
- **Design and execution of new wall-mounted identification signs for amenities.**
 - PVD-coated 3 mm thick aluminium with UV-printed message (including Braille).
 - Indicative dimensions: 0.6 m length × 0.6 m height information sign.
 - Location: at amenities access; minimum 2 units or more.

STRUCTURAL

- **Testing Campaign**
 - Defects mapping – for the entire reinforced concrete area.
 - Extraction of concrete cores and related works; minimum quantity 20 cores or more.
 - Compressive strength test on all cores; minimum quantity 20 tests or more.
 - Depth of carbonation test; minimum quantity 20 tests or more.
 - Chloride content test; minimum quantity 10 tests or more.
 - Sulphate Content Test on Foundations and Ground Beams Samples; minimum quantity 5 tests or more.
 - Extraction of reinforcement samples and testing; minimum quantity 2 tests or more.
 - Half-cell potential measurement; minimum quantity 15 units or more.
 - Schmidt hammer test; minimum quantity 50 tests or more.
 - Final report.
- **Rehabilitation Works**
 - Repair of exposed reinforced concrete slab surfaces (spalling, voids, and delamination), given in square meters of structurally repaired surfaces, including all required products, equipment, works, workmanship, and experienced labour; minimum quantity 50 m² or more.
 - Repair of exposed reinforced concrete column and wall surfaces (RC jacketing or CFRP wrapping), given in square meters of structurally repaired surfaces, including all required products, equipment, works, workmanship, and experienced labour; minimum quantity 40 m² or more.
 - Crack injection in slabs, beams, columns, and walls, given in linear meters of structurally repaired cracks, including all required products, equipment, works, workmanship, and experienced labour; minimum quantity 50 Lm or more.

- The operator must comply with all requirements set out in:
 - *Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25*
 - *Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25*

ELECTRICAL

○ **Cables & Branch Circuits**

- Cables and branch circuits to be tested and checked for operational condition.
- Perform insulation resistance and dielectric withstand tests as per IEC 60502-1, continuity test per IEC 60228, earth resistance per IEC 60364-6, and voltage drop test under full load.
- Cables failing tests to be replaced with proper sizes and types as per load and installation location.
- All branch circuit wiring shall be single-core copper, PVC insulated wires in conduits (minimum 2.5 mm² for lighting and 4 mm² for sockets/power).
- Each conduit to include a separate protective earth wire.
- Cable sizing to follow BS standards considering derating factors and environment.
- Wires and cables include:
 - conduits and fittings, draw wires and the like,
 - cable connectors and joints (joint boxes, sealing boxes, shrouds, etc.)
 - allowances for entry lengths, fittings, and accessories,
 - fixing accessories for walls, ceilings, and trays/ladders,
 - spare parts as required for continuity of operation and agreed with Employer.

○ **Distribution Panels & Panel boards**

- Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted, installed in lockable cabinets with warning signs.
- DP's shall have moulded case circuit breakers thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
- Lighting and Power Panel Boards will have moulded case switches on the incoming and miniature circuit breakers on the outgoing.

- All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth bus.
 - Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability. Surge Protective devices are to be provided in each distribution panel.
 - A minimum of one panel shall be installed in each floor with maximum distance of 45 meters.
 - Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
 - Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.
 - All circuits feeding lighting to be protected by an 100mA RCBO configuration.
 - All circuits feeding socket outlets to be protected by an 30mA RCBO configuration.
 - All boards shall be lockable, installed in dedicated rooms or closets and away from water pipes according to NEC clearances standards. IP 41 rated enclosures shall be used for indoor installations and IP 65 in outdoor and humid areas.).
 - Panel boards include:
 - Conduits and fittings, draw wires and the like (except where conduit work is required to be measured separately),
 - Cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - Allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - Necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Conduits & Cable Trays**
- Cable trays will be heavy duty, hot dip galvanized after fabrication and will be installed with central supporting, two-sided hanging system and brackets as required.
 - Rigid metal hot-dip galvanized conduits will be installed in exposed areas where the conduits may be subject to mechanical damage.
 - Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where the ceiling is used as an air plenum (above false ceiling) installations and in exposed non-hazardous indoor locations.

- Due to high humidity, cables trays and conduits shall be treated properly for anti-corrosion and to withstand high humidity.
- The minimum size of conduits for indoor applications shall be 20 mm diameter and 50 mm diameter for exterior installations. A filling capacity of 40% shall be provided for all conduits. Separate conduits and wire ways shall be used for normal light and power circuits and low current systems wiring.
- Conduits are deemed to include:
 - fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Sockets & Outlets**
 - Socket outlets, electrical outlets and isolators, conforming to IEC standards, will be provided to serve various fixed and portable equipment and general appliances throughout the facilities.
 - Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-proof socket outlets shall be used in wet and exposed areas. A socket outlet shall be added every 20 m for general use and dedicated socket outlets shall be installed for dedicated fixed equipment.
 - Socket outlets, electrical outlets and isolators shall be provided to serve various fixed and portable equipment and general appliances throughout the project.
 - All special purpose sockets indicated for specific equipment shall be fed from a separate dedicated circuit.
 - Wiring devices are deemed to include:
 - Outlets,
 - wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panel board,
 - fixing and supporting material.
 - spare parts as required for continuity of operation and agreed with Employer.

○ **Lighting System**

- The lighting design and lamp selection will be based on achieving recommended illumination levels taking into consideration day light effect, proper colour rendering and temperature for each task. Glare will be kept to minimum as SLL recommendations issued by CIBSE.
- Lighting fixtures used in each type of space will be determined based on the functional requirements of the space as well as the architectural consideration.
- The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP65 rated lighting fixtures with stainless steel housing shall be used to withstand the high humidity of the surrounding environment.
- High Efficiency Light Emitting Diode (LED) lamps will be utilized throughout the project.
- Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
- Achieve the minimum lighting levels as per below:
 - Corridors: 150 lux
 - Toilets: 100 lux
 - Offices: 500 lux; uniformity greater than 0.6
 - Ticketing Booth: 500 lux; uniformity greater than 0.6
 - Stairs: 100 lux
 - Workshops and technical areas: 300 lux; add task lighting as needed.
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panel board,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.).

○ **Emergency Lighting & Exit Signs**

- Illumination of means of egress shall be provided in exit corridors, exit stairs, exit discharge lobbies, etc. in compliance with BS 5266. Illumination shall be continuous using self-contained fixtures with 1.5 hrs battery autonomy.
- For escape routes up to 2 m in width, floor surfaces shall be illuminated with not less than 1 lux and with a ratio (maximum to the minimum illuminance) not greater than 40:1 along the centre line of the escape route. The reference plane of the task area shall be illuminated with not less than 10% of the required maintained illuminance for the task, but it shall not be less than 15 lux.
- Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in Arabic, French, and English, illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs battery autonomy.

○ **Lighting Control Systems**

- Indoor Lighting shall be controlled by local switches/push buttons at 1250 mm above finished floor level and at approximately 15 cm from the door frame.
- Motion sensors shall be utilised in toilets, corridors, offices and storage areas.
- Emergency lighting dedicated for life safety purposes (including stairways) shall be maintained and shall not be subject to any control.

○ **Grounding System (TN-S)**

- A complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning.
- The earth electrode shall consist of multi earth rods buried in the ground around the building and interconnected by a ring copper earth conductor.
- Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit.
- Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to assure equal potential.
- Combined resistance to ground of the whole network is not to exceed 5 Ohms.
- Grounding System includes:
 - a complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with

branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),

- Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
- Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
- Bonding to all metallic equipment and to building reinforcement & steel structure,
- Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.

○ **Lightning Protection System (ESE)**

- Early Streamer Lightning Protection system is to be provided in compliance with NFC17-102.
- Early Streamer Emission (ESE) system shall consist of:
 - ESE air terminal(s),
 - Air termination network,
 - Down conductors,
 - Lightning stroke counter,
 - Antenna mast diverter,
 - Extension mast(s),
 - Bolts, brackets, connecting strip,
 - Test joint and earth termination network.
- Lightning Protection System shall include:
 - Early Streamer Emission air terminals,
 - Lightning stroke Counter,
 - Surge protection devices,
 - Test links,
 - Air terminal and connection to the steel reinforcement and steel columns,

- Earth pits and earth electrodes including hand holes and ground termination network,
 - Physical protective measures,
 - Saddles, clips, cleats, holdfasts, strike pads, and the like,
 - Conductor connections/welding and junctions including, tinning, sweating and providing any jointing materials, heat, holes, rivets, bolts, nuts, washers and clamps, etc.,
 - Bends of any type,
 - Conduits and fittings,
 - Excavating trenches and backfilling.
- **UNINTERRUPTIBLE POWER SUPPLY (UPS)**
 - Rack mounted UPS units with 30 minutes battery autonomy shall be provided for ICT, Access control & security systems.
 - Single UPS units shall be provided for offices desktops and Audio-visual systems.
 - UPS packages include:
 - UPS units, automatic static bypass transfer switch, external bypass switch, input/output isolation transformer, and output transformer where applicable or required,
 - VRLA batteries, battery chargers, battery cabinets and racks and interconnecting cables and accessories,
 - Termination of incoming and outgoing cables including cable terminal boxes and accessories,
 - Remote control and indicating panels and interconnects,
 - Interconnection control cables and other accessories,
 - Spare parts, tools and instruments, as required for continuity of operation and agreed with Employer.

FIRE ALARM DETECTION SYSTEM

- **System Overview & Control Panel**
 - This document outlines the technical scope of work for the Fire Alarm Detection System to be implemented, operated, and maintained by the BOT Operator in compliance with Local codes, and applicable international standards.

- The system aims to provide early detection, accurate notification, and efficient coordination in the event of a fire, ensuring safety of occupants and protection of property.
- The fire alarm system shall be provided for all building levels as per codes.
- The Fire Alarm Detection System shall be addressable, microprocessor-based, and designed for zoning, with full loop isolation and system redundancy. It shall be capable of:
 - Support smoke, heat, and multi-sensor detectors.
 - Identify individual device alarms and faults.
 - Communicate with central monitoring stations (if required).
 - Support multiple loops for scalability.
- **Fire Alarm Control Panel (FACP) Components:**
 - Addressable, UL-listed and/or EN 54 certified
 - Modular design, expandable loops
 - Graphical LCD display
 - Event log storage (minimum 1,000 events)
 - Battery backup for 24-hour standby + 5 minutes in alarm
 - Built-in diagnostics and test mode
 - Networkable with other panels if needed
- **Detection Devices**
 - Photoelectric smoke detectors.
 - Rate-of-rise heat detectors.
 - Multi-sensor detectors where appropriate.
- **Initiation, Notification, & Cabling**
 - Manual Call Points (MCPs):
 - Break-glass type,
 - Installed at exits and corridors,
 - Maximum spacing 30 m.
 - Audible and Visual Notification Devices:
 - Sounders, strobes, or combined A/V devices.
 - Minimum 75 dB @ 3 m, wall-mounted at suitable height.
 - Flash rate 1 Hz, visible in bright areas.
 - Horn/strobe synchronization required.
 - Interface Modules:

- Input/output modules for device monitoring and control.
- Network and Cabling:
 - Fire-resistant, shielded twisted pair cables
 - All cabling in conduits/trays, labelled and separated from power
 - Conformity with TIA/EIA standards and IEC 60331 (circuit integrity).

MECHANICAL

- **Plumbing Fixtures**
 - Supply, install, connect, and test new plumbing fixtures (10 EWCs, 8 lavatories, 4 urinals) similar to existing fixtures or according to European Standards.
- **Faucets & Drainage System**
 - Supply, install, connect, and test new faucets for 8 public lavatories, 4 urinals, and 10 ablution units in compliance with European Standards.
 - Include all connections, joints, fittings, and necessary fixing accessories, along with waste drainage systems including all fittings and accessories.
- **Floor Drains & Cleanouts**
 - Inspect all floor drains and cleanouts, including covers.
 - Replace any defective or missing drains and covers.
- **Toilet Exhaust System**
 - Inspect all public toilet exhaust systems, including fans, ducts/pipes, and air outlets.
 - Replace defective components as required.
- **Air Conditioning Units**
 - Inspect all split AC indoor and outdoor units for condition and functionality.
 - Replace any defective components or damaged units.
- **Portable Fire Extinguishers (ABC Type)**
 - Supply and install wall-mounted 6 kg ABC portable fire extinguishers at 1.2 m above floor level.
 - Minimum quantity: 10 units or more.
- **Portable Fire Extinguishers (CO₂ Type)**

- Supply and install wall-mounted 4.5 kg CO₂ portable fire extinguishers at 1.2 m above floor level.
- Minimum quantity: 2 units or more.
- **Portable Fire Extinguishers (Foam Type)**
 - Supply and install wall-mounted 9-liter foam portable fire extinguishers at 1.2 m above floor level in the generator room.

7.4 Upper Cable Car Building

ARCHITECTURAL

- **Steel Protection**
 - Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
 - Polyurethane Coloured Coating: paint system obtained from single supplier consisting high build polyurethane coloured exterior coating over anti-corrosive pigmented primer and barrier coat. Colour of polyurethane coating applied on weathering face is to be selected by the Engineer from manufacturer's full range of colours and gloss.
 - The Operator shall provide corrosion protection to the steelwork, based on type of substrate which has the following durability and maintenance characteristic: Fully compliant to the pertinent provision of BS EN ISO 12944. Conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3. (Mat color RAL 1000 or as approved by engineer).
 - Location:
 - Existing and exposed steel elements
 - Gates, doors and the like (B4)
 - Balustrades (GF-B1)
 - Roof structure (GF)
 - Fabric canopies structure (GF)
 - Cable car steel structure (B1).
- **Tiling**
 - Inspection and removal of existing damaged tiles; substrate and waterproofing condition to be checked and rectified accordingly.

- Full-bodied porcelain tiles and fittings; unglazed anti-slip for exterior and wet areas (R11); glazed polished for interior areas (minimum R9); including cement-sand screed, fill, adhesive/mortar, grout; thin-set adhesive class C2TES1 to BS ISO 13007-1; high-performance grout class CG2AW to BS EN 13888.
- Unglazed/glazed porcelain tiles, minimum 10 mm thick, class Bla rectified to BS ISO 13006 to administrative areas, offices areas flooring and the like (GF-B1) — replacement of damaged tiles to match existing.
- Unglazed/glazed porcelain tiles, minimum 12 mm thick, class Bla rectified to BS ISO 13006 to **circulation areas flooring and the like (GF-B1)** — replacement of damaged tiles to match existing.
- Unglazed/glazed porcelain tiles, minimum 14 mm thick, class Bla rectified to BS ISO 13006 to large crowds, **storage areas flooring and the like (B4)**.
- **Fabric**
 - Remove and dispose existing fabric for steel canopies.
 - Acrylic fabric for canopies; solution-dyed 100% acrylic fibers; UV resistant; fabric weight ≥ 300 g/m²; tensile strength ≥ 130 daN (warp) / 80 daN (weft); tear resistance ≥ 3 daN (both directions); (Color RAL 1000 or as approved by engineer).
 - Location: Outdoor canopies (GF).
- **Pipe And Tube Railings**
 - Balustrades to comply with applicable FLS requirements; balustrades and personnel protective elements to be structurally verified; all fasteners and anchor bolts stainless steel 316.
 - Steel railings with protective coating system: tubing to ASTM A500; pipe to ASTM A53; plates and shapes to ASTM A36; refer to high-performance coatings for coating systems. (Mat colour RAL 1000 or as approved by engineer).
 - Minimum height: 1000 mm from floor.
 - Maximum gap between horizontal rails: 180 mm.
 - Maximum distance from floor to bottom rail: 110 mm.
 - Solid infill or protective panel required up to 450 mm from floor (to prevent climbing/slipping through).
 - Location: Exterior–Interior areas: balustrade, ticketing, stairs handrail, queuing, separations/gates between visitors waiting/departure area and cable car routing and the like to comply with FLS (B1).
 - Perforated galvanized steel sheet infill panels: ASTM A653 Z275, minimum 3 mm thick with protective coating system

- Location: Parapet located in the void between the concrete balustrade soffit and floor (B1).
- **Sound Absorbing Wall Units & Ceiling Units**
 - Acoustical ceiling units: ASTM E1264; lightweight, textured mineral, lay-in or shuffle fit ceiling tile range with glass wool core, fine textured, acoustically transparent glass fibre face scrim and abrasion resistant black paint finish; suitable for environments up to 95 percent relative humidity; sound absorption NRC 0.8; Metal Suspension-System Standard: Provide manufacturer's standard, direct-hung, fully concealed, metal suspension system and accessories of type, structural classification, and finish indicated that complies with applicable requirements in ASTM C635/C635M classified for severe environment performance; acoustic sealant; complete.
 - Location: Ceiling: projection room (GF).
- **Sheet Carpeting**
 - Replace projection room floor carpets; check and rectify substrate condition.
 - Heavy-duty tufted carpet; tuft bind ≥ 22 N; appearance retention rating Heavy traffic, ≥ 3.0 per ASTM D7330; Critical Radiant Flux ≥ 0.45 W/cm² per NFPA 253; including trowelled smooth cement-sand screed
 - Location: Floors: projection room (GF).
- **Roof Tiles**
 - Inspect and replace damaged tiles with similar to match existing; check/rectify substrate and waterproofing (where applicable).
 - Location: Roof (GF).
- **Toilet & Laundry Accessories**
 - Miscellaneous fixtures and fittings: soap dispenser; toilet tissue holder; mirror (min 6 mm polished plate glass), surface-mounted with nickel-plated brass clips; including hardboard filler; fittings and fixings stainless steel; complete —
 - Location: Two public toilets (B1).
- **Toilets Compartments**
 - Dismantle existing toilet compartments, store for reuse, repair and re-install in location.

- Toilet and shower compartments: high-pressure laminated factory-finished partitions and doors to match existing; including pilaster shoes and sleeves, brackets, door stop and hook; hardware and ironmongery; fittings and fixings; complete as required.
- Location: Replacement of damaged WC cubicles in B1 and maintenance of the others.
- **Linear Metal Ceiling**
 - Replace damaged metal ceiling system in WCs area.
 - Metal pans, formed to snap on to carries securely, without separate fasteners; Aluminium sheet to ASTM B209, alloy and temper recommended by manufacturer; pan thickness not less than 0.6mm; powder coated; same as existing colour and finish complying with requirements in ASTM C635 for applications indicated; carrier system for interior application HDG cold rolled sheet steel minimum Z275 to ASTM A653, complete with carriers, splice sections, stabilizing components, connector clips, alignment clips, levelling clips, hangers, molding, trim, retention clips, load-resisting struts, fixture adapters, and other suspension components required to support ceiling units and other ceiling-supported construction, HDG rods; complete
 - Repair WC false ceiling in B1 to match existing.
- **CMU Wall Partitions**
 - 100 mm CMU wall plastered and painted both sides, with 60-minute fire rating.
 - Enclose the staircase at level B1 with fire-rated walls to separate it from the lower levels (refer to *Appendix 13- Upper Cable Car, Level B1 Fire Rated Zone Sketch*).
 - Divide the floor area into two separate zones, each $\leq 300 \text{ m}^2$ (refer to *Appendix 13- Upper Cable Car, Level B1 Fire Rated Zone Sketch*).
- **Hollow Metal Doors & Frames**
 - Flush steel doors: 45 mm thick, constructed from steel section frame minimum 1.5mm thick, galvanized steel (Z275) sheet both skins minimum 1.3mm thickness; powder coated finish complying to ANSI A250.3; including fittings and fixings; provide weep holes in bottoms of exterior doors; hardware; fire rated, infill with non-combustible thermal insulating material core, including intumescent strip, fittings and fixings; complete.
 - All storage/ancillary rooms to be free of hazardous/high-hazard contents; additional requirements may apply if otherwise.
 - Single leaf metal fire-rated door 30 min to separate **lower levels (B1)**; as per FLS; door to swing in direction of egress; quantity 3 doors.

- Double leaf metal fire-rated door 30 min with Panic Hardware for **Generator and Technical room (B4)**; as per FLS; door to swing in direction of egress; quantity 2 doors.

SIGNAGE & WAYFINDING

- **Design and execution of new suspended Identification sign at the stair access.**
 - Welded steel frame covered by a folded PVD coated 3mm thick aluminium with UV printed message.
 - Indicative dimensions: 0.6m length x 0.6m height information sign.
 - Location: At stair access
- **Design and execution of new wall mounted main identification sign including information about destination.**
 - PVD coated 3mm thick alumini with UV printed message.
 - Indicative dimensions: 0.8m length x 1.2m height information sign.
 - Location: At stair access
- **Design and execution of new general information / restriction sign.**
 - PVD coated 3mm thick aluminum with UV printed message (including Braille).
 - Indicative dimensions: 1.2m length x 2.3m height information sign.
 - Locations: Wall facing queuing

STRUCTURAL

- **Testing Campaign**
 - Defects Mapping; for the entire reinforced concrete area.
 - Extraction of Concrete Cores and related works; minimum quantity 20 Units or more.
 - Compressive Strength Test on all cores; minimum quantity 20 Units or more.
 - Depth of Carbonation Test; minimum quantity 20 Units or more.
 - Chloride Content Test; minimum quantity 10 Units or more.
 - Sulphate Content Test on Foundations and Ground Beams Samples; minimum quantity 5 Units or more.
 - Extraction of Reinforcement Samples and Testing; minimum quantity 2 Units or more.
 - Half-cell Potential Measurement; minimum quantity 15 Units or more.
 - Schmidt Hammer Test; minimum quantity 50 Units or more.

- Final Report.
- **Rehabilitation Works**
 - Repair of exposed reinforced concrete slabs surfaces (spalling, voids, delamination), measured in m² of structurally repaired surfaces, including all required products, equipment, works, workmanship, and experienced labour.
 - Repair of exposed reinforced concrete columns and walls surfaces (RC jacketing or CFRP wrapping), measured in m² of structurally repaired surfaces, including all required products, equipment, works, workmanship, and experienced labour.
 - Cracks injection in slabs, beams, columns, and walls, measured in linear meters of structurally repaired cracks, including all required products, equipment, works, workmanship, and experienced labour.
 - The operator must comply with all requirements set out in:
 - *Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25*
 - *Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25*

ELECTRICAL

- **Cables & Branch Circuits**
 - Cables and branch circuits to be tested and checked if they are still operational. The necessary tests are Insulation resistance & Dielectric Withstand tests according to IEC 60502-1, Continuity Test according to IEC 60228, Earth resistance test according to IEC 60364-6 and voltage drop test under full load.
 - Cables that fail the tests shall be replaced with proper sizes and types according to electrical load being served and area of installation.
 - All branch circuit wiring shall be single-core copper, PVC insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
 - All cables are to be sized in accordance with BS code and taking into consideration the derating factors and environmental conditions.
 - Wires and cables are deemed to include:
 - conduits and fittings, draw wires and the like (except where conduit work is required to be measured separately),

- cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - spare parts as required for continuity of operation and agreed with Employer).
- **Distribution Panels**
- Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted, installed in lockable cabinets with warning signs.
 - DP's shall have molded case circuit breakers thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
 - Lighting and Power Panel Boards will have molded case switches on the incoming and miniature circuit breakers on the outgoings.
 - All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth bus.
 - Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability. Surge Protective devices are to be provided in each distribution panel.
 - A minimum of one panel shall be installed in each floor with maximum distance of 45 meters.
 - Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
 - Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.
 - All circuits feeding lighting to be protected by an 100mA RCBO configuration.
 - All circuits feeding socket outlets to be protected by an 30mA RCBO configuration.
 - All boards shall be lockable, installed in dedicated rooms or closets and away from water pipes according to NEC clearances standards. IP 41 rated enclosures shall be used for indoor installations and IP 65 in outdoor and humid areas.
 - Panel boards shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,

- Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - AC or DC power supply for switchgear control and operation.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Cable Trays & Conduits**
- Cable trays will be heavy duty, hot dip galvanized after fabrication and will be installed with central supporting, two-sided hanging system and brackets as required.
 - Rigid metal hot-dip galvanized conduits will be installed in exposed areas where the conduits may be subject to mechanical damage.
 - Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where the ceiling is used as an air plenum (above false ceiling) installations and in exposed non-hazardous indoor locations.
 - Due to high humidity, cables trays and conduits shall be treated properly for anti-corrosion and to withstand high humidity.
 - The minimum size of conduits for indoor applications shall be 20 mm diameter and 50 mm diameter for exterior installations. A filling capacity of 40% shall be provided for all conduits. Separate conduits and wire ways shall be used for normal light and power circuits and low current systems wiring.
 - Conduits are deemed to include:
 - Fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required to ensure continuity of operation, as agreed with the Employer.
- **Sockets & Wiring Devices**
- Socket outlets, electrical outlets and isolators, conforming to IEC standards, will be provided to serve various fixed and portable equipment and general appliances throughout the facilities.
 - Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-proof socket outlets shall be used in wet and exposed areas. A socket outlet shall be

added every 20 m for general use and dedicated socket outlets shall be installed for dedicated fixed equipment.

- Socket outlets, electrical outlets and isolators shall be provided to serve various fixed and portable equipment and general appliances throughout the project.
- All special purpose sockets indicated for specific equipment shall be fed from a separate dedicated circuit.
- Wiring devices are deemed to include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panel board,
 - Fixing and supporting material.
 - Spare parts as required to ensure continuity of operation, as agreed with the Employer.

○ **Lighting**

- The lighting design and lamp selection will be based on achieving recommended illumination levels taking into consideration day light effect, proper color rendering and temperature for each task. Glare will be kept to minimum as SLL recommendations issued by CIBSE.
- Lighting fixtures used in each type of space will be determined based on the functional requirements of the space as well as the architectural consideration.
- The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP65 rated lighting fixtures with stainless steel housing shall be used to withstand the high humidity of the surrounding environment.
- High Efficiency Light Emitting Diode (LED) lamps will be utilized throughout the project.
- Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
- Use dimmable lights inside the Amphitheatre.
- Achieve the minimum lighting levels as per below:
 - Corridors: 150 lux
 - Toilets: 100 lux
 - Offices: 500 lux; uniformity greater than 0.6
 - Ticketing Booth: 500 lux; uniformity greater than 0.6
 - Stairs: 100 lux

- Workshops and technical areas: 300 lux; add task lighting as needed.
- Amphitheatre: 200 lux
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panel board,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.)
- **Emergency Lighting & Exit Signs**
 - Illumination of means of egress shall be provided in exit corridors, exit stairs, exit discharge lobbies, etc. in compliance with BS 5266. Illumination shall be continuous using self-contained fixtures with 1.5 hrs battery autonomy.
 - For escape routes up to 2 m in width, floor surfaces shall be illuminated with not less than 1 lux and with a ratio (maximum to the minimum illuminance) not greater than 40:1 along the centre line of the escape route. The reference plane of the task area shall be illuminated with not less than 10% of the required maintained illuminance for the task, but it shall not be less than 15 lux.
 - Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in Arabic, French, and English , illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs battery autonomy.
- **Controls**
 - Indoor Lighting shall be controlled by local switches/push buttons at 1250 mm above finished floor level and at approximately 15 cm from the door frame. Motion sensors shall be utilized in toilets, corridors, offices and storage areas. Emergency lighting dedicated for life safety purposes (including stairways) shall be maintained and shall not be subject to any control.

○ **Grounding (TN-S)**

- A complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning. The earth electrode shall consist of multi earth rods buried in the ground around the building and interconnected by a ring copper earth conductor. Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit. Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to assure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
- Grounding system shall be:
 - A complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),
 - Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure,
 - Calculating / measuring earth fault loop impedance and checking its compliance international standards requirements.

○ **Lightning Protection (ESE)**

- Early Streamer Lightning Protection system is to be provided in compliance with NFC17-102. Early Streamer Emission (ESE) system: shall consist of ESE air terminal(s), air termination network, down conductors, lightning stroke counter,

antenna mast diverter, extension mast(s), bolts, brackets, connecting strip, test joint and earth termination network.

➤ Lightning Protection System shall include:

- Early Streamer Emission air terminals,
- Lightning stroke counter,
- Surge protection devices,
- Test links,
- Air terminal and connection to the steel reinforcement and steel columns,
- Earth pits and earth electrodes including hand holes and ground termination network,
- Physical protective measures,
- Saddles, clips, cleats, holdfasts, strike pads, and the like,
- Conductor connections/welding and junctions including, tinning, sweating and providing any jointing materials, heat, holes, rivets, bolts, nuts, washers and clamps, etc.,
- Bends of any type,
- Conduits and fittings,
- Excavating trenches and backfilling.

○ **UPS**

➤ Rack mounted UPS units with 30 minutes battery autonomy shall be provided for ICT, CCTV, Access control & security systems. Single UPS units shall be provided for offices desktops and Audio-visual systems.

➤ UPS units shall include:

- UPS units, automatic static bypass transfer switch, external bypass switch, input/output isolation transformer, and output transformer where applicable or required,
- VRLA batteries, battery chargers, battery cabinets and racks and interconnecting cables and accessories,
- Termination of incoming and outgoing cables including cable terminal boxes and accessories,
- Remote control and indicating panels and interconnects,
- Interconnection control cables and other accessories
- Spare parts as required for continuity of operation and agreed with Employer.

○ **Fire Alarm Detection**

- This document outlines the technical scope of work for the Fire Alarm Detection System to be implemented, operated, and maintained by the BOT Operator in compliance with Local codes, and applicable international standards. The system aims to provide early detection, accurate notification, and efficient coordination in the event of a fire, ensuring safety of occupants and protection of property. The fire alarm system shall be provided for all building levels as per codes
- The Fire Alarm Detection System shall be addressable and microprocessor-based, designed with zoning capability, full loop isolation, and system redundancy. The system shall be capable of performing the following functions:
 - Supporting smoke, heat, and multi-sensor detectors
 - Identifying individual device alarms and faults
 - Communicating with central monitoring stations (if required)
 - Supporting multiple loops for scalability
- System Components
 - Fire Alarm Control Panel (FACP):
 - ✓ Addressable, UL-listed and/or EN 54 certified
 - ✓ Modular design, expandable loops
 - ✓ Graphical LCD display
 - ✓ Event log storage (minimum 1,000 events)
 - ✓ Battery backup for 24-hour standby + 5 minutes in alarm
 - ✓ Built-in diagnostics and test mode
 - ✓ Networkable with other panels if needed
 - Detection Devices:
 - ✓ Photoelectric Smoke Detectors
 - ✓ Rate-of-Rise Heat Detectors
 - ✓ Multi-sensor Detectors (where appropriate).
- **Fire Alarm Detection System**
 - Manual Call Points (MCPs)
 - Break glass type
 - Installed at exits and in corridors, max 30m spacing
 - Audible and Visual Notification Devices:
 - Sounders, strobes, or combined A/V devices
 - 75 dB minimum at 3m, wall-mounted at suitable height
 - Flash rate 1Hz, visible in well-lit areas
 - Horn/strobe synchronization required

- Interface Modules:
 - Input/output modules to monitor and control
- Network and Cabling:
 - Fire-resistant, shielded twisted pair cables
 - All cabling in conduits/trays, labeled and separated from power
 - Conformity with TIA/EIA standards and IEC 60331 (circuit integrity).

Audio Video System

○ **Audio Video Solution:**

The BOT Operator shall deliver a complete AV solution for a sound and video room upper car building. The system shall include a projector, a high-fidelity audio system, content playback systems, and all supporting infrastructure.

➤ **Projection System**

- Projector:
 - ✓ Long throw laser or LED projector with $\geq 6,000$ lumens brightness
 - Screen:
 - ✓ Fixed-frame projection screen (or curved, depending on room shape)
 - ✓ Minimum gain of 1.0; ambient light rejecting (ALR) or acoustic-transparent if needed
- Size optimized for 14m throw distance and viewer distance

➤ **Audio System**

- Loudspeaker System:
 - ✓ Column array loudspeaker
 - ✓ Maximum SPL @ 1 m6 : 112 dB-SPL (118 dB-SPL peak)
 - Amplification & DSP:
 - ✓ Multi-channel DSP amplifier(s)
 - ✓ Digital signal processor (DSP) for equalization and delay management
- Calibration using real-time analyzer (RTA)

➤ **Cabling & Infrastructure**

- Shielded cables suitable for high-humidity environments:
 - ✓ Optical HDMI, Cat6A/STP, balanced audio cables
- Power protection systems:
 - ✓ Power conditioners, surge protectors, and UPS for AV rack
- Cable management:

- ✓ Concealed cabling using conduits or rugged casing that blends with natural surfaces
- Equipment Rack:
 - ✓ Ventilated, lockable AV rack installed in a service-accessible location.

MECHANICAL

- Inspect electric **water pumps** and all related fittings/connections/joints/valves; replace defective items.
- Inspect **domestic water tanks** and all related fittings/connections/joints/valves; replace defective items.
- Inspect sound and image **exhaust system** including fans, ducts and air outlets; replace defective items.
- Supply, install, connect and test **new HVAC system** for the theatre including equipment, ducts, dampers, supply/return/exhaust diffusers with all necessary fixing accessories and fittings.
- Inspect **diesel fuel tanks** and all related fittings/connections/joints/valves; replace defective items.
- Supply, install, connect and test new **plumbing fixtures** (6 EWCs, 6 lavatories, 3 urinals) similar to existing or per European Standards.
- Supply, install, connect and test **new faucets** for 6 public lavatories and 3 urinals per European Standards; include all connections/fixings; provide waste drainage system with all fittings/accessories.
- Inspect all **floor drains and cleanouts** including covers; replace defective/missing drains and covers.
- Inspect all **public toilets exhaust systems** including fans, ducts/pipes and air outlets; replace defective items.

- Inspect all **split AC indoor and outdoor units**; replace defective items.
- Supply and install wall-mounted 6 kg ABC portable **fire extinguishers** at 1.2 m above floor; min 8 Units or more.
- Supply and install wall-mounted 4.5 kg **CO₂ portable fire extinguishers** at 1.2 m above floor in generator room; min 2 Units or more.
- Supply and install wheeled **foam portable fire extinguishers** for generator room.

7.5 Restaurant

The restaurant is a key visitor facility within the Jeita Grotto site, providing food and beverage services to guests. Given its importance, the scope of essential works is focused on shell and core interventions that secure the structure, waterproofing, fire safety, and base building systems. Interior fit-out works remain excluded, to preserve flexibility for the Operator to determine layouts, finishes, furniture, and equipment.

ARCHITECTURAL

- **Roof Tiles**
 - Inspect and replace damaged tiles with similar ones to match existing conditions.
 - Verify substrate condition and waterproofing (where applicable) and carry out necessary rectification prior to tile replacement.
 - Application Area: Roof — replacement of damaged tiles as identified.

WASTE MANAGEMENT

- **Waste Collection and Segregation**
 - The Operator shall provide a designated waste collection point to serve the facilities. Each collection point shall include three (3) colour-coded 1,100 L containers for the temporary storage of segregated waste streams, namely:
 - Organics: For biodegradable waste such as food residues and garden waste.
 - Comingled Dry Recyclables: For mixed recyclable materials including paper, plastics, metals, and glass

- Residual / Non-Recoverable waste: For general waste that cannot be recovered or recycled.
- The Operator shall ensure containers are positioned, sized, labelled and maintained appropriately, and shall prepare the collect waste for offsite transportation in coordination with approved disposal authorities.
- **Compliance Requirement:**
 - The Operator must comply with all requirements set out in:
Appendix 10- Solid Waste Management Report – Sep. 25

Fire Alarm Detection System

- **General Scope**
 - This document outlines the technical scope of work for the Fire Alarm Detection System to be implemented, operated, and maintained by the BOT Operator in compliance with Local codes, and applicable international standards.
 - The system aims to provide early detection, accurate notification, and efficient coordination in the event of a fire, ensuring safety of occupants and protection of property.
 - The fire alarm system shall be provided for all building levels as per codes.
 - The Fire Alarm Detection System shall be addressable, microprocessor-based, and designed for zoning, with full loop isolation and system redundancy.

The system shall be capable of:

 - Supporting smoke, heat, and multi-sensor detectors
 - Identifying individual device alarms and faults
 - Communicating with central monitoring stations (if required)
 - Supporting multiple loops for scalability
- **System Components**
 - Fire Alarm Control Panel (FACP)
 - Addressable, UL-listed and/or EN 54 certified
 - Modular design, expandable loops
 - Graphical LCD display
 - Event log storage (minimum 1,000 events)
 - Battery backup for 24-hour standby + 5 minutes in alarm
 - Built-in diagnostics and test mode

- Networkable with other panels if needed
- Detection Devices
 - Photoelectric Smoke Detectors
 - Rate-of-Rise Heat Detectors
 - Multi-sensor Detectors (where appropriate))
- Manual Call Points (MCPs)
 - Break-glass type
 - Installed at exits and along corridors, maximum spacing 30 m
- Audible and Visual Notification Devices
 - Sounders, strobes, or combined audio/visual devices
 - Minimum 75 dB at 3 m, wall-mounted at suitable height
 - Flash rate 1 Hz, visible in well-lit areas
 - Horn/strobe synchronization required
- Interface Modules
 - Input/output modules to monitor and control
- Network and Cabling
 - Fire-resistant, shielded twisted-pair cables
 - All cabling in conduits/trays, labelled and separated from power
 - Conformity with TIA/EIA standards and IEC 60331 (circuit integrity)

7.6 Administration

The Administration Building provides essential support functions for the operation of the Jeita Grotto site. The scope of work focuses on ensuring the facility remains structurally safe, compliant, and functional, while maintaining flexibility for the Operator to determine the interior fit-out, finishes, and operational layouts.

The essential works for the Administration Building are mandatory and limited to structural, fire safety, and building systems upgrades required to achieve safe and durable shell-and-core performance.

ARCHITECTURAL

- **Roof Tiles**
 - Inspect and replace all damaged roof tiles with matching materials that replicate the existing finish and profile.
 - Verify the condition of the substrate and waterproofing layers (where applicable), rectifying defects as necessary prior to reinstallation.

- Application Area: Roof — replacement of damaged tiles as required.

Waste Management

○ **Waste Collection and Segregation**

- The Operator shall provide a designated waste collection point to serve the facilities. Each collection point shall include three (3) colour-coded 1,100 L containers for the temporary storage of segregated waste streams, namely:
 - Organics: For biodegradable waste such as food residues and garden waste.
 - Comingled Dry Recyclables: For mixed recyclable materials including paper, plastics, metals, and glass
 - Residual / non-recoverable waste: For general waste that cannot be recovered or recycled.
- The Operator shall ensure containers are positioned, sized, labelled and maintained appropriately, and shall prepare the collect waste for offsite transportation in coordination with approved disposal authorities.

○ **Compliance Requirement:**

- The Operator must comply with all requirements set out in:
Appendix 10- Solid Waste Management Report – Sep. 25.

Fire Alarm Detection System

○ **General Scope**

- This document outlines the technical scope of work for the Fire Alarm Detection System to be implemented, operated, and maintained by the BOT Operator in compliance with local codes and applicable international standards. The system aims to provide early detection, accurate notification, and efficient coordination in the event of a fire, ensuring safety of occupants and protection of property. The fire alarm system shall be provided for all building levels as per codes.

○ **System Overview**

- The Fire Alarm Detection System shall be addressable, microprocessor-based, and designed for zoning, with full loop isolation and system redundancy. It shall be capable of:
 - Supporting smoke, heat, and multi-sensor detectors
 - Identifying individual device alarms and faults

- Communicating with central monitoring stations (if required)
- Supporting multiple loops for scalability
- **System Components**
 - Fire Alarm Control Panel (FACP)
 - Addressable, UL-listed and/or EN 54 certified
 - Modular design, expandable loops
 - Graphical LCD display
 - Event log storage (minimum 1,000 events)
 - Battery backup for 24-hour standby + 5 minutes in alarm
 - Built-in diagnostics and test mode
 - Networkable with other panels if needed
 - Detection Devices
 - Photoelectric Smoke Detectors
 - Rate-of-Rise Heat Detectors
 - Multi-sensor Detectors (where appropriate)
 - Manual Call Points (MCPs)
 - Break glass type
 - Installed at exits and in corridors, max 30 m spacing
 - Audible and Visual Notification Devices
 - Sounders, strobes, or combined A/V devices
 - 75 dB minimum at 3 m, wall-mounted at suitable height
 - Flash rate 1 Hz, visible in well-lit areas
 - Horn/strobe synchronization required
 - Interface Modules
 - Input/output modules to monitor and control
 - Network and Cabling
 - Fire-resistant, shielded twisted pair cables
 - All cabling in conduits/trays, labelled and separated from power
 - Conformity with TIA/EIA standards and IEC 60331 (circuit integrity)

7.7 Parking Building (Basements & Interfaces)

The Parking Building, including basements and associated interfaces, is a critical element for visitor circulation and site operations. Its rehabilitation is necessary to ensure structural

safety, durability, and compliance with modern fire, life safety, and accessibility standards while providing a safe and efficient environment for vehicles and pedestrians.

Scope & intent. The Operator shall design, rehabilitate, and commission the multi-level Parking Building (GF/B1/B2/B3 and immediate interfaces) to achieve safe circulation, life-safety compliance, structural durability, and operational reliability in a high-humidity, high-traffic environment. Works include architectural/civil finishes, structural investigation and repairs, geotechnical protection, electrical and lighting upgrades, fire detection and alarm, security and parking control systems, mechanical/drainage/firefighting, traffic management and wayfinding, and all testing/commissioning. Requirements below are **minimums** and shall be read in conjunction with the project-wide standards in Section 4 (General Requirements). Where values differ, these Parking-specific values govern.

ARCHITECTURAL & CIVIL WORKS

○ **Steel Protection**

- Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
- Polyurethane Colored Coating: paint system obtained from single supplier consisting of high build polyurethane colored exterior coating over anti-corrosive pigmented primer and barrier coat. Color of polyurethane coating applied on weathering face is to be selected by the Engineer from manufacturer's full range of colors and gloss.
- The Operator shall provide corrosion protection to the steelwork, based on type of substrate which has the following durability and maintenance characteristic: Fully compliant to the pertinent provision of BS EN ISO 12944. Conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3. (Mat color RAL 1000 or as approved by engineer).
- Applied to existing and exposed steel elements.
- Location: Doors, windows and the like. (B1; Storage, Office).

○ **Pipe & Tube Railings**

- Balustrades to comply with applicable FLS requirements; Balustrades and personnel protective elements to be structurally verified; all fasteners and anchor bolts to be stainless steel 316.
- Steel railings with protective coating system: tubing to ASTM A500; pipe to ASTM A53; plates and shapes to ASTM A36; refer to high performance coatings for coating systems; (Mat color RAL 1000 or as approved by engineer).
- "Minimum overall height: 1000 mm from the floor

- Maximum gap between horizontal rails: 180 mm
 - Maximum distance from floor to bottom rail: 110 mm
 - Solid infill or protective panel required up to 450 mm from the floor (to prevent climbing or slipping through)"
 - Location: (GF-B1-B2-B3) Wall mounted handrail that will be positioned on the existing concrete parapet to comply with the height requirements set by FLS.
- **Infill Pannels for Parapets**
 - Perforated galvanized steel sheet infill panels: ASTM A653 Z275, minimum 3mm thick with protective coating system
 - Location: Parapets. (GF-B1-B2-B3) located in the void between the concrete balustrade soffit and floor.

Signage & Wayfinding

- **Design and execution of new floor mounted gantry.**
 - Structure in Powder coated Galvanized steel hanging sign that informs the maximum clear height.
 - Indicative dimensions: 4.0m length x 3.0m height structure and 2.0m length x 0.3m height information sign.
 - Location: at the ramp access.
- **Design and execution of new suspended signs** indicating the floor level and exit (with color coddging).
 - Welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 2m length x 0.3m height information sign.
 - Location: on the floor and ramp access; minimum quantity 7 Unit or more.
- **Design and execution of new wall mounted directional sign indicating the pedestrian path.**
 - PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 0.6m length x 0.6m height information sign.
 - Location: at two locations on each floor; minimum quantity 9 Unit or more.
- **Design and execution of new wall mounted stair floor identification sign.**
 - PVD coated 3mm thick aluminum with UV printed message.

- Indicative dimensions: 0.60m length x 0.60m height information sign.
- Location: on the stairs; minimum quantity 6 Unit or more.

STRUCTURE

○ **Structural Investigation & Rehabilitation**

➤ Testing Campaign:

- Defects Mapping covering the entire reinforced concrete area.
- Extraction of Concrete Cores and related works; minimum quantity 12 cores or more.
- Compressive Strength Test on All Cores; minimum quantity 12 tests or more.
- Depth of Carbonation Test; minimum quantity 12 tests or more.
- Chloride Content Test; minimum quantity 6 tests or more.
- Sulfate Content Test on Foundations and Ground Beams Samples; minimum quantity 3 tests or more.
- Extraction of Reinforcement Samples and Testing; minimum quantity 2 tests or more.
- Half-cell Potential Measurement; minimum quantity 6 Unit or more.
- Schmidt Hammer Test; minimum quantity 30 tests or more.
- Final Report.

➤ Rehabilitation Works:

- Repair of Exposed Reinforced Concrete Slab Surfaces:
Includes treatment of spalling, voids, and delamination. Measurement shall be in square meters of structurally repaired surface area and shall comprise the supply of all required materials, equipment, skilled workmanship, and experienced labor. Minimum quantity: 700 m² or more.
- Repair of Exposed Reinforced Concrete Columns and Walls:
Includes structural strengthening works using RC jacketing or CFRP wrapping systems. Measurement shall be in square meters of structurally repaired surface area and shall comprise the supply of all required materials, equipment, skilled workmanship, and experienced labor. Minimum quantity: 20 m² or more.
- Crack Injection in Slabs, Beams, Columns, and Walls:
Includes the injection of structural cracks using approved materials and

methods. Measurement shall be in linear meters of repaired cracks and shall comprise the supply of all required materials, equipment, skilled workmanship, and experienced labor. Minimum quantity: 50 Lm or more.

- **Soil Scour Under Footings Treatment**

- All described works, including all required products and equipment, to divert the river, establish safe platforms, excavate near the exposed footing, inject concrete under exposed footings, construction of reinforced concrete ground beam, erosion protection measures, and monitoring movements and settlements.
- quantified are per linear meters of treated strip foundation; approximate quantity 15 Lm or more.

- **Compliance with Structural Report**

- The operator must comply with all requirements set out in:
 - *Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25*
 - *Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25.*

ELECTRICAL

- **Cables & Branch Circuits Tests**

- Cables and branch circuits shall be tested and verified for operational condition. The required tests includes: Insulation Resistance & Dielectric Withstand Tin accordance with IEC 60502-1, Continuity Test in accordance with IEC 60228, Earth Resistance Test in accordance with IEC 60364-6 and Voltage Drop Test under full load conditions. Cables that fail any of the above tests shall be replaced with properly sized and typed cables corresponding to the electrical load served and the area of installation.
- All branch circuit wirings shall be single-core copper, PVC insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
- All cables are to be sized in accordance with BS code and taking into consideration the derating factors and environmental conditions.

- Wires and cables are deemed to include:
 - Conduits and fittings, draw wires and similar accessories (except where conduit work is required to be measured separately),
 - Cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - Allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - Necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Distribution Panels**
 - Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted, installed in lockable cabinets with warning signs.
 - DP's shall have molded case circuit breakers, thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
 - Lighting and Power Panel Boards will have molded case switches on the incoming and miniature circuit breakers on the outgoings.
 - All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth buses.
 - Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability. Surge Protective devices are to be provided in each distribution panel.
 - A minimum of one panel shall be installed in each floor with maximum distance of 45 meters.
 - Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
 - Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.
 - All circuits feeding lighting to be protected by an 100mA RCBO configuration.
 - All circuits feeding socket outlets to be protected by an 30mA RCBO configuration.
 - All boards shall be lockable, installed in dedicated rooms or closets and away from water pipes according to NEC clearances standards. IP 41 rated enclosures shall be used for indoor installations and IP 65 in outdoor and humid areas.
 - Panelboards are deemed to include:

- Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - AC or DC power supply for switchgear control and operation.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Cable Trays**
- Cable trays will be heavy duty, hot dip galvanized after fabrication and will be installed with central supporting, two-sided hanging system and brackets as required.
 - Rigid metal hot-dip galvanized conduits will be installed in exposed areas where the conduits may be subject to mechanical damage.
 - Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where the ceiling is used as an air plenum (above false ceiling) installations and in exposed non-hazardous indoor locations.
 - Due to high humidity, cables trays and conduits shall be treated properly for anti-corrosion and to withstand high humidity.
 - The minimum size of conduits for indoor applications shall be 20 mm diameter and 50 mm diameter for exterior installations. A filling capacity of 40% shall be provided for all conduits. Separate conduits and wire ways shall be used for normal light and power circuits and low current systems wiring.
 - Conduits are deemed to include:
 - Fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Socket Outlets**
- Socket outlets, electrical outlets and isolators, conforming to IEC standards, will be provided to serve various fixed and portable equipment and general appliances throughout the facilities.
 - Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-

proof socket outlets shall be used in wet and exposed areas. A socket outlet shall be added every 20 m for general use and dedicated socket outlets shall be installed for dedicated fixed equipment.

- Socket outlets, electrical outlets and isolators shall be provided to serve various fixed and portable equipment and general appliances throughout the project.
- All special purpose sockets indicated for specific equipment shall be fed from a separate dedicated circuit.
- Wiring devices are deemed to include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panelboard,
 - Fixing and supporting material.
 - Spare parts as required for continuity of operation and agreed with Employer.

○ **Lighting Design & Lamp Selection**

- The lighting design and lamp selection will be based on achieving recommended illumination levels taking into consideration day light effect, proper color rendering and temperature for each task. Glare will be kept to minimum as SLL recommendations issued by CIBSE.
- Lighting fixtures used in each type of space will be determined based on the functional requirements of the space as well as the architectural consideration.
- The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP65 rated lighting fixtures with stainless steel housing shall be used to withstand the high humidity of the surrounding environment.
- High Efficiency Light Emitting Diode (LED) lamps will be utilized throughout the project.
- Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
- In Car Parking, achieve the requirements below:
 - Minimum average illuminance: 75 lux
 - Minimum maintained illuminance: 50 lux
 - Uniformity (minimum/average): ≥ 0.4
 - Technical Areas: 300 lux
 - Stairs: 100 lux

- Provide wall-mounted lighting fixtures for the entrance ramp which is not covered by ceiling.
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panelboard,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.).
- **Illumination of means of egress**
 - Illumination of means of egress shall be provided in exit corridors, exit stairs, exit discharge lobbies, etc. in compliance with BS 5266. Illumination shall be continuous using self-contained fixtures with 1.5 hrs. battery autonomy.
 - For escape routes up to 2 m in width, floor surfaces shall be illuminated with not less than 1 lux and with a ratio (maximum to the minimum illuminance) not greater than 40:1 along the center line of the escape route, with minimum distance every 15m along evacuation routes. The reference plane of the task area shall be illuminated with not less than 10% of the required maintained illuminance for the task, but it shall not be less than 15 lux.
 - Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in Arabic, French, and English , illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs battery autonomy.
- **Lighting Control**
 - Indoor Lighting shall be controlled by local switches/push buttons at 1250 mm above finished floor level and at approximately 15 cm from the door frame. Motion sensors shall be utilized in toilets, corridors, offices and storage areas. Emergency lighting

dedicated for life safety purposes (including stairways) shall be maintained and shall not be subject to any control.

○ **Outdoor Lighting**

- Outdoor lighting for the parking and landscape areas within the facility site limits shall be designed to provide an adequate level of illuminance, comfort and amenity purposes. All outdoor lighting shall be coordinated with the landscape and site infrastructure works. Lighting criteria for outdoor car parks shall be at least 5 lux in compliance with BS 5489, CIE 115 codes.
- LED luminaires shall generally be used for exterior lighting. All exterior lighting shall be fed from low voltage feeder pillars where the location and supply to be coordinated with the site layout, landscape, and the infrastructure design. Outdoor lighting shall be switched on/off based on available daylight, using photocells.
- Exterior lighting fixtures, are deemed to include:
 - Wires/cables including protective earthing conductors, conduits, trunking and other raceways and fittings (excluding underground duct-banks and trenches where required to be measured separately) from lighting fixture back to upstream lighting fixtures or to final branch circuit panel board,
 - Earthing system, as applicable,
 - Relevant connections accessories,
 - Hermetically sealed category B capacitors,
 - Terminals, lugs, protective devices and boxes,
 - Lamps/light sources, ballasts/drivers, transformers, ignitors, etc. and all luminaire components,
 - Junction boxes,
 - Internal wiring from junction box to and between luminaires components,
 - Aiming and adjustment,
 - Spare parts (lamps, control gear, etc.) as required for continuity of operation and agreed with Employer.
- Lighting columns / poles are deemed to include:
 - Lighting fixture / luminaires including lamps / light sources, control gear / drivers, surge protection devices, transformers, ignitors, etc. and all luminaire components,
 - Aiming and adjustment,
 - Lighting column / pole, supporting bracket/arm, template, fixation plate, bolts and nuts, caps, handholes, etc.,

- Column concrete base (foundation) and associated cables draw-pit and other related civil works, as per the approved high mast/column detail,
 - Earthing system, as applicable,
 - Cabling inside column,
 - All relevant poles accessories and fittings.
- **Earthing**
- A complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning. The earth electrode shall consist of multi-earth rods buried in the ground around the building and interconnected by a ring copper earth conductor. Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit. Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to ensure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
 - Grounding system shall be:
 - A complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),
 - Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure
 - Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.

○ **Lightning Protection**

- Early Streamer Lightning Protection system is to be provided in compliance with NFC17-102. Early Streamer Emission (ESE) system: shall consist of ESE air terminal(s), air termination network, down conductors, lightning stroke counter, antenna mast diverter, extension mast(s), bolts, brackets, connecting strip, test joint and earth termination network.
- Lightning Protection System shall include:
 - Early Streamer Emission air terminals,
 - Lightning stroke counter,
 - Surge protection devices,
 - Test links,
 - Air terminal and connection to the steel reinforcement and steel columns,
 - Earth pits and earth electrodes including hand holes and ground termination network,
 - Physical protective measures,
 - Saddles, clips, cleats, holdfasts, strike pads, and the like,
 - Conductor connections/welding and junctions including, tinning, sweating and providing any jointing materials, heat, holes, rivets, bolts, nuts, washers and clamps, etc.,
 - Bends of any type,
 - Conduits and fittings,
 - Excavating trenches and backfilling.

○ **UPS**

- Rack mounted UPS units with 30 minutes battery autonomy shall be provided for CT, CCTV, Access control & security systems.
- UPS units shall include:
 - UPS units, automatic static bypass transfer switch, external bypass switch, input/output isolation transformer, and output transformer where applicable or required,
 - VRLA batteries, battery chargers, battery cabinets and racks and interconnecting cables and accessories,
 - Termination of incoming and outgoing cables including cable terminal boxes and accessories,
 - Remote control and indicating panels and interconnects,
 - Interconnection control cables and other accessories

- Spare parts, tools and instruments, as required for continuity of operation and agreed with Employer.

FIRE PROTECTION

○ **Fire Alarm detection System**

- This document outlines the technical scope of work for the Fire Alarm Detection System to be implemented, operated, and maintained by the BOT Operator in compliance with Local codes, and applicable international standards.
- The system aims to provide early detection, accurate notification, and efficient coordination in the event of a fire, ensuring safety of occupants and protection of property.
- The fire alarm system shall be provided for all parking levels as per codes
- The Fire Alarm Detection System shall be addressable, microprocessor-based, and designed for zoning, with full loop isolation and system redundancy. It shall be capable of:
 - Supporting smoke, heat, and multi-sensor detectors
 - Identifying individual device alarms and faults
 - Communicating with central monitoring stations (if required)
 - Supporting multiple loops for scalability.
- System Components
 - Fire Alarm Control Panel (FACP)
 - ✓ Addressable, UL-listed and/or EN 54 certified
 - ✓ Modular design, expandable loops
 - ✓ Graphical LCD display
 - ✓ Event log storage (minimum 1,000 events)
 - ✓ Battery backup for 24-hour standby + 5 minutes in alarm
 - ✓ Built-in diagnostics and test mode
 - ✓ Networkable with other panels if needed
 - Manual Call Points (MCPs)
 - ✓ Break glass type
 - ✓ Installed at exits and in corridors, max 30m spacing
 - Audible and Visual Notification Devices
 - ✓ Sounders, strobes, or combined A/V devices
 - ✓ 75 dB minimum at 3m, wall-mounted at suitable height
 - ✓ Flash rate 1Hz, visible in well-lit areas

- ✓ Horn/strobe synchronization required
- Interface Modules
 - ✓ Input/output modules to monitor and control
- Network and Cabling
 - ✓ Fire-resistant, shielded twisted pair cables
 - ✓ All cabling in conduits/trays, labeled and separated from power
 - ✓ Conformity with TIA/EIA standards and IEC 60331 (circuit integrity)

SECURITY & PARKING CONTROL

- **Parking Control System**
 - This Scope of Work outlines the technical requirements and responsibilities of the BOT Operator for the design, supply, installation, configuration, operation, maintenance, and handover of a fully Parking Control System.
 - System Components and Features
 - Entry/Exit Parking with:
 - ✓ Ticket dispensers
 - Automatic Barriers:
 - ✓ Heavy-duty boom barriers with loop detectors
 - ✓ Manual override and safety sensors
 - LPR cameras at all entry and exit lanes
 - Pay-on-foot Kiosks:
 - ✓ Touch screen
 - ✓ Cashless payment (credit/debit cards)
 - ✓ Receipts and validation features
 - Parking Management System (PMS)
 - Network & Cabling Infrastructure
 - CAT6A cabling for all terminals and LPR cameras
 - Fiber backbone (if applicable)
 - IP switches (PoE-enabled) and industrial-grade enclosures
 - Patch panels, conduits, and termination accessories
 - Wall Mounted rack.

MECHANICAL

- **Storm Water**

- Supply, install, connect and test above ground, **storm drainage system**, PVC plastic pipe as per ASTM D2665, including piping, fittings, cleanouts, connections, joints, garage drain fixtures as per ASME A112.6.3 for **basement 1 and 2**, channel drain fixtures as per ASME A112.3.1, factory- fabricated oil interceptor complete with all necessary fixing accessories and fittings
- Supply, install, connect and test above ground, **storm drainage system**, PVC plastic pipe as per ASTM D2665, including piping, fittings, cleanouts, connections, joints, garage side drain fixtures as per ASME A112.6.3 for **basement 3**, channel drain fixtures as per ASME A112.3.1, factory- fabricated oil interceptor, oil interceptor complete with all necessary fixing accessories and fittings.

- **Fire Extinguishers**

- Supply and install wall-mounted 6 kg ABC portable fire extinguishers 1.2m above floor level; minimum quantity 25 Unit or more.

- **Sand Box**

- Supply and install sand box; 100L non-combustible absorbent at control post; minimum quantity 3 Unit or more;
- Supply, install and test 65mm diameter black steel 2 dry risers: 10 m length each, complete with all necessary fixing accessories and fittings
- Supply, install and test 65/40 mm outlets for each floor; minimum quantity 8 Unit or more.

GEOTECHNICAL

- **General**

- The Operator shall provide all equipment, workmanship, and execute the required works to the satisfaction of the Engineer.
- Works including design, supply of all material, installation, ancillary works, method statement of works, design calculations, shop drawings.

- **Geotechnical Stabilization**

- Stabilize the face of the rock in Locality 5 (Refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) using anchored wire mesh after removing unstable fragments.

Works shall be measured per surface area of stabilized zone; minimum quantity 15 m² or more.

- Protect exposed surface in Basement (Refer *Appendix 8- Geotechnical Assessment Report - Sep. 25*)
 - Clear loose detached rock debris.
 - Apply shotcrete over the exposed rock face combined with anchored high-tensile mesh.

Works shall be measured per surface area of reinforcement; minimum quantity 30 m² or more.

- **Compliance with Geotechnical Report**

- The Operator must comply with all requirements set out in:
Appendix 8- Geotechnical Assessment Report - Sep. 25.

TRANSPORTATION

- **Safety Barriers**

- Supply and install protective barriers (such as Jersey barriers) around the central void between ramps at Basement 3.

Clarifications & Exclusions

- This section defines **minimum performance**; products are **design-and-build** selections subject to compliance.
- Quantities are indicative; the Operator shall **verify in design**.

7.8 Open Areas, Landscape & Site Infrastructure

The open areas, landscaping, and site infrastructure are critical to ensuring safe circulation, accessibility, and overall site resilience. These works support both visitor movement and environmental protection, while also maintaining harmony with the natural setting of the grotto.

Open Areas such as roads, walkways, gardens, waiting areas, crowd management provisions and similar spaces.

ARCHITECTURE

- **HIGH PERFORMANCE COATINGS**

- Verify suitability of substrates, including surface conditions and compatibility, with finishes and primers. Proper surface preparation to be conducted prior to applying painting systems and to follow manufacturer recommendations.
 - Reinforced concrete repairs to be conducted where needed and as per structural requirements with suitable anti corrosion cementitious mortar for protecting steel reinforcement rods and suitable non shrink grout complying to ASTM C1107"
 - Polyurethane Colored Coating: paint system obtained from single supplier consisting high build polyurethane colored exterior coating over anti-corrosive pigmented primer and barrier coat. Color of polyurethane coating applied on weathering face is to be selected by the Engineer from manufacturer's full range of colors and gloss.
 - The Operator shall provide corrosion protection to the steelwork, based on type of substrate which has the following durability and maintenance characteristic: Fully compliant to the pertinent provision of BS EN ISO 12944. Conforming to high durability (H) to BS EN 12944-5 for corrosivity category C3.(Mat color RAL 1000 or as approved by engineer).
 - Steel and galvanized steel protection to existing and exposed steel elements
 - Applied to:
 - furniture & steel benches.
 - Gates, doors and the like;
 - Fabric canopies' structure.
- **FABRIC**
- Remove and disposal existing fabric for steel canopies.
 - Acrylic fabric for canopies; Solution-dyed 100% acrylic fibers; UV resistant; fabric weight minimum 300g/m²; Tensile strength: ≥130 daN (warp) / 80 daN (weft), tear resistance: ≥3 daN (both directions); Color RAL 1000 or as approved by engineer).
 - Location: Outdoor canopies.
- **Signage & Wayfinding**
- Design and execution of new floor mounted gantry in Powder galvanized steel hanging iconic identification sign.
 - Indicative dimensions: 4.0m length x 2.8m height (gantry) supporting identification sign 3.5m length and 0.5m height.
 - To be located at the main access.
 - Design and execution of new floor mounted pole to identify car slot for ADA and electrical connection.

- PVD coated 3mm thick aluminum with message in reflective vinyl.
- Indicative dimensions: 2.2m length pole including a 0.3m length and 0.4m height identification plate.
- To be located at each car slot; minimum quantity 20 Units or more.
- Design and execution of new floor mounted pole to identify buses slots.
 - PVD coated 3mm thick aluminum with message in reflective vinyl.
 - Indicative dimensions: 2.2m length pole including a 0.3m length and 0.4m height identification plate.
 - To be located at each bus slot; minimum quantity 10 Units or more
- Design and execution of new YAH map sign at the main pedestrian decision points.
 - Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting and Braille).
 - Indicative dimensions: 1,4m length and 2,2m height.
 - To be located at main decision points; minimum quantity 3 Units or more.
- Design and execution of new general information / restriction sign.
 - Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting).
 - Indicative dimensions: 1,4m length and 2,2m height.
 - To be located at main decision points; minimum quantity 2 Units or more.
- Design and execution of main directional signs at the main access of the outdoor car park.
 - Floor mounted powder coated steel structure to hang welded steel frame covered by a folded PVD coated 3mm thick aluminum with UV printed message (including lighting); Indicative area 2.50m²; minimum quantity 2 Units or more.
- Design and execution of all education signs.
 - Floor mounted powder coated steel tub to hang PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 1,2m height tube supporting a 0,6m length and 0,6m height sign plate.
 - To be located at main decision points. minimum quantity 12 Units or more.

ELECTRICAL

○ **Cable & Branch Circuits**

- Cables and branch circuits shall be tested and verified for operational condition. The required tests include Insulation Resistance and Dielectric Withstand Tests in accordance with *IEC 60502-1*, Continuity Test in accordance with *IEC 60228*, Earth Resistance Test in accordance with *IEC 60364-6*, and Voltage Drop Test under full load conditions. Cables that fail any of the above tests shall be replaced with properly sized and typed cables corresponding to the electrical load served and the area of installation. Armored cables shall be used for all directly buried installations.
- All branch circuit wiring shall be single-core copper, PVC insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
- All cables are to be sized in accordance with BS code and taking into consideration the derating factors and environmental conditions.
- Wires and cables are deemed to include:
 - Conduits and fittings, draw wires and similar accessories (except where conduit work is required to be measured separately),
 - Cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - Allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - Necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - Spare parts as required for continuity of operation and agreed with Employer.

○ **Distribution Panels**

- Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted.
- DP's shall have molded case circuit breakers thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
- Lighting and Power Panel Boards will have molded case switches on the incoming and miniature circuit breakers on the outgoings.
- All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth bus.

- Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability. Surge Protective devices are to be provided in each distribution panel.
- Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
- Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.
- All circuits feeding lighting to be protected by an 100mA RCBO configuration.
- All circuits feeding socket outlets to be protected by an 30mA RCBO configuration.
- IP 65 enclosures with anti-corrosion treatment shall be used, with lockable doors and proper clearances as per NEC requirements.
- Panelboards shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - AC or DC power supply for switchgear control and operation.
 - Spare parts as required for continuity of operation and agreed with Employer.

○ **Socket outlets**

Socket outlets, electrical outlets and isolators, conforming to IEC standards, will be provided to serve various fixed and portable equipment and general appliances throughout the facilities.

Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-proof socket outlets shall be used in wet and exposed areas.

Wiring devices are deemed to include:

- outlets,
- wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panelboard,
- fixing and supporting material.
- spare parts as required for continuity of operation and agreed with Employer.

○ **Earthing**

- A complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning.
- The earth electrode shall consist of multi earth rods buried in the ground around the building and interconnected by a ring copper earth conductor.
- Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit.
- Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to assure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
- Grounding system shall be:
 - A complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),
 - Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure,
 - Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.
- **Cable ducts**
 - Cable ducts and duct banks are to include:
 - Excavation, including backfilling, disposal of surplus excavated material and earthwork support,
 - Duct couplers, plugs, bends and other duct accessories,
 - Duct racks/spacers.
 - Keeping the excavation free from water, however arising, including ground water.
 - Manholes, handholes are to include:

- Excavation including backfilling, disposal of surplus excavated material and earthwork support,
- Concrete, reinforcement, formwork and waterproofing,
- Blockwork, brickwork and rendering,
- Building in ends of pipes including cutting pipes,
- Keeping the excavation free from water, however arising, including ground water,
- Step irons, covers and frames.

GEOTECHNICAL

○ **General**

- The Operator shall provide all equipment, workmanship, and execute the required works to the satisfaction of the Engineer.
- Works including design, supply of all material, installation, ancillary works, method statement of works, design calculations, shop drawings.

○ **Geotechnical Stabilization**

- Reinforce the rock face in Locality 1 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) above the entrance near security stands, through installing a double layer steel mesh anchored with rock bolts.
Works are measured per surface area of stabilized zone. Minimum quantity 1,000 m² or more.
- Dismantle the existing unstable sections of the dry - stacked gravity wall located above Snack in locality 2 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*).
Reconstruct the wall using mortared stone masonry with adequate drainage.
Works are measured per linear meter of wall length. Minimum quantity 120 LM or more.
- Stabilize local failure in Locality 3 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) to the right side of the snack. Remove fallen debris after inspecting and documenting the location. Scale loose/ unstable fragments. Install wire mesh with anchors over the affected area. Reinstate the parapet wall/ damaged utilities.
Works are measured per surface area of stabilized zone; Minimum quantity 1,000 m² or more.
- Extend the wire mesh to cover the inner rock faces in Locality 4 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*) above the train parking.
Works are measured per surface area of stabilized zone. Minimum quantity 80 m² or more.

- The Garden Wall - Locality 15 (refer to *Appendix 8- Geotechnical Assessment Report - Sep. 25*). Replace the existing dry-stacked wall with a composite wall of concrete toe and rebuild the upper portion with mortar pointing and existing boulders. This includes:
 - Excavation and foundation preparation, dismantling the existing wall along the exposed length of the river-facing wall.
 - Constructing concrete toe wall deep enough to provide scour protection.
 - Rebuilding the upper portion of the wall using existing boulders but with cement mortar bonding between stones with proper compaction and stone interlocking.
 - Installing adequate weepholes and surface drains and conduct regular inspections particularly after storms and high flow events.
 - Works are measured per Linear Meter of Wall length; Minimum quantity 30 LM or more.
- General Rockfall Hazards near Grotto:
 - Conduct regular visual walkthroughs of accessible areas near and above the grotto to identify any signs of rock instability (e.g. loose blocks, cracks, or fallen debris).
 - Clearly flag and isolate at risk zones using visible materials such as cones, fencing, or warning tape — especially under overhangs or zones with known detachment risk.
 - Perform photo documentation and report all observations
 - Re-check flagged areas periodically and after rainfall or seismic events to track any changes or new hazards.
- **Compliance with Geotechnical Report.**
 - The operator must comply with all requirements set out in:
Appendix 8- Geotechnical Assessment Report - Sep. 25.

TRANSPORTATION

- **Line Marking**
 - Line marking works within the ground floor area (Main Entrance/Exit Gate to Lower Cable Car Building), including the application of lane demarcations, and entry/exit guidance markings on the pavement to ensure organized and safe vehicular mobility.
- **Traffic Management**

- Supply and apply directional arrows on the pavement (Main Entrance/Exit Gate to Lower Cable Car Building) to guide Vehicle Circulation within the Ground Floor area; minimum quantity 12 Units or more.
- Supply and install regulatory and directional signs with posts within the ground floor area (Main Entrance/Exit Gate to Lower Cable Car Building) to clearly indicate entry and exit points, guide traffic flow, and ensure safe and organized vehicular mobility; minimum quantity 36 Units or more.

Waste Management

○ Waste Bins

- The Operator shall supply and install litter bins with two (2) compartments integrated within Open Space. These bins shall be provided to collect comingled dry recyclables and residual/non-recoverable waste.
- The Operator shall locate and install bins in compliance with the following requirements:
 - Bins shall not obstruct pedestrian flow routes, particularly at street corners, junctions, narrow pavements, or areas used by wheelchair users and prams.
 - Bins shall be clearly visible and accessible, avoiding placement behind obstructions such as parked cars, trees, or benches.
 - Areas of higher footfall (e.g., activation zones) shall be provided with a greater number of bins to accommodate higher waste generation.
 - Bins shall be installed near public transport waiting points, such as bus and taxi stops.
 - Bins shall be distributed at intervals not exceeding 50m, with maximum spacing of 75m in parks and 25m in activation zones.
 - All bins shall be clearly labelled to indicate waste segregation streams.

○ Compliance with Waste Management Report

- The operator must comply with all requirements set out in:
Appendix 10- Solid Waste Management Report – Sep. 25.

LANDSCAPE

○ General Requirements

- Implement measures to prevent pollution and maintain cleanliness in natural environments, pathways, and tourist areas through effective waste management, regular cleaning, and environmentally friendly practices.
- **Balustrade**
 - Adjust concrete parapets with a minimum height of 100 cm. by adding steel Balustrades to comply with applicable FLS requirements; Balustrades and personnel protective elements to be structurally verified; all fasteners and anchor bolts to be stainless steel 316. Steel railings with protective coating system: tubing to ASTM A500; pipe to ASTM A53; plates and shapes to ASTM A36; refer to high performance coatings/anticorrosion/specific paint system for metals/ for coating systems. steel to be colored: Mat color (RAL 1000) Location: the trail between the parking areas and the grottos (areas facing the cliff). Length around 100m.
 - Inspect the existing concrete parapet and carry out necessary repair works, wherever deterioration, structural deficiencies and safety issues are identified. Big openings to be closed using Perforated galvanized steel sheet infill panels: ASTM A653 Z275, minimum 3mm thick with protective coating system. Location: the trail between the parking areas and the grottos (areas facing the cliff). Length around 300m.
- **Dismantling intrusive features**
 - Carefully dismantle existing structures, including artificial columns and statues, ensuring minimal disruption to surrounding areas. Clear the site of debris and prepare the ground for new possible future use. Location: Facing the eastern side of the parking area toward the mountain. Total area of work around 1500 m2.

7.9 Technical Rooms

The under-road basement and other small constructions form part of the supporting infrastructure of the grotto site. These elements require essential interventions to ensure structural safety, waterproofing, and compliance with life safety standards.

The essential works include structural and waterproofing repairs, installation of emergency lighting and signage

ARCHITECTURAL

- **Signage & Wayfinding**

- Design and execution of new wall mounted safety sign.
 - PVD coated 3mm thick aluminum with UV printed message.
 - Indicative dimensions: 0.25m length x 0.35m height information sign.
 - To be located at the service rooms access. Minimum quantity 25 Units or more.
- **Wastewater Treatment**
 - The operator must comply with all requirements set out in:
Appendix 9- Wastewater Treatment Report – Sep. 25

ELECTRICAL

- **Existing Generators**
 - Existing generators (400 KVA & 175 KVA indoor type and 100KVA outdoor type) shall be tested in accordance with codes and standards to check their availability, performance and operation capability for the coming years.
 - The indoor diesel generating sets (400 KVA & 175 KVA) shall be complete with associated auxiliaries, start-up system, cooling system, fuel storage and power transfer systems, synchronization panel, and Automatic transfer switches (ATS). The ratings of generators are to be sized based on the actual loads and any future loads to be considered in the project. The generators shall be 4-stroke cycle, 1500 rpm, Prime rated, class G2 to ISO 8528-1, using light fuel diesel oil. Set to be complete with cooling system, lubricating oil system, exhaust system, electric starting system, storage battery (lead-acid, sealed-in-plastic type, complete with battery rack and inter-cell connectors); battery charger; electronic governor, instruments, protection and control equipment, etc. The diesel generator sets shall be isolated from the fuel tanks room with 2 hours fire-rated walls.
 - A synchronization panel connecting the two diesel generators shall located in a nearby enclosed room. The Synchronizing Board will ensure a smooth parallel operation of the generators. It will be divided into two main sections, the parallel control and totalizing compartment and the electrically operated circuit breakers compartment.
 - The generators' room will be renovated taking into consideration arrangements for sound reduction, ventilation, soot filters and accessibility.
 - The Main Distribution Boards (MDB) shall conform to form 3b to IEC 61439- 1, IP42, dead front, metal enclosed, free standing.
 - MDB's will have air circuit breaker with electronic trip unit for main breakers. Breakers will be fixed moulded case type, with electronic trip units for outgoing branches.

- **Cables & Branch Circuits**

- Cables and branch circuits to be tested and checked if they are still operational. The necessary tests are Insulation resistance & Dielectric Withstand tests according to IEC 60502-1, Continuity Test according to IEC 60228, Earth resistance test according to IEC 60364-6 and voltage drop test under full load. Cables that fail the tests shall be replaced with proper sizes and types according to electrical load being served and area of installation.
- All branch circuit wiring shall be single-core copper, PVC insulated wires pulled in conduits with a minimum of 2.5 mm² for lighting installations and 4 mm² for socket and power installations. A separate protective earth wire shall be provided in each conduit.
- All cables are to be sized in accordance with BS code and taking into consideration the derating factors and environmental conditions.
- Wires and cables are deemed to include:
 - Conduits and fittings, draw wires and the like (except where conduit work is required to be measured separately),
 - Cable connectors and cable joints (where permitted) including joint boxes, sealing boxes, shrouds and the like and materials and heat for making the joints,
 - Allowance in cable length for cables entering fittings and accessories, equipment or control gear,
 - Necessary components and accessories for fixing cables on walls, ceilings and on cable trays/ladders.
 - Spare parts as required for continuity of operation and agreed with Employer.

- **Distribution Panels**

- Distribution Panels shall conform to form 2b to IEC 61439-1, totally enclosed dead front construction, free standing or wall mounted, installed in lockable cabinets with warning signs.
- DP's shall have molded case circuit breakers thermal magnetic for ratings below 250A and electronic for breakers rated over 250A. All panels will be provided with ammeters, voltmeters (or electronic measuring unit instead) and pilot lights.
- Lighting and Power Panel Boards will have molded case switches on the incoming and miniature circuit breakers on the outgoing.
- All Panels will be fully rated for the available short circuit current. All bus bars will be copper, with full size neutral and half sized earth bus.

- Distribution panels and final branch panels will be sized for a minimum of 20% future capacity and space availability. Surge Protective devices are to be provided in each distribution panel.
- Maximum of 8 Nos. general single socket outlets can be connected in a circuit.
- Typical circuit breaker sizes are 16A for lighting circuits and 20A for power circuits MCB/RCBO type.
- All circuits feeding lighting to be protected by an 100mA RCBO configuration.
- All circuits feeding socket outlets to be protected by an 30mA RCBO configuration.
- All boards shall be lockable, installed in dedicated rooms or closets and away from water pipes according to NEC clearances standards. IP 41 rated enclosures shall be used for indoor installations and IP 65 in outdoor and humid areas.
- Motor control centers (MCC's) shall be free-standing, sectionalized type, modular, compartmented, Form 3b –to IEC 61439, fully withdrawable for each motor starter, main incoming breaker / switch, and each outgoing feeder circuit breaker. MCC shall be IP41 for indoor installation and IP65 for outdoor installation and in wet/mechanical areas. All controls shall be provided in the MCC's to enable a clean and simple interface with other systems.
- Panelboards shall include:
 - Termination of incoming and outgoing cables to equipment including cable glands, terminations and accessories,
 - Fixing and support structures and materials required for installation of wall or floor mounted equipment as indicated,
 - AC or DC power supply for switchgear control and operation.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Cable trays**
 - Cable trays will be heavy duty, hot dip galvanized after fabrication and will be installed with central supporting, two-sided hanging system and brackets as required.
 - Rigid metal hot-dip galvanized conduits will be installed in exposed areas where the conduits may be subject to mechanical damage.
 - Electrical metallic tubing (EMT) will be used for emergency branch wiring and in areas where the ceiling is used as an air plenum (above false ceiling) installations and in exposed non-hazardous indoor locations.
 - Due to high humidity, cables trays and conduits shall be treated properly for anti-corrosion and to withstand high humidity.

- The minimum size of conduits for indoor applications shall be 20 mm diameter and 50 mm diameter for exterior installations. A filling capacity of 40% shall be provided for all conduits. Separate conduits and wire ways shall be used for normal light and power circuits and low current systems wiring.
- Conduits are deemed to include:
 - Fixings including saddles or cramps,
 - Bending, cutting, screwing and jointing, providing all conduit fittings, special boxes, adaptable boxes, floor-trap boxes, purpose made boxes, junction boxes required for drawing in cables, flameproof boxes and expansion joints etc.,
 - Cutting and jointing conduit to fittings,
 - Flexible conduit and extensible conduit.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Socket outlets, electrical outlets and isolators**
 - Socket outlets, electrical outlets and isolators, conforming to IEC standards, will be provided to serve various fixed and portable equipment and general appliances throughout the facilities.
 - Earth fault protection will be provided for outlets within 0-180 cm of a sink edge and other wet locations, where not protected by earth fault circuit breakers. Weather-proof socket outlets shall be used in wet and exposed areas. A socket outlet shall be added every 20 m for general use and dedicated socket outlets shall be installed for dedicated fixed equipment.
 - Socket outlets, electrical outlets and isolators shall be provided to serve various fixed and portable equipment and general appliances throughout the project.
 - All special purpose sockets indicated for specific equipment shall be fed from a separate dedicated circuit.
 - Wiring devices are deemed to include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or controlled circuit (for switches etc.) or to final branch circuit panelboard,
 - Fixing and supporting material.
 - Spare parts as required for continuity of operation and agreed with Employer.
- **Lighting Design & Lamp Selection**

- The lighting design and lamp selection will be based on achieving recommended illumination levels taking into consideration day light effect, proper color rendering and temperature for each task. Glare will be kept to minimum as SLL recommendations issued by CIBSE.
- Lighting fixtures used in each type of space will be determined based on the functional requirements of the space as well as the architectural consideration.
- The protection class of the lighting fixtures will be specified in accordance with the location where they are installed. IP65 rated lighting fixtures with stainless steel housing shall be used to withstand the high humidity of the surrounding environment.
- High Efficiency Light Emitting Diode (LED) lamps will be utilized throughout the project.
- Illumination of means of egress, emergency lighting and exit signs will also be achieved by LED type lighting luminaires.
- Lighting lux level in technical rooms shall be at least 300 lux.
- Lighting fixtures shall include:
 - Outlets,
 - Wires including protective earthing conductors, conduits, trunking and other raceways and fittings from outlet back to upstream outlet or to final branch circuit panelboard,
 - Lamps and luminaire components,
 - Fixing and supporting material.
 - Control gear / drivers, transformers and the like,
 - Batteries for self-contained fixtures,
 - Installation including fixation, suspension rods and supporting material,
 - Spare parts as required for continuity of operation and agreed with Employer.
 - All components will require complete product documentation, including test certifications (IP rating, IK rating, CRI, lumen output, etc.).
- **Exit signs and emergency**
 - Exit signs and emergency means of illuminations shall be provided in technical rooms in accordance with BS requirements. The Exit signs shall be ceiling or wall mounted, single or double faced as required, engraved in Arabic, French, and English , illuminated and provided with graphical legends and arrows pointing in exit direction. Exit signs shall be maintained using self-contained fixtures with 1.5 hrs. battery autonomy.
- **Indoor Lighting**

- Indoor Lighting shall be controlled by local switches/push buttons at 1250 mm above finished floor level and at approximately 15 cm from the door frame. Emergency lighting dedicated for life safety purposes shall be maintained and shall not be subject to any control.
- **Earthing**
 - A complete system of electric service grounding (TN-S) shall be provided to comply with the latest British Standards BS7430 and BS 7671 requirements taking into consideration the personnel safety and proper equipment functioning. The earth electrode shall consist of multi earth rods buried in the ground around the building and interconnected by a ring copper earth conductor. Protective earth conductors run separately from the earth bar of the main distribution board to the distribution panel boards earth bars then to each lighting and power circuit. Equipotential bonding conductors shall be connected to all exposed and extraneous conductive parts to assure equal potential. Combined resistance to ground of the whole network is not to exceed 5 Ohms.
 - Grounding system shall be:
 - A complete system as specified including trenches excavation, backfilling, reinstatement, etc... (excluding protective earthing conductors that run with branch circuit wiring and protective earthing cables run with main and sub-feeders which are measured separately),
 - Earthing loops conductors, conduits for earthing conductors, lattices, pits, electrodes, connectors, clamps, earthing conductors from earthing loops, earth lattices and building steel rebars to building earth bars, exothermic welding to these earthing loops and rebars, earthing conductors from earthing busbars to subject equipment (transformers, generators, switchboards, etc.), equipotential earthing of mechanical plant rooms and equipment, earthing of telecommunications rooms and equipment and electrical identification as required by specifications,
 - Bonding and connection between earthing networks, at various levels of rock cut line, where applicable,
 - Bonding to all metallic equipment and to building reinforcement & steel structure
 - Calculating / measuring earth fault loop impedance and checking its compliance with international standards requirements.
- **UPS**

- Rack mounted UPS units with 30 minutes battery autonomy shall be provided for ICT, CCTV, Access control & security systems.
- UPS units shall include:
 - UPS units, automatic static bypass transfer switch, external bypass switch, input/output isolation transformer, and output transformer where applicable or required,
 - VRLA batteries, battery chargers, battery cabinets and racks and interconnecting cables and accessories,
 - Termination of incoming and outgoing cables including cable terminal boxes and accessories,
 - Remote control and indicating panels and interconnects,
 - Interconnection control cables and other accessories
 - Spare parts as required for continuity of operation and agreed with Employer

7.10 Equipment

The Operator shall perform, at its own cost and within an allocated amount of up to **USD 380,000**, deemed included in and accounted for under its scope, the required upgrade and/or replacement of the following equipment:

- Cable Car
- Generator serving the Cable Car
- Train locomotives and wagons
- Boats

The USD 380,000 amount is a provisional allowance deemed included in the Operator's offer, to be used only for approved upgrades/replacements of the cable car, generator serving the cable car, train locomotives and wagons, and boats. The allowance shall not limit the Operator's obligation to operate and maintain all equipment safely and legally. If the approved safety-critical works exceed the allowance, the Operator shall notify the Employer immediately and submit a prioritized safety plan; operation of any unsafe equipment shall be suspended until rectified or expressly authorized by the competent authority.

- The upgrades shall primarily focus on ensuring the safe, reliable, and efficient operation of the above equipment, enhancing visitor safety and comfort, improving overall operational performance, and promoting environmental protection.

- The Operator shall carry out a comprehensive assessment of the equipment, identify the required improvements, and submit to the Ministry of Tourism a detailed technical and financial proposal outlining the recommended upgrade and/or replacement works, including any manufacturer upgrades where applicable. The Ministry of Tourism shall review the Operator's proposal and, where appropriate, grant approval to proceed with the proposed works.
- The Ministry of Tourism may, at its discretion, undertake the tendering process and seek offers directly for any of the above upgrade and/or replacement works. In such case, the Operator shall remain responsible for the cost of the approved works, within the allocated amount of USD 380,000, and such cost shall be deemed included in the Operator's obligations and scope.
- Notwithstanding any review, approval, authorization, tendering process, or offer obtained by the Ministry of Tourism, the Operator shall remain solely responsible and liable for the safety, proper functioning, operation, maintenance, and performance of the equipment following completion of the upgrades and/or replacements. Any approval or authorization granted by the Ministry of Tourism shall not be construed as a transfer, limitation, waiver, or sharing of the Operator's responsibilities or liabilities. Shall any balance remain from the allocated amount of USD 380,000 upon completion of the approved works, the Ministry of Tourism shall determine and instruct how such remaining funds are to be utilized.

8. Performance & Functional Requirements

All works shall be designed and executed to meet defined performance and functional requirements, ensuring that the grotto and its facilities remain safe, durable, environmentally responsible, and operationally resilient. The following criteria shall apply:

- **Durability**
 - Apply external coatings and metalwork protection to high-durability classes in accordance with BS EN ISO 12944 and relevant exposure categories.
 - Select materials for corrosion resistance and low maintenance.
- **Safety**
 - Ensure compliant egress capacity.
 - Provide guarding and handrails with correct geometry.

- Meet required illumination levels.
- Provide battery autonomy for emergency systems and survivability of all critical circuits.
- **Environmental Performance**
 - Use LED lighting with time and occupancy controls.
 - Provide drainage with oil interceptors for all vehicle areas.
 - Execute construction to minimize waste, noise, vibration, dust, and chemical emissions in accordance with the Cave Environmental Management Plan (CEMP).
- **Operational Continuity**
 - Phase works to sustain visitor access.
 - Prioritize noisy or disruptive works during the seasonal winter closure of the Lower Cave.

9. Execution Constraints (All Works)

Given the sensitivity of the grotto and its surroundings, all construction activities shall comply with strict execution constraints to protect the cave environment, safeguard visitors, and ensure controlled access. The following requirements shall apply to all works.

- **Cave Environment**
 - No hot works without permit; open flames are prohibited.
 - Avoid percussive drilling; favor manual handling.
 - Use only small electric or battery-powered plant inside caves.
 - Protect all surfaces from impact and capture debris during works.
 - No fixings permitted into speleothems.
- **Noise, Vibration, and Dust**
 - Define thresholds within the CEMP.
 - Continuously monitor chambers during critical works.
- **Access and Logistics**
 - Restrict working hours as required.
 - Enforce controlled load limits.

- Ensure escorted movements through the access tunnel and visitor pathways.

10. Surveys, Design & Deliverables

10.1 Surveys & Investigations

The Operator shall carry out all necessary surveys and investigations to verify existing conditions and inform design. This shall include topographic and utility confirmation, structural defects mapping and testing consistent with the Parking Building scope, and targeted geotechnical verification for slopes and rock faces as referenced in *Appendix 8-Geotechnical Assessment Report - Sep. 25.* (attached herein)

10.2 Design Submissions

The Operator shall prepare and submit design documentation covering all disciplines and principles required to guide the works. Deliverables shall include:

- A Basis of Design Report outlining heritage and environmental design principles, lighting strategy, durability measures, and life safety provisions.
- Discipline-specific designs covering architectural, structural, geotechnical, water and environmental, electrical and lighting, mechanical, fire detection and alarm, access control, transportation, landscape, signage and wayfinding, wastewater and solid waste, and health and safety systems.
- Method statements for cave works, rock stabilization, traffic coatings, electrical upgrades, and drainage interventions.
- A Cave Environmental Management Plan (CEMP) and, where required, a Heritage Impact Statement.

10.3 Pre-Construction Records

Prior to works, the Operator shall document existing conditions through room-by-room and facility-by-facility condition surveys, including text, photographs, and 360-degree imagery where practicable. Risk registers and phasing diagrams shall also be prepared.

10.4 Close-Out & Handover Documents

At project completion, the Operator shall provide full close-out documentation to support handover. Deliverables shall include as-built drawings in both native and PDF formats,

O&M manuals, asset registers, spare-parts lists, and test certificates covering electrical, lighting, life safety, earthing and lightning protection, and drainage. Warranties and commissioning reports verifying performance shall also be submitted, including tests for lighting levels, emergency lighting, fire alarm, UPS runtime, drainage flow, and parking systems.

In addition, the Operator shall provide environmental monitoring results before and after the works, including microclimate logs and turbidity data where applicable, as well as environmental commissioning records covering CO₂ pulse ventilation efficacy, radon baseline, and post-works microclimate confirmation.

11. Testing, Commissioning, Training & Trial Operations

For the avoidance of doubt, the “Preliminary Phase” referenced by the RFP means completion life-safety and core-operation items to the point of passing the Section 11 tests/commissioning and two-week trial operations, enabling Taking-Over for operation.

All completed systems and facilities must be verified for functionality, safety, and integration before being placed into operation. Testing, commissioning, training, and trial operations are required to confirm readiness and to prepare staff for safe and efficient operation.

- Conduct factory and site tests in accordance with applicable standards.
- Perform integrated systems commissioning, covering power, lighting, fire alarm, parking control, UPS, and lightning protection systems.
- Carry out boat operation drills, cable car emergency procedures, and evacuation walk-throughs.
- Integrate ticketing throttle logic with CO₂ alarms (Amber/Red) and conduct at least one full-day simulation with guides and control-room operators.
- Provide structured training for operations and maintenance personnel, including systems operation, emergency response, conservation protocols, and cleaning and lampenflora control.
- Undertake trial operations consisting of a minimum two-week soft-opening cycle for major visitor routes, with live monitoring and punch lists.
- Trial operations shall include functional testing of CO₂ alarms, dashboard alerts, ticketing throttle, group-release throttle, boat-dispatch throttle, turnstile/boarding controls, and pulse-ventilation procedures for both galleries. Tests shall verify alarm thresholds at 2,800 ppm, 3,200 ppm and 3,600 ppm, 5-minute rolling-average logic,

data logging, cloud push, manual verification procedure, recovery criteria, and operational role assignments for ticketing, guides, dock staff and control room.

12. Measurement & Payment

Measurement and payment provisions define how works will be valued and verified against this Scope of Work.

13. Handover, Warranties & Defects

The Operator must complete all documentation, provide training, and hand over the works in a safe, operable condition. Warranties and environmental responsibilities shall extend into the Defects Notification Period.

- Deliver complete documentation and training prior to Taking-Over.
- Provide warranties consistent with material suppliers' conditions, including for coatings, luminaires and drivers, electrical gear, control systems, and marine or boat components.
- Maintain environmental protection measures and support lampenflora monitoring throughout the Defects Notification Period.

14. Exclusions & Interfaces

Certain works are excluded from this SOW to preserve flexibility for the Operator and to clearly define project scope. These exclusions prevent scope overlap and limit obligations to the essential and enhancement works defined herein.

- Restaurant and administration interiors, including detailed fit-out, furniture, and specialized equipment, are excluded.
- This SOW shall deliver safe, durable shell and core works together with base building systems only.
- Concessions, retail kiosks, and operator-specific branding or content are excluded.

List of Appendices

- Appendix 1- Inspection and Corrective Actions, by Spéléo Club du Liban - 06/06/26.
- Appendix 2- Monitoring Stations for the Lower & Upper Grottoes

- Appendix 3- SOCOTEC - Life & Fire Safety Inspection – Lower Cave - 04/02/16
- Appendix 4- SOCOTEC – Life & Fire Safety Inspection – Lower & Upper Caves -15/03/16
- Appendix 5- SOCOTEC – Life & Fire Safety Inspection – Lower Cave - 02/04/16
- Appendix 6- Structural Assessment of Existing Facilities – Operator SOW - Dec. 25
- Appendix 7- Structural Assessment of Existing Facilities – Visual Inspection - Jun. 25
- Appendix 8- Geotechnical Assessment Report - Sep. 25
- Appendix 9- Wastewater Treatment Report – Sep. 25
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- Appendix 11- JEITA GROTTO: TOPO BUILDINGS V2
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- Appendix 13- Upper Cable Car, Level B1 Fire Rated Zone Sketch

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مع جردة ٢٠٠٨

Volume Y: Property Statement (Available upon request)