ENVIRONMENT SOCIAL IMPACT ASSESMENT

Environmental Social Impact Assessment (ESIA) for Installation of 11.3 MW Solar PV Systems in Addu City, Eydhafushi, Fuvahmulah City, Hinnavaru, Thinadhoo, and Kulhudhuffushi City

Prepared by
Ibrahim Miflal Fayaz

Powerchina Hudaong Engineering Corporation Ltd (HDEC)	Maldives Resort Construction Pvt Ltd	Esplan Private Limited

ESPLAN

ENVIRONMENTAL SOCIAL IMPACT ASSESSMENT (ESIA) FOR INSTALLATION OF 11.43 MW SOLAR PV SYSTEMS IN ADDU CITY, EYDHAFUSHI, FUVAHMULAH CITY, HINNAVARU, THINADHOO, AND KULHUDHUFFUSHI CITY

April 2023

Proponent:
POWERCHINA HUDAONG ENGINEERING CORPORATION LTD (HDEC)

Consultant
Esplan Private Limited

އައްޑޫ ސިޓީ، ހޯރަފުށި، ފުވައްމުލައް، ހިންނަވަރު، ތިނަދޫ އަދި ކުޅުދުއްފުށި ސިޓީގައި ބެހެއްޓުމަށް ހަމަޖެހިފައިވާ 11.43މެގަވޮޓްގެ އަވިން ކަރަންޓު އުފައްދާ މަޝްރޫއުއިން ތިމާވެއްޓަށް އަސަރުކުރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓް

އޭޕްރިލް 2023

މަޝްރޫއުގެ އިދާރާ:

ޕަވަރޗައިނާ ހުބޭއްގެ އިންޖިނިއަރިންގ
ކޯރޕަރޭޝަން ލިމިޓެޑް (އެޗްބީއީސީ)

އީ.އައި.އޭ ކޮންސަލްޓަންޓް:

އެސްޕްލޭން ޕްރައިވެޓް ލިމިޓެޑް

Response to EPA Letter Dated: 203-ECA/PRIV/2023/380

Information Lacking in the ESIA for the proposed Installation of 11.3 MW Solar PV Systems in Addu City, Eydhafushi, Fuvahmulah City, Hinnavaru, Thinadhoo, and Kulhudhuffushi City

1. **Please provide an A3 sized site layout indicating all components of the project.**

A3 sized site layout indicating all the project component are attached in appendix B of the document. The maps provided are in digital format which is sufficient enough to generate A3 sized prints.

2. **Provide information on how the proposed temporary sites will be utilized, such as whether they will be used for material storage or as labour quarters. If they are intended for use as labour quarters or office space, please explain how utilities will be provided.**

Temporary site will only be for material use. For labor quarters and office a place will be rented based on availability.

3. **Please provide a more detailed account of climate parameters for the project sites including Temperature and Rainfall based on recorded data from nearby weather stations.**

Detailed climate parameters for the project sites are provided in chapter 4.2 and 4.3 of the document

4. **Please provide results of the survey of utility lines in the project site as per the approved ToR**

As per the project design, pre agreements will be made with the existing utility providers where compensation and contingency measures will be taken to mitigate any damages which may be caused during the project construction/operational phases. However, it is of note that trenches will be dug with careful consideration and upon consulting the utility service provider in the islands.

Furthermore, the areas in Thinadhoo, Hinnavaru and Eydhafushi are reclaimed areas where development and utility provisions are yet to be established.

For the sites in Airport area there are no existing overlaps of utility service lines

For Addu city Hithadhooo area Utility lines is provided in the EIA report (Figure 4-35).

5. **Please identify the vulnerable and disadvantaged population at the project vicinity. That would be particularly impacted because of project implementation.**

For the sites in Thinadhoo, Hinnavaru and Eydhafushi, the area is within the reclaimed areas of the island, which are planned to be developed, and there are no immediate residents or other such facilities that intercept the project boundaries. Additionally it is of note that the project site will be demarcated. In this regard, access will be restricted to authorized personal only.

For Addu city, vulnerable community for harbor users were consulted during the EIA formulation stage and details are provided in chapter 6.9.

6. **Please provide a description of the land use based on Land Use Plans as stated in the approved TOR for the proposed project.**

Careful considerations were taken on the landuse for islands where land use plans have not been updated/approved. In this regard, the island councils were consulted in the site selection process.

7. **Please provide responses of proponent to queries and concerns raised by all the stakeholders during stakeholder consultation.**

Below find the responses from the Consultant, project proponent and project PMU for the issues raised by the key stakeholders.

A. REGIONAL AIRPORTS COMPANY LIMITED (RACL)

Project activities will adhere all the legal instruments and SOPs under the Civil Aviation Authorities and other local laws and regulations.
Glare assessment for both airport location has been done by the proponent and attached along with the report.

B. MALDIVES CIVIL AVIATION AUTHORITY (CAA)
DIRECTORATE OF AVIATION SECURITY ADMINISTRATION (DASA)

- Proponent will share the detail structural design and construction methodologies with CAA for their approval.
- During the construction and operational phase, workers will follow the SOP prepared for the airport sites.
- Glare assessment has been done by the proponent and attached in the report

C. DASA:

- Project activities will follow all the legal instruments set by the relevant authorities
- PMU from Ministry highlighted that enough spacing for patrolling and special attention to emergency exists will be given when installing the solar PV structure.

D. ENVIRONMENTAL PROTECTION AGENCY

- Soil profile for the project site has been done by the proponent.

- Air quality monitoring will be done during the construction phase and mitigation measures set in the EIA will be followed during the construction phase.
- Any changes in the project activity will be shared with EPA and other relevant authorities.

E. MINISTRY OF ENVIRONMENT CLIMATE CHANGE AND TECHNOLOGY

- Consultant highlighted that special mitigation measures will be proposed for Kulhuduffushi site.

NATIONAL DISASTER MANAGEMENT AUTHORITY (NDMA)

- Management options for waste generated during both construction and operation stage will be highlighted in the EIA report and it will be in line with the local regulation and World Bank requirements
- Environmental Safeguard Officer and a Health Safety Officer will be hired to oversee both environmental and health safety during the construction phase.
- All the island councils are well informed about the scope of the project and is an important stakeholder during the EIA formulation process.

MINISTRY OF NATIONAL PLANNING HOUSING AND INFRASTRUCTURE

- Project activities are in line with the local regulations.

UTILITY REGULATORY AUTHORITY

KULHUDHUFFUSHI CITY COUNCIL

- Logistical schedule will be shared with the council when the project starts.

EYDHFASHI COUNCIL

- Detail of project design will be shared with the council when finalizing the design.

HINNAVARU COUNCIL

- Council does not have any major concern for the proposed project

THINADHOO COUNCIL

- Proponent will be responsible to relocate the uprooted trees to an designated areas.

FUVAHMULAH CITY COUNCIL

- Logistical schedule will be shared with the council when the project starts.

ADDU CITY COUNCIL

- Key points from proponent side were incorporated in chapter 6.8.6.

WOMEN DEVELOPMENT COMMITEES

- No major concern was highlighted during the stakeholder meeting.

8. **Please provide list of participants from Kulhudhuffushi City Council and Fuvahmulah WDC in the stakeholder consultation meeting**

Details provided in chapter 6.8.1 and 6.15.4 of the document.

9. **Eydhafushi council stated the proposed location for the project needs to be revised to rectify any conflicts with the LUP. Was this considered? If not, please provide justification.**

Revised location is provided in chapter 2.1.2 of the report.

10. **Thinadhoo council raised concern for potential erosion close to the project site. How is this taken into consideration? Please provide how this will be addressed.**

- As provided in the report, geo bags were installed to protect the reclaimed area from potential erosion.

11. **Labels on figure 6-2 does not appear to be correct. Please correct them.**

Revised in the report.

12. **Please provide stakeholder consultations carried out with NGOs and CSOs operating in project islands.**

Multiple attempts were made to contact the NGOs and CSOs in the respective islands, however only 2 NGO from Kulhuduffushi and Eydhafushi responded. The details of discussion is presented in chapter 6.16 of the report.

13. **Please examine and consider potential impacts on the community for utilizing valuable land space for this project.**

A. The infrastructure to be established within the project is designed to serve as multiuse. In this regard apart from the airport areas, the underneath area will be utilised as parking spaces, market areas, or in a way recreational activities will be facilitated as such (jogging, walking, etc).

B. While it is of note that the spaces allocated were selected based upon consultation with the island community and council. In this regard, the land use plans of the islands were studied in accordance of the project scope to limit overlaps with the island development projects.

14. **Please provide a detailed account of how the preferred alternative was selected and how alternatives described was discarded concluding proposed option was better. The comparison provided under section 9 provides a list of advantages and disadvantages but not an overall score/reason for not selecting over the proposed.**

Overall preferred reason is explained in chapter 9.5 of the report.

Table of Contents

List of Tables

Authors and Acknowledgements

The environmental consultant for this report is **Mr. Ibrahim Miflal Fayaz** (License No: EIAP08/2020).

The key contributors to this ESIA Report are:

Name	Contributing Role
Mr. Ibrahim Miflal Fayaz	EIA Consultant
Mr. Ismail Ajmal	EIA Consultant and Author
Mr. Haider	Technical Contributor (HDEC)
Mr Ali Raza	Technical Contributor (HDEC)
Mr. Saaif Mohamed Rashed	Surveyor and Contributor
Mr. Mauman Abdul Rasheed	Surveyor and Contributor
Mr. Mohamed Hanaan	Surveyor and Contributor
Mr. Mohamed Aflah	Surveyor

EIA Consultant's Declaration

I hereby declare the information presented in this Environment Impact Assessment Report presented to the Environmental Protection Agency, is based on true, complete, and correct information gathered to the best of my knowledge and available information.

Ibrahim Miflal Fayaz
EIAP08/2020

Proponent’s Declaration

The proponent’s declaration letter is attached to Appendix G.

Executive Summary

This Environmental Social Impact Assessment (ESIA) document has been formulated in accordance with the EIA regulation of the Maldives for the proposed establishment of 11.43 MW solar photovoltaic systems for power generation in 8 locations.

- The project locations encompasses the following regions/islands:
    - Kulhudhuffushi City
    - B. Eydhafushi
    - Lh. Hinnavaru
    - G.Dh. Thinadhoo
    - Fuvahmulah City
    - Addu City (Hithadhoo, Feydhoo, Hulhumeedhoo)

- The methodologies applied in the formulation of this ESIA is on the basis of the EIA regulation and the joint expertise of the ESIA team. Data was obtained through on-site data collection, engineering documents, and relevant published scientific sources.

- The project is carried under the umbrella of the Ministry of Environment, Climate Change and Technology's 'Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE)' project. In this regard, the project is in line with the government's policies of transiting to renewable and clean energy sources from polluting fossil based sources as per the status quo.
- The project proponent is POWERCHINA HUDAONG ENGINEERING CORPORATION LTD (HDEC)
- The main objectives of this ESIA is to safeguard the environmental and social dynamics associated with the project while ensuring compliance with the set legal framework and best practices.
- The operational phase of the project is expected to save 45.28 million Rufiyaa worth of diesel fuel per year. Additionally, this translates to a savings of 14,811 MT annual carbon emissions from the Maldives.
- The negative impacts of the project are mostly associated with the construction phase of the project. These include impacts such as noise and air pollution, nuisances caused to the public during construction activities such as logistical mechanisms, and use of heavy machineries. Furthermore, to some extent vegetation clearance is expected in Fuvahmulah City and Thinadhoo. However, the trees will be transplanted in areas designated by the respective island/city councils. In cases where trees would not be transplanted, two trees will be planted for each tree uprooted/cleared in accordance with the regulatory framework.
- With regard to the identified potential impacts, respective mitigation measures are identified in the report where the proponent commits to undertake through the course of the project duration including both the construction and operational phase of the

project. These measures include demarking the project sites with adequate signage, regular inspection of project site and personals and sound management of waste generated. In addition, works carried out at the airport sites at Fuvahmulah and Kulhuduffushi shall adhere all the requirements in the proposed SOPs developed by the relevant authorities as discussed in the report. In general the share of the acute environmental impacts envisaged in the construction phase of the project, can be minimised through adhering to the mitigation measures defined in this report.

- Occupational safety measures and envisaged hazard scenarios are highlighted in the report; which are relatively similar to developments of similar scale.
- Relevant legal instruments and guidelines are stated and highlighted in the report. The project will adhere to the set legislative framework including the relevant guidelines.
- Stakeholders identified through the scoping process were approached; key notes and reservations highlighted in the consultations are summarized in this report.
- A community engagement plan for the proposed project is included to establish positive relationships, building trust, identifying community concerns, and ensuring compliance with regulatory requirements. In this regard the project proponent seeks to engage with the local community and authorities, to obtain feedback and input, address any concerns, and develop solutions that are acceptable to all parties. The plan will help to minimize negative impacts on the environment and community, and ensure the success of the project.
- Project alternatives including the no project option are discussed in this report. Both the positive and negative impacts were technically weighed to deduce the most favourable option to go ahead with the proposed project.
- The project monitoring plan is formulated to ensure the effectiveness of the mitigation measures proposed, contribute to sustainable development, to be proactive in dealing with the issues which may arise during the course of the project. These include analysing ground water, air quality, vibration, and physically inspecting that all the health and social aspects are monitored both during construction and operation stage. The details area included in the report.
- As such projects are often subjected to negative changes to the existing socio-economic environment, a grievance redress mechanism is formulated to resolve the issues through receipt and processing of the complaints logged.
- With regard to the proposed scope, the project can be said as a net environmentally positive project due to the reduction of GHGs from transiting from diesel based power generation. Additionally the project will reduce the expenses made to purchase imported fossil fuel to cater the power generation needs of the project locations while creating jobs and awareness on renewable energy.

ސާދާ ހުލާސާ

މި ރިޕޯޓް ތައްޔާރުކޮށްފައިވަނީ މަޝްރޫޢު ދަށުން ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ބަލާ ރިޕޯޓް ތައްޔާރުކުރަން ހަދާފައިވާ ގަވާއިދާ އެއްގޮތްވާގޮތުގެ މަތިން، އިރުގެ އަލިން ކަރަންޓު އުފެއްދުމަށް ޖުމްލަ ރާއްޖޭގެ 8 ހިސާބެއްގައި ކުރިއަށް ގެންދިއުމަށް ހުށަހަޅާފައިވާ ޕްރޮޖެކްޓުން ތިމާވެށްޓަށް ކޮށްފާނެ އަސަރުތައް ބަޔާންކޮށް، އެއިން ދިމާވާނެ ގެއްލުންތައް ކުޑަކުރުމަށް މަގުތައް ބަޔާން ކޮށްފައެވެ.

- މި ޕްރޮޖެކްޓް ކުރިއަށް ގެންދިއުމަށް ކަނޑައަޅާފައިވާ ސަރަހައްދުތައް ތިރީގައި ލިސްޓުކޮށްފައި އެވަނީއެވެ:
  - ކުޅުދުއްފުށި ސިޓީ
  - ބ. އޭދަފުށި
  - ޅ. ހިންނަވަރު
  - ގދ. ތިނަދޫ
  - ފުވައްމުލަކް ސިޓީ
  - އައްޑޫ ސިޓީ (ހިތަދޫ، ފޭދޫ، ހުޅުމީދޫ)
- މި ރިޕޯޓް ތައްޔާރުކުރަން ބޭނުންކުރެވިފައިވަނީ ތިމާވެށްޓަށް އަސަރުކުރާ މިންވަރު ބަލާ ރިޕޯޓް ތައްޔާރުކުރަން ހަދާފައިވާ ގަވާއިދާ، މި މަސައްކަތަށް ކޮންސަލްޓަންޓް ގެ ފަރާތުން އެކުލަވާލާފައިވާ ޑިޒައިން ޑޮކިއުމަންޓް، ކަމާ ގުޅުންހުރި ފަރާތްތަކާއި ބައްދަލުކޮށް ހޯދާފައިވާ މަޢުލޫމާތާއި، މި މަސައްކަތަށް ޚާއްސަކޮށް ކުރެވިފައިވާ ދިރާސާތަކާއި، މަސައްކަތު ސަރަހައްދުގެ ފޮޓޯތަކާއި ދެން ތަފާތު ސަރުކާރު އިދާރާތަކުން ހޯދާފައިވާ މަޢުލޫމާތު ބޭނުންކޮށްގެންނެވެ.
- މި މަޝްރޫޢުގެ އިދާރާކުރާ ފަރާތަކީ ހުޅުމާލެ އިންޖިނިއަރިންގ ކޯޕަރޭޝަން ލިމިޓެޑް (އެޗްއީސީއެލް)
- މި މަޝްރޫޢަކީ، މިނިސްޓްރީ އޮފް އެންވަޔަރަމަންޓް، ކްލައިމެޓްޗޭންޖް އެންޑް ޓެކްނޮލޮޖީގެ ދަށުން ކުރިއަށް ގެންދާ އެޝުއަރ ޕްރޮޖެކްޓް ގެ ބައެއްގެ ގޮތުން، މިހާރު ވެސް ރަށްރަށުގައި ހުރި ކަރަންޓު އުފައްދާ ސިސްޓަމުތަކާ ގުޅުވައިގެން ގްރިޑާ އެއްކޮށް ކަރަންޓު އުފައްދާ ސިސްޓަމް ތަކާ އެއްގޮތްވާ ގޮތުގެ މަތިން ކުރިއަށް ގެންދާ ޕްރޮޖެކްޓެކެވެ.
- މި ރިޕޯޓް އުފައްދާ ކަރަންޓުގެ މައިގަނޑު މަސައްކަތަކީ މި ޕްރޮޖެކްޓްގެ ދުވަސްވަރު ތިމާވެށްޓާއި އިޖުތިމާޢީ ގޮތުން ދިމާވާ ނޭދެވޭ އަސަރުތައް ކުޑަކުރުމެވެ، މި ޕްރޮޖެކްޓްގެ ދުވަސްވަރު ޢާންމުންނަށް އަސަރުކޮށްދާނެ ކަންކަން ޕްރޮޖެކްޓް ހިންގުމުގެ ކުރިން މަސައްކަތުގެ ތަފްސީލް ހިއްސާކޮށް ރަށުގެ އަސާސީ ޚިދުމަތްތައް ދިނުމުގައި ހުރަސް ނާޅާ ގޮތަށް ރާވައިގެން ކަމަށް ދިމާވެދާނެ ކަންތައްތައް ކުޑަކޮށް މަސައްކަތް ކުރިއަށް ގެންދިއުމެވެ.
- މަސައްކަތު ހިނގުމުން ދާއިރު، މަސައްކަތުގެ މާހައުލުގައި ދިމާވެދާނެ ހިރާސްތެރިކަން އަދި އަޑުގަދަ، އެކަށޭނަ ވިސްނުމާ ކުރެ ކުރެވިދާނެ މަގުތަކާއި ދެމެހެއްޓުން މިނިވަންކަމުގައި އަދި އެކްސިޑެންޓުތައް ވާނެއެވެ.
- މި މަސައްކަތާއި ގުޅިގެން ފަރާތަކަށް ލިބުނު ރަށުގެ އާބާދީގެ ހިމާޔަތް ކަށަވަރުކުރަން ޓެކްނިކަލް މަޝްވަރާގެ ވަސީލަތް ގާއިމުކޮށްފައިވާނެއެވެ. އަދި މީގެ އިތުރުން ޕްރޮޖެކްޓާއި ގުޅުން ހުރި ގަވާއިދުތަކާއި ސަރުކާރުގެ މަޝްވަރާ ބަލައިގަނެވޭނެއެވެ.
- ހަރަކާތްތަކާ މަސައްކަތާއި ގުޅުންހުރި ފަރާތްތަކުން ފަރާތްތަކަށް ޚަބަރުދީ އެހީތެރިކަމާއި މަޝްވަރާކުރެވޭނެއެވެ. މިގޮތުން އެ ފަރާތްތަކުން ފާރަވެރިކަމާ ނަތީޖާތައް މިރިޕޯޓުގައި ހިމަނާފައިވާނެއެވެ.
- މި މަޝްރޫޢުން، އަހަރެއްގެ މައްޗަށް 45.28 މިލިއަން ރުފިޔާ ތެލަށް ކުރާ ހަރަދު ކުޑަ ކުރުވުމުގެ ސަބަބުން ސަލާމަތް ކުރެވޭނެއެވެ. އަދި އަހަރެއްގެ މައްޗަށް 14811 މެޓްރިކް ޓަނުގެ ކާބަން ޖައްވަށް ދޫކުރުން ސަލާމަތް ކުރެވޭނެއެވެ.

- މި މަޝްރޫޢުގެ ތެރޭގައި ދިމާވެދާނެ އަސަރުތަކާއި ގެއްލުންތައް، ފާހަގަ ކުރެވޭ ކަންކަން މި ރިޕޯޓުގައި އަލިއަޅުވާލާފައިވެއެވެ. މިގޮތުން، އެންމެ ފާހަގަ ކުރެވޭ ކަންކަމަކީ އުމްރާނީ މަސައްކަތް ހިނގަމުންދާ ވަގުތުގައި އިޖްތިމާޢީ ގޮތުން ކޮށްފާނެ ނުރައްކާ އަސަރުތަކެވެ. އަދި ބައެއް ސަރަޙައްދުތަކުގައި ސޯލާ ޕެނަލް ހަރުކުރުމަށް ބިން ސާފުކުރުމުގެ ތެރޭގައި ގަސް ކަނޑަން ޖެހުމާއި ގަސްތަކަށް ހާނިކަން ބަދަލު ކުރަން ޖެހުމުން ތިމާވެއްޓަށް ލިބިދާނެ ގެއްލުންތައް ފާހަގަ ކުރެވެއެވެ. ނަމަވެސް، މި ކަންކަމާ މި ރިޕޯޓުގައި ބަޔާންކޮށްފައިވާ ތަދާބީރު ކަމުގެ ފިޔަވަޅުތަކާއި އެކު ކުޑަ ކުރެވޭނެ ކަންކަމެވެ. އަދި މިނަ ނުރައްކާ އަސަރުތަކަށް ފާހަގަ ކުރެވިފައިވާ މަސައްކަތް ހިނގަމުންދާ ވަގުތުގައި ކުރާނެ ކަމަށެވެ.

- މި މަޝްރޫޢުގެ މިހާރު ކަނޑައަޅާފައިވާ ކަންކަމަށް ބަދަލު ގެނައުމުން ނުކުންނާނެ ނަތީޖާތައް ރިޕޯޓުގައި އަލިއަޅުވާލާފައިވެއެވެ. މިގޮތުން މި މަޝްރޫޢު ކުރިއަށް ނުގެންގޮސްފި ނަމަ ނުކުންނާނެ ނަތީޖާއަށް އަލި އަޅުވާލާފައިވެއެވެ.

- މަޝްރޫޢުގެ ސަބަބުން، ޕްރޮޖެކްޓް ހިނގަމުންދާ ދުވަސްވަރު އަދި ޕްރޮޖެކްޓްގެ އުމްރާނީ މަސައްކަތް ނިމި ބޭނުންކުރާ ދުވަސް ހިމެނޭގޮތަށް، ޕްރޮޖެކްޓްގެ ސަބަބުން ކުރާ އަސަރުތައް ދެނެގަތުމަށްޓަކައި މޮނިޓަރިން ޕްލޭން އެކުލަވާލާ މިރިޕޯޓުގައި ހިމަނާފައިވެއެވެ.

- މި މަޝްރޫޢުގެ މަސައްކަތްތަކާއި ހިނގަމުންދާއިރު ނުކުމެދާނެ ޝަކުވާ ކަންކަން ހައްލުކުރުމަށްޓަކައި މައްސަލަ ހައްލު ކުރާނެ އުސޫލެއް ކަނޑައަޅާ (grievance redress mechanism) މިރިޕޯޓުގައި ބަޔާން ކޮށްފައިވެއެވެ.

- ހުރިހާ ފަރާތާ މަޝްރޫޢުގެ ސްޓޭކްހޯލްޑަރުން ބަލާ އަދި މި މަޝްރޫޢުގެ ވަކި ވަކި މަސައްކަތްތަކަށް ބަލާއިރު މި މަސައްކަތްތަކަކީ ޖުމްލަ ގޮތެއްގައި ތިމާވެއްޓަށް އިޖްތިމާޢީ އަދި އިގްތިސާދީ ގޮތުން ފައިދާ ކުރާނެ މަޝްރޫޢެއް ކަމުގައި ދެކެވެ. ނަމަވެސް، މި މަޝްރޫޢު ކުރިއަށް ގެންދިއުމުގައި، މި ރިޕޯޓުގައި ބަޔާންކޮށްފައިވާ ތަދާބީރު ކަމުގެ ފިޔަވަޅުތަކާއި މޮނިޓަރިން ޕްރޮގްރާމާއެކު ކުރިއަށް ގެންދިޔުމަކީ ކޮންސަލްޓަންޓުގެ ލަފާއެވެ.

1 INTRODUCTION

1.1 PROJECT BACKGROUND

The Government of Maldives, since 2009, has embarked on a policy to achieve low carbon development and reduce dependence on fossil fuel. One of the approaches to achieve these targets is through scaling-up of renewable energy resources, particularly energy. The Maldives being one of the pilot countries of the Scaling-Up Renewable Energy Program in Low Income Countries (SREP), an Implementation Plan (IP) was submitted to the Climate Investment Fund (CIF) on October 2012. This SREP-IP, which was endorsed in November 2012 sub-committee, aims to "develop renewable energies on a large scale, to effectively contribute to poverty reduction and sustainable development". Thus, a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) was conceptualized within the boundaries of the SREP and policies of the government. This program aims to encourage involvement of private parties in the renewable energy sector of the Maldives. The program will combine technical assistance with private sector investment, to scale-up the deployment of PV based generation on the islands. The aim of ASPIRE project is to encourage and facilitate private investments in the RE sector by addressing the barriers, namely:

1. Associated high risk of investing in RE sector such as high capital investments with repatriation of profits.
2. Limited local familiarity with the technology
3. Little private sector exposure to the institutions in the sector
4. Lack of fully evolved regulatory framework in the sector
5. Domestic capital has little experience and/or appetite for investing in this sector
6. Small scale of power distribution and dispersed investment projects make it difficult to attract private sector and to reach economies of scale.

In order to address these barriers, the ASPIRE Project originally launched in 2014 assisted in the development of an investment framework to mobilize private sector funds, and targeted to install PV capacities in larger islands. The framework consists of various contractual obligations that involve all key stakeholder parties, and has the provision of security package support covering termination risks and payment delays risks are also covered, along with the potential for tariff buy down envisioned, to mitigate first mover risks and to make the subproject attractive for investment. Site security is also a non-fiscal guarantee provided directly by the GoM in support for the project, all of which is meant to reduce investment risks for developers.

The outcome of this framework had already been demonstrated through the award of the first PPA for 1.5 MW capacity of distributed rooftop PV systems on public buildings Hulhumale' commissioned in 2018. Furthermore, another PPA for a 5.6 MW of ground-mounted PV system and rooftop solar PV is currently being installed and planned to be commissioned in August 2023.

This ESIA is of concern of 11.43 MW PV installation planned for Addu City, Fuvahmulah City, GDh. Thinadhoo, B.Eydhafushi, Lh.Hinnavaru and Kulhudhuhfushi City is phase 3 of ASPIRE project. Through competitive bidding process the project was awarded to a joint venture of Megafirst Coorporation Berhad (Malaysia) and PowerChina Huadong Engineering Coporation LTD (China).

As a continuation of the ongoing efforts through ASPIRE project, through world bank assistance in 2021 Ministry of Environment (ME) had launched the Accelerating Renewable Investments & Sustainable Energy (ARISE) Project as a means to address the limits of solar PV grid absorption capacity, by increasing storage capacity and by upgrading the existing grids of the islands and enable further scale up of solar PV through the private sector through the ASPIRE model.

1.2 PROJECT PROPONENT

The project proponent is PowerChina Huadong Engineering Coporation LTD (HDEC).

The office address and contact details for the proponent are provided below.

Table 1-1 Proponent Details

Address:	PowerChina Huadong Engineering Coporation Limited (HDEC) No.201 Gaojiao Road, Yuhang District, Hangzhou City, Zhejiang Province 311122 People’s Republic of China
Contact Information:	Website: www.hdec.com Email: ec_aspire@hdec.com> Phone: 0571-56628888 / +960

1.3 PURPOSE AND OBJECTIVES OF THIS ESIA

The primary objectives of this report are as follows:

1. Identify anticipated environmental and social risks and impacts associated with the proposed activities of the project.
2. Safeguard the environmental and social dynamics of the project.
3. Ensure compliance with the established legal framework and best practices.
4. Enable informed decision-making.
5. Promote environmentally and socially sound sustainable development by identifying and implementing appropriate measures.
6. Ensure the project proponent's commitment to safeguard the environmental and social aspects associated with the project.

Specific to the project's scope, the following aspects were taken into account:

1. Ecological assessment: Evaluate the potential impacts of the project on the natural environment, including changes to wildlife habitats, impacts on protected species, and effects on biodiversity.
2. Social assessment: Assess the potential social impacts of the project, such as impacts on local communities, cultural heritage, and traditional practices.
3. Economic assessment: Evaluate the potential economic impacts of the project, including effects on employment, income, and local industries.
4. Health and safety assessment: Assess the potential health and safety issues associated with the project, including impacts on air and water quality, noise pollution, and risks related to the construction and operational phases of the project.

These assessments will provide a comprehensive understanding of the project's potential environmental, social, economic, and health and safety implications, allowing for appropriate measures to be implemented to mitigate any adverse effects and promote sustainable development.

1.4 PROJECT JUSTIFICATION

Maldives as a nation is largely dependent upon foreign imported fossil fuels to meet its energy demand. This is one of the core challenges in increasing the overall energy security of the nation. Additionally, this further stresses the national foreign reserve and also contributes significantly to the national GHG emissions. The National Action Plan on Air Pollutants identifies electricity generation from diesel as a major source of GHG emissions totaling to 71.6% of the country’s CO2 emissions (Ministry of Environment, 2019).

Table 1-2 existing data in relation to the islands within the scope of the project (Maldives Energy Authority , 2019)

Island	**Electricity Provider**	**CO_2 Emissions (tCO_2) Year 2019**	**Existing Solar PV Capacity (kW)**	**Diesel Fuel Consumption (Litres)**	**Total Diesel Generators installed capacity (kW)**
Eydhafushi	Fenaka	3,293	1	4,573,825	1700
Hinnavaru	Fenaka	2,583	-	1,145,355	1160
Thinadhoo	Fenaka	6,262	-	2,679,558	3800
Fuvahmulah City	Fenaka	9,747	-	3,748,600	4600
Kulhudhuffushi City	Fenaka	9,488	11	3,667,028	4400
Addu City	Fenaka	29,245	1,618	11,970,457	15,446

Table 1-3 the expenses on fuel is expected to be reduced along with the entailed GHG emissions through the solar PV installations through the project

Island	Area	Diesel Savings per year/Million MVR	CO2 Reduced in MT
Eydhafushi	13,170	6.3	2064
Hinnavaru	8114	3.16	1032
Thinadhoo	26458	7.73	2529
Fuvahmulah City	26540	6.31	2064
Kulhudhuhfushi City	21204	7.26	2374
Addu City	26235	14.52	4748
	Total	**45.28**	**14811**

It is of note that the proposed project is in line with the government’s energy policies and upon completion will contribute to the nation’s target of achieving net carbon neutrality by 2030, as committed in the Nationally Determined Contributions (NDC).

1.5 METHODOLOGIES APPLIED

The methodologies applied in the formulation of this ESIA is on the basis of the EIA regulation and the joint expertise of the ESIA team. Data was obtained through on-site data collection, engineering documents, and relevant published scientific sources.

The gathered data was used to assess the impacts associated with the project. Feasible mitigation measures were studied and proposed in response to the identified potential adverse impacts associated with the project. The Terms of Reference, of this assessment is included in the Appendix A.

1.5.1 DATA COLLECTION

Table 1-4 the data collection methodologies adopted for the stated respective parameters for this assessment

Data Parameter	Description
Traffic Analysis	Manual traffic count method was utilized for the traffic flow analysis. Vehicles were classified based on the respective engine capacity and form factor. Movements for each set of classification were recorded separately at a defined intersection of the road.
Noise level	Noise pollution at the project site was measured using a handheld mobile device. Data from multiple locations were accounted and geo-referenced.
Stakeholder Consultation	Stakeholder consultations were conducted through virtual means and in person as well. A scoping meeting was held virtually by EPA on the

	15th of November 2022. Participants includes EPA, the respective councils, MECCT, project proponent, local representative of the proponent, and representatives from the EIA consultant team. As for the stakeholder consultations, the identified stakeholders were consulted and their reservations/recommendations were accounted as per the TOR of this assessment:
Climate	Climate data were sourced from Maldives Meteorological Services, and other secondary sources
Environmentally protected areas and sensitive areas	Referenced from Environmental Protection Agency.
Terrestrial Vegetation	Aerial imagery, physical observation and existing literature were used.
Built Environment	Built environment were assessed through visual inspection and through stakeholder consultation.
Ground Water	Water sample was collected from existing ground water wells in glass bottles and tested in MWSC analytical laboratory. ● Conductivity: Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition) ● pH: Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition) ● Salinity: Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition) ● Temperature: in situ analysis through an infrared thermometer. ● TDS: Electrometry ● DO: In-house Test method (Adapted from HACH BOD LDO® Probe (Model LBOD10101) manual)
Hazard Vulnerability	Collected through existing literature and referenced from available secondary data sources
Air Quality	Carbon Monoxide surface concentration, Sulphur dioxide and Nitrogen dioxide levels were taken from satellite based modelled data sourced from GEOS-5 (Goddard Earth Observing System), and Global Modelling and Assimilation Office (GMAO) / NASA. Sampling locations are geo-referenced and included in this report.
Existing Environment	Data for the existing environment were sourced through visual inspection, stakeholder consultations, and from relevant literature.
Socio-economics conditions	Data for the socio-economic conditions were sourced through physical observation, stakeholder consultations, and from relevant literature.

Engineering Parameters	Engineering documents, including concepts, structural details, and Bills of Quantities were sourced from the proponent

1.6 LITERATURE REVIEW

Assessments conducted for similar projects, purposes and relevant context to the proposed project were studied for the formulation of this report. In this regard, the following are the assessments reviewed for this report.

- Ahmed, 2014, Environmental and Social Management Framework for the proposed Solar PV Projects under Accelerating Sustainable Private Investment for Renewable Energy (ASPIRE) Programme, CDE
- JICA, 2009, Feasibility Study for application of Photovoltaic Power on Male’ and Hulhumale’ Islands in the Republic of Maldives, Final Report, JICA
- Environment and social management report proposed installation of 5mw grid-tied solar photovoltaic system in greater male’ region, kaafu atoll, Foresight Surveyors 2021

2 PROJECT LOCATIONS

The project covers 8 different locations from the regions of;

- Kulhudhuffushi City
- B. Eydhafushi
- Lh. Hinnavaru
- G.Dh. Thinadhoo
- Fuvahmulah City
- Addu City

Careful considerations were taken on the landuse for islands where land use plans have not been updated/approved. In this regard, the island councils were consulted in the site selection process.

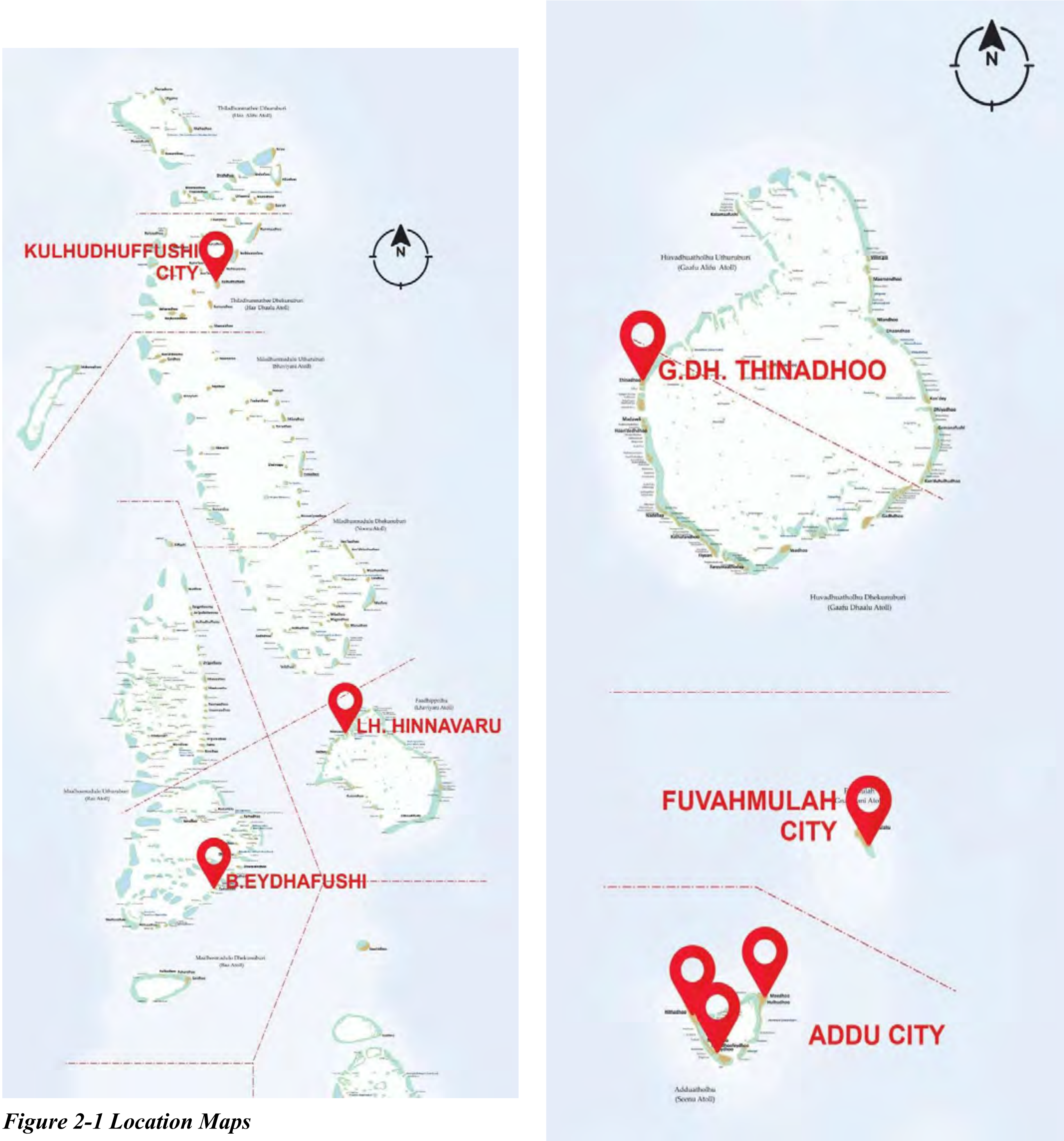


Figure 2-1 Location Maps

2.1.1 KULHUDHUFFUSHI CITY

Kulhudhuhfushi is an island located in the eastern side of Haa Dhaalu (Thiladhunmathi Dhekunuburi) Atoll, with geographic coordinates of 6°37’0”North and 73°3’0”East. It is the most populous island in north of the Maldives, with a registered population of 9,838; out of which 4,798 are females and 5040 are males (President's Office , 2023). Recently, it received the city status, and its land area is 247 hectares (ha), with a length of approximately 2.5 km and a width of 0.89 km.

The island has two wetland areas, with the larger one located in the northern end and the smaller one in the south end. In 2018, the wetland area in the north of the island was reclaimed to build an airport. Kulhudhuhfushi is considered the northernmost hub of the Maldives, and many people from HA, Hdh, and Shaviyani atoll move to the island to access education and health services. The island is an economic hub, and most people are involved in retail and wholesale businesses.

A total area of 16792 m2 from two sections is allocated from the proposed project. The northern section has an area of 9766 m2 while the southern section covers an area of 7026 m2.

As indicated in the following figure 2-2, the proposed project area in Kulhudhuffushi City is within the boundaries of the Kulhudhuffushi Regional Airport.

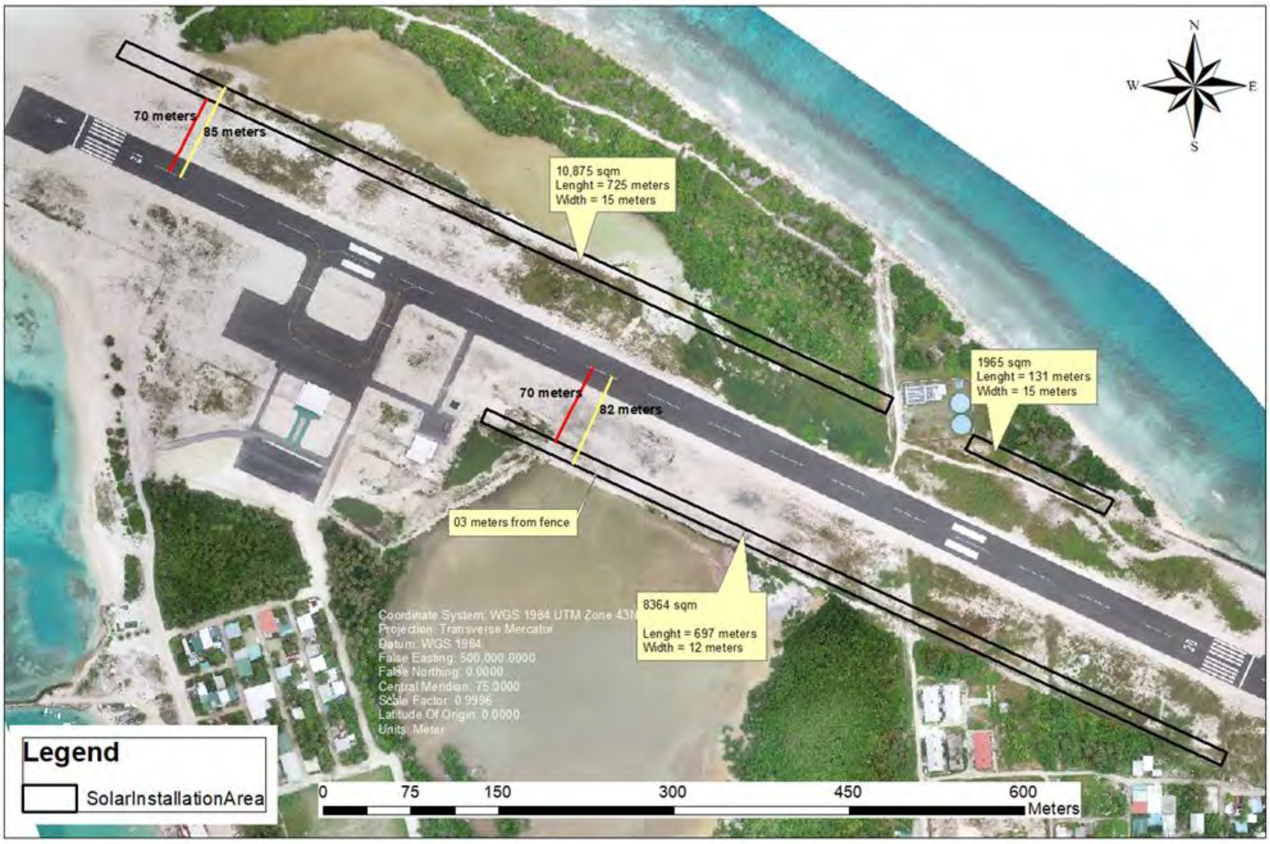


Figure 2-2 Kulhuduffushi City Project Area

2.1.2 EYDHAFUSHI

Eydhafushi, located in the eastern rim of Baa Atoll, is the administrative capital of the atoll. Its geographic coordinates are 5° 6'7.81"N, 73° 4'7.03"E, and it is the most populous island in the atoll, with a resident population of 3,339; out of which 1600 are females and 1739 are males (President's Office , 2023). The total area of the island is 55 hectares, including 25 hectares of reclaimed land. Most of the services in the atoll are established in Eydhafushi since it is the capital. The reclamation of Eydhafushi was done in 2014, aimed at providing space for new residential developments as the island had reached its maximum capacity.

Although Eydhafushi does not have unique environmental features, Baa Atoll is the first declared biosphere reserve in the Maldives with many environmentally sensitive sites. The major economic activities on the island include government employment, working in resorts, retail business, and fishing. The project is planned to be implemented in the reclaimed land of Eydhafushi, which involves the installation of 1MW of Solar PV outside of the ring road of the island and in the stadium area. Four areas adding up to 13170m² has been designated by the council for the project

The Island Waste Management Centre (IWMC) is the closest facility to the site, located few meters to the east of the middle PV installation section. The children's park of Eydhafushi and proposed recreational beach are also in proximity to the site. Furthermore, based on the land use plan, public housing is planned to be constructed near the site.

The following figure 2-3 indicates the proposed project site of Eydhafushi, which is located at the reclaimed area of the island.

Figure 2-3 Eydhafushi Project Area

2.1.3 HINNAVARU

The island of Hinnavaru is the second most populated island in Lhaviyani atoll, situated in the north-western part of the atoll at geographic coordinates 5°29'35.85"N, 73°24'46.07"E. The island has a resident population of Hinnavaru is 4,873; out of which 2392 are females and 2481 are males (President's Office, 2023). and, similar to other islands chosen for the project, has a significant amount of reclaimed land. The total land area of Hinnavaru is 50 hectares, with approximately 50% of it being reclaimed land. The island is located about 5 kilometers away from the Madivaru domestic airport. A total area of 8114m² has been designated by the council for the project

Hinnavaru doesn't possess any remarkable environmental characteristics. However, the roads and houses of Hinnavaru are notable for their uniqueness, with narrow streets.

The following figure 2-4 indicates the proposed project site of Hinnavaru, which is located at the reclaimed area of the island.

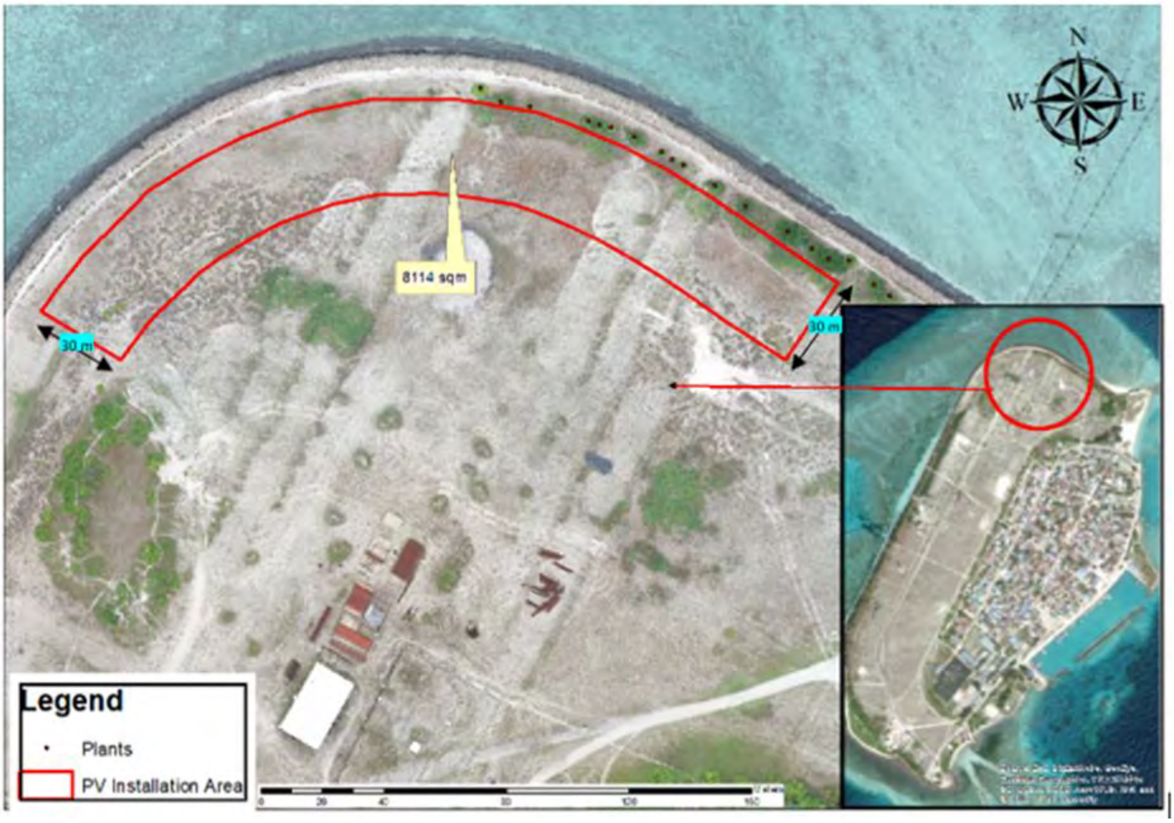


Figure 2-4 Hinnavaru Project Area

2.1.4 THINADHOO

Thinadhoo is situated in the western edge of Huvadhu atoll, with geographic coordinates of 0.5311° N, 72.9977° E. Thinadhoo has a resident population of 7,456; out of which 3,678 are females and 3,778 are males (President's Office , 2023). making it the most populous island in Huvadhoo atoll, which is the largest atoll in the Maldives in terms of geography and serves as the capital of South Huvadhu atoll. Currently, the land area of Thinadhoo is approximately 180 hectares, of which 80 percent is reclaimed land. There are no notable environmental features on the island.

The proposed project entails the installation of 2MW of solar PV on the outer road on the western side of Thinadhoo. The area is currently barren, with some recently planted small coconut palms and shrubs. Coastal Protection geobags were installed in this location in 2016. The Island Waste Management Centre is located immediately north of the site, while residential developments are few meters to the east of the proposed site. A park is also located 20 meters to the east of the site, and the main Islamic Center of Thinadhoo is approximately 80 meters east of the proposed site. A total area of 26458m² has been designated by the council for the project.

The following figure 2-5 indicates the proposed project site of Thinadhoo, which is a longtitudinal stretch in the western coast of the island.

Figure 2-5 Thinadhoo Project Area

2.1.5 FUVAHMULAH CITY

Fuvahmulah City, has a a resident population of 12,790; out of which 6,270 are females and 6,520 are males (President's Office, 2023) is the third most populous city in the Maldives. The island, which is both an atoll and a city, is located between the equator and the southernmost Addu atoll at 73°25´40"E and 0°17´53"S. With a land area of 424 hectares, it is also the third largest island in the country. A notable feature of Fuvahmulah is that approximately one third of the island is composed of protected wetlands and marshlands that surround the two largest freshwater lakes in the Maldives: Bandaara Kilhi and Dhadimagi Kilhi.

As indicated in the following figure 2-6, the proposed project area in Fuvahmulah City is within the boundaries of the Fuvahmulah Regional Airport. Fuvahmulah airport started its operation in November 2011. The airport is situated at an altitude of 6 feet (2 meters) above the average sea level. It has a single runway, which is 1,100 meters (3,609 feet) long. A total area of 8509m² has been designated withing the airport boundary for the project

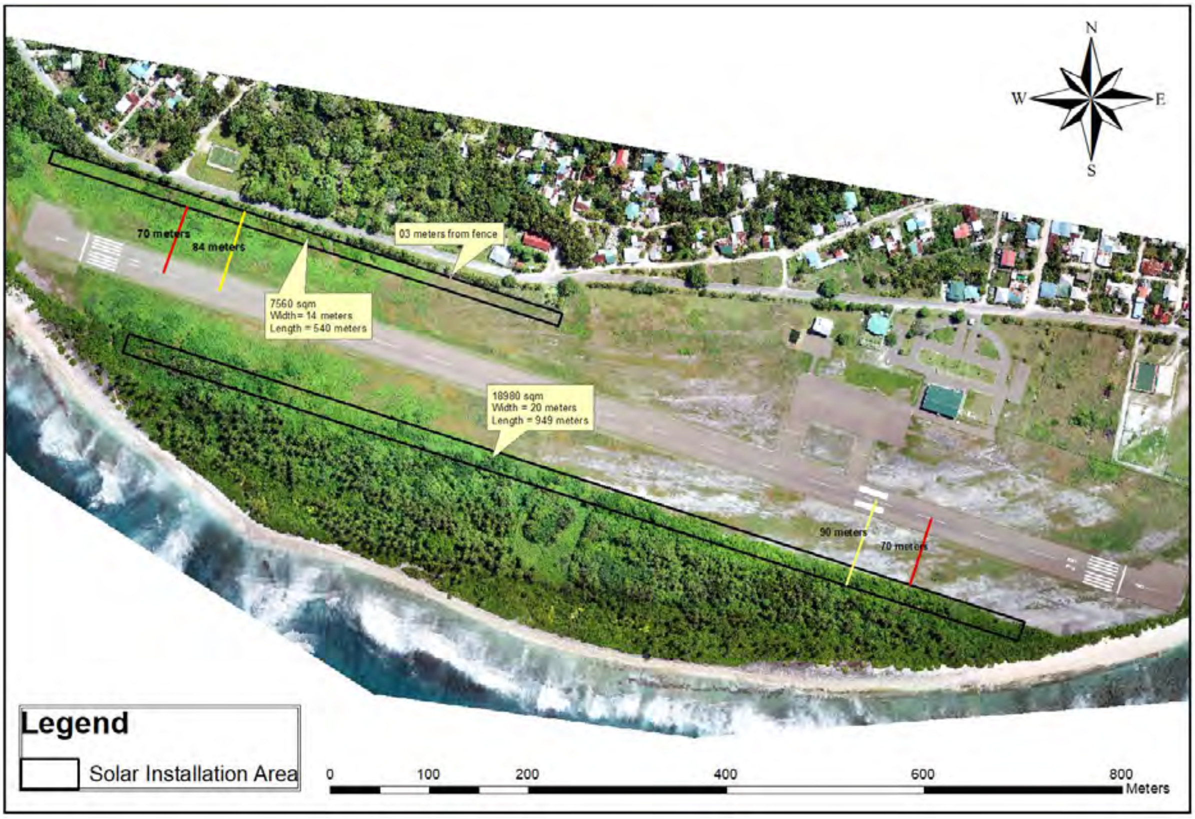


Figure 2-6 Fuvahmulah Project Area

2.1.6 ADDU CITY

Addu City, located in the southern-most atoll of the Maldives, is the second-largest urban area in the country in terms of population, with a resident population of 33,690 people (President's Office 2023). The city comprises six administrative islands: Hithadhoo, Maradhoo-Feydhoo, Maradhoo, Feydhoo, Hulhudhoo, and Meedhoo. Hithadhoo, Maradhoo-Feydhoo, Maradhoo, and Feydhoo are connected by a link road and to the international airport located in Gan, while Hulhudhoo and Meedhoo are located separately in the eastern rim of the atoll.

Addu City is a hub for economic activities in the region, as it is home to Gan International Airport, one of three international airports in the country, and Hithadhoo port, one of four ports in the Maldives. The city also plays a role in tourism, with three resorts, one city hotel, and eight guest houses. Additionally, fishing and agriculture are prominent economic activities, with agriculture being especially prevalent in Hulhudhoo and Meedhoo islands.

Addu City boasts remarkable environmental features, including the largest protected area network in a single atoll in the Maldives, known as the Addu Nature Park. Currently, the park encompasses three protected areas, namely Eydhigali Kilhi and Koattey wetland and marine area, an all-year-round manta point off Kandihera-Maakandu channel, and the British Loyalty shipwreck. Moreover, four new areas were declared protected in Addu on September 9, 2020.

Consequently, Addu was designated a UNESCO biosphere reserve on October 28, 2020, following the addition of these areas to the park.

Addu Football Stadium (Hithadhoo):

The Addu Football Stadium, located in Hithadhoo, also serves as an important landmark. The council identified the parking areas for the stadium in this location, and a designated area of 7665 m² is intended for solar installation. The parking areas are situated to the east of the stadium and on either side of the main viewing stand. Furthermore, the site includes stadium infrastructure such as a football pitch with a running track, along with outdoor gym, volleyball courts and a basketball court.

The following figure 2-7 indicates the proposed project site of Hithadhoo which is located at the stadium of the island.

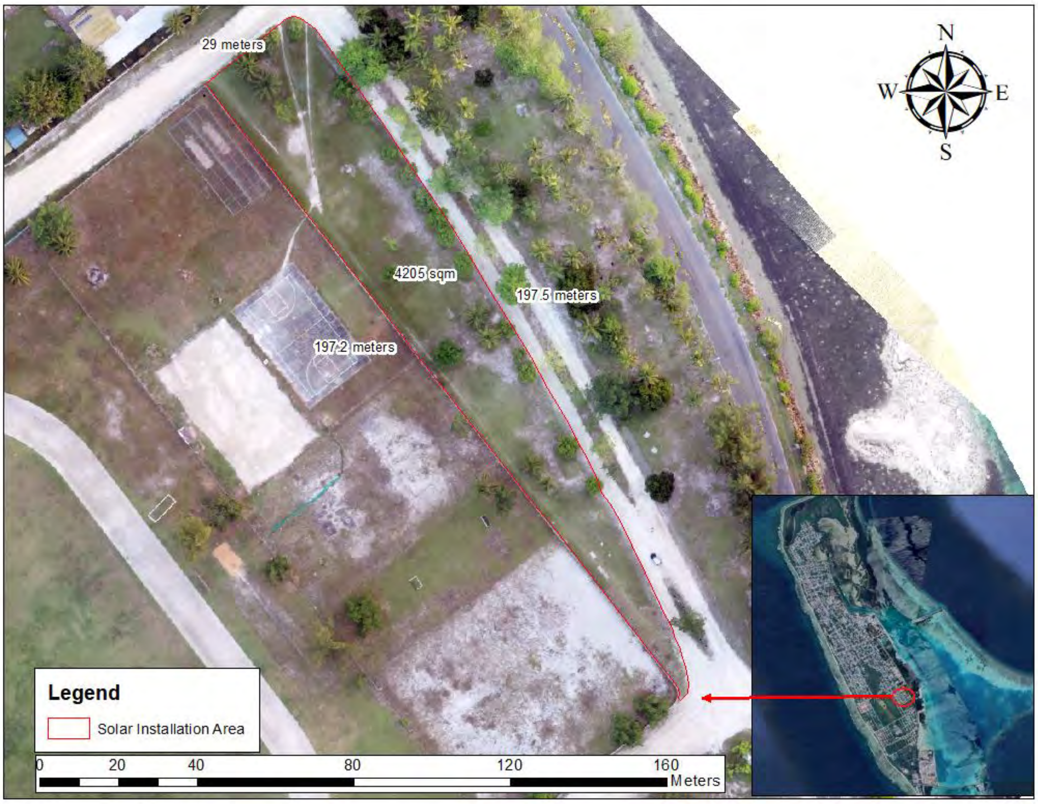


Figure 2-7 Hithadhoo Project Area

Feydhoo Habour:

The proposed PV installation will occupy a total area of 6,870 m², which was reclaimed during harbour construction works in 2015 and is currently not being used for any productive purpose. The western side of the reclamation land has no existing infrastructure, while the eastern side is home to a fuel supply shed, the main ferry terminal, and the bus terminal, all of which are situated about 450 meters east of the proposed site. The installation site is also located around 7 meters from the link road, a busy highway that connects all the inhabited islands of Addu, except for Hulhudhoo and Meedhoo. On the opposite end of the link road, there are residential and commercial developments, including restaurants and shops, located around 18 meters from the PV installation area.

The following figure 2-8 indicates the proposed project site of Feydhoo which is located at the Feydhoo Harbour.

Figure 2-8 Feydhoo Project Area

Maradhoo Feydhoo Harbour:

The proposed solar PV installation at Maradhoo Feydhoo harbour will cover an area of 4,500 m². The harbour's construction was completed in 2022 and the island is connected to Gan International Airport and all the inhabited resident islands in Addu through the Link Road, except for Hulhudhoo and Meedhoo. It is important to note that the road is often busy, and any activities near it may affect traffic flow. In addition the site is also located approximately 0.03 meters away from Bank of Maldives Gan branch and Maradhoo Feydhoo Youth Center.

The following figure 2-9 indicates the proposed project site of Maradhoo Feydhoo which is located at the Maradhoo Feydhoo Harbour.

Figure 2-9 Maradhoo Feydhoo Project Area

Hulhumeedhoo near STP:

The council has allocated an area of 7200 m² for the installation of Solar PV in Hulhumeedhoo. The site is located adjacent to the periphery wall of the sewerage treatment plant and is bordered by the Island Waste Management Centre, located 50 meters to the north, and the Maakilhi protected wetland area, located 5 meters to the west. Private agricultural lands are situated about 1 meter to the south of the site. It is worth noting that historically, the cleared part of this site was used as a landfill before the construction of the Island Waste Management Centre.

The following figure 2-10 indicates the proposed project site of HulhudhooMeedhoo which is located at the HulhudhooMeedhoo near STP.

Figure 2-10 Hulhumeedhoo Project Area

2.2 OBJECTIVES OF THE PROJECT

The project aims to establish a total of 11.43 MW solar PV systems across 8 sites in 6 different administrative regions with the following major objectives:

- Installation of Solar PV systems for power generation

- Minimise the national dependency on polluting fossil fuels, while reducing the expenses on fuel and create a path to transit to renewable energy
- Minimise the emission of GHGs and other polluting by-products which are harmful to human health and the environment.
- Community empowerment and economic development through the jobs created economic opportunities created from the project
- Raise awareness on renewable and clean energy production

2.3 DESIGN AND STRUCTURE

Site specific design and structure drawings are presented in Appendix C of this report.

2.4 PROJECT ACTIVITIES – CONSTRUCTION PHASE

2.4.1 Civil Works:

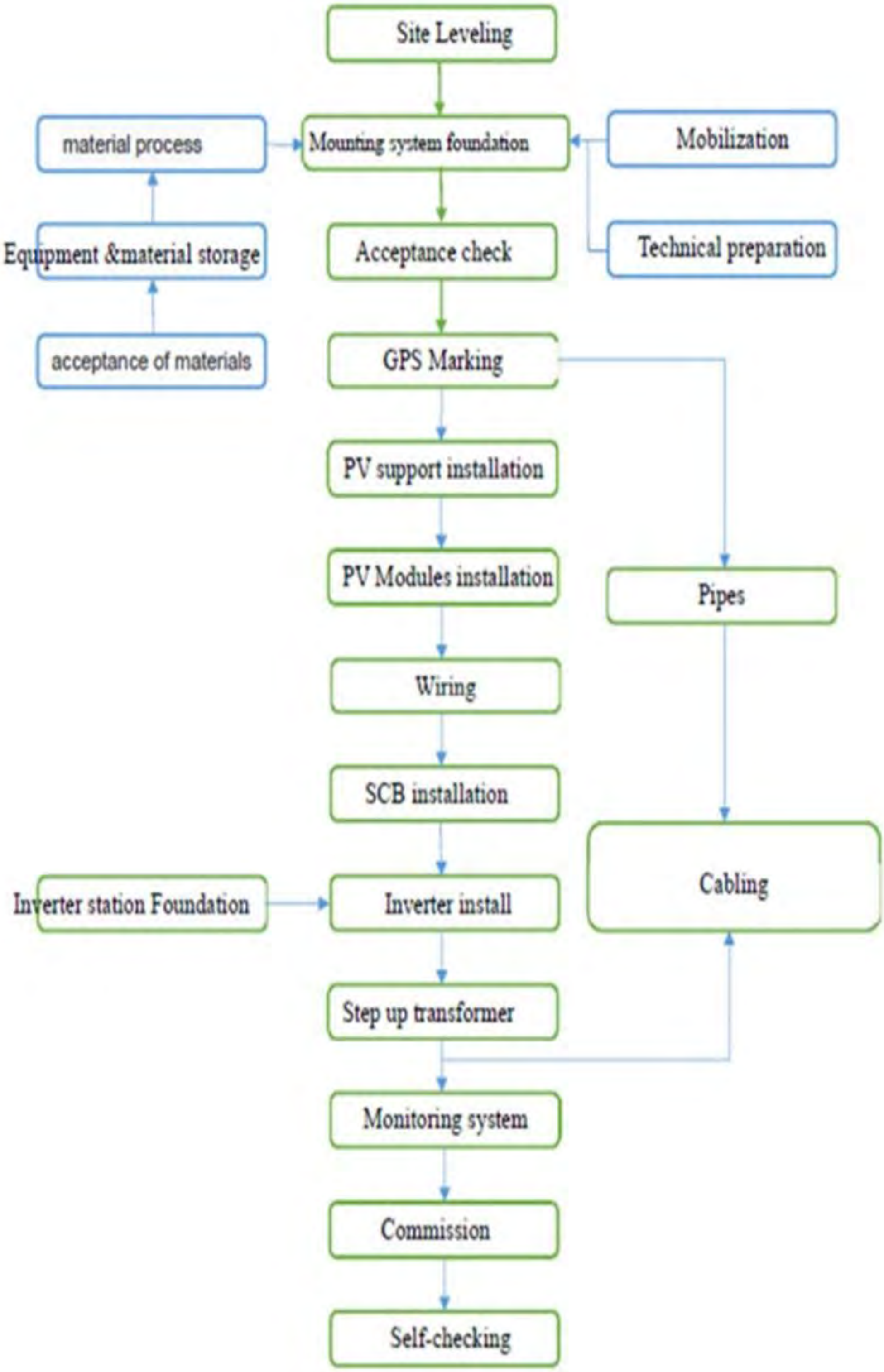


Figure 2-11 Main Construction Flow of the PV Area

2.4.1.1 SITE LEVELING:

2~4 excavators will be used per island for rough grading from high to low for bushes and grass. Ground levelling will be conducted according to the requirement for module rack foundation, to ensure stable arrangement of strip foundation.

Figure 2-12 Site Levelling with Excavator

Site stripping principles: Mainly bushes and trees shall be removed. Destruction of vegetation in flat areas shall be reduced as far as possible to prevent water loss and soil erosion and meet local environmental protection requirements. Site leveling principles: Levelling shall be conducted mainly for pits, steep slopes, and earth hummocks in the site area to meet the requirement for module installation. Earth-rock cut and fill balance shall be reached as far as possible to reduce spoils.

Site leveling for Fuvahmulah site and Addu Hulhumeedhoo Site will be different from the other project sites.

Clearing of the area prior to excavation

The area to be excavated shall be free and clear of any materials stored related to other packages that might hinder a continuous and smooth working environment. All these materials shall be removed and transferred from the border of the excavation areas.

Top Soil Removal and leveling

Establish survey markers to identify the working area in which the removal of topsoil is required. Strip the topsoil to the subsoil level or as instructed by the engineer. Use tracked equipment such as Backhoe, Excavator, wheel loader, dozer, and tipper. Dispose of and stockpile the topsoil separately from subsoil or other excavated material for subsequent reuse in covering the required area. Ensure that sufficient material for this purpose is preserved. Place the topsoil in lots at the location shown on the drawing or approved by the engineer/project manager. works to ensure that the required formation level will be reached and avoid any over-excavation.

Excavation works shall be done as follows: Excavation will be done using a combination of excavators and hydraulic rock-breaking hammers. The number of equipment within the combination will be deployed on the project site and shall work simultaneously. The contractor is to use multiple excavators and breaking hammers (if required) to adhere to the program of works provided HSE rules are adhered to.

Rock Excavation:

Excavation In rocks may be carried out by a tracked bulldozer or ripper or by any other method approved by the engineer.

Finalization of the formation level

Before reaching the formation level, the final 0.5m of rock layer shall be excavated using light jackhammers to ensure the integrity of the founding stratum after the excavation. In case after reaching the formation level, any loose or unsuitable surface found during the inspection by the consultant will be removed and will be backfilled with C10 concrete or suitable soil materials in accordance with the approved Method Statement.

Filing requirements and procedures

The Surveyor shall check the formation level once the excavation is done per approved shop drawings, where the final formation levels shall comply with the approved design requirements. Any over-excavation shall be backfilled with C10 concrete, and work shall be done as per the approved Method Statement for Backfilling Works using C10 Mass Concrete (for Over Excavated Areas and Unsuitable Soil / Surface).

The final excavation level shall be leveled together with the side slope, shall be trimmed, and shall be free from any loose/soft materials. The area will be clean and free from debris, deleterious materials, and any unsuitable soil/surface as defined in project specifications.

2.4.2 Engineering Surveying:

2.4.2.1 ORGANIZATION OF CONSTRUCTION SURVEYING:

(1) Competence of Surveyor:

The focus of surveying control of this Project is strip foundation leveling to ensure the accuracy of subsequent rack installation. The contractor will organize surveyors with theoretical knowledge and practical experience to carry out the surveying of this Project.

(2) Organization:

The Project Manager Department will lead to forming of a professional surveying group comprising professional surveyors. The surveying control network of this Project will be set up by the surveying team, and transferred to the surveying group of the Project Department upon acceptance confirmation of the Owner and the Engineer.

2.4.2.2 CONFIGURATION AND MANAGEMENT OF MEASURING EQUIPMENT:

- All the measuring instruments and steel rulers can only be used after being evaluated as qualified.
- Engineering surveying specifications shall be strictly followed.
- All measuring instruments must be kept by special professional personnel.

2.4.2.3 ESTABLISHMENT OF CONSTRUCTION CONTROL NETWORK:

- For surveying construction control points, perform a closed error check to ensure that all errors meet specification requirements.
- Use GPS or total station for surveying and positioning.

2.4.2.4 ELEVATION CONTROL:

According to the national benchmark marks indicated in the general layout or the relative reference points of benchmark specified in the survey and design drawings, lead accurately with the total station the points to corresponding locations around the construction site for monitoring and ensure that the benchmark positions for monitoring are firm and stable without sinking or deformation.

2.4.3 Earth-Rock Works:

2.4.3.1 EARTH EXCAVATION:

Except for site leveling, earthworks of this bid section mainly include shallow foundation excavation of inverter and box-type transformer foundation. Conduct excavation with machinery and perform foundation clearing manually and mechanically with earth transported with dump truck; excavate to the foundation bottom with 200mm reserved for manual clearing to prevent disturbance of foundation earth; fill the low-lying places within the site area with excavated earth; and provide two 1m3 excavators and 4 dump trucks at the site.

2.4.3.2 ROCK EXCAVATION:

The surface layer is a silty soil or highly weathered layer, with mudstone distributed below. If any rock layer which cannot be excavated by conventional method is met during foundation excavation, use a quartering hammer for excavation, perform foundation clearing manually and mechanically, and transport excavated rocks with a dump truck to low-lying places within the site area for backfilling or to nearby pits for burying then foundation construction since the foundation bottom may be uneven in mass rock excavation.

2.4.3.3 EARTH BACKFILLING:

1) Selection of backfill materials: Select qualified earth for backfilling, and remove foreign matters and drain the accumulated water before backfilling.

2) Compact in layers the backfill manually or mechanically; water and tamp the backfill layer by layer as per the specified layer thickness and the compacting factor required by the design; and place a layer after the previous layer is proven qualified after sampling and testing as specified.

2.4.3.4 CONCRETE CUSHION:

In this Project, the plain concrete cushion is provided for the strip foundation, and foundations of the box-type transformer, inverter, etc.

- After foundation excavation is accepted by the design personnel, upon inspection, place plain concrete for the cushion, mark the elevation point before concrete placement of the cushion, and ensure no water accumulated in the foundation bottom and that the concrete grade and thickness of the cushion meet design requirements.

2.4.4 Reinforcement Works:

In this Project, reinforcement binding should be conducted for strip foundations, and foundations of box-type transformers, inverters, etc. Reinforcement requirement: Reinforcement shall be provided with a delivery quality certificate and re-testing report and not be used in this Project until passing the welding test; each bundle must be labeled; reinforcement shall be inspected and stored after arrival as per the batch number and specification.

(1) Structural Column Reinforcement

Common reinforcement is mainly used. Main reinforcement shall be aligned before binding. The main reinforcement of columns is designed to be lapped. Any lapping and anchorage at a column-beam junction shall be handled as per the design requirement. Where the column section of reinforcement is shorter than or equal to 4, welding of the same section is accepted, otherwise, the reinforcement shall be welded twice in a staggered manner, with a joint distance of over 60d.

(2) Beams and Slab Reinforcement

During reinforcement construction, beam reinforcement shall be bound before slab reinforcement. The binding sequence of reinforcement is given as follows: marking of stirrup position on the main beam formwork----installing stirrup onto main reinforcement of the main reinforcement beam, and separately fixing stirrups according to the marked stirrup position----installing main reinforcement and bend reinforcement of main beam and main and bend reinforcement of secondary beams, stirrups, and bearing reinforcement of main and secondary beams----binding beam-bottom main reinforcement and stirrup at certain interval----binding hanger bar----binding other main reinforcement. Frame beam joint: The upper reinforcement joint shall be set within the middle 1/3 of the span, and the lower reinforcement joint at the node, with an overlapping length of 60d. Joints shall be set in a staggered manner.

2.4.5 Formwork:

Formwork and its support system must be strong, stiff, and stable enough. The support system must be able to withstand all upper loads including construction loads. Materials for formwork must be selected and inspected carefully. Formwork shall also feature easy fabrication, installation, and removal, firmness and durability, convenient transportation, and trimming.

2.4.6 Concrete Works:

This Project involves a small volume of concrete, about 20,000m3 in total, mainly for the strip foundation of PV racks and some frame structures. The placement involves a large area and is not centralized. It is preliminarily considered to use concrete mixed on-site. A JS750 concrete mixing station with a capacity of 35m3/h can meet the concrete demand of site construction. If commercial concrete is available near the site and convenient road transportation is provided, commercial concrete can be used.

2.4.7 Concrete Transportation:

Concrete mixed on-site can be transported by a dump truck and commercial concrete by tanker.

2.4.7.1 CONCRETE PLACEMENT AND VIBRATION:

Concrete shall be placed after reinforcement binding, formwork erection and reinforcement, accurate embedding and reservation, filling of the concrete placement application form, self-inspection of the contractor and obtaining of approval of the Engineer. Construction preparation shall be made before placement to ensure smooth traffic and normal and power supply, and appropriate measures shall be taken for rain, etc. according to weather forecast.

2.4.7.2 CONCRETE CURING:

The concrete is watered and covered by plastic film/hessian cloth for curing, with a curing period of not less than 14d.

2.4.8 Construction of PV Support Foundation:

After the steel structure is completed, the foundation for the PV support will be completed. However, for reference, we purposed a few designs, one of which we adopted later phases.

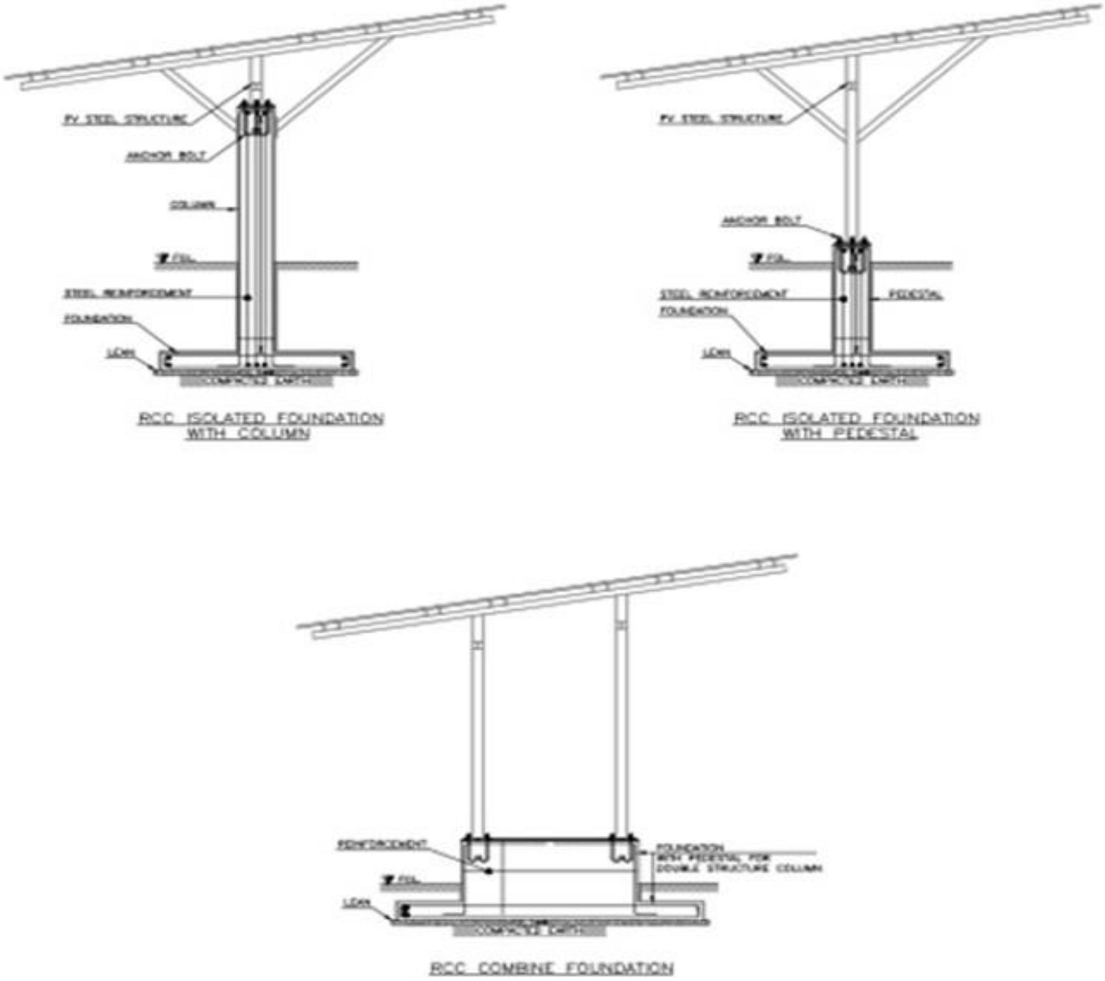


Figure 2-13 Support Foundation

2.4.9 Inverter and Transformer Foundation:

A Raft foundation is used for the inverter and box-type transformer, with brick laid for the periphery, and structural columns and the top ring beam arranged, so as to ensure that the foundation can meet the strength requirements. Meanwhile, ventilation openings and sump wells are set, as shown in Figure 2-14.

Construction procedure: foundation excavation → bed → raft placement (dowel bar embedded) → equivalent strength → construction of brick masonry → placement of structural columns and top ring beam (installation of embedded parts) → curing.

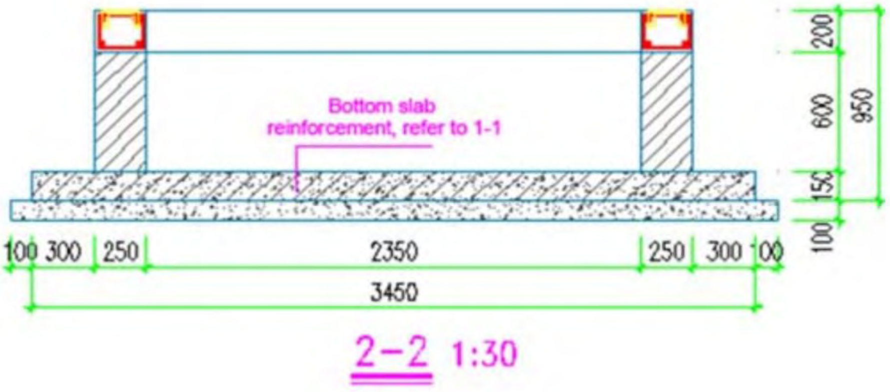


Figure 2-14 Inverter and Transformer Foundation

2.4.10 Installation of Support:

2.4.10.1 PREPARATION OF LABOUR FORCE:

Personnel for each workbench: 1 manager, 1 technician, 1 safety officer, 1 surveyor, 12 - 20 workers; check whether construction personnel have corresponding operation certificates. The mounting structure is required for the project area. The entire mounting structure comprises the foundations, array frames that provide the main mechanical support, and array super-structure onto which the PV modules are bolted. Array foundations may be precast piles, concrete piles, or any other design as necessary which will only be finalized after the complete design.

2.4.10.2 CONSTRUCTION METHODOLOGY FOR SUPPORT:

- For a concrete foundation, a minimum of 500x500x500mm pit will be excavated for each foundation, following which a steel column will be placed in each pit and concrete will be poured into the pit or can be used precast foundation based on the final design
- After the completion of foundation installation, front and rear columns will be erected and bolted. In the case of pile foundation, the installation procedure is easy and quick. The column will be put into the pile, and it will be bolted by using electric drills.
- Construction personnel shall be familiar with construction drawings and shall understand corresponding specification requirements.
- Based on the first strip foundation, other strip foundations shall be embedded in the same direction successively, with a pile interval of 3.2-6.5 m based on the final design.

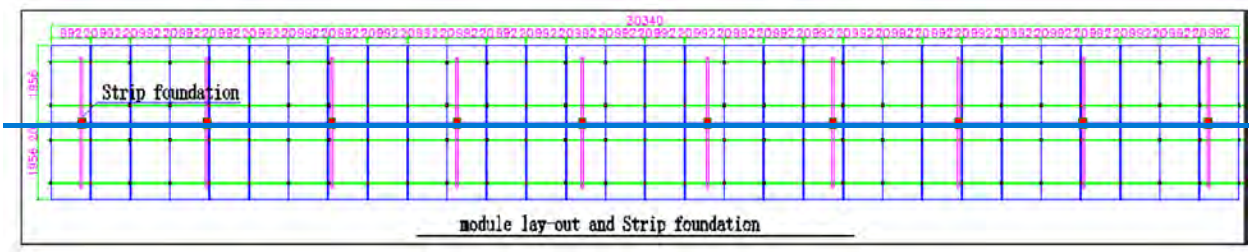


Figure 2-15 Module layout and Strip Foundation

- Installation of Main Beam and Front and Rear Supports where required

Purlin hangers shall be distributed on the cant beam according to the size shown in the figure, installed from bottom to top and from left to right, and fixed on the cant beam with outer hexagon bolts.

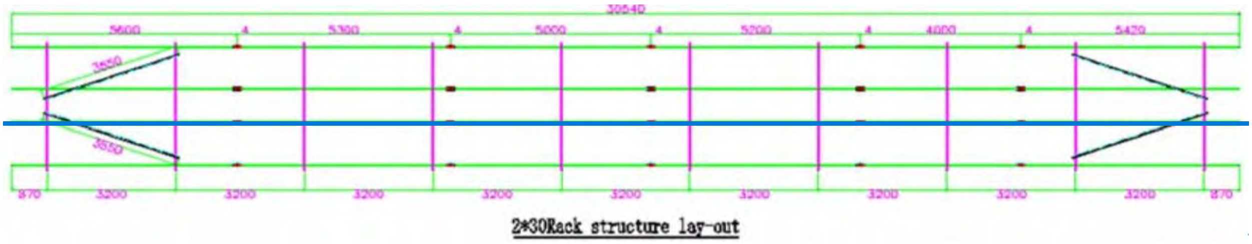


Figure 2-16 Rock structure layout

2.4.11 Installation of Bolts and Solar Panel

This type of panel is installed vertically. It shall be placed on the purlin first, with bolts tightened, and then installed in turn from top to bottom, starting from the left side. The edge of the panel must be in line with that of the previous one. Panels installed for 2 * 30 single arrays requires 60 panels. The node diagram is attached, only for reference.

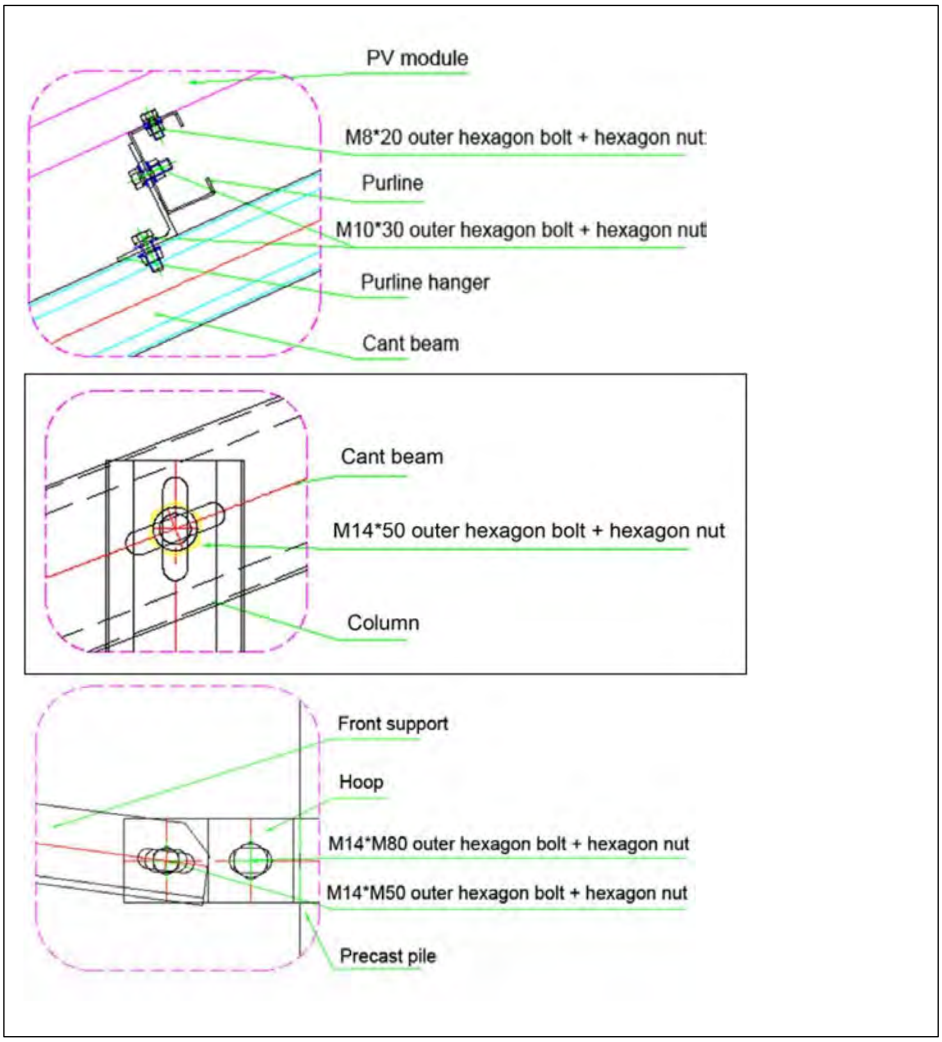


Figure 2-17 Installation of Bolts and Solar Panel

Justification

The method explained is a typical method which has been used and experienced in different areas of the world for fixation of similar structures.

2.4.12 Installation of PV Modules:

2.4.12.1 CONSTRUCTION REQUIREMENTS FOR MODULES:

- Construction personnel shall be familiar with construction drawings and shall understand corresponding specification requirements.
- Modules in the same string must be installed in the same power and current level; that is, modules with power and current labels (the same shape and color) pasted on sides shall be mounted in the same string.

- Modules shall be fixed with clamp splice. Position: Long edge of modules;

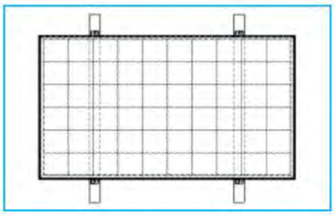


Figure 2-18 Position of Clamp Splice for PV Module

- The installation position range of the clamp splice is as follows. The spacing of the purline on site shall be confirmed so as to ensure that clamping positions meet the installation requirements.

- The maximum voltage of the module system shall be 1500 V, and 30 modules constitute a string. Electrical continuity tests shall be carried out after strings are connected in a direction consistent with that of the combiner box.

- Connecting cables and connectors of PV systems shall be safe and sealed. The cross-sectional area of cables and connector capacity must meet the requirements of the maximum open-circuit voltage of the system. The cross-sectional area is 4 mm².

- During the plug-in of junction box connectors, a “click” sound indicates that the connector is in place. In case the plug-in fails, heating or even burnout of junction box terminals may occur. The specific plug-in is as follows:

Unqualified Qualified

Figure 2-19 Standardized PV Plug-in

2.4.13 Quality Requirements for Installation of Modules:

All solar cell modules in the same string shall be in the same plane, with upper and lower edges in straight lines.

a) The long edge of one solar cell module shall be perpendicular to the horizontal purine (C-shaped steel), and the clearance between solar modules shall be the same.

b) Solar cell modules shall be installed in a neat and aesthetic manner.

c) During grounding installation, adjacent two modules shall be connected through the grounding wire BVR-6, free of omission and poor connection. For the upper row and the lower row, the outermost modules in every PV string (30 modules) shall be connected twice to the special grounding hole of PV support with the grounding wire BVR-6.

2.4.13.1 PRECAUTIONS FOR LOADING, TRANSPORTATION, STORAGE AND INSTALLATION OF PV MODULES:

- The modules should be stored in the original package before installation. Protect the package from damage. Unpack the modules as per the recommended unpacking procedures.
- Do not stand, climb, walk or jump on unpacked pallets of modules.
- Unpacking must be carried out by two or more persons at the same time. It is forbidden to use the wires or junction boxes of the modules to carry the modules. Handling the modules requires two or more people with non-slip gloves.
- During the transfer of modules, external impact shall be minimized. When modules are transferred by forklift or hoisted by a crane, it is necessary to ensure the integrity of external packaging cases and avoid damage to external packaging cases and pallets.
- Do not stack more than two layers during storage in the warehouse.
- Do not expose the modules to rain or moisture. Store the finished product in a well-ventilated, waterproof and dry place
- Before installing, wiring, operating, or maintaining PV modules, all safety precautions must be read and understood. Direct current (DC) is generated when the battery surface of the module is exposed to direct sunlight or other light sources, and direct contact

with the live parts of the module, such as terminals, may result in the death of personnel whether connected to the module or not.

- In the process of loading and unloading, modules shall be hoisted by cranes, meanwhile considerable waggle of modules shall be minimized and the collision between boxes and vehicles shall be strictly prohibited.

- When installing modules, installation personnel shall wear head protection devices, insulating gloves and safety shoes, with other insulation tools.

- Since wires shall not be exposed to sunlight, UV-resistant wires shall be adopted.

- No components of PV modules are allowed to be replaced, including diodes, junction boxes and wiring plugs.

- Modules can generate a voltage of more than 30 V under sunlight, which exceeds the safety range. Accordingly, improper operation at the electrical connecting part will cause sparks, electric shocks or even fire, so that modules shall not be in direct contact with wiring terminals under any circumstances.

- During the transport and installation of modules, children are strictly forbidden to contact with modules and solar PV power generation systems, from which they must keep away.

- Modules shall not be placed at places where combustible gas is easy to produce or gather.

- Do not step on modules under any circumstances.

- To avoid damage to glasses, no heavy objects are allowed to be placed on modules; no articles that may cause damage to modules are allowed.

- Modules shall be handled carefully to avoid bumps. Improper handling and placement may result in glass breakage and loss of electrical performance, thus affecting power generation.

- Do not wear metal jewelry during installation.

Justification

The method explained for the installation of the PV modules over the mounting frame is the standard mounting method for such installations.

General Safety

PV module installation should be conducted by certified technicians or by people with experience in PV system installation. Operation by personnel who are not familiar with the relevant safety procedures will be risky to the PV modules and to the person.

2.4.14 Inverter:

2.4.14.1 CONSTRUCTION CONTENT:

2.4.14.2 CONSTRUCTION METHODS:

- **Foundation:** Install the foundation of the power distribution unit as per the construction drawings, namely, firstly select qualified materials and define actual position of the foundation; check the embedded parts of civil works, measure their elevations and take the embedded part at the highest position as reference; calculate thickness of the sizing block between the channel steel and embedded part and then install the sizing block and channel steel in position; calibrate the elevation and horizontal dimension; weld securely the presser foot channel steel, sizing block and embedded parts and connect to the grounding grid; notify the Supervisor for acceptance inspection in advance. After the foundation section steel of LV panel and cabinet is installed in place, its top should be 10mm higher than the levelled ground.

- **Equipment in position:** Transport the equipment to the place near the installation point as per predetermined sequence and install the same in place with hydraulic trolley or roller. Align and fix the cabinet and make acceptance inspection after fixing. To avoid damage to indoor floor, a layer of rubber and board, where necessary, should be laid along the dragging or rolling path.

2.4.15 Installation of Step-up Transformer:

A total of 16 transformers and RMUs are proposed under the project. However, the transformer will be placed on different islands based on the installed capacity. Each transformer is placed over a metal frame which is placed over 4-6 columns/piles that emerge from the ground. These columns/piles will either be made out of steel or RC. Since the design has not been completed at the time of this report, the exact type of column to be used has not been finalized

2.4.15.1 CONSTRUCTION METHODOLOGY:

- **Foundation**: Identification of the exact location where the transformer is to be placed. The required materials and machinery will be mobilized to the site as per the mobilization and demobilization method. The base of the pile/ foundation will be strengthened by casting concrete as per the design. The required concrete will either be mixed in the site of premix concrete will be sourced from a secondary party.

- **Equipment in position:** Transport the equipment to the place near the installation point as per the pre-determined sequence and install the same in place with a Crane. Align and fix them and make an acceptance inspection after fixing.

- **Installation:** Define the foundation location of the box-type transformer with reference to its installation drawing and install the foundation channel steel with the horizontal error controlled, tighten the foundation channel steel, install the transformer onto the foundation channel steel, adjust the transformer with vertical and horizontal errors and tighten the connecting bolt of the transformer.

Figure 2-20 Typical way to install a transformer

Justification

Given the small size of the area, precast foundation seems to be the most suitable type of foundation for the project, rather than screw piles or the other different type of piles. However, design engineers will explore the best possible design for the project. If piling will be required then piling can safely be carried out by using a suitable piling machine.

2.4.16 Cable Laying and Fabrication Schemes:

2.4.16.1 CONSTRUCTION CONTENT:

In the Project, the cable laying and fabrication mainly include the laying of AC and DC cables, control system cables and communication system cables and installation of cable heads at the photovoltaic site. These cables are mainly buried directly underground or in sleeves.

2.4.16.2 CONSTRUCTION METHODOLOGY:

- Mark the cable route on the ground with a suitable paint. This is the cable that will connect the Inverters system to transformer. No road crossing is required during the construction as all the site are along the road.

- Cable line will be excavated by a mini excavator or by manual method to the depth of 0.3-1m at the 1m width of the bucket. Civil works at any cable trench or similar place related to cable laying is completed and handed over.

- The cable connecting the adjacent PV modules will run below the mounting structures.

- All the cabling drawings are complete and reviewed. Prior to construction, check that the type, specification, voltage class, quantity, path and starting and end positions of all the cables to be laid are accurate.

- The cable signs are complete, legible and classified duly.

2.4.16.3 LIST OF CABLE TOOLS

1. Bolt Clipper
2. Pay-off rack
3. Saw Bow
4. Press Plier
5. Electrical Press Plier
6. Heat Gun

2.4.16.4 CONSTRUCTION STEPS:

(1) Cable laying:

1) Method (as shown):

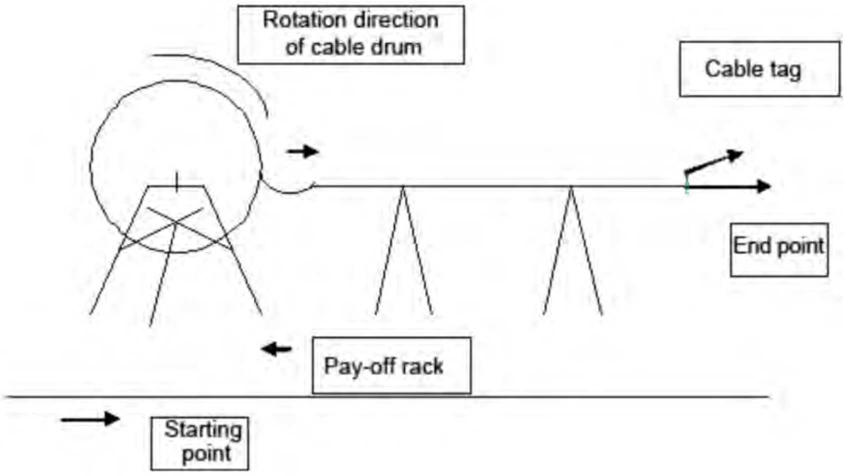


Figure 2-21 Construction Steps

2) Precautions:

- As shown in the figure above, the cable should be led from the cable drum which shall not contact the ground but 100mm - 150mm above the ground. The cable should be so laid to avoid such phenomena as flattened cable Armor, twisted cable or damaged outer sheath.
- The bending radius of cable should not be less than 10D (D - OD of cable).

Justification

The explained method is the standard for laying cables in such similar projects carried out.

2.4.17 Array Test:

2.4.17.1 TESTING CONDITIONS:

At the completion of the construction work, final testing and commissioning will be carried out in coordination with the relevant government institutions such as FENAKA. System synchronization and all required testing will be carried out

2.4.17.2 TEST AND REQUIREMENTS FOR TECHNICAL PARAMETERS:

- Electrical performance parameters shall be tested as per applicable local regulations.
- The open-circuit voltage of arrays shall be meet the design requirements.

2.5 PROJECT MANAGEMENT

The contractor will be in charge of the project management, while the proponent's Project Management Unit will oversee the works as per the schedule and deliverables. The accommodation and other facilitation of the labourers will be the responsibility of the proponent

2.6 SITE SETUP

Generally, construction sites of the given scale are potentially hazardous areas where unauthorized access should be prevented. In this regard site will be demarcated by fencing the project boundary. These barriers must remain and should be maintained for the entire duration of the project. Visible and recognizable signage indicating the hazardous nature of the site will be posted strategically in the project area. Site access will only be allowed through designated gates, and should be shut when not utilised.

Since the project location lies in an active urban area and the transfer route of materials will also encompass these areas, it is important to identify the peak traffic hours of the road network. Proper logistical planning should be made to avoid hindrances to the daily commute of the residents and road users.

The project materials will be imported and unloaded at regional ports of Kulhudhuffushi City and Addu City strategically with regard to the proximity of project sites. This is to reduce the logistical expenses and to limit the carbon footprint entailed with the project works.

Table 2-1 logistical arrangements.

Port: receiving the imported materials	Project Locations
Hithadhoo Regional Port	▪ Addu Stadium (Hithadhoo) ▪ Maradhoo Feydhoo Harbour Area (Maradhoo Feydhoo) ▪ Hulhudhoo Meedhoo STP site (Hulhudhoo Meedhoo) ▪ Gn. Fuvahmulah Airport ▪ G.Dh. Thinadhoo
Kulhuduffushi Regional Port	▪ Kulhudhuffushi Aiport ▪ Lh. Hinnavaru ▪ B. Eydhafushi

2.7 DURATION AND PROJECT SCHEDULE

Detailed Project Schedule is included in Appendix K.

2.8 PROJECT INPUTS AND OUTPUTS

Each component of the project has inputs and outputs based on human resources, economics and the environment. However, since the works are carried out in house, project inputs and outputs are greatly conserved and limited.

2.9 INPUTS – CONSTRUCTION PHASE

Table 2-2 major inputs associated with the project encompassing its components

Input/ Resource	Estimated Quantity	Source and mean of management
Construction and assembling staff	10 per site	Contractor's permanent staff Project staff Labourers (local)
Project Management	1	Proponent's permanent Staff
Site Supervisor	1	Proponent's permanent Staff
Civil Engineer	1	Proponent's permanent Staff
Structural Engineer	1	Proponent's permanent Staff
Environmental Safeguard Officer	1	Proponent's permanent Staff
Health and Safety Officer	1	Proponent's permanent Staff
Excavators	6	Proponent's equipment or rented
Landing Craft	2	Proponent's equipment or rented
Cargo boats (dhoni)	2	Proponent's equipment or rented
Crane	1 – 15 T	Proponent's equipment or rented
Concrete Mixer	10	Proponent's equipment or rented
Loader	1	Proponent's equipment or rented
Welding Equipment	1-4 per site	Proponent's equipment or rented
Machinery and equipment	As required	Proponent's equipment or rented
Electricity	As per demand	Fenaka – temporary connections
Water	As per demand	Fenaka – temporary connections
Construction materials Cement, Sand, Aggregate, Paint, steel	As required for the concrete support footings	Imported and supplied to the respective islands

2.10 OUTPUTS AND WASTE MANAGEMENT – CONSTRUCTION PHASE

Table 2-3 major outputs associated with the project and its components

Materials / Output	**Anticipated quantities**	**Method of disposal**
Waste generated in the construction phase	Approximately 1-2 tonnes per site	Collected and sorted and transferred to the island waste management centre of the respective location.
Waste oil and grease	Minute quantities	Collected in impermeable containers and transported to the designated waste collection area in accordance with the legal framework
Air Pollution	Particulates in moderate quantities and emissions from vehicles and during concrete mixing. In minute quantities	External impacts minimised through dust screens, demarcation boundary walls and maintenance of the vehicles and air pollution inducing equipment. Provision of adequate protective equipment to the workers.
Noise Pollution	> 75 db (A) at peak times	Minimised by site demarcation barriers. Provision of adequate protective equipment to the workers. Mainly from drilling, excavation, fastening, and concrete mixing

2.11 Mobilization and demobilization of machinery:

- Movable machinery with wheels will be mobilized by driving. Immovable items will be moved by loading them into trucks or crane trucks. In the case of normal trucks, items will be loaded onto and unloaded from the truck either by using a crane or an excavator, or a forklift. Depending on the item to be loaded and unloaded, the most appropriate machine will be selected for loading and unloading. Machines with metal tracks will be carried over trailers. No such machine will be moved on the paved road.

- At project completion, demobilization will take place in a similar fashion where machineries will be taken back to the sites from where they are from or to another site of the contractor at the mobilization stage. Step by step procedure to be followed during the mobilization and demobilization is provided below.

- Handling instruction of items, especially fragile items must be followed in mobilizing such items.

2.12 OUTPUTS AND WASTE MANAGEMENT – OPERATIONAL PHASE

Apart from routine maintenance works, the project is not expected to create waste of significance in the operational phase.

2.13 UTILITIES

During the construction phase, temporary service connections will be obtained for water, sanitation and electricity, from the respective service providers of the islands. In order to reduce the resource consumption and improve efficiency, equipment will be switched off while not in use. Furthermore, equipment of higher efficiency will be preferred over others. The Contractor is responsible for obtaining the required utility permits and establishing those services during the construction phase.

2.14 ACCIDENT AND HAZARD SCENARIOS

General precautionary methods applied for virtually all similar projects will be implemented. Precautions will be taken for safety of workers during the construction stage.
All workers will be given instructions about health and safety at site. The Site Engineers and Supervisors will give a brief on daily basis before the work starts to all workers, and all proper health and safety precautions will be implemented on site. Materials of concern will be handled in accordance with the respective material safety data sheets. Multilingual safety signs will be used on site, some of which are shown in the following figure.

Figure 2-22 Safety Signs

Personal protective equipment will be available for all the workers with regard to the type of work carried and with respect to the type of material handled. Emergency first aid kit will be at site for minor injuries. In case of any health related emergencies/injuries local health care facilities will be contacted and instructions given will be directed. First aid and PPE provisions will be facilitated by contractor for the workers and authorized personals who may enter the site premises.

Dust screens are required to be at the full height of the building as work progresses. Placing of construction materials outside the project boundary should be limited as much as possible, and in cases where it is due to logistical arrangements; the materials should not be placed for no longer than few hours. Work place floor should be managed with much care, to avoid construction materials or equipment falling accidentally to lower floors/ground. In this regard, as a precautionary measure, screens should be erected to intercept falling objects and debris.
In addition, all the necessary safety measures in accordance with the national regulation on Construction Safety-Standards (2019/R-156) should be adhered.

Assessment for accident and hazard is given in the table which is based on 3 stages of the building lifecycle; namely construction, use and maintenance of the building. Risk levels and probability are qualitatively assessed based on the categorization of High, Moderate and Low.

Performance Consideration	**Risk Level**	**Risk Probability**	**Responsible personnel**
Presence of hazardous substances. These may include but not limited to substances such as oxidisers, corrosive agents, etc. Instructions provided in the material safety data sheet of construction materials of concern should be followed	High	Low	Project Manager, Site Supervisor
Sufficient access / space around new section or building for use of cranes, scaffolding during construction	Moderate	Moderate	Project Engineer
Construction workers protection from proximity to HV electrical , High risk energy sources	High	Moderate	Site Supervisor
Traffic / Pedestrian risks for planned loading and unloading for construction vehicles Risks associated with the mobilization and demobilisation works	High	Moderate	Site Supervisor Project Manager
Social considerations with regard to the Neighbourhood. Eg: Public recreational areas, mosque, schools, etc.	Low	Low	Project Manager
Screen design to reduce / eliminate the risk of falls from height during the construction period	High	Moderate	Project Engineer Project Manager
Sufficient space is planned for access and installations	Low	Moderate	Project Engineer
Floor surfaces: - Should not hinder accessibility - Should be of non slip coverings - Complimentary with the tasks required	Moderate	Moderate	Project Engineer
Safe Access to lighting fixtures to change fitting, bulbs in cases where lighting is required	Low	Moderate	Project Engineer Maintenance Officer
Safe access to high working areas – for instance during PV installations	Low	Moderate	Project Engineer Maintenance Officer
Accessible panel and structure cleaning methods	Low	High	Project Engineer

			Maintenance Officer
Accessible dirt or rubbish collection points	Moderate	Moderate	Project Engineer Maintenance Officer

High risk scenarios stated in the above table, with specific mitigation is given below

- Presence of hazardous substances. These include but not limited to substances such as oxidisers, corrosive agents, etc. While the risk level is high the probability is low as the use of such materials are low. The project aims to procure materials of low environmental impact and sustainable in nature.

- Construction workers will be protected from / proximity to HV electrical, high risk energy sources. While the risk level is high, the probability is given as moderate. Proper insulator gloves and protective cloth are to be worn by workers in close proximity to high-risk energy sources. Moreover, it must be ensured that these are not exposed at any given time. In addition to this, experienced and trained workers will be used for any electrical works.

- Traffic / pedestrian risks are minimised for planned loading & unloading for construction vehicles. While the risk level is high, the probability is generally moderate. Probability can even be lower in this case as there were not many pedestrians using the area during the study period and traffic was minimum as well. Signboards and barricades should be placed to discourage any pedestrians or traffic nearing the project site. Obstruction to pedestrians during dewatering due to dewatering pipes is unavoidable and does not pose a direct risk.

- Falling objects during installation and hoisting. The risk level is high due to the high-level damage falling objects may cause individuals. The probability is also taken as moderate due to the increasing number of such cases in the construction industry of Maldives. Probability of occurrence can be made lower with safety measures being fully implemented at site. These include warning signboards on the roads on potential falling objects from the site, placing a watchman to act as a guide to any oncoming traffic with respect to any potential falling objects, securing construction materials in each floor slab, keeping a buffer of 5ft or greater from the slab edge to the material placement location, and wearing safety protection gear at site at all times. The Regulation on Construction Safety Standards also addresses the risks of falling objects and all works will be fully adhered to the regulation.

- During the operational phase of the project, in spaces where traffic movement is accepted as such the underneath area is to be utilised for parking; adequate signage and reflective/indicative painting shall be coated in the support structures of the PV systems to increase the visibility and limit hazard scenarios.

2.15 DISEASE PREVENTION, HEALTH AND WELLBEING

As covid19 measures has been eased by the HPA, no disease specific measures are presented. However, basic and proactive health measures are presented and needs to followed to ensure the health and wellbeing of the workforce and the respective island communities.

- Basic WASH facilitation should be established
- Proper PPE should be provided to avoid propagation of diseases amongst the work force. For example, some diseases such as pneumonitis can be developed from exposure to dust and could be communicable.
- Have an established understanding or inform the established respective health facility in the island regarding the scope and workforce of the project.
- Any sign of sickness should be proactively addressed and consulted with the medical practitioners present in the city/island
- In case of epidemics or disease outbreaks, instructions and measures taken by public health officials should be strictly followed.
- Labour facilities should be within the set rules and regulations, while ensuring the basic human dignity and respect are upheld. This include the provision of healthy meals within adequate intervals, hydration, proper sleeping facilities, etc.

2.16 PROJECT IMPACT AREA

Project impact area is detailed in the impacts sections.

2.17 TEMPORARY SITE SETUP

Temporary sites are near the project site and the allocations were made being mindful for the vegetations and areas which vegetation clearance were not required. For all the islands temporary sites will be utilize for storage of materials and machineries required for the project. Additionally, project staffs will be accommodated in rented houses in each respective islands.

2.17.1 KULHUDHUFFUSHI CITY

The council have allocated an area of approximately an area of 10,000 square feet. The area is in a recently reclaimed area near the harbor. No vegetation or any hard structure are visible in the project vicinity.

Figure 2-23 Kulhudhuffushi Temporary Site

2.17.2 EYDHAFUSHI

Eydhafushi temporary site is located near the project site in the reclaimed area. No structure or vegetation is present in the area.

Figure 2-24 Eydhafushi Temporary Site

2.17.3 HINNAVARU

Hinnavaru temporary site also is located near the project site in the reclaimed area. No structure or vegetation is present in the area. However little shrubs that may need to be cleared are seen in the site.

Figure 2-25Hinnavaru Temporary Site

2.17.4 THINADHOO

The council have allocated an area of approximately an area of 10,000 square feet. The area is adjacent to the project site. No vegetation or any hard structure are visible in the project vicinity. However little shrubs that may need to be cleared are seen in the site.

Figure 2-26Thinadhoo Temporary Site

2.17.5 FUVAHMULAH

The council have allocated an area of approximately an area of 8,000 square feet. The area is next to the airport and has little vegetation, which needs to be removed including 7 mature Ruh and 3 juvenile Ruh along with 2 mature dhiggaa gas.

Figure 2-27 Aerial View Temporary Site

2.17.6 ADDU CITY

2.17.6.1 HULHUMEEDHOO

The temporary sites for Hulhumeedhoo are an area in the harbour this is faraway from the project site. However, it will be easy to undock since it’s near the harbour. No vegetation or any hard structure are visible in the project vicinity. However little shrubs that may need to be cleared are seen in the site.

Figure 2-28 Meedhoo Temporary Site

2.17.6.2 FEYDHOO

Addu city council has allocated an area from the west side of the Feydhoo harbour area. This is a recently built harbour so no hard structure or vegetation is present. This area will be used by all project sites in the connecting islands, which includes; Hithadhoo Stadium area and Maradhoo Feydhoo Harbor area.

Figure 2-29 Feydhoo Temporary Site

2.18 COMMUNITY ENGAGEMENT PLAN

Community Dialogue:

As part of its commitment to community engagement, the Developer shall hold meetings at designated town halls and community halls on each of the islands to discuss the development of the Solar PV project launched by the Government of Maldives with the support of ASPIRE. This project aims to improve the lives of people living in these islands by reducing their reliance on costly diesel generators and creating new, long-term jobs. Islanders in these select islands mainly rely on tourism and fisheries, and this initiative will enable them to learn new skills and earn a livelihood through the trainings provided by the Developer.

During these meetings, the importance of this Solar Power project will be explained to the local community. The islands are at risk of the adverse impacts of climate change, which is causing a rise in sea level due to the emission of gases from burning fossil fuels. The Developer will explain that solar power can help mitigate the impacts of climate change as it does not emit any greenhouse gases.

Solar energy is produced by conducting the sun's radiation, which is a process that is void of any smoke, gas, or other chemical by-products. This is the driving force behind all green energy technology, as nations work towards meeting their climate change obligations by reducing emissions.

Overall, the meetings held by the Developer will allow the local community to gain a better understanding of the project and its potential benefits. By engaging with the community, the Developer is showing its commitment to sustainable development that benefits all stakeholders.

Developer's Strategy

Theme	Relevant Sections
Informed Participation	The Developer will conduct an Informed Consultation and Participation (ICP) process that will build upon the steps outlined below in Consultation and will result in the Affected Communities' informed participation. ICP involves a more in−depth exchange of views and information, and an organized and interactive consultation, leading to the Developer is incorporating into their decision−making process the views of the Affected Communities on matters that affect them directly, such as the proposed mitigation measures, the sharing of development benefits and opportunities and implementation issues.

Disclosure of Information	The Developer will provide affected communities with access to relevant information on: (i) the purpose, nature and scale of the project; (ii) the duration of proposed project activities; (iii) any risks to and potential impacts on such communities and relevant mitigation measures; (iv) the envisaged stakeholder engagement process; and (v) the grievance mechanism.
Consultation	When affected communities are subject to identified risks and adverse impacts from a project, the Developer will undertake a process of consultation in a manner that provides the affected communities with opportunities to express their views on project risks, impacts and mitigation measures and allows the Developer to consider and respond to them. Effective consultation is a two–way process that should: begin early in the process of identification of environmental and social risks and impacts and continue on an ongoing basis as risks and impacts arise; (i) be based on the prior disclosure and dissemination of relevant, transparent, objective, meaningful and easily accessible information which is in a culturally appropriate local language(s) and format and is understandable to affected communities; (ii) focus inclusive engagement on those directly affected as opposed to those not directly affected; be free of external manipulation, interference, coercion, or intimidation; enable meaningful participation, where applicable; and Be documented. The consultation process should: capture both men's and women's views, and if necessary, through separate forums or engagements; Reflect men's and women's different concerns and priorities about impacts, mitigation mechanisms, and benefits, where appropriate; The Developer will document the process, in particular the measures taken to avoid or minimize risks to and adverse impacts on the Affected Communities, and will inform those affected about how their concerns have been considered.
Feedback and Reporting	The Developer will provide periodic reports to the affected communities that describe progress with implementation of the project action plans on issues that involve ongoing risk to or impacts on affected communities and on issues that the consultation process or grievance mechanism have identified as a concern to those communities.

Stakeholders Mapping

The consultation will be carried for the Project including the engagement of several stakeholders to ensure that the planning process would take into consideration the opinions and concerns of the different stakeholders. The stakeholder engagement process will commence with a stakeholder analysis process to identify following stakeholders:

- Those involved in Project preparation;
- Those directly affected by the Project (individuals, groups, communities);
- Those likely to be indirectly affected either by virtue of their proximity to the Project or subject to disrupted access to communal property within the Project footprint;
- Those with an influence on Project development;
- Those whose interests make them stakeholders; and
- Those with the capacity to be partners in the development.

Pre-Construction Phase Engagement Activities

During pre–construction phase, the Developer will arrange local community meetings in town halls / community halls of each island where project is undertaken to provide the information and awareness of advantages of project. These local community meetings will be arranged on a weekly basis separately with women, teenagers and elderlies in pre–construction phase. Other important engagement activities will include:

- Importance of project for local community
- Timeline of project; commencement, completion and operation
- Consideration of local community's queries and grievance mechanism
- Community development initiatives, employment and skilled training plan
- Awareness of greenhouse gases, Climate Change and their effects on island

Construction Phase Engagement Activities

During construction, the Developer will provide information on a quarterly basis to local communities. Other important engagement activities will include:

- Follow up focus group discussion with vulnerable groups as needed to address and solve any issues raised in the quarterly community meetings;
- Meetings as needed in connection with submissions and settlement of complaints, in line with the Grievance Redress Mechanism;
- Meetings with project company on monthly basis or more often as needed to provide information on the progress of the stakeholder consultation meetings and community development initiatives and any social and environmental issues that have been encountered and how they have been solved; and
- Disseminating feedback on complaints escalated and management resolutions on issues arising.

Operations Phase Engagement Activities

The CEP will be reviewed and updated, including the stakeholder list, prior to Project commissioning to ensure that relevant and meaningful engagement activities are continued as needed. The operational phase CEP will be reviewed before the start of operations.

Regarding activities, it is foreseen that the most important engagement activity for the operation phase will be meetings in connection with the continued implementation and follow up of the community development plan that will be introduced during the construction phase, as well as follow up on any unforeseen operation phase impacts.

Pre-Construction Phase Engagement Plan

Agenda	Description
• A monthly seminar on a weekly basis. These seminars will be conducted in nearby and faraway communities with a 60:40 ratio respectively. • Project awareness and importance • Advantages for the local community • Description of training in the next phase of the project	• Total people to attend sessions: 05-25 women per island 05-25 men per island 05-25 elderlies per island 05-25 children per island 05-25 under 18 per island

Construction Phase Engagement Plan

Agenda	Description
• A monthly training session at an early stage of the construction phase: • Basic skills training of construction workers like fabricators, riggers, helpers, carpenters, gardeners, etc. • For women freelancing and stitching training will be provided.	• Total people to attend sessions: 05-25 women per island 05-25 men per island 05-25 elderlies per island 05-25 children per island 05-25 under 18 per island
• Recruitment of trained workers at the peak start of the construction phase	• Total people to be employed: 1 Person per island on daily wages which will be around 350 MVR/ Day

Operation Phase Engagement Plan

Agenda	Description
• In the operation phase local employment will be carried out on a contract basis. • Maintenance of panels, Electricians, Gardeners, and Security personnel	• Total people to be employed: • 1 Person per island on daily wages which will be around 350 MVR/ Day

Educational/Refresher Seminars:

As it is 15 years project, so community engagement will be continued for the personal development and nourishment of local school kids, adults, women and elder people of each island. The Developer aims to arrange a grand seminar annually. It may comprise:

- Awareness of greenhouse gases, Climate Change and their effects on island
- Importance of solar power project
- Benefits of solar power project for islanders

Since islands of Maldives are well known for their captivating rich nature sceneries. In 2019 almost two million tourists hit the islands of Maldives and that is a marvelous figure to boost the socio-economic culture of any country. To attract the international community following trainings will be furnished by the Developer annually:

- Communication Skills

Timeline for Implementation:

The community engagement plan spans a 15-year process, with regard to the course of the whole project. Planned detailed schedule is attached in Appendix K of this document.

3 POLICY AND LEGISLATIVE FRAMEWORK

3.1 LAWS, REGULATIONS, STANDARDS AND GUIDELINES

This chapter outlines the legislative and regulatory framework applicable to the current proposed project. Given that the project takes place at a local scale, the frameworks that are applicable are mostly at the national level.

The table below outline the legislative and regulatory frameworks which need to be adhered to by the current project.

The instruments covered under this analysis include:

Instruments Covered

- Environmental Protection and Preservation Act
- Environmental Impact Assessment Regulations (2012/R-27)
- Maldives National Building Act (4/2017)
- Maldivian Land Act, 2002
- Land Transport Act, 2009
- Disaster Management Act
- Energy Act
- Utilitiy Regulatory Act (26/2020)
- Waste Management Act 2022
- Maldives Civil Aviation Act (2/2001)
- Maldives Civil Aviation Authority Act (2/2012)
- Waste Management Regulation, (2013/R-58)
- Maldives Civil Aviation Regulations
- Air Safety Circulars by Maldives Civil Aviation Authority
- Conventions relevant to Civil Aviation signed by the Maldives
- Land Use Plan and Implementation Regulation
- Mosquito Control Regulation 2007
- Regulation on Aggregate and sand mining
- Regulation on cutting down, uprooting, digging out and exporting of trees and palms from one island to another
- Water Resources Conservation and Management Regulation, 2021/R22
- Regulation on Construction Safety Standards (2019/R-156)
- Environmental Liability regulation 2011
- Guideline for Duty Exemption of Renewable Energy Producing Systems and Related Item
- Guideline for Power System Design Approval

- Strategic Action Plan (SAP) 2019 – 2023
- Maldives National Building Code
- Guide to Groundwater Improvement Measures in Small Low-Lying Islands Maldives, 2021
- Dewatering Regulation
- Regulation on protection and preservation of island vegetation and flora, 2022
- Maldives Civil Aviation Authority Act (Act No: 2/2012)

Table 3-1relevant legal instruments of the project

Instrument	**Description**	**Relevance to the project**
Environmental Protection and Preservation Act (4/93) EPPA	The EPPA acts as the umbrella law on environmental protection and preservation. The Act outlines the statuary and regulatory powers of the Ministry/Agency entrusted work related to environmental protection and preservation. The Act mandates the production of an EIA for any developmental project which may have a potentially detrimental impact on the environment. The Act also provides the mandate to penalise for any breach of the provisions in the Act, outlining the fines that may be applied to breaches of varying degrees. It also provides the mandate to the government to claim compensation for any damages to the environment.	The proponent of the current project is required to adhere to all provisions in the Act, in particular the EIA requirements.
Maldives National Building Act (4/2017)	Enacted in 2017, this Act deals with compliance issues and procedures, roles and duties of all parties concerned with developments including the regulatory authority, building owners, developers and contractors, occupation of the buildings, licensing of building practitioners, and refers to the Building Code for more detailed guidance on construction procedures and best practice.	All provisions under the National Building Act has to be complied with, particularly as it related to the Building Code.

	The Act also includes the creation of a standardised building code, a fine regime for persons who do not comply with the Act and subsequent Regulations, giving priority to Maldivian workers in the construction sector and, guaranteeing compensation for services rendered. The Act also provides a dispute resolution mechanism for parties who seek to contest fines and other actions taken against them under this Act. The dispute must be lodged within 14 days of the action and a response to the disputed action must be given within 1 month.	
Maldives Land Act, 2002	The Act governs the allocation of Maldivian land for different purposes and uses and other issues regarding the issuing of land, issuing of state dwellings for residential purposes, conduct regarding state dwellings or private dwellings constructed for residential purposes and the sale, transfer and lease of Maldivian Land.	The Act governs issues related to land in general
Land Transport Act, 2009	The Act concerns the registrations of land vehicles, the safety, and conduct of road transport in general.	The current project should be designed in compliance with the Act, and should ensure the safeguards are met during the construction phase as well.
Maldives Energy Act, 18/2021	Provides the legal framework for standards and regulations for the provision of Energy production and consumption in the Maldives.	The project should be designed, established and operated in compliance with the Act.
Land Use Plan and Implementation Regulation	Under the Maldivian Land Act of 2002, all lands in the islands under the lands development policy, a Land Use Plan shall be developed and approved from Ministry of Housing and Infrastructure (currently Ministry of Planning and Infrastructure) prior to use of the lands. The regulation outlines key aspects that	Should align with the land use plan of the island

	need to be considered while preparing land use plans as well as describes guidelines on developing and allocating lands for various purposes.	
Waste Management Act (24/2022)	The law is the principle legal measure which governs the implementation, and enforcement of solid waste management practices, and policies. The Act aims to reduce the waste generated and is purposed to minimise pollution and environmental damage by throughout all stages of solid waste. The Act defines penalties on mismanagement of solid waste, and actions which may negatively impact human health, environment and economy through handling of waste.	The project should align and fully adhere the Act in its management of Solid Waste.
Maldives Civil Aviation Act (2/2001)	This Act makes provision in respect of the registration and operation of civil aircraft in the Maldives; construction, registration, operation and use of civil aerodromes; other matters relating to civil aircraft and aerodromes; and safety of civil aviation in the Maldives.	The proponent should ensure the project's dynamics with regard to the Kulhudhuffushi and Fuvahmulah site is in accordance with the Act
Maldives Civil Aviation Regulations	The regulation is aimed at complying with the ICAO requirements and harmonisation with international standards	The project shall not disrupt the conduct of the regulations made by CAA. Therefore, close collaboration with the regional airports and Civil Aviation Authority should be made during the course of the project in the sites where the regional airports are within.
Air Safety Circulars	These include the following: ▪ The Maldives Runway Safety Programme (MRSP)	Even though the activities under the circulars are carried out by the relevant respective circulars, the

	▪ Assessment of Runway Surface Friction Characteristics ▪ Ground Handling ▪ Safety Management System	proponent shall ensure the proposed project does not pose any interference to the enforcement of these circulars.
Mosquito Control Regulation, 2007	The regulation covers prevention of mosquito growth during construction and repair/maintenance works.	The proponent should adhere the regulation in order to avoid mosquito breeding in the project sites
Regulation on Aggregate and Sand mining	The Regulation covers the framework for sandmining in the Maldives. Coral mining from the house reef and the atoll rim has been banned through a directive from the President's Office date 26th September 1990.	This Regulation would not have any implication on the project, as imported manufactured materials will be used for the construction works.
Regulation on cutting down, uprooting, digging out and exporting of trees and palms from one island to another	The regulation was enacted to preserve the natural greenery of the islands, and to mitigate the associated issues from uprooting and cutting down of trees. The regulation defines applicable circumstances and the conduct to be followed for uprooting and cutting down of trees. Furthermore, the regulation defines the types of palms and trees which will be regulated under the regulation.	Careful consideration should be given to this regulation as the Thinadhoo and Hulhumeedhoo STP sites include trees to some extent.
Regulation on protection and preservation of island vegetation and flora, 2022/R-92	The regulation aims to ● improve the greenery of the islands of the Maldives ● protect old trees and sustain them ● regulate the conduct of felling/uprooting/transporting of coconut palms through a decentralized mechanism ● take measures to protect from the impacts of felling/uprooting of trees from the islands of Maldives, specifically the vegetation near the coast ● state the conditions which coconut palms and trees could be	Careful consideration should be given to this regulation as the Thinadhoo and Hulhumeedhoo STP sites include trees to some extent.

	uprooted/felled and transported to other areas for replantation	
Water Resources Conservation and Management Regulation, 2021	The Regulation was enacted in 2021 by the powers vested through the Water and Sanitation Act 8/2020. The regulation aims to ensure the sustainability, preservation, and development of the water resources, through enforcement and setting standards.	The project should be designed in compliance with the Act, and should ensure the safeguards are met during the construction phase as well.
Regulation on Construction Safety Standards (2019/R-156)	Enacted under the Maldives National Building Act (4/2017), the Regulation on Construction Safety Standards (2019/R-156) provides a minimum safety standard to ensure safety of construction workers and the public. It also defines the penalties for any violation of these rules defined by the regulation. The regulation also defines the responsibilities of the developer or contractor of the project. This includes the following: 1. Preparation of a health and safety handbook or paper specific for the project, if the project value is above MVR 1,500,000. a. All workers must be trained on the health and safety measures. b. All health and safety measures in then handbook/paper must be implemented. 2. Preparation of an Emergency Response Plan for projects valued above MVR 1,500,000. 3. Assigning of a Site Supervisor a. The site supervisor must have a minimum of 5 years of	The responsibilities ascribed to the developer/contractor, and the safety requirements and measures for emergencies is required to be integrated in to the proposed project.

	experience in site supervision of construction sites. b. The site supervisor can be assigned the supervision of more than one sites. c. Responsibilities of the supervisor are defined in the regulation. 4. Projects with a valuation above MVR 5,000,000 must have an insurance policy to compensate for injuries to workers, the general public and any damage to the surrounding properties of the site. 5. Implementation of public safety measures surrounding the site. 6. All workers at the site must be equipped with proper Personal Protective Equipment (PPE). 7. Hoarding of the site. Minimum requirements for hoarding the site has been defined in the regulation. The regulation also provides a standard operating procedure in the case emergencies. It also provides the responsibilities of the proponent of the project. Which are: 1. In the absence of a contractor for the project, all the responsibilities defined in the regulation for the contractor falls upon the proponent. 2. In case the proponent is aware of any activities which are against any laws and regulations, they must inform the permitting body or the Ministry.	
Environmental Liability Regulation 2011	The Regulation was enacted in 2007 by the powers vested through the EPPA 4/93. The Regulation covers the penalties and legal avenues available to the Ministry/Agency to claim compensation	In case of environmental damages due to the project, the regulation will be considered.

	against parties which have caused damages to the environment.	
Guideline for Power System Design Approval	The guideline for Power System Design Approval is made under law no. 26/2020 "Utility Regulatory Authority's Act". With this guideline, all Power Systems Designs for the provision of electricity services need to be approved prior to commencement of any procurement and installation works of any part of the power system. In addition, this will act as a guiding document for URA Licensed Engineers (Electrical) and Utility Companies for the submission of Power System Design documentation for approval by the Utility Regulatory Authority. The document also details out the approval process which needs to be followed by all licensed engineers.	All the provision under this guideline will be complied both in construction and operational phase
Strategic Action Plan (SAP) 2019 – 2023	The Action Plan is the central policy framework which outlines the existing administration's policy for the current 5 year presidential term which is from 2019 to 2023.	The project is in line with document
The Code regulates the duties of the contractors, and outlines best practices, in addition to regulations to be adhered to during construction work. It covers aspects such as structural	The proposed development will conform to the guidelines provided in the Building Code.	The Code regulates the duties of the contractors, and outlines best practices, in addition to regulations to be adhered to during construction work. It covers aspects such as structural stability, fire safety, access, moisture control, durability, services and facilities, and energy efficiency.

stability, fire safety, access, moisture control, durability, services and facilities, and energy efficiency.		
Dewatering Regulation 2013	The main purpose of the regulation is to protect groundwater resources of the nation from impacts of dewatering, pollution and to protect the environment from release of ground water in the process.	Dewatering is not expected during the course of the project.
It is of note that the proponent should abide and follow all the components of the legal framework of the Maldives, and at all circumstance should follow the industry best practices and be proactive to ensure environmental, social and economic safeguards.		

3.2 RELEVANT PERMITS

The following describes the relevant permits for the proposed project.

- ESIA Decision Statement
- CAA approval for the design and structure of the project components which fall to the airport areas.

4 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 GENERAL CLIMATOLOGY

Climate data has been taken from the nearest weather stations to the project sites.

Maldives experiences warm and humid climate throughout the year with an average temperature ranging from 25 to 31 degree Celsius. The country receives an annual average rainfall of 1,924.7mm in the central parts of Maldives, where Male' is located. (Department of Meteorology, 2012).

The climate of the Maldives is dependent upon the Indian Ocean Monsoons. Monsoon wind reversal plays a significant role in weather patterns.

The two monsoon seasons observed in the Maldives include the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The northeast monsoon is the dry season that occurs from December to February and the southwest monsoon is the rainy season, which lasts from May to September. The transition period of northeast monsoon occurs from October to November while that of southwest monsoon occurs between March and April. The 'four seasons' of the Maldives is highlighted in the following table.

Table 4-1Four Seasons of the Maldives

Seasons	Duration
South West Transition	March to April
South West	May to September
North East Transition	October to November
North East	December to February

4.2. Temperature

The Maldives experiences a warm and humid tropical climate throughout the year. The presence of vast sea and oceans surrounding the islands helps moderate the temperature.

The average temperature in the Maldives ranges from 25°C to 32°C. However, seasonal fluctuations occur due to the influence of the monsoon. The warmest period is typically observed during March and April, extending up to the onset of the southwest monsoon in mid-May. The highest temperature ever recorded was 36.0°C on September 12, 1991, at the Kadhdhoo Meteorological Office. Conversely, the lowest temperature ever recorded was 18.2°C on December 23, 2002, at the Hanimaadhoo Meteorological Office.

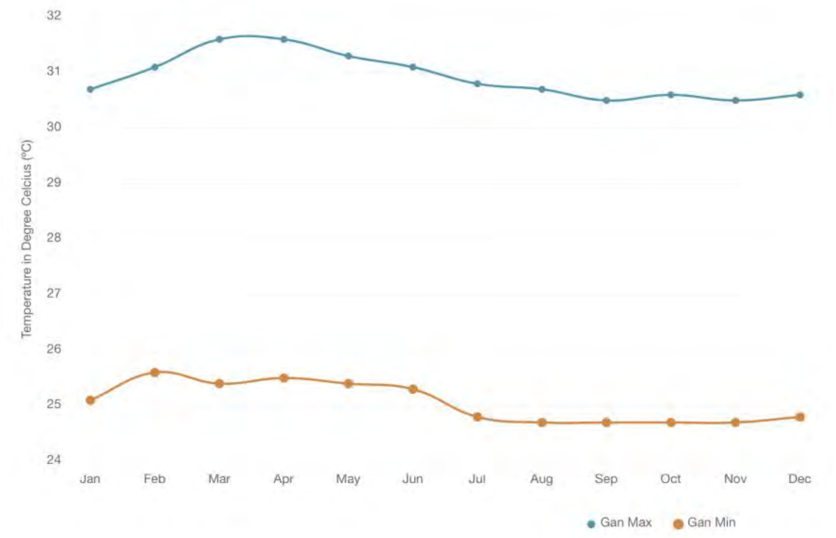


Figure 4-1 shows the average temperature recorded at the nearest weather station in Addu city for the project sites in GDh. Thinadhoo, Addu City and Fuvahmulah City.

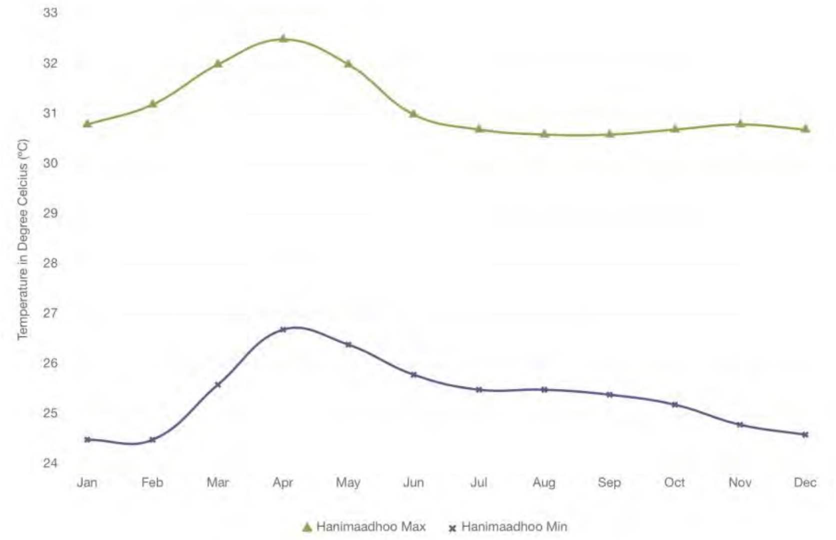


Figure 4-2 Shows the average temperature recorded at the nearest weather station in Hanimaadhoo for the project sites in Lh. Hinnavaru and HDh. Kulhuduffushi

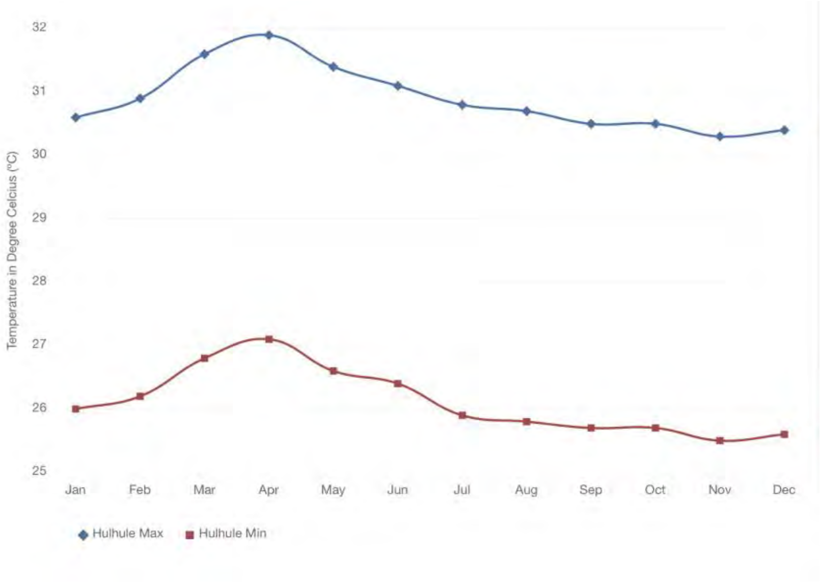


Figure 4-3 Shows the average temperature recorded at the nearest weather station in Hulhule for the project sites in B. Eydhafushi.

4.2 WIND

Wind is an important indirect process affecting formation, development and seasonal dynamics in the Maldives. Winds often help to regenerate waves that have been weakened by traveling across the reef and they also cause locally generated waves in lagoons. Therefore, winds are an important factor, as being the dominant influence on the hydrodynamics in most coastal areas. The two monsoon seasons have a dominant influence on winds experienced across Maldives. Since Maldivian islands are spread across the equator, monsoons are relatively moderate while strong winds and gales are rare.

Wind is an important indirect process affecting the formation, development and seasonal dynamics of the Maldivian islands. Reversal of winds in the Maldives means change of seasons from North East monsoon to South West or vice versa.

General wind surface wind pattern over the country during North East monsoon is north-easterly direction whereas during South West monsoon mean wind flow is westerly.

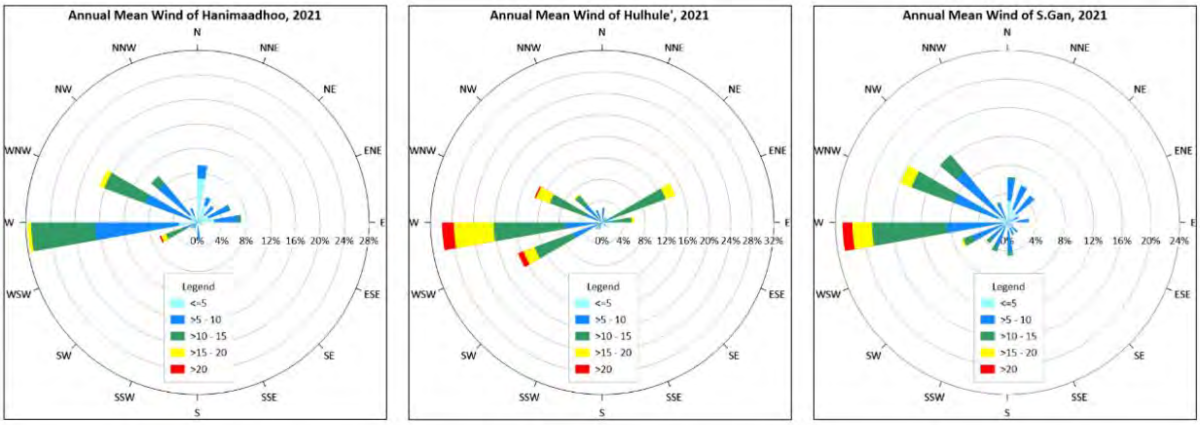


Figure 4-4 General Climate and Weather Highlights 2021, (Maldives Meteorological Service , 2022)

4.3 RAINFALL

The average annual rainfall for the Male' area is 1,826.3mm (National Bureau of Statistics, 2020). There are regional variations in average annual rainfall. Southern atolls receive more rain compared to the northern atolls (MEC, 2004). Mean monthly rainfall also varies substantially throughout the year with the dry season getting considerably less rainfall. The north east monsoon is known as the dry season and the south west monsoon the rainy season. Across the length of the Maldives, the amount of annual rainfall received increases from the north to the south. According to the schedule provided, the Project Team will not be subjected to excessive rainfall throughout the excavation and foundation works/ or during any other Project activity.

4.3.1 Annual Rainfall – GDh. Thinadhoo, Addu City and Fuvahmulah City

Rainfall data was collected from the nearest weather station at Addu city. On average, the southern atolls receive about 2,218 mm of rainfall per year. Heaviest rainfall in 24 hours was 228 mm recorded at the meteorological office Addu City on 24 November 2015.

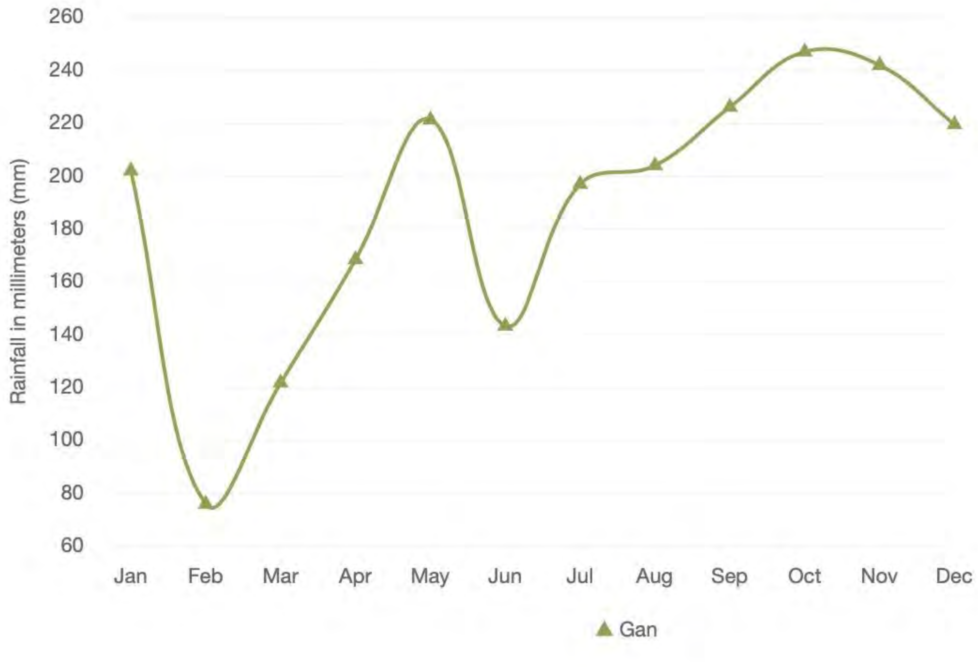


Figure 4-5 shows the annual rain pattern for the southern part of the Maldives.

4.3.2 Annual Rainfall – B.Eydhafushi

The nearest weather station for the proposed project in Eydhafushi is located at Hulhule. On average central part of the Maldives, the annual rainfalls recorded was 1,966 mm.

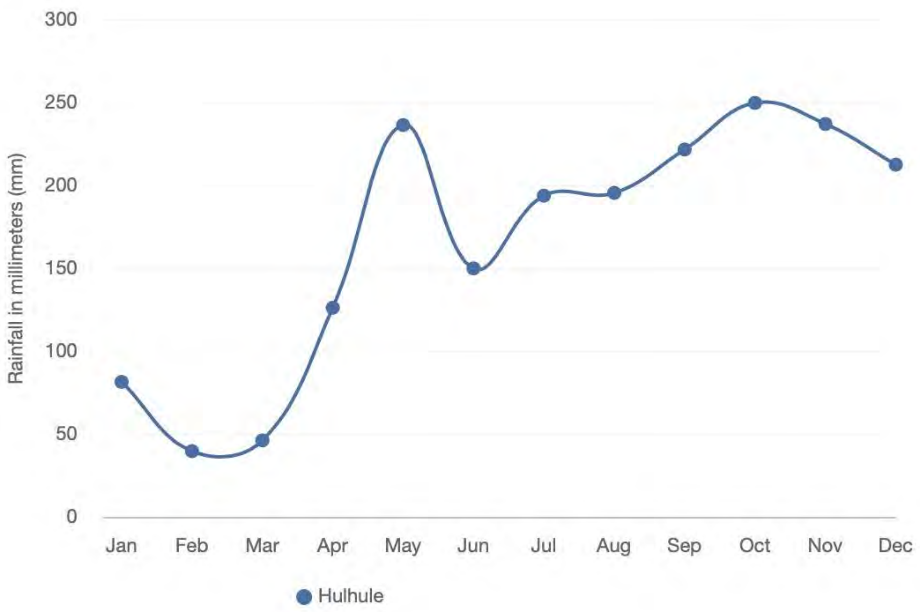


Figure 4-6 shows the annual rainfall from the nearest weather station located at Hulhule'

4.3.3 Annual Rainfall – Lh. Hinnavaru and HDh. Kulhuduffushi

The nearest weather station for the proposed site in Hinnavaru and kulhuduffushi is located at HDh. Hanimaadhoo. On average, the northern atolls receive about 1,779 mm of rainfall per year.

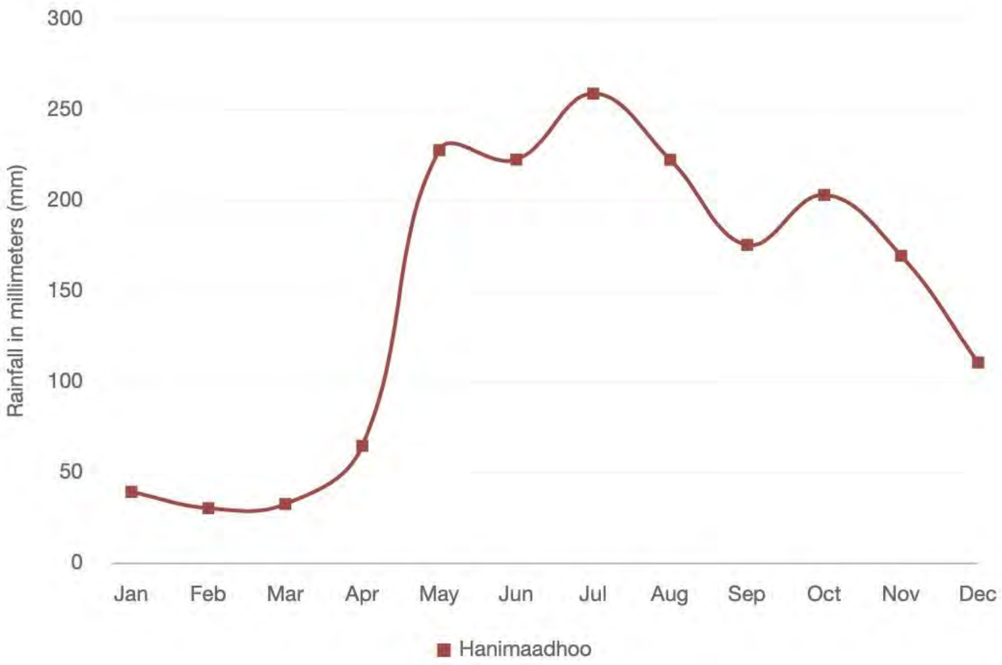


Figure 4-7 shows the average rainfall from the nearest weather station located at HDh. Hanimaadhoo

4.4 RISKS OF HURRICANES AND STORMS

The basis of the hazard risk analysis for this report was taken from the UNDP risk assessment study of the Maldives and the Multi Hazard Risk Atlas of the Maldives from ADB.

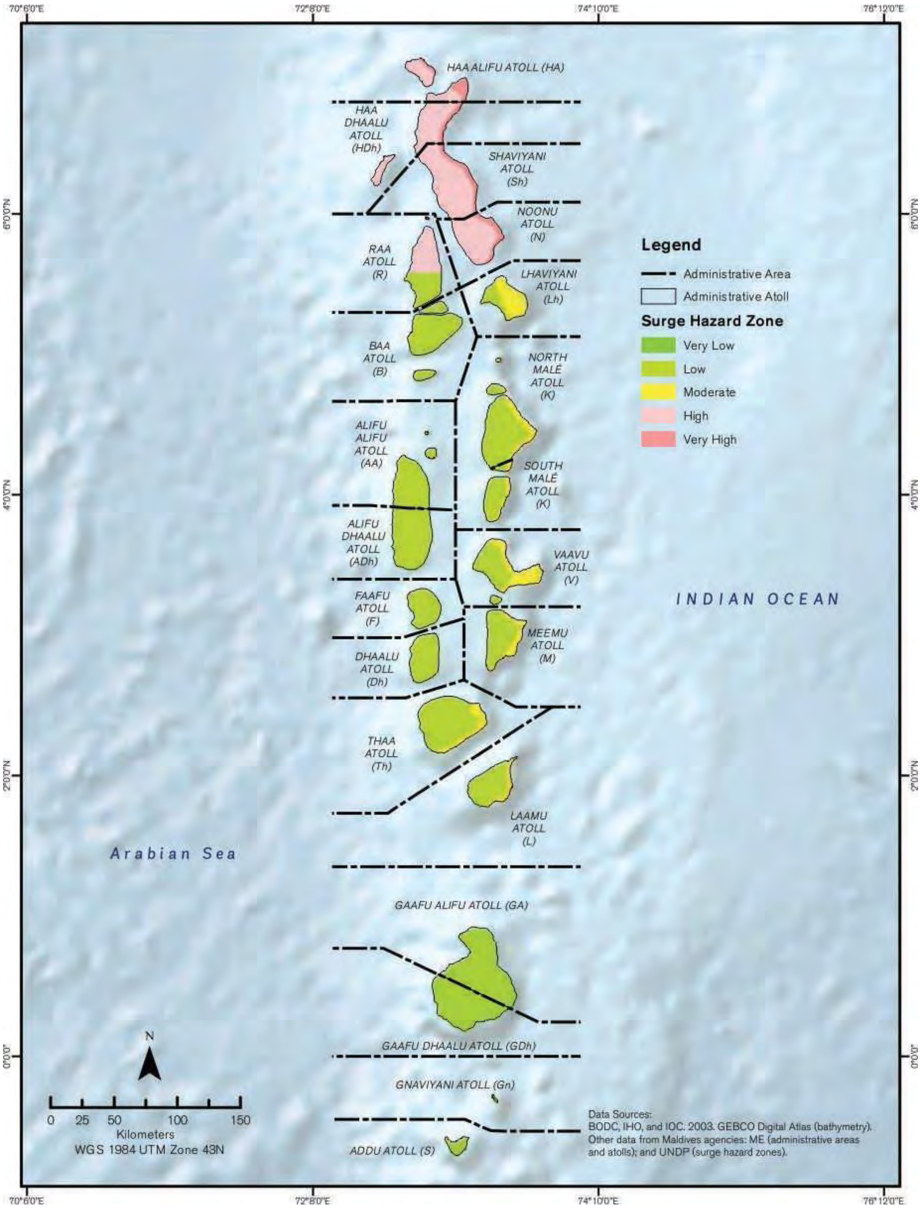


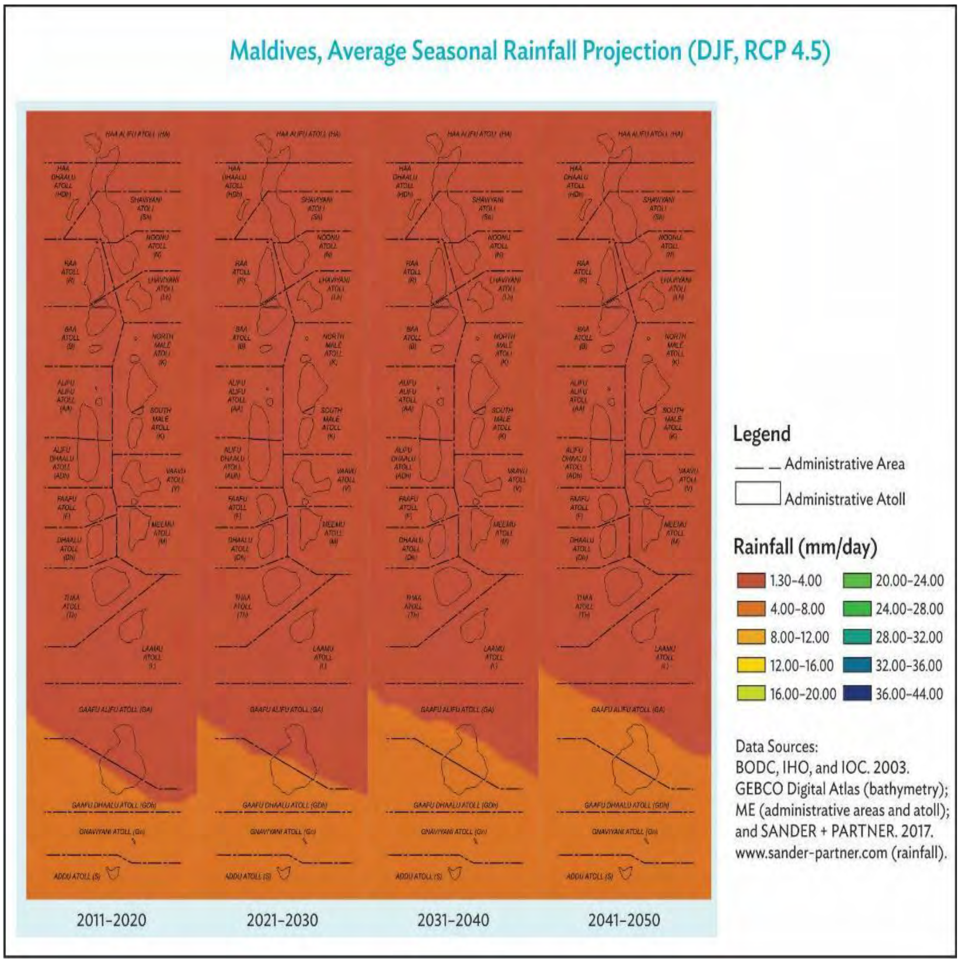
Figure 4-8 Surge Hazard Map

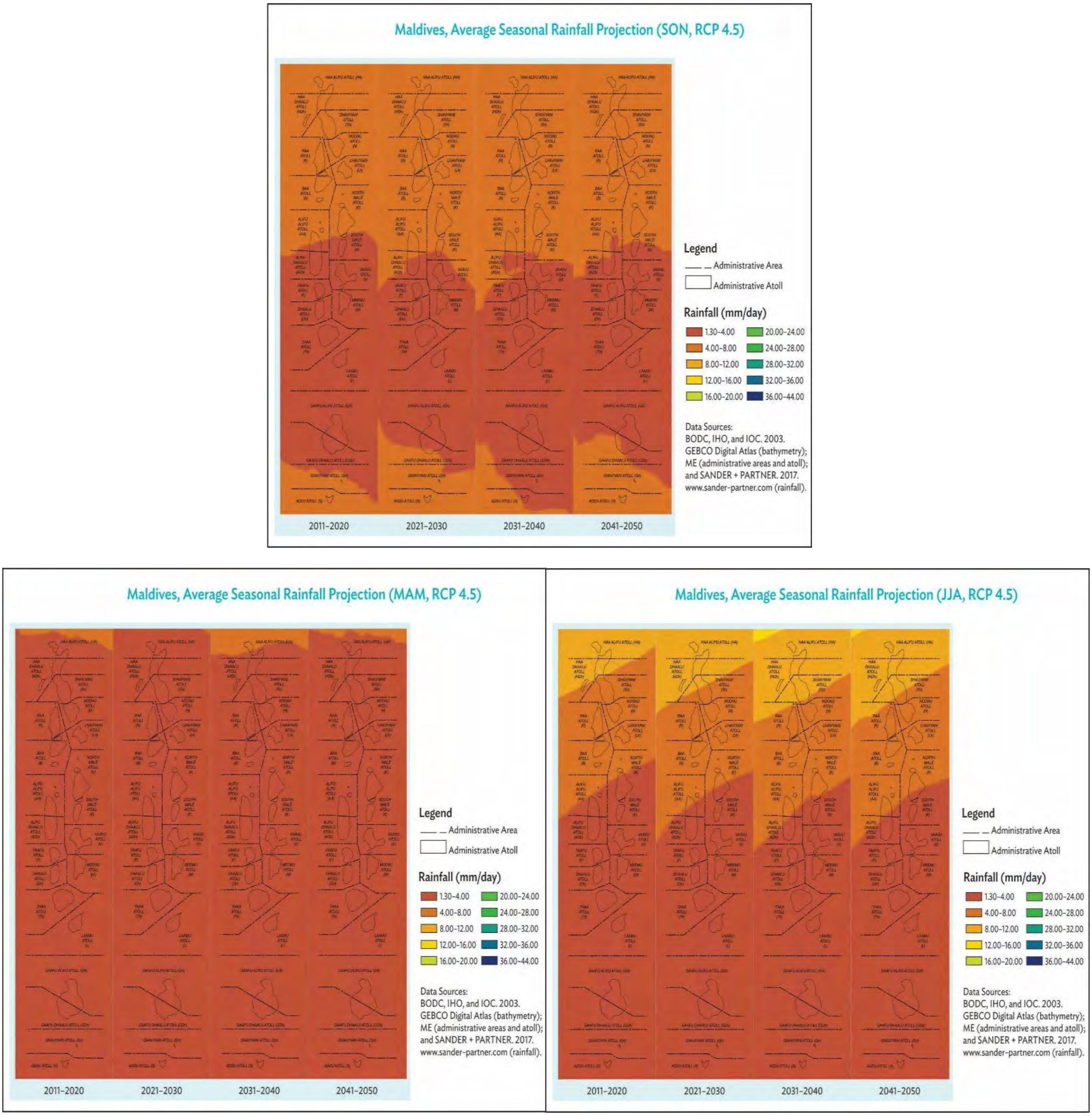
With regard to the project locations, the project islands' hazard zones are indicated in the table below:

Table 4-2 Hazard Zones

Island	**Hazard Zone**
Kulhudhuffushi City	Very High
Lh. Hinnavaru	Low
B. Eydhafushi	Low
G.Dh. Thinadhoo	Low
Fuvahmulah City	Low
Addu City	Low

For rainfall projections, for this report Representative Concentration Pathway (RCP) 4.5 based projections made in the 'Multihazard Risk Atlas of the Maldives' was accounted. Stated below are the relevant maps. (ADB, 2020).





Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry); ME (administrative areas and atoll); and SANDER + PARTNER. 2017. www.sander-partner.com (rainfall).

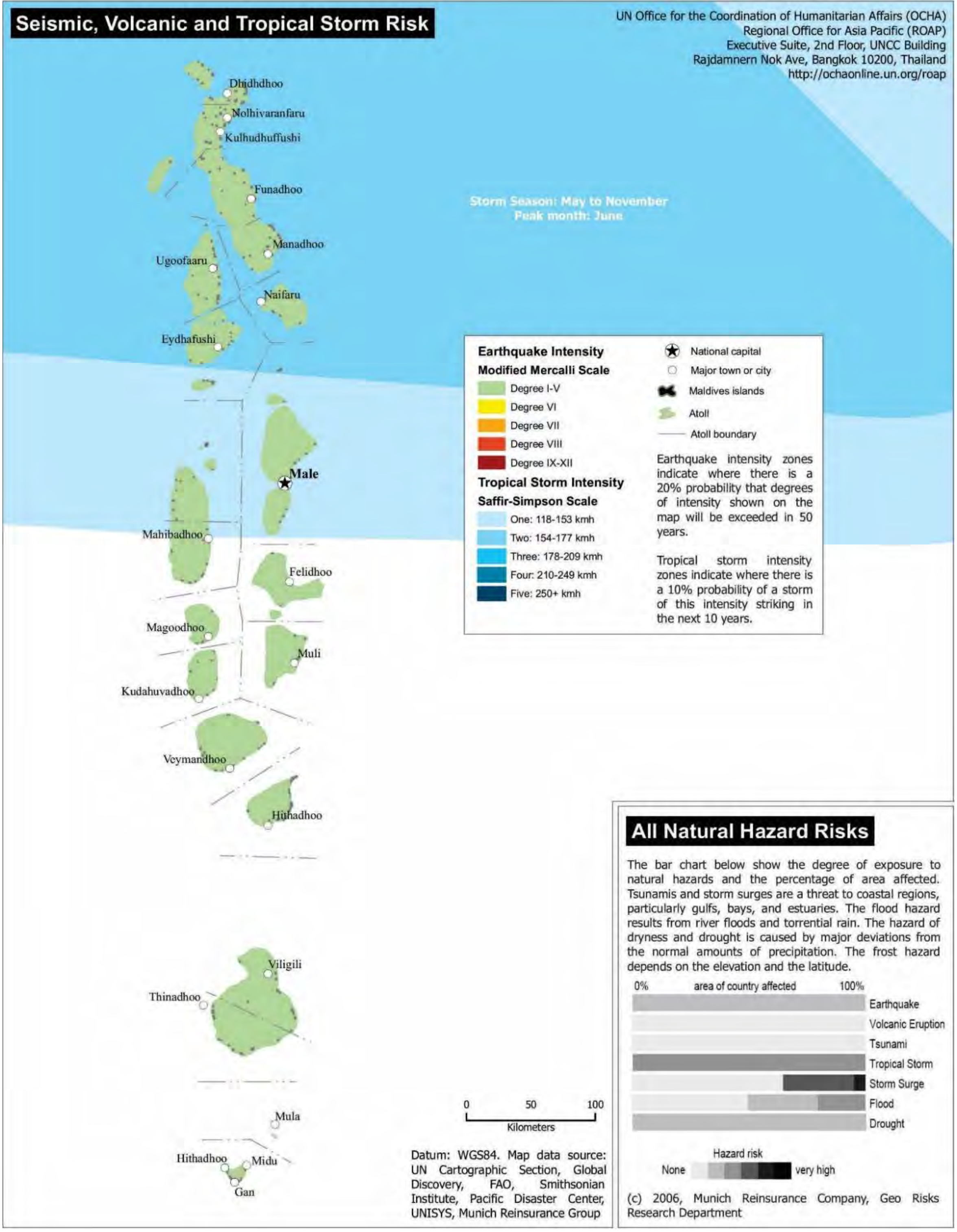
Figure 4-9 Average Seasonal Rainfall Projection

Table 4-3 Rainfall Projection

Island	**Rainfall (mm/day)**	**Description**
Kulhudhuffushi City	1.30-4.00	December- January-February
	1.30-4.00	March- April - May
	8.00 – 12.00	June – July – August
	4.00 – 8.00	September – October - November
Lh. Hinnavaru	1.30-4.00	December- January-February
	1.30-4.00	March- April - May
	4.00 – 8.00	June – July – August
	4.00 – 8.00	September – October - November
B. Eydhafushi	1.30-4.00	December- January-February
	1.30-4.00	March- April - May
	4.00 – 8.00	June – July – August
	4.00 – 8.00	September – October - November
G.Dh. Thinadhoo	4.00 – 8.00	December- January-February
	1.30-4.00	March- April - May
	1.30-4.00	June – July – August
	1.30-4.00	September – October - November
Fuvahmulah City	4.00 – 8.00	December- January-February
	4.00 – 8.00	March- April - May
	1.30-4.00	June – July – August
	4.00 – 8.00	September – October - November
Addu City	4.00 – 8.00	December- January-February
	1.30-4.00	March- April - May
	1.30-4.00	June – July – August
	4.00 – 8.00	September – October - November

With regard to the information aided map below published from UN- OCHA (United Nations Office for the Coordination of Humanitarian Affairs, Regional office for Asia Pacific , 2007); The islands geographical location to the the modified Mercalli Scale interms of earthquake intensity and, tropical storm risks with regard to the Saffir-Simpsons scale is indicated below in table 4-3:

Table 4-4 Seismic, Volcanic and Tropical Storm risk map of the Maldives (OCHA Regional Office for Asia Pacific, 2007)



Earthquake intensity zones indicate where there is a 20% probability that degrees of intensity shown on the map will be exceeded in 50 years.

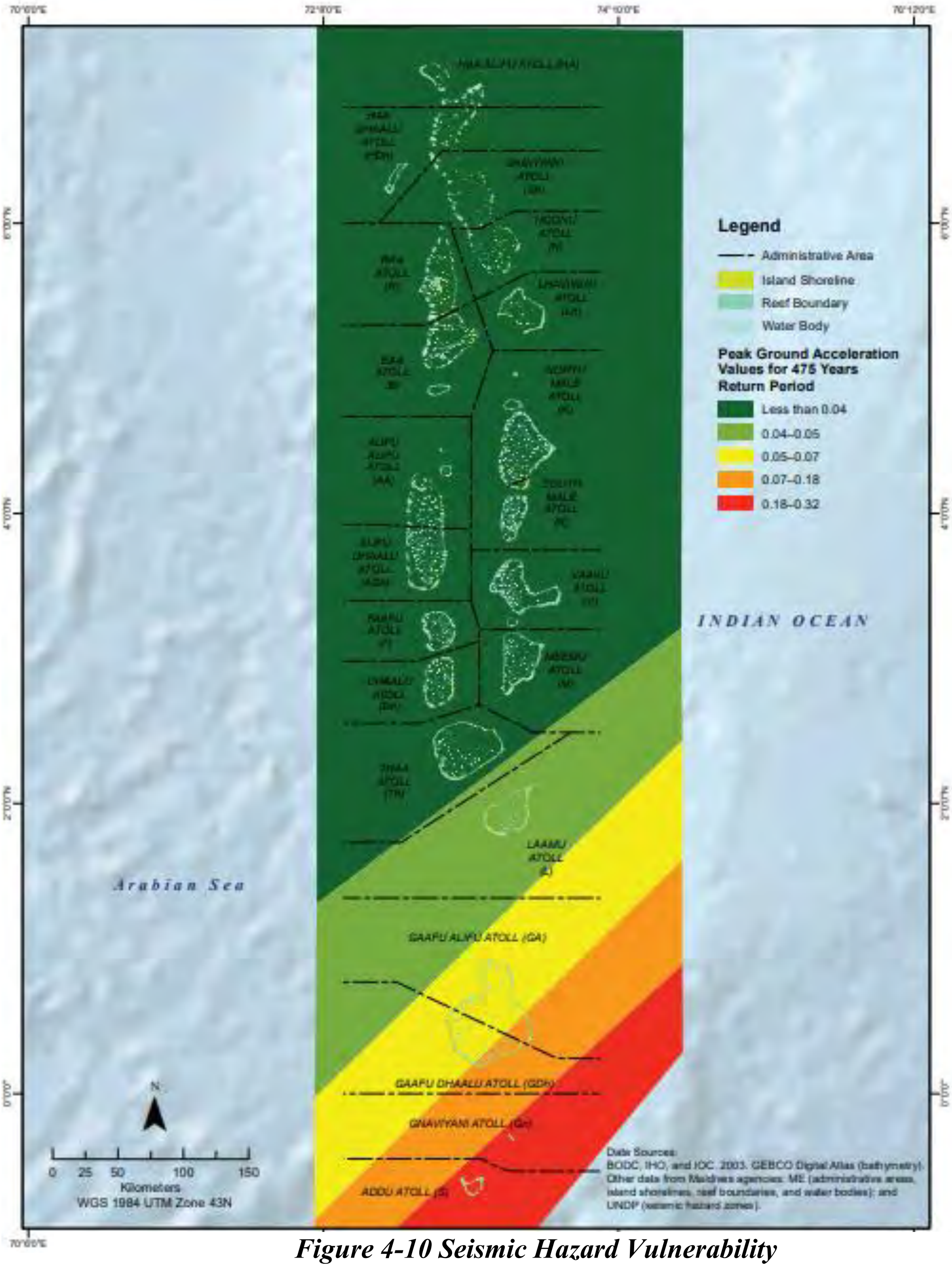
Tropical storm intensity zones indicate where there is a 10% probability of a storm of this intensity striking in the next 10 years.

Datum: WGS84. Map data source: UN Cartographic Section, Global Discovery, FAO, Smithsonian Institute, Pacific Disaster Center, UNISYS, Munich Reinsurance Group

The bar chart below show the degree of exposure to natural hazards and the percentage of area affected. Tsunamis and storm surges are a threat to coastal regions, particularly gulfs, bays, and estuaries. The flood hazard results from river floods and torrential rain. The hazard of dryness and drought is caused by major deviations from the normal amounts of precipitation. The frost hazard depends on the elevation and the latitude.

(c) 2006, Munich Reinsurance Company, Geo Risks Research Department

4.5 SEISMIC HAZARD VULNERABILITY



Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry). Other data from Maldives agencies: ME (administrative areas, island shorelines, reef boundaries, and water bodies); and UNDP (seismic hazard zones).

Figure 4-10 Seismic Hazard Vulnerability

Table 4-5 Seismic Hazard Vulnerabilty Risk

Island	**Hazard Zone**
Kulhudhuffushi City	< 0.04
Lh. Hinnavaru	< 0.04
B. Eydhafushi	< 0.04
G.Dh. Thinadhoo	0.05-0.07
Fuvahmulah City	0.07-0.18
Addu City	0.07-0.18

4.6 AIR QUALITY

Parameters identified for air quality data for the baseline survey are stated in the following table with the respective geo-referencing.

Table 4-6 Air Quality Data

Parameter	Geo reference /	Date of collection	Reading
Kulhudhuffushi City			
Carbon monoxide surface concentration	6.37° N, 73.04° E	08th January 2023, 15:38	210 ppbv
Carbon dioxide surface concentration	6.37° N, 73.04° E	08th January 2023, 15:38	422 ppmv
Sulphur dioxide surface mass	6.37° N, 73.04° E	08th January 2023, 15:38	5.03 µg/m^3
Nitrogen dioxide	6.37° N, 73.04° E	08th January 2023, 15:38	1.57 ppbw
PM$_{10}$	6.37° N, 73.04° E	08th January 2023, 15:38	0.15 µg/m^3
PM$_{2.5}$	6.37° N, 73.04° E	08th January 2023, 15:38	19 µg/m^3
Lh. Hinnavaru			
Carbon monoxide surface concentration	5.29° N, 73.24° E	08th January 2023, 07:14	184 ppbv
Carbon dioxide surface concentration	5.29° N, 73.24° E	08th January 2023, 07:14	421 ppmv
Sulphur dioxide surface mass	5.29° N, 73.24° E	08th January 2023, 07:14	5.25 µg/m3
Nitrogen dioxide	5.29° N, 73.24° E	08th January 2023, 07:14	0.16 ppbw
PM$_{10}$	5.29° N, 73.24° E	08th January 2023, 07:14	34 µg/m3
PM$_{2.5}$	5.29° N, 73.24° E	08th January 2023, 07:14	19 µg/m3
B. Eydhafushi			
Carbon monoxide surface concentration	5.06° N, 73.06° E	08th January 2023, 07:07	181 ppbv
Carbon dioxide surface concentration	5.06° N, 73.06° E	08th January 2023, 07:07	421 ppmv
Sulphur dioxide surface mass	5.06° N, 73.06° E	08th January 2023, 07:07	4.61 µg/m3
Nitrogen dioxide	5.06° N, 73.06° E	08th January 2023, 07:07	0.14 ppbw
PM$_{10}$	5.06° N, 73.06° E	08th January 2023, 07:07	10 µg/m3
PM$_{2.5}$	5.06° N, 73.06° E	08th January 2023, 07:07	19 µg/m3
G.Dh. Thinadhoo			
Carbon monoxide surface concentration	0.31° N, 72.59° E	08th January 2023, 07:02	156 ppbv
Carbon dioxide surface concentration	0.31° N, 72.59° E	08th January 2023, 07:02	421 ppmv
Sulphur dioxide surface mass	0.31° N, 72.59° E	08th January 2023, 07:02	0.11 µg/m3
Nitrogen dioxide	0.31° N, 72.59° E	08th January 2023, 07:02	0.04 ppbw
PM$_{10}$	0.31° N, 72.59° E	08th January 2023, 07:02	14 µg/m3
PM$_{2.5}$	0.31° N, 72.59° E	08th January 2023, 07:02	8 µg/m3
Fuvahmulah City			

Carbon monoxide surface concentration	0.17° S, 73.25° E	08th January 2023, 06:54	155 ppbv
Carbon dioxide surface concentration	0.17° S, 73.25° E	08th January 2023, 06:54	421 ppmv
Sulphur dioxide surface mass	0.17° S, 73.25° E	08th January 2023, 06:54	0.09 µg/m3
Nitrogen dioxide	0.17° S, 73.25° E	08th January 2023, 06:54	0.06 ppbw
PM_{10}	0.17° S, 73.25° E	08th January 2023, 06:54	12 µg/m3
$PM_{2.5}$	0.17° S, 73.25° E	08th January 2023, 06:54	6 µg/m3
Addu City – Hithadhoo			
Carbon monoxide surface concentration	0.35° S, 73.05° E	08th January 2023, 06:45	163 ppbv
Carbon dioxide surface concentration	0.35° S, 73.05° E	08th January 2023, 06:45	421 ppmv
Sulphur dioxide surface mass	0.35° S, 73.05° E	08th January 2023, 06:45	0.08 µg/m3
Nitrogen dioxide	0.35° S, 73.05° E	08th January 2023, 06:45	0.08 ppbw
PM_{10}	0.35° S, 73.05° E	08th January 2023, 06:45	10 µg/m3
$PM_{2.5}$	0.35° S, 73.05° E	08th January 2023, 06:45	6 µg/m3
Addu City – Hulhumeedhoo			
Carbon monoxide surface concentration	0.35° S, 73.13° E	08th January 2023, 06:49	161 ppbv
Carbon dioxide surface concentration	0.35° S, 73.13° E	08th January 2023, 06:49	421 ppmv
Sulphur dioxide surface mass	0.35° S, 73.13° E	08th January 2023, 06:49	0.08 µg/m3
Nitrogen dioxide	0.35° S, 73.13° E	08th January 2023, 06:49	0.09 ppbw
PM_{10}	0.35° S, 73.13° E	08th January 2023, 06:49	9 µg/m3
$PM_{2.5}$	0.35° S, 73.13° E	08th January 2023, 06:49	5 µg/m3

4.7 ENVIRONMENTALLY SIGNIFICANT LOCATIONS

Environmentally sensitive areas and Environmentally Protected Areas are defined and described referencing to the EPA’s published list. Protected areas and environmentally significant locations identified at each project site are presented in Appendix F of this document.

4.7.1. HDh. Kulhudhufushi

The island has two wetland areas, with the larger one located in the northern end and the smaller one in the south end. The wetland at the project site is a white clay mangrove, home to endangered species, migratory bird and plays an important role as a natural defence system against natural disasters.

4.7.2. Addu city

Addu city have 7 protected areas and was designated a UNESCO biosphere reserve on October 28, 2020. List of environmentally protected areas in addu atoll are;

- Eidhigali Kilhi Koattey Area
- Kandihera-Maakandu Channel (Addu Manta Point)
- British Loyalty Shipwreck
- Kuda Kandu Area
- Maakilhi and Feheli Kilhi
- Maafishi Kilhi
- Mathi Kilhi

However, it must be noted that none of these protected areas are in close proximity to the project site which may have any negative impact.

4.7.3. Fuvahmulah City

A notable feature of Fuvahmulah is that approximately one third of the island is composed of protected wetlands and marshlands that surround the two largest freshwater lakes in the Maldives: Bandaara Kilhi and Dhadimagi Kilhi. Fuvahmulah have 3 protected sites namely, Dhandimagu kilhi, Thoondi Area and Farikede Area.

4.8 GROUNDWATER ASSESSMENTS

The following parameters are the baseline water quality of the sites. The water quality test results from the MWSC laboratory are included in Appendix D.

Table 4-7 Water Test Results

#	Sampled Time	Location	Appearance	Temperature °C	Conductivity µS/cm	Salinity ‰	TDS mg/L	pH	Turbidty
1	03/12/2022 16:00	Eydhafushi Project Location	Clear	24.1	640	0.31	320	7.6	0.129
2	03/12/2022 16:00	Eydhafushi Control Site	Clear	23.8	710	0.35	355	7.6	0.106
3	02/12/2022 16:00	Hinnavaru Project Location	Clear	23.8	2460	1.27	1231	7.3	0.209
4	02/12/2022 16:00	Hinnavaru Control Site	Clear	23.8	1044	0.52	522	7.6	0.122
5	17/09/2022 10:00	Hithadhoo Stadium Site	Clear with particles	24.1	749	0.37	375	7.3	0.251
6	17/09/2022 11:00	Hithadhoo Control site	Clear with particles	23.9	1685	0.85	843	7.2	0.224
7	17/09/2022 16:00	Hulhumeedhoo Site	Clear with particles	24.1	948	0.47	474	7.3	0.229
8	17/09/2022 1300	Feydhoo Site	Clear with particles	24.0	924	0.45	462	7.3	0.310
9	09/01/2023	Thinadhoo Site 1	Clear with particles	24.0	784	0.38	392	7.4	<0.1
10	09/01/2023	Thinadhoo Site 2	Clear with particles	24.0	351	0.17	175.7	8.1	0.289
11	06/01/2023	Kulhudhuffushi Airport (Site)	Clear with particles	24.6	2040	1.04	1021	9.1	-

12	06/01/2023	Kulhudhuffushi Control	Clear with particles	24.3	956	0.47	478	7.5	-
13	06/01/2023	Kulhudhuffushi wetland	Clear with particles	24.8	11830	6.74	5910	8.6	1.37
14	13/01/2023	Fuvahmulah Airport (Site)	Clear with particles	24.1	332	0.16	166.2	7.0	0.41
15	13/01/2023	Fuvahmulah Control	Clear with particles	24.8	676	0.33	338	7.4	0.28
16	09/02/2023	Maradhoo Feydhoo	Pale yellow with particles	24.7	918	-	459	7.7	<0.036
17	09/02/2023	Maradhoo Feydhoo (Control)	Pale yellow with particles	24.5	705	-	352	7.6	<0.036
18	09/02/2023	Feydhoo (Control)	Pale yellow with particles	24.7	777	-	389	7.1	<0.036
19	09/02/2023	Hulhumeedhoo (control)	Clear with particles	24.5	442	-	221	7.8	<0.036

4.9 NOISE LEVELS

One of the most significant environmental and health hazards is noise pollution and it is extremely important to determine the baselines noise level near the proposed site.

The noise levels are referenced from the chart below. (Centres for Disease Control and Prevention, 2019)

Table 4-8 Noise Level Reference

Description	Average Sound level in decibels	Typical Response (after routine or repeated exposure)
Softest sound that can be heard	0	Sounds at these dB levels typically does not cause any hearing damages
Normal breathing	10	
Tickling watch	20	
Soft whisper	30	
Refrigerator hum	40	
Normal Conversation	60	
City traffic (inside the car)	80-85	You may feel annoyed
Gas-powered lawnmowers and leaf blowers	80-85	Damage to hearing possible after 2 hours of exposure
Car horn at 5 meters	100	Hearing loss possible after 15 minutes
Maximum volume for personal listening devices	105 - 110	Hearing loss possible in less than 5 minutes
Shouting in the ear	110	Hearing loss possible in less than 2 minutes
Standing beside or near sirens	120	Pain and injury
Fire crackers	140- 150	Pain and injury

The table below indicates the sound meter readings for the respective locations:

Table 4-9 Noise Level

Sample	Administrative location	Date and Time	Location	Average sound level in dB	Max sound level in dB
HKS	Kulhudhuffushi City, Site	22/1/23 17:50	Marked in Appendix B of this document	38.2	50.1
HKR	Kulhudhuffushi City, Nearest Residence	22/1/23 17:40		56.2	66.3
BES	Eydhafushi, Project Site	03/01/23 16:53		64.8	78.5

BER	Eydhafushi Nearest Residence	03/01/23 16:59		49.1	81.4
LHHPS	Hinnavaru Project Site	02/01/23 11:01		38.4	65.2
LHNR	Hinnavaru Nearest Residence	02/01/23 11:13		45.4	56.1
GDTS	Thinadhoo, Project Site	04/01/23 17:59		56.8	71.4
GDTR	Thinadhoo Nearest Residence	04/01/23 17:54		62.7	80.5
SMFS	Maradhoo Feydhoo,Project Site	01/01/23 13:32		64.4	78.5
SMFR	Maradhoo Feydhoo, Nearest Residence	01/01/23 13:29		30.1	72.3
SFS	Feydhoo, Project Site	01/02/23 12:27		21.6	50.9
SFR	Feydhoo, Nearest Residence	01/02/23 12:25		63.8	80.8
SHMS	Hulhumeedhoo, Project Site	02/02/23 15:23		18.6	34.1
SHMR	Hulhumeedhoo, Nearest Residence	02/02/23 15:27		45.7	62.6
SHS	Hithadhoo Project Site	02/02/23 09:15		30.3	67.4
SHR	Hithadhoo, Nearest Residence	02/02/23 09:18		30.3	68.4

4.10 SOIL ASSESMENT

Soil assessments were carried out on all the project locations. The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Borehole / Standard Penetration Test (SPT)
2. Dynamic Cone Penetration (DCP) tests
3. Mackintosh Probe
4. Electrical Resistivity Test
5. Thermal Conductivity Test

Full detailed reports of the Soil Investigations are presented in Appendix I of this report.

4.10.1 KULHUDHUFFUSHI CITY

The assessment showed that site has gravelly sand soil, DCP tests were conducted. As distance from the runway increases, soil softens due to compaction. It is recommended for design purposes, to consider DCP results, even though SPT provides accurate bearing capacity.

4.10.2 B. EYDHAFUSHI

Given that the site's soil is predominantly gravelly sand, the DCP test results are considered more accurate and reliable than those from the MP test. Consequently, it is recommended to utilize the safe bearing capacity of 120 kPa for designing the foundation.

4.10.3 LH. HINNAVARU

As the site's soil consists primarily of gravelly sand, the DCP test results are deemed more accurate and reliable compared to MP test results. Therefore, it is advised to refer to the safe bearing capacity of 150 kPa for foundation design purposes.

4.10.4 G.DH. THINADHOO

The site features gravelly sand soil, making the DCP test results both more accurate and reliable than those from the MP test. It is recommended to utilize the safe bearing capacity of 170 kPa when designing the foundation.

4.10.5 FUVAHMULAH CITY

This report presents safe bearing capacity values determined using two sets of equations and provides a discussion and recommendations for boreholes BH1 and BH2. While both boreholes exhibit varying (N1)60 values at depths between 1.5 and 6 meters, only two boreholes were investigated. To ensure safety, it is advisable to use the lower value of the two as the safe bearing capacity. Therefore, we recommend adopting a safe bearing capacity of 185 kPa for foundation design purposes.

4.10.6 ADDU CITY

4.10.6.1 HITHADHOO STADIUM

In this report, safe bearing capacities for boreholes BH1 and BH2 are calculated using two equations, with varying (N1)60 values at 1.5-3m depths. Given only two boreholes were studied, using the lower value is safer. Therefore, a 197 kPa safe bearing capacity is recommended for foundation design.

4.10.6.2 MARADHOO FEYDHOO HARBOR

The report calculates safe bearing capacities for BH1 and BH2 using two equations and discusses their varying (N1)60 values at depths of 1.5-3m. Since only two boreholes were examined, it's safer to use the lower value. A 197 kPa safe bearing capacity is recommended for foundation design.

4.10.6.3 FEYDHOO HARBOR

The report discusses safe bearing capacities for BH1 and BH2, calculated with two equations, and notes their different (N1)60 values at depths of 1.5-3m. As only two boreholes were studied, using the lower value is safer. Therefore, a 185 kPa safe bearing capacity is recommended for foundation design.

4.10.6.4 HULHUMEEDHOO STP

This report evaluates safe bearing capacities for BH1 and BH2 using two equations, noting their different (N1)60 values at 1.5-3m depths. With only two boreholes studied, it's safer to use the lower value. A 197 kPa safe bearing capacity is recommended for foundation design

4.11 TRAFFIC SURVEYS

Traffic surveys were not done in some islands due to the number of vehicles being less. The locations where these were taken are marked in Appendix of this document.

4.11.1 KULHUDHUFFUSHI CITY

The project site is the airport site, and therefore, a traffic survey was conducted in the adjacent road of the airport.

The traffic survey was conducted on the 20th January 2023 from a time period starting from 09:50 to 10:00, and 17:40 to 17:50. During this time, it is of note that the traffic flow was smooth, without any congestions or halts.

The following table describes the results.

Table 4-10 Kulhudhuffushi City Traffic Survey between 09:50 to 10:00

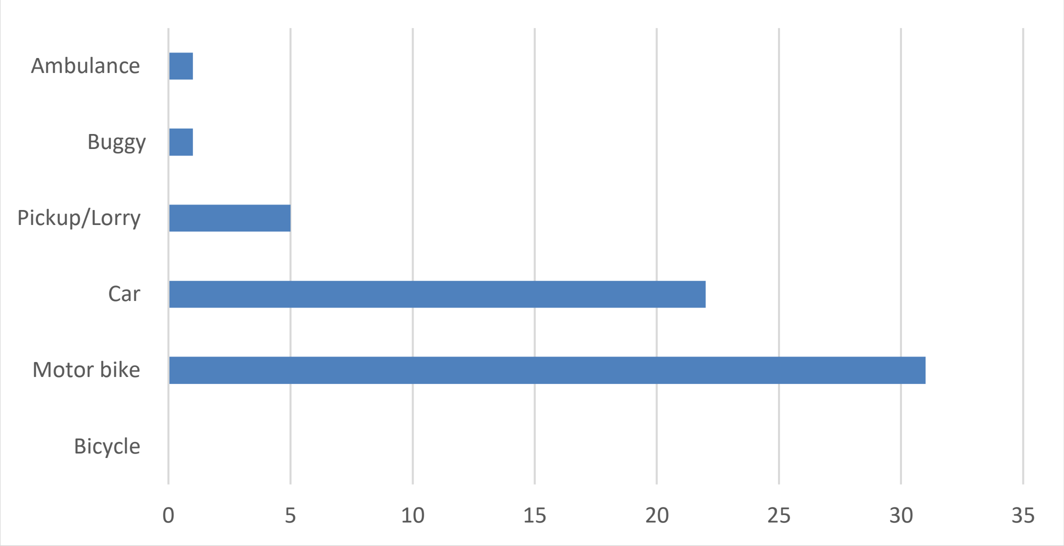
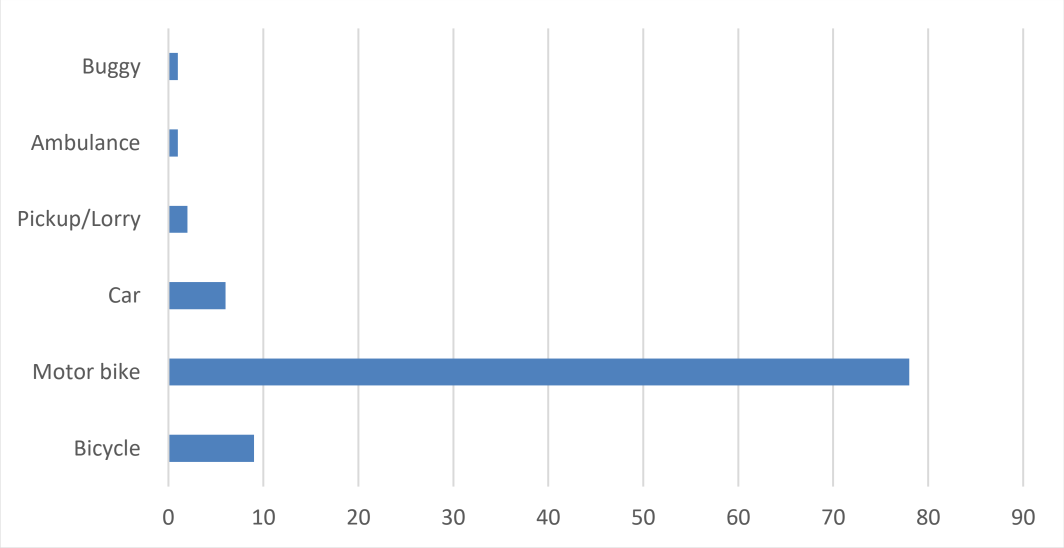


Table 4-11 Kulhudhuffushi City Traffic Survey between 17:40 to 17:50



4.11.2 LH. HINNAVARU

The project site is located at the north western end of the reclaimed area of the island where it is currently undeveloped. Therefore, the traffic in the area was very low, and the number of vehicles in the island is accounted from the council records as of 2nd December 2022.

Table 4-12 Hinnavaru Total Number of Vehicles

Type	Number
Motorcycle	110
Car	4
Ambulance	2
Pickup	4
‘Rashupickup’ (3 wheeled electric pickup’)	35

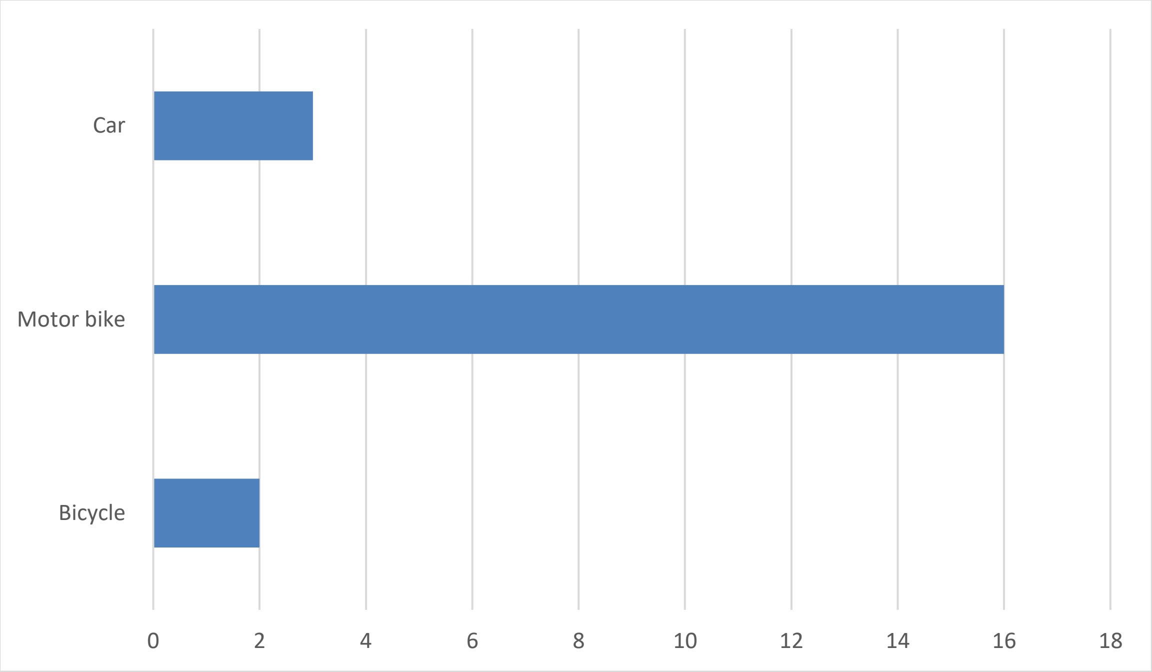
4.11.3 B. EYDHAFUSHI

The project site is the reclaimed area of the island where it is currently undeveloped for the most part. Therefore, traffic was very low, and the traffic survey was conducted within the urbanised area of the island.

The traffic survey was conducted on the 3rd December 2022 from a time period starting from 1637 to 1647. During this time, it is of note that the traffic flow was smooth, without any congestions or halts.

The following table describes the results.

Table 4-13 Eydhafushi Traffic Survey between 16:37 to 16:47



4.11.4 G.DH. THINADHOO

The traffic survey was conducted on the 4th of January 2023 from a time period starting from 1745 to 1755. During this time, it is of note that the traffic flow was smooth, without any congestions or halts.

The following table describes the findings of the traffic survey.

Table 4-14 Thinadhoo Traffic Survey between 13:25 to 13:35

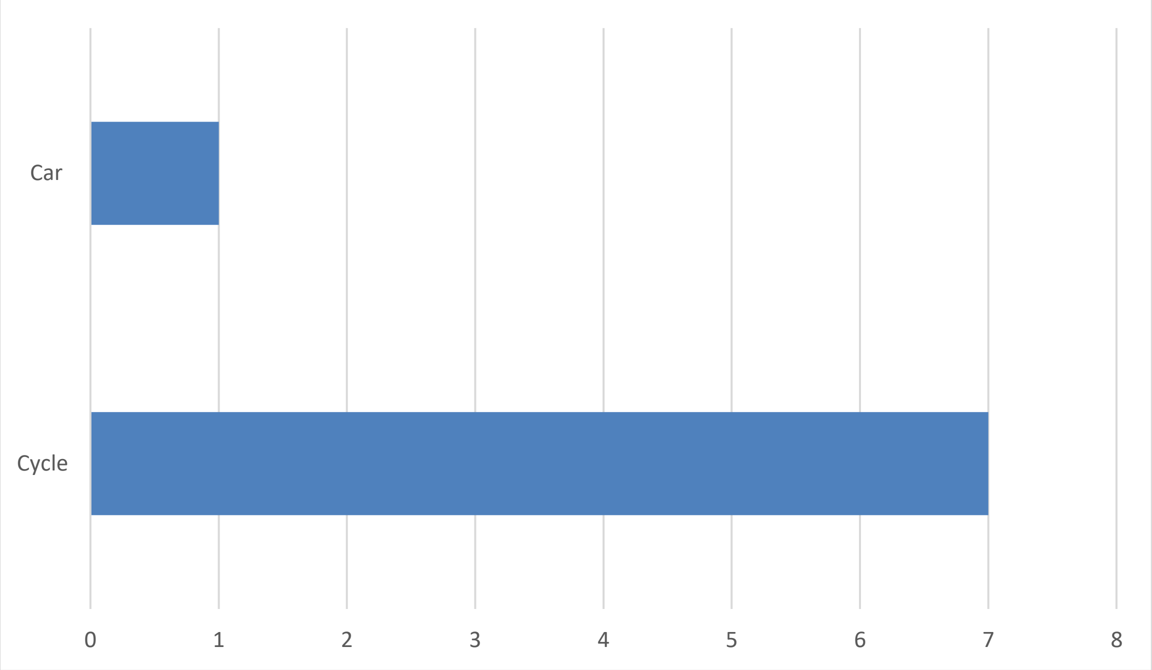
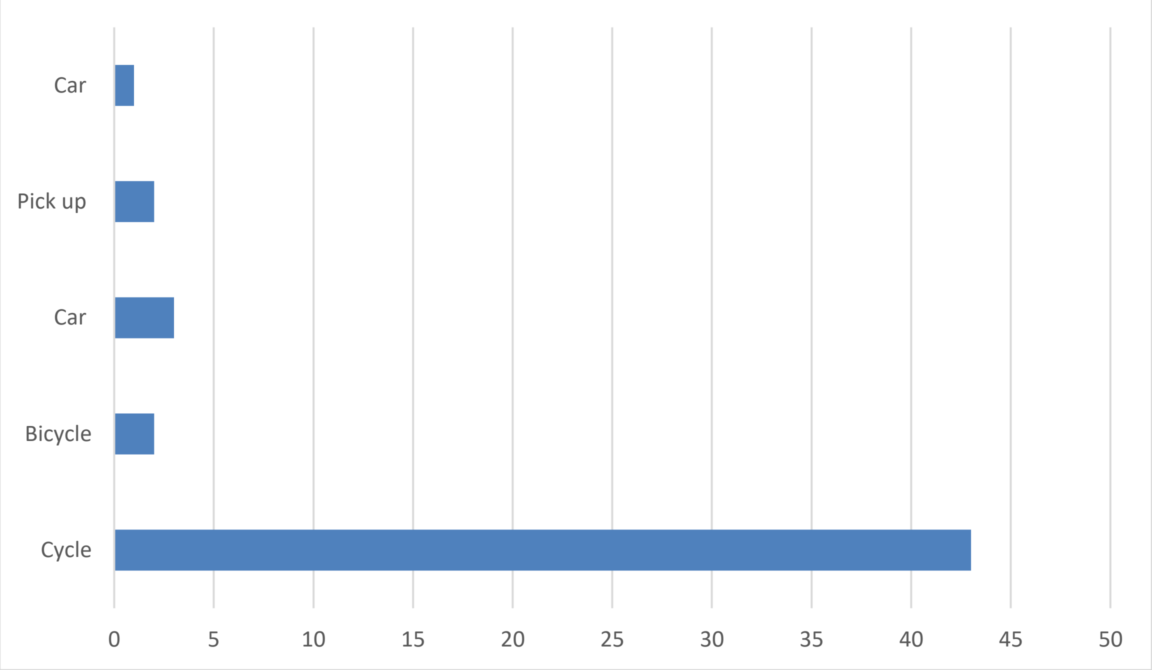


Table 4-15Thinadhoo Traffic Survey between 17:45 to 17:55



4.11.5 FUVAHMULAH CITY

The project site is the airport site, and therefore, a traffic survey was conducted in the adjacent road of the airport.

The traffic survey was conducted on the 11th March 2023. It is of note that the traffic flow was smooth, without any congestions or halts.

Figure 4-11 Fuvahmulah Traffic Survey between 13:04 to 13:14

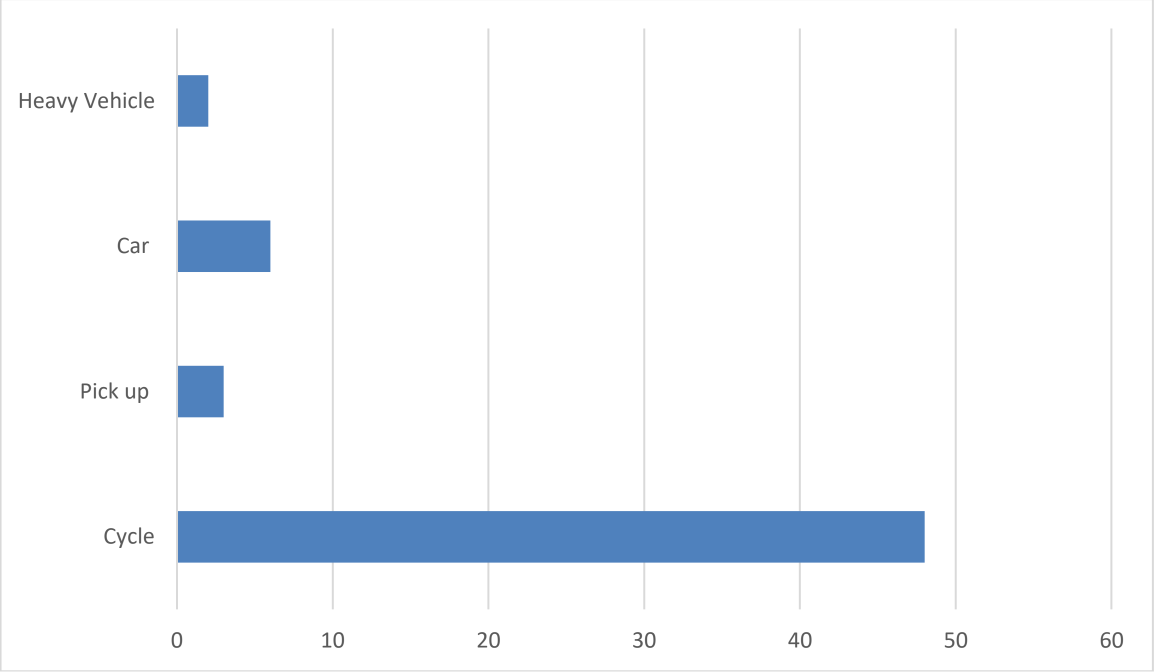
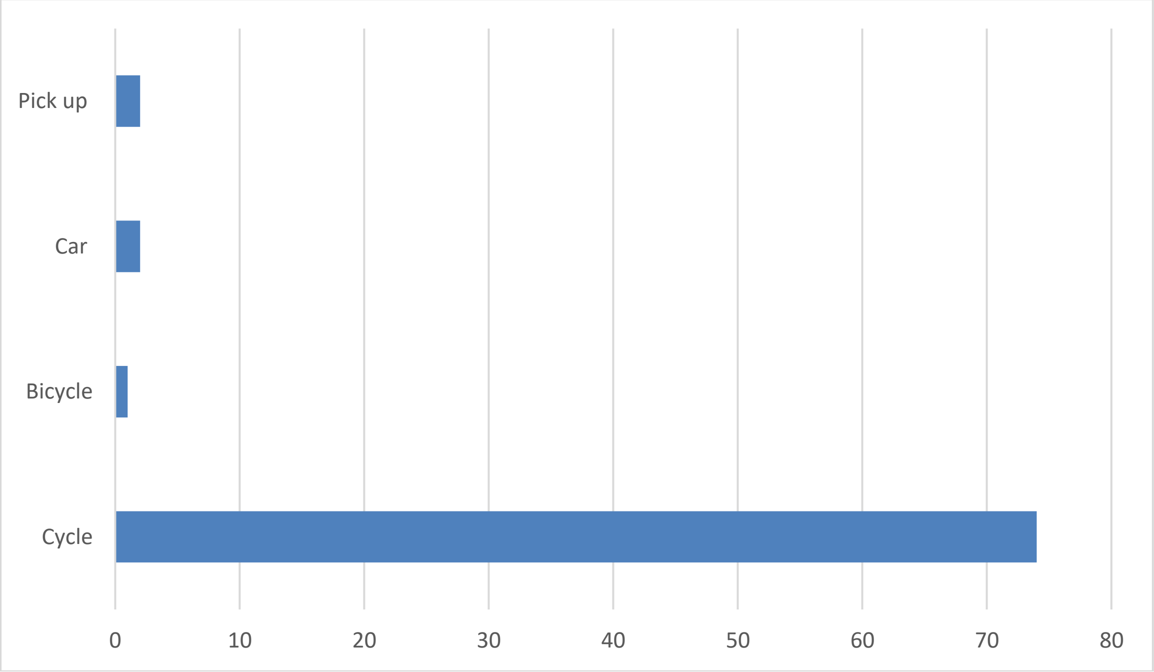


Table 4-16Fuvahmulah Traffic Survey between 17:32 to 17:42



4.11.6 ADDU CITY

4.11.6.1 HULHUMEEDHOO

The project site is near the waste centre far away from the residential area, and therefore, a traffic survey was conducted in the road connecting the road and the residential area.

The traffic survey was conducted on the 2nd February 2023. It is of note that the traffic flow was smooth, without any congestions or halts.

Figure 4-12 Hulhumeedhoo Traffic Survey between 12:10 to 12:20

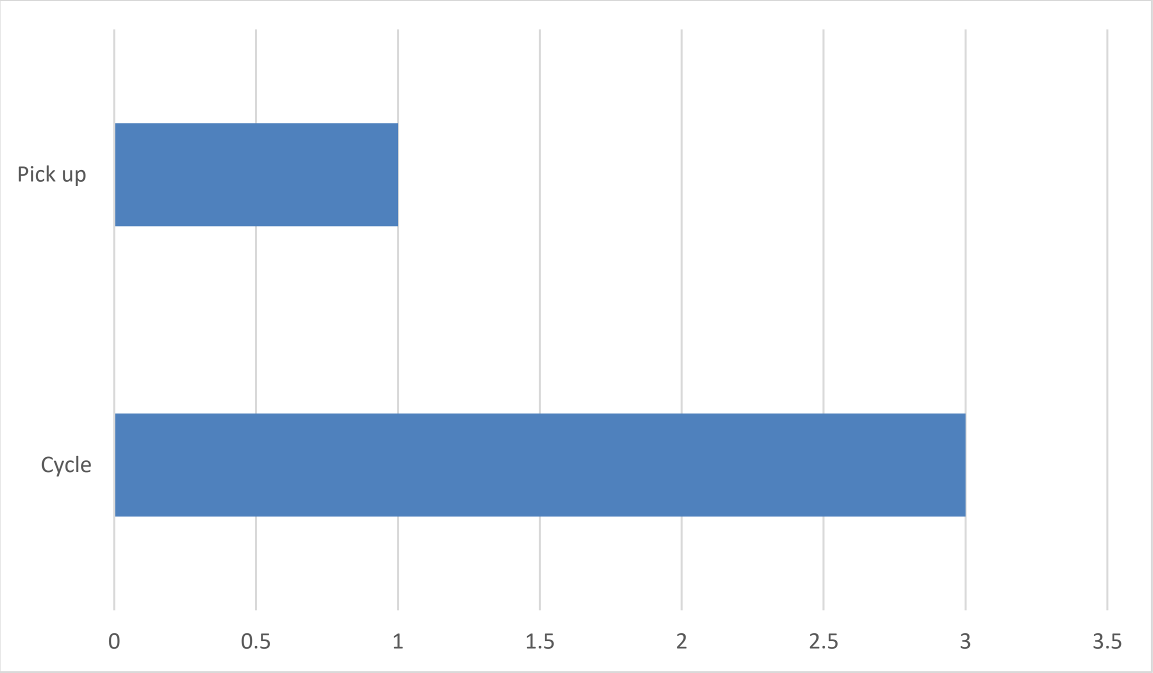
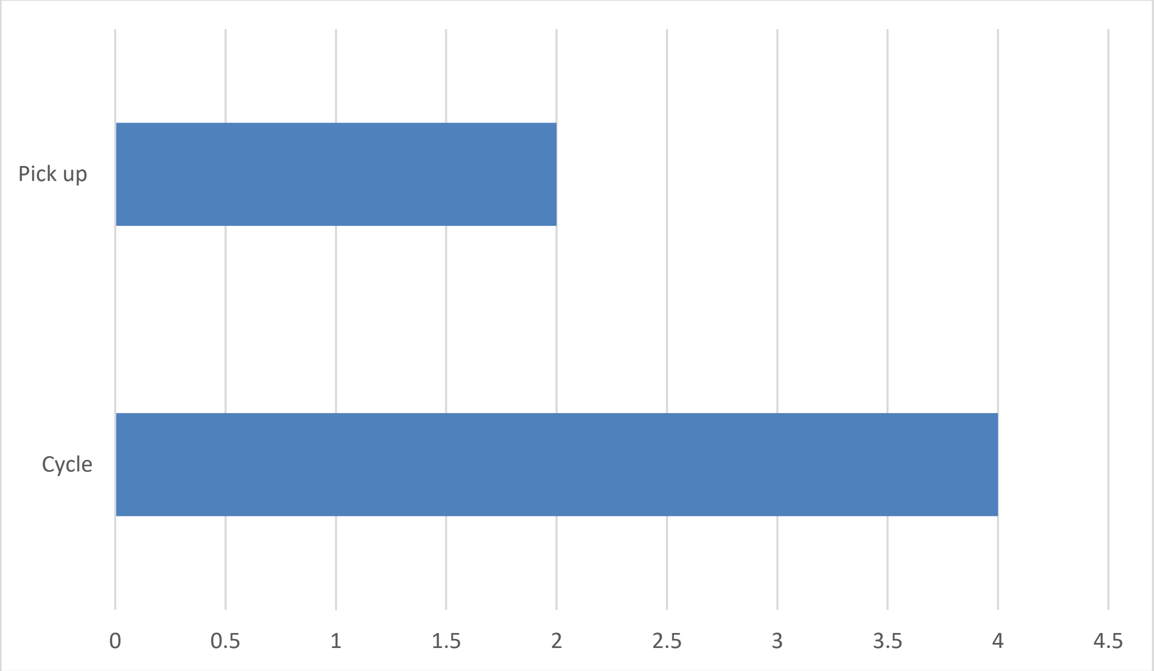


Figure 4-13 Hulhumeedhoo Traffic Survey between 16:41 to 16:51



4.11.6.2 FEYDHOO

The project site is in the outer ring road which makes it the busiest road of the island.

The traffic survey was conducted on the 4th March 2023. It is of note that the traffic flow was smooth.

Figure 4-14 Feydhoo Traffic Survey between 09:06 to 09:16

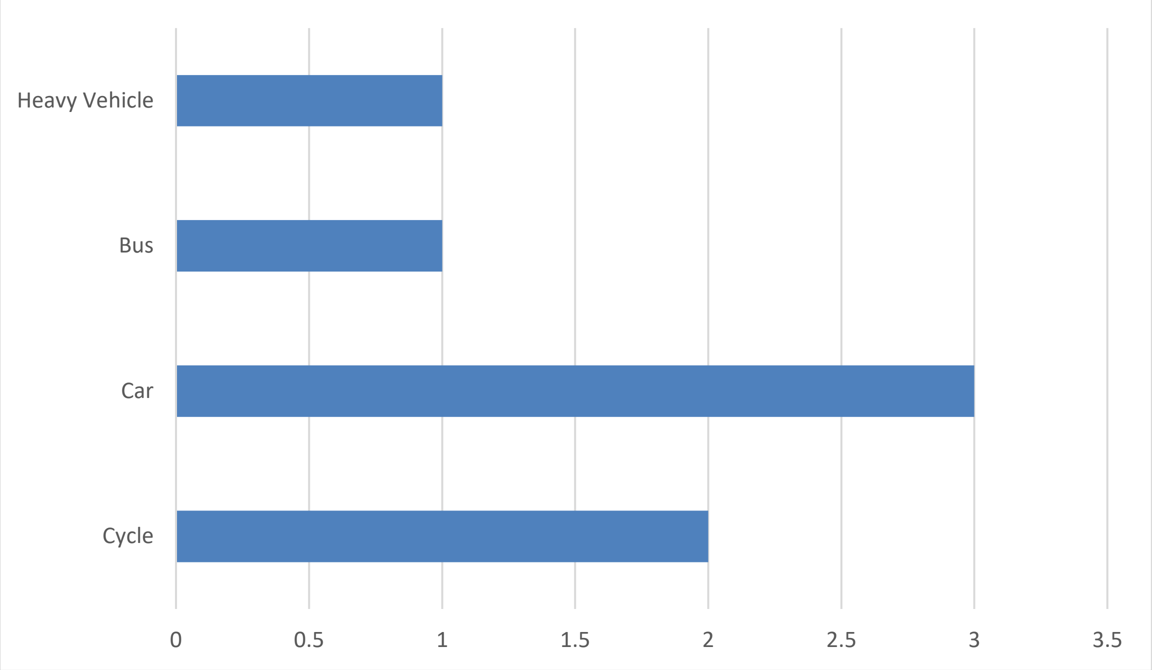
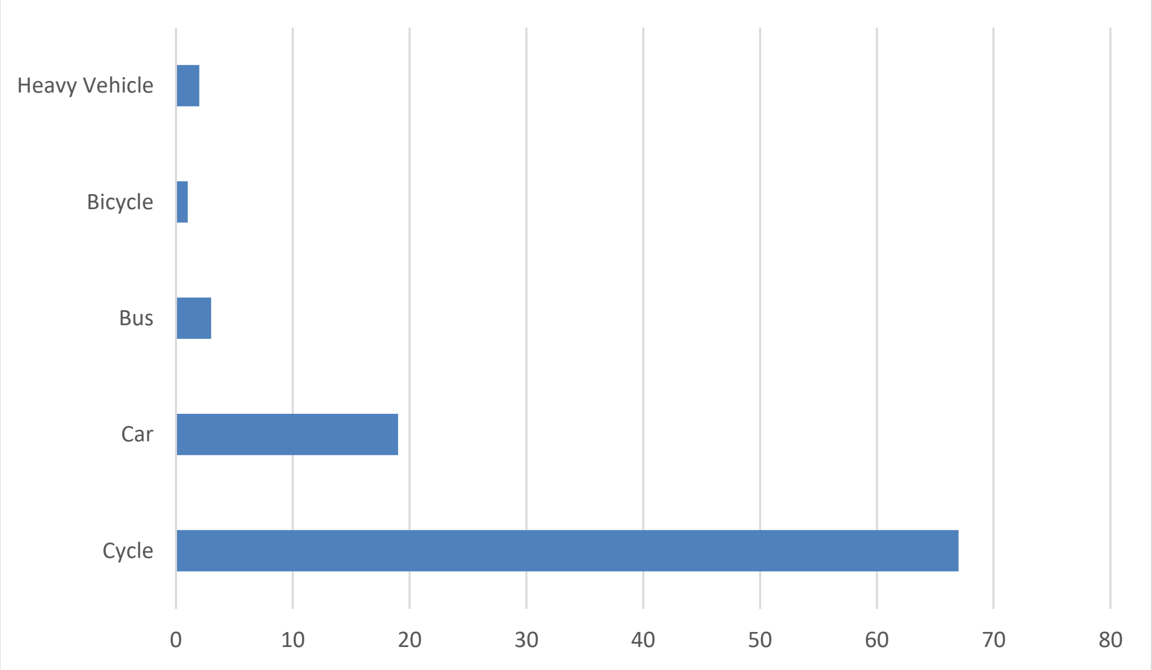


Figure 4-15Feydhoo Traffic Survey between 16:22 to 16:22



4.11.6.3 MARADHOO FEYDHOO

The project site is in the outer ring road which makes it the busiest road of the island.

The traffic survey was conducted on the 4th March 2023. It is of note that the traffic flow was smooth, without any congestions or halts.

Figure 4-16 Maradhoo Feydhoo Traffic Survey between 09:20 to 09:30

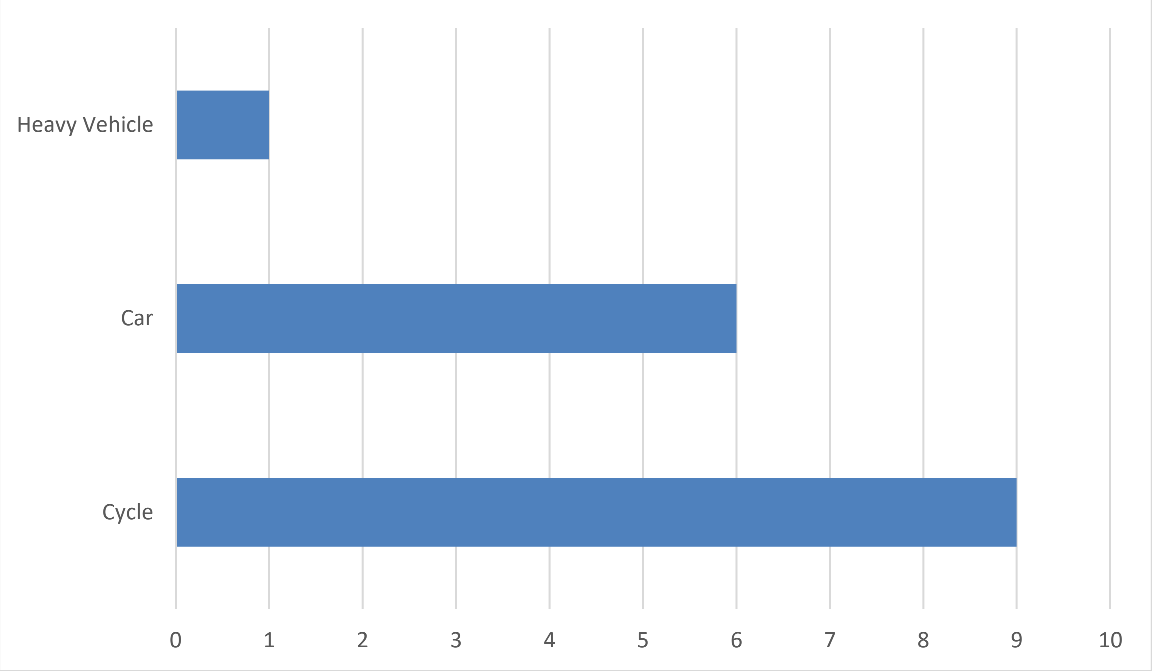
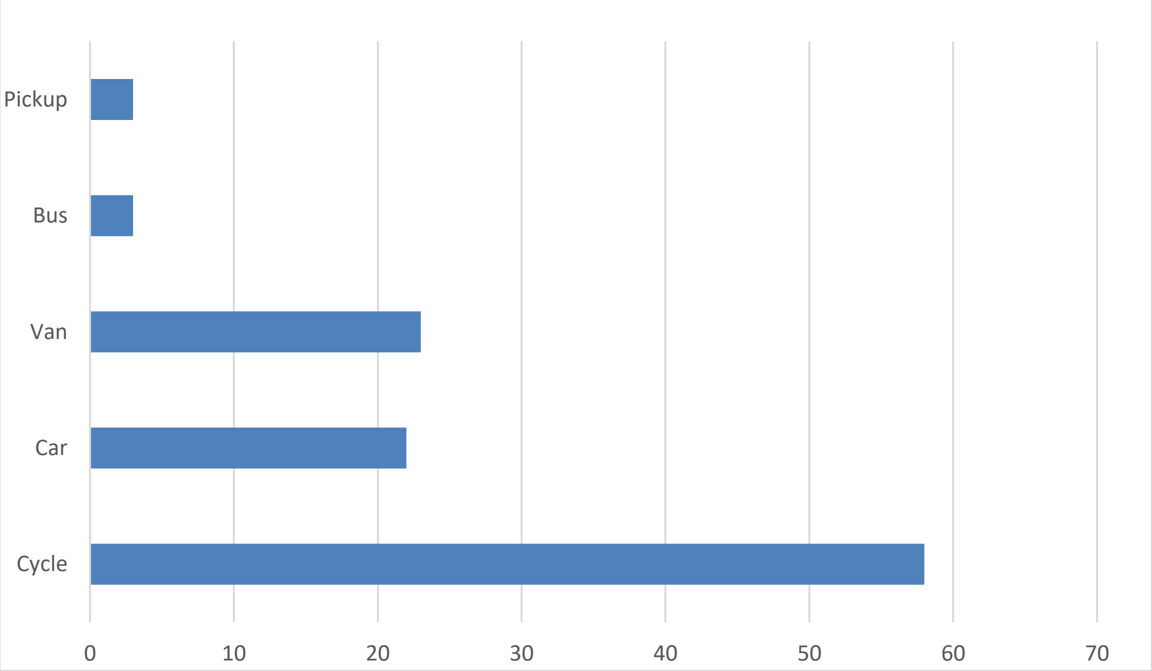


Figure 4-17 Maradhoo Feydhoo Traffic Survey between 16:05 to 16:15



4.11.6.4 HITHADHOO

The project site is right outside the stadium area and this area is right inside the outer ring road. Hence, the traffic is really low in this area.

Figure 4-18 Hithadhoo Stadium Traffic Survey between 10:10 to 10:20

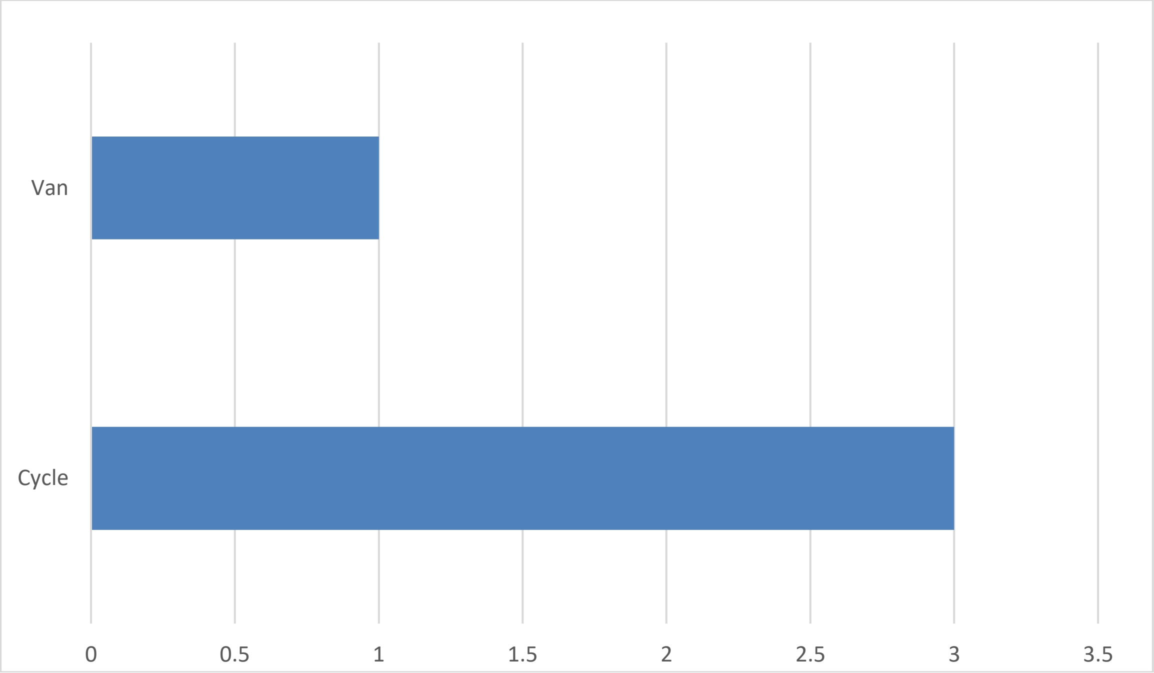
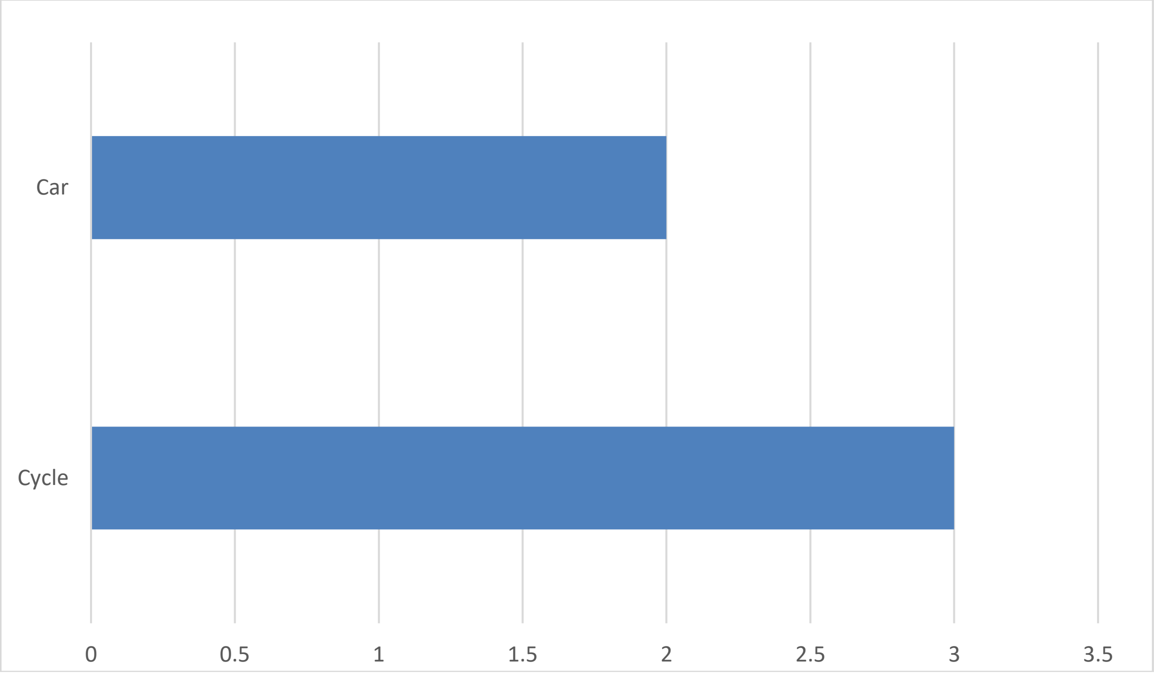


Figure 4-19Hithadhoo Stadium Traffic Survey between 17:33 to 17:43



4.12 TERRESTRIAL VEGETATIONS

4.12.1 KULHUDHUFFUSHI CITY

As the project site is within the airport boundaries, mature tall trees are not present. In this regard, significant vegetation clearance of trees is not expected. However, to lay the concrete support footings shrubs and low laying grasses needs to be cleared.

Figure 4-20 Kulhudhufushi Site

4.12.2 B. EYDHAFUSHI

The site is a relatively new reclaimed area and therefore mature trees in the project site are not present. However, few shrubs near the outskirts of the project boundary is present

Figure 4-21 Eydhafushi Reclaimed Area Project Site

4.12.3 LH. HINNAVARU

The site is a relatively new reclaimed area and therefore mature trees in the project site are not present. However, few shrubs near the outskirts of the project boundary is present

Figure 4-22 Hinnavaru Proposed Site Area

4.12.4 G.DH. THINADHOO

The site proposed, encompasses a reclaimed area. Since it has been reclaimed few shrubs are near the outskirt. This site goes from one end to the other of the island. The area has some mature trees.

The area is not densely vegetated; however, coconut palms and beefwood trees of approximate age of 6-7 years are present in the area. The number of palm trees are 25.

Figure 4-24 Aerial overview of the site

Figure 4-23 Eye-level view of the site

4.12.5 FUVAHMULAH CITY

The project site is within the airport boundaries and divided into two sites. One on the northern side which is 7560 square meter and on the northern side of the airport a total area of 18980 square meter. On the northern side of the runway mature tall trees are present. Northern part of the project area boundary is heavily vegetated and needs to be removed.

The area was so heavily vegetated (Figure 4-27) there were difficulties in accessing most of the areas. Hence, the vegetation was surveyed using high definition aerial photography with high accuracy and ground truthing undertaken by visually inspecting the area to generalize the abundance of trees within clearance areas. 32 mature coconut palm trees were inspected in the project boundary which needs to be uprooted and planted in a place where the council identifies. The areas vegetation is the common type of vegetation seen in the Maldives. The following species of vegetation were present in the area Boashi (*Tournefortia argentea*), Nika (*Ficus benghalensis*), Uni (*Guettarda speciose*), Boa kashikeyo (*Pandanus tectorius*), Magoo (*Scaevola taccada*), Ruh (*Cocos nucifera*), Kaani (*Cordia subcordata*) and Dhigga (*Talipariti tiliaceum*). However the project boundary was mainly dominated by Magoo.

In this regard, significant vegetation clearance of trees expected. However, to lay the concrete support footings shrubs and low laying grasses needs to be cleared.

Figure 4-25 Aerial View of the project Site

Figure 4-26 Eye level view of Southern Project Site

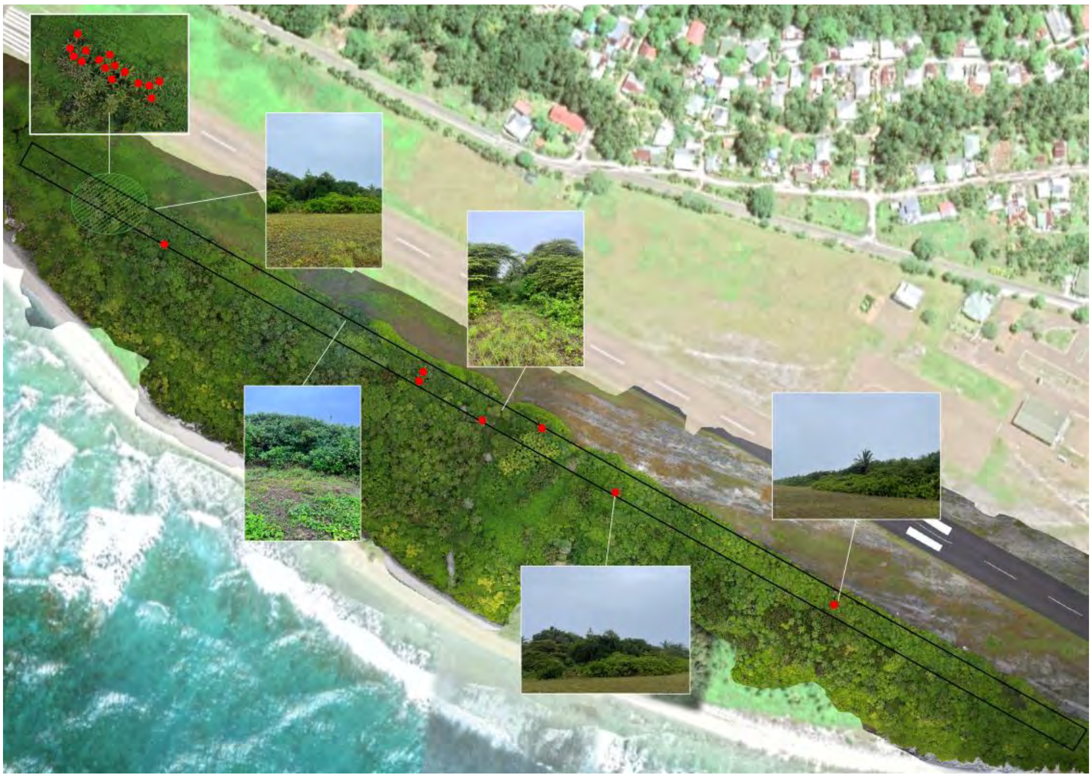


Figure 4-27 Depth Map of the vegetation on northern side

4.12.6 ADDU CITY

4.12.6.1 HULHUMEEDHOO

The proposed site is an area that was used as a landfill, prior to construction of Island Waste Management Waste Centre. There were shrubs and some invasive vegetation present in the area and would need removal.

Figure 4-28 Aerial view of Hulhumeedhoo project Site

Figure 4-29 Eye level viiew of Hulhumeedhoo Site

4.12.6.2 FEYDHOO

Feydhoo Harbour area allocated for the project works is a recently reclaimed area. The area is the west and east side of the harbour. While small trees and shrubs are present at the outskirts of the project area, no significant overlaps in vegetation present at the area was observed to the project plots.

Figure 4-31 Feydhoo Harbor West Site aerial view

Figure 4-30 Feydhoo Harbour South Aerial View

4.12.6.3 MARADHOO FEYDHOO

Similar to Feydhoo site, Maradho Feydhoo Harbour area allocated for the project works is a recently reclaimed area. While juvenile ruh (Cocos nucifera) and shrubs are present at the outskirts of the project area, no significant overlaps in vegetation were present at the area of the project plots.

Figure 4-32 Maradhoo Feydhoo Project Site Aerial View

Figure 4-33 Maradhoo Feydhoo Harbor Eye Level View

4.12.6.4 HITHADHOO

Hithadhoo stadium area adjacent to a football pitch with running track, together with volley ball courts and a basketball court. The site is divided into two parts North side and South side of the mentioned sports stadium. Within the project boundary of the north some vegetation were presented. There were 11 Dhigga (*Talipariti tiliaceum*), 4 Ruh (*Cocos nucifera*) and 1 Nika (*Ficus benghalensis).*

Figure 4-34Hithadhoo Stadium East project side Aerial View

Figure 4-35 Hithadhoo West project Site aerial view

4.13 BUILT ENVIRONMENT

Visual observations were made to check the surrounding environment of the project site. To cover a wider area drone pictures were used. In addition to the use of drones, utility service providers were consulted to determine the location of service lines that run under the project site. The underground of the area was surveyed using different methods.

4.13.1 KULHUDHUFFUSHI CITY

The proposed site location for the Kulhudhuffushi City is the airport area of the island.
Apart from the established airport infrastructures, there is a MWSC water plant in close proximity which is around Depth Map of the vegetation on northern side 0.05km to the project site. However, from the meeting with the city council, the process of relocating the plant is ongoing.

Figure 4-36 MWSC Water Plant

4.13.2 EYDHAFUSHI

The proposed project site is located in a reclaimed area that is largely undeveloped. The closest existing infrastructure to the site includes the Island Waste Management Centre, which is approximately 0.01km away, and a children's park, which is approximately 0.02km away. Given that the area has recently been reclaimed, there is limited existing infrastructure in place.
The following aerial images indicates the adjacent built environment to the project sites.

Figure 4-37The Island Waste Management Centre of Eydhafushi

Figure 4-38 Eydhafushi Stadium Area

4.13.3 LH. HINNAVARU

The proposed land area of the project is a reclaimed area which is to date undeveloped to the most part.

Figure 4-39 Proposed Site area for Hinnavaru

4.13.4 G.DH. THINADHOO

The proposed site area does not include any built infrastructures, and is mostly vegetated areas with small intersecting walk paths.

Figure 4-40 Thinadhoo Project Site

4.13.5 FUVAHMULAH CITY

The proposed site location for the Fuvahmulah City is the airport area of the island. Adjacent to the proposed site on the southern side, approximately 0.05km away, is a historical area called "Vasha Veyo." Shown in figure 4-41.

Figure 4-41 Vasho Veyo near Project Site

4.13.6 ADDU CITY

4.13.6.1 HULHUMEEDHOO

The site is located adjacent to the periphery wall of the sewerage treatment plant and is bordered by the Island Waste Management Centre, Underneath the project site household small garbage such as ovens, washing machines etc observed hence the proponent would need to clear this area pre construction.

The waste generated by clearing the area shall be taken to WAMCO site by the proponent whereas the waste will be safely handled by them.

Figure 4-42 Island Waste Management Center

4.13.6.2 FEYDHOO

Feydhoo Harbour area allocated for the project works is a recently reclaimed area. It is of note that no infrastructure overlaps with the project boundary, and therefore, no site clearance in the sense of demolition is expected.

Figure 4-43Feydhoo Project Site

4.13.6.3 MARADHOO FEYDHOO HARBOUR

Similar to Feydhoo harbour area, no infrastructure overlaps with the project boundary, and therefore, no site clearance in the sense of demolition is expected.

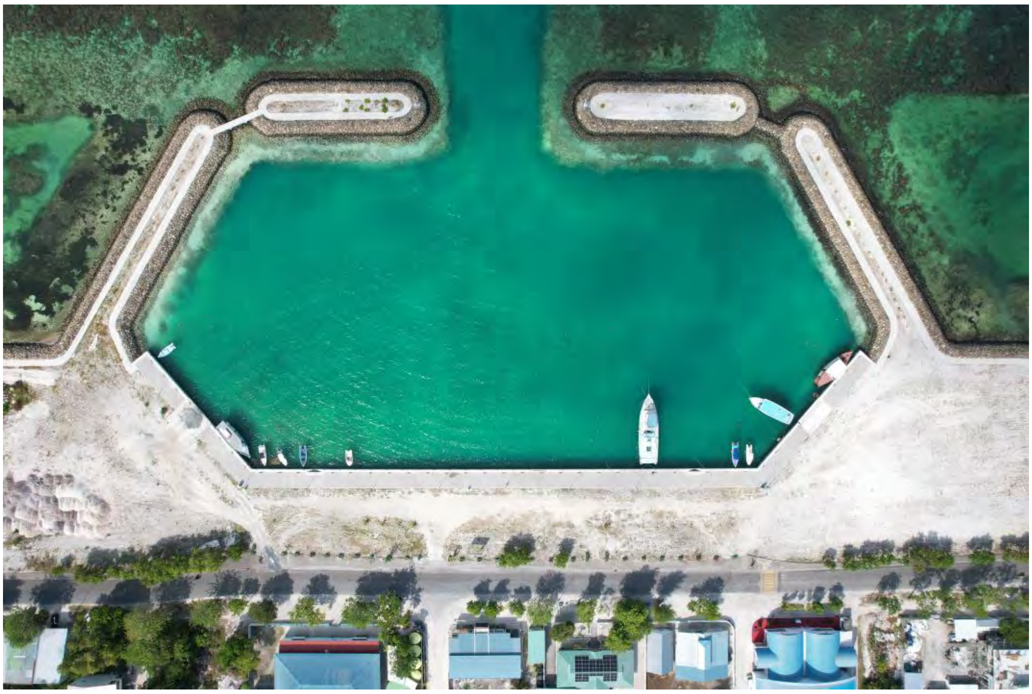


Figure 4-44Maradhoo Feydhoo Project Site

4.13.6.4 HITHADHOO

The proposed site is on two sides of the Hithadhoo Stadium. On the project site on the west side road lamp posts are seen and underneath cables of the light systems are laid out.

Within the project boundary of the north a newly built outdoor gym has been built. The design will be adjusted in order to facilitate the gym by using the Solar PV system to shade the outdoor gym.

Figure 4-46 Hitadhoo West Project Site Lamp Posts

Figure 4-45 Hithadhoo East Outdoor Gym

4.14. GLARE ASSESSMENT FOR THE AIRPORT SITES

Glare studies were conducted for the project sites within airport sites (Kulhudhuffushi and Fuvahmulah).

The study reports are in Appendix E.

5 SOCIO-ECONOMIC ENVIRONMENT

5.1 POPULATION

The islands/ city-regions selected for this project is amongst the most populous regional hubs, due to its administrative significance, economic and social importance.

5.1.1 KULHUDHUFFUSHI CITY

Kulhudhuffushi City is the most populous island in the northern region of the Maldives, with a registered population of 9,838; out of which 4,798 are females and 5040 are males (President's Office , 2023).

5.1.2 B. EYDHAFUSHI

B. Eydhafushi, the administrative capital of Baa Atoll is the atoll’s most populous island with a resident population of 3,339; out of which 1600 are females and 1739 are males (President's Office , 2023).

5.1.3 LH. HINNAVARU

Hinnavaru is the most populous island of Lhaviyani atoll, after its capital Naifaru. The registered resident population of Hinnavaru is 4,873; out of which 2392 are females and 2481 are males (President's Office, 2023).

5.1.4 G.DH. THINADHOO

G.Dh Thinadhoo, the atoll capital has a registered resident population of 7,456; out of which 3,678 are females and 3,778 are males (President's Office , 2023).

5.1.5 FUVAHMULAH CITY

Fuvahmulah, the nation's only single island administrative atoll has a resident population of 12,790; out of which 6,270 are females and 6,520 are males (President's Office , 2023).

5.1.6 ADDU CITY

As a whole, excluding the Greater Male' region, Addu City is the biggest population carrier of the nation.

The resident population disaggregated data of Addu City's population is indicated in the following table 5-1 (President's Office , 2023).

Table 5-1 Addu Population

Island/ Sub region	**Population**	**Female**	**Male**
Hithadhoo	16,040	7,885	8,155
Maradhoo	3,652	1,793	1,859
Maradhoo-Feydhoo	1,850	913	937
Feydhoo	5,508	2,675	2,833
Meedhoo	2,953	1,448	1,505
Hulhudhoo	3,687	1,799	1,910
Total	**33,690**	**16,513**	**17,199**

5.2 ECONOMIC ACTIVITIES

5.2.1 KULHUDHUFFUSHI CITY

Kulhudhuffushi is the capital of Thiladhumathi Dhekunuburi or H.Dh Atoll. It is of note that island is the fourth administrative region to gain the city status. The island is an economic hub where visitors from neighbouring islands are drawn into, for trade purposes. Additionally, the island has an established seaport where 30% import duty exemption is applicable to selected goods. With regard to the registered tourist facilities, the island has one guest house (Ministry of Tourism, 2023).

Table 5-2 Economic Activities of Kulhudhuffushi City

Employment by sector/Industry	Service sector (61%), Agriculture (10%), other industries (28%)
Labour force participation rate	56.1 %
Average earning Men	MVR 74.89/hr
Average earning Women	MVR 74.89/hr

5.2.2 EYDHAFUSHI

Eydhafushi is the atoll capital and has been serving as a regional economic and social services hub. The island houses regional branches of public offices and state-owned companies. In this regard, many of the residents hold government employment. Additionally, many of the islanders are employed in the neighbouring tourist establishments. The number registered tourist facilities in the island are 1 (Ministry of Tourism, 2023).

Table 5-3 Eydhafushi Economic Activities

Employment by sector/Industry	Service sector (67%), Agriculture (10%), other industries (28%)
Labour force participation rate	52.5 %
Average earning Men	MVR 56.95/hr
Average earning Women	MVR 68.43/hr

5.2.3 HINNAVARU

The number of registered tourist facilities in the island is 1 (Ministry of Tourism, 2023). The employment distribution of the island and income distribution is indicated below (National Bureau of Statistics, 2016).

Table 5-4 Hinnavaru Economic Activities

Employment by sector/Industry	Service sector (68%), Agriculture (18%), other industries (21%)
Labour force participation rate	48.7 %
Average earning Men	MVR 57.92/hr
Average earning Women	MVR 44.27/hr

5.2.4 THINADHOO

The number registered of tourist facilities in the island is 1 (Ministry of Tourism, 2023). The employment distribution of the island and income distribution is indicated below (National Bureau of Statistics, 2016).

Table 5-5 Thinadhoo Economic Activities

Employment by sector/Industry	Service sector (68%), Agriculture (18%), other industries (21%)
Labour force participation rate	48.7 %
Average earning Men	MVR 57.92/hr
Average earning Women	MVR 44.27/hr

5.2.5 FUVAHMULAH CITY

Fuvahmulah's economy is embedded and interweaved with its unique and diverse natural beauty. The island has 19 registered tourist facilities, indicating the flourishing and healthy tourism industry (Ministry of Tourism, 2023). The employment distribution of the island and income distribution is indicated below (National Bureau of Statistics, 2016).

Table 5-6 Fuvahmulah Economic Activities

Employment by sector/Industry	Service sector (68%), Agriculture (9%), other industries (21%)
Labour force participation rate	48.7 %
Average earning Men	MVR 55.99/hr
Average earning Women	MVR 57.17/hr

5.2.6 ADDU CITY

Addu is amongst the economic hubs of the Maldives. The registered tourist facilities in the city is 22 (Ministry of Tourism, 2023).

The employment distribution of the island and income distribution is indicated below (National Bureau of Statistics, 2016).

Table 5-7 Addu City Economic Activities

Employment by sector/Industry	Service sector (74%), Agriculture (5%), other industries (20%)
Labour force participation rate	46.1 %
Average earning Men	MVR 60.78/hr
Average earning Women	MVR 54.09/hr
Average Household expenditure (Monthly) (Maldives Bureau of Statistics, 2019)	MVR 22,375

5.3 TRANSPORTATION MEANS

5.3.1 Kulhudhuffushi City

Kulhudhuffushi enjoys the services of seaport and a regional airport within the island. Furthermore, the inter-island highspeed ferry system (RTL) of H.Dh Atoll is centralised to the island.

Furthermore, Hanimaadhoo International Airport is approximately 16 km away from the island.

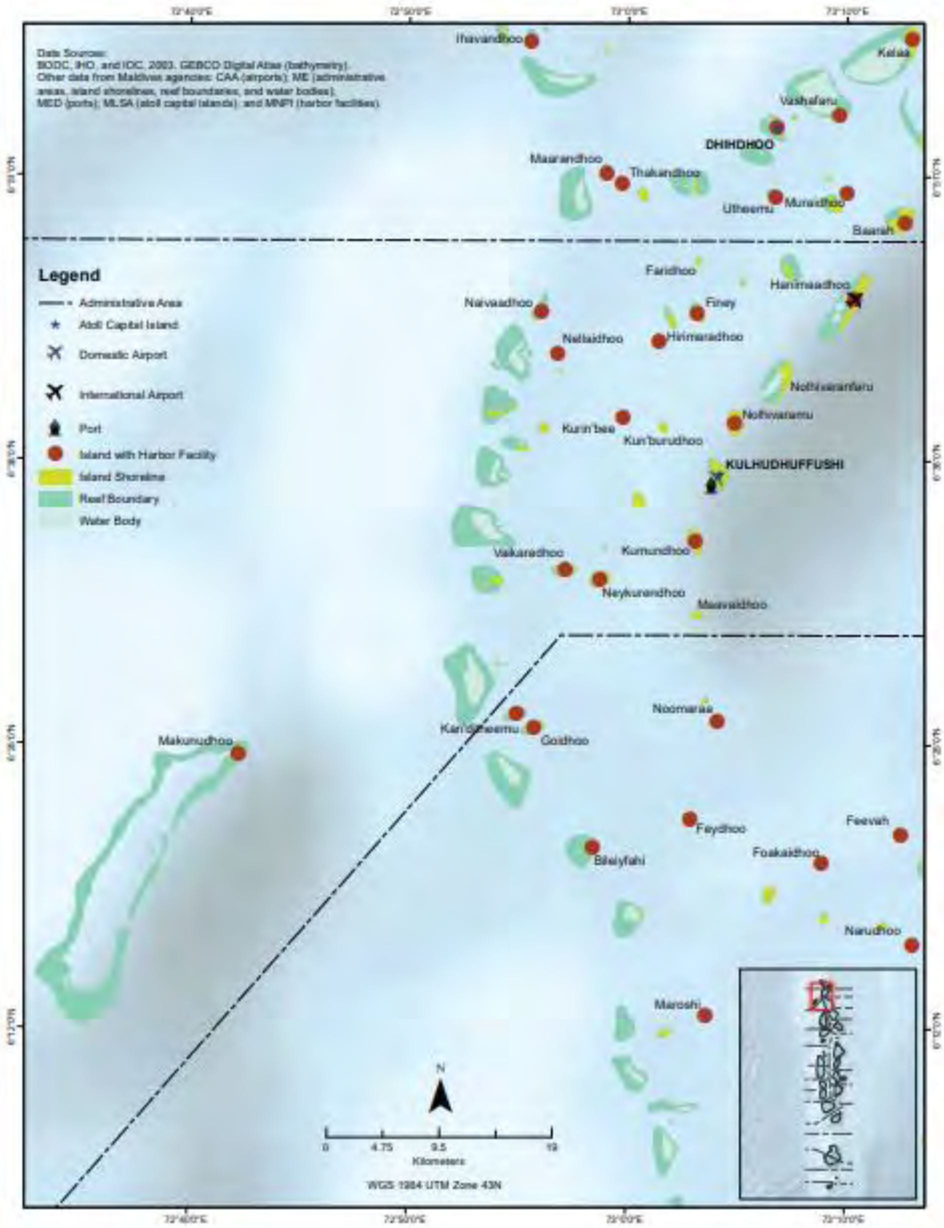


Figure 5-1 Transportation means of H.Dh Atoll, map (ADB, 2020)

5.3.2 Eydhafushi

Eydhafushi has an established harbor facilitating inter and intra atoll transfers of passengers and goods. The closes airport is the regional airport of B. Dharavandhoo which is approximately 8.5 km from the island.

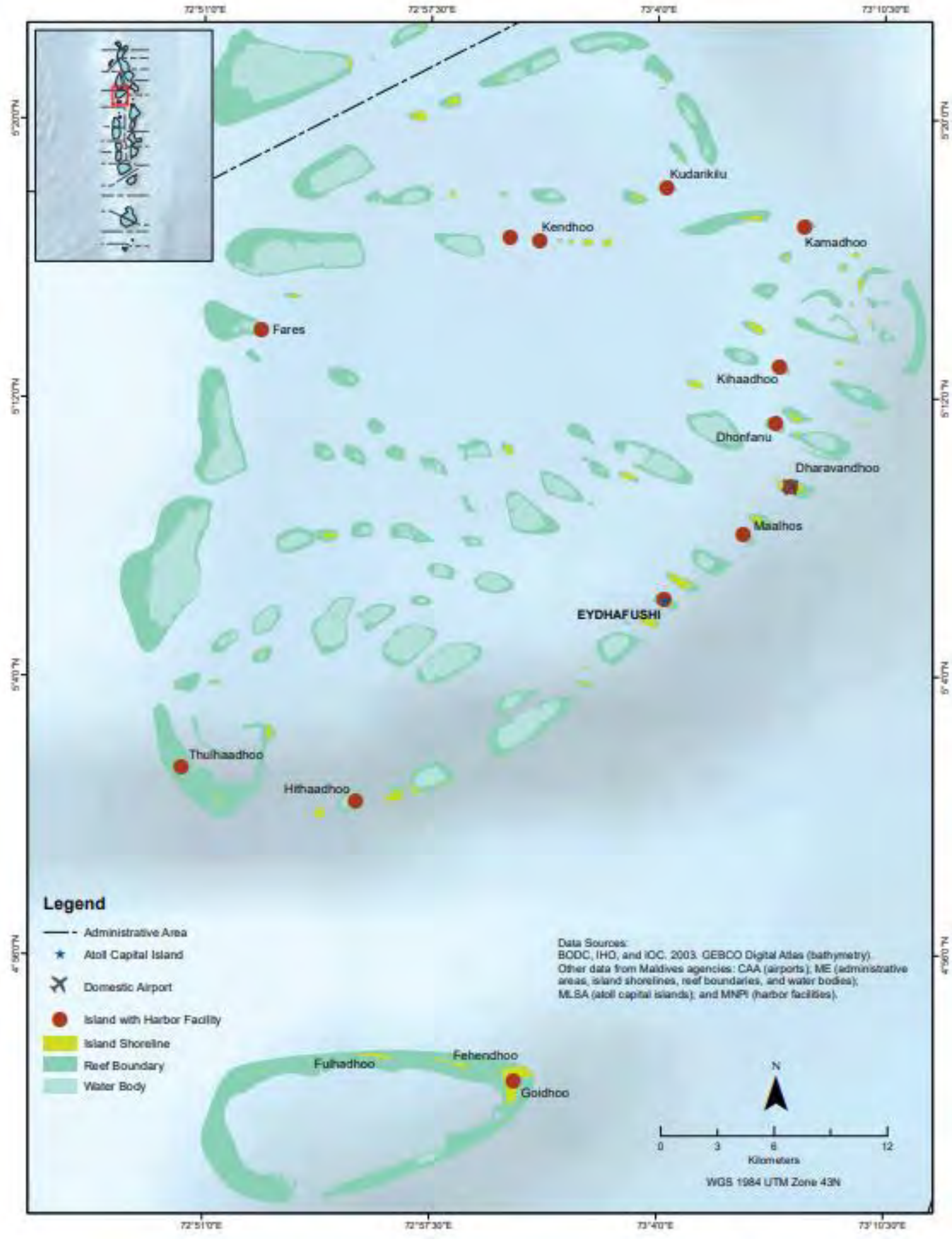


Figure 5-2 Transportation means, B Atoll (ADB, 2020)

5.3.3 Hinnavaru

Hinnavaru has an established harbour, facilitating inter and intra atoll transfers of passengers and goods. The nearest airport is the regional airport at Lh. Madivaru, which is approximately 5 km from Hinnavaru.

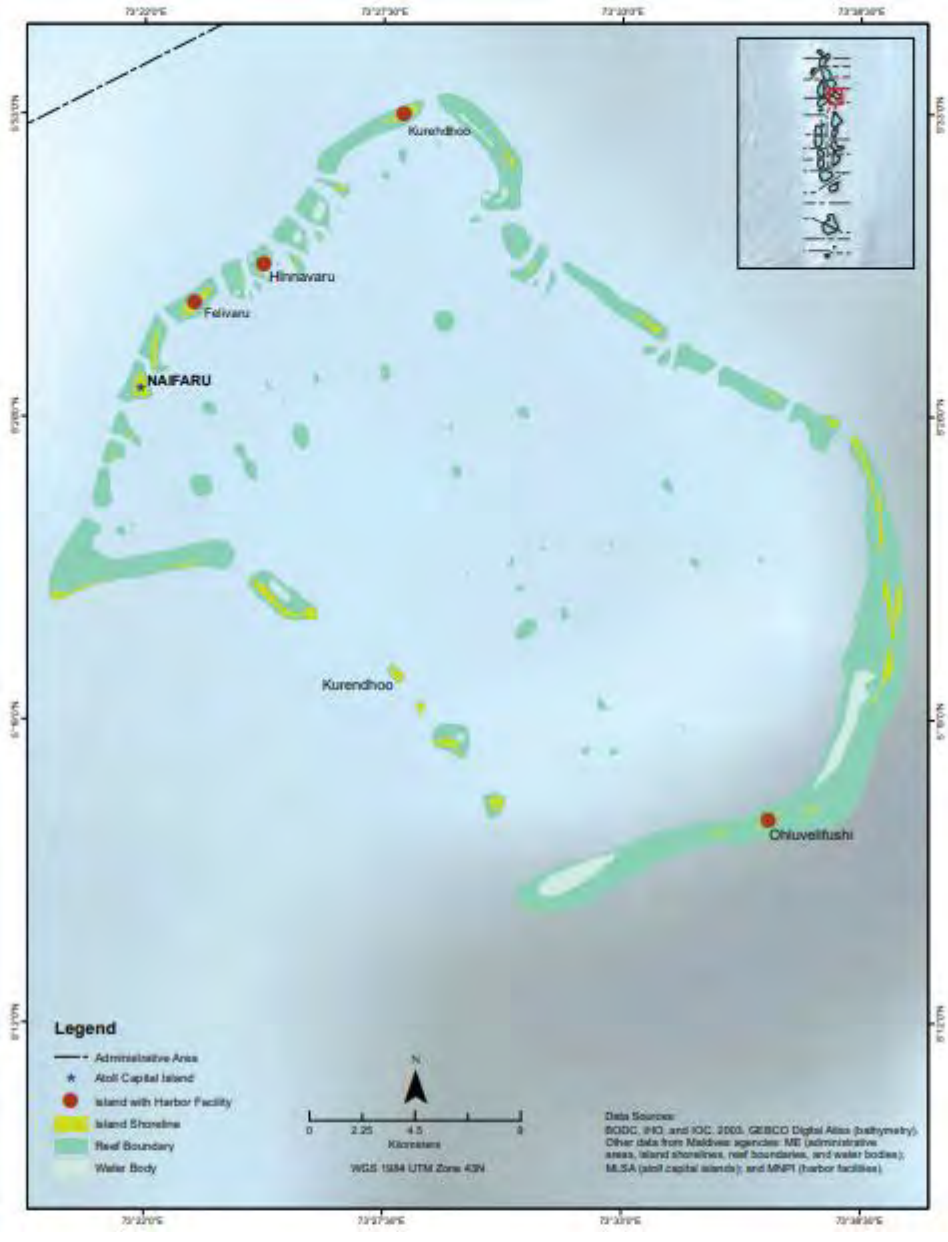


Figure 5-3Transportation means of Lh. Atoll (ADB, 2020)

5.3.4 Thinadhoo

Thinadhoo has an established harbour, facilitating inter and intra atoll transfers of passengers and goods. The nearest airport is the regional airport at G.Dh. Kaadhedhoo, which is approximately 3 km from the island. One more airport at G Dh. Faresmaathodaa has been started to operate recently.

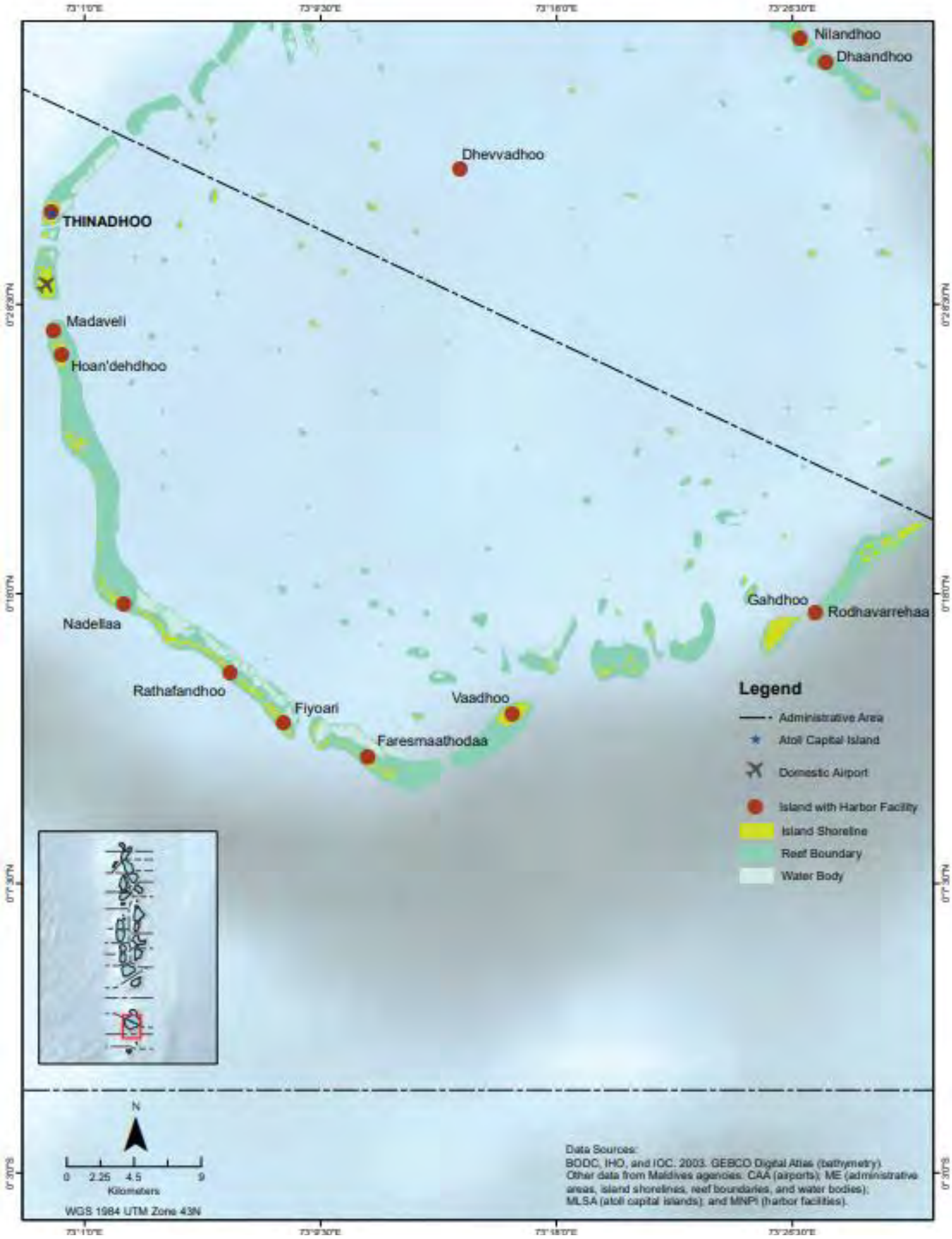
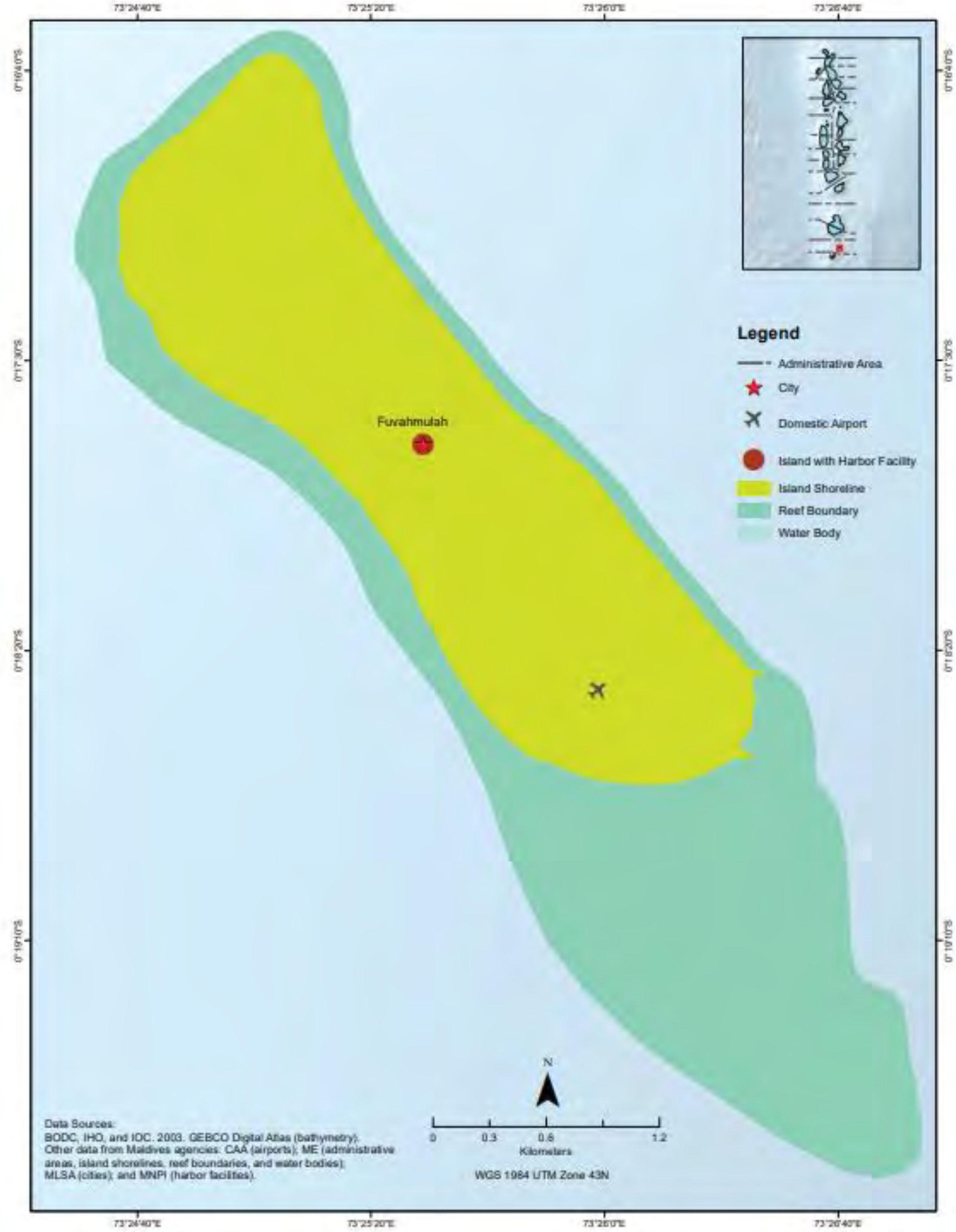


Figure 5-4 Transportation means of G.Dh Atoll (ADB, 2020)

5.3.5 Fuvahmulah City

The city of Fuvahmulah has the facilities of harbour for inter atoll transfers of passengers and goods. The City has a regional airport.

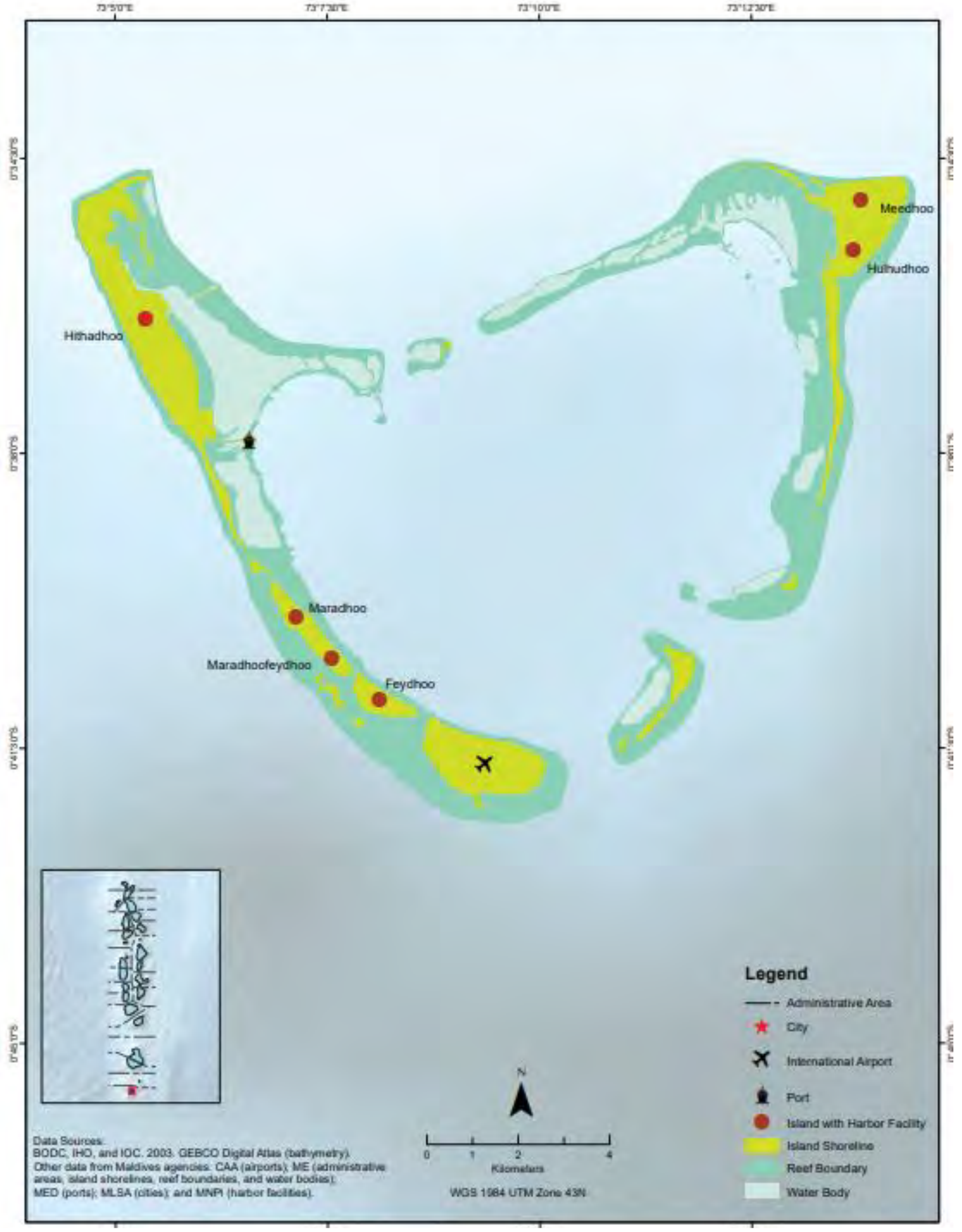


Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry).
Other data from Maldives agencies: CAA (airports); ME (administrative areas, island shorelines, reef boundaries, and water bodies);
MLSA (cities); and MNPI (harbor facilities).

Figure 5-5 Transportation means of Gn Atoll (ADB, 2020)

5.3.6 Addu City

Addu as the representing, economic hub of the south of Maldives, has an established sea port facility in Hithadhoo (Hithadhoo Regional Port) where 30% of duty exemption is applicable to goods offloaded. Additionally, seaports have been established within the atoll to facilitate inter and intra atoll transfers of passengers and goods. It is of note that the site locations of the scope of this project has direct facilitations to harbours. Addu City has an international airport located at Gan.



Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry).
Other data from Maldives agencies: CAA (airports); ME (administrative areas, island shorelines, reef boundaries, and water bodies);
MED (ports); MLSA (cities); and MNPI (harbor facilities).

Figure 5-6Transportation means of Addu Atoll (ADB, 2020)

5.4 UTILITIES

It is of note that the nation enjoys 24 hr universal electricity access to all inhabited islands. The electricity provider for the selected islands/cities are Fenaka. Details of electrical utility services are described below in Table 5-8.

Table 5-8 Details of Electrical Utility Services

Island	**Electricity Provider**	**Electricity Production (kWh)**	**Diesel Fuel Consumption (Litres)**	**Total Diesel Generators installed capacity (kW)**	**Existing Solar PV Capacity (kW)**
Eydhafushi	Fenaka	**4,573,825**	4,573,825	1700	1
Hinnavaru	Fenaka	**3,587,680**	1,145,355	1160	-
Thinadhoo	Fenaka	**8,697,526**	2,679,558	3800	-
Fuvahmulah City	Fenaka	**13,537,181**	3,748,600	4600	-
Kulhudhuffushi City	Fenaka	**13,177,706**	3,667,028	4400	11
Addu City	Fenaka	406,180,49	11,970,457	15,446	1,618

Detail of current electricity demand and projected demand for the year 2023 is presented in the table 5- 9 below.

Table 5-9 Demand for the year 2023

	Existing diesel electricity demand (2019/2020)	Projected diesel electricity demand (2023)	PV fraction respect to (2019/2020) demand)	PV fraction respect to 2023 peak demand	Diesel Fuel Saving (L)
Island Grid	Peak (MW)	Peak (MW)	Peak Load %	Peak Load %	
Addu (Mainland)	9	11.98	140%	105%	4,883,108.11
Addu (Hulhumeedhoo)	1.11	1.44	180%	139%	887,837.84
Fuvahmulah	3.4	4.65	59%	43%	887,837.84
Thinadhoo	2.8	3.83	88%	64%	887,837.84
Kulhuduffushi	4	3.38	58%	68%	665,878.38
Eydhafushi	1	1.33	200%	150%	665,878.38
Hinnavaru	0.8	0.95	125%	105%	443,918.92

5.5 HEALTHCARE

As the islands/cities in the project scope are regional urban centres, adequate healthcare facilities have been established to address general medical conditions and incidents. However, depending on the circumstances referrals may be required to better medical facility.

5.6 CULTURALLY SIGNIFICANT AREAS

Only in the proposed project site of Fuvahmulah has a culturally significant area. It has been identified in Figure 4-41 of this document. The proposed project will not have any significant impact as the culturally significant area is located outside the project boundary.

5.7 Uncertainties

Uncertainties are virtually unavoidable in environmental impact assessments. In environmental assessments, uncertainty can be branched into three principal categories; scenario uncertainty, model uncertainty, and parameter uncertainty. Uncertainty is commonly related to the inherent nature of it, either limitations in the available knowledge or the randomness of the related systems and its components. It is of note that the field data collected are of a limited time window, where the nature of the environmental and other relevant conditions may only be representative to that period of time. In addition, it is of note that models (including software) carries uncertainties due to imperfections and assumptions made in the formulations as well. Furthermore, the report includes information collected from second parties where the provided information could vary in terms of accuracy. In addition to this, the accuracy of data and impact prediction may vary due to human errors, and limitations of data collection equipment used.

6 STAKEHOLDER CONSULTATIONS

The following are the stakeholders identified for this assessment as per the TOR.

- Regional Airports Company Limited (RACL)
- Maldives Civil Aviation Authority
- Directorate of Aviation Security Administration
- MoECCT
- National Disaster Management Authority
- Ministry of National Planning Housing and Infrastructure
- Utility Regulatory Authority
- Fenaka
- Identified Vulnerable groups
- Island/City Councils
- General Public
- NGOs and CSOs
- Women’s Development Committees

6.1 REGIONAL AIRPORTS COMPANY LIMITED (RACL)

Meeting with RACL was conducted virtually on the 25th of Dec 2022, at Regional Airports Corporation Limited. The following are the details of the participants of the meeting.

Name	Designation	Contact details
Ahmed Ibrahim	COO	info@airports.mv
Fathimath Seeza	Project Officer	seeza@airports.mv

Summary of Discussions

- A brief description of the project was presented by the consultant

The points noted by RACL are summarized below:

- The design structure and other components of the project within the boundary of the airports should be in line with the Civil Aviation regulations.
- The ESIA should include the required technical survey done for both airports (Kulhudhuffushi and Fuvahmulah)
- The panels should be coated with anti-glare/reflective coating to eliminate disturbances which may be caused for the air-traffic operations. In this regard, the panels should be approved by the Civil Aviation Authority
- For the construction and Maintenance works, protocols under the SOP by Directorate of Aviation Security Administration should be followed
- If any vehicles are to be used within the airport boundaries, the vehicles need to be registered for access, and strict guidance should be followed.
- Construction and maintenance works should not be carried for a period of 1 hour prior to flight landing, and 30 minutes after landing.
- If foreign staff/workers are to be utilised, they should have a valid work document approved by the relevant authorities.
- The work site should be cleaned daily and no materials/debris should be left within the airport boundaries.
- Due to the sensitive nature of the airport premise, at any times either construction, maintenance or operational, no material should be left in a manner which it could be potentially blown in to runway or other spaces within the boundary.

6.2 MALDIVES CIVIL AVIATION AUTHORITY (CAA) DIRECTORATE OF AVIATION SECURITY ADMINISTRATION (DASA)

The meeting with Maldives Civil Aviation Authority (CAA) and Directorate of Aviation Security Administration (DASA) was conducted in a hybrid form where CAA representative participated in person while DASA representatives joined virtually through Microsoft teams.

Name	Entity	Designation	Contact details
Ahmed Nasheed	DASA	Chief Superintendent	dasa@defence.gov.mv
Nuzhath Ahmed	MoECCT		nuzhath.ahmed@environment.gov.mv

Masoodh	DASA		dasa@defence.gov.mv
Hassan Samah	CAA	Aerodrome Inspector	civav@caa.gov.mv
Mohamed Hamdhaan Zuhair	MOECCT	Social and Safeguard Officer	hamdhaan.zuhair@environment.gov.mv

Summary of Discussions
A brief summary of the project was presented by the consulted.

CAA:

- The detail structure documents should be presented, and the height of the structure should be within the permitted levels
- As the PV panels will be established in a stretch, it is recommended to provide exit/entry gaps between the panels at strategically selected locations
- Habitat space which may foster and attract wild life should not be given in the design as the area is an air space.
- Glare assessments should be presented
- Work safety measures should be followed
- The contractor/proponent should coordinate with the Regional Airports Corporation Limited, and they should be well informed on the works
- Safety regulations of CAA should be followed
- Construction methodologies needs to presented and approved by CAA
- The distance between the fence and the solar PV structures should accommodate the airport patrol vehicles with adequate space

DASA:

- There is a potential hazard of patrol vehicles crashing into the proposed solar PV structure due to the close proximity of patrolling paths. In this regard enough spacing and adequate measures should be taken to reduce the likelihood of incident occurrence. Additionally, protective measures in order to reduce any damage to the solar PV structures should be at place, as such erecting a fence
- Special consideration should be given to the design of the system to not obstruct any emergency exits or critical movement paths required for airport functioning
- DASA will consult internally and provide a final say regarding the project
- A construction work plan should be presented including all the relevant details such as construction and work methodology, types of equipment and materials, etc.
- Workers under the project should not breach the permitted work areas, and control measures should in place to monitor staff movement.

6.3 ENVIRONMENTAL PROTECTION AGENCY

Meeting with EPA was conducted at the Agency's office on the 15th of December 2022. The following are the details of the participants of the meeting.

Name	Designation	Contact details
Aishath Amjidha	Legal Assistant	aishath.amjidha@epa.gov.mv
Aminath Ameera	Environment Analyst	aminath.ameera@epa.gov.mv

Summary of Discussions

- A brief description of the project was presented by the consultant

The points noted by EPA are summarized below:

- Provide the detailed work schedule of the construction phase of the project, particularly for Kulhudhuffushi City site, due to the close proximity to the environmentally significant mangrove area.
- Soil profile should be done for Kulhdhuffushi area.
- Monitor the air quality parameters before and during the construction periods of the project
- The construction phase to be scheduled in a way which doesn't overlaps with the bird migratory seasons for Kulhudhuffushi site.
- The conduct of the construction phase should be in a manner with the least negative environmental implications.
- No waste should be left at site; waste should be managed well and the site should be kept clean.
- Since the selected are in Kulhudhuffushi is reclaimed on a marshy area, structure design should be based on the findings of soil profiling studies.
- If any changes to the project sites is brought, EPA should be notified.

6.4 MINISTRY OF ENVIRONMENT CLIMATE CHANGE AND TECHNOLOGY

Meeting with MoECCT was conducted virtually on the 18th of Dec 2022, through Google Meet. The following are the details of the participants of the meeting.

Name	Designation	Contact details
Abdul Rasheed	Assistant Engineer	abdul.rasheed@environment.gov.mv
Rayya Hussain	Environment Analyst	rayya.hussain@environment.gov.mv

Summary of Discussions

- A brief description of the project was presented by the consultant

The points noted by MoECCT are summarized below:

- Detailed work methodology and project design should be in the conduct of least environmental implications.
- Special consideration should be taken for Kulhudhuffushi site due to its environmental significance

6.5 NATIONAL DISASTER MANAGEMENT AUTHORITY (NDMA)

Meeting with NDMA was conducted virtually on the 12th of Dec 2022, through Google Meet. The following are the details of the participants of the meeting.

Name	Designation	Contact details
Haleemath Nahula	Development & Resilience Officer	haleemath.nahula@ndma.gov.mv

Summary of Discussions

- A brief description of the project was presented by the consultant
- NDMA emphasised on the ownership of the project in the aspects of sustainability. This is with regard to the maintenance of the project structures and functionality during the operational phase of the project. It was further noted that an appropriate transitional plan should be formulated encompassing handover manuals and maintenance details.
- NDMA advised to keep the respective island councils well informed and involved at all stages of the project.
- As many of the project sites are in close proximity to the coast, it was advised to take special consideration to impacts of erosion and other potential disaster events which may arise from the location. Additionally, it was noted to study the flood prone areas of the islands of the project in relation to the project components and to take the necessary steps to mitigate its impacts wherever applicable.
- As most of the Solar PV structures are to be placed at urban areas of the islands, NDMA stressed on the importance of the structures' sustainability to wear and tear.
- It was further highlighted by NDMA, to study the proximity of the project site to infrastructure of high hazard nature such as petrol sheds.
- NDMA noted on the importance of enabling multiple social services from the PV structures while taking special consideration of the most vulnerable.
- It was noted to ensure that the project is designed in accordance with the Land Use Plans of the respective islands. In this regard, NDMA emphasised on the importance of carrying consultations with relevant stakeholders, specifically the respective islanders, including the vulnerable.

- With regard to the waste generated from the project, NDMA noted on the importance of formulating a proper Waste Management Plan which is in line with the set legal framework and environmental best practices.
- If vegetation removal at any point of the project is required, applicable legal environmental articles should be followed.
- As the Kulhudhuffushi site is a reclaimed wetland area, necessary ground stabilisation and conditioning works to be carried out.
- A functional, safety plan should be formulated and followed during both the construction and operation phase of the project which should include the usage of proper Personal Protective Equipment. In this regard, appropriate lightings should be at place if working during night time or times of low light. As some components of the project is expected to cause noise, to avoid nuisances to the public, limit such works to the daytime.

6.6 MINISTRY OF NATIONAL PLANNING HOUSING AND INFRASTRUCTURE

Meeting with the Ministry of National Planning, Housing and Infrastructure was held at the Ministry on the 20th of December 2022.
The following are the details of the participants of the meeting.

Name	**Designation**	**Contact details**
Ahmed Sujeeth	Engineer	ahmed.sujeeth@planning.gov.mv
Ibrahim Shihan	Engineer	ibrahim.shihan@planning.gov.mv

Summary of Discussions

- A brief description of the project was presented by the consultant

The points noted by MNPHI are summarized below:

- The team requested for details and standards followed in considering the design and structural aspects of the project which includes the following parameters:
    - Standard followed in selecting the height of the proposed system in urban areas
    - Design considerations followed to reduce the obstruction the usability of road lights
    - Distance considered between the systems and the shoreline

6.7 UTILITY REGULATORY AUTHORITY

A project brief was presented to the Utility Regulatory Authority which includes the project components and relevant dynamics.
The Authority provided written comments for the project which is in Appendix J.

6.8 ISLAND COUNCILS

6.8.1 KULHUDHUFFUSHI CITY COUNCIL

Meeting with Kulhudhuffushi City Council was held virtually through Google Meet on the 11th of January 2023.
The following are the participants of the meeting:

Participant	Designation	Contact
Ahmed Abdulla	Council Member	info@kulhudhuffushicity.gov.mv
Adam Ali	Council Officer	

The following summarizes the key points discussed:

- A project brief was presented by the consulted
- Council requested further information on the temporary storage arrangements
- Requested the project team to consult with MWSC as relocation works of water tanks within the airport area is planned
- It is the request of council to provide a logistical schedule and plans for better facilitation of harbour facilities
- If excavations are required, provided detailed routes/locations and have consultations with the council

6.8.2 EYDHFASHI COUNCIL

Meeting with B. Eydhafushi Council was conducted at Eydhafushi on the 3rd of Dec 2022.
The following are the details of the participants of the meeting.

Name	Designation	Contact details
Mohamed Fathih	Council President	info@eydhafushi.gov.mv
Zaid Ali	Council Member	info@eydhafushi.gov.mv

Summary of the discussions:

- The council requests aesthetic considerations and multi functionality in the design of the solar PV systems.
- The current locations to be revised in accordance with the newly drafted Land Use Plan of the island.
- The existing Island Waste Management Centre has the capacity to manage the expected waste generation from the project.
- The existing harbour has the capacity to facilitate the transfer of the materials required to the island. It is advised that the proponent inform the council on material transfer schedule for better facilitation of the process.

- The underneath area of the solar PV installations at the stadium site to be designed as parking slots.

6.8.3 HINNAVARU COUNCIL

Meeting with Lh. Hinnavaru Council was conducted at Hinnavaru on the 2nd of Dec 2022. The following are the details of the participants of the meeting.

Name	Designation	Contact details
Hassan Shafiu	Council President	hinn.office@gmail.com
Mohamed Ahmed	Administrative Officer	

Summary of the discussions:
The project was briefed by the consultant's team to the council

The points noted by the Council are summarized below:

- To increase the height of the support structure as much as possible.
- The project has been well briefed to the islanders and they are well aware of the project
- As for future developments, a campus of the Maldives National University is planned to be established nearby the project site, and the area is planned to be developed for commercial activities.
- In case of injuries during the project, the island health centre is capable to attend for minor injuries, while serious injuries have to be referred to Naifaru Hospital or Male'.
- As for the construction waste generated from the project, the existing island waste management centre is capable to cater.

6.8.4 THINADHOO COUNCIL

Meeting with Thinadhoo Council was held virtually through Google Meet on the 29th of January 2023.

The following are the participants of the meeting:

Participant	Designation	Contact
Ibrahim Ali	Head of Projects Department	ibrahim.ali@thinadhoo.gov.mv
Ibrahim Nazim	Project Officer	ibrahim.nazim@thinadhoo.gov.mv

The following summarizes the key points discussed:

- It is the council's request to utilise the underneath area of the panels, with infrastructure such as benches.
- The council proposes the uprooted trees (if required) to be relocated to the newly reclaimed area of the island.
- The council highlighted on the importance of utilising soft engineering methods to protect the area from eroding.

- The council requested for a 3D rendered imagery of the project infrastructure.
- The council noted that they are looking forward for the implementation and successful completion of the project.

6.8.5 FUVAHMULAH CITY COUNCIL

Meeting with Fuvahmulah City Council was held virtually through Google Meet on the 9th of January 2023.

The following are the participants of the meeting:

Participant	Designation	Contact
Ahmed Hussain	Assistant Council Executive	info@fuvahmulah.gov.mv
Hawwa Rasheed	Assistant Director	

The following summarizes the key points discussed:

- A project brief was presented by the consulted.
- The council considers the current proposed location a preferable location as the foreseen negative impacts are relatively low with regard to the design and plan.
- With regard to the logistics of importing the required materials to the island; the council recommended to coordinate with the council office by sharing the logistical arrangement plan.

6.8.6 ADDU CITY COUNCIL

Meeting with Addu City Council was held virtually through Google Meet on the 26th of December 2022.

The following are the participants of the meeting:

Participant	Representing entity	Designation	Contact
Mohamed Shuaau	Addu City Council	Deputy Mayor	projects@adducity.gov.mv
Hussain Zareer		Councillor	
Mariyam Azleema		Assistant Council Executive	
Fathimath Nishaan		Senior Council Officer	
Ifaad Waheed	MECCT	Communication Specialist	
Zulkarnain Haider	HDEC	Project Engineer	
Yousuf	MRC	Director Engineering	

The following summarizes the key points discussed:

- The consultant provided a brief summary of the project.

- The council noted on the importance of the designs of the proposed PV mounting structures to serve multiple socio-economic services depending on the location installed.
- As the project has been developed in consultation with the council from the inception stages of the project; the council has no major issues with regard to the project modalities and design as of now.
- With regard to the material logistics of the project, the council requested to liaise and coordinate with the council for the facilitation of harbour services. It was further highlighted that there are set guidelines on harbour use which needs to be followed.
- Council further noted that space is available from Hithadhoo Harbour area, and the council has no issues in including the area to the project scope. However, Project Engineer Haider noted that at this stage of the project it is not possible to revise the project concepts as the required engineering and conceptual documents are near finalisation.

- Council requested to incorporate charging stations in the project scope. Project Engineer Haider noted that it is beyond the scope of the project and requested to consult with the electrical service provider (Fenaka), as they will be the responsible party in providing the service.

6.9 VULNERABLE GROUPS

A perception survey was conducted among vulnerable groups of residents living in the project's respective islands to understand their views and opinions about the project.

14th January 2023.

Alamaa Boat - Captain: 7922080
Newline - Abdul Hakeem Captain 7788298
Newline- Hussein - Crew – 7852440

- The scope and components of the project were described to the participants.
- It was noted that with regard to the proposed project site and methodology, the participants did not foresee any significant nuisances or difficulties
- Additionally, the participants noted that they are not consulted for such development projects during the formulation stages.
- The participants in general raised concerns with regard to the environmental challenges facing the city of Addu.

6.10 GENERAL PUBLIC

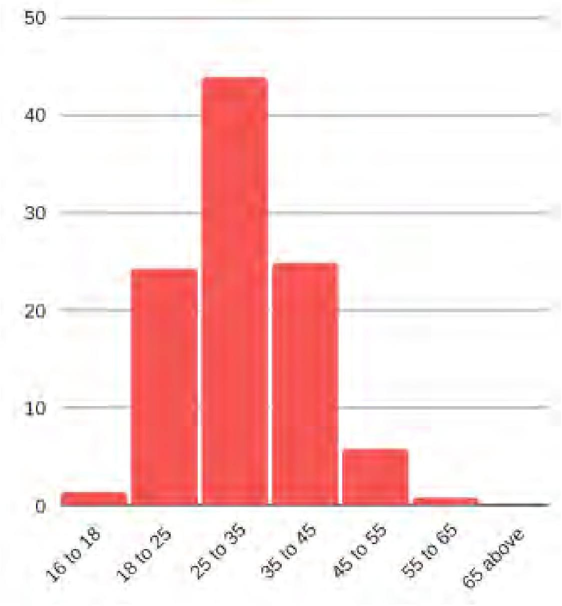
A public perception survey was conducted for the residents of the respective city/island residents of the project. It is of note that the survey was conducted by the ASPIRE team during the inception and screening stages of the project. The results are described in the following:

6.10.1 KULHUDHUFFUSHI CITY

Information of the respondents:

Table 6-1 Age distribution of the survey Kulhudhuffushi City

Total	164
Female	21.3
Male	78.7



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all

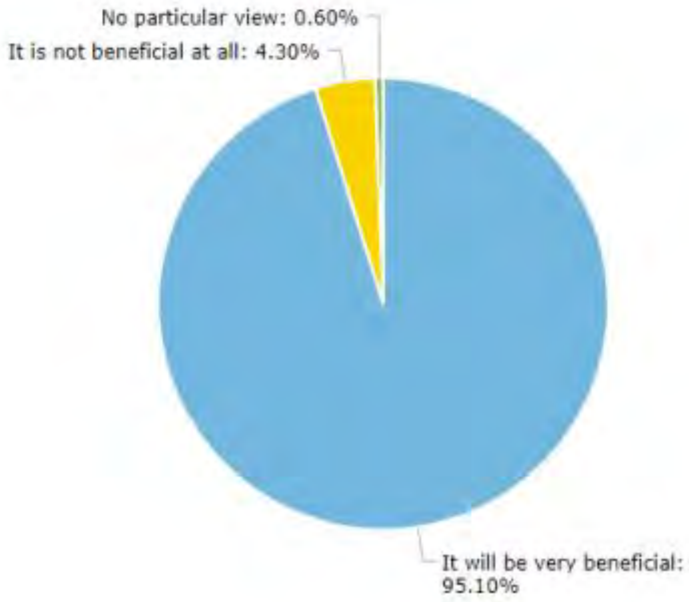


Figure 6-1 General Perception of the Project

The respondents were given the following choices as responses to seek their perception on the location of the proposed project:

- Has no particular view
- Location is not ideal

- Location is ideal

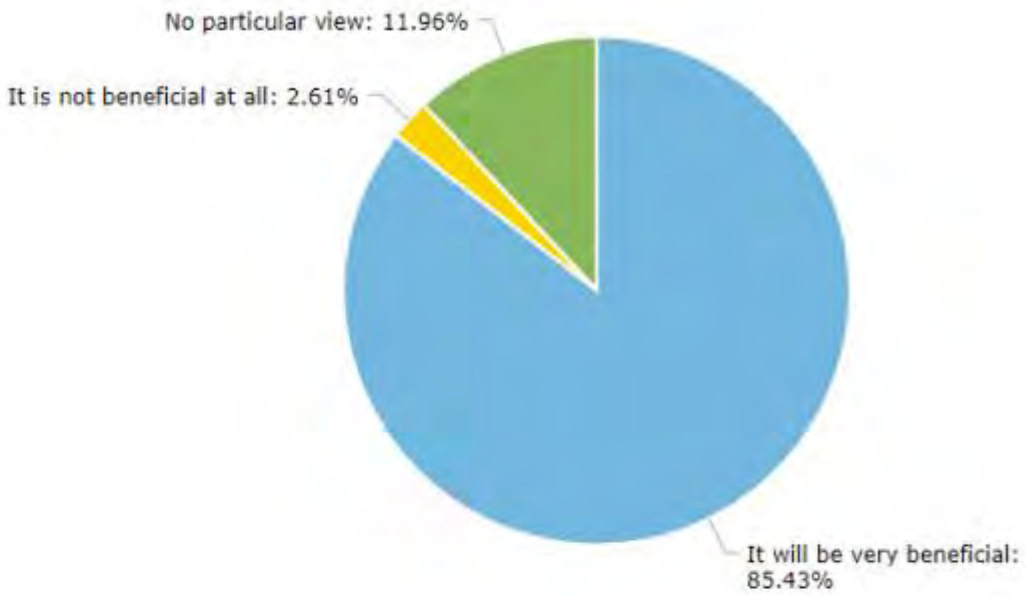


Figure 6-2 Perception on the project location

To seek the perception on the environmental and social impacts regarding the proposed project, respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

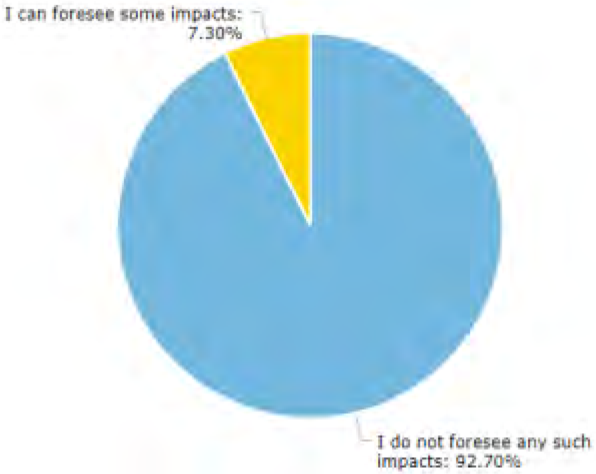


Figure 6-3perception on the potential impacts on public and private property from the project

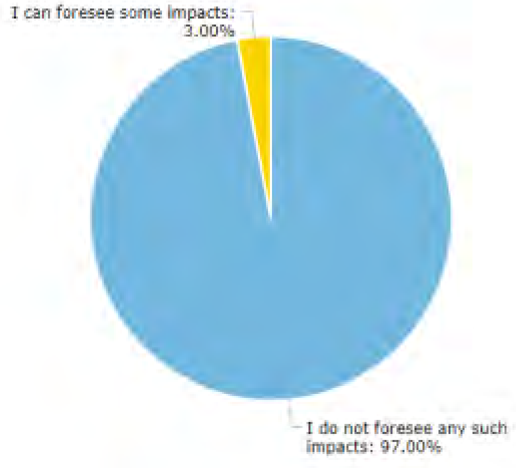


Figure 6-4 Perception on the potential impacts on the livelihood from the project

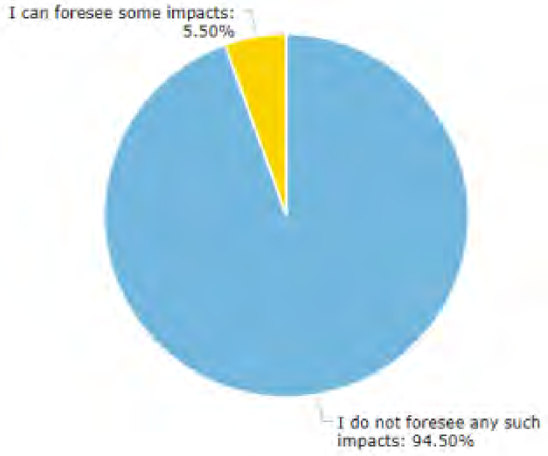


Figure 6-5 Perception on the impacts on safety from the project

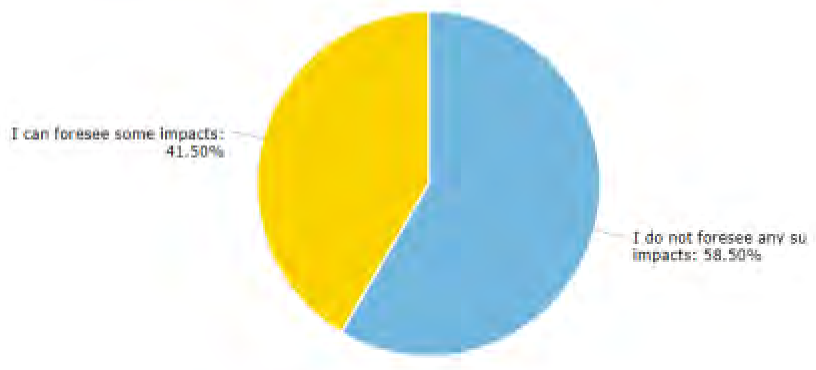


Figure 6-6 Perception on the potential implications from the influx of a labour force from the project

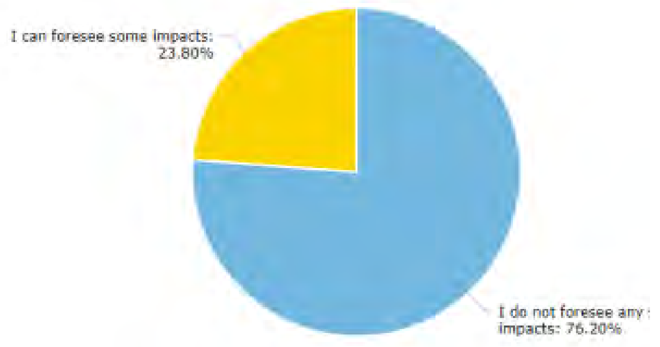


Figure 6-7 Perception on the potential impacts related noise, vibration, and dust

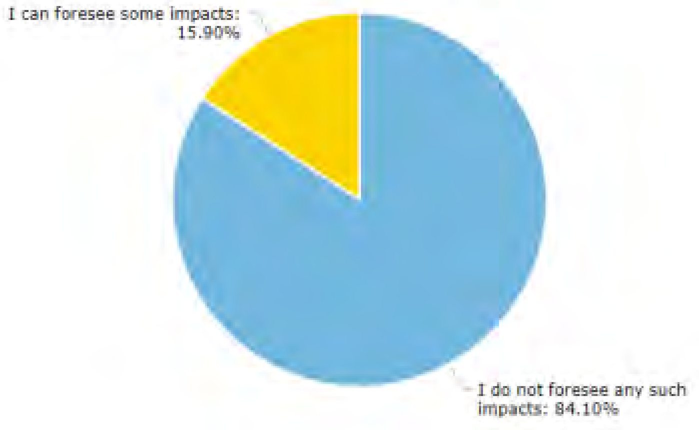


Figure 6-8 Perception on the potential impacts on traffic

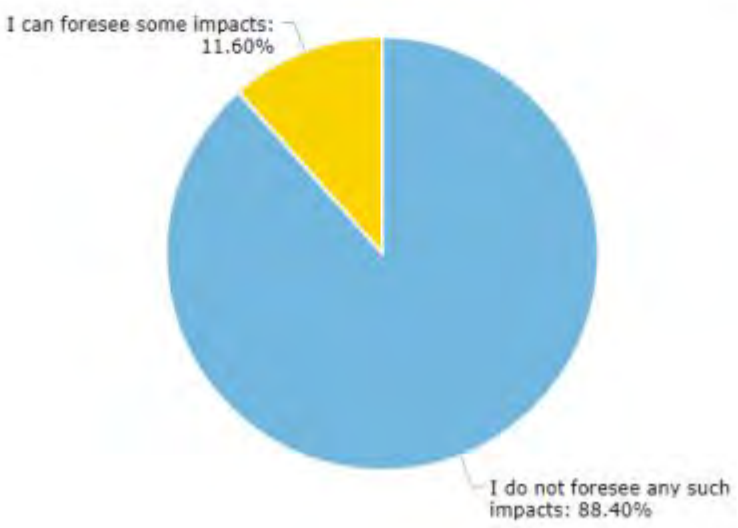


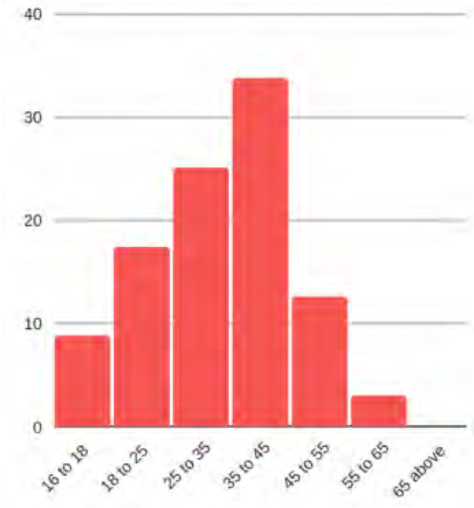
Figure 6-9 Perception on the potential impacts on groundwater

6.10.2 EYDHAFUSHI

Information of the respondents:

Total	104 responses
Female	28.8%
Male	71.2%

Table 6-2 Age distribution of the survey



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all

Figure 6-10 General Perception of the Project

The respondents were given the following choices as responses to seek their perception on the location of the proposed project:

- Has no particular view
- Location is not ideal
- Location is ideal

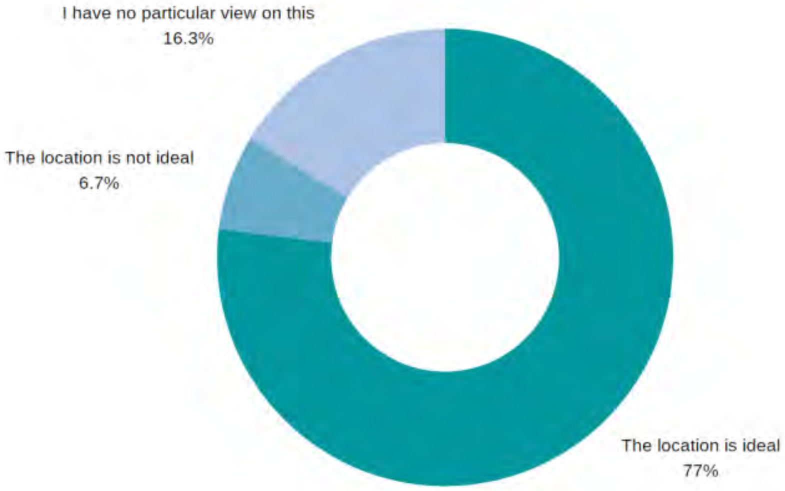


Figure 6-11 Perception on the project location

To seek the perception on the environmental and social impacts regarding the proposed project, respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

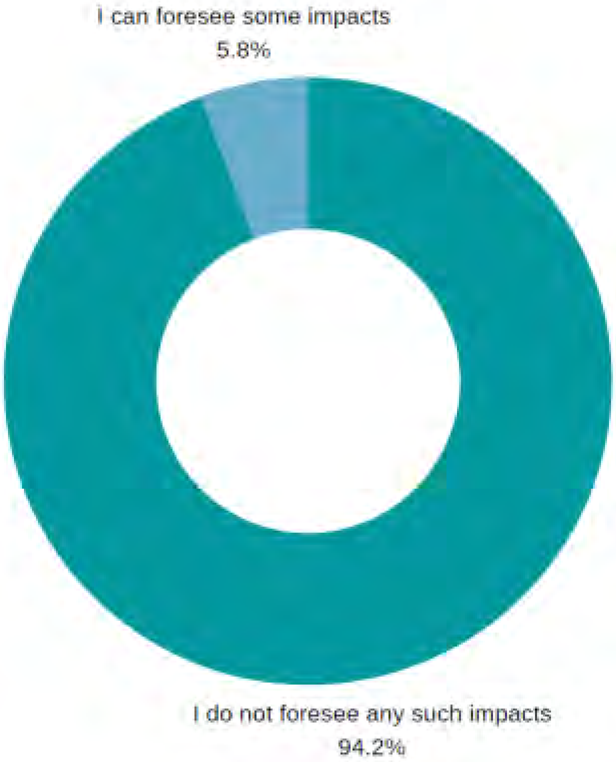


Figure 6-12 perception on the potential impacts on public and private property from the project

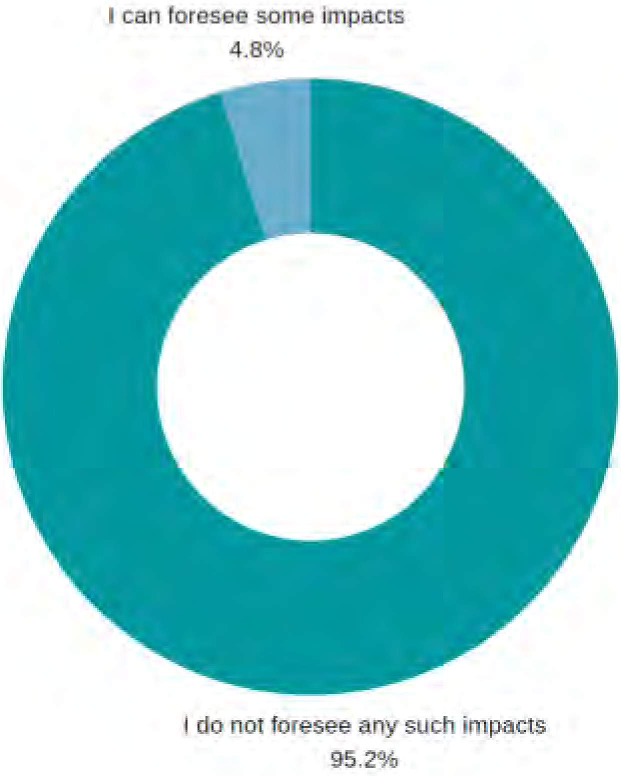


Figure 6-13 Perception on the potential impacts on the livelihood from the project

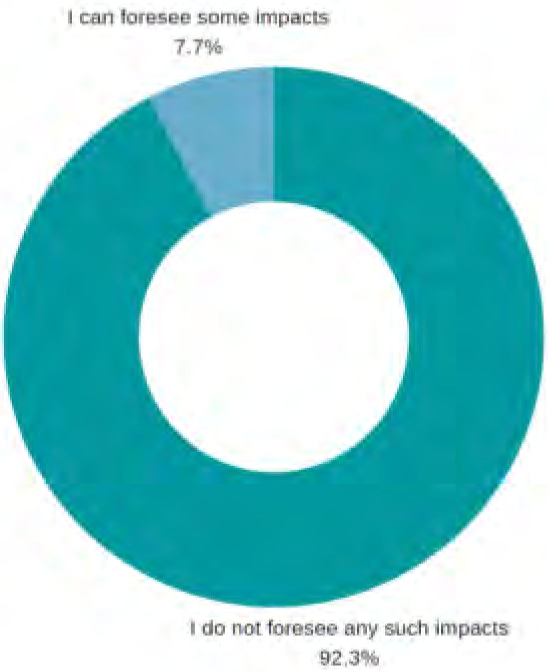


Figure 6-14 Perception on the impacts on safety from the project

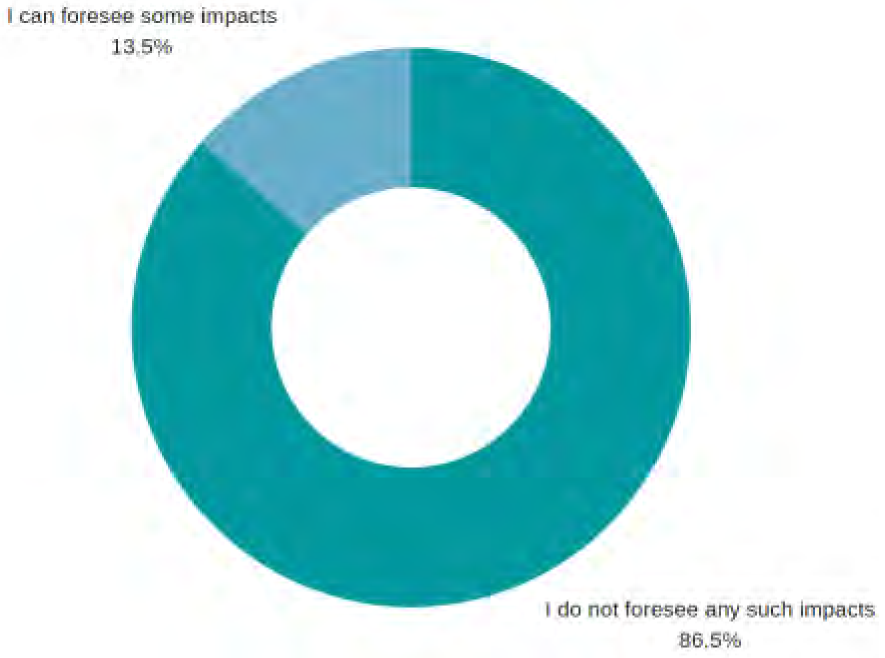


Figure 6-15 Perception on the potential implications from the influx of a labour force from the project

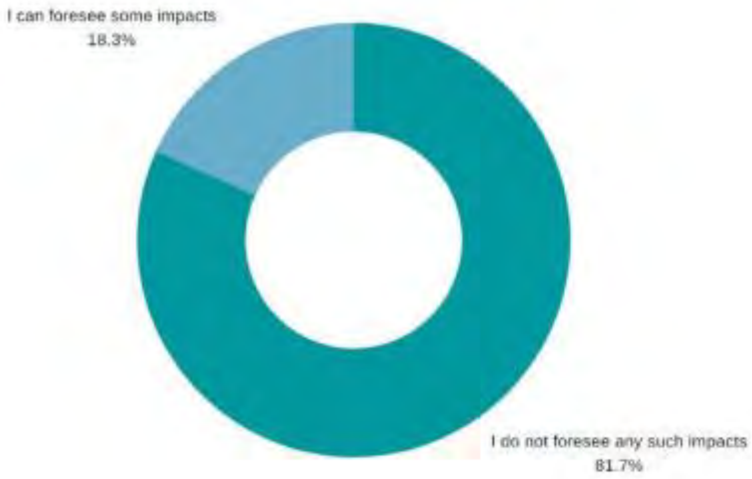


Figure 6-16 Perception on the potential impacts related noise, vibration and dust

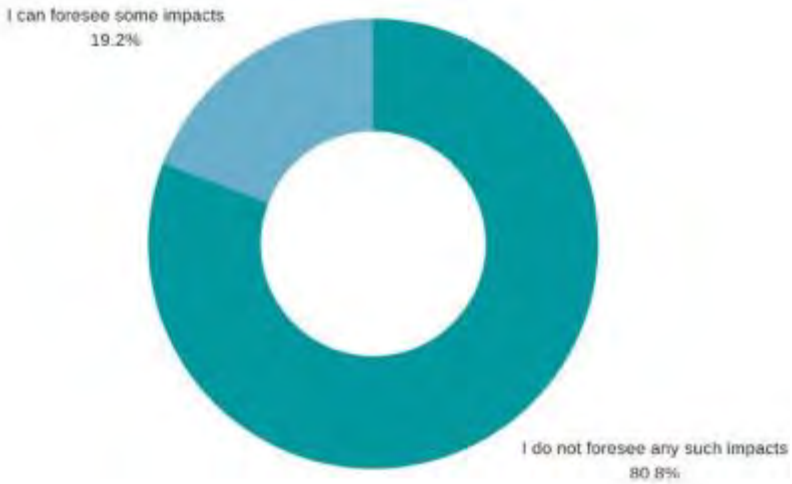


Figure 6-17 Perception on the potential impacts on traffic

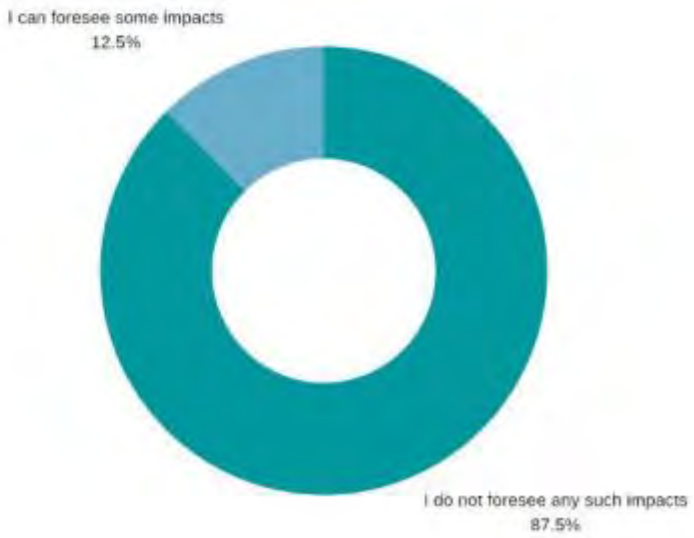


Figure 6-18 Perception on the potential impacts on vegetation

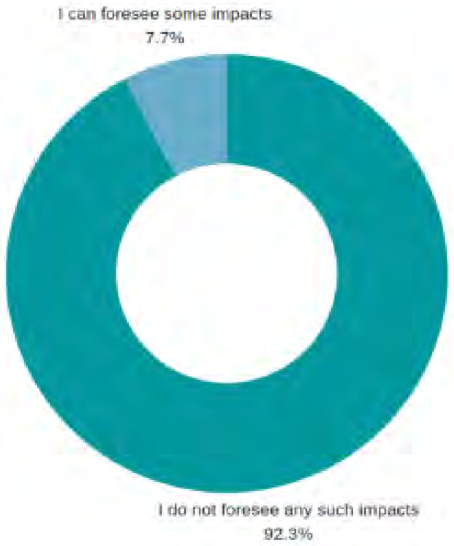


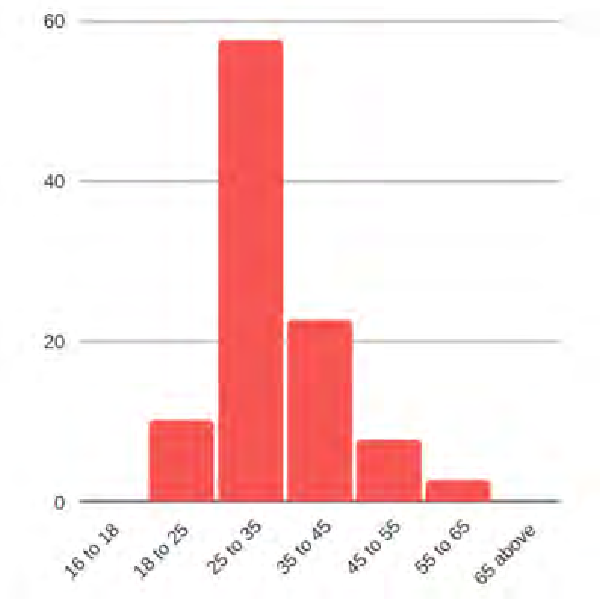
Figure 6-19 Perception on the potential impacts on groundwater

6.11 HINNAVARU

Information of the respondents:

Total	42 responses
Female	60 %
Male	40 %

Table 6-3 Age distribution of the survey



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all

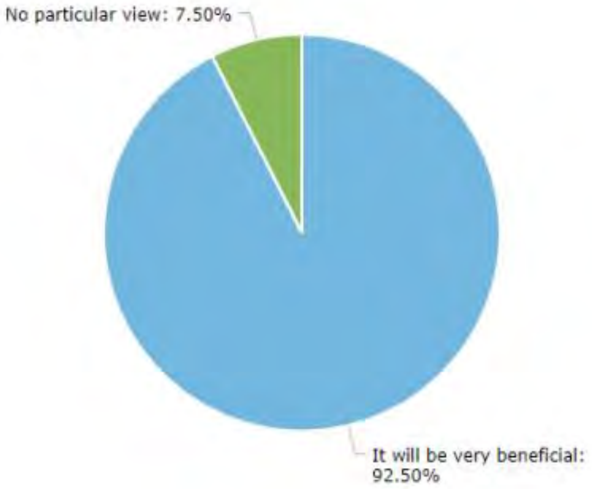


Figure 6-20 General Perception of the Project

The respondents were given the following choices as responses to seek their perception on the location of the proposed project:

- Has no particular view

- Location is not ideal
- Location is ideal

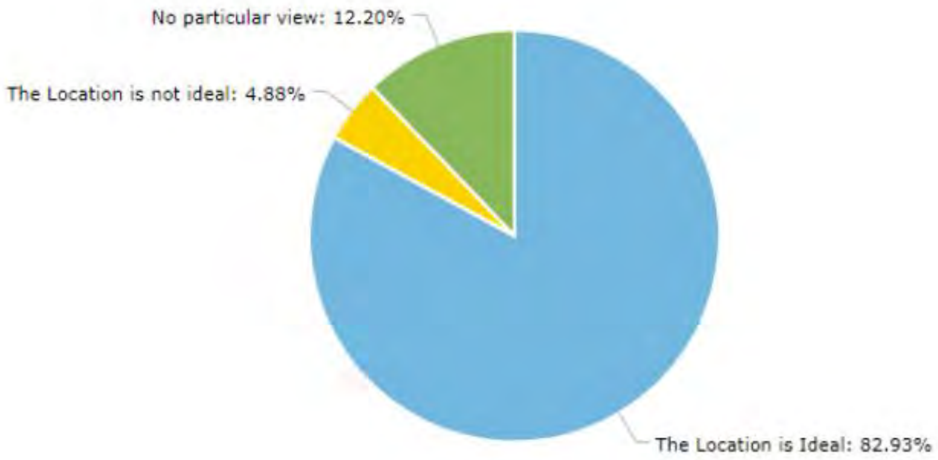


Figure 6-21 Perception on the project location

To seek the perception on the environmental and social impacts regarding the proposed project, respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

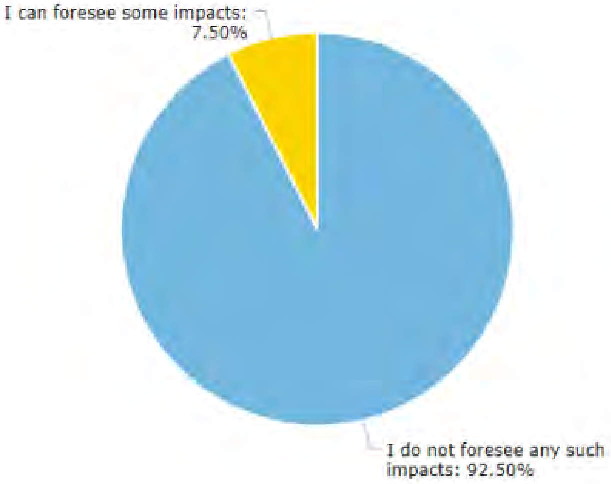


Figure 6-22 perception on the potential impacts on public and private property from the project

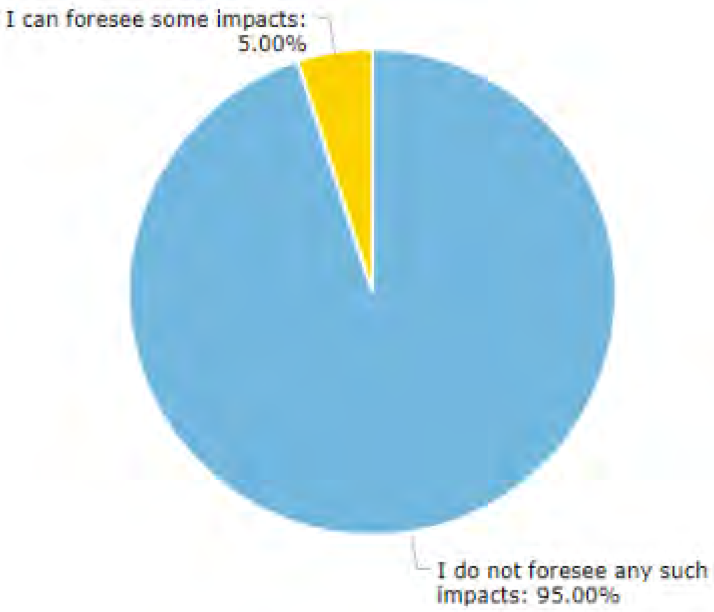


Figure 6-23 Perception on the potential impacts on the livelihood from the project

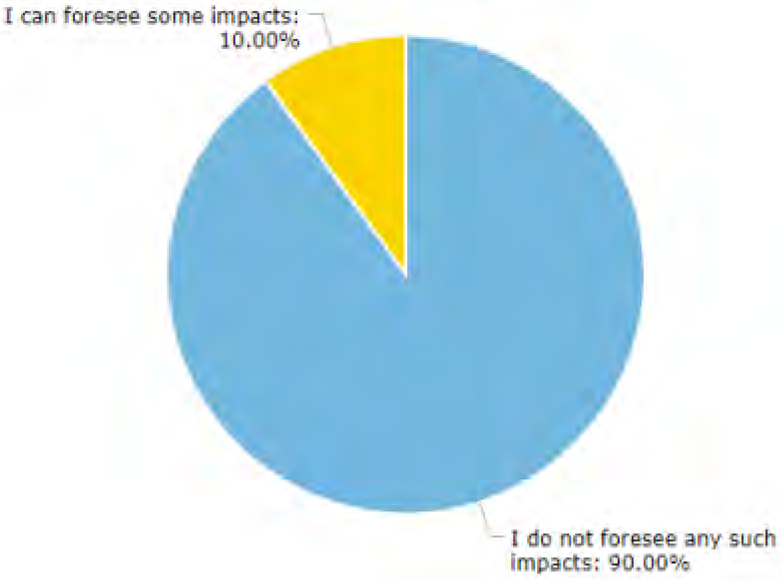


Figure 6-24 Perception on the impacts on safety

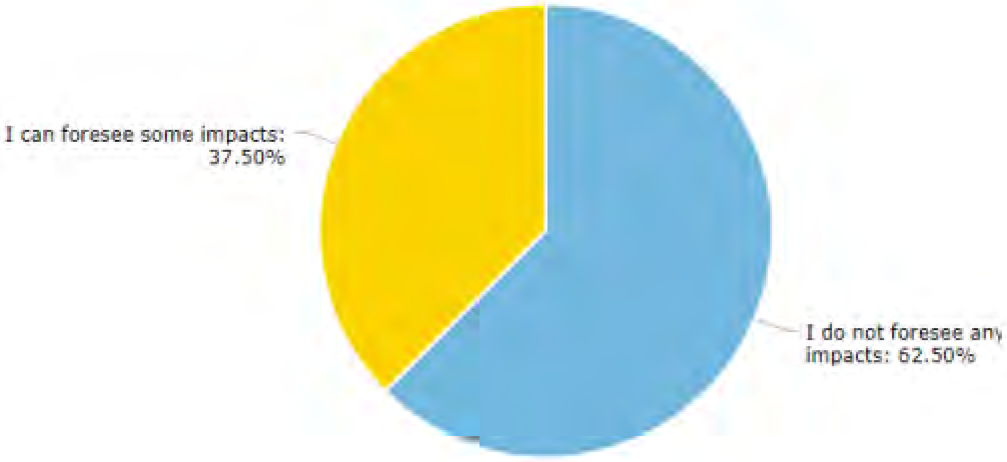


Figure 6-25 Perception on the potential implications from the influx of a labour force from the project

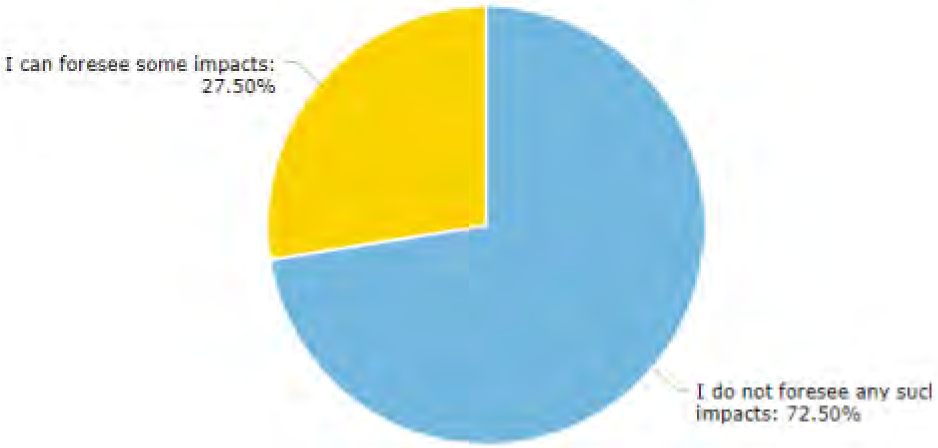


Figure 6-26 Perception on the potential impacts related noise, vibration and dust

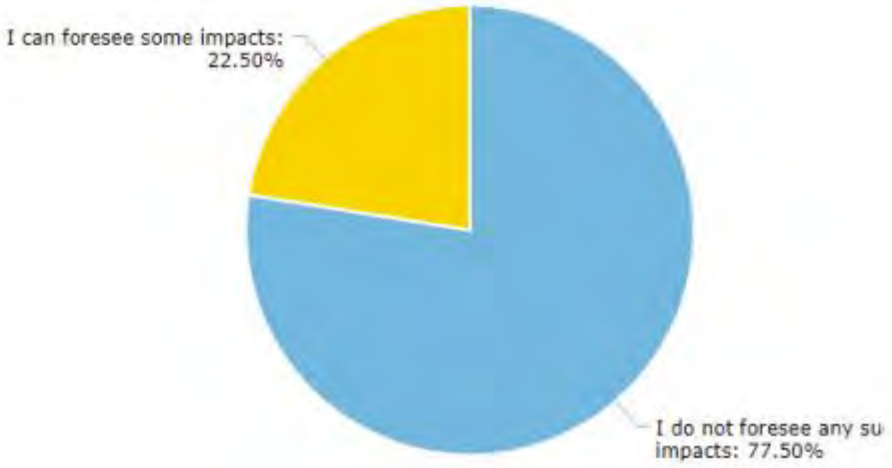


Figure 6-27 Perception on the potential impacts on traffic

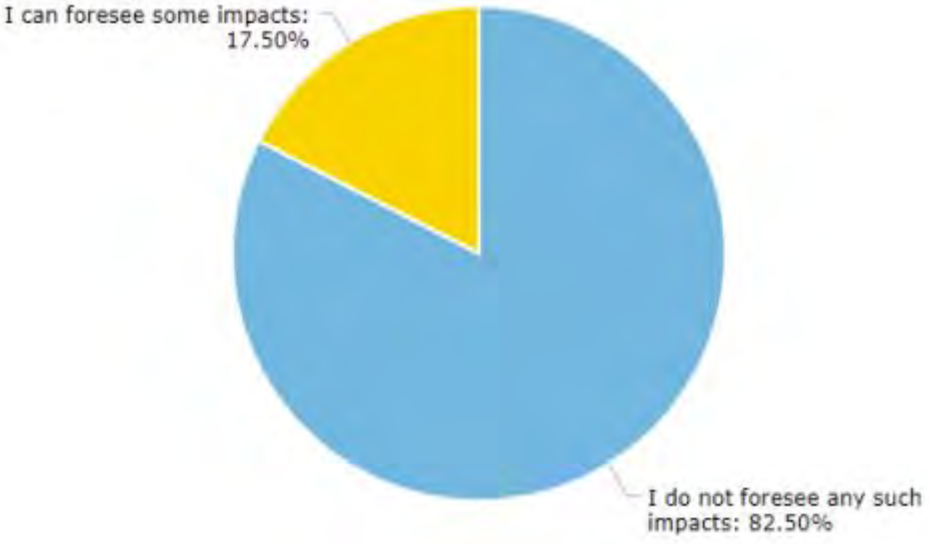


Figure 6-28 perception on the potential impacts on vegetation

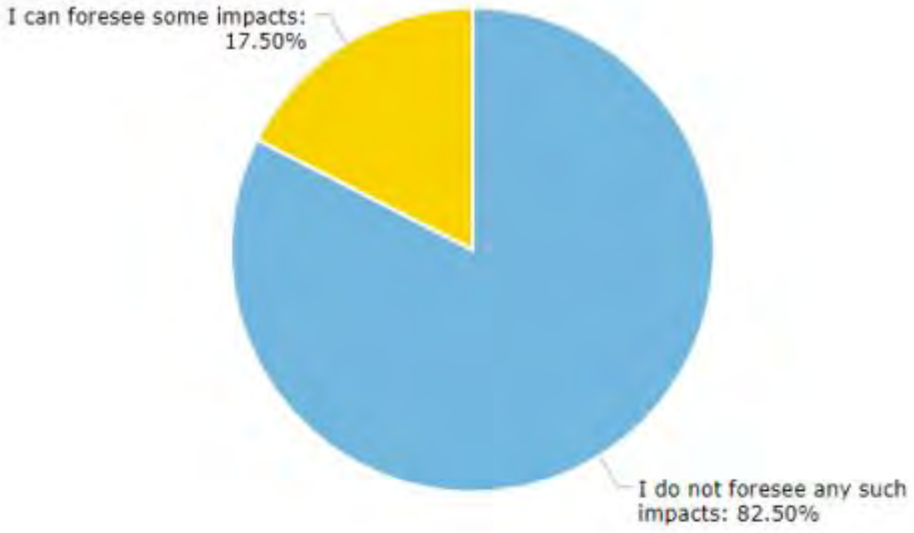


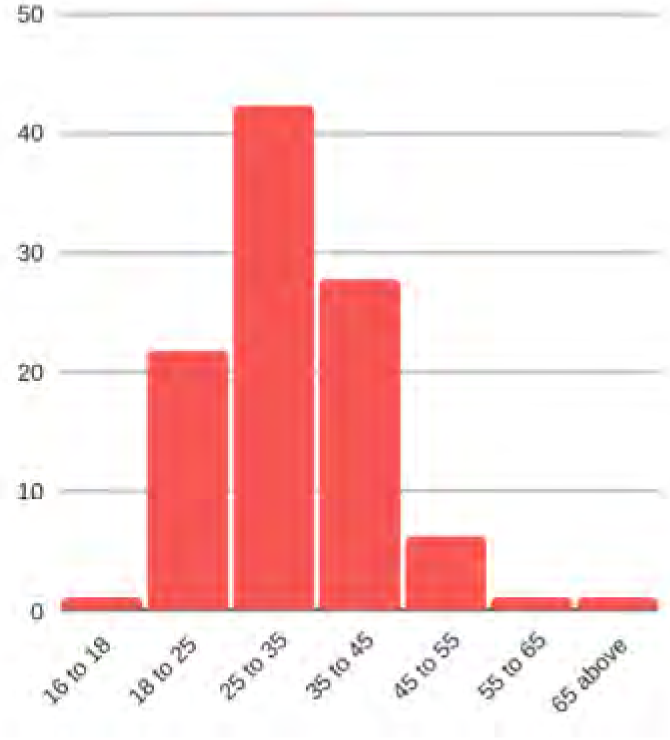
Figure 6-29 Perception on the potential impacts on groundwater

6.12 G.DH. THINADHOO

Information of the respondents:

Total	164
Female	31.90 %
Male	68.10 %

Table 6-4 Age distribution of the survey



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all

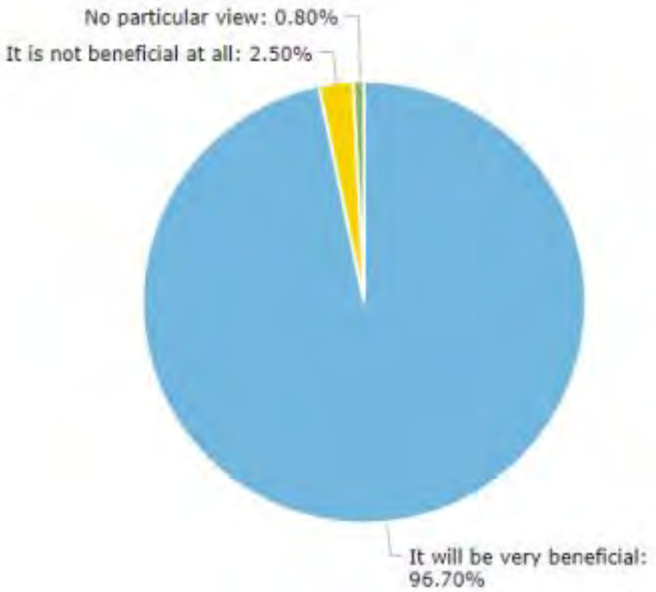


Figure 6-30 General Perception of the Project

The respondents were given the following choices as responses to seek their perception on the location of the proposed project:

- Has no particular view
- Location is not ideal
- Location is ideal

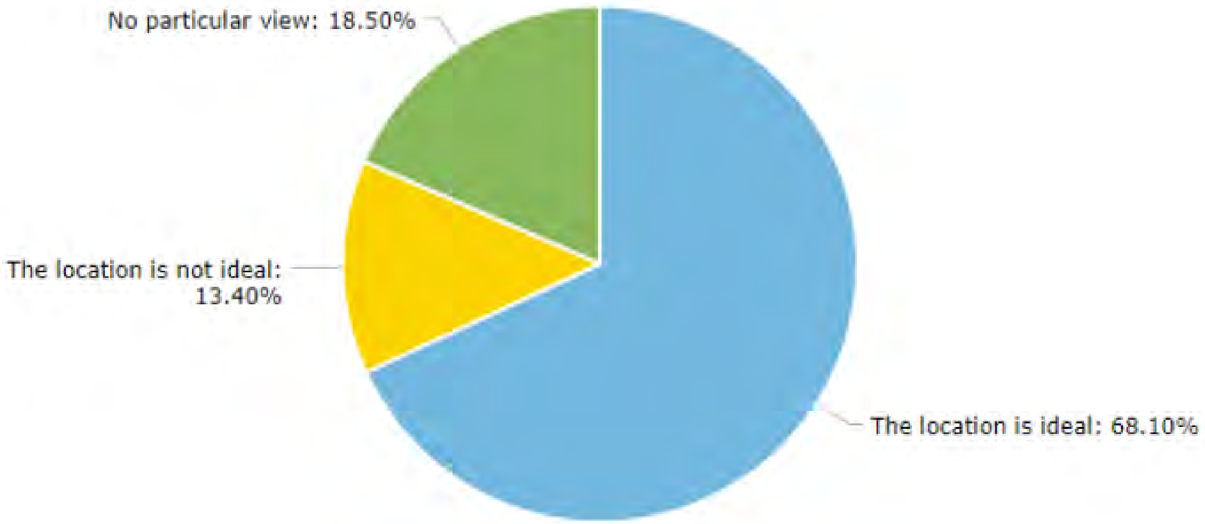


Figure 6-31 Perception on the project location

To seek the perception on the environmental and social impacts regarding the proposed project, respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

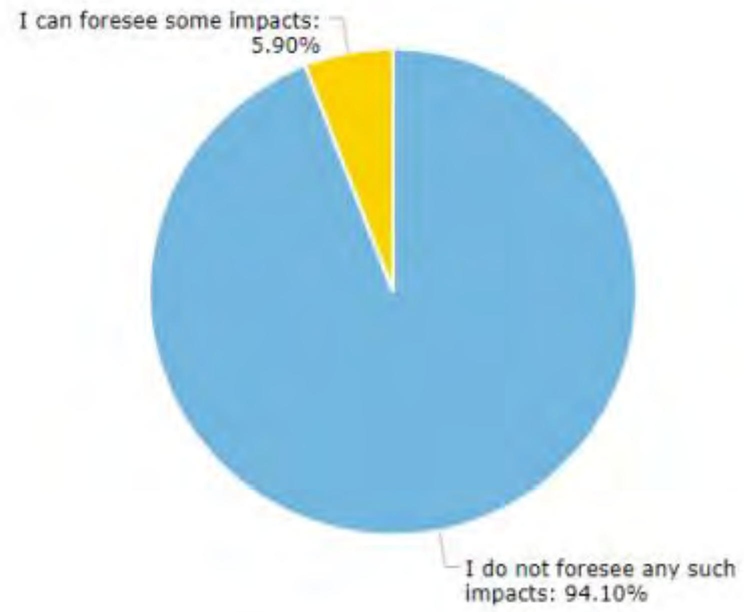


Figure 6-32 Perception on the potential impacts on property

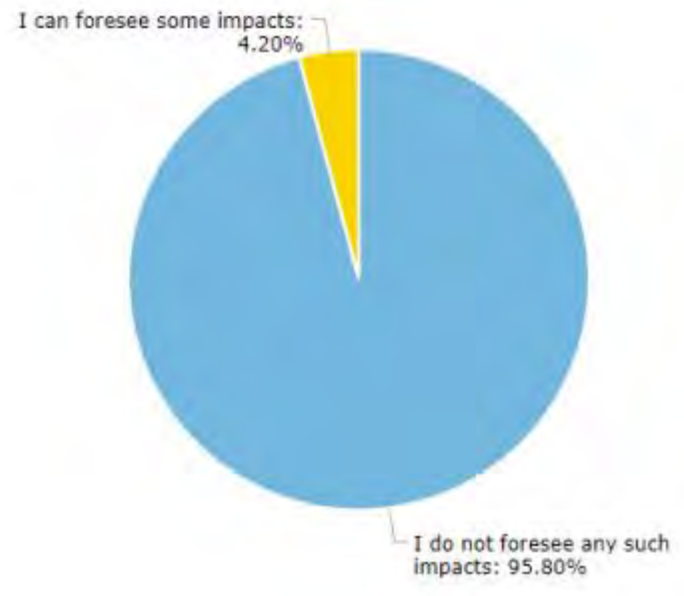


Figure 6-33 Perception on the potential impacts on the livelihood from the project

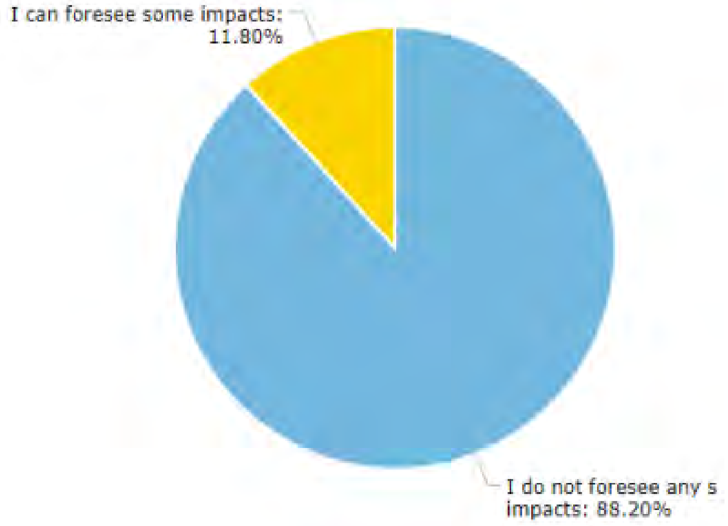


Figure 6-34 Perception on the impacts on safety from the project

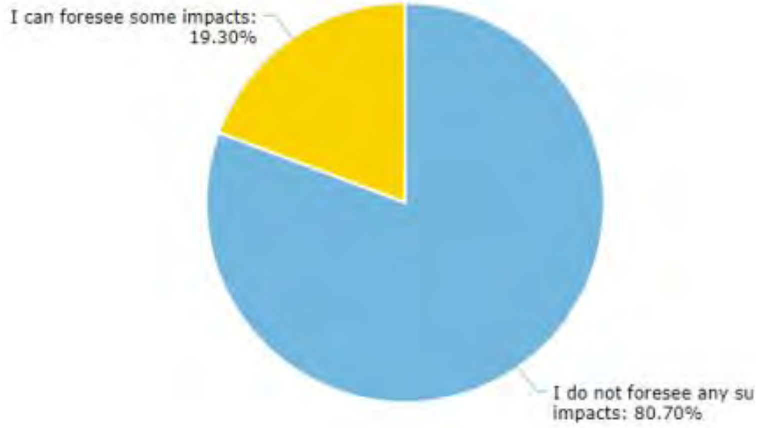


Figure 6-35 Perception on the potential implications from the influx of a labour force from the project

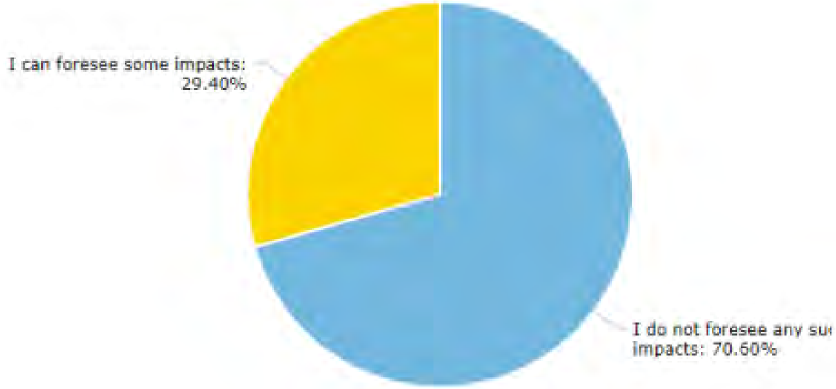


Figure 6-36 perception on the potential impacts related noise, vibration, and dust

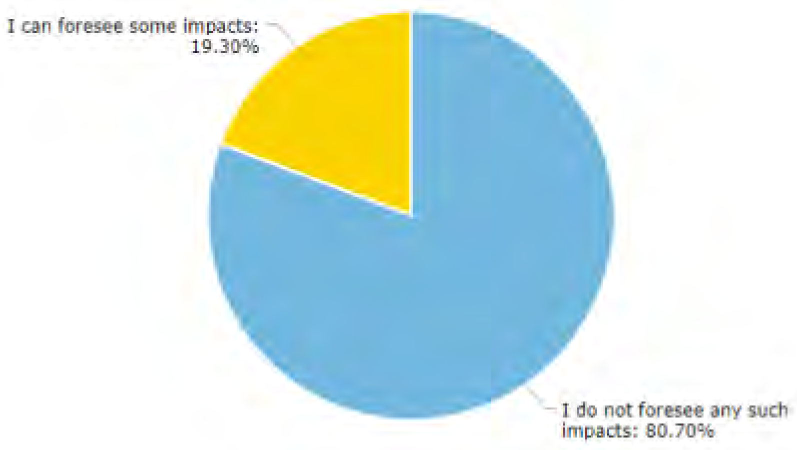


Figure 6-37 Perception on the potential impacts on traffic

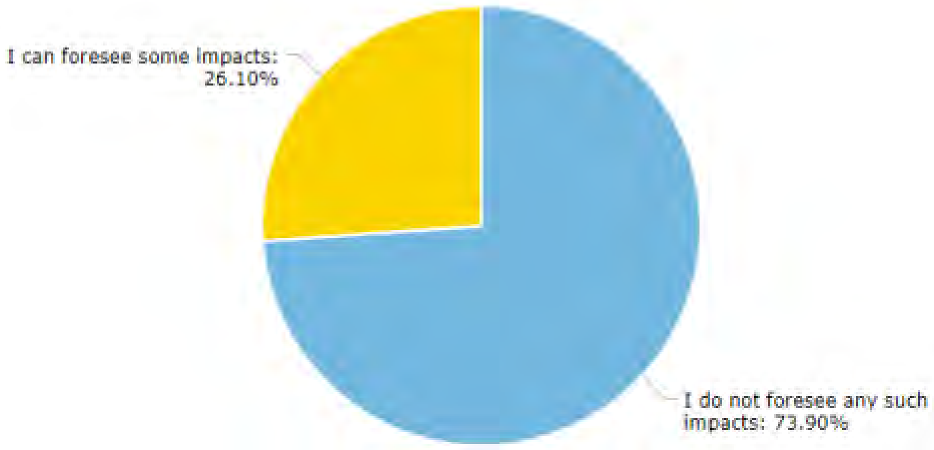


Figure 6-38 perception on the potential impacts on vegetation

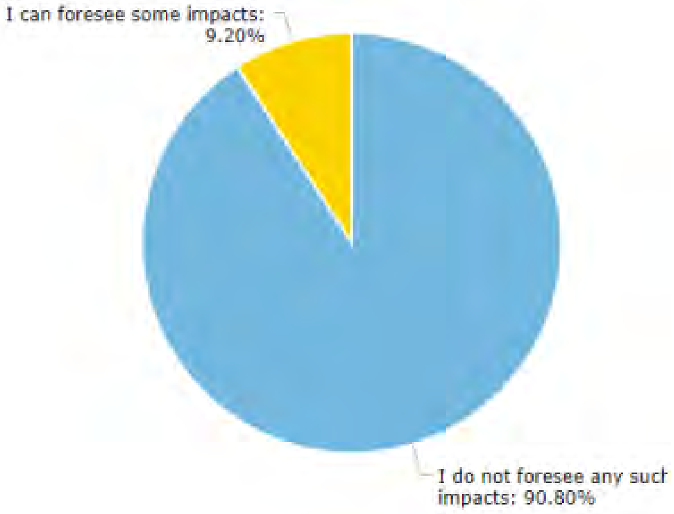


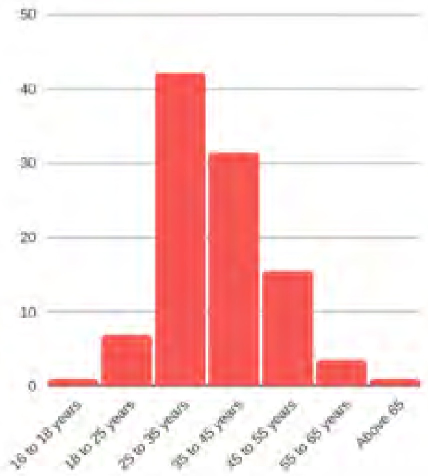
Figure 6-39 Perception on the potential impacts on groundwater

6.13 FUVAHMULAH CITY

Information of the respondents:

Total	156 responses
Female	36 %
Male	64 %

Table 6-5 Age distribution of the survey



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all

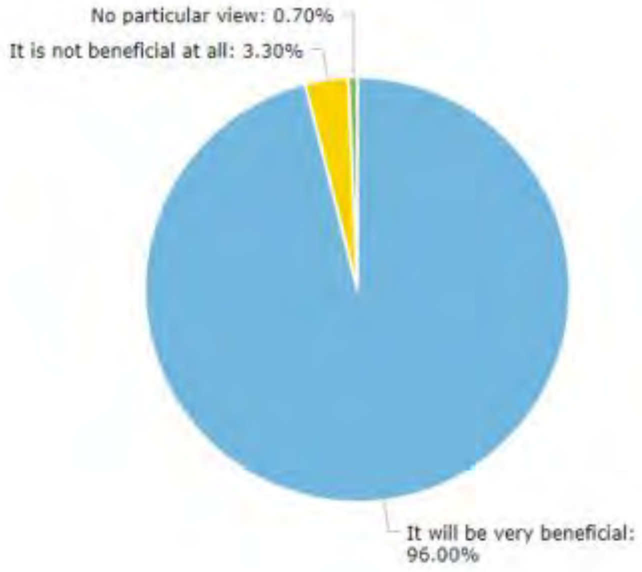


Figure 6-40 General Perception of the Project

The respondents were given the following choices as responses to seek their perception on the location of the proposed project:

- Has no particular view
- Location is not ideal
- Location is ideal

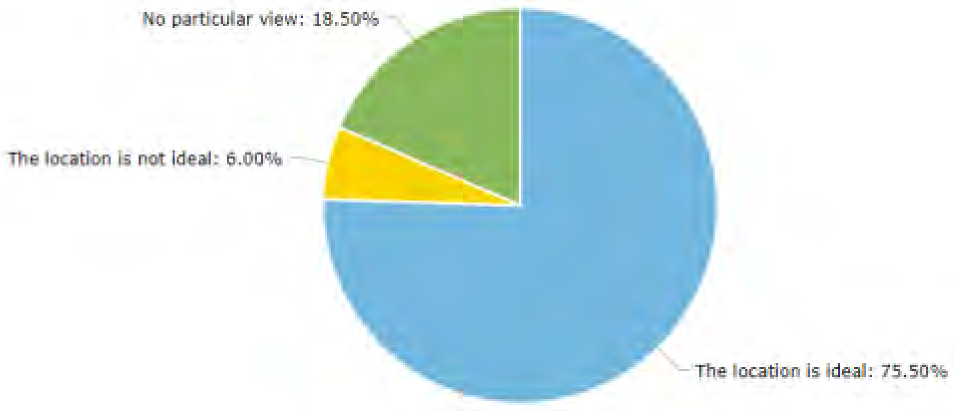


Figure 6-41 Perception on the project location

To seek the perception on the environmental and social impacts regarding the proposed project, respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

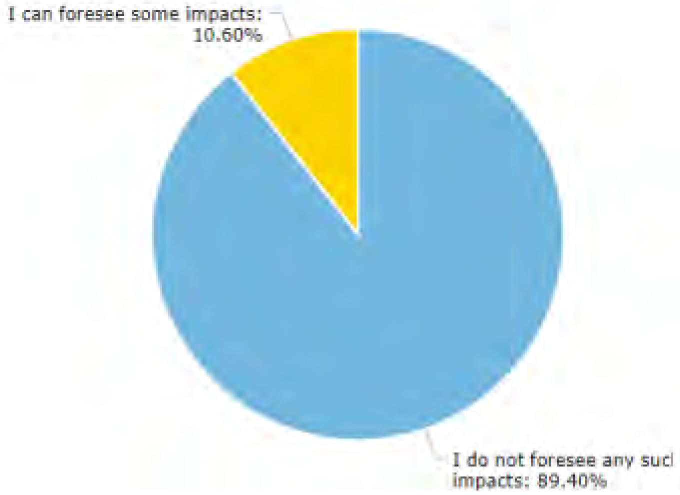


Figure 6-42 perception on the potential impacts on public and private property from the project

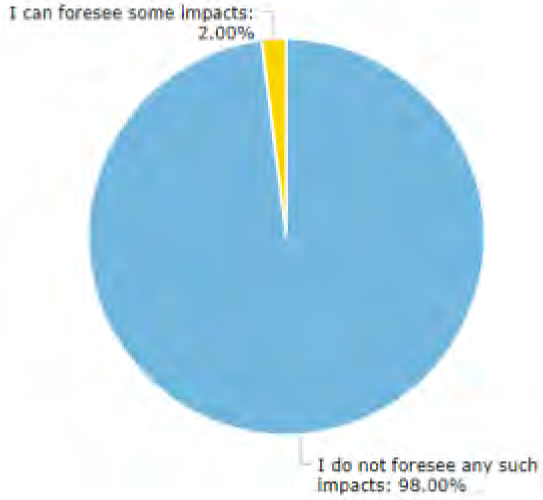


Figure 6-43 Perception on the potential impacts on the livelihood from the project

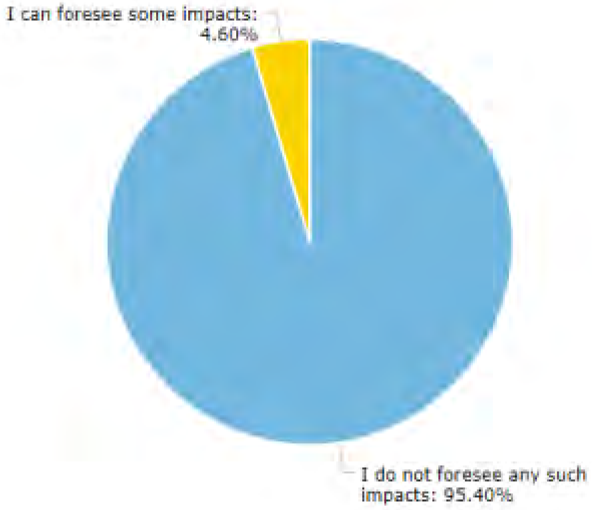


Figure 6-44 Perception on the impacts on safety from the project

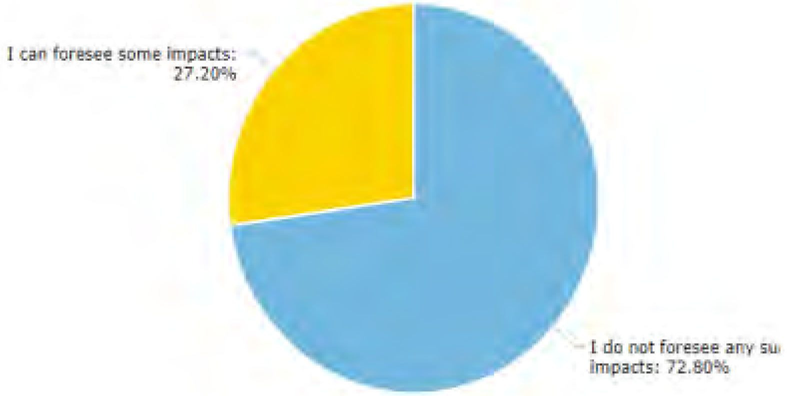


Figure 6-45 Perception on the potential implications from the influx of a labour force from the project

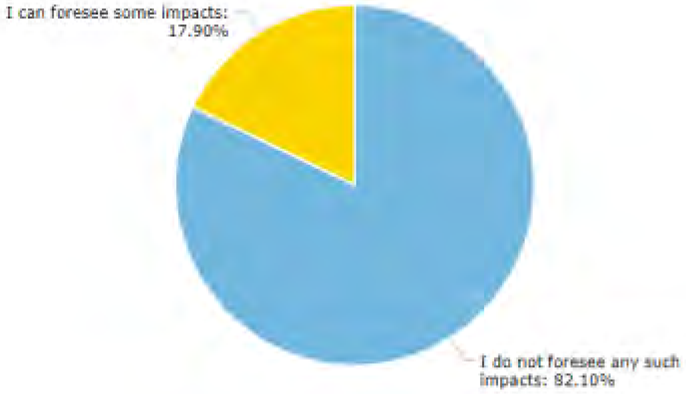


Figure 6-46 Perception on the potential impacts related noise, vibration and dust

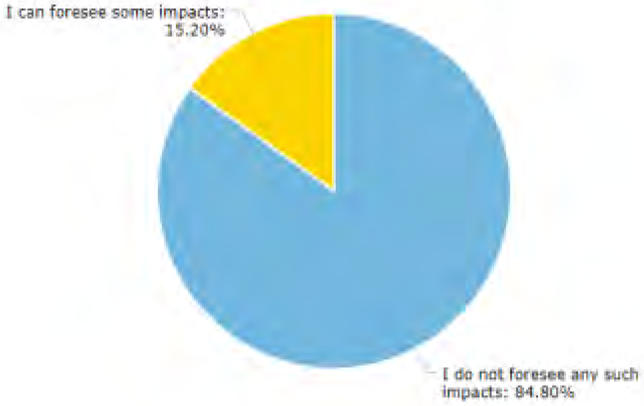


Figure 6-48 Perception on the potential impacts on traffic

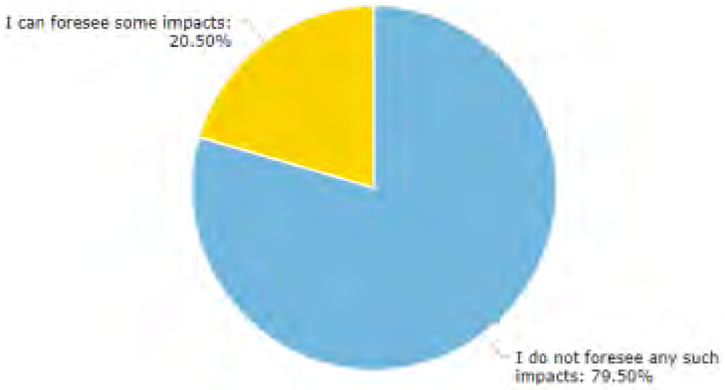


Figure 6-47 perception on the potential impacts on vegetation

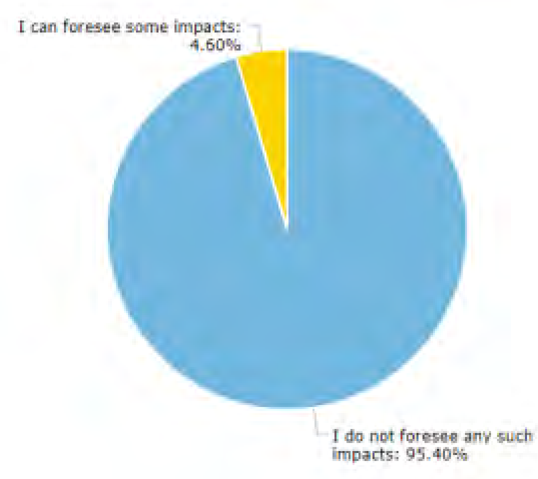


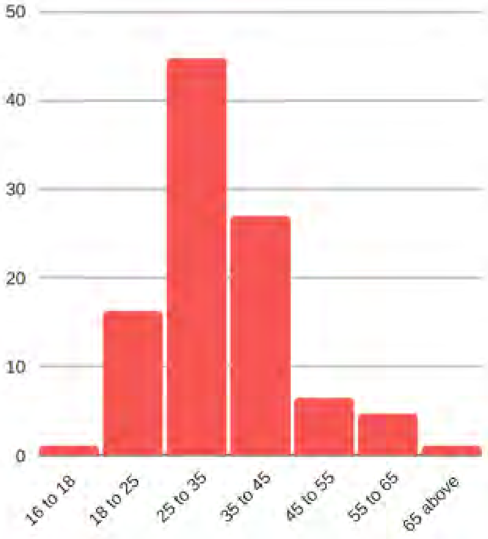
Figure 6-49 Perception on the potential impacts on groundwater

6.14 ADDU CITY

Information of the respondents:

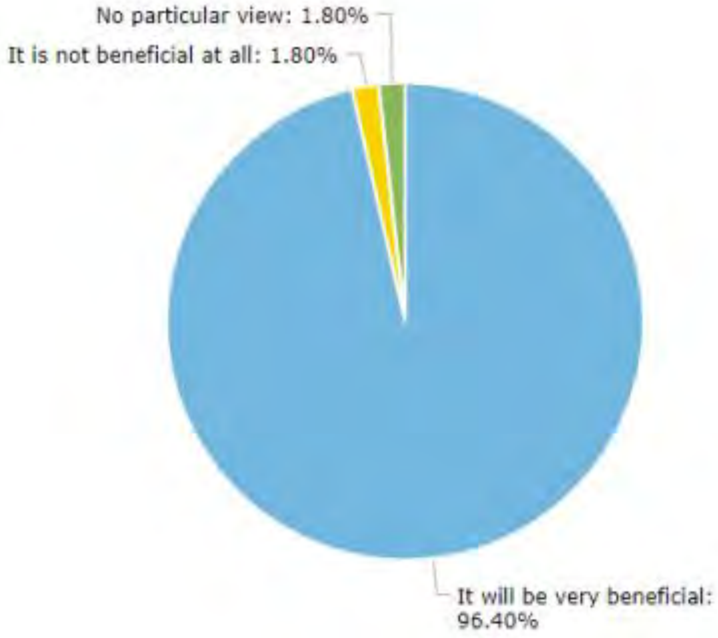
Total	115 responses
Female	42 .10 %
Male	57. 90 %

Table 6-6 Distribution of the survey



The respondents were asked on their general perception of the project with the following choices of:

- The project is beneficial
- The project is not beneficial at all



Location of the proposed project:

- Has no particular view
- Location is not ideal
- Location is ideal

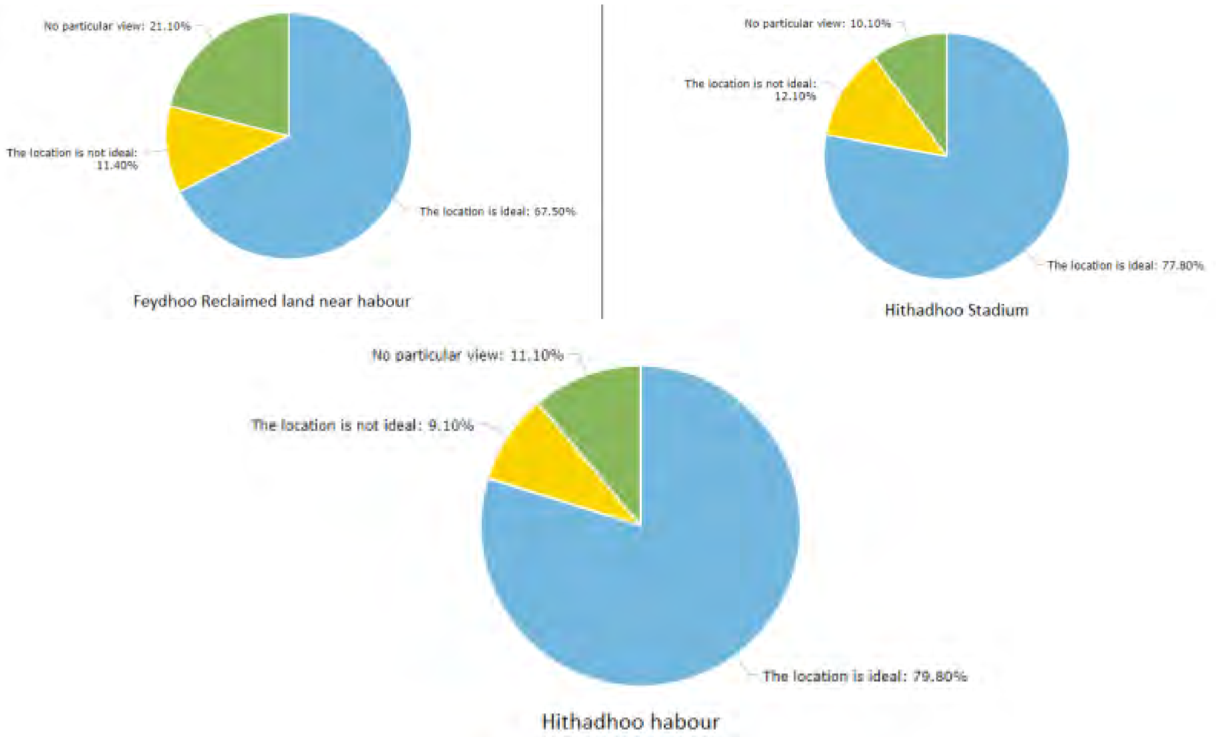


Figure 6-50 Figure 6 41 Perception on the project location

Respondents were asked on specific key areas of livelihood, property implications, safety, on the influx of a potential labour force for the project, impacts from vibration, noise, dust, traffic disruptions, impacts on vegetation and water. The results are described in the following:

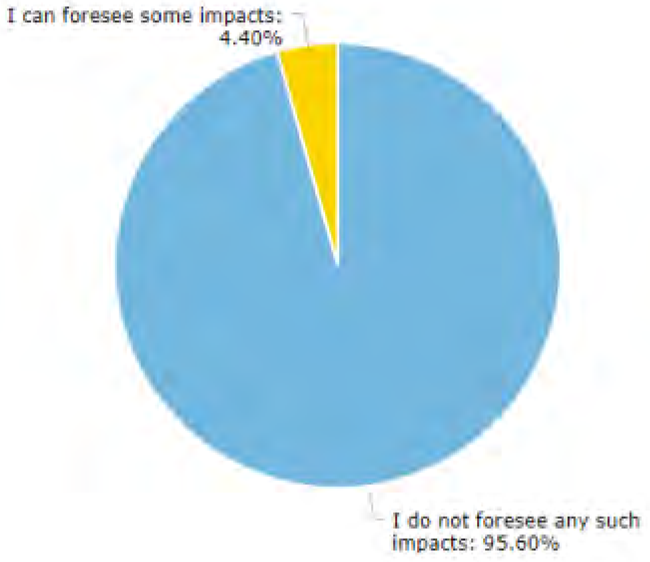


Figure 6-51 perception on the potential impacts on public and private property from the project

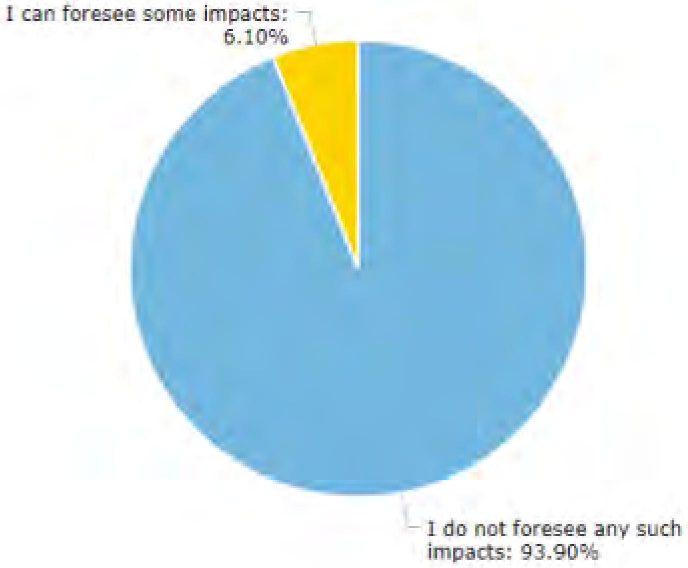


Figure 6-52 Perception on the potential impacts on the livelihood from the project

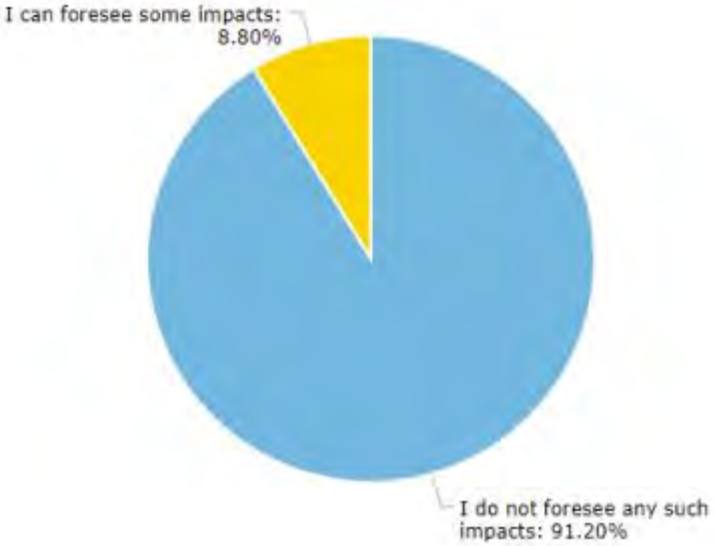


Figure 6-53 Perception on the impacts on safety

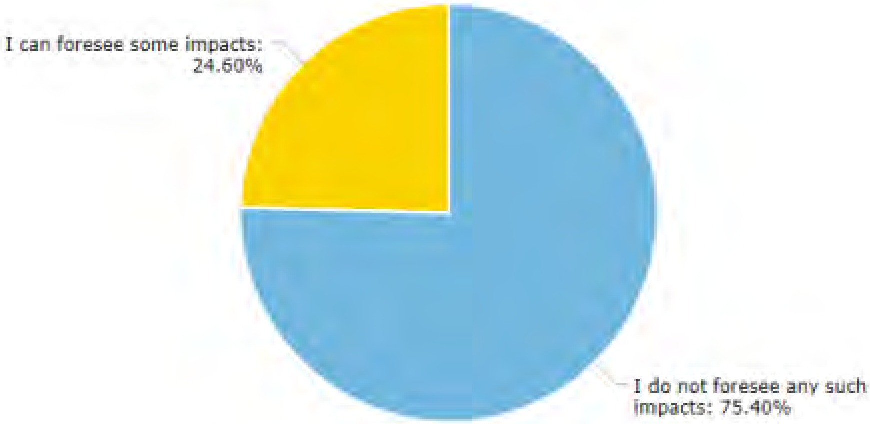


Figure 6-54 Perception on the potential implications from the influx of a labour force from the project

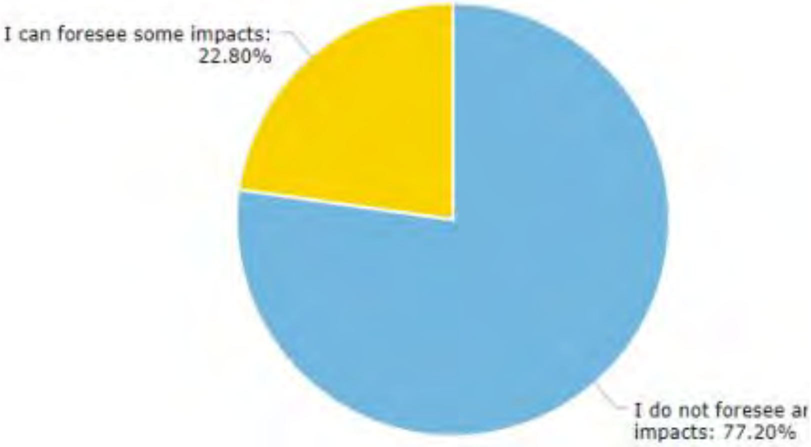


Figure 6-55 Perception on the potential impacts related noise, vibration and dust

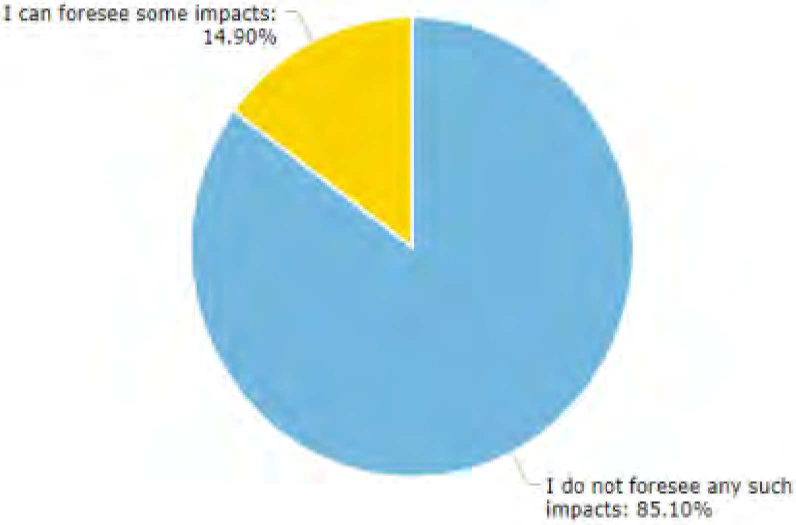


Figure 6-56 Perception on the potential impacts on traffic

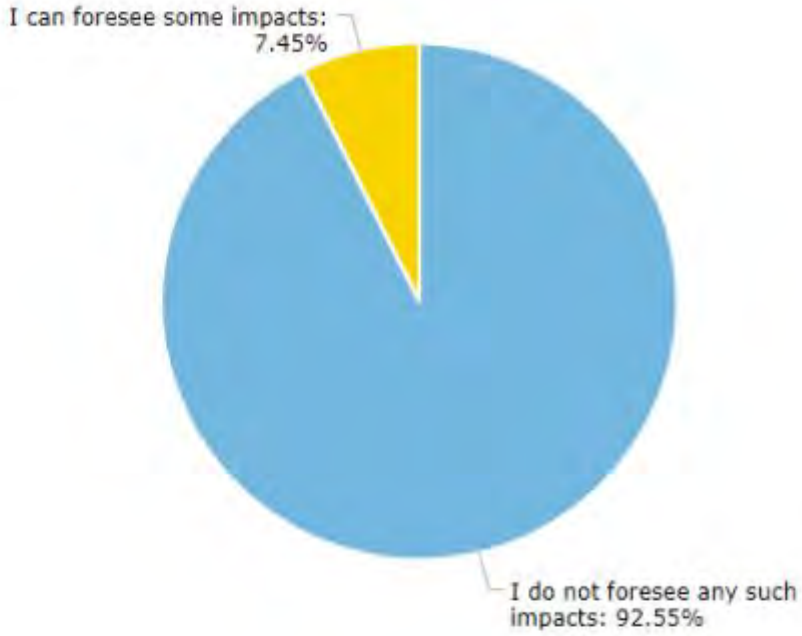


Figure 6-57 perception on the potential impacts on vegetation

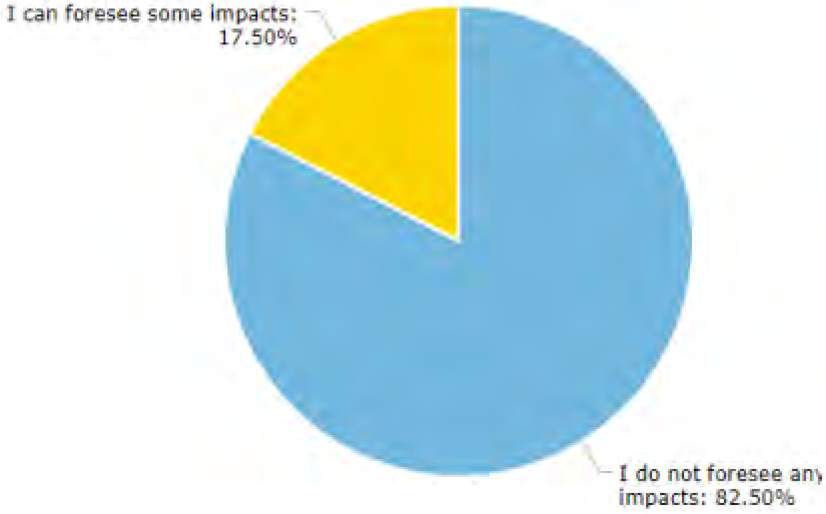


Figure 6-58 Perception on the potential impacts on groundwater

6.15 WOMEN'S DEVELOPMENT COMMITEES

6.15.1 KULHUDHUFFUSHI WDC

Meeting with WDC representatives was held on the 5th of January 2023, virtually through Google Meet.

The following are the details of the participants of the meeting.

Name	**Designation**	**Contact details**
Athifa Mohamed	Vice President	wdc@kulhudhuffushicity.gov.mv
Firasha Ibrahim	Member	

Summary of the discussions:

- The project was briefed to the WDC representatives

The points noted by the WDC representatives are summarized below:

- The committee would like to know more about the project.
- It is the request of WDC to share the details of the opportunities available for WDC to engage in the project.

6.15.2 FUVAHMULAH WDC

Meeting with WDC representatives was held on the 3rd of January 2023, virtually through Google Meet.

The following are the details of the participants of the meeting.

Name	**Designation**	**Contact details**
Mariyam Dhiyana	President	mariyam.dhiyana@fuvahmulah.gov.mv

Summary of the discussions:

- The project was briefed to the WDC representatives

The points noted by the WDC representatives are summarized below:

- As per the job opportunities and administrative collaboration with the project, the WDC will have to meet the rest of the members and decide.
- Expressed interest in involving in the project trainings and job opportunities

6.15.3 EYDHAFUSHI WDC

Meeting with WDC representatives was held on the 10th of January 2023, virtually through google Meet.

The following are the details of the participants of the meeting.

Name	Designation	Contact details
Zeema Ibrahim	President	xeemanaseer@gmail.com

Summary of the discussions:

- The project was briefed to the WDC representatives
-

The points noted by the WDC representatives are summarized below:

- To share with WDC about any job opportunities during the operational and construction phase.
- Expressed interest in participating in training during the operational and construction phase.

6.15.4 ADDU WDC

Meeting with WDC representatives was held on the 16th of January 2023, virtually through Google Meet.
The following are the details of the participants of the meeting.

Name	Designation	Contact details
Nusrath Rasheed	President	wdc@adducity.gov.mv
Nauma Abdulla	Vice President	
Aishath Dhusooma	Member	
Khadeeja Ibrahim Didi	Member	
Mariyam Naseera	Member	
Anoosha Mufeedh	Member	
Fathimath Heena	Member	
Salmana Moosa	Member	
Hawwa Zahira	Member	

Summary of the discussions:

- The project was briefed to the WDC representatives

The points noted by the WDC representatives are summarized below:

- The committee expressed interest to know more about the project.
- It is the request of WDC to share the details of the opportunities available for WDC to engage in the project.
- WDC expressed interest in assisting to seek interested individuals for the training programs which is included in the community engagement plan of the proponent

6.16.Meeting with NGOs

NGOs and CSOs operating in the respective project locations were approached through telephone. However only two NGOs from B.Eydhafushi and HDh.Kulhuduffushi responded. The key points highlighted are summarized below:

- The project was briefed to the NGO representatives by the consultant
- Both NGOs highlighted that they were not fully aware of the project scope.
- Highlighted that capacity building and creating awareness on solar energy is important and they are happy to participate in such training programs.

The following are the details of NGOs consulted:

Name	NGO	Island	Contact

Hussain Shimhaz (Member)	Foundation of Eydhafushi Youth Linkage (FEYLI)	B.Eydhafushi	feylimail@gmail.com
Afa Hussain (Founder)	BeLeaf	HDh.Kulhuduffushi	beleaf.mv@gmail.com

7 IMPACT PREDICTION

This chapter discusses the envisaged environmental impacts associated with the project components for both the construction and operational phase, along with the methodologies used for impact prediction. It is of note that any development or project which alters the environmental conditions may lead to impacts on the social and economic dynamics of the respective place.

7.1 IMPACT IDENTIFICATION

Environmental and socio-economic impacts associated with the project were identified by thoroughly studying the project activities against their interactions and environmental pressures. This was done in conjunction with referring to relevant previous environmental studies of similar scope and baseline data. In this regard, the existing project environment and built environment of impact vicinity was surveyed and assessed. Furthermore, information derived from stakeholder consultations and outcomes of the project scope to formulate the Terms of Reference of this ESIA were considered. In addition to this, the professional experience and judgement of the project team was accounted in the impact identification exercise.

Stated below are the major impacts identified for the project

- Impacts on flora and fauna
- Impacts to ground water
- Impacts on air quality
- Particulate emissions – dust
- Noise and vibrations
- Landscape integrity
- Transport and traffic issues
- Impacts on the provision of electricity
- Impacts on the accessibility to socio-economic activities
- Health hazards and safety
- Disturbances to residents and cultural facilities and activities

7.2 IMPACT SIGNIFICANCE

7.2.1 METHODOLOGY

The criteria used to assess the significance of the environmental and socio-economic impacts of the proposed project was developed by referencing matrices proposed by (Hanna, 2009) and, (Canter & Canty, 1993).

The criteria used in assessing the impact significance of the proposed project are explained in the table 7-1.

Table 7-1 Impact Significance

Criteria	**Definition**	**Scale Explained**
Magnitude *(M)*	The severity of the impact	-1 = Positive effect 0 = Negligible effect 1 = Low negative effects 2 to 8 = Moderate negative effect 9 to 15 = High negative effect
Spatial Distribution *(G)*	The scale of the impact in terms area / geography	1 = less than 1 square kilometres 2 = 1 to 100 square kilometres 3 = 101 to 1000 square kilometres 4 = 1001 to 10,000 square kilometres 5 = greater than 10,000 square kilometres
Probability *(P)*	Likelihood of the impact occurring	1 = less than 25% occurrence 2= 25 – 75 % occurrence 3 = Greater than 75 % occurrence
Reversibility *(R)*	How long it would take for the receptor to recover from the impact	1 = Short 2 = Medium 3 = Long 4 = Non-recoverable

Impact significance were assigned using the following formula, for this assessment

$$Impact\ Significance = [Magnitude\ (M)]\ \times [Spatial\ Distribution\ (G) + Probability\ (P) + Reversibility\ (R)]$$

$(M) \times (G+P+R) = Impact\ Significance$

Significance class definition for environmental impacts are outlined in the following Table 7-2.

Table 7-2 Significance Class Definitions

Grading Points	**Significance**	**Colour Code**
>50	Significant, major negative impact	Red
21 - 50	Significant, moderate negative impact	Orange
1 - 20	Minor negative impact	Yellow
0	Insignificant	White
Negative scale	Positive impacts	Green
-	Unknown or insufficient data to assign significance	Grey

7.3 IMPACT SUMMARY

The impact matrix for both the construction and operational phase are stated in the following table 7-3.

Table 7-3 Impact Matrix

Component / Activity	**Magnitude**	**Spatial Distribution**	**Probability**	**Reversibility**	**Significance**	**Colour code**
Project Phase: Construction						
Ground water impacts	1	1	1	1	3	🟨
Impacts on Soil	1	1	1	1	3	🟨
Impacts due to Noise Pollution	2	1	3	1	10	🟨
Impacts due to Air Pollution	1	1	3	1	5	🟨
Impacts from vibration	1	1	1	1	3	🟨
Impacts from vehicle emissions	1	1	3	1	5	🟨
Accidental spillages	2	1	1	1	6	🟨
Marine water pollution	2	1	1	1	6	🟨
Vegetation removal	8	1	3	2	48	🟧
Impacts on flora and fauna during material handling and transporting	2	1	3	1	10	🟨
Impacts to traffic	1	1	1	1	3	🟨
Sociocultural conflict due to the influx of workforce	2	1	1	1	6	🟨
Impacts on the economy	-1	5	3	3	11	🟩
Project Phase: Operational						
Impacts on the economy	-1	5	3	3	11	🟩
Reduced Air Pollution	-1	5	3	3		🟩
Impacts during maintenance works	1	1	3	3		🟨

7.4 IMPACT DESCRIPTION

The table below describes the respective impacts identified

Impact	**Description**
General impact description for the whole project	
Impacts on Flora and Fauna	The following are the identified effects but are not limited to, on plants which can be potentially caused from the implementation of the proposed project: ● Dust deposition on leaf surfaces has been known reduce synthesis of chlorphyll-a due to shedding effects. ● Dust deposition on plants can cause stomata clogging in plants ● Reduction of protein and starch content of the leaves has been observed in plants which are in dusty environment (Sett, 2017) The project footprint area consists of some shrubs and trees, in Hulhumeedhoo STP site which are expected to be cleared for the establishment of the proposed system. The proposed PV installation site in G.Dh. Thinadhoo requires vegetation clearance to some extent.
Occupational Health and Safety	Construction work and construction sites are often termed as ‘high risk’ due to the associated multiple health and safety hazards. As such, it is important to assess and identify each and every component of the physical project activities with utmost importance and caution. Fatal accidents have occurred during construction works in Male' area where workers, and public who utilize the surrounding areas have been impacted. Furthermore, the risk is higher since the construction site is at the midst of a residential neighbourhood. According to the US Occupational Safety and Health Administration the common construction site accidents are falls, struck by an object, electrocution, getting caught or in between equipment and machines. During the construction phase of the project health and safety issues are of the major concern due to the use of machineries, equipment and materials which can cause injuries to the workers and residents within close proximity to the project site.
Fire Risks	During the construction phase, ignition sources and fuel sources can be from numerous paths. Identified ignition sources are stated below, but not limited to: ● Lighting sources ● Welding equipment ● Machineries and tools Fuel sources identified are stated below, but not limited to: ● Waste material with high calorific value ● Packaging material

	● Volatile substances ● Structural components ● Fuel operated machineries Operational Phase This should be taken into consideration for the operational phase as well during maintenance works which may include welding and cutting.
Impacts to the ground water and soil	Construction materials spillage accidentally or due to negligence of best practices is the biggest concern of the project. The magnitude and extent of the impact will depend on the quantity and characteristics of the material spilled. Hazardous chemicals and fuel spillages has the potential to cause significant environmental damages which may have prolonged effects. However, with the mitigation measures and ensuring workplace best practices it is of note that such a scenario is unlikely. Even though shallow excavation is expected for the concreted footings, dewatering is not expected as the scale is not close to that magnitude.
Topographic Changes. Drainage patterns and flooding	The project is not expected to cause major topographic changes as the structure support footprints are relatively small. However, it depends on how well the trenches are backfilled.
Impacts on ambient air quality	Works similar to the proposed, includes activities such as mixing of cement, laying of construction mixes, and other fine particulates which produces dust and particulate emissions having a wide array of effects to the surrounding natural environment, human, and built environment as well. It should be noted that the project will utilise heavy vehicles during construction. Emissions from these vehicles will release particulate matters including black carbon. The following are the identified effects but are not limited to, on plants which can be potentially caused from the implementation of the proposed project: ● Dust deposition on leaf surfaces has been known reduce synthesis of chlorphyll-a due to shedding effects. ● Dust deposition on plants can cause stomata clogging in plants ● Reduction of protein and starch content of the leaves has been observed in plants which are in dusty environment (Sett, 2017) The following are the identified effects but are not limited to, on humans which can be potentially caused from the implementation of the proposed project:

	● In general particulates from such construction works where cement, dust/particulate inducing materials are often used, can be harmful to the health when inhaled. Fine particulates ($PM_{2.5}$) can get into deep parts of the lung and/or to the blood. Larger particulates (PM_{10}) can cause irritation in eyes, nose and throat. ● People with underlying health issues such as heart or lung diseases, elderly, and children can be classified as a high risk category from issues related to particulates ● Furthermore, health complications can be induced in people with underlying health issues from inhaling particulates (Centres for Disease Control and Prevention, 2019) In addition to this, paints used for road markings can release VOCs to the ambient air during the application process. However, these VOC emissions are expected to diminish within a short period of time. VOCs can cause the following health complications: ● Irritation in eyes, ears and throat ● Shortness of breath ● Headache ● Fatigue ● Nausea ● Dizziness ● Skin problems Long term exposure may negatively impact the liver, kidney or central nervous system of the body. It is of note that the severity of impact depends on the concentration, length of exposure and also the health of the individual being exposed. (British Columbia Center for Disease Control, 2018) During the operational phase of the proposed project, it is expected to have an increase in the amount of emissions and particulates released to the air through the required electrical power generation. This is projected due the increase number of users (max capacity of 10,000) and their entailed emission footprint during the time of use of the facility
Noise and vibrations	Construction works of similar scope are expected to significantly contribute to the ambient noise pollution of the respective area. Contributors to noise pollution include loaders, compacters, pneumatic equipment, trucks, machine mounted percussion drills, mixers, generators, pumps, breaking equipment, hammers, etc. Major impacts due to the increase of noise pollution includes, but are not limited to: ● Sleeplessness

	● Interference with communication ● Increased stress levels on both humans and animals ● Negative impacts to the hearing of the construction workers and to individuals within impact proximity ● Annoyance ● Effects on the performance of daily tasks (Graeme Shannon, 2015), (World Health Organization, 1980) These types of noises are temporary and are relatively intermittent. Due to the high peaks already endured in the neighbourhood and the common occurrence of construction projects throughout the capital, it is not anticipated noise from this project will be perceived as a significant impact on the community. Similar to the noise pollution contributors, activities that utilize loaders, pneumatic equipment, trucks, and machine mounted percussion drills, mixers, generators, pumps, breaking equipment, hammers, and similar equipment are considered to generate the most vibrations.
Landscape integrity	Landscape changes brought in by the project is very much subjective to individual human nature. However, most of the existing sites are not virgin environments as they have experienced human alterations. It is of note that the project facilitates greening the underneath area, facilitates the setting to walkways, resting areas, parking, open air local markets, etc. Furthermore, the visible solar PV systems allows the respective islands to be marketed as an environmentally friendly area. Therefore, the project is expected to bring a net positive change from the project.
Transport and traffic issues	During the construction phase, logistical arrangements may lead to roads been temporarily closed to ensure social safeguards related to the project. This may cause temporary nuisances to the general public, and may have to make changes to the commute. The project works as such includes trenching for cable laying required for the grid connections in the islands. Additionally, this may cause elevational changes in the roads/paths, if proper backfilling is not conducted.
Solid Waste	Waste from the construction phase is expected to be heavy waste such as wood (pallets storage boxes), moulding casts, plastic, domestic wrapping bags, municipal waste, etc. This causes a negative impact due to the nuisance to the neighbourhood, traffic flow disruptions in times of waste collection. The impact to the area caused from the generated waste is expected to be short term. However, if the waste are not properly managed the following issues can be caused: ● Hazardous substances leakage to the ground and infiltrate to the water table

	● Can become a breeding ground of vectors and pests, causing disease outbreaks ● Lowered aesthetics of the area ● Fire hazards
Impacts on the accessibility and socio-economic activities	During the construction phase, due to the road closure and other related disturbances; the project will cause temporary negative impacts to the socio-economics. However, during both construction and operational phases, job opportunities will be created for the island communities, where as per the community engagement plan priority will be given to locals. The infrastructure to be established within the project is designed to serve as multiuse. In this regard apart from the airport areas, the underneath area will be utilised as parking spaces, market areas, or in a way recreational activities will be facilitated as such (jogging, walking, etc). While it is of note that the spaces allocated were selected based upon consultation with the island community and council. In this regard, the land use plans of the islands were studied in accordance of the project scope to limit overlaps with the island development projects.
Disruptions in electricity	During the construction period of the project, it is expected to cause power disruptions during works related to grid connections.
Weather related hazards and risks ***Kulhudhuffushi and Fuvahmulah Airport area***	As the project sites are in close proximity to coastal sites with little wind breaking structures both biotic and abiotic to break high winds; the project site during construction poses significant hazards during times of strong winds and storms. Particularly at sensitive areas such as the Airport sites of **Kulhudhuffushi** and **Fuvahmulah,** special consideration should be taken.
Stresses on Kulhudhuffushi wetland area	As the wetland is in close proximity to the project site, there is the potential risk of building materials and waste could be blown to the site. However, special consideration and monitoring will be taken during works at the site as it is an Airport site as well.
Stresses on the Utilities	During the operational phase, it is expected to ease the existing demand on fossil fuel power generation and project towards sustainable power generation pathways through experiencing the added economic benefits.
Cultural facilities and activities	With regard to the current scope of the project, there are no culturally significant site within the project vicinity.
Vegetation removal and ground remediation works	Ground remediation and reconditioning works are required in the given site as the existing site was previously used as a waste site. Furthermore, vegetation removal is expected in this area.

Hulhumeedhoo STP site and Fuvahmulah Site	

7.5 IMPACT AREA MAPS

The following describes the considerations taken in zoning impact areas.

Table 7-4 Impact Area Zoning

Colour	Description	
🟥	Direct	Project Boundary
🟧	Moderate	Within 50 to 100 m from the project boundary
🟨	Indirect	Indirect impacts due to material transfer and logistical arrangements. These include disruptions to traffic and other social nuisances.

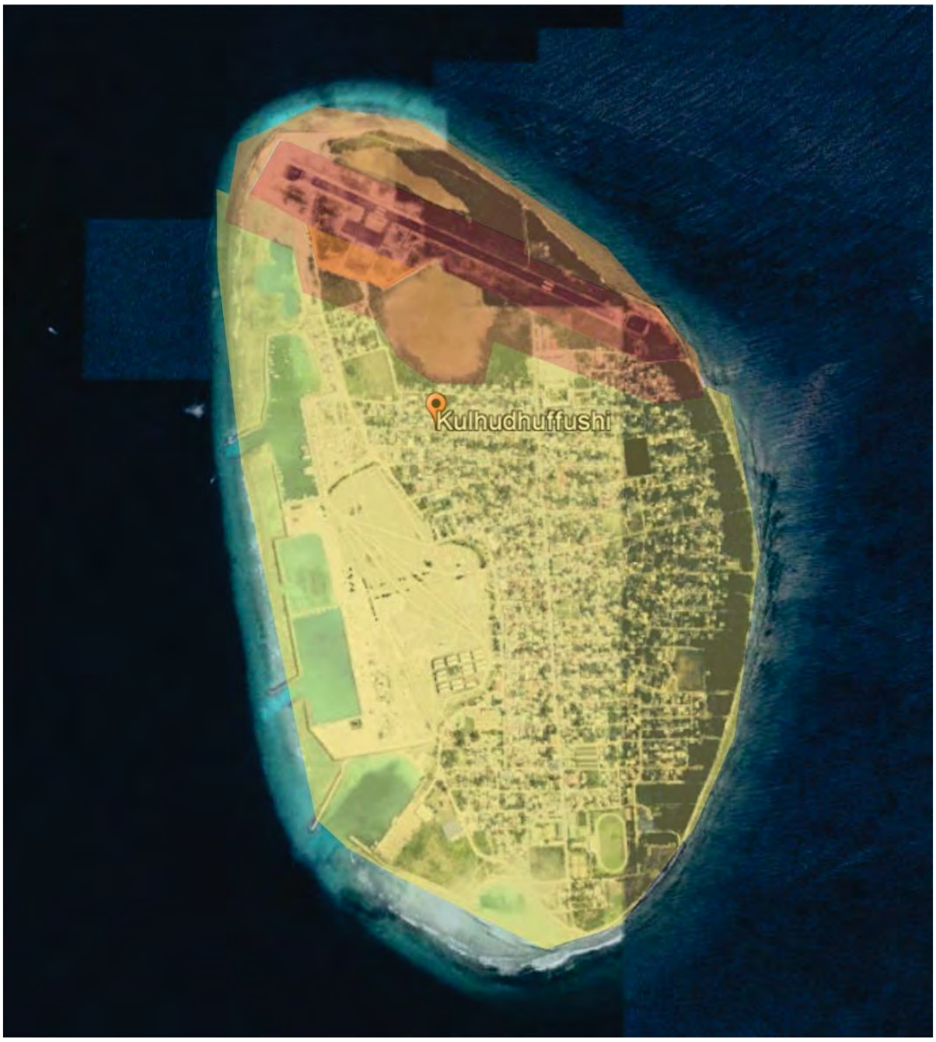


Figure 7-1 Impact Map, Kulhudhuffushi

Figure 7-2 Impact Map, Eydhafushi

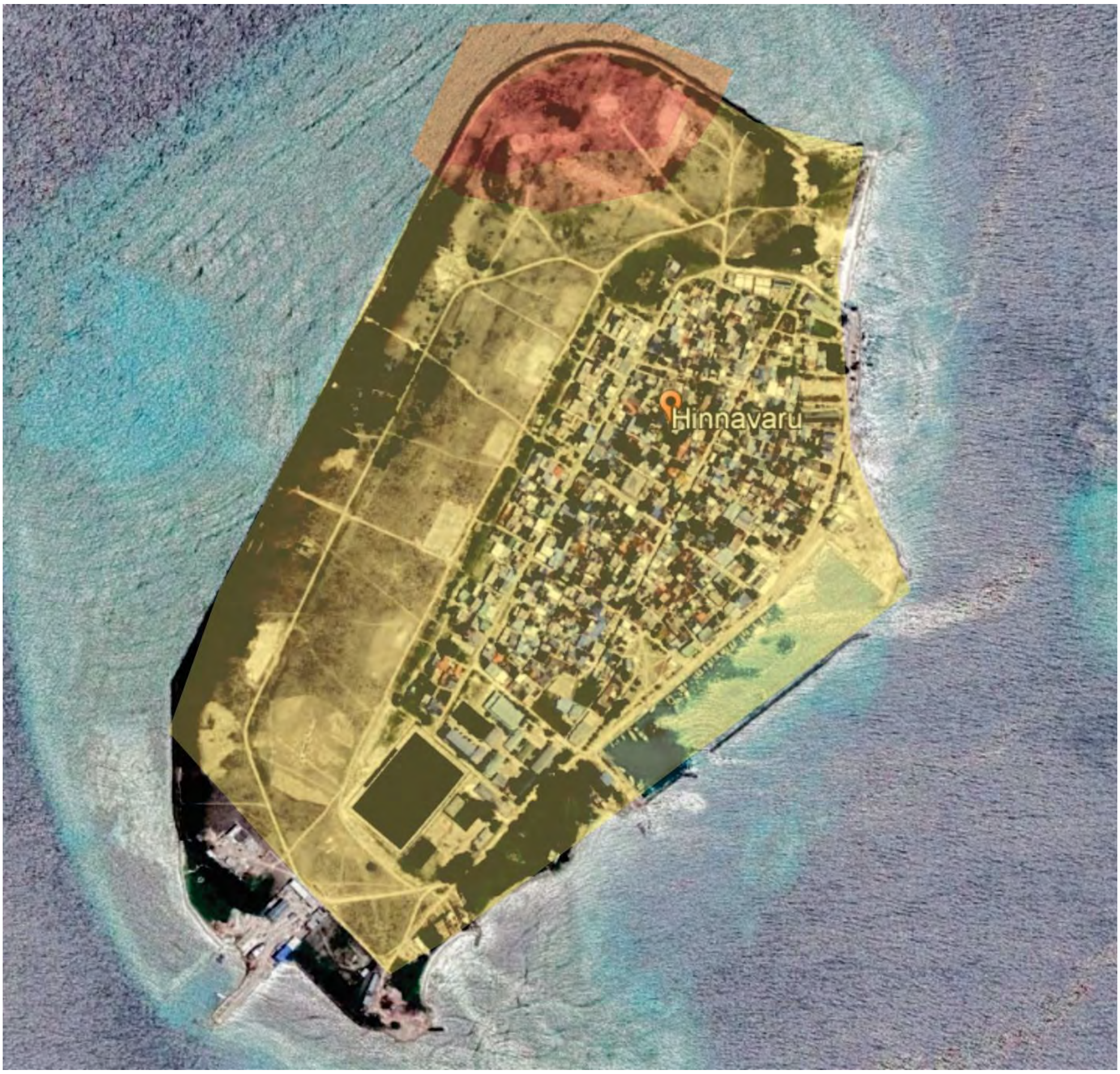


Figure 7-3 Impact Map, Hinnavaru

Figure 7-4 Impact Map, Thinadhoo

Figure 7-5 Impact Map, Hithadhoo Stadium Area

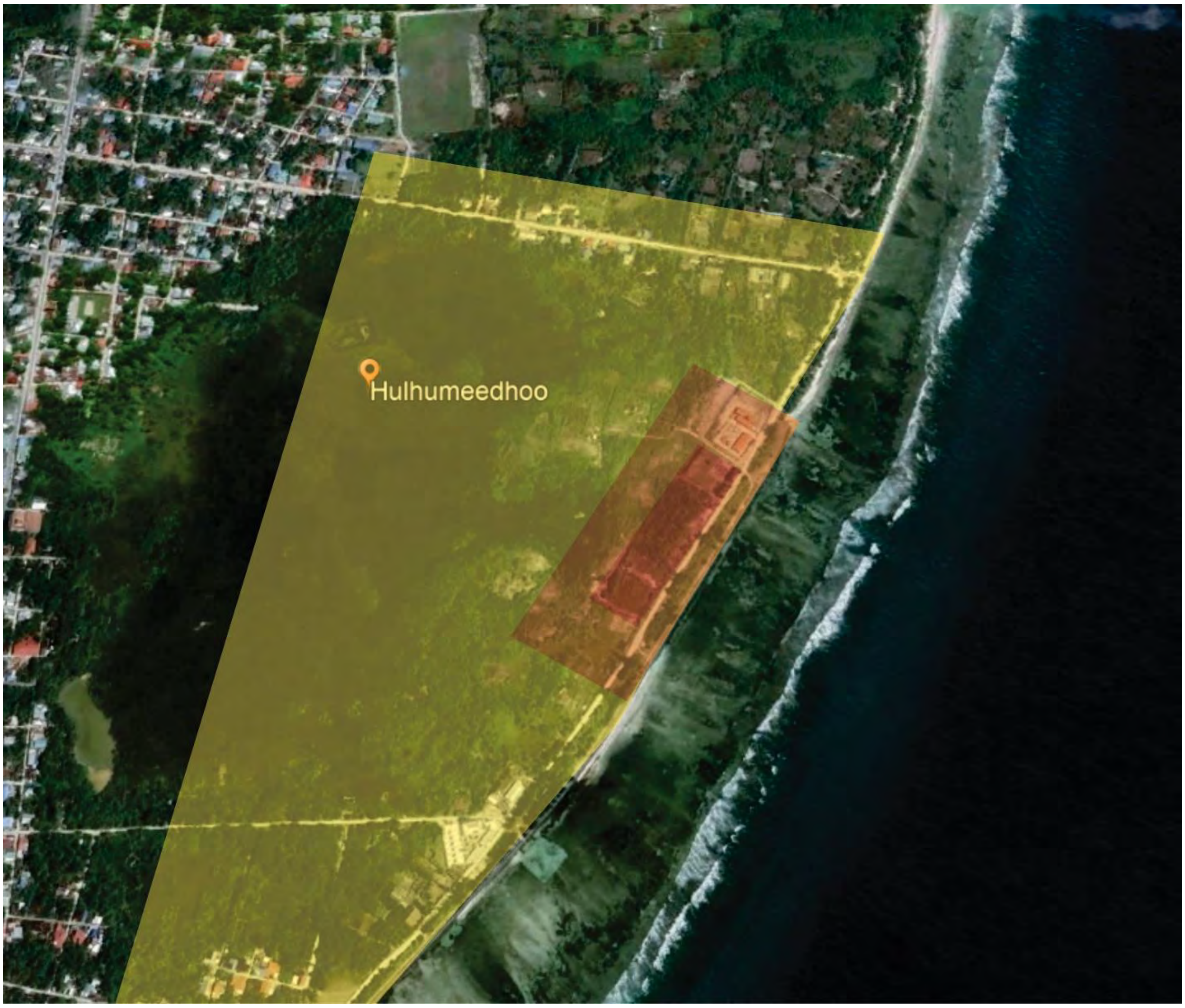


Figure 7-6 Impact Map, HulhudhooMeedhoo STP site

Figure 7-7 Impact Map, Maradhoo Feydhoo Harbour area

Figure 7-8 Impact Map, Feydhoo Harbour area

7.6 INDIRECT AND CUMULATIVE IMPACTS

All development projects that causes changes to the existing environment or that have socioeconomic implications may have impacts beyond its specific site and location. These cumulative impacts are a result of the effects of changes in constituent parts affecting the system. Similar mechanisms may also be present in the current proposed project, with the changes in socio-economic and other dynamics contributing to, and working in tandem with other changes elsewhere, then having a wider range of impacts. However, calculating and investigating the cumulative impacts require a wider analysis and possibly looking at a longer time horizon.
Nevertheless, due to complex nature and diversity of social and economic activities which may be introduced as an indirect effect of completing the scope of this project – it is difficult to predict the respective impact nature of these activities might be entailed with.

With respect to the planned and ongoing major infrastructure development projects in the project sites, the project will be supplying clean energy compared to other conventional means used in the country. The table below highlights and describes the projects' cumulative/indirect impact projects in relation to major ongoing/planned infrastructure projects.

Table 7-5 projects 'cumulative/indirect impact projects in relation to major ongoing/planned infrastructure projects.'

Location	**Projects** (President's Office, 2023)	**Expected impacts**
Kulhudhuffushi City	Infrastructure projects ongoing and planned: ● School Building – Afeefudhin ● School Buildings ● Jalaaludhin School Building ● Establishment of Police stations ● 105 Housing units ● TIVET establishment ● Construction of a Multi purpose Hall ● Installing Street Lights ● Construction of 400 housing units ● Tertiary Hospital Building ● Establishment of a Yatch Marina	As the tabulated ongoing and planned projects are expected to cause an increase in the energy demand; the power generated from the proposed project will provide an environmentally friendly alternative to GHG emitting energy production means such as from the existing diesel based generators. In this regard the proposed project is expected to cause a positive impact. However, harbour developmental projects and harbour upgrading projects might cause disruptions with the current project as some of the project sites are within harbour areas. While, this can be an issue, prescheduling and informing the relevant parties involved can resolve the issue.
B. Eydhafushi	Infrastructure projects ongoing and planned: ● Establishment of Waste bio treatment plant	
Lh. Hinnavaru	Infrastructure projects ongoing and planned: ● Establishment of Waste Management Centre ● New Hospital Building ● Housing Units – 100	
G.Dh. Thinadhoo	Infrastructure projects ongoing and planned: ● National University Campus ● Construction of a regional Hospital Building ● Islamic Centre building ● Development of 1500 and 200 housing units	
Fuvahmulah City	Infrastructure projects ongoing and planned: ● School building (Hafiz Ahmed) ● ICT faculty building ● Jalaaludhin School Building ● Fuvahmulah School Building ● Construction of Mosque ● Establishment of Centre for Holy Quran ● Establishment of TIVET Institution ● Hospital Building ● Construction of 400 Housing Units	
Addu City	Infrastructure projects ongoing and planned: ● Establishment of Addu Tourism Zone	

	● Establishment of Eldery Home ● New School at Feydhoo ● Irushaadhiyya School Building ● Construction of Mosque MaradhooFeydhoo ● Immigration Office building Hithadhoo ● Class rooms Addu High school ● Sharafudhhin School Building ● Police Accommodation Building Hithadhoo ● Islamic Centre Hithadhoo ● Construction of Mosque ● Fish Plant	

The project in overall is expected to serve the environmental, social and economic dynamics positively as the project is expected to reduce the amount of GHGs emitted along with other polluting by products from fossil fuel based energy generation. Furthermore, due to the reduction in the use of fossil fuels, economic savings are expected. These factors can encourage the replicating of such projects elsewhere in the nation and contribute its national determined target of becoming netzero by 2030.

7.7 LIMITATIONS AND UNCERTAINITIES

Due to vast interlinked environmental, bio-physicochemical characteristics of the components involved, it is difficult to accurately assess the impacts. Furthermore, the cumulative, direct and indirect environmental and socio-economic reactions to the project's components are very much related to many external factors which could alter the final result. The impact identification and prediction are assessed based on the available data, professional experience and judgement of the ESIA team, data received from external parties, and also relevant scientific literature. Furthermore, it is of note that the data received from external sources regarding similar projects may have variations to the current project setting.

In addition, it is of note that ecosystems often do not respond in linear fashion following disturbances, and is more towards to nonlinear ways where they exhibit marked thresholds in their dynamics and social – environmental systems act as strongly coupled, complex and evolving integrated systems (Folke, Carpenter, Elmqvist, & Gunderson, 2002)

While social and environmental impacts of resources/services/projects can be expressed in lifecycle phases which includes the embodied energy usage of materials; it is difficult to assess the full overall impacts of the project. In this regard, it is of note that full life cycle impacts are not included in the study (for example: the carbon and emission footprint of material manufacture and import processes). Furthermore, as the project is expected to bring in aesthetic changes to the project site. Aesthetics are subjective and difficult to assess.

Acknowledging these limitations, in predicting the future and complexity of the natural environment along with the inherent uncertainties the project team has identified and deduced the impacts to the best of the available knowledge and professional judgement.

8 MITIGATION MEASURE

Given the certain occurrence of environmental and social impacts resulting from the project, it is crucial to implement appropriate measures to minimize and mitigate them. As previously noted, most of the identified impacts can be mitigated with precautionary measures, and implementing them earlier in the process could significantly reduce the overall negative impact on the environment, society, and economy. This section will outline the relevant mitigation and management measures for the proposed development project, which must be adopted during both the construction and operational phases to effectively reduce the severity of the impacts.

8.1 Justification for Mitigation measures

The measures proposed for environmental management and mitigation in this report were chosen based on several factors. The primary consideration was the practicality of implementing the measures in a cost-effective manner, using locally available expertise, technology, and equipment. These measures have been successfully used in the construction industry in the Maldives, with minimal use of manpower. Therefore, they are deemed to be the most suitable for the proposed development.

8.2 Limitation for Mitigation measures

However, there are limitations to the proposed mitigation measures. They are designed to address only the impacts that have been identified, and these impacts themselves have inherent limitations. The magnitude and severity of the impacts are estimated based on literature and experience, which means that there is a degree of uncertainty associated with the proposed mitigation measures.

The following table 8-1 identify the proposed general mitigation measures for all the project sites including Hinnavaru, Eydhafushi, Thinadhoo, Fuvahmulah and Addu city. The table 8-2 and table 8-3 identifies the specific mitigation measures proposed for the Thinadhoo and Addu city Hulhumeedhoo site.The table 8-4 identifies the specific mitigation measures proposed for the airport site at HDh. Kulhuduffushi. The table 8-5 identifies the specific mitigation measures for the proposed site at Fuvahmulah.

Table 8-1Proposed General Mitigation Measures for all sites at Hinnavaru, Eydhafushi, Thinadhoo, Fuvahmulah and Addu city

Project Activity	**Potential Environmental and Social Impacts**	**Proposed Mitigation Measures**	**Implementing Responsibility**	**Estimated Quantities / Material Specifications**	**Cost Estimate**	**Comments (Primary, secondary or cumulative impact)**
Detailed design and planning Phase						
Design and planning	Social cohesion	Incorporation of stakeholder considerations and recommendations to the project design and implementation	Proponent and MECCT	-	In cost	Primary
Design and planning	Social Cohesion Hazard Environmental Safeguards	Plan logistical routes which is the most efficient and minimise interaction with environmentally sensitive or protected areas. Furthermore, ensure temporary sites such as storage sites are selected in consideration with the existing surrounding built and social environment.	Proponent and MECCT	-	In cost	Primary

Pre-Construction Phase – Site Preparation						
Site preparation	Worksite hazards	Demark the work site with adequate signage. To increase the visibility during low light, use reflective tape and cautioning lights.	Proponent	As needed	In Cost	Primary
Planning and preparation	Social cohesion	Set up an online grievance mechanism where complaints can be logged to the proponent. It is advised to use an online form for this to make it more accessible. A QR code with the link is advised to be put up on a board outside the site where it is visible and read without endangering the safety of the person. It is advised to take necessary actions to safeguard the environmental and socio-economics associated with the project.	Proponent	-	In cost	Primary

		However, it is advised to set up a non-internet-based grievance redress mechanism as well, to improve the accessibility.				
Logistics and Storage	Social Cohesion Health and Safety Environmental Safeguards	Ensure the storage facility is appropriate to the material stored. Refer to Material Safety Data Sheets of the materials stored. Ensure the logistical arrangements are made to avoid and minimize hazards as much as possible through pre planning routes and informing the relevant authorities	Proponent	As needed	In Cost	Primary
Logistics	Social Cohesion Health and Safety Environmental Safeguards	During material transfers, including sea and land, ensure that the environmentally protected and sensitive sites are informed to the logistical crew and set conduct in a manner	Proponent	As needed	In Cost	Primary

		which minimises the risks to these areas				
Security	Hazard Health and Safety	Allow only authorized personals with adequate protective equipment to the site	Proponent	As needed	In Cost	primary
Planning and preparation	Health and Safety	Erect dust screens during construction/demolition where particulate matter may be released	Proponent	As needed	In Cost	Primary
Throughout	Health and Safety Social Cohesion	Remove waste from the project site on daily basis	Proponent	As needed	In Cost	Primary
Logistics	Health and Safety Social Cohesion	In case of road closure; alternative safe routes shall be provided to road users.	Proponent	As needed	In Cost	Primary
Logistics and planning	Health and Safety. Environmental Safeguards Social Cohesion	Machinery servicing which involves lubricants, waste oil, oil-based substances or any of hazardous nature should be conducted on a base with impermeable lining	Proponent	As needed	In Cost	Primary
Construction Phase						
All activities	Health and Safety	Ensure no construction material and equipment	Proponent	As needed	In Cost	Cumulative

	Social Cohesion	are left outside the project area				
Site servicing All activities	Health and Safety Social Cohesion	Remove waste from the project site on daily basis	Proponent	As needed	In Cost	Cumulative
Logistics	Health and Safety Social Cohesion	In case of road closure; alternative safe routes shall be provided to road users.	Proponent	As needed	In Cost	Primary
Logistics Construction equipment management	Health and Safety. Environmental Safeguards Social Cohesion	Machinery servicing which involves lubricants, waste oil, oil-based substances or any of hazardous nature should be conducted on a base with impermeable lining	Proponent	As needed	In Cost	Primary
Storage, logistics, handling	Health and Safety. Environmental Safeguards Social Cohesion	Ensure all the materials are sealed while special precautions should be given to volatile liquids and liquids with potential hazardous character. Regular site supervision should be conducted for safety assurance.	Proponent	As needed	In Cost	Primary

Employment	Social Cohesion	Hire workers locally, as much as possible . If hiring foreign workers, conduct health screening prior to recruitment. Ensure valid work visa permit is present Identify an emergency contact for all the workers hired.				Primary
Trenching	Social Cohesion Health and Safety	While excavating, and making trenches for connections and foundation works; use pipe/cable detectors to avoid any damage to existing, established service networks of the islands. Utilise light low impact equipment rather than heavy machineries. Continuous monitoring observation should be practiced to avoid damages to any	Proponent	1 per site (cable detector)	In cost	Primary

		cables/pipes laid previously. Liase with the relevant responsible parties (Fenaka/Dhiraagu/ Ooredoo / etc) in the islands/cities to avoid accidents.				
	Social Cohesion Health and Safety	Pre contract/agreement with the cable/pipe laid service providers on the conduct, in case of damage during the works of the proposed project	Proponent	As needed	In cost	Primary
	Social Cohesion	Ensure labour living conditions are adequate and within the HPA guidelines and ensure the labour rights under the set legislative framework are fulfilled.	Proponent	As needed	In Cost	Primary
	Health and Safety	Ensure emergency first aid health facilities are arranged at site. In cases of serious injuries, or disease manifestations the relevant health authorities should be	Proponent	As needed	In Cost	Primary

		informed and their instructions must be strictly followed.				
Vehicle and logistics	Social Cohesion Health and Safety Environmental safeguards	Ensure the vehicles used are well maintained and fitted with air pollution control devices.	Proponent	As needed	In Cost	Primary
Work timings	Social Cohesion Health	Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration and noise. These works should not be carried out at odd hours.	Proponent	As needed	In Cost	Primary
Site preparation (daily)	Health and Safety Hazard Social Cohesion	The work surface shall be moistened in regular intervals to minimise windblown dust and debris to cause public nuisances. However, the supervisor must ensure this does not pose slippery surface hazard to the workers	Proponent	As needed	In Cost	Primary
Site preparation and management (daily)	Health and Safety	The work surface shall be moistened in regular	Proponent	As needed	In Cost	Primary

	Hazard Social Cohesion	intervals to minimise windblown dust and debris to cause public nuisances. However, the supervisor must ensure this does not pose slippery surface hazard to the workers				
Work scheduling and management	Health and Safety Social Cohesion	Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration and noise. These works should not be carried out at odd hours.	Proponent	As needed	In Cost	Primary
Vehicle fleet management	Health and Safety Hazard Social Cohesion Environmental safeguards	Ensure the exhaust silencers are well maintained	Proponent	As needed	In Cost	Primary
Equipment and work management	Health and Safety Hazard Social Cohesion	Ensure the equipment used are serviced and well maintained	Proponent	As needed	In Cost	Primary

	Environmental safeguards					
Work management	Health and Safety Hazard Social Cohesion Environmental safeguards	For flammable volatile substances and gasses: ● Use fire resistance containers for storage ● Keep away from heat and ignition sources ● Ensure the containers are sealed ● Ensure the storage area is well ventilated	Proponent	As needed	In Cost	Primary
Work management	Health and Safety Hazard Social Cohesion Environmental safeguards	For Potentially combustible materials ● Store in fire resistance containers ● Keep away from ignition and heat sources	Proponent	As needed	In Cost	Primary
Work management	Health and Safety Hazard	Combustible waste ● Waste should be collected and	Proponent	As needed	In Cost	Primary

	Social Cohesion Environmental safeguards	removed from the work area on daily basis ● Housekeeping best practices				
Work management	Health and Safety Hazard Social Cohesion Environmental safeguards	Storage of oxygen such as oxidising chemicals, oxygen cylinders or piped systems ● Should not be stored at project site ● Should be taken to the required amount for the site and kept at safe storage away from residential area	Proponent	As needed	In Cost	Primary
Work management and best conduct	Health and Safety Hazard Social Cohesion Environmental safeguards	Smoking within the premises, work area and storage area should not be allowed. Proper signage and markings should be set.	Proponent	As needed	In Cost	Primary
Work management and safety	Health and Safety Hazard	Presence of light fittings near combustible materials	Proponent	As needed	In Cost	Primary

	Social Cohesion Environmental safeguards Health and Safety Hazard Social Cohesion Environmental safeguards	▪ Give preference to lower power alternative lightings such as LED				
Work management and safety	Health and Safety Hazard Social Cohesion Environmental safeguards	Electrical extension ▪ Ensure extension leads are fully uncoiled ▪ Limit extension lead and adaptors ▪ Ensure extension leads are not overloaded ▪ Ensure flexible power cables are kept as short as possible and safety routed	Proponent	As needed	In Cost	Primary
Operational and Maintenance Phase						
Maintenance	Hazard	Demark work site	Proponent	As needed	In Cost	Primary

	Health and Safety Social Cohesion					
Safety	Hazard Health and Safety Social Cohesion	Use proper PPE and safety jackets/vests when conducting maintenance works	Proponent	As needed	In Cost	Primary
Maintenance and safety	Hazard Health and Safety Social Cohesion	In case of road closure; alternative safe routes shall be provided to road users.	Proponent	As needed	In Cost	Primary
Waste Management	Hazard Health and Safety Social Cohesion Environmental Safeguards	Remove waste from the project site on daily basis	Proponent	As needed	In Cost	Primary
Vehicle management	Hazard Health and Safety Social Cohesion Environmental Safeguards	Ensure the exhaust silencers are well maintained	Proponent	As needed	In Cost	Primary

Equipment Management	Hazard Health and Safety Social Cohesion Environmental Safeguards	Ensure the equipment used are serviced and well maintained	Proponent	As needed	In Cost	Primary
Work scheduling and management	Hazard Health and Safety Social Cohesion Environmental Safeguards	Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration and noise. These works should not be carried out at odd hours.	Proponent	As needed	In Cost	Primary
Maintenance	Hazard Health and Safety Social Cohesion Environmental Safeguards	Implement strict policies on littering on the facility premises	Proponent	As needed	In Cost	Primary
Maintenance	Hazard Health and Safety Social Cohesion	Place dustbins in accessible proximity to limit littering.	Proponent	As needed	In Cost	Primary

	Environmental Safeguards					
Accessibility and site safety	Health and Safety Social Cohesion Environmental Safeguards	Accessibility to the whole spectrum of the users should be ensured with special regard to the most vulnerable	Proponent	As needed	In Cost	Primary
Maintenance	Hazard Health and Safety Environmental Safeguards	Ensure regular maintenance works are conducted to keep the functioning of the critical systems	Proponent	As needed	In Cost	Primary
Accessibility, safety and maintenance	Hazard Health and Safety Social Cohesion Environmental Safeguards	Use reflective coating and indicative signage to limit accidents and hazards in areas where traffic is expected as such the parking area underneath the panels	Proponent	As needed	In Cost	Primary
All relevant activities; including maintenance, monitoring, inspection, reporting, etc	Hazard Health and Safety Social Cohesion	Ensure all maintenance, monitoring and reporting works at the airport sites are carried as per the legal framework, directions, standards, guidelines, circulars, etc. set by the	Proponent		In cost	Primary

		relevant authorities (DASA, RACL, CAA)				

Table 8-2 Specific Mitigation Measures for Thinadhoo Site

Project Activity	**Potential Environmental and Social Impacts**		**Proposed Mitigation Measures**	**Implementing Responsibility**	**Estimated Quantities / Material Specifications**	**Cost Estimate**
	Site Preperation Phase					
Vegetation clearance and site conditioning	Social Cohesion Environmental safeguards		As some areas needs vegetation clearance to some extent, limit clearance to the minimum required. Additionally, if feasible, place the concrete footings strategically in a manner which avoids removal of natural vegetations as much as possible. In cases where palms and trees (thinadhoo – beef wood) needs to be cleared, consider	Proponent	As needed	In Cost

			replanting upon consulting with the island council.			

Table 8-3 Specific Mitigation Measures for Addu - Hulhumeedhoo Site

Project Activity	Potential Environmental and Social Impacts	Proposed Mitigation Measures	Implementing Responsibility	Estimated Quantities / Material Specifications	Cost Estimate	Comments (Primary, secondary or cumulative impact)
Site Preperation Phase						
Vegetation clearance and site conditioning	Social Cohesion Environmental safeguards	For the Hulhudhoo-Meedhoo project site, vegetation clearance and ground conditioning will be required. In this case consider planting 2 new plants of the same species in an area designated by the city council. The proponent should keep records of trees felled and replanted. This needs to be submitted in the	Proponent	As needed	In Cost	Primary

		monitoring report for/to assess future environmental and social impacts from the project.				
Ground conditioning	Social Cohesion Environmental safeguards Hazards	Sieve and segregate waste from the Hulhudhoo-Meedhoo project site during the ground conditioning works. This is because the site has been used as a waste dumpsite. Therefore, the ground may not be stable to support the structures in the long run. However, the decision on this will be based on the relevant engineers direction and is beyond the scope of the ESIA consultant.	Proponent	As needed	In Cost	Primary

Table 8-4Proposed Mitigation Measures for Kulhudhufushi City Airport Area

Project Activity	**Potential Environmental and Social Impacts**	**Proposed Mitigation Measures**	**Implementing Responsibility**	**Estimated Quantities / Material Specifications**	**Cost Estimate**	**Comments**
Specific to Kulhudhuffushi Site	Social Cohesion Environmental safeguards Hazards	The Kulhudhuffushi site is in close proximity to the wetland area which is rich in biodiversity and also provides many ecosystem services, notably as a resting place and a refuge for migratory birds as well. Therefore, with regard to the project scope and activities, the following measures needs to be taken to minimise and eliminate the potential negative impacts associated. ● Cover materials (dust screens and covers) which has the	Proponent	As needed	In Cost	

		potential to be wind-blown and transported to the neighbouring wetland areas. ● Keep the site clean. Empty cement/sand/etc bags or any other disposable packaging and packings should be collected. The collected waste materials should not be allowed to be blown by the wind ● While transferring materials to project site, use proper coverings which is adequate to the respective material ● Use dust screens				

Operational and Maintenance Phase						
All relevant activities; including maintenance, monitoring, inspection, reporting, etc	Hazard Health and Safety Social Cohesion	Ensure all maintenance, monitoring and reporting works at the airport sites are carried as per the legal framework, directions, standards, guidelines, circulars, etc. set by the relevant authorities (DASA, RACL, CAA)	Proponent		In cost	

Table 8-5 Proposed Mitigation Measures for Fuvahmulah City Airport Area

Project Activity	Potential Environmental and Social Impacts	Proposed Mitigation Measures	Implementing Responsibility	Estimated Quantities / Material Specifications	Cost Estimate	Comments
Pre-Construction Phase – Site Preparation						
Vegetation clearance and site conditioning	Social Cohesion Environmental safeguards	The relocation of trees and palms within the project area should be prioritized. If relocation is not possible, either because of the tree's condition, two trees or palms must	Proponent	As needed	In Cost	

		be planted in a location designated by the city council for every tree that is removed. The project must not involve the removal of any vegetation within the 20-meter coastal zone. The proponent should keep records of trees removed and replanted. This needs to be submitted in the monitoring report to assess future environmental and social impacts from the project. No protected trees shall be removed.				
Ground conditioning	Social Cohesion Environmental safeguards Hazards	The ground levelling should be undertaken as per the requirements of the airport operator.	Proponent	As needed	In Cost	

		For the cable laying ensure that preexisting levels are maintained. If any tar surfaces are cut within the project site, it needs to be resurfaced to preexisting levels.				
Operational and Maintenance Phase						
All relevant activities; including maintenance, monitoring, inspection, reporting, etc	Hazard Health and Safety Social Cohesion	Ensure all maintenance, monitoring and reporting works at the airport sites are carried as per the legal framework, directions, standards, guidelines, circulars, etc. set by the relevant authorities (DASA, RACL, CAA)	Proponent		In cost	

9 ALTERNATIVES

Number of alternatives were considered to the proposed project along with its potential environmental and social implications including 'no project' scenario. Both the positive and negative impacts were technically weighed to deduce the most favourable option. The project alternatives are stated in the following subsections.

9.1 FOUNDATION METHODS

Piling method can be used as an alternative foundation method. Foundation piling is a technique used to support structures by driving or drilling piles into the ground to transfer the structural load to deeper and more stable soil layers. Piling foundations are commonly used in construction projects that require stability and durability, such as high-rise buildings, bridges, and offshore structures.

Table 9-1Advantages and Disadvantages of Foundation Methods

Advantages	**Disadvantages**
Stability: Foundation piling can provide a stable base for structures built on soft or unstable soils, ensuring the stability of the structure and reducing the risk of settling or subsidence.	Cost: Foundation piling can be expensive, particularly when compared to other types of foundations like shallow foundations. The cost of materials, equipment, and labor can add up quickly, especially for large or complex projects.
Versatility: Piling foundations can be used for a variety of structures, including bridges, buildings, and offshore structures.	Environmental impact: Foundation piling can have environmental impacts, particularly when driven into sensitive or protected soils or ecosystems. Noise pollution and vibration during piling installation can also have adverse impacts on nearby communities and wildlife.
Durability: Foundation piling can provide long-lasting and durable support for structures, as they are typically made from materials like concrete or steel that are resistant to corrosion and degradation.	Limited access: Foundation piling requires access to specialized equipment and skilled labor, which may not be readily available in all locations. This can increase costs and cause delays in project timelines.
Speed of installation: Piling foundations can be installed quickly, especially when using pre-fabricated or pre-cast piles, reducing construction time and costs.	Uncertainty: Foundation piling can be affected by unforeseen factors like hidden obstacles or changes in soil conditions, which can result in increased costs and project delays.

9.2 NO PROJECT OPTION

In general, the no project option will mean business as usual for the selected project areas. This will mean the GHG emissions savings and other entailed environmental impacts of diesel generated power systems will continue to prevail. Furthermore, if the capacity increase based on the energy demand is for diesel based power generation means; the selected islands/cities will be carbon locked for a foreseeable future. In this regard, investing for renewable in the future will be an additional burden to the economy of the nation as a whole.

9.3 FLOATING SOLAR

Opting floating solar may not be suitable for most of the island settings due to the limited availability of lagoon space and additional engineering considerations which needs to be accounted. This would be costly for the project and additionally the maintenance of such systems would be more challenging than the proposed land solar systems.

Table 9-2 Advantages and Disadvantages of Floating Solar

Advantages	Disadvantages
Higher efficiency: Floating solar panels can be more efficient than land-based systems due to the cooling effect of water, which can help to reduce panel temperature and improve energy output.	Higher costs: Floating solar systems can be more expensive to install and maintain than land-based systems due to additional engineering considerations, including the need for mooring systems and specialized anchoring structures.
Flexible installation: Floating solar systems can be easily installed, relocated or expanded in a country like Maldives where land is limited.	Maintenance challenges: Floating solar systems can be more challenging to maintain than land-based systems, as access to the system is more difficult and requires specialized equipment.
Reduced water usage: Water resources are limited, floating solar panels can reduce the water usage required for land-based systems, which often use significant amounts of water for cleaning and maintenance.	Environmental impact: Floating solar systems may have environmental impacts on water bodies, including changes to water temperature and the potential for shading and reduced photosynthesis in aquatic ecosystems.
Utilization of existing water bodies: As an island nation, Maldives has a lot of water bodies like lagoons, lakes, and reservoirs that can be utilized for floating solar installations. This would not only save valuable land but	Floating solar systems can be vulnerable to extreme weather conditions, including storms, high winds, and waves. This can increase maintenance costs and the risk of damage or failure of the system.

also provide additional benefits like reducing water evaporation and algae growth.	

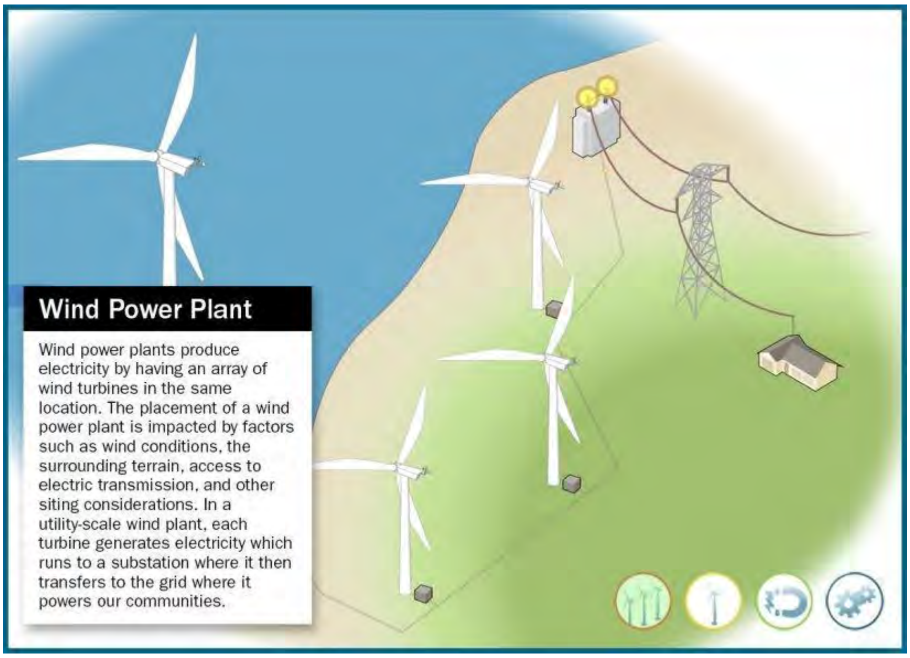
9.4 ALTERNATIVE TECHNOLOGY – ONSHORE WIND

Power generation through harnessing/utilizing wind energy by wind turbines is an alternative mean of power generation to the proposed project scope. It is of note that this modal of electrical power generation at a utility scale has not established in the nation yet. Therefore, the technology feasibility needs to be conducted if opting wind turbine as an alternative to the Solar PV systems. This would require an extensive assessment on site selection which needs to consider the availability of wind throughout the year, and also the social considerations such as availability of suitable land as well.

One of the key factors which needs to be taken into consideration is the maintenance cost and burden of such as system due to its reliance on moving parts when compared to the proposed Solar PV system technology.

Table 9-3 Advantages and Disadvantages of Onshore Wind

Advantages	**Disadvantages**
Abundant wind resource: Maldives is an island nation with a flat topography and relatively low vegetation, which can provide consistent and strong wind resources suitable for wind energy generation.	Land availability: The availability of suitable land is a key factor in the feasibility of onshore wind energy projects. Maldives is a small island nation with limited land resources, making it challenging to find suitable locations for wind turbines.
Cost-effective: Onshore wind energy can be a cost-effective solution for energy generation, as the cost of wind turbines has decreased in recent years, and the operating costs are relatively low.	Social and environmental impact: The installation and operation of wind turbines can have social and environmental impacts, including noise pollution, visual impacts, and potential harm to wildlife and their habitats.
Low carbon emissions: Onshore wind energy does not produce any greenhouse gas emissions during the energy generation process, making it an environmentally friendly alternative to fossil fuels.	Weather conditions: Onshore wind turbines can be vulnerable to extreme weather conditions like storms and high winds, which can result in damage to the turbines or loss of energy production.



Wind Power Plant

Wind power plants produce electricity by having an array of wind turbines in the same location. The placement of a wind power plant is impacted by factors such as wind conditions, the surrounding terrain, access to electric transmission, and other siting considerations. In a utility-scale wind plant, each turbine generates electricity which runs to a substation where it then transfers to the grid where it powers our communities.

Figure 9-1 typical diagram for onshore wind turbines (US Department of Energy, Office of Energy Efficiency and Renewable Energy , n.d.)

9.5 PREFERRED ALTERNATIVE

Putting up Solar PV on roof tops however since a number of roofs will need to be attained for this purpose and due to long term nature of the project, land areas which can be used for multiple purposes are the most ideal. Rooftops are considered not the most ideal because of the scale of the project and duration. 1 ha of roof space will be needed to install solar PV on the roofs. Will be difficult to find such large space for solar installation on rooftops on small islands.

Furthermore, legally this will require agreements to be signed with multiple roof owners hence more likely to have complications. Moreover, rooftops are uncertain in terms of renovations needed to buildings within 15 years. If rooftops new buildings need to be prioritized which are not in abundant supply in most islands. Hence in islands where there is space that can be given for the purpose of the project land areas are preferred.

10 MONITORING

This chapter highlights the proposed Environmental Monitoring Plan by the ESIA team. It is of note that monitoring is one of the fundamentals in Environmental Impact Assessments. The proposed plan was designed by taking into account sampling and analysis of key environmental parameters in order to:

- Ensure the effectiveness of the mitigation measures proposed
- Monitor the project’s environmental, social, and economic impacts
- Contribute towards sustainable development

- Assess the impacts caused (if any), and continuously fashion out mitigation measures a necessary
- Verify the environmental impacts predicted in the ESIA study, which would be beneficial for long term data assessments to minimise uncertainties associated with similar projects
- Provide data for environmental assessments such as environmental/energy/resource/etc audits related to the project

The methodology used for monitoring will be similar if not the same as those used in this environmental assessment. It is of note that the monitoring data should be collected with qualified individuals or a team, led by a registered environmental consultant with a permanent EIA consultancy licence.

Table 10-1 Monitoring Sample Document

Project Title:
Name of the Island:
Monitoring Date:
Period Covered:
Prepared by:
Contributions:

Introduction
Give a brief introduction about the project and the monitoring being carried out

Methodology of data collection and analysis
Brief detail of the methodology applied for undertaking the monitoring assessment

Environmental Monitoring
Baseline parameters undertaken in this assessment can be made as the basis.

Risks and Mitigations
Please indicate any critical unresolved risks that affect the course of the system operation, analyse the cause, assess the potential impacts on the environment, provide the proposed mitigation strategy

Problems Encountered
Indicate any problem areas encountered and any corrective measures that will have to be taken.

Recommendations and Adaptations as Solution
If specific recommendation is noted during the monitoring phase, specify it in the report
Conclusions
Reference
Appendix

10.1 Frequency of Reporting

It is critical that monitoring of the environmental parameter mentioned in the report format will be initiated during construction periods and continued throughout the operational phase of the project.

- Every month during the construction phase
- Annually for 2 years during operational phase
- Additionally, those noted to be monitored daily and weekly should be documented and kept ready to be shared with any relevant authority if requested

Table 10-2 Monitoring parameters and details

Proposed Mitigation Measure	Parameters to be monitored	Location	Measurements (Incl. methods & equipment)	Frequency of Measurement	Responsibilities (Incl. review and reporting)	Cost (equipment & Individuals)
Detailed design and planning Phase						
Incorporation of stakeholder considerations and recommendations to the project design and implementation	Approved engineering documents after consulting the relevant stakeholders. Approved ESIA for the proposed project	-	Submit approved drawings to Ministry of National Planning, Housing & Infrastructure, MECCT, Island council, atoll councils and City Councils	-	Implementation by HDEC, MECCT and EPA	Project budget
Plan logistical routes which is the most efficient and minimise interaction with environmentally sensitive or protected areas. Furthermore, ensure temporary sites such as storage sites are selected in consideration with the existing surrounding built and social environment.	Road closure schedule Public announcement	Project site	Updating schedule with key stakeholders Public announcement in respective islands through social media and other means	-	Implementation by HDEC, MECCT and EPA	Project budget
Pre-Construction Phase						
Demark the work site with adequate signage.	Presence of fence at the	Project site at each Island		Weekly	Implementation by HDEC,	

To increase the visibility during low light use reflective tape and cautioning lights.	project site with proper signages				MECCT and EPA	
Set up an online grievance mechanism where complaints can be logged to the proponent		At each island	Online grievance mechanism	Once	Implementation by HDEC, MECCT and EPA	Project budget
Ensure the storage facility is appropriate to the material stored. Refer to Material Safety Data Sheets of the materials stored. Ensure the logistical arrangements are made to avoid and minimize hazards as much as possible through pre planning routes and informing the relevant authorities	Check for any leakage Water Quality	Project site	Visual inspection Water testing	Monthly during pre-construction phase	Implemented by project proponent	MVR 5000 for water testing and consultant fee
During material transfers, including sea and land, ensure that the environmentally protected and sensitive sites are informed to the logistical crew and set conduct in a manner which minimises the risks to these areas	Check for any leakage during sea transportation Water Quality	Project site	Visual inspection Water testing	Monthly during pre-construction phase	Implemented by project proponent	MVR 5000 for water testing and consultant fee
Allow only authorized personals with adequate protective equipment to the site	List of workers at each site	Project site	-	Worker's attendance and	Implemented by project proponent	Project budget

	List of equipment used at each site			list of equipment used everyday		
Erect dust screens during construction/demolition where particulate matter may be released	Dust screens	Project site at each Island		Once and when needed	Implementation by HDEC, MECCT and EPA	Project budget
Remove waste from the project site on daily basis	Waste segregation	Project site	Physical inspection	Daily	Implemented by project proponent	Project budget MVR 250-MVR 1000 per day for waste disposal depending on respective island
In case of road closure, alternative safe routes shall be provided to road users.	Road closure schedule Public announcement	Project site	Updating schedule with key stakeholders Public announcement in respective islands through social media and other means	-	Project proponent	Project budget
Machinery servicing which involves lubricants, waste oil, oil-based substances or any of hazardous nature should be conducted on a base with impermeable lining	Check for oil leakage Water quality Air quality	Project site	Visual inspection Water testing Air quality testing equipment	Every month	Project proponent	MVR 5000 for water testing and consultant fee

Construction Phase						
Ensure no construction material and equipment are left outside the project area	-	Project site	Physical inspection	Daily	Project Proponent	Project budget
Remove waste from the project site on daily basis	Waste segregation	Project site	Physical inspection	Daily	Project Proponent	Project budget MVR 250-MVR 1000 per day for waste disposal depending on respective island
In case of road closure; alternative safe routes shall be provided to road users.	Road closure schedule Public announcement	Project site	Updating schedule with key stakeholders Public announcement in respective islands through social media and other means	-	Project proponent	Project budget
Machinery servicing which involves lubricants, waste oil, oil-based substances or any of hazardous nature should be conducted on a base with impermeable lining	Check for oil leakage Water quality Air quality	Project site	Visual inspection Water testing Air quality testing equipment	Every month	Project proponent	MVR 5000 for water testing and consultant fee
Ensure all the materials are sealed while special precautions should be given to volatile	Check for any leakage Water quality	Project site	Visual inspection Water testing	Every month	Project proponent	MVR 5000 for water testing and consultant fee

liquids and liquids with potential hazardous character. Regular site supervision should be conducted for safety assurance.	Site supervisor					MVR 5000-MVR 10000 per month as site supervisor's salary
Hire workers locally, as much as possible . If hiring foreign workers, conduct health screening prior to recruitment. Ensure valid work visa permit is present Identify an emergency contact for all the workers hired.	Valid health check-up document Valid work visa	-	-	Once and when needed	Project proponent	Project budget
While excavating and making trenches for connections and foundation works; use pipe/cable detectors to avoid any damage to existing, established service networks of the islands. Utilise light low impact equipment rather than heavy machineries. Continuous monitoring observation should be practiced	Ground Vibration Disconnection of any existing service	Project site	Physical experience	Continuously during any excavation work	Project proponent	Project budget

avoiding damages to any cables/pipes laid previously. Liase with the relevant responsible parties (Fenaka/Dhiraagu/ Ooredoo / etc) in the islands/cities to avoid accidents.						
Pre contract/agreement with the cable/pipe laid service providers on the conduct, in case of damage during the works of the proposed project	Pre signed contracts	-	-	Once	Project proponent	
-Ensure labour living conditions are adequate and within the HPA guidelines and ensure the labour rights under the set legislative framework are fulfilled.	Health and Safety Officer	Project Site	-	-	Project Proponent	MVR 5000-MVR10000 per month
Ensure emergency first aid health facilities are arranged at site. In cases of serious injuries, or disease manifestations the relevant health authorities should be informed, and their instructions must be strictly followed.	Health and Safety Officer	Project Site	-	-	Project Proponent	MVR 5000-MVR10000 per month
Ensure the vehicles used are well maintained and fitted with air pollution control devices.	Noise Air pollution	Project site	Sound meter for noise Air quality measuring device	Daily during construction phase	Project proponent	Project budget

Ensure the exhaust silencers are well maintained	Ground vibration		Physical inspection for vibration			
Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration and noise. These works should not be carried out at odd hours.	Noise Air pollution Ground vibration	Nearest residential place	Sound meter for noise Air quality measuring device Physical inspection for vibration	Daily during construction phase	Project proponent	Project budget
The work surface shall be moistened in regular intervals to minimise windblown dust and debris to cause public nuisances. However, the supervisor must ensure this does not pose slippery surface hazard to the workers	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month
The work surface shall be moistened in regular intervals to minimise windblown dust and debris to cause public nuisances. However, the supervisor must ensure this does not pose	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month

slippery surface hazard to the workers						
Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration and noise. These works should not be carried out at odd hours.	Noise Air pollution Ground vibration	Project site	Sound meter for noise Air quality measuring device Physical inspection for vibration	Daily during construction phase	Project proponent	Project budget
Ensure the equipment used are serviced and well maintained	vehicle maintenance log	Project site	Physical inspection	Monthly during construction phase	Project proponent	Project budget
For flammable volatile substances and gasses: ● Use fire resistance containers for storage ● Keep away from heat and ignition sources ● Ensure the containers are sealed Ensure the storage area is well ventilated	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month
For Potentially combustible materials ● Store in fire resistance containers	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month

Keep away from ignition and heat sources						
Combustible waste ● Waste should be collected and removed from the work area on daily basis Housekeeping best practices	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	Project budget MVR 250-MVR 1000 per day for waste disposal depending on respective island
Storage of oxygen such as oxidising chemicals, oxygen cylinders or piped systems ● Should not be stored at project site Should be taken to the required amount for the site and kept at safe storage away from residential area	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month
Smoking within the premises, work area and storage area should not be allowed. Proper signage and markings should be set.	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month
Presence of light fittings near combustible materials Give preference to lower power alternative lightings such as LED	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month
Electrical extension ▪ Ensure extension leads are fully uncoiled	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project proponent	MVR 5000-MVR 10000 per month

▪ Limit extension lead and adaptors ▪ Ensure extension leads are not overloaded Ensure flexible power cables are kept as short as possible and safety routed						
As some areas needs vegetation clearance to some extent, limit clearance to the minimum required. Additionally, if feasible, place the concrete footings strategically in a manner which avoids removal of natural vegetations as much as possible. In cases where palms and trees (thinadhoo – beef wood) needs to be cleared, consider replanting upon consulting with the island council. For the Hulhudhoo-Meedhoo project site, vegetation clearance and ground conditioning will be required. In this case consider planting 4 new plants of the same species in an area designated by the city council.	Keep a log of trees removed and relocated	Project site	Physical inspection	Once	Project proponent	Project budget

The proponent should keep records of trees felled and replanted. This needs to be submitted in the monitoring report for to assess future environmental and social impacts from the project.						
Sieve and segregate waste from the Hulhudhoo-Meedhoo project site during the ground conditioning works. This is because the site has been used as a waste dumpsite. Therefore, the ground may not be stable to support the structures in the long run. However, the decision on this will be based on the relevant engineer's direction and is beyond the scope of the ESIA consultant.	Water quality	Project site	Visual inspection Water testing	Every month	Project proponent	MVR 5000 for water testing and consultant fee
The relocation of trees and palms within the project area should be prioritized. If relocation is not possible, either because of the tree's condition, two trees or palms must be planted in a location designated by the city council for every tree that is removed.	Keep a log of trees removed and relocated	Project site	Physical inspection	Once	Project proponent	Project budget

The project must not involve the removal of any vegetation within the 20-meter coastal zone. The proponent should keep records of trees removed and replanted. This needs to be submitted in the monitoring report to assess future environmental and social impacts from the project. No protected trees shall be removed.						
The ground levelling should be undertaken as per the requirements of the airport operator. For the cable laying ensure that pre-existing levels are maintained. If any tar surfaces are cut within the project site, it needs to be resurfaced to pre-existing levels.	Ground vibration	Project site	Physical inspection for vibration	Daily during construction phase	Project proponent	Project budget
The Kulhudhuffushi site is in close proximity to the wetland area which is rich in biodiversity and also provides many	Water quality Air quality	Project site	Visual inspection Water testing	Every month	Project proponent	MVR 5000 for water testing and consultant fee

ecosystem services, notably as a resting place and a refuge for migratory birds as well. Therefore, with regard to the project scope and activities, the following measures needs to be taken to minimise and eliminate the potential negative impacts associated. ● Cover materials (dust screens and covers) which has the potential to be wind-blown and transported to the neighbouring wetland areas. ● Keep the site clean. Empty cement/sand/etc bags or any other disposable packaging and packings should be collected. The collected waste materials should not be allowed to be blown by the wind ● While transferring materials to project site, use proper coverings which is adequate to the respective material ● Use dust screens			Air quality testing equipment			

Operation and Maintenance Phase						
Demark work site	Fencing and proper construction signages	Project site	-	When required	Project Proponent Fenaka	Project budget
Use proper PPE and safety jackets/vests when conducting maintenance works	Health and Safety Officer	Project Site	-	When required	Project Proponent Fenaka	MVR 5000-MVR10000 per month
In case of road closure; alternative safe routes shall be provided to road users.	Public announcement	Project site	Public announcement in respective islands through social media and other means	-	Project Proponent Fenaka	Project budget
Remove waste from the project site on daily basis	Site supervisors	Project site	Physical inspection	Daily	Project Proponent Fenaka	MVR 5000-MVR 10000 per month
Ensure the exhaust silencers are well maintained	vehicle maintenance log	Project site	Physical inspection	Monthly during operational phase	Project Proponent Fenaka	Project budget
Ensure the equipment used are serviced and well maintained	equipment maintenance log	Project site	Physical inspection	Monthly during operational phase	Project Proponent Fenaka	Project budget
Inform the neighbouring houses and residents with due time prior to works which generates significant amount of vibration	Noise Air pollution	Nearest residential place	Sound meter for noise Air quality measuring device	Daily during Operational phase	Project proponent Fenaka	Project budget

and noise. These works should not be carried out at odd hours.	Ground vibration		Physical inspection for vibration			
Implement strict policies on littering on the facility premises	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project Proponent Fenaka	MVR 5000-MVR 10000 per month
Place dustbins in accessible proximity to limit littering.	Site supervisors	Project site	Physical inspection	Daily during construction phase	Project Proponent Fenaka	MVR 5000-MVR 10000 per month
Accessibility to the whole spectrum of the users should be ensured with special regard to the most vulnerable	Site supervisors	Project site	Physical inspection	Throughout the operational phase	Project Proponent Fenaka	MVR 5000-MVR 10000 per month
Ensure regular maintenance works are conducted to keep the functioning of the critical systems	Site supervisors	Project site	Physical inspection	Throughout the operational phase	Project Proponent Fenaka	MVR 5000-MVR 10000 per month
Use reflective coating and indicative signage to limit accidents and hazards in areas where traffic is expected as such the parking area underneath the panels	Construction signages and road safety signages	Project site	Physical inspection	Throughout the operational phase	Project Proponent Fenaka	Project Budget
Ensure all maintenance, monitoring and reporting works at the airport sites are carried as per the legal framework,	Site supervisors	Project site	Physical inspection	Throughout the operational phase	Project Proponent Fenaka	MVR 5000-MVR 10000 per month

directions, standards, guidelines, circulars, etc. set by the relevant authorities (DASA, RACL, CAA)						

11 GRIEVANCE REDRESS MECHANISM

It is important to have an avenue for any affected persons to raise their concerns regarding the project and such issues addressed promptly. For this purpose, a grievance redress mechanism becomes integral part of stakeholder engagement process. The mechanism needs to take into special consideration vulnerable groups and how easy access to the grievance mechanism is ensured to such parties.

A three-tier system will be established under the project to ensure a fair process for addressing grievances. This GRM was developed based on the experience of previous projects implemented through Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) project.

Table 11-1GRM based on the tiers.

Tiers of Grievance Mechanism	Nodal Person for Contact	Contacts, Communication and Other Facilitation by Project	Timeframe to address grievance
First Tier: Site level Contractor (During Construction phase) Independent Power Producer (IPP) (During Operation Phase)	A person designated for the task need to be identified for the purpose by IPP and Electricity Service Provider.	• In the IPP or Contractor offices and the project site, there will be an Information Board providing details of the Grievance redress mechanism listing the names and contact telephones/emails. • Grievances can be registered by contacting the designated person through phone/email or by submitting a letter of complaint or by filling a Tier-1 complaint form. The Tier-1 form must be available online (Digital form) on the websites of the Ministry of Environment Climate Change and Technology (MoECT) and should be accessible by scanning a QR code in the site board. • All grievances received by contractor/IPP should be added to a common online sheet maintained by MoECT. • For those who cannot properly write, a staff will assist in filling the complaint form and get it signed by the aggrieved party. • A formal receipt of the complaint will be provided to the aggrieved party through email or through text message. • The IPP/Contractor jointly will screen the grievance to determine whether the grievance is related to ARISE project or not.	14 working days

		• If it is related to the project, the aggrieved party will be informed in writing (copied to MoECT) how the case will be processed as per this grievance redress mechanism. This should occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued letter should be read to the person in presence of a witness and the witness should declare their witness to this event. • Alternatively, if it is not related to the project, the aggrieved party will be informed that it is not related to the project in writing (copied to ME) and will inform how the case will be handled. This communication will occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason), the issued letter will be read to the person in presence of a witness and the witness should declare their witness to this event. • Where the grievance is related to the project, the IPP/Contractor will come up with a solution either by (i) discussing internally; (ii) joint problem solving with the aggrieved parties, MoECT and Island Council or; (iii) a combination of both options. • The IPP/Contractor will communicate the final decision in writing, in terms how the grievance was handled to the aggrieved party within 14 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued decision should be read to the person in presence of a witness and the witness should declare their witness to this event. • The aggrieved party must acknowledge the receipt of decision and submit their agreement or disagreement with the decision within 10 days. • If no acknowledgement is submitted from the aggrieved party then the decision will be considered as accepted. • If the grievance is not resolved to the satisfaction of the aggrieved party within 14 working days of submission of the grievance to tier 1 then the aggrieved party may notify local council in writing, of the intention to move to tier 2.	
Second Tier: Local Council (Island or	Local Council will be the second point	• Where the aggrieved party is not happy with the outcome of the decision by the IPP/contractor or where the aggrieved party is of the view that the council is not capable of justly solving the issue or where the grievance	14 working days

City Council or any other party which performs such a function)	of contact. Designated contact persons should be established within the Council with a designated contact number.	is not resolved within 14 working days the grievance can be upgraded to tier 2. • Grievances can be registered by contacting the designated person through phone/email or by submitting a letter of complaint or by filling a Tier-2 complaint form. The Tier-2 form must be available online (Digital form) on the websites of the Ministry of Environment Climate Change and Technology (MoECT) and should be accessible by scanning a QR code in the site board. • All grievances received by the local council should be added to a common online sheet maintained by MoECT. • In the council office and the project site there will be an Information Board providing details of the Grievance redress mechanism listing the names and contact telephones/emails. • For those who cannot properly write, a staff will assist in filling the complaint form and get it signed by the aggrieved party. • A formal receipt of the complaint will be provided to the aggrieved party. • The aggrieved party will submit a copy of the decision from tier 1 and the letter submitted raising their disagreement to decision where the reason for upgrading to tier 2 is the disagreement with the decision from tier 1. • The aggrieved party will submit a copy of the grievance form submitted through tier 1 or the grievance letter submitted to council, where the reason for upgrading to tier 2 is due to lack of response from the IPP/Contractor. • The council will screen the grievance to determine if the issues and concerns raised in the complaint falls within the mandate of the project. • If it is related to the project, the council will inform the aggrieved party in writing (copied to MoECT) how the case will be processed as per this grievance redress mechanism. This should occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued letter will be read to the person in presence of a witness and the witness should declare their witness to this event.	

		• Alternatively, if it is not related to the project, the council will inform the aggrieved party that it is not related to the project in writing (copied to MoECT) and will inform how the case will be handled. This communication will occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason), the issued letter will be read to the person in presence of a witness and the witness should declare their witness to this event. • Where the grievance is related to the project, the council will come up with a solution either by (i) discussing within the council; (ii) joint problem solving with the aggrieved parties, MoECT and the contractor/IPP or; (iii) a combination of both options. • The council will communicate the final decision in writing, in terms how the grievance was handled to the aggrieved party within 14 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued decision will be read to the person in presence of a witness and the witness should declare their witness to this event. • The aggrieved party must acknowledge the receipt of decision and submit their agreement or disagreement with the decision within 10 days. • If no acknowledgement is submitted from the aggrieved party then the decision will be considered as accepted. • If the grievance is not resolved to the satisfaction of the aggrieved party within 14 working days of submission of the grievance to tier 2 then the aggrieved party may notify MoECT, in writing, of the intention to move to tier 3.	
Third Tier: Ministry of Environment Climate Change and Technology	MoECT will forward the grievance to the Project Management Unit (PMU) of the Ministry. A dedicated number should be allocated to	• Where the aggrieved party is not happy with the outcome of the decision by the council or where the aggrieved party is of the view that the council is not capable of justly solve the issue or where the grievance is not resolved within 14 working days the grievance can be upgraded to tier 3. • Grievances can be registered by contacting the designated person through phone/email or by submitting a letter of complaint or by filling a Tier-3 complaint form. The Tier-3 form must be available online (Digital form) on the websites of the Ministry of Environment Climate Change	14 Working Days

		and Technology (MoECT) and should be accessible by scanning a QR code in the site board. • All grievances received by the local council should be added to a common online sheet maintained by MoECT. • For those who cannot properly write, the ME staff will fill a complaint form and get it signed by the aggrieved party. • A formal receipt of the complaint will be provided to the aggrieved party. • The aggrieved party will submit a copy of the decision from the council and the letter submitted to council raising their disagreement to decision where the reason for upgrading tier 2 is the disagreement with the council decision. • The aggrieved party will submit a copy of the grievance form submitted to council or the grievance letter submitted to council, where the reason for upgrading to tier 2 is due to lack of response from the council. • Ministry will forward all the grievances related to the project to the Project Management Unit. • PMU will screen the grievance to determine if it is related to the project. • If it is related to the project PMU will inform the aggrieved party in writing how the case will be processed as per this grievance redress mechanism. This should occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued letter should be read to the person in presence of a witness and the witness should declare their witness to this event. • Alternatively, if it is not related to the project, PMU will inform the aggrieved party that it is not related to the project in writing and should inform how the case will be handled. This communication should occur within 03 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued letter should be read to the person in presence of a witness and the witness should declare their witness to this event.	

		• Where the grievance is related to the project, the PMU will come up with a solution either by (i) Discussing in the project steering/technical committee; (ii) joint problem solving with the aggrieved parties, the council, Energy Service Provider and the contractor/IPP (iii) undertaking site visits and holding onsite discussions or; (iii) a combination of all these options. • The PMU will be responsible to ensure that there is no cost imposed on the aggrieved person, due to the grievance mechanism at the third tier. • ME will communicate the final decision in writing, in terms how the grievance was handled to the aggrieved party within 14 working days of receiving the complaint. If the aggrieved party is unable to read (for whatever reason) the issued letter should be read to the person in presence of a witness and the witness should declare their witness to this event. • The aggrieved party must acknowledge the receipt of decision and submit their agreement or disagreement with the decision within 10 days. • If no acknowledgement is submitted from the aggrieved party then the decision will be considered as accepted.	

- For issues pertaining to sexual exploitation and abuse (SEA) and sexual harassment (SH) the grievance form and board should give direction on the appropriate contact numbers of Ministry of Gender (1421) to contact regarding such cases. Confidentiality of the aggrieved party should be maintained in such cases.

- In the event a grievance regarding SEA/SH is submitted the grievance should be immediately communicated to Task Team of the World Bank.

12 Conclusion

The document presents an Environmental Social Impact Assessment (ESIA) for the establishment of 11.43 MW solar photovoltaic systems in 8 locations in the Maldives, in accordance with the EIA regulation of the country. The proposed project is part of the government's efforts to transition from polluting fossil fuels to renewable energy sources to meet the energy demands of the nation. The report has been formulated based on on-site data collection, engineering documents, and available literature, to ensure compliance with legal frameworks and best practices while safeguarding environmental and social dynamics associated with the project. The project is expected to save 45.28 Million Ruffiya worth of diesel fuel per year and reduce annual carbon emissions by 14,811 MT. Negative impacts are primarily associated with the construction phase and include noise and air pollution, nuisances caused to the public, and vegetation clearance. However, the proponent commits to mitigating these impacts through adherence to the mitigation measures defined in the report.

The project includes acute negative impacts which the most significant includes vegetation clearance in Thinadhoo and Fuvahmulah City. In the common understanding of irreversible damages to the environment, the project does not encompasses such. Occupational safety measures and potential hazards are identified and legal instruments and guidelines are stated. Stakeholders were consulted and their feedback summarised in the report. A community engagement plan is included, and project alternatives, as well as a project monitoring plan and grievance redress mechanism, are discussed.

Overall, the project is expected to have a positive environmental impact by reducing greenhouse gas emissions and promoting renewable energy while creating job opportunities and raising awareness. In this regard, referring to the net impacts associated with the project, both positive and negative, going ahead with the project undertaking the measures outlined in the project outweighs the negatives and is beneficial to the environment and socio-economic dynamics of the nation.

APPENDIX A – Terms of Reference

އެންވަޔަރަމަންޓަލް ޕްރޮޓެކްޝަން އޭޖެންސީ
Environmental Protection Agency

No: **203-ECA/PRIV/2022/647**

Terms of Reference for Environmental Social Impact Assessment (ESIA) for Installation of 11.3 MW Solar PV Systems in Addu City, Eydhafushi, Fuvahmulah City, Hinnavaru, Thinadhoo, and Kulhudhuffushi City.

The following is the Terms of Reference (ToR) following the scoping meeting held on **15th November 2022** for undertaking an Environmental and Social Impact Assessment (ESIA) for the **Installation of 11.3 MW Solar PV systems in Addu City, Eydhafushi, Fuvahmulah City, Hinnavaru, Thinadhoo, and Kulhudhuffushi City**. The Proponent of the project is **POWERCHINA HUDAONG ENGINEERING CORPORATION LTD (HDEC).** The ESIA consultant of this project is **Mr. Ibrahim Miflal Fayaz (EIA License No. EIA P06/2020).** representing Maldives Resort Construction PVT LTD.

While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the ESIA report. The proposed structure of the report is as follows.

1. Executive summary:

Summary of the project in both English and Dhivehi, highlighting the key points of the report. This section shall include the project description, potential environment and socio-economic impacts associated with the project. The summary should cover specific aspects that were identified for each of the islands where project is implemented. Additionally, the summary shall include conclusion and/or recommendations identified from the assessment.

2. Introduction and rationale:

Describe the purpose of the project and, if applicable, the background of the project and the tasks already completed. Provide information on the funding institutions and institutional arrangements where applicable. Clearly identify the rationale and objectives to enable the formulation of alternatives. Define the arrangements required for the environmental and social assessment and if relevant, including how work carried out under this contract is linked and sequenced with projects executed by other consultants, and how coordination between other consultants, contractors, government institutions will be carried out. List the donors, and the institutions the consultant will be coordinating with and the methodologies used. This should include (but should not be limited to) the following;

- Project background: Overall description of ASPIRE project and description of activities planned under 11.3 MW PV installation.
- Name and contact details of the Proponent
- Environmental and Social Impact Assessment team. Including details of each team member's contribution to the report.
- Rationale of the project
- Aims and objectives of the project
- Methodologies applied for the assessment

- Literature review. This should cover previous ESIA and other literature especially highlighting potential impacts of projects of this nature.

3. Study area:

The report shall include an A3-size scaled or of acceptable resolution plan/maps/imagery with indications of the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental and social impact assessment highlighting the proposed development location and size of the facility. The study area should include adjacent buildings and related infrastructure, nearby environmentally and socially sensitive sites (e.g. mosque, environmentally sensitive and protected sites, schools). Relevant developments in the areas must also be considered including residential areas, all economic ventures and cultural sites.

The study area shall be described with respect to the project sites of:

- Addu City
- B. Eydhafushi
- Fuvahmulah City
- Lh. Hinnavaru
- G.Dh. Thinadhoo
- Kulhudhuffushi City

4. Scope of work

Identify and number tasks of the project encompassing major project components in the phases of project development and design, mobilization, construction, demobilization and operational phases.

5. Description of the proposed project

Project design and management

Include details of the construction, progress, target dates, and schedule. This should be provided for each island where project is implemented separately clearly identifying mobilization and demobilization plan for each island. Specifically, the following aspects need to be covered in detail:

- Approved drawings this should be based on the approval of MoECCT and in consultation with site owners (A3 sized).
- Capacity of PV in each island
- Maximum and minimum energy output
- Number of substations/transformers that would be placed in each island
- Highlight the intended use of the underneath of the panels as per the requirements and how the design accommodates for this use.
- Master plan concepts in A3 size or acceptable resolution detailing the structural components of the proposed works.
- Details of the project management team both during construction and operational phase including number of staff for each site.
- Mobilization plan: this should cover transport of construction material, temporary construction site (storage and staff accommodation) setup including location, workforce required for each site, utility arrangement at the construction site (storage and staff accommodation). These aspects need to be covered for each of the project locations separately.

- Construction Plan: this should cover construction method including foundation method (raft foundation, or piling method), cable installation method, mounting structure installation method, transformer installation method, vegetation relocation method, commissioning plan and any other electrical or civil aspects involved in the project should be covered here.

- Labour management during construction:
    - Estimated number of workers (indicate whether local or expatriate and male or female).
    - Accommodation arrangements, whether on-site or at neighbouring islands.
    - Services for workers including how sanitary, food and drinking water arrangements will be provided at the work site
    - COVID 19 special considerations during setting up of the labour camp and work site such as provision for handwashing facilities, social distancing (each bedside to be separated by 3 – 6 ft) etc.
    - Requirements for reporting on complaints/grievances including responding to Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH) related issues.

- Labour Requirements during Operations
    - Specify if additional labour will be required to operate the newly proposed developments.
    - COVID19 special considerations applicable to operational staff should be mentioned

- Fire Hazard, Health and Safety:
    - Types and estimated quantities of PPEs and first aid boxes that will be required to carry out the proposed works.
    - COVID 19 special consideration such as wearing mask, frequent hand washing, use of hand sanitizers etc.
    - Vulnerability analysis of the fuel storage tanks to fire hazard.
    - Provision to fire safety, including details of firefighting equipment that will be established, signage, alarm system etc.

- Waste Management
    - Details of waste management during construction and operational phase.
    - Waste fuel and oil management details if and where relevant.
    - Long term plan for Hazardous waste management during any decommissioning, breakage of phase out

- Resource Requirement
    - Table highlighting all project inputs and outputs including quantity should be defined for each of the project locations. This should include equipment, resources and man power required for project implementation.

- Maintenance plan for the PV site. Manpower required for maintenance and community involvement during maintenance should also be covered in the maintenance plan.
- Community Engagement Plan: Covering the community activities that will be undertaken for the 15 year period including awareness raising activities, trainings and job opportunities available to the public through the project. This part should also cover any CSR initiatives that will be undertaken through the project.
- Air safety aspects and management plans considered for the installation in Fuvahmulah and Kulhudhuhfushi airport sites.

- Traffic management during construction stage for each of the project sites including material transport.

Project Development

Provide a schedule outlining the proposed phasing, sequencing and duration of components, including;

- Pre-construction, construction, operation and decommissioning
- The activities to date, including baseline assessments
- Key factors controlling the schedule and uncertainties relating to the project

6. Description of the environment:

Assemble, evaluate and present the environmental and social baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and level of detail to be carried out by the consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. All data must be collected as per the requirements of the EPA Data Collection Guideline (published on www.epa.gov.mv).

Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction and from at least two benchmarks. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points and vegetation transects for posterior data comparison. Information should be divided into the categories shown below:

Climate

- Temperature & rainfall
- Hazard Vulnerability
- Vulnerability of the location of the project sites to flooding, tsunami, storm surge and beach erosion.

Physical Parameters

- Groundwater quality assessment of the site and atleast at least one control site including the following parameters, Temperature, Salinity, pH, TDS, Total Petroleum Hydrocarbon and EC.
- Surface water quality at Kulhudhuhfushi Kulhi site covering the following parameters: Temperature, Salinity, Turbidity, pH, TDS, Total Petroleum Hydrocarbon and EC.
- Noise level at the site and the closest residential/commercial buildings to the site and 05 meters away from the site.
- Traffic Survey of all the sites. For Kulhudhuhfushi and Fuvahmulah this survey can cover the roads leading to airport. For rest of the sites the survey should cover the adjacent road to the site. The survey should cover both peak and off-peak travel hours.
- Glare assessment for airport sites.
- Soil profiles of each of the project sites.

Note: Absence of facilities in the country to carry out the water quality tests will not exempt the proponent from the obligation to provide the necessary data. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

Built Environment

- Status of adjacent buildings including photographic records of existing conditions of the buildings (if any)
- Condition of the adjacent roads leading to the site.
- Survey of the utility lines (power, telephone, fibre optic, water and sewerage) that are going through the site. (cable detector and manual detection methods (for example digging) should be used to physically determine and verify the location of all utility lines)
- Current electricity demand in each island

Biological Assessment

- Survey of the terrestrial fauna especially in the highly vegetated areas of the Fuvahmulah and environmentally sensitive kulhudhuhfushi location.
- Vegetation present at the project sites: Describe the number and type of vegetation present at the road extension areas or connection points and the foot print. The amount of vegetation that require compensation and estimated cost must be indicated (if any such vegetation are present). Vegetation cover maps shall be included where appropriate (identifying the areas subjected for vegetation removal and translocation/replantation). Emphasis must be given to translocate trees (within the source island or out of the island in instances where space scarcity is an issue) as much as possible. Methods of vegetation removal and translocation must be described, which should yield the preferred method for the project site and access road. Locations for compensatory. Replantation must be identified and indicated on a map where needed.

- Protected Areas and Environmentally Sensitive Sites: Provide information on the environmentally protected and sensitive areas that exists close to the proposed new developments (such as turtle nesting sites, wetlands and mangrove areas). Indicate distances from the project sites and if the protected area is in the project impact zone and if there are any observed potential impacts. Proximity of the site to surface water bodies or sensitive habitats (e.g. coats, mangroves, wetlands) should also be identified.

Socio-economic Environment

- Demographic and socioeconomic data for each of the project location. This includes population, main economic activities, social infrastructure and services and access to services, poverty and gender disparities that exist at the project location.
- Identification of the vulnerable and disadvantaged population at the project vicinity. That would be particularly impacted as a result of project implementation
- Description of the land use including planned land use adjacent to the site. Use available land use plans to describe this section.
- Areas of Historic and Cultural Significance: Provide information on areas of historic and cultural significance (such as mosques, graves etc.) that exist close to the proposed new developments. Indicate distance from the selected project site.

7. Legislative and Regulatory Considerations

Identify the relevant legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project and identify the appropriate authority jurisdictions that will specifically apply to the project. Refer to the World Bank environmental and social policies and standards (ESF) that are applicable to the project.

8. Potential risks and impacts (environmental and socio-cultural) of proposed project incl. all stages

The ESIA report should identify all the risks and impacts, direct and indirect, permanent and temporary, partial and full, induced and cumulative, during and after construction, and evaluate the magnitude and significance of those impacts. Particular attention shall be given to impacts associated with the following:

Impacts on natural environment

a) Physical / Chemical: describe impacts on groundwater, soil, noise, air and waste.
- Impacts of noise pollution and disturbances (both in construction and operations).
- Impacts on ground water table and quality due to construction, operations and any accidental spillage during civil works
- Impacts on ground vibrations to nearby buildings.
- Impacts on air quality due to dust and vehicle emissions.
- Marine water pollution due to spillage during material transfer.

b) Biological: describe impacts on vegetation and fauna.
- Impact due to vegetation removal
- Impacts to vegetation and fauna due to improper handling and driving during material transportation.
- Impacts due to material spillage during transfer of construction materials to the project island.

c) Sociological / Cultural: describe impacts of road traffic, nearby sensitive areas, health and safety of resident staff / contracted labour and sociocultural conflict.
- Sociocultural conflict due to arrival of expatriate workers (if accommodation is to be arranged in nearby inhabited islands).
- Impacts due to illegal immigrants being potentially recruited by the contractor.
- Impacts and risks associated with illicit behaviour, Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH) and gender-based violence.
- Risks related to non-compliance with labour regulations such as
  - Using workers without of contracts;
  - Not complying to terms and conditions related to hours of work, wages, overtime, etc.;
  - Lack of work permits if migrant workers are hired; and
  - Lack of a GRM for workers to raise/report on labour issues.
- Risks that project impacts fall disproportionately on disadvantaged or vulnerable groups
- Risks and impacts on women
- Any prejudice or discrimination towards individuals or groups in providing access to development resources and project benefits, particularly to vulnerable/disadvantaged groups
- Risks and impacts associated with land and natural resource tenure and use and impacts on local land use patterns, tenurial arrangements, land access and availability, livelihoods, food security and land values
- Risks to cultural heritage

d) Economic / Enhancement Plans: describe any potential benefits or losses to the economy.
- Employment opportunities to nearby islands and the region.
- Benefit to local economy due to purchasing of locally available construction materials.
-

e) Accidents, Injuries and Health and Safety
- Health and safety of construction workers and the fuel storage tank operators.
- COVID19 restrictions and special considerations for the contractor (potential mitigation measures may include toolbox talks, daily temperature checks, cleaning procedures, shift roaster, arrangement for social distancing in labour camps, establishment of handwashing facilities at work site and labour camp etc.).
- Fire hazard due to improper handling of fuel and waste oil.
- Accidents and injuries due to traffic mismanagement.

The methodology used to identify and assess the significance of the impacts shall be outlined and referenced. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems, consultations, and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.

9. Alternatives to the proposed project:

Describe alternatives including "no action option" should be presented. Determine the best practical environmental option. Alternatives examined for the proposed project that would achieve the same objectives including the "no action alternative". This should include alternative location, construction technologies, taking into account environmental, social and economic factors. The report should highlight how the location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

10. Mitigation and management of negative impacts

Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures. Mitigation measures to avoid or compensate habitat destruction caused by land clearance and depletion of groundwater quality due to potential fuel spillage due to improper fuel handling and/or storage will have to be considered. Mitigation measures should be provided for COVID19 related aspects such as toolbox talks, daily temperature checks, cleaning procedures, shift roaster, arrangement for social distancing in labour camps, establishment of handwashing facilities at the work site and labour camp, PPEs etc. Mitigation measures should pay special attention to gender issues - gender segregated safe accommodation/toilet facilitates and adaptation of code of conduct. Actions should describe measures to report and respond to risks of Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH) risks. Contractors to comply with labour regulations pertaining terms/conditions of employment etc. Grievance/compliant handling mechanism should also be described.

Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental and Social Management Plan (ESMP) for the proposed project, identifying responsible persons, their duties and commitments shall also be given. The environmental and social management plan should be presented in matrix format, clearly indicting the responsible person, cost, equipment and resources required for each proposed action. In cases where impacts are unavoidable arrangements to compensate for the environmental and / or social effect shall be given.

Mitigation measures should be presented as a matrix consistent to the format provided below.

Project Activity	**Potential Environmental and Social Impacts**	**Proposed Mitigation Measures**	**Institutional Responsibilities** (Implementation and Supervision)	**Estimated Quantities Required and Material Specifications Recommended**	**Cost Estimates**	**Comments** (e.g. secondary impacts**)**
Detailed design and planning Phase						
Pre-Construction Phase -Site Preparation						
Construction Phase						
Operation and Maintenance Phase						

The proposed ESMP matrix shall be translated to Dhivehi language and provided as an Annex to the report.

ESMP Implementation

Assess staffing capacity and requirements to implement the ESMP and also to manage the key Environmental and social risks/impacts & emergencies including during operation. Estimated budget requirements for ESMP implementation should be included and should ideally propose to have a dedicated E&S specialists with the contractor and also during operations.

Contingency Plan

Provide guidance on Emergency procedures. Identify scenarios of equipment/machinery of failure/malfunction & accidents and detail out emergency procedures. These could be linked to OHS measures.

Development monitoring and reporting plan

Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for vegetation clearance and/or translocation, groundwater quality, noise, air and managing grievances. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

The monitoring program should give details of the following;

- Monitoring indicators to be measured for evaluating the performance of each mitigatory measure (for example national standards, engineering structures, extent of area replanted, etc.).
- Monitoring mechanisms and methodologies

- Monitoring frequency
- Monitoring locations
- Cost of monitoring
- Responsible party

The recommended format for presenting the monitoring program is given below.

Proposed Mitigation Measure	**Parameters to be monitored**	**Location**	**Measurements** (Incl. methods & equipment)	**Frequency of Measurement**	**Responsibilities** (Incl. review and reporting)	**Cost** (equipment & Individuals)
Detailed design and planning Phase						
Pre-Construction Phase						
Construction Phase						
Operation and Maintenance Phase						

Biodiversity Management Plan

Formulation of a biodiversity management plan concerning the impacts from the proposed project activities to the terrestrial and marine biodiversity. The plan shall identify specific components of the projects which may alter/impact the biodiversity of the islands from the project activities. The plan shall cover management pathways/models for both marine and terrestrial species, including habitat, environmentally sensitive or protected areas within the project impact boundary.

11. Formulation of a Grievance Redress Mechanism (GRM):

The mechanism should be furnished to fulfil the following objectives throughout the course of the project:

- receive and address any concerns, complaints, notices of emerging conflicts, or grievances (collectively "*Grievance*") alleging actual or potential harm to affected person(s) (the "*Claimant(s)*") arising from Project;
- assist in resolution of Grievances between and among Project Stakeholders; as well as the various government ministries, agencies and commissions, CSOs and NGOs, and others (collectively, the "*Stakeholders*") in the context of the Project;
- address grievances that arise from project workforce;
- Conduct itself at all times in a flexible, collaborative, and transparent manner aimed at problem solving and consensus building.

In addition to community grievances, a Grievance Redress Mechanism (GRM) for workers need to be defined. Need to identify the mechanism through which worker complains will be logged and addressed in a transparent manner.

12. Stakeholder consultation, Inter-Agency coordination and public/NGO participation

Identify appropriate mechanisms for providing information on the development proposal and stakeholders, government authorities and their views need to be presented in the ESIAESIA report. The stakeholder consultation should cover both the general public and also other government stakeholders and other interest groups. The report needs to describe the process followed in identifying vulnerable groups that need consultation. The following needs consultation:

1. Government Stakeholders
    - Regional Airports Company Limited (RACL) regarding airport sites
    - Maldives Civil Aviation Authority regarding airport sites
    - Directorate of Aviation Security Administration regarding Airport sites
    - Environmental Protection Agency especially regarding Kulhudhuhfushi site which is an environmentally sensitive site, also regarding vegetation removal/relocation.
    - MoECCT regarding Kulhudhuhfushi site which is an environmentally sensitive site, also regarding vegetation removal/relocation.
    - Disaster Management Authority
    - Ministry of National Planning Housing and Infrastructure
    - Utility Regulatory Authority
    - Fenaka
2. Island Level Stakeholders
    - Consultation of identified vulnerable groups
    - Island/City Council.
    - General public
    - NGO and CSOs operating in the island.
    - Womens Development Committees of each island/city.

For island level stakeholders, physical meetings should be undertaken at each of the project site. Virtual meetings maybe conducted with government level stakeholders. Date, time and minutes and key outcomes of the consultations need to be presented in the ESIA report. The ESIA report should outline the responses from the proponent and/or MoECCT regarding the issues raised by the consulted stakeholders.

13. Conclusion

This section shall specify the environmental and social acceptability of the project, considering the impacts and measures identified during the assessment process. It shall also identify any other conditions or external requirements for ensuring the success of the project.

1. **Validation and Disclosure-** The draft executive summary and the ESMP (matrix table in mitigation chapter) in local language should be disclosed in the project island in printed format and disseminated as appropriate or made available via online means for public commenting. This should be completed prior to or at the time of submitting the report to the EPA and the World Bank for clearance, so the period for public commenting can be sequenced in parallel to the review process. The consultant will assist the project in disclosure documents in all major affected settlements and at the project island and national level. The final cleared version of the report will be disclosed in major project websites and social media platforms with a summary of major findings through the disclosure process reflected as an annex.

2. **Presentation**- The ESIA addendum report shall be concise and focus on significant environmental and social issues. It shall contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulation 2012 and subsequent amendments.

3. **References**
   Submit a list of all references, (books, articles, technical reports and other information sources) cited in the various chapters of the ESIA study with full biographic references, and the following conventional procedures cited in the literature: author, year, title, source, number of pages, and city of publication or issuance.

14. Timeframe for submitting the ESIA report

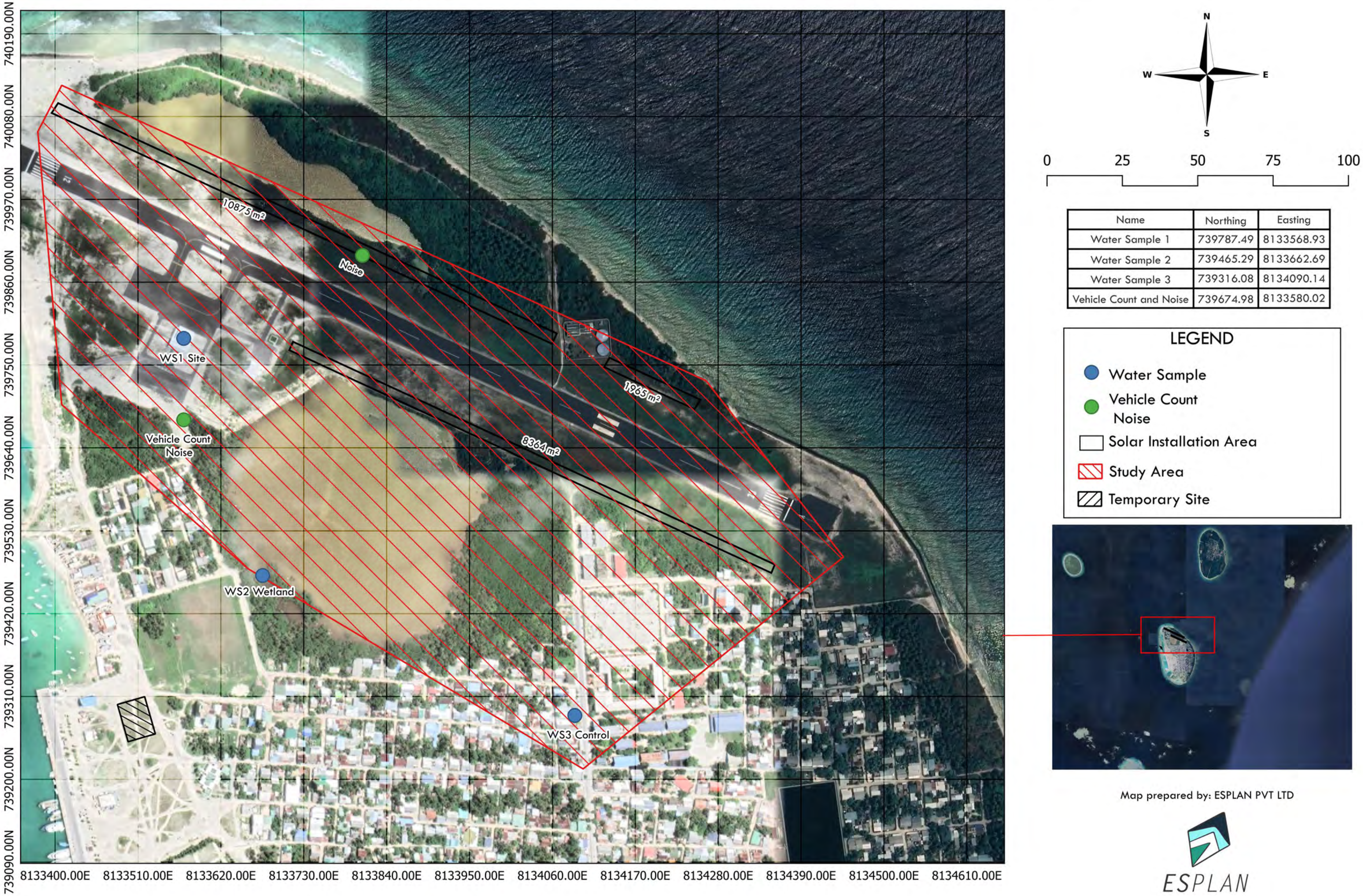
The developer must submit the completed ESIA report within 6 months from the date of this Term of Reference.

……………………………………………

23rd November 2022

APPENDIX B – Survey Maps

KULHUDHUFFUSHI STUDY AREA AND SURVEY LOCATIONS

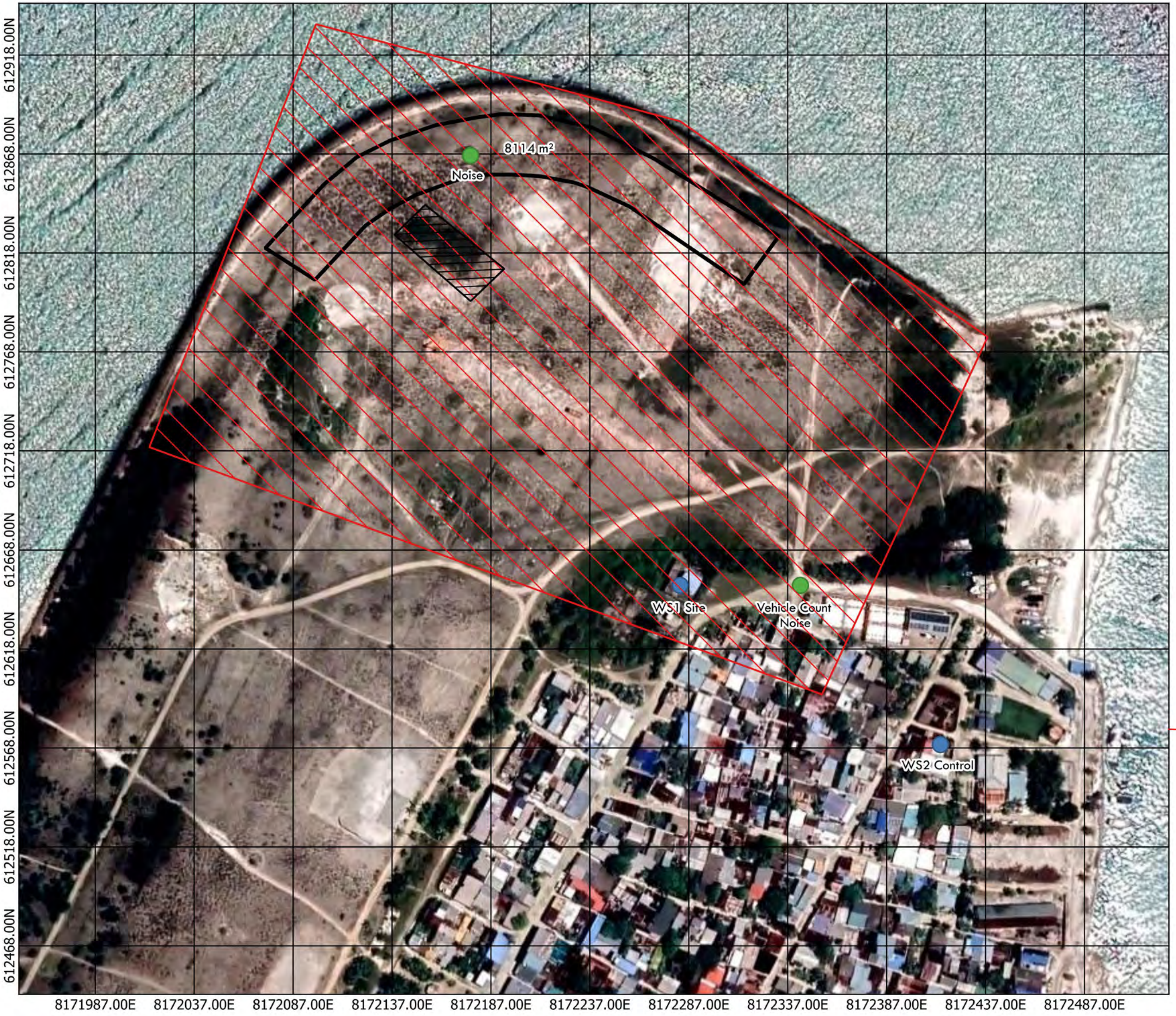


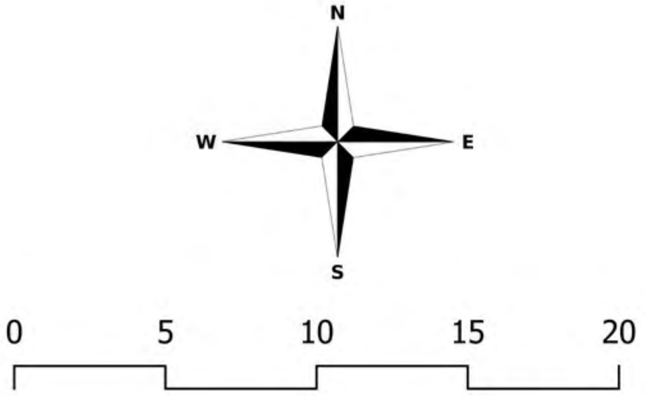
Name	Northing	Easting
Water Sample 1	739787.49	8133568.93
Water Sample 2	739465.29	8133662.69
Water Sample 3	739316.08	8134090.14
Vehicle Count and Noise	739674.98	8133580.02

Map prepared by: ESPLAN PVT LTD

ESPLAN

HINNAVARU STUDY AREA AND SURVEY LOCATIONS

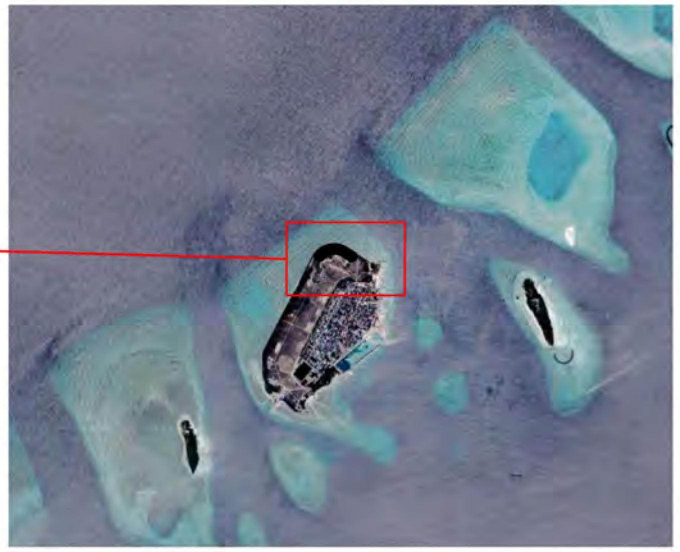




Name	Northing	Easting
Water Sample 1	612651.58	8172286.84
Water Sample 2	612569.31	8172414.17
Vehicle Count and Noise	612648.96	8172344.10
Noise (site)	612873.57	8172188.85

LEGEND

- ● Water Sample
- ● Vehicle Count Noise
- ☐ Solar Installation Area
- ▨ Study Area
- ▨ Temporary Site



Map prepared by: ESPLAN PVT LTD

ESPLAN

EYDHAFUSHI STUDY AREA AND SURVEY LOCATIONS

Name	Northing	Easting
Water Sample 1	8134152.48	568549.19
Water Sample 2	8134198.28	568672.56
Vehicle Count and Noise	8134196.28	568646.48
Noise (site)	8134172.54	568550.20

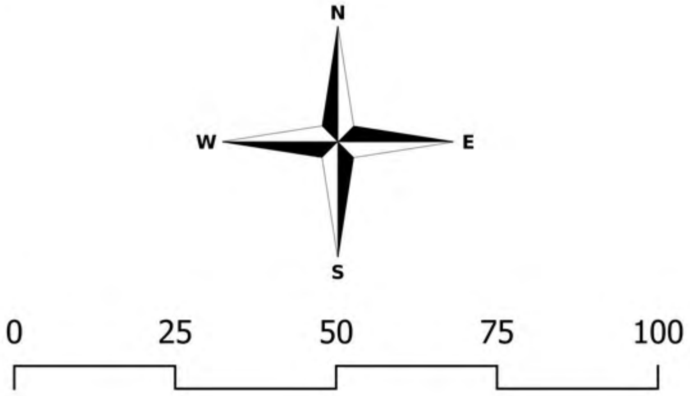
LEGEND

- ● Water Sample
- ● Vehicle Count Noise
- ☐ Solar Installation Area
- ▨ Study Area
- ▨ Temporary Site

Map prepared by: ESPLAN PVT LTD

ESPLAN

THINADHOO STUDY AREA AND SURVEY LOCATIONS



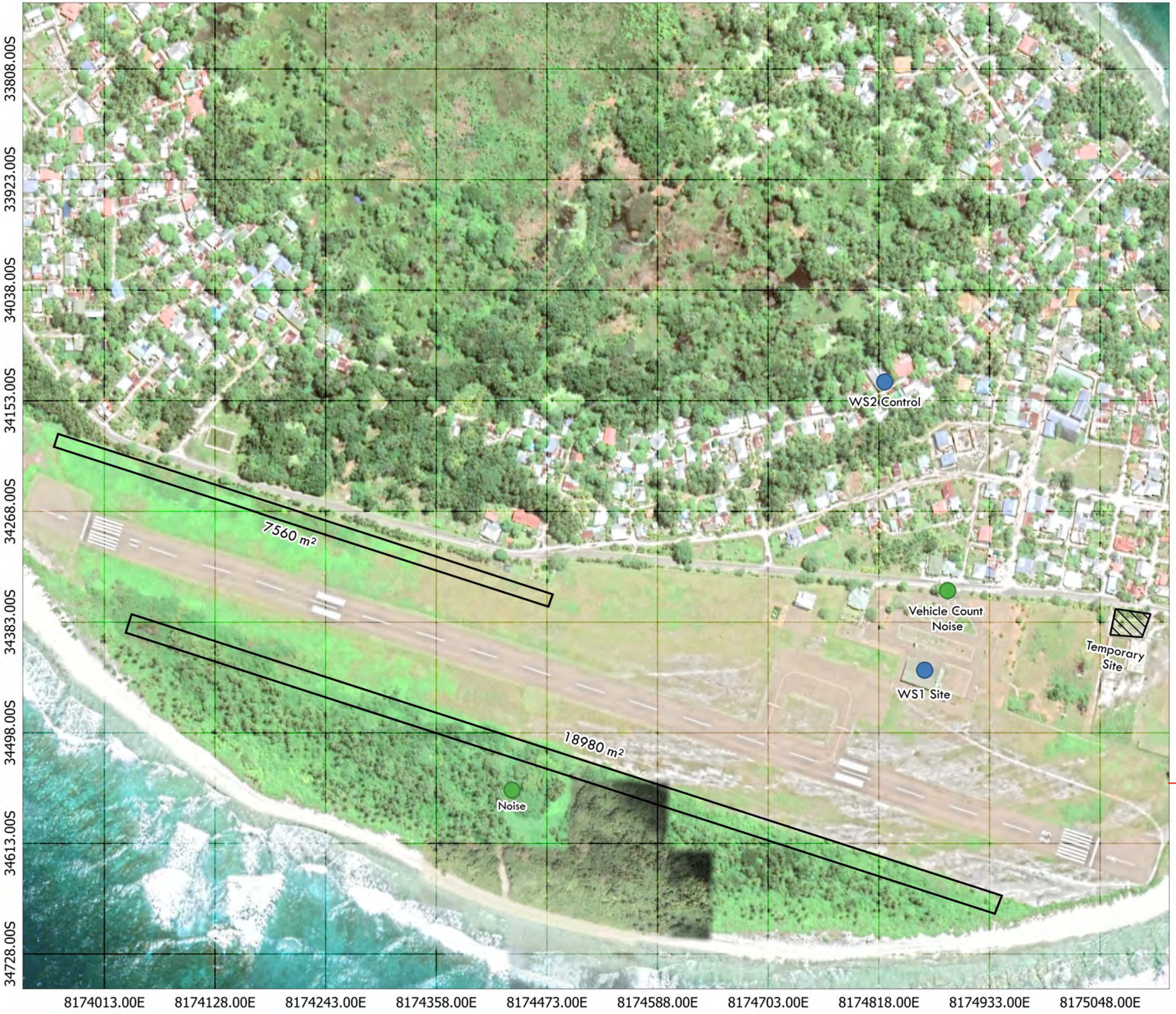
Name	Northing	Easting
Water Sample 1	59309.10	8125607.63
Water Sample 2	59164.33	8126077.83
Vehicle Count and Noise	59195.38	8125587.87
Noise (site)	59434.11	8125567.51

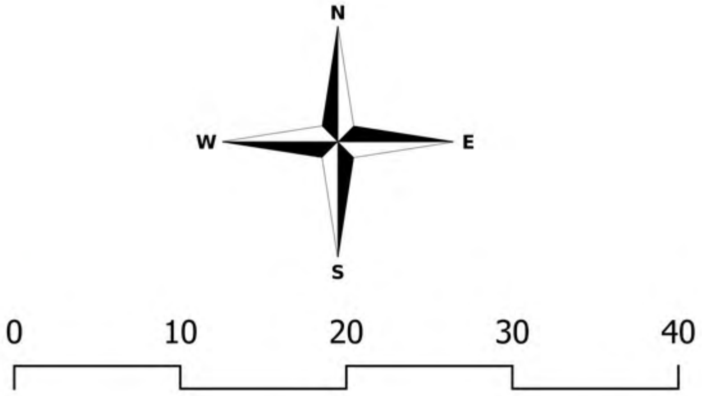
LEGEND

- ● Water Sample
- ● Vehicle Count Noise
- ☐ Solar Installation Area
- ▨ Study Area
- ▨ Temporary Site

Map prepared by: ESPLAN PVT LTD

FUVAHMULAH STUDY AREA AND SURVEY LOCATIONS





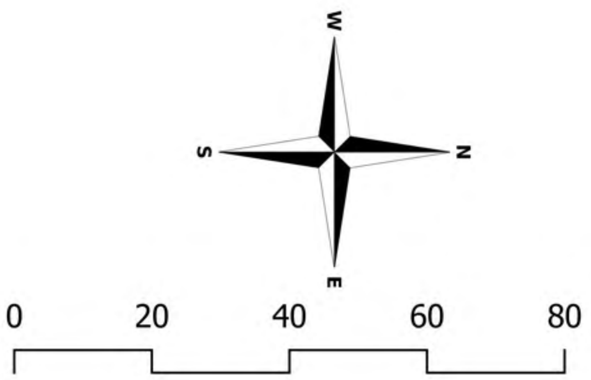
Name	Northing	Easting
Water Sample 1	-34436.83	8174864.46
Water Sample 2	-34138.42	8174821.71
Vehicle Count and Noise	-34352.95	8174887.85
Noise (site)	-34565.87	8174458.78

LEGEND

- ● Water Sample
- ● Vehicle Count Noise
- ☐ Solar Installation Area
- ▨ Study Area
- ▨ Temporary Site

Map prepared by: ESPLAN PVT LTD

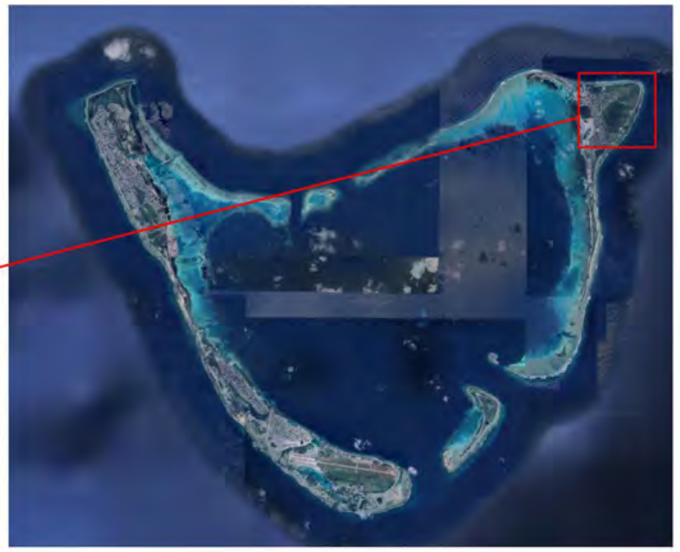
HULHUMEEDHOO STUDY AREA AND SURVEY LOCATIONS



Name	Northing	Easting
Water Sample 1	-65458.81	8152688.23
Water Sample 2	612569.31	8172414.17
Vehicle Count and Noise	-65965.94	8152385.63
Noise (site)	-66368.47	8151445.38

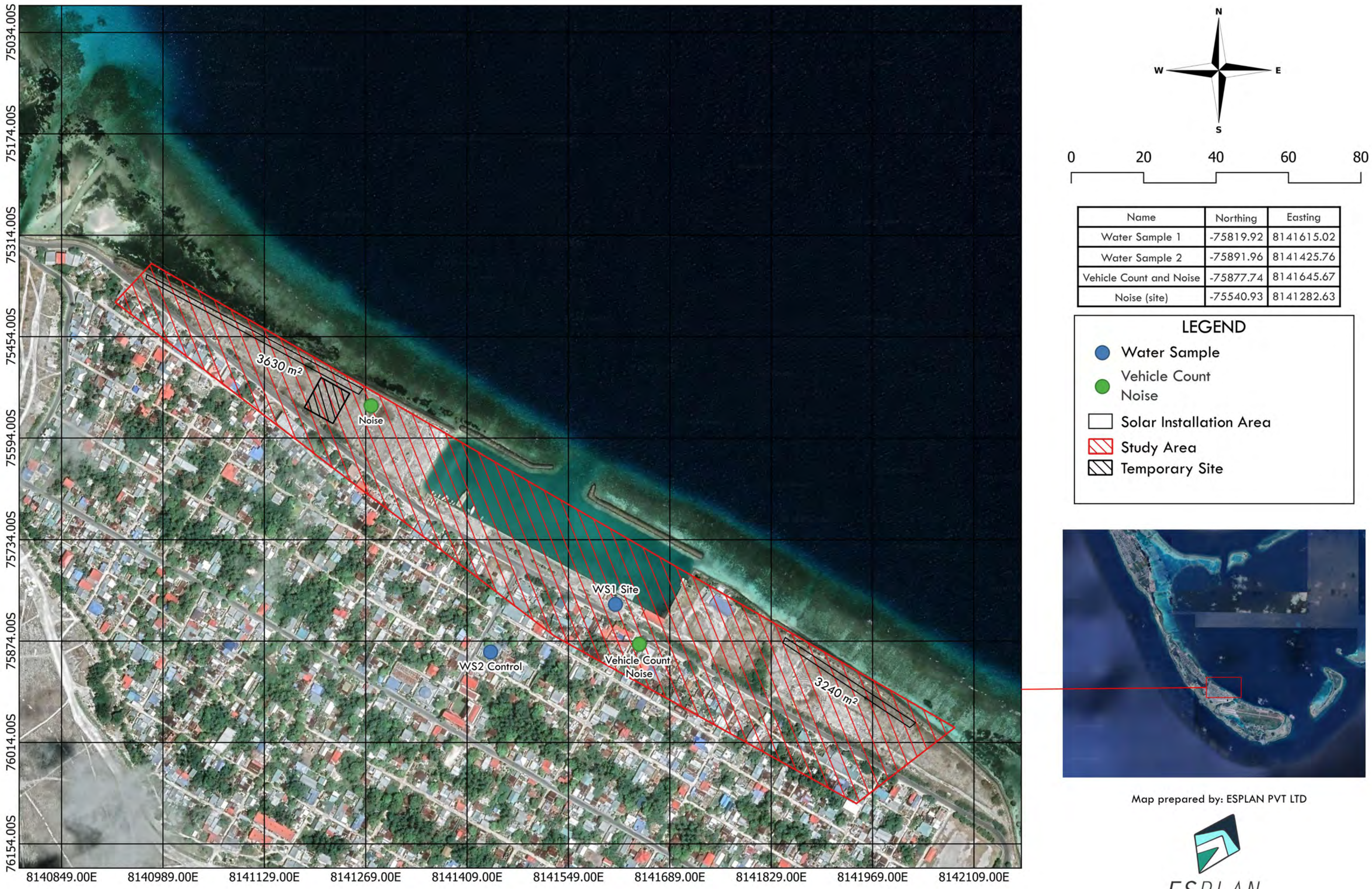
LEGEND

- 🔵 Water Sample
- 🟢 Vehicle Count Noise
- ☐ Solar Installation Area
- ▨ Study Area



Map prepared by: ESPLAN PVT LTD

FEYDHOO STUDY AREA AND SURVEY LOCATIONS



Name	Northing	Easting
Water Sample 1	-75819.92	8141615.02
Water Sample 2	-75891.96	8141425.76
Vehicle Count and Noise	-75877.74	8141645.67
Noise (site)	-75540.93	8141282.63

Map prepared by: ESPLAN PVT LTD

ESPLAN

MARADHOO FEYDHOO STUDY AREA AND SURVEY LOCATIONS

Name	Northing	Easting
Water Sample 1	-74841.07	8140390.98
Water Sample 2	-74756.71	8140123.36
Vehicle Count and Noise	-74761.45	8140333.16
Noise (site)	-74990.52	8140542.33

LEGEND

● Water Sample

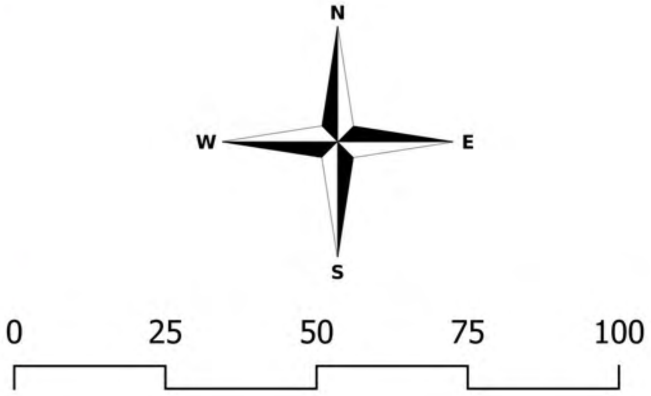
● Vehicle Count Noise

☐ Solar Installation Area

▨ Study Area

Map prepared by: ESPLAN PVT LTD

HITHADHOO STUDY AREA AND SURVEY LOCATIONS



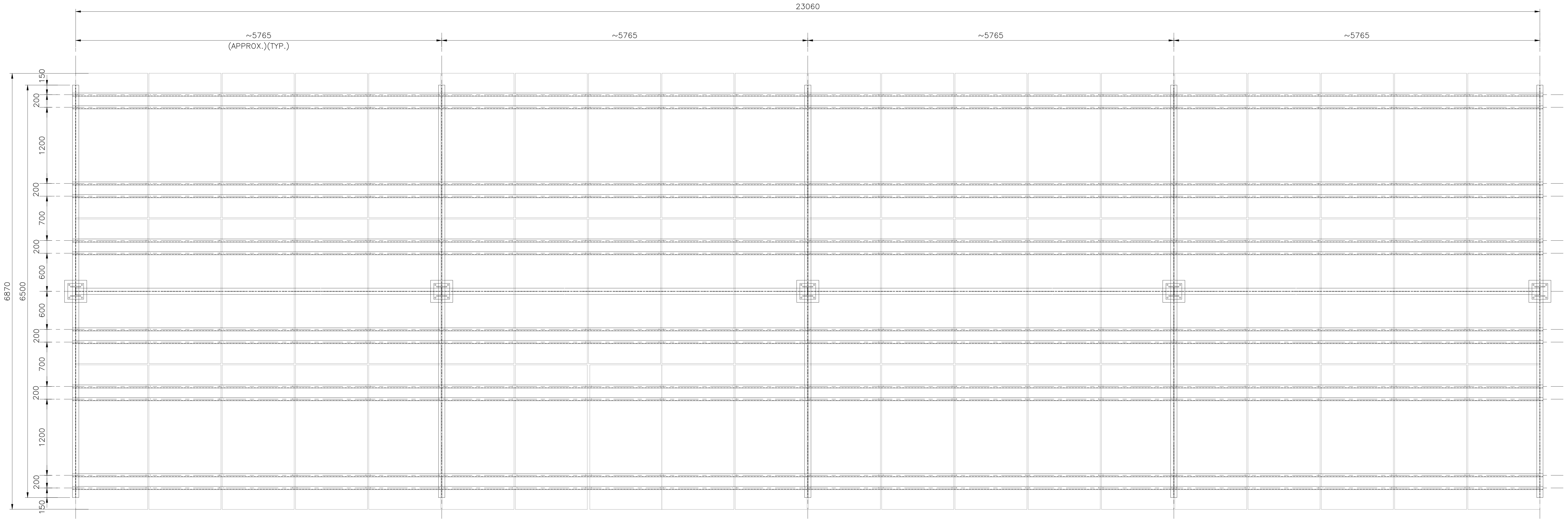
Name	Northing	Easting
Water Sample 1	-68504.23	8136964.39
Water Sample 2	-68259.30	8136802.58
Vehicle Count and Noise	-68380.24	8137162.85
Noise (site)	-68684.24	8137082.76,

LEGEND

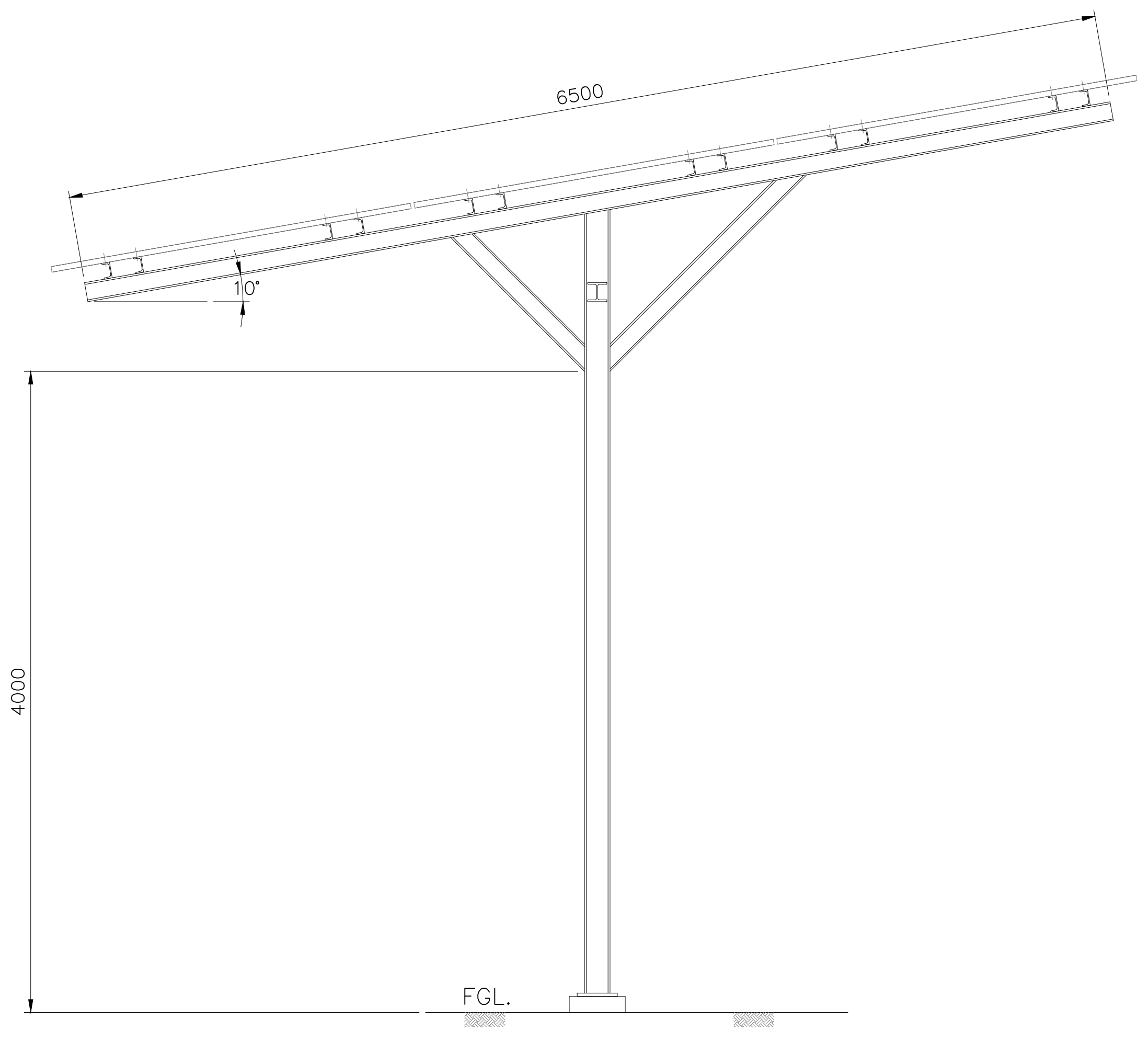
● Water Sample
● Vehicle Count Noise
☐ Solar Installation Area
▨ Study Area

Map prepared by: ESPLAN PVT LTD

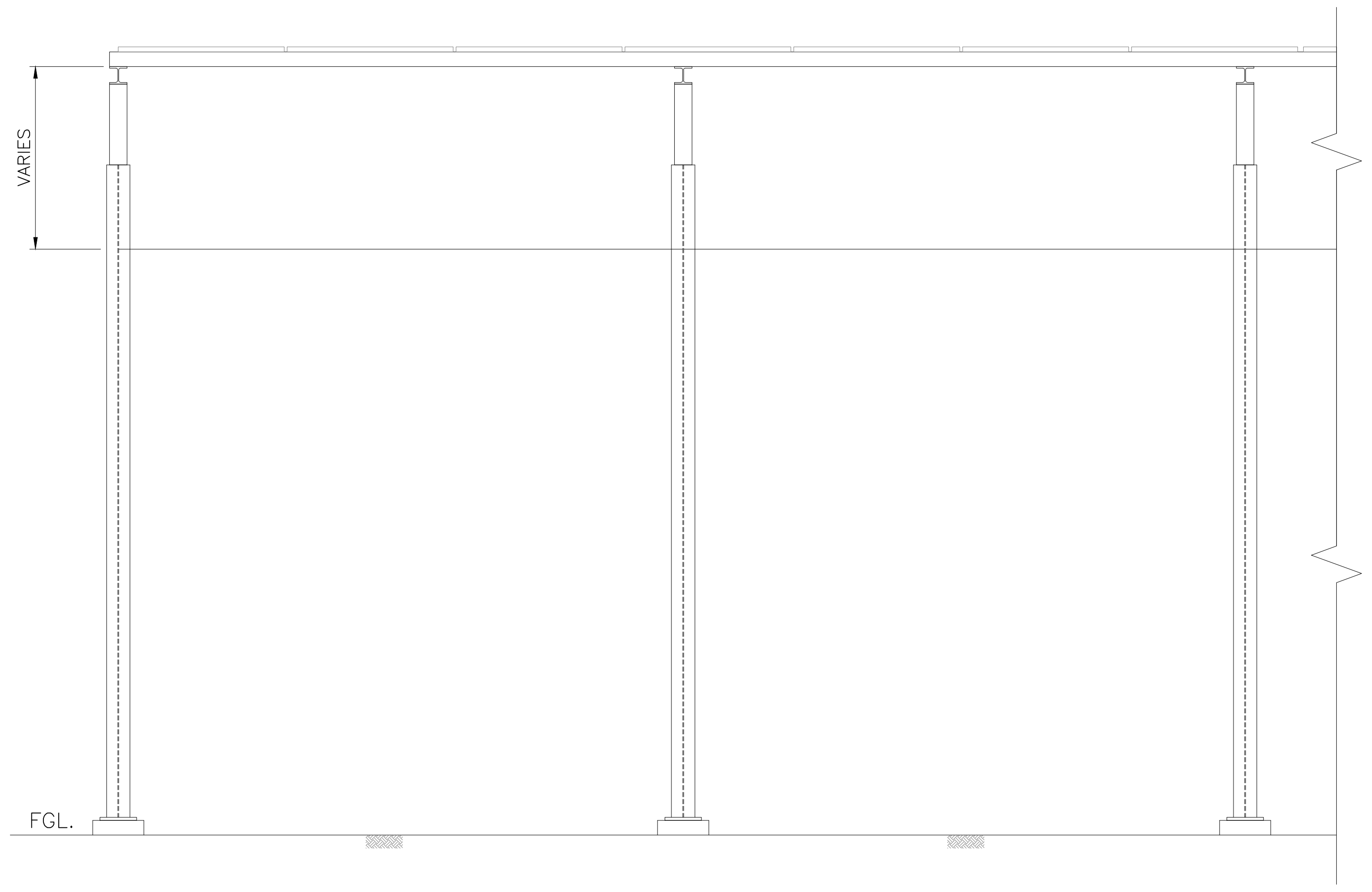
APPENDIX C – Project Site Specific Designs



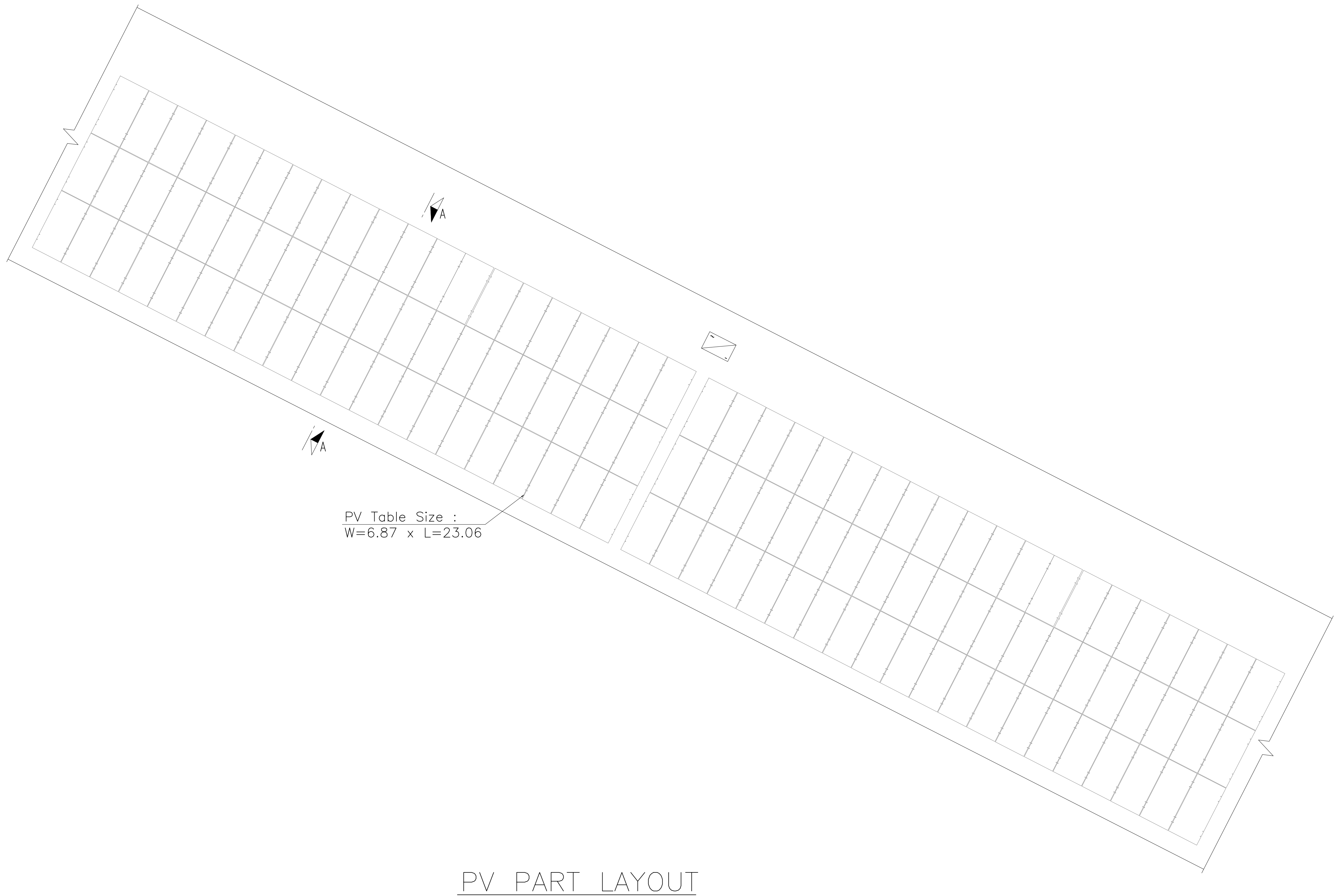
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1
FOR PV TABLE SIZE 6870x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS

DESCRIPTION	DWG. NO.
PV LAYOUT FOR FEYDHOO HARBOUR	–

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

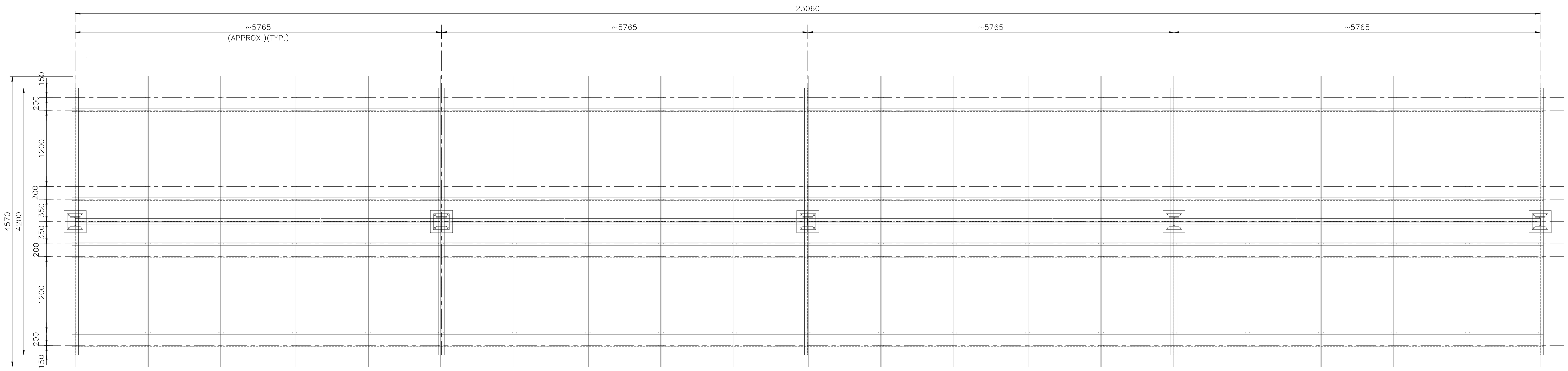
PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

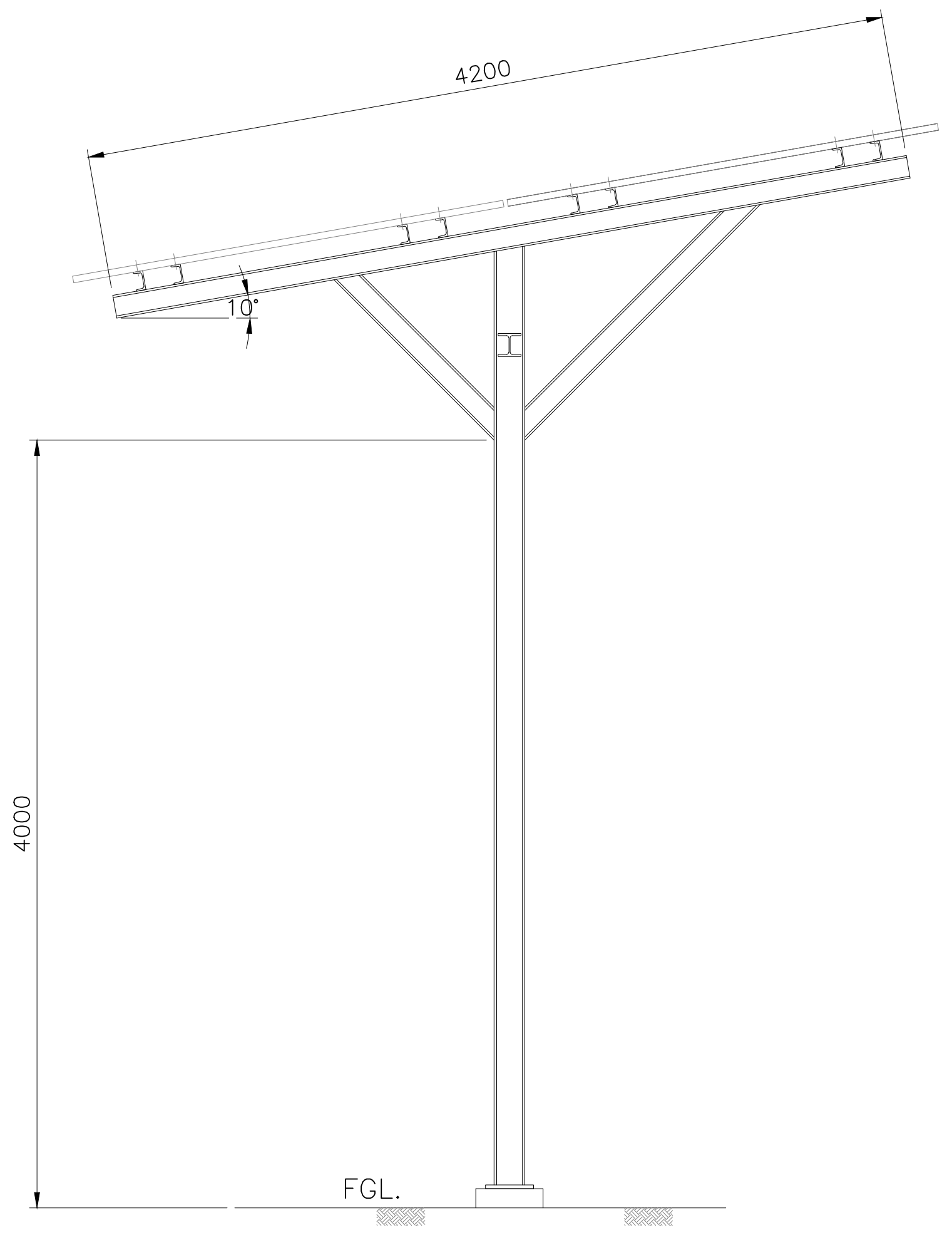
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

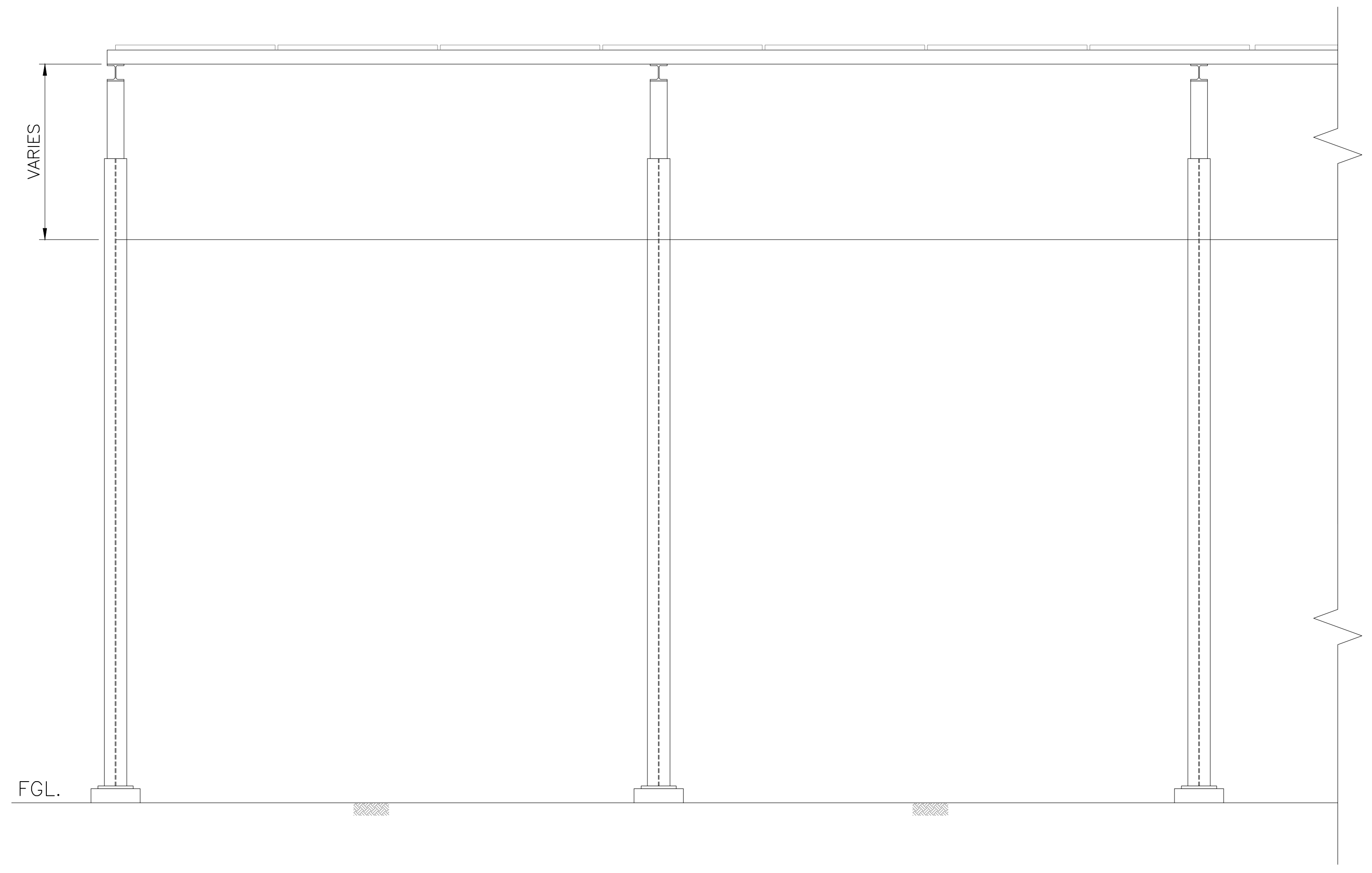
SECTION: CIVIL
SCALE: AS SHOWN
PAGE: 1/1
CONCEPTUAL PV STRUCTURE DRAWING FOR FEYDHOO HARBOUR (WALKWAY)



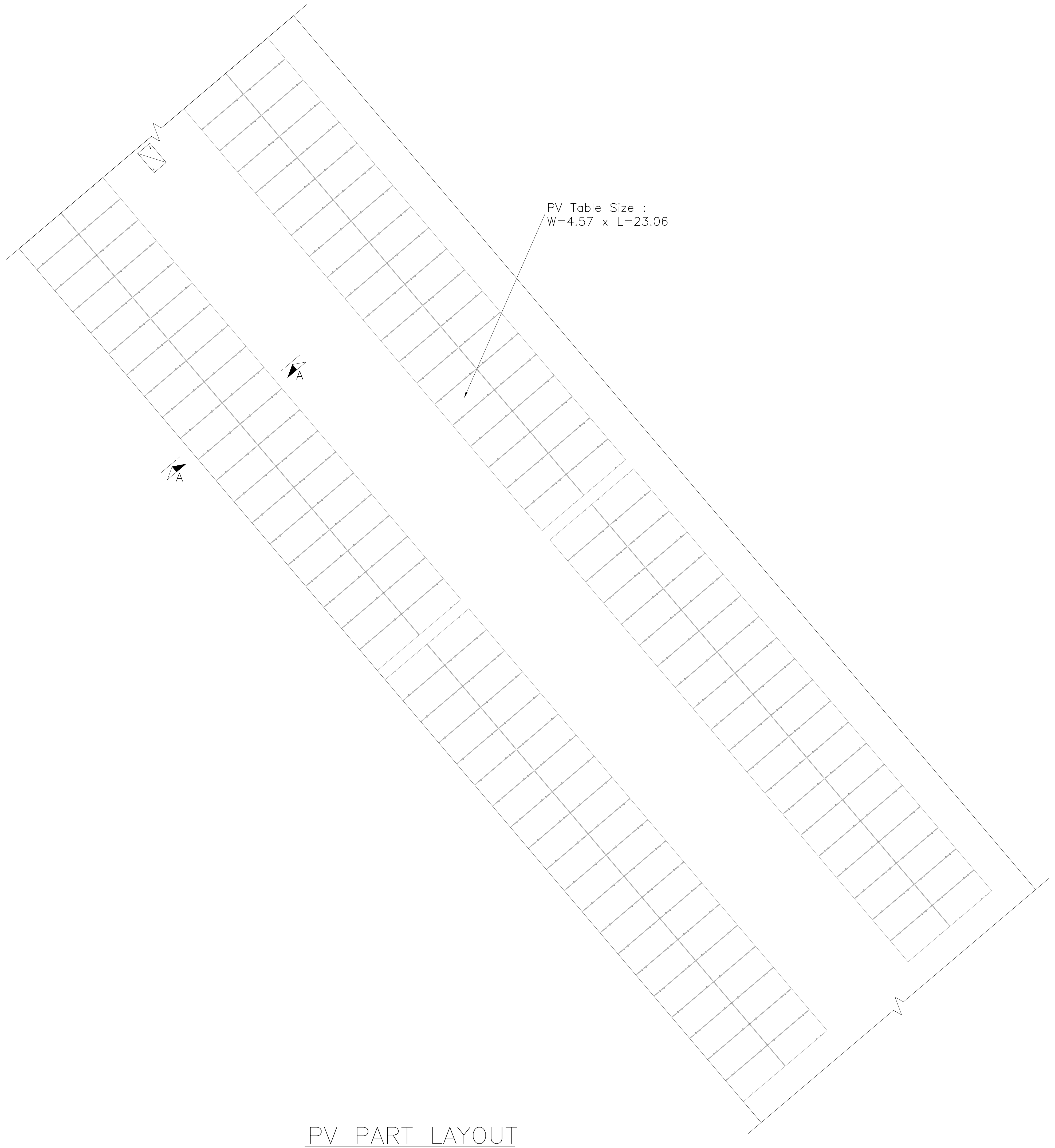
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-2
FOR PV TABLE SIZE 4570x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS

DESCRIPTION	DWG. NO.
PV LAYOUT FOR MARADHOO FEYDHOO HARBOUR	-

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

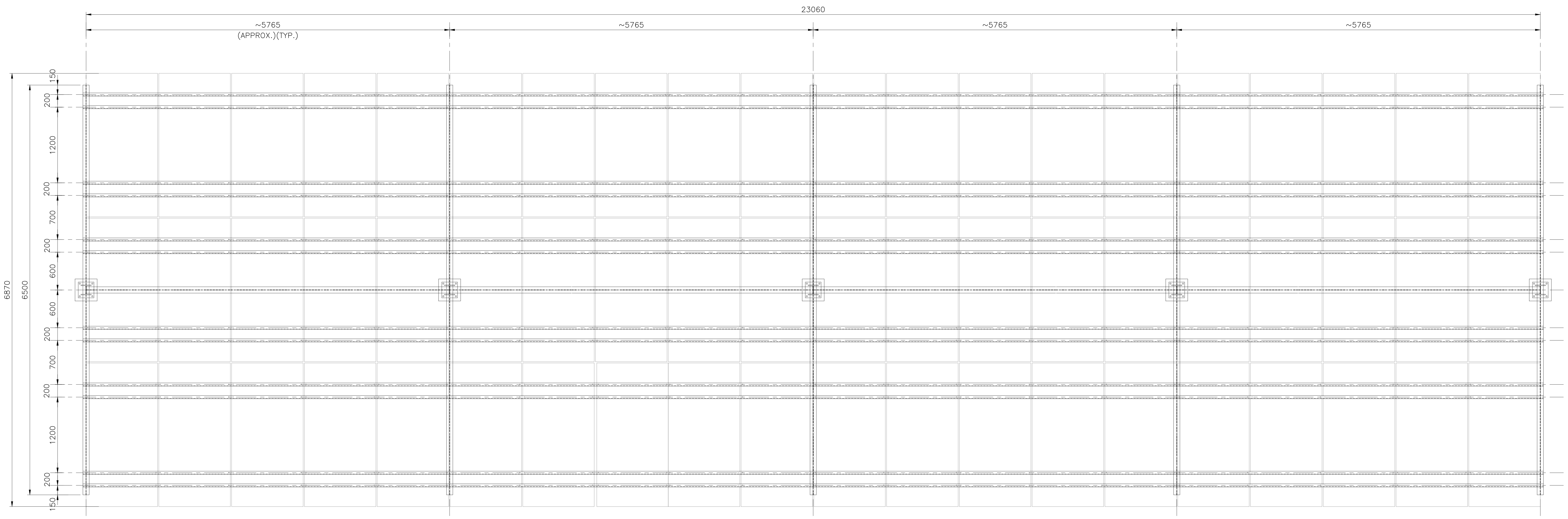
PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

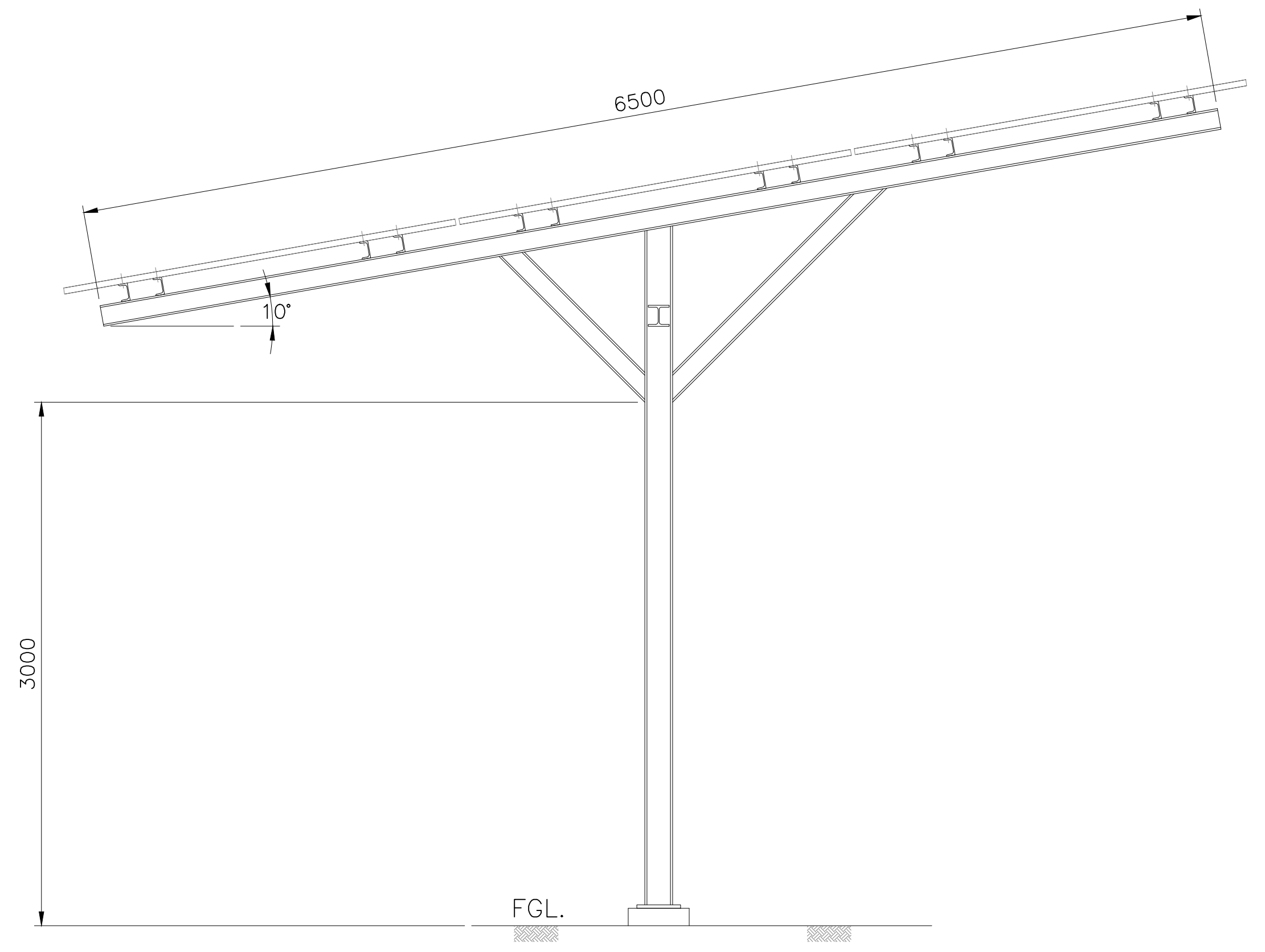
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

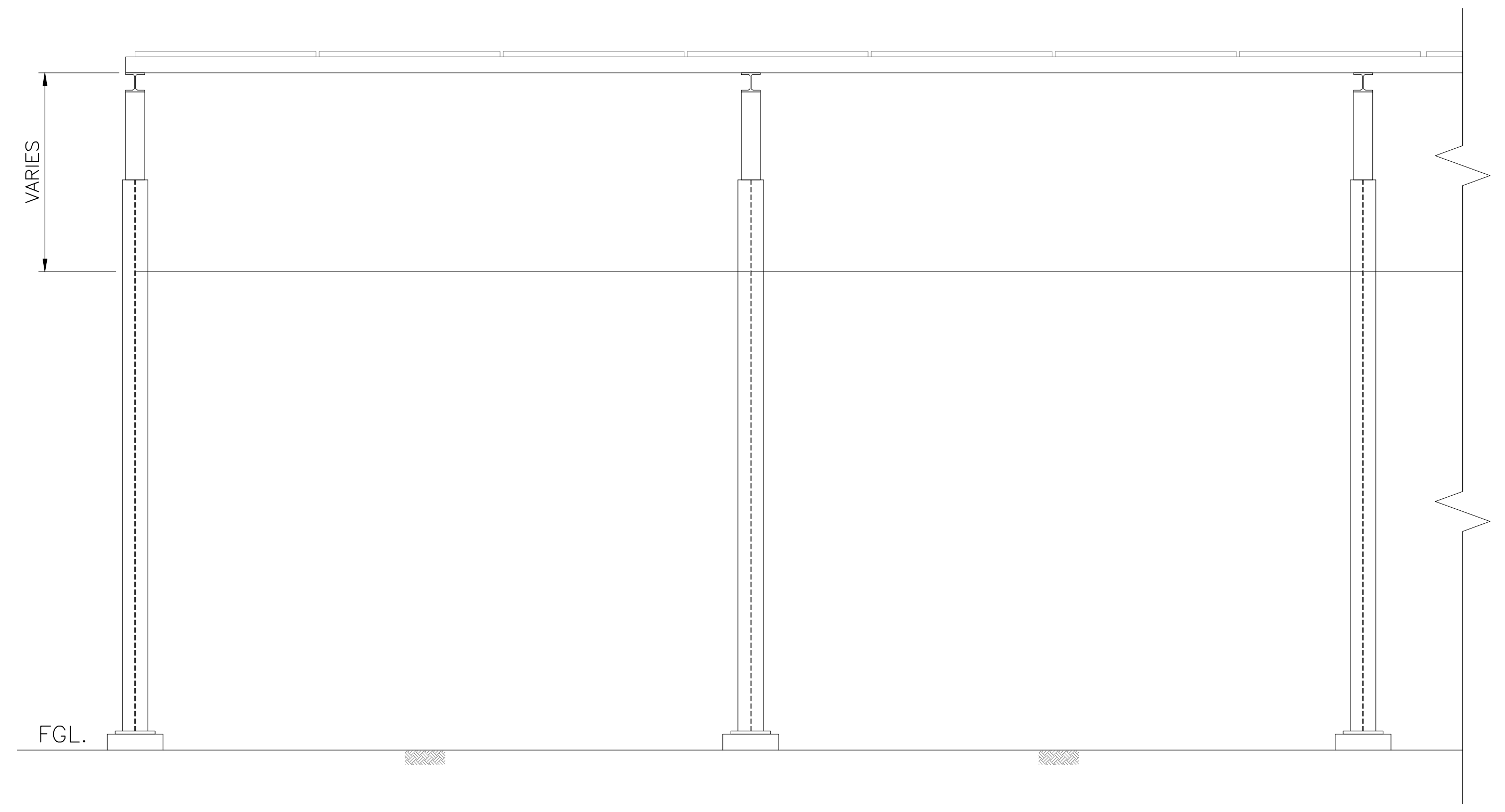
SECTION: CIVIL	PAGE:	CONCEPTUAL PV STRUCTURE DRAWING FOR MARADHOO FEYDHOO HARBOUR (WALKWAY)
SCALE: AS SHOWN	1/1	



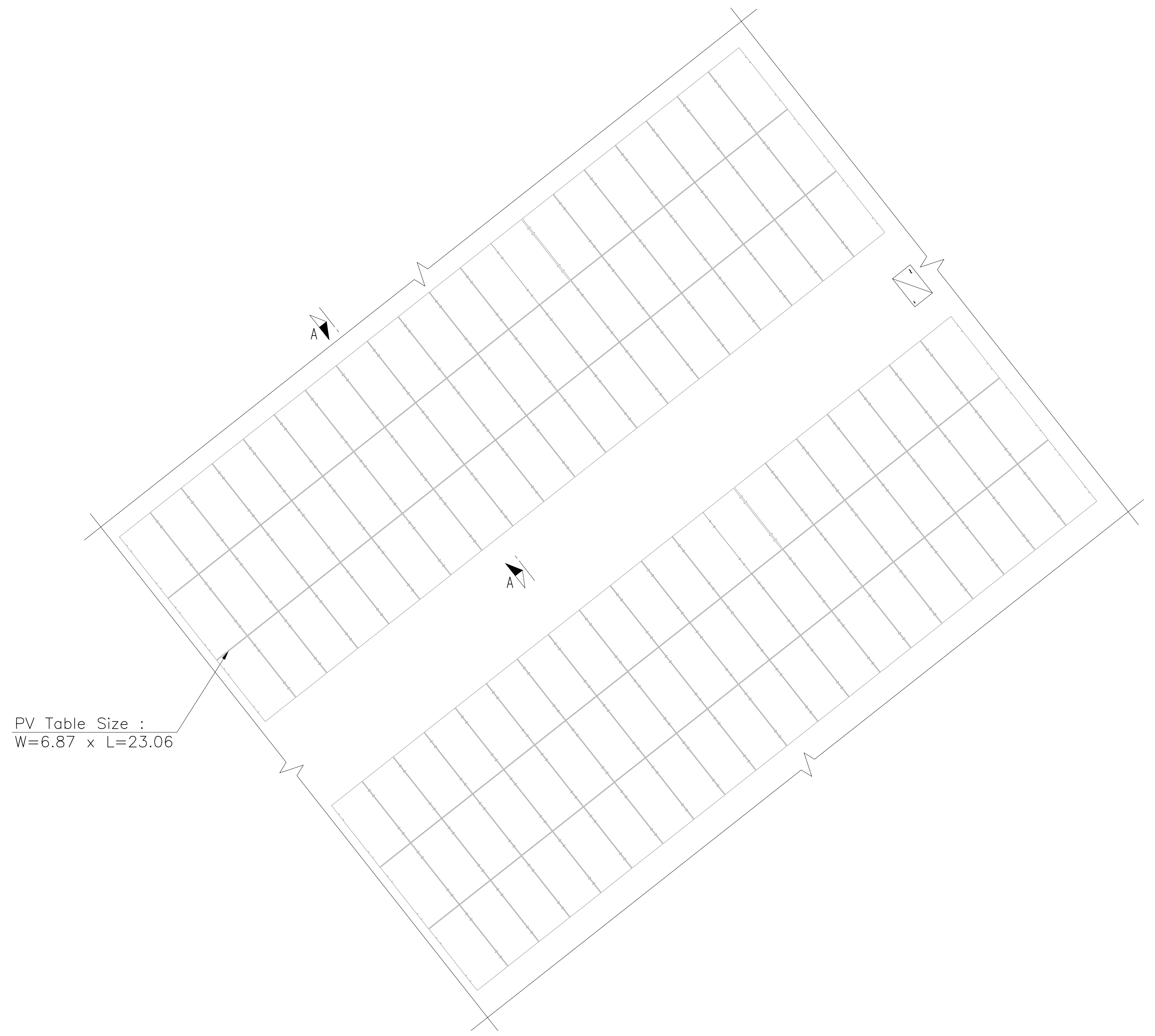
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1
FOR PV TABLE SIZE 6870x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS

DESCRIPTION	DWG. NO.
PV LAYOUT FOR HITHADOO STADIUM	-

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

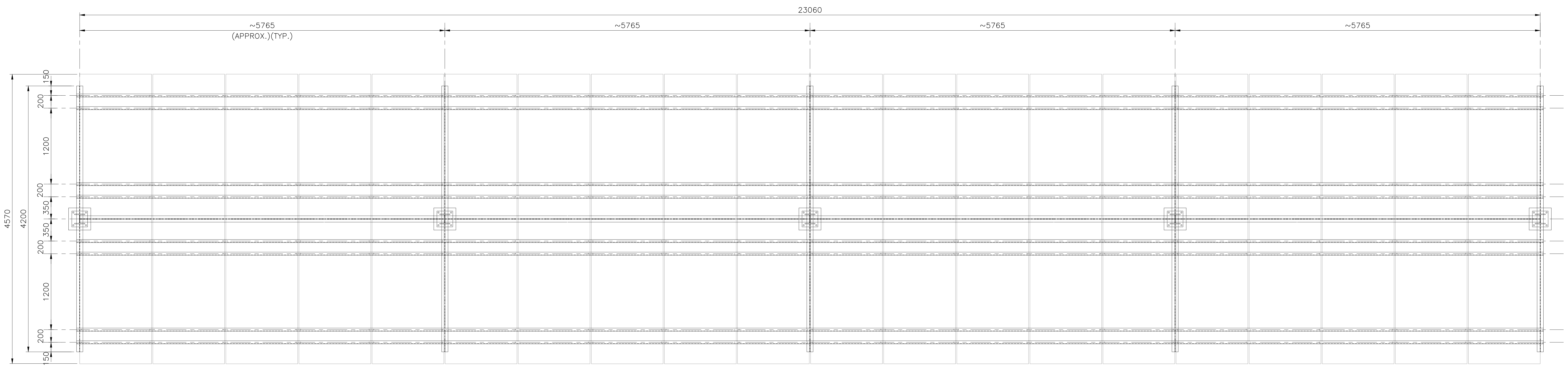
OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

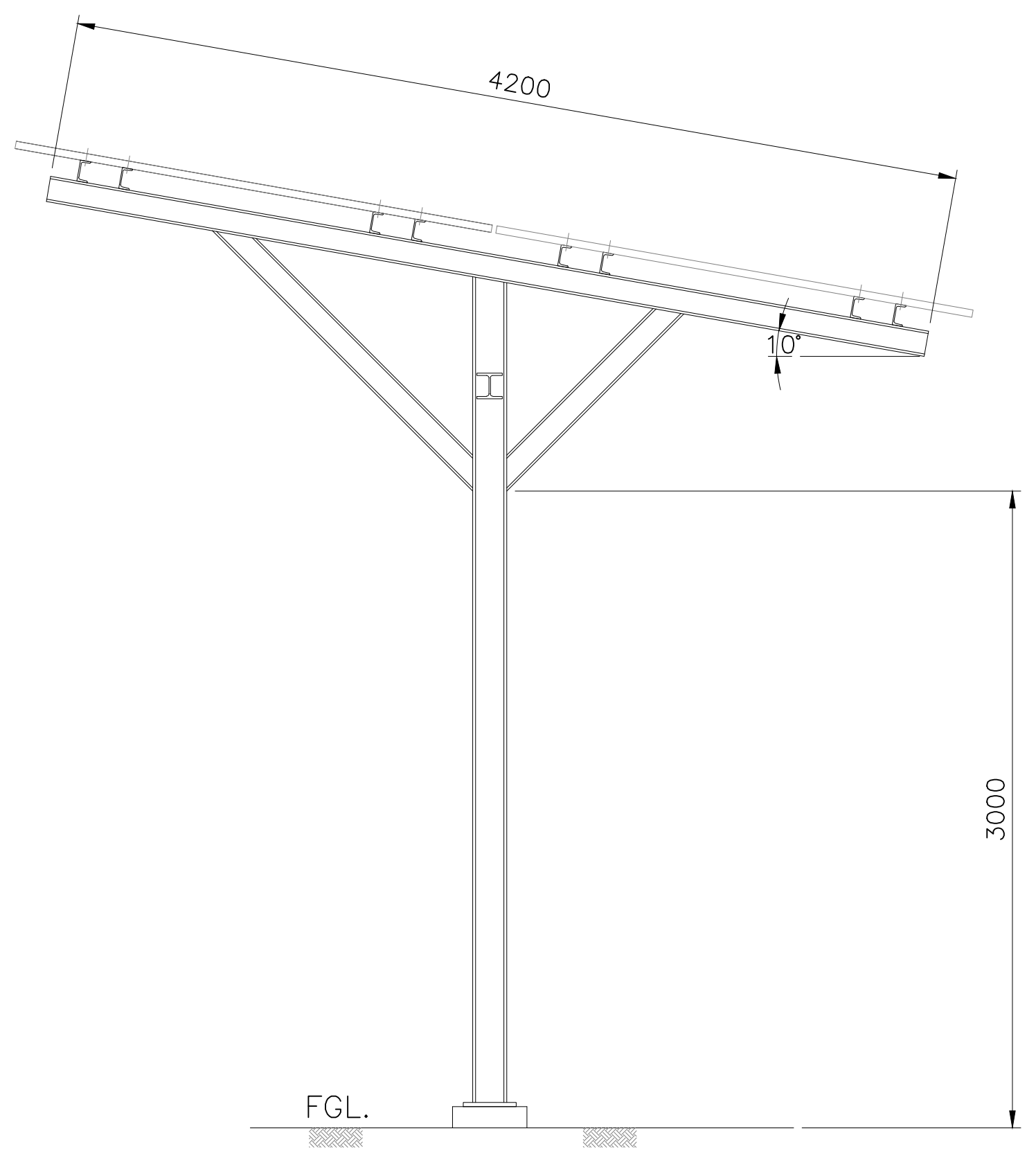
CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

SECTION: CIVIL
SCALE: AS SHOWN
PAGE: 1/2
CONCEPTUAL PV STRUCTURE DRAWING FOR HITHADOO STADIUM (CARPORT)

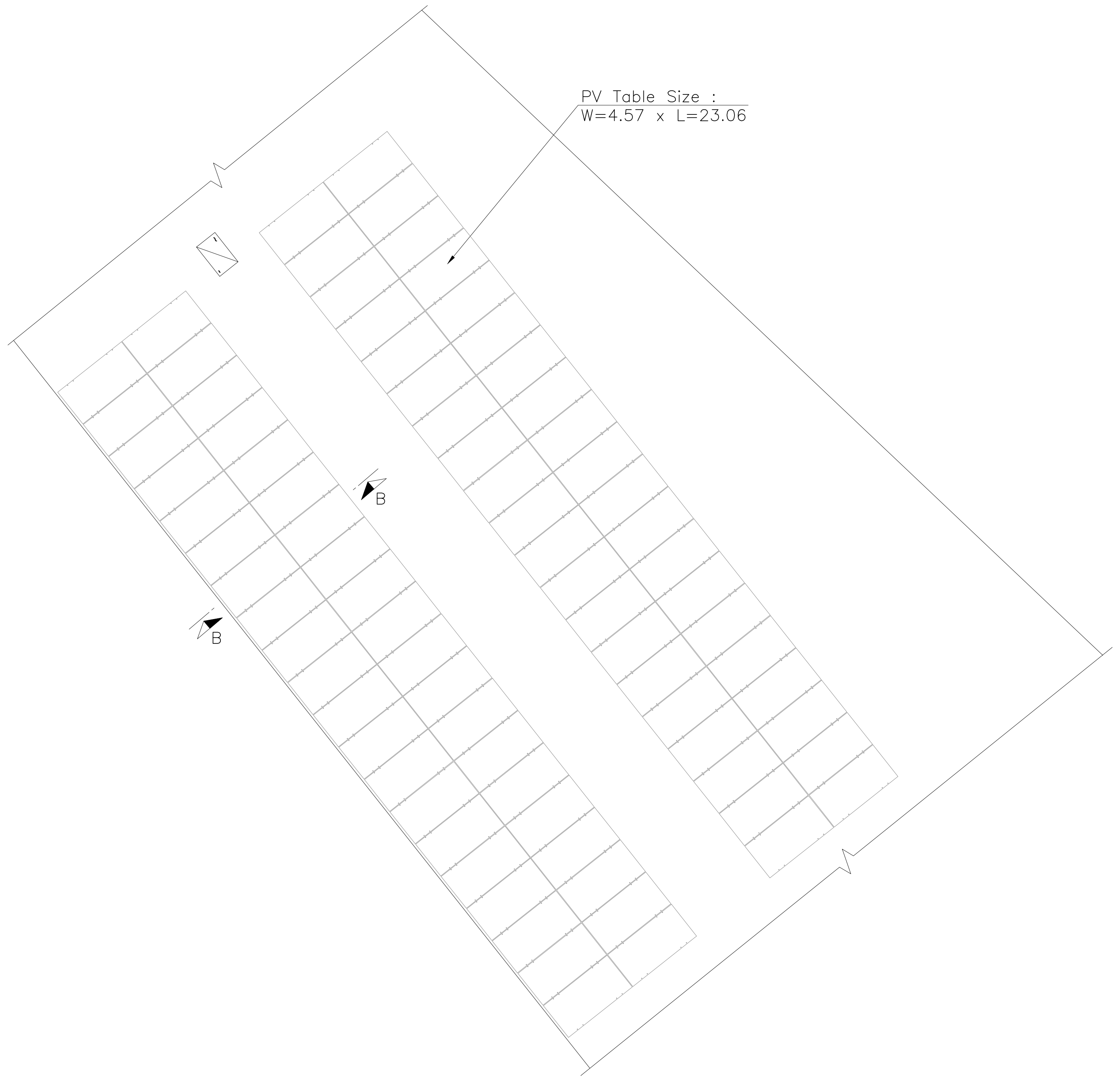
REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR HITHADOO STADIUM	–

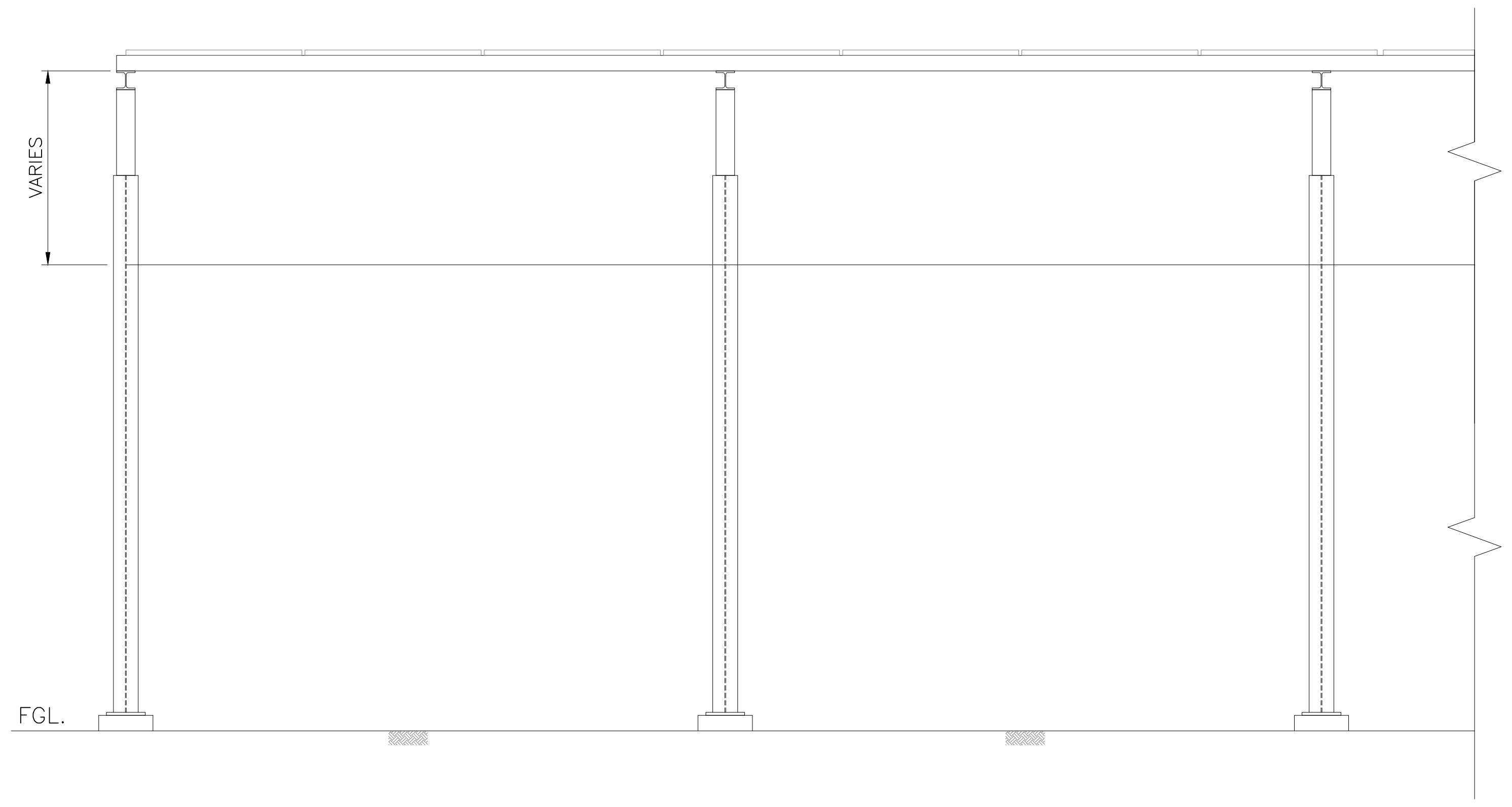


TYPICAL PLAN OF PV TABLE STRUCTURE TYPE–2
FOR PV TABLE SIZE 4570x23060



SECTION B–B
SHORTER SIDE ELEVATION





LONGER SIDE ELEVATION

PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

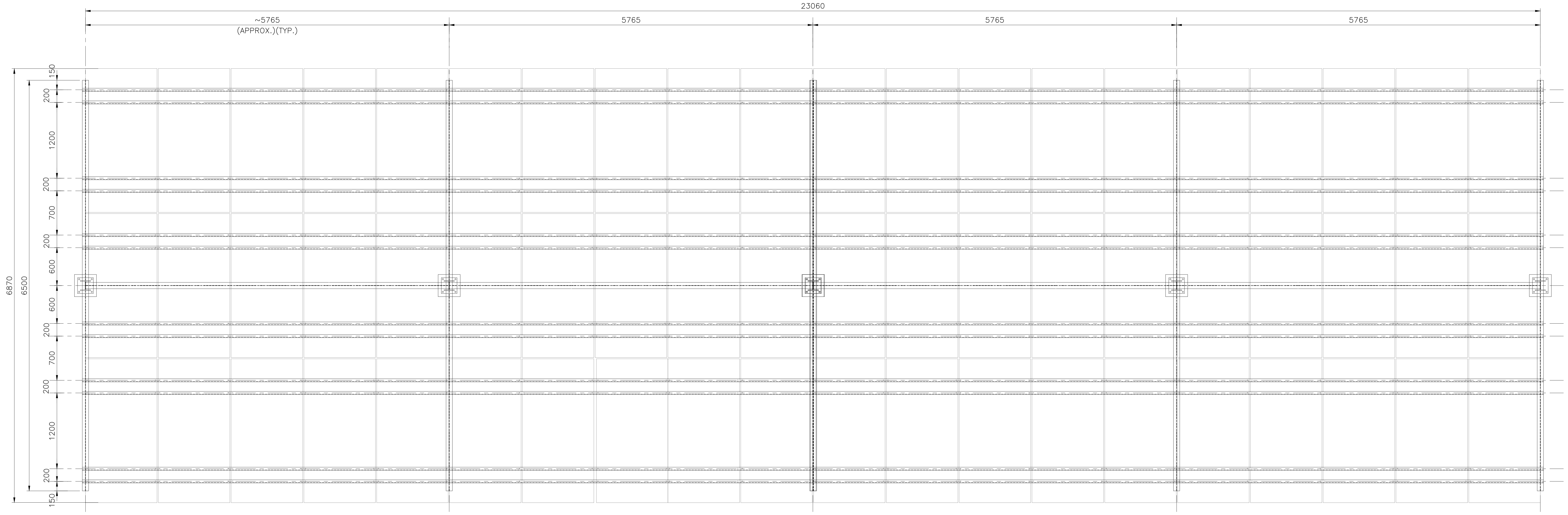
PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

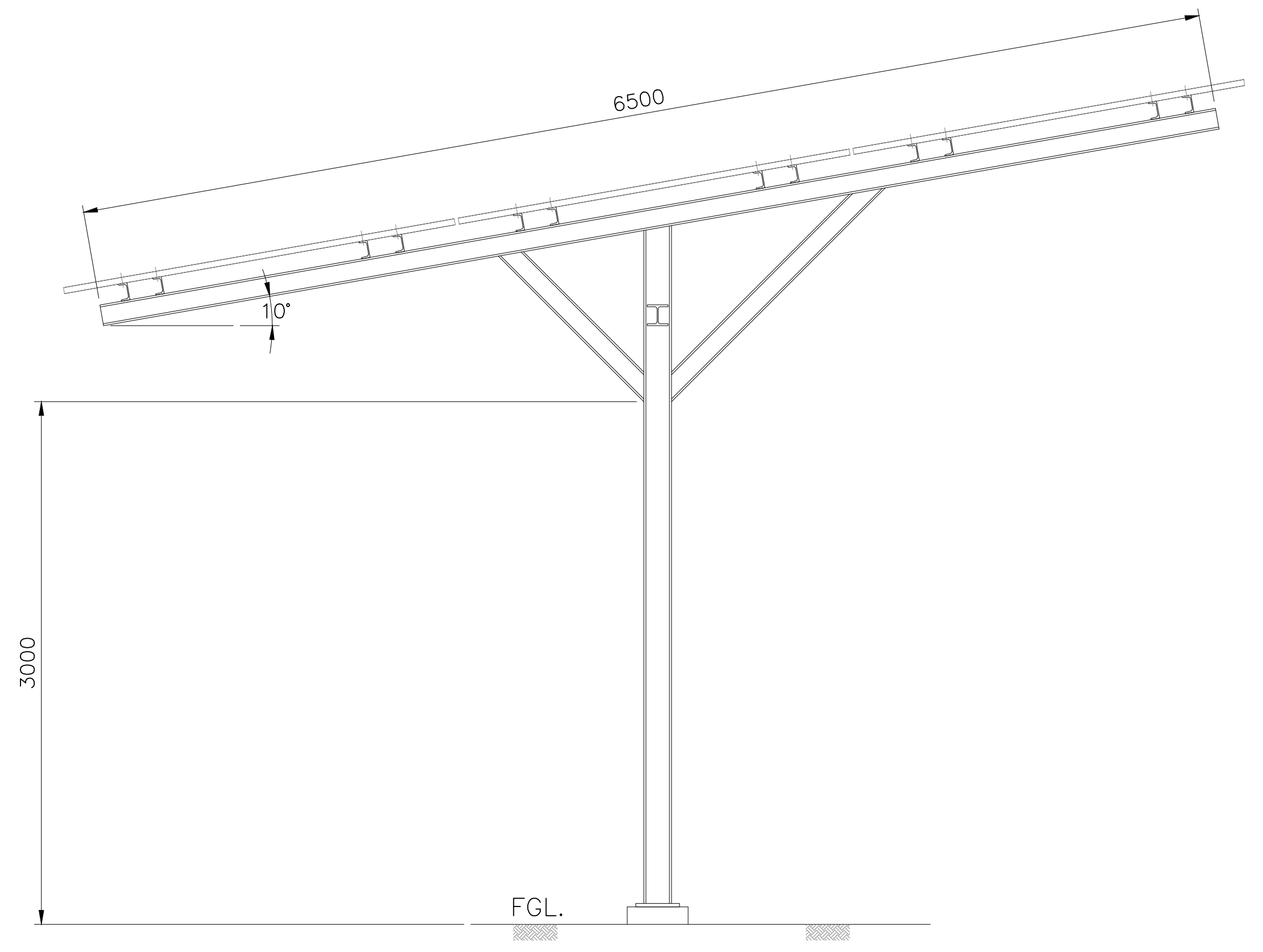
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

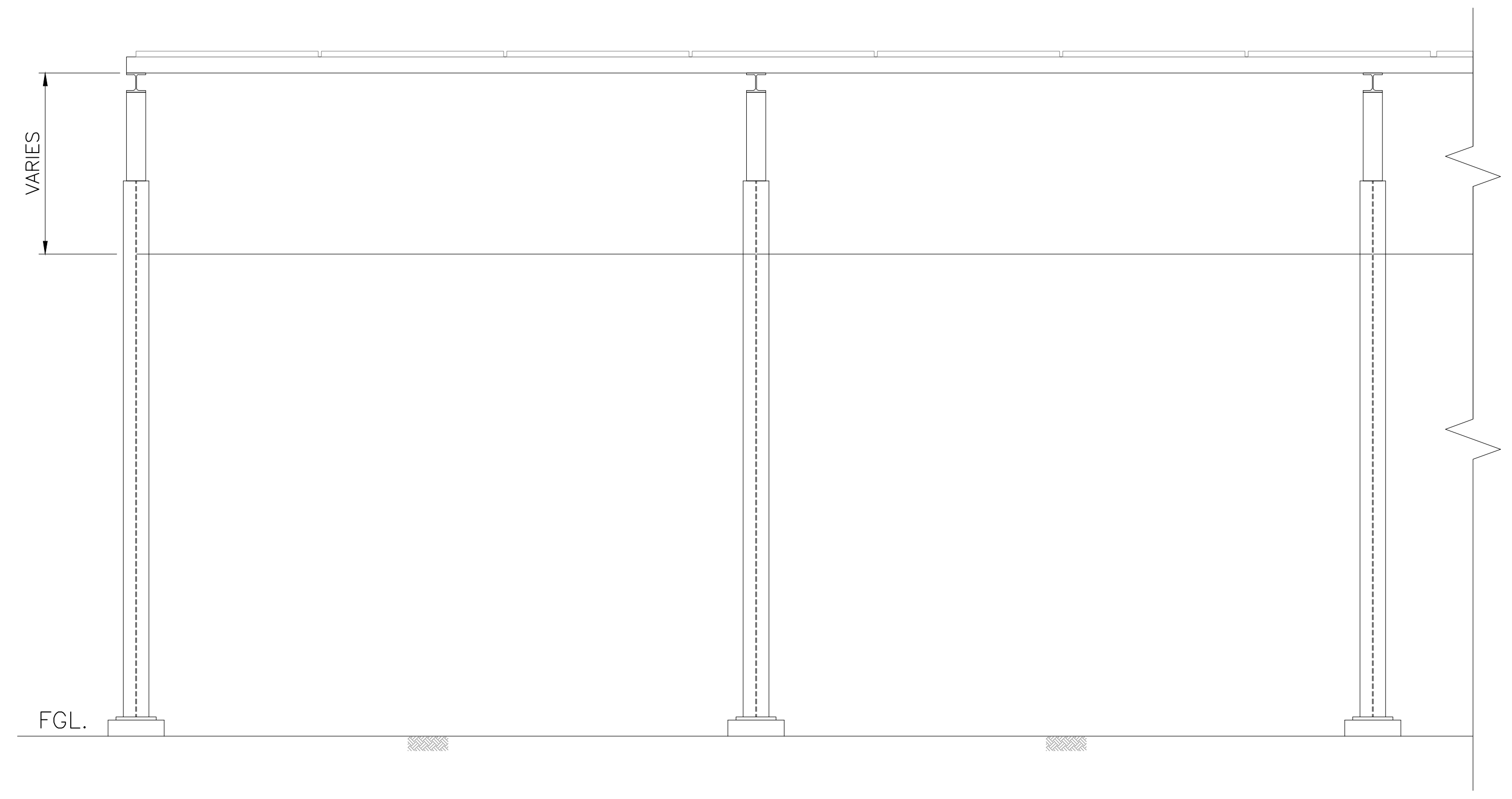
SECTION: CIVIL SCALE: AS SHOWN	PAGE: 2/2	CONCEPTUAL PV STRUCTURE DRAWING FOR HITHADOO STADIUM (CARPORT)



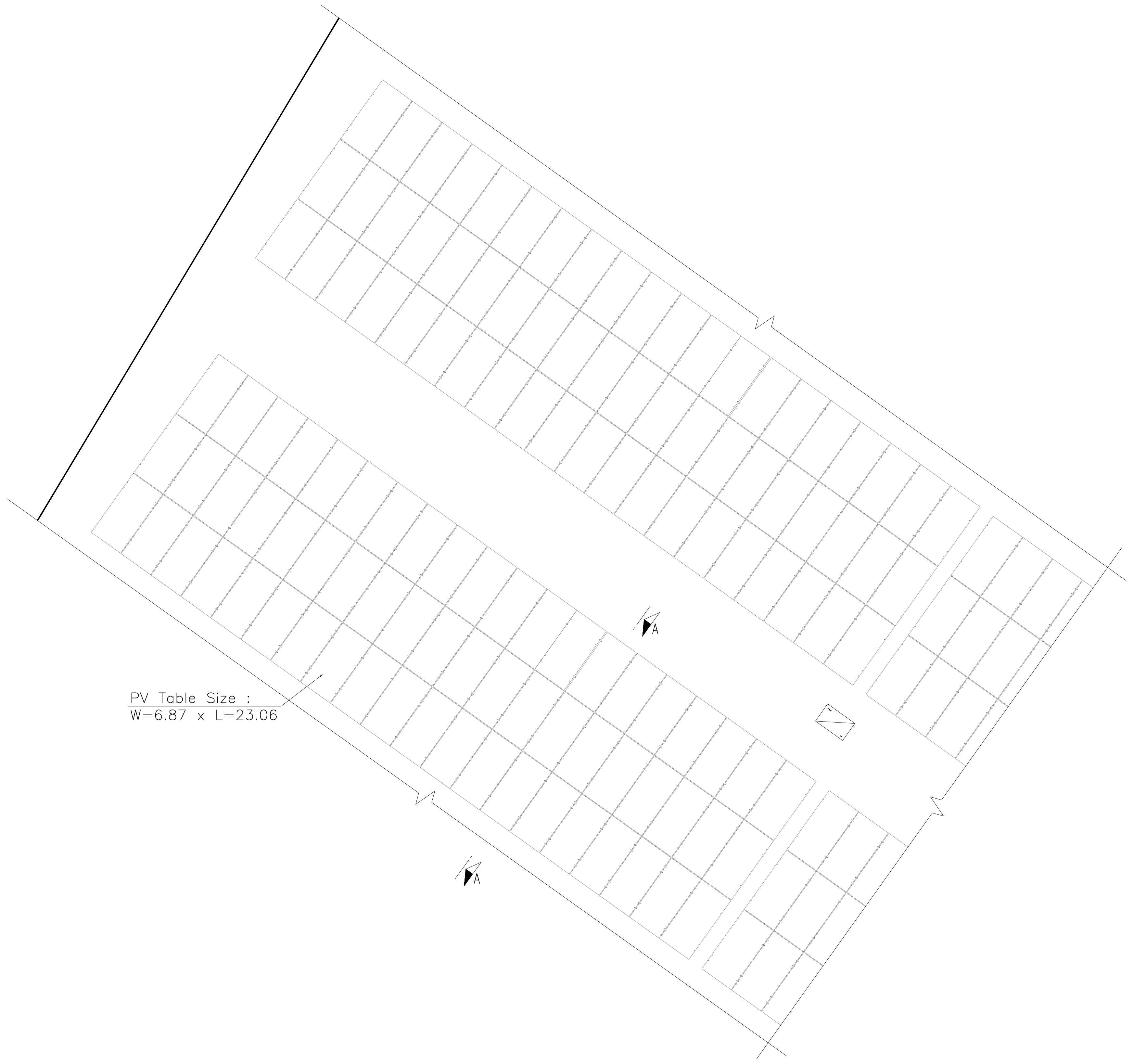
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1
FOR PV TABLE SIZE 6870x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR HULHUDHOO-MEEDHOO STP	-

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:
ASPIRE
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MFPI
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

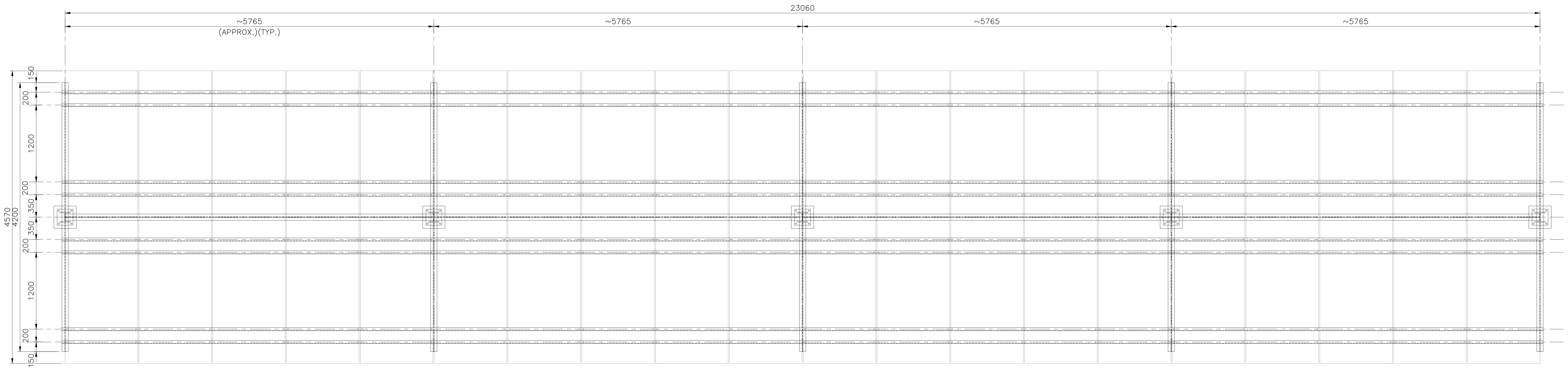
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
中国水电建设集团国际工程有限公司
SINOHYDRO CORPORATION LIMITED
SINOHYDRO CORPORATION LIMITED.

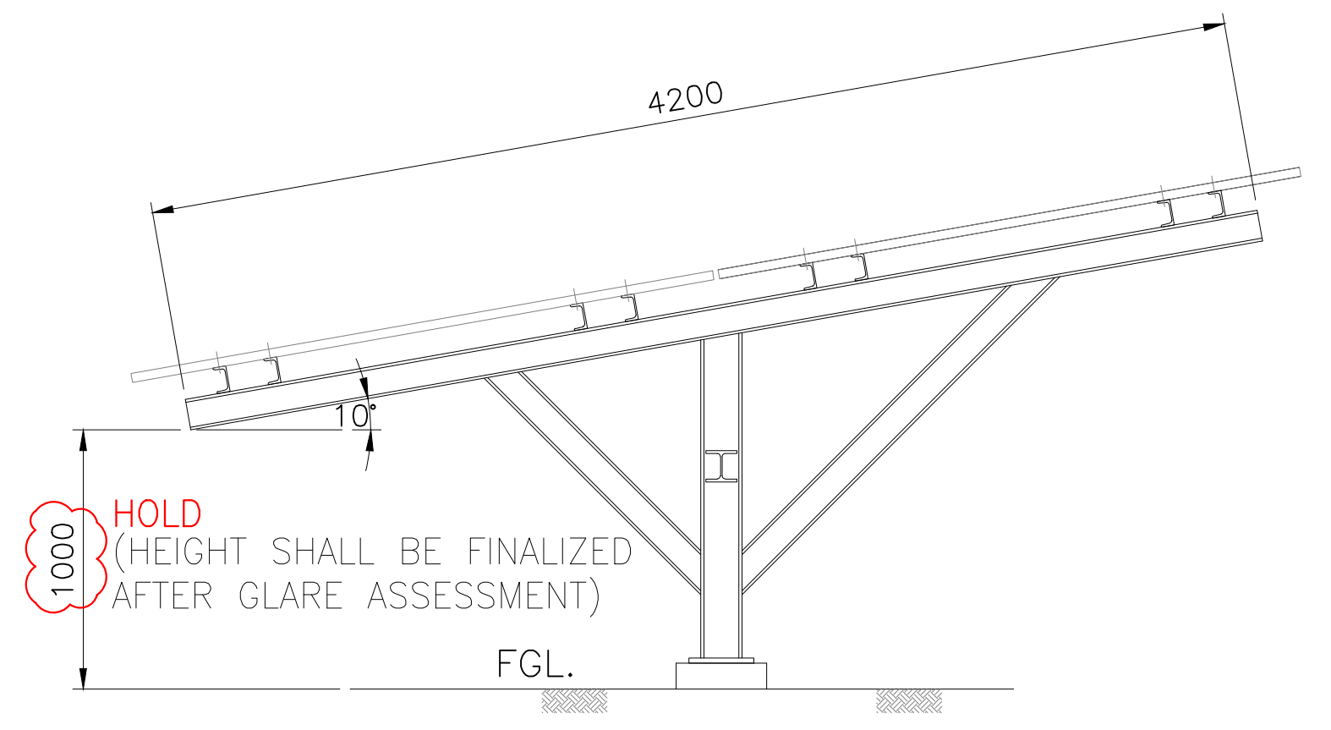
SECTION: CIVIL
SCALE: AS SHOWN
PAGE: 1/1
CONCEPTUAL PV STRUCTURE DRAWING FOR
HULHUDHOO-MEEDHOO STP (CARPORT)

REFERENCE DRAWINGS

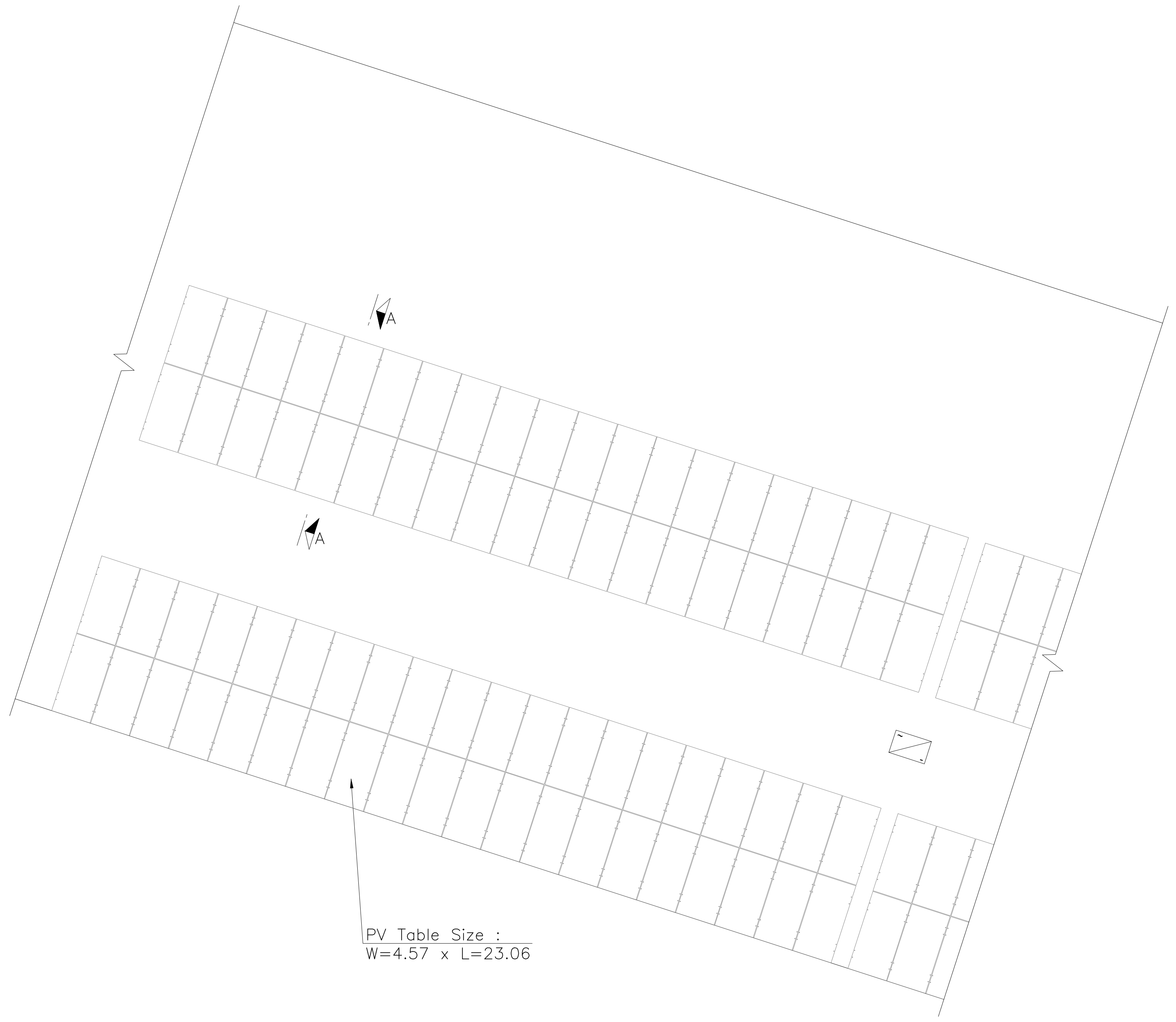
DESCRIPTION	DWG. NO.
PV LAYOUT FOR FUVAHMULAH AIRPORT	–



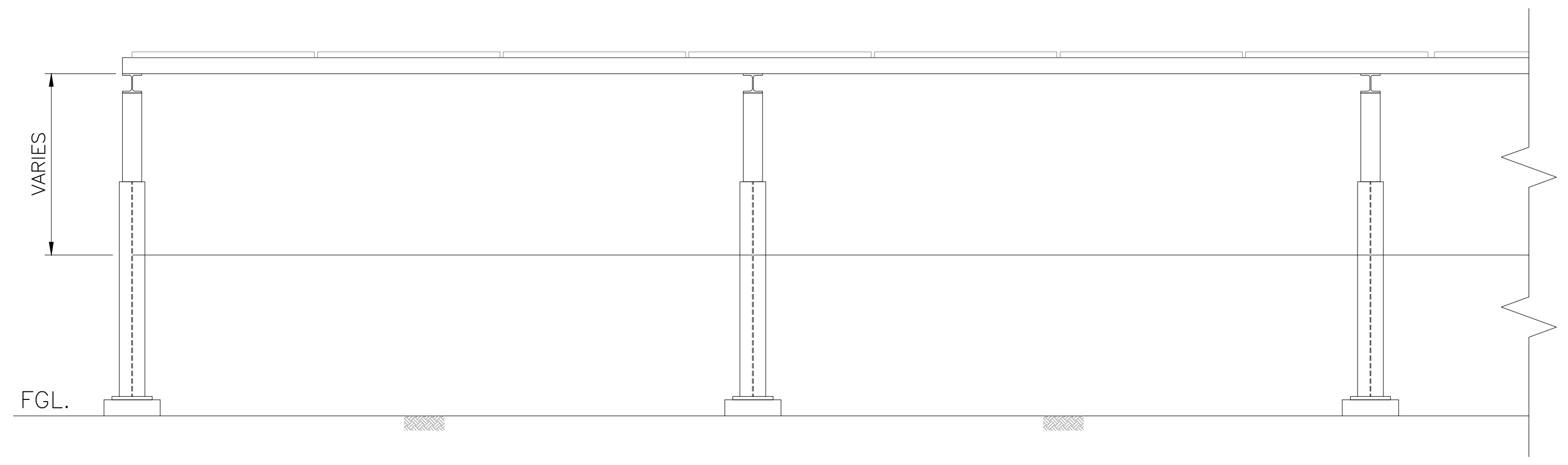
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-2
FOR PV TABLE SIZE 4570x23060



SECTION A–A
SHORTER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME



LONGER SIDE ELEVATION

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

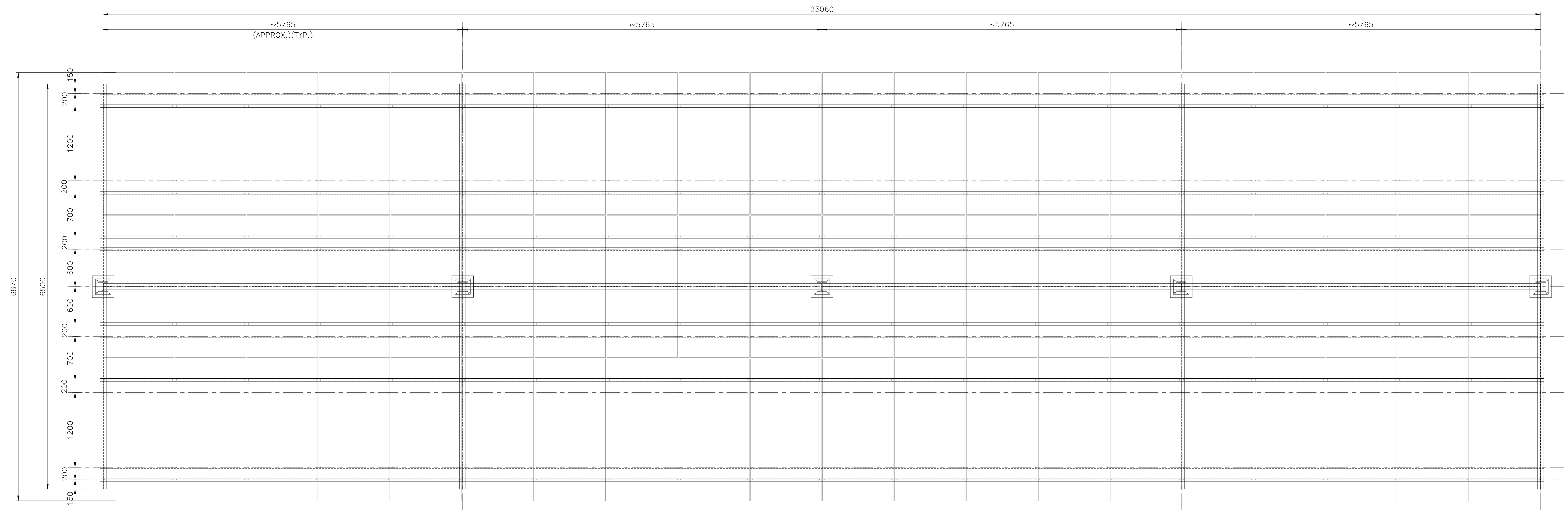
PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

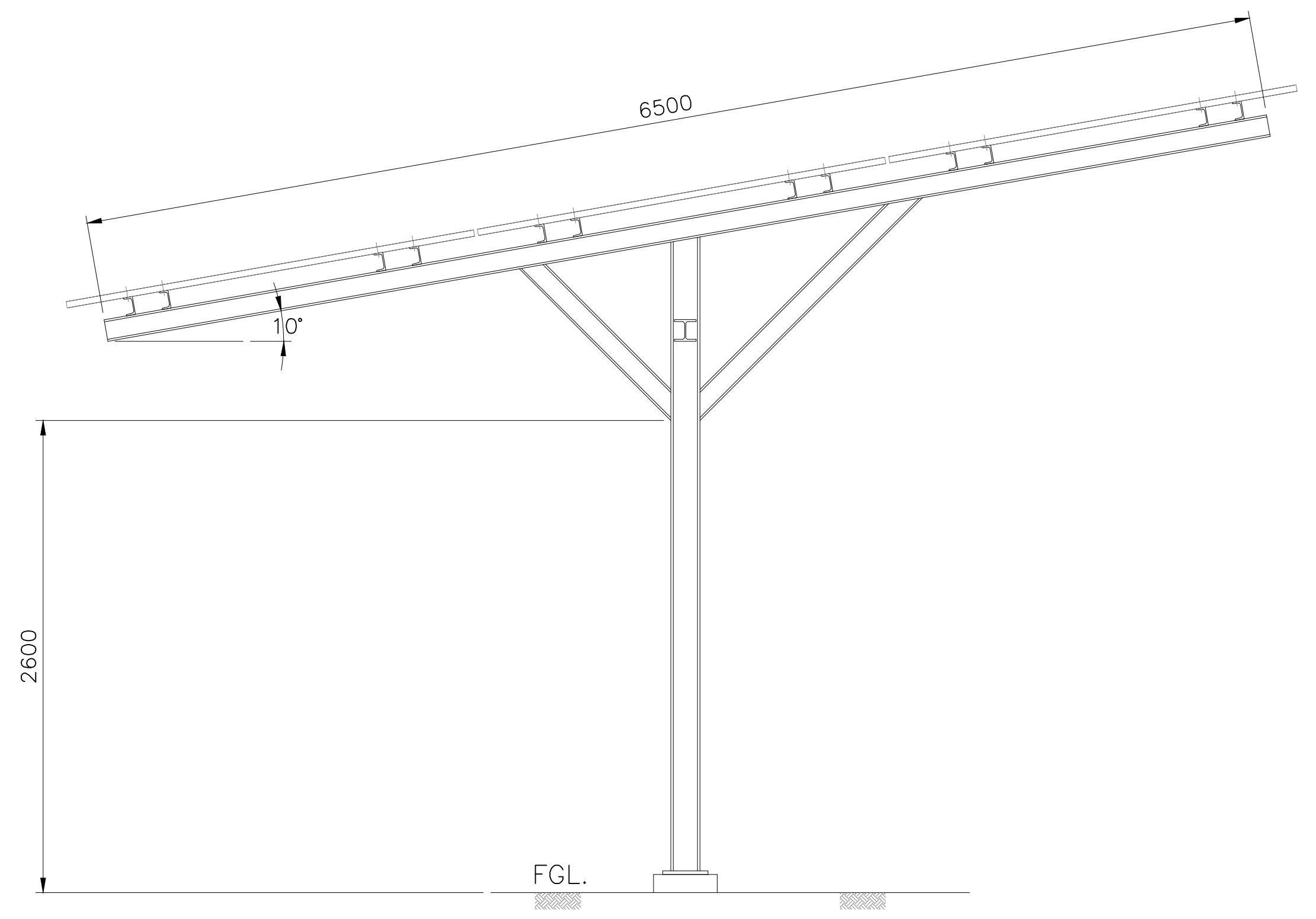
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

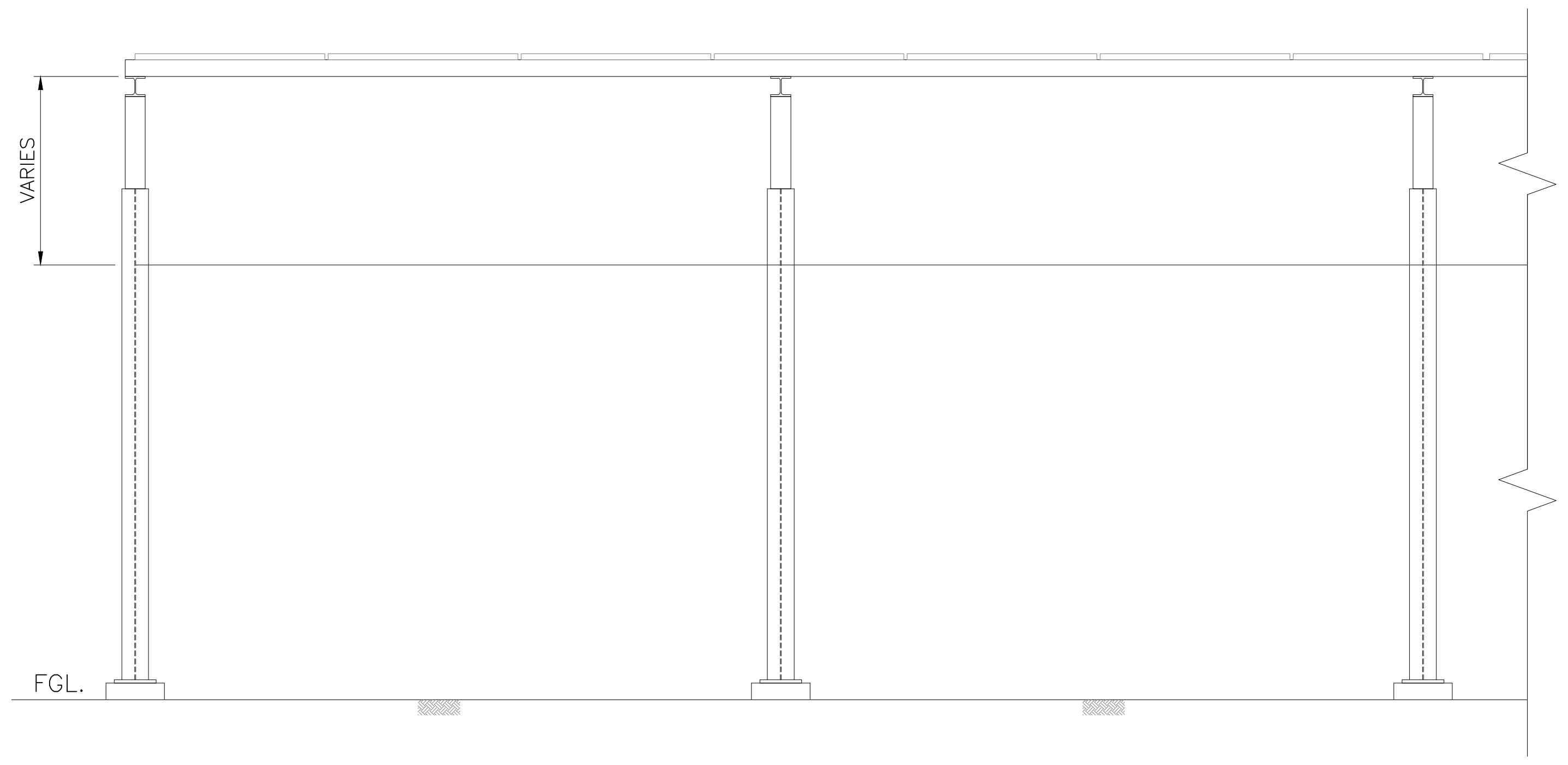
SECTION: CIVIL	PAGE:	CONCEPTUAL PV STRUCTURE DRAWING FOR FUVAHMULAH AIRPORT (GROUND MOUNTED)
SCALE: AS SHOWN	1/1	



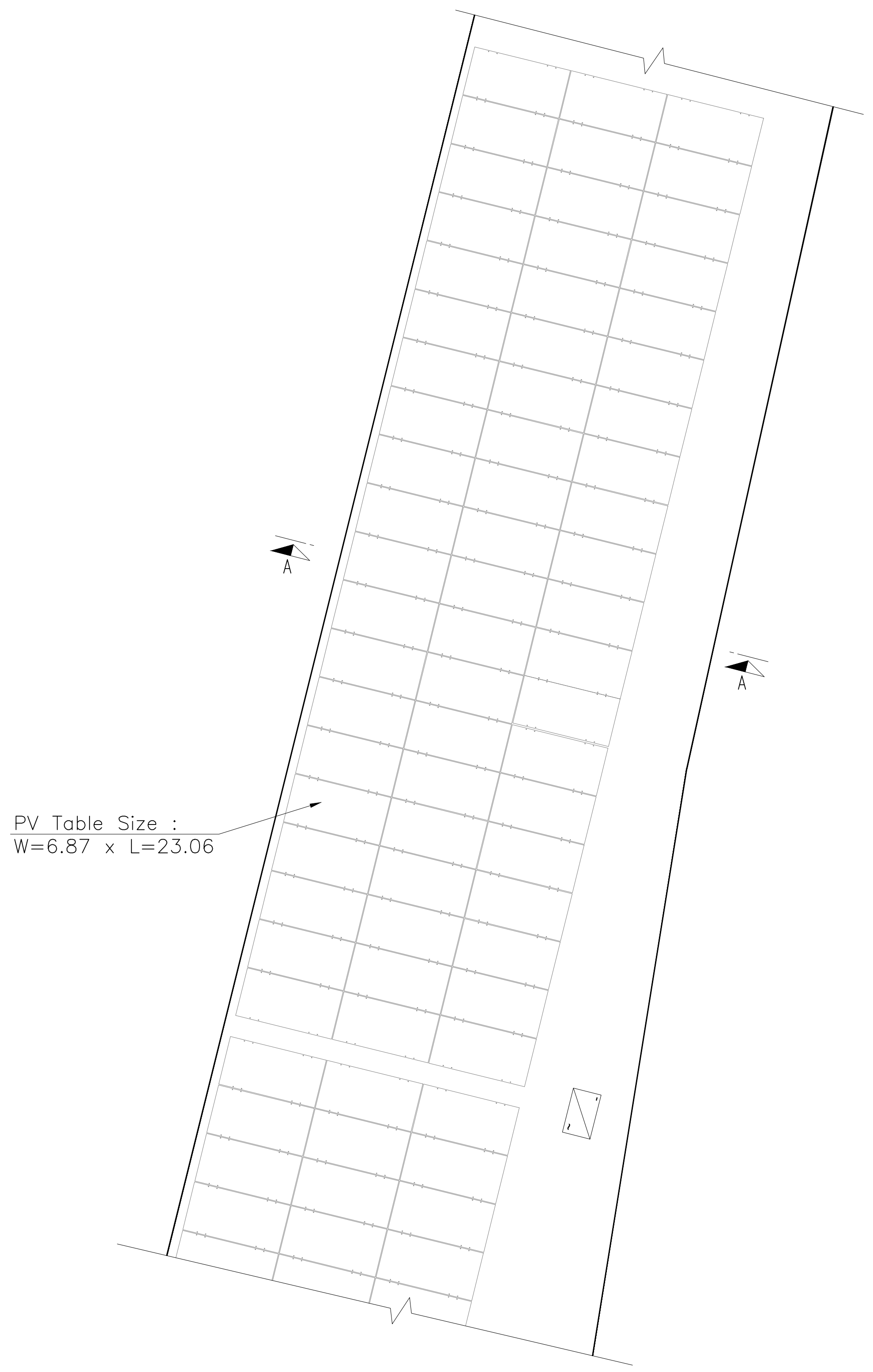
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE–1
FOR PV TABLE SIZE 6870x23060



SECTION A–A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT

NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR THINADHOO WEST BEACH	–

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

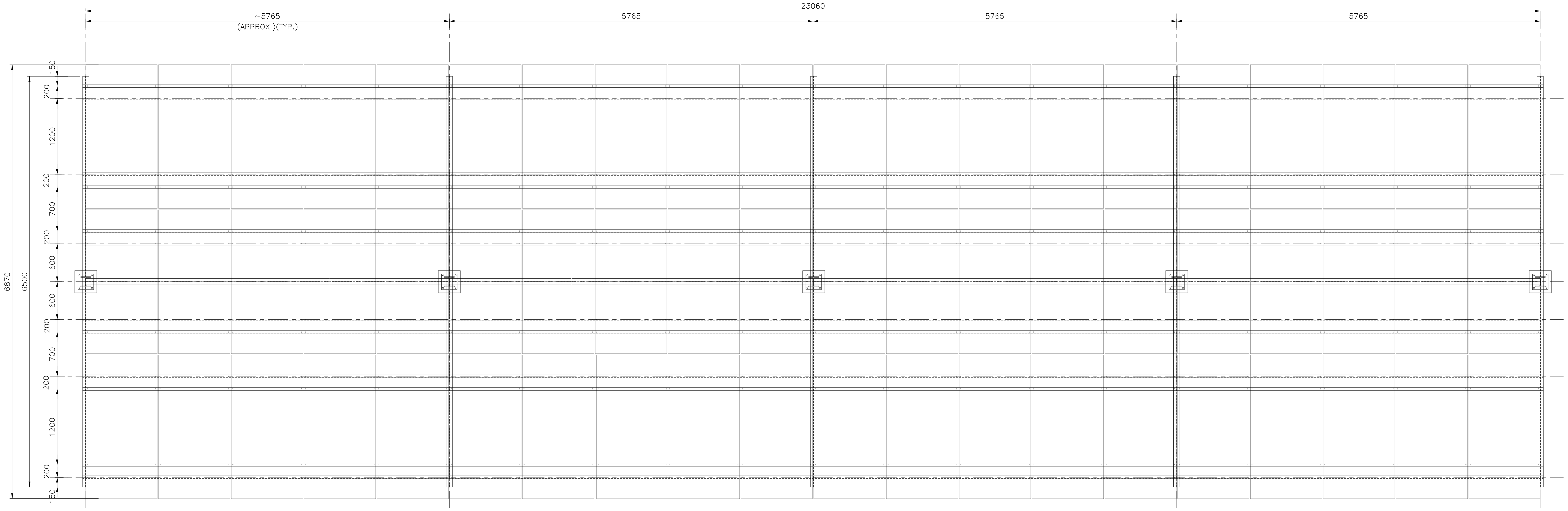
PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

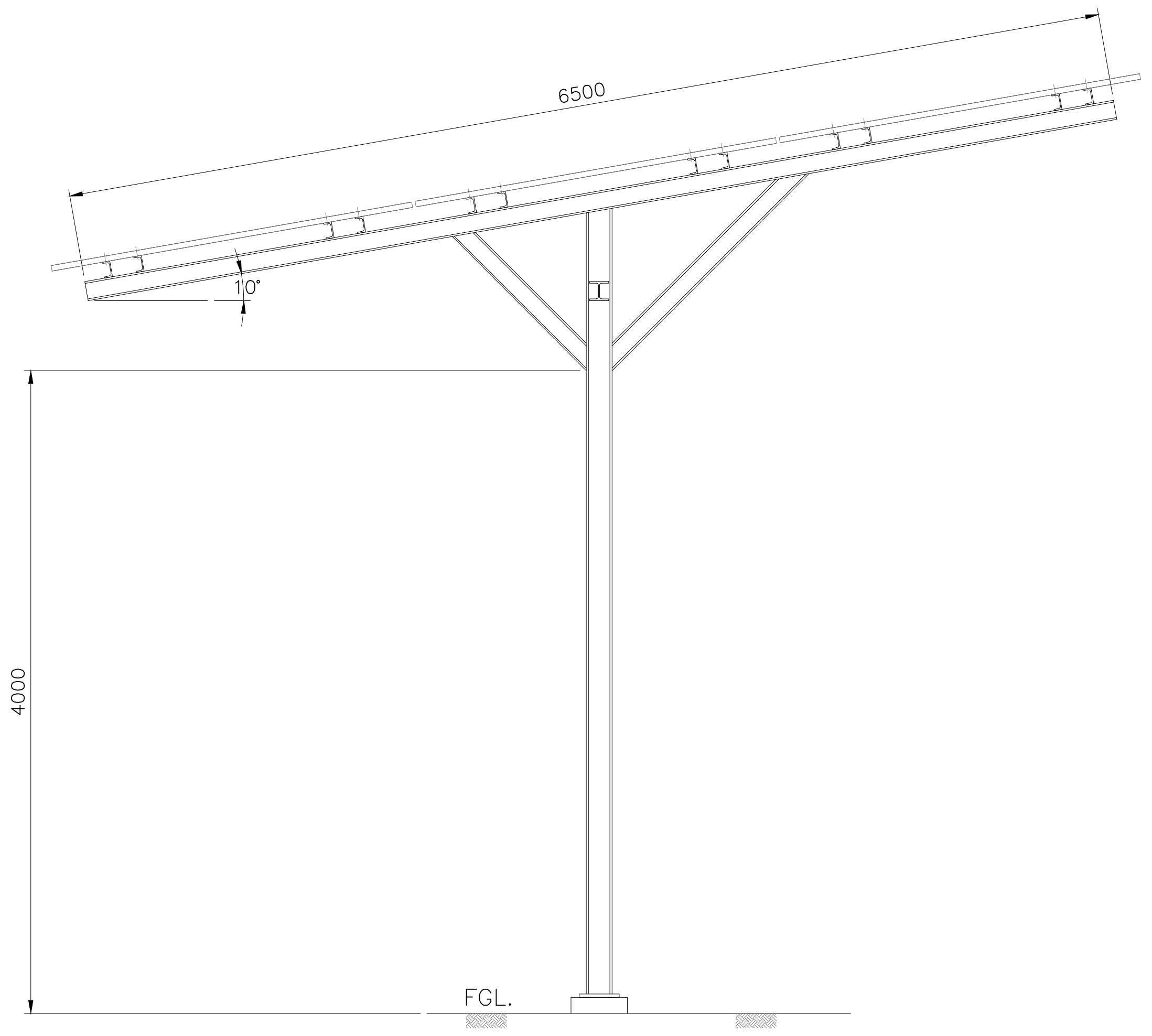
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

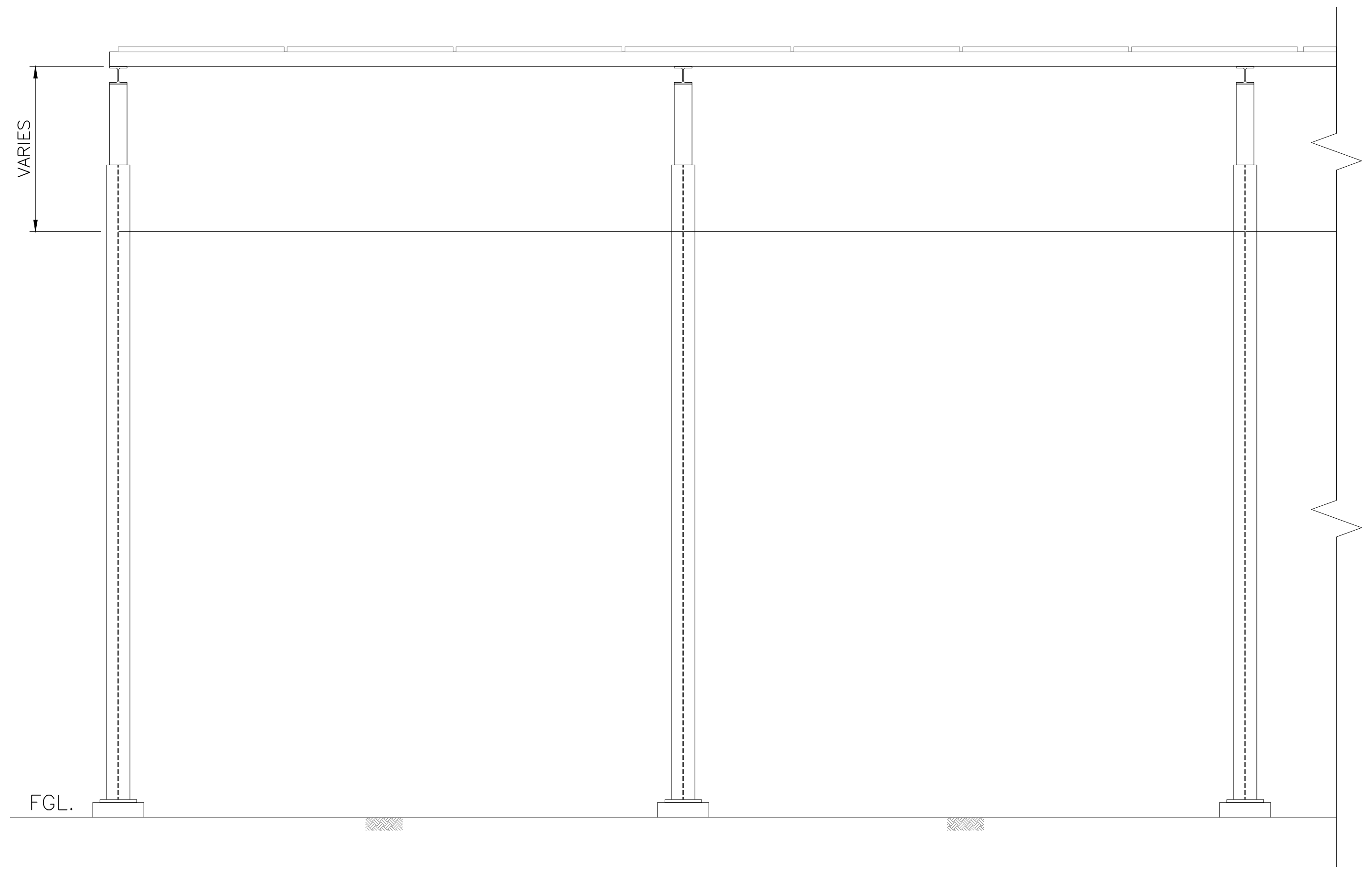
SECTION: CIVIL SCALE: AS SHOWN	PAGE: 1/1	CONCEPTUAL PV STRUCTURE DRAWING FOR THINADHOO WEST BEACH (WALKWAY)



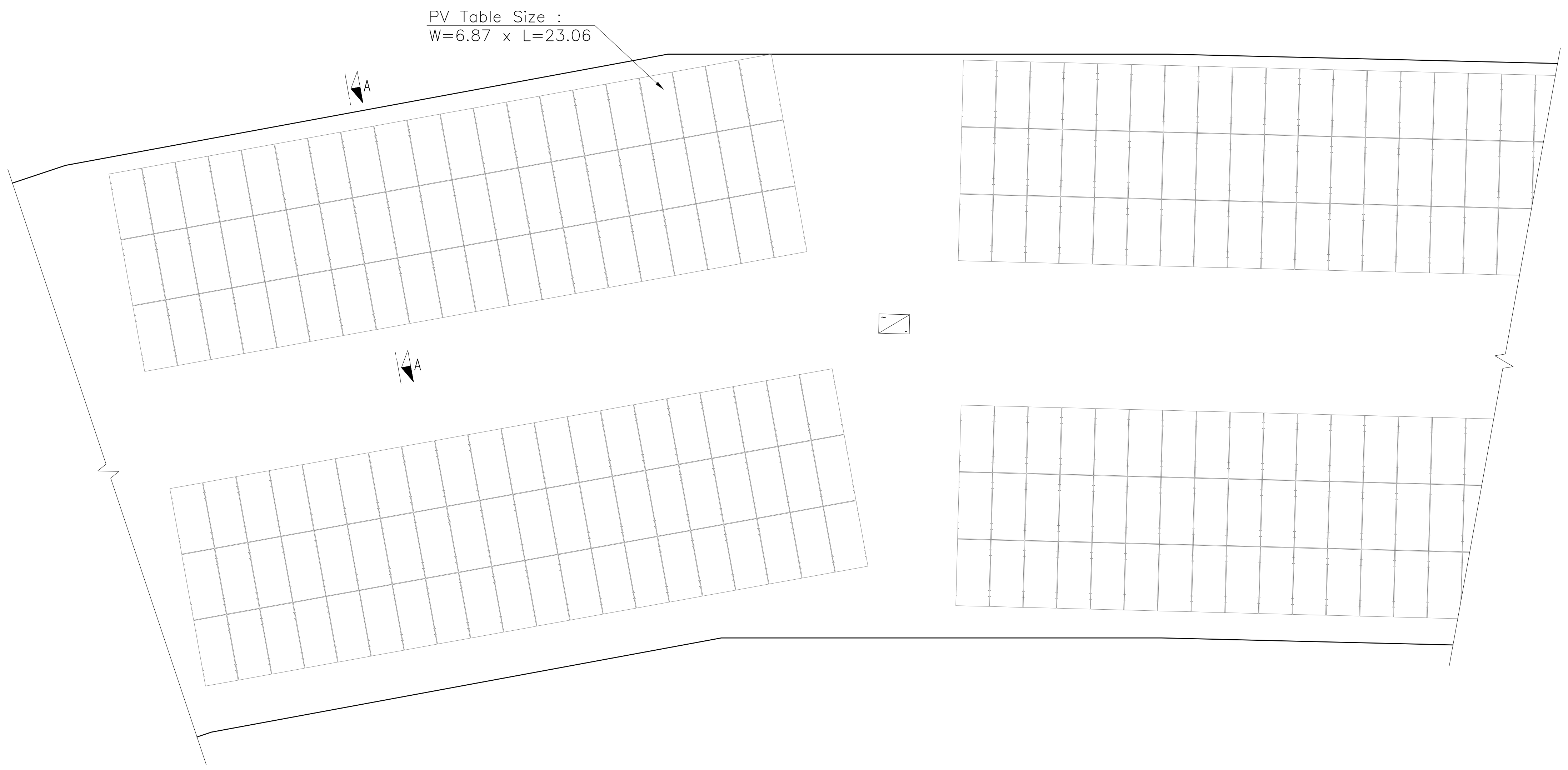
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1
FOR PV TABLE SIZE 6870x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR HINNAVARU PUBLIC BEACH	–

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

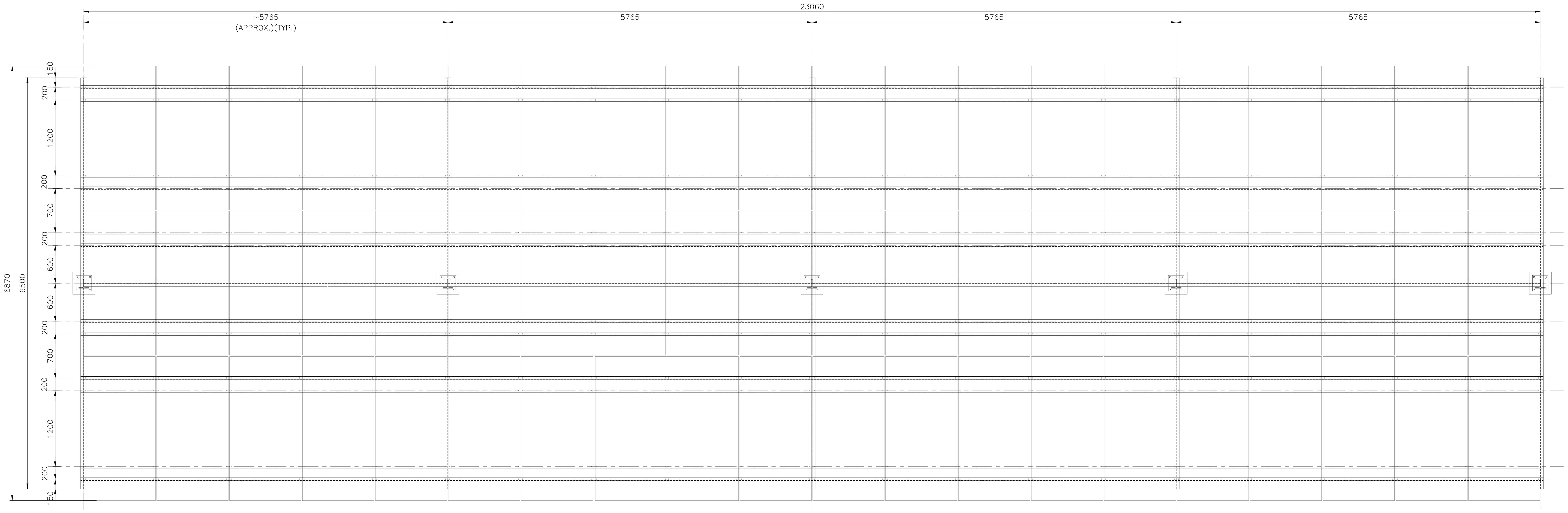
PROJECT:
ASPIRE
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MFPI
Mega First Power Industries Sdn Bhd
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

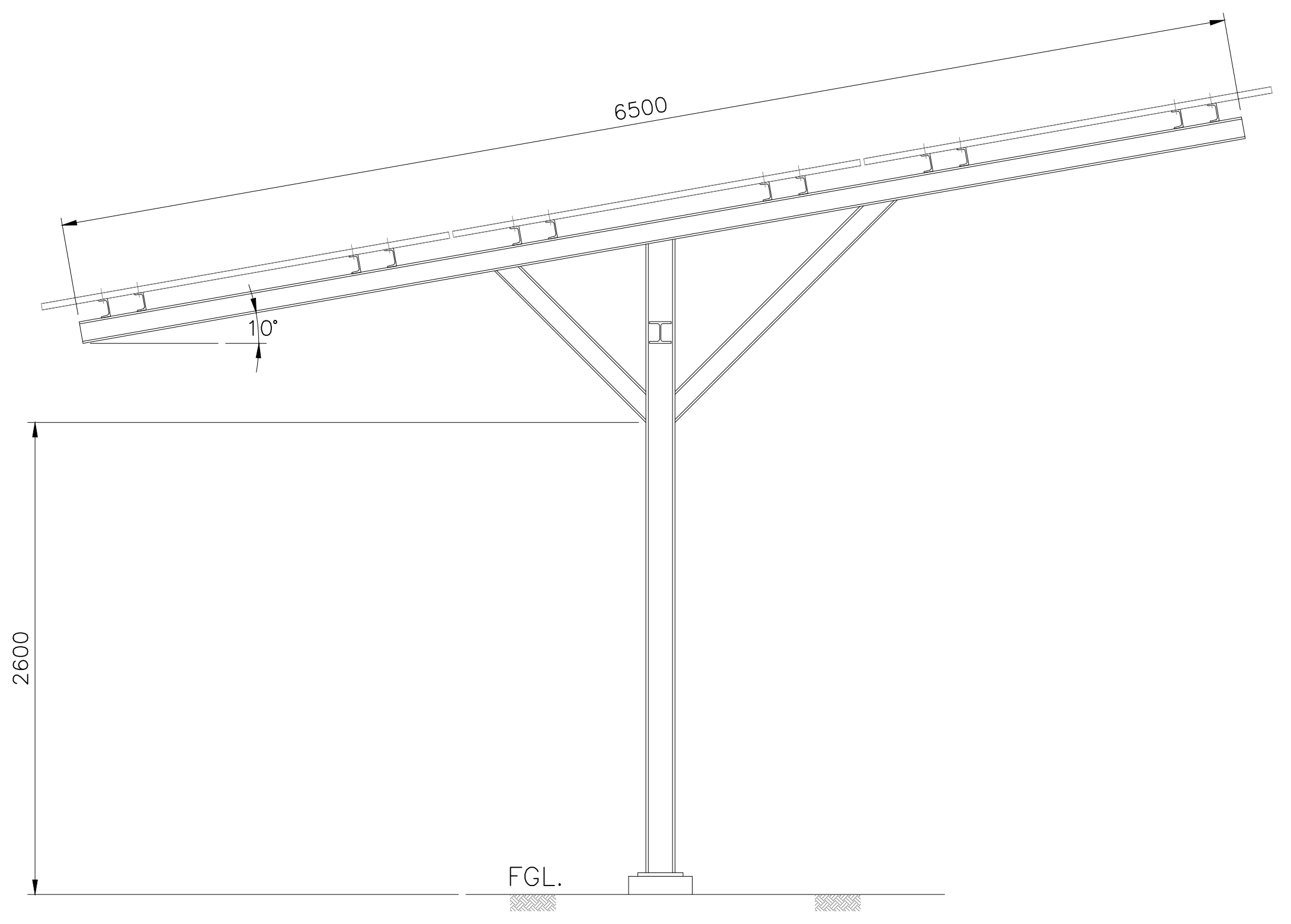
OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
中国水电建设集团国际工程有限公司
SINOHYDRO CORPORATION LIMITED
SINOHYDRO CORPORATION LIMITED.

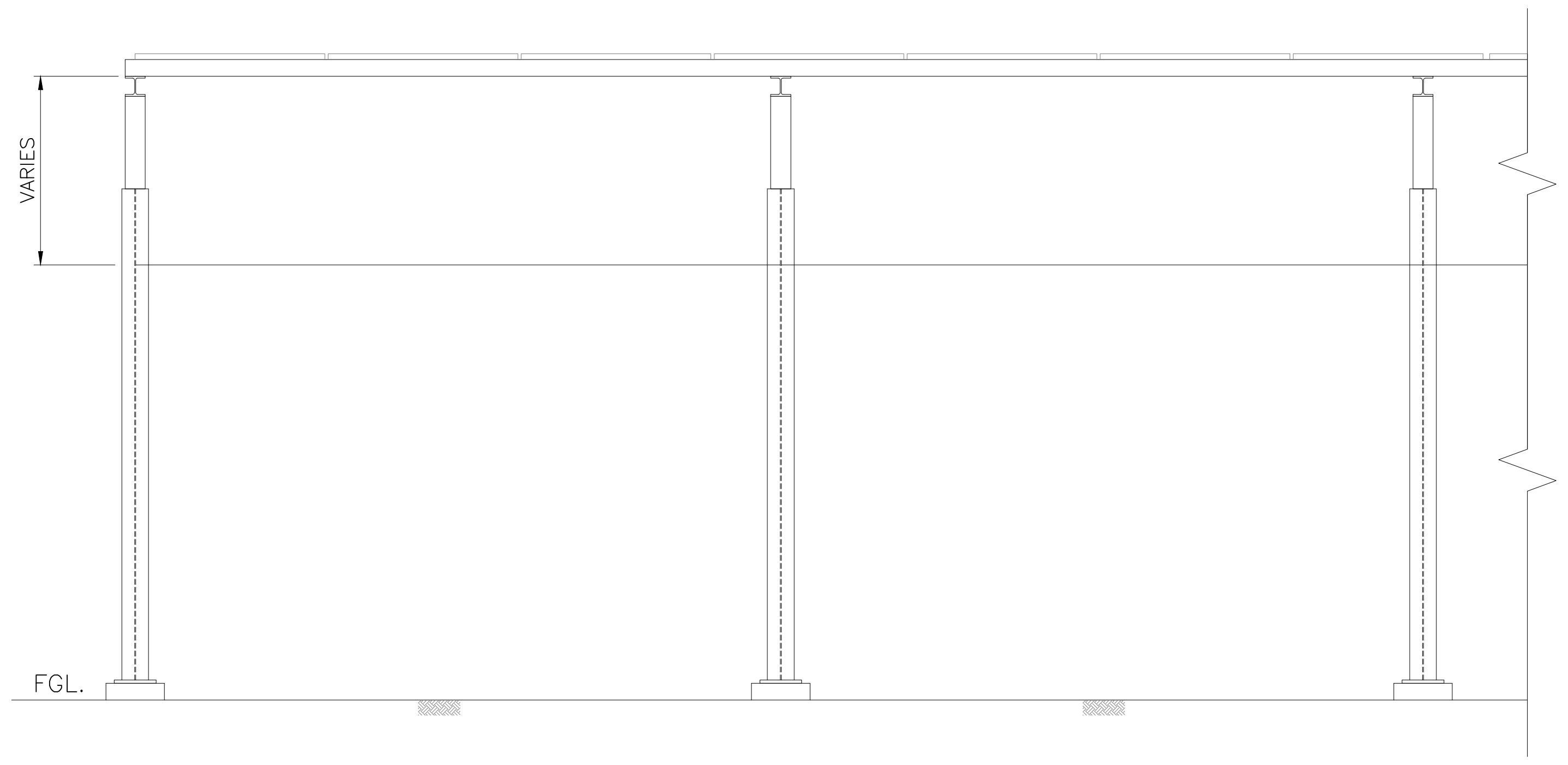
SECTION: CIVIL	PAGE:	CONCEPTUAL PV STRUCTURE DRAWING FOR HINNAVARU PUBLIC BEACH (CARPORT)
SCALE: AS SHOWN	1/1	



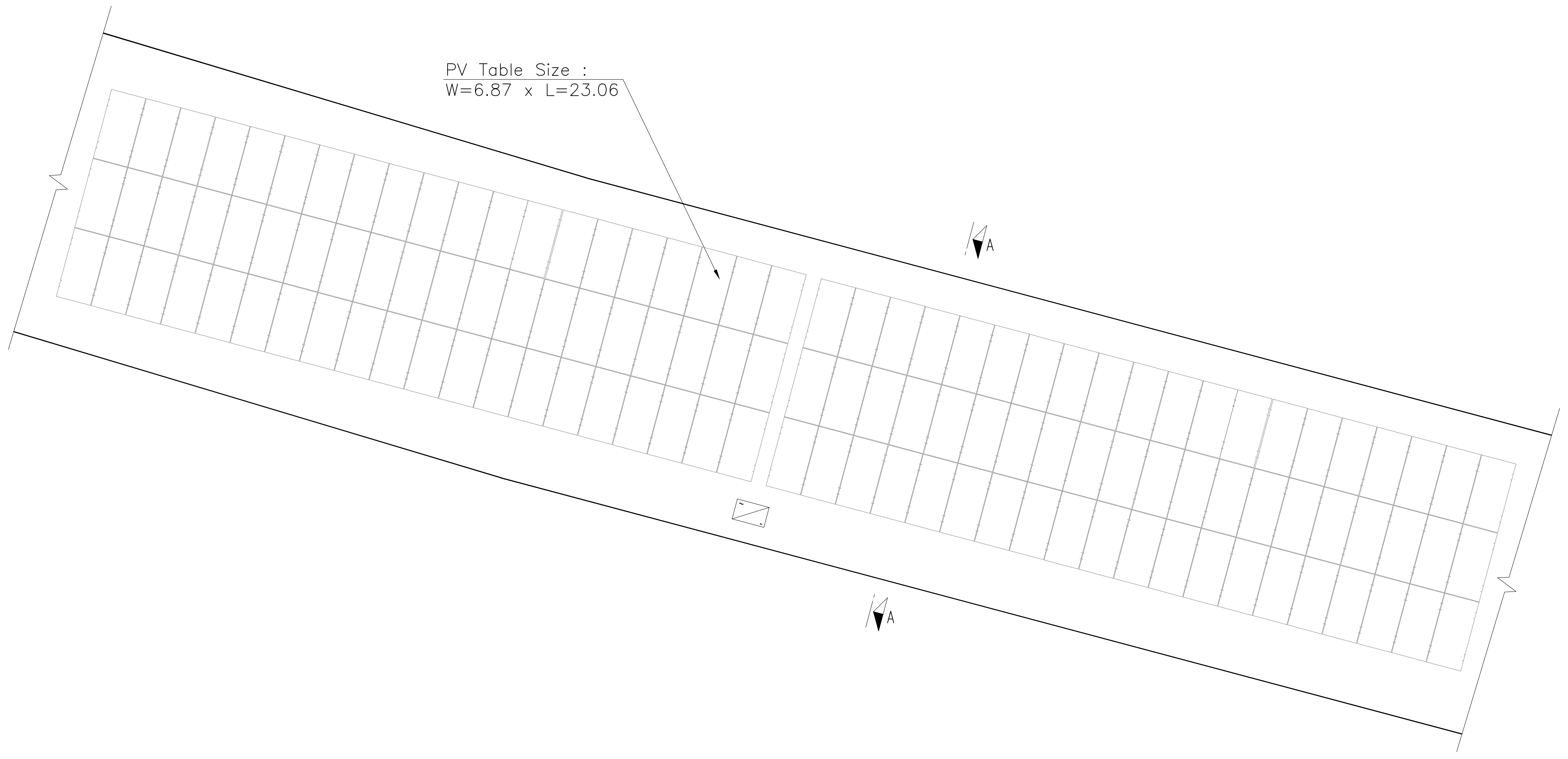
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1
FOR PV TABLE SIZE 6870x23060



SECTION A-A
SHORTER SIDE ELEVATION



LONGER SIDE ELEVATION



PV PART LAYOUT

NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR EYDHAFUSHI RING ROAD	-

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:

ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:

MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

OWNER'S ENGINEER:

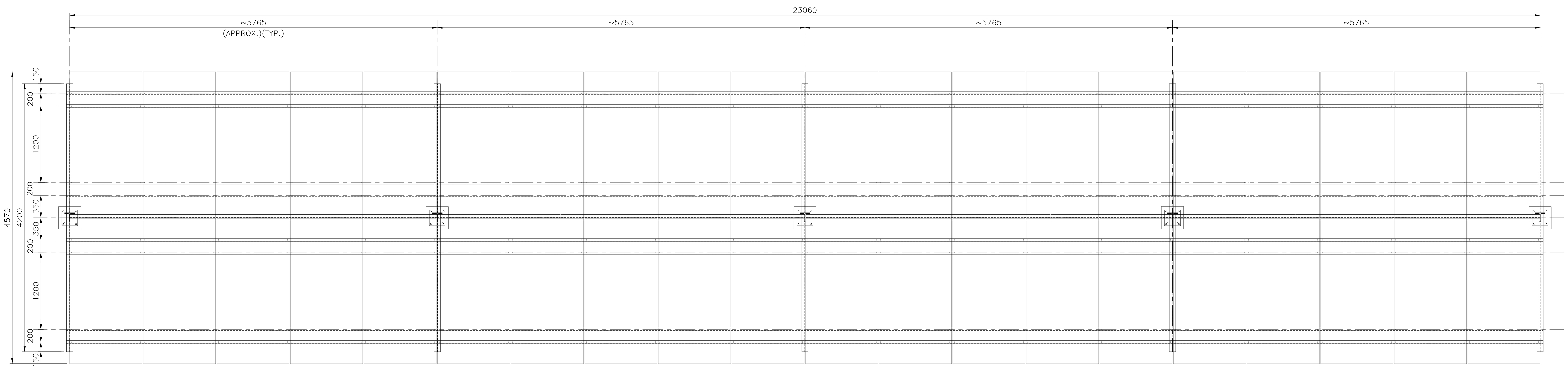
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:

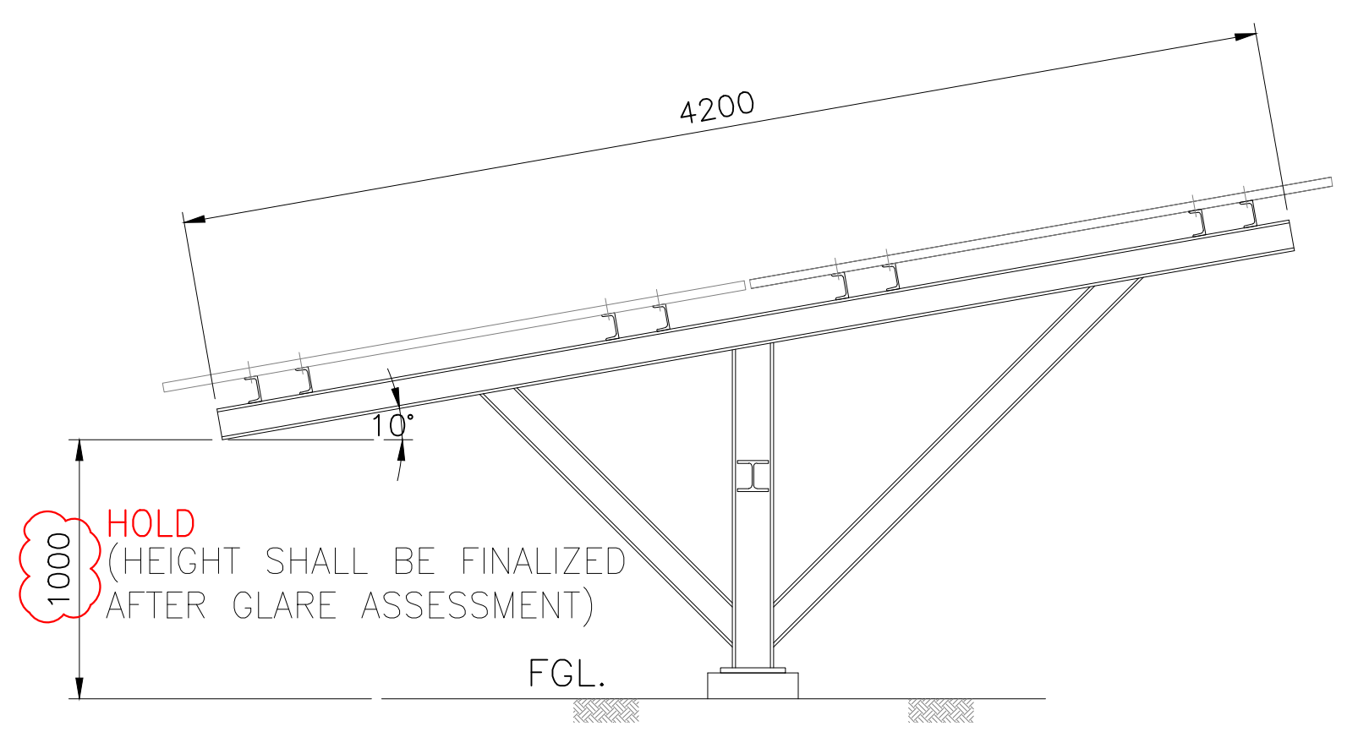
SINOHYDRO CORPORATION LIMITED.

SECTION: CIVIL	PAGE:	CONCEPTUAL PV STRUCTURE DRAWING FOR EYDHAFUSHI RING ROAD (WALKWAY)
SCALE: AS SHOWN	1/1	

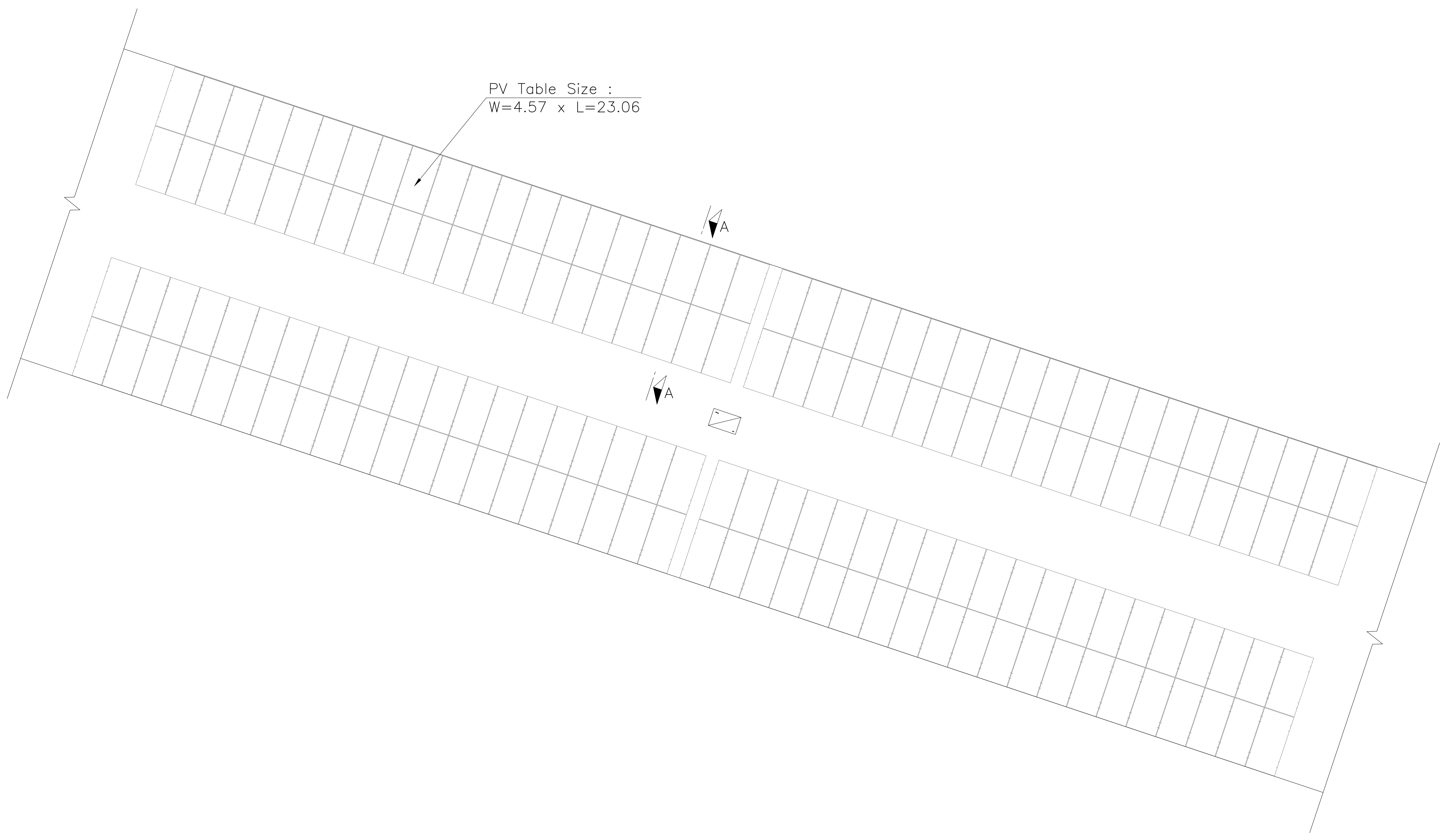
REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR KULHUDHUFFUSHI AIRPORT	–

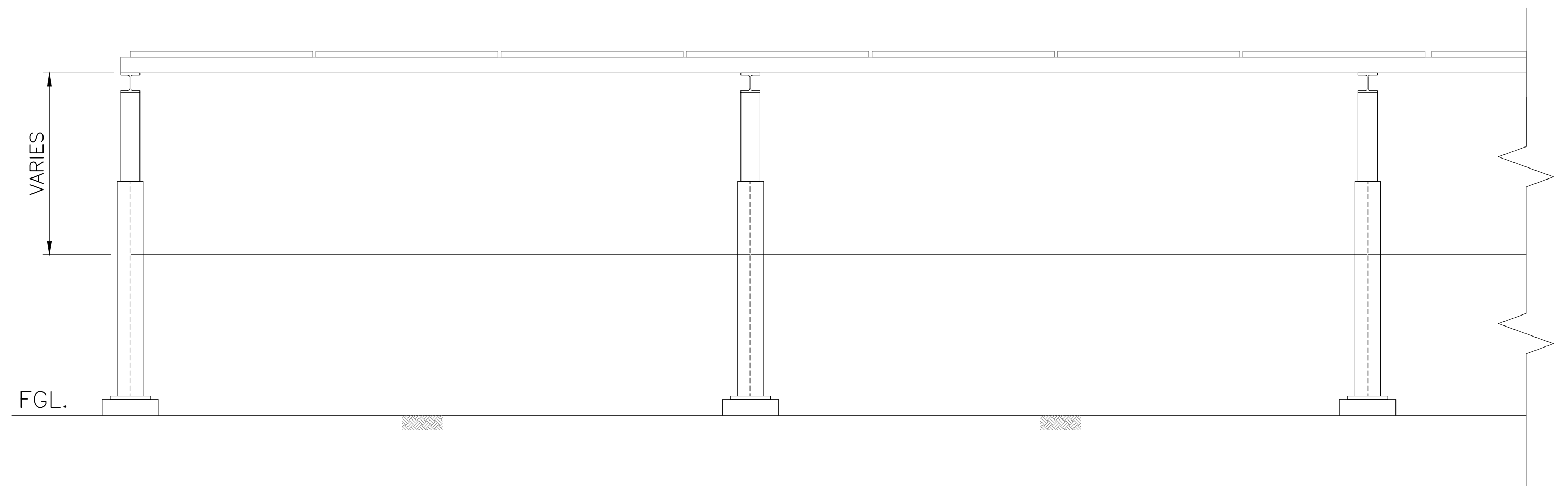


TYPICAL PLAN OF PV TABLE STRUCTURE TYPE–2
FOR PV TABLE SIZE 4570x23060



SECTION A–A
SHORTER SIDE ELEVATION





LONGER SIDE ELEVATION

PV PART LAYOUT

NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:
ASPIRE
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

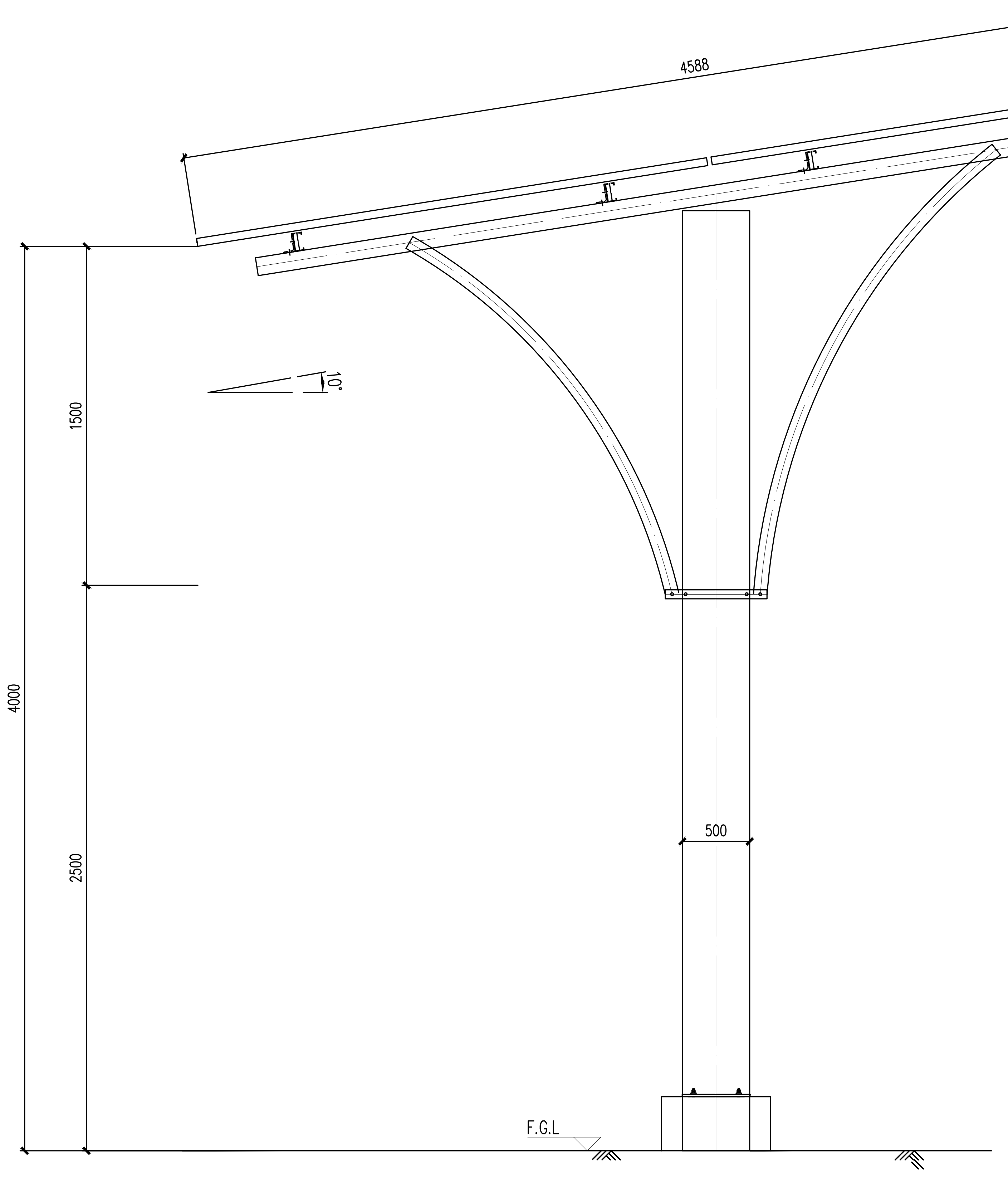
OWNER:
MFPI
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

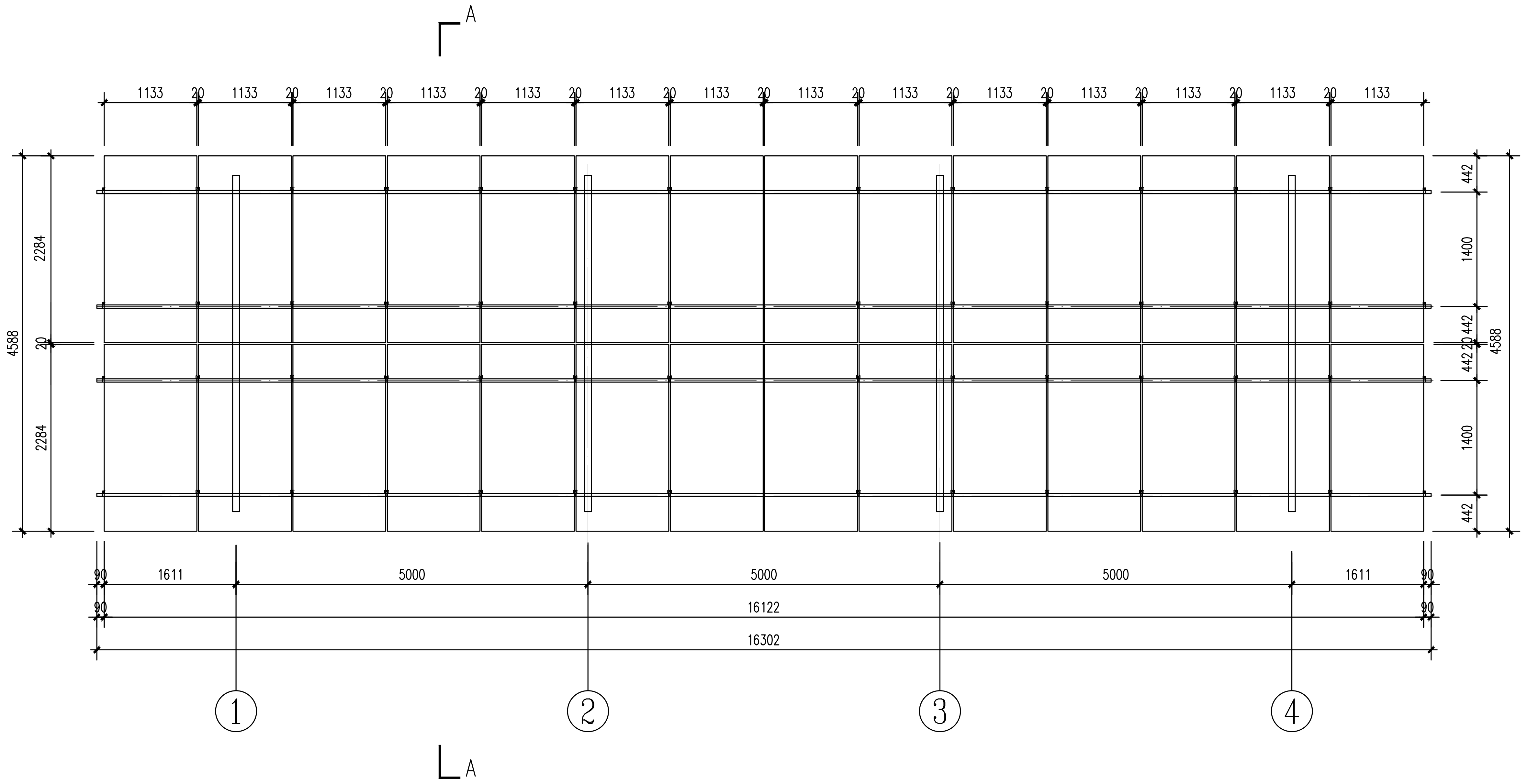
CONTRACTOR:
中国水电建设集团国际工程有限公司
SINOHYDRO CORPORATION LIMITED
SINOHYDRO CORPORATION LIMITED.

SECTION: CIVIL
SCALE: AS SHOWN
PAGE: 1/1
CONCEPTUAL PV STRUCTURE DRAWING FOR KULHUDHUFFUSHI AIRPORT(GROUND MOUNTED)

会签专业	会签者	日期	会签专业	会签者	日期



SECTION A-A 1:20



TYPICAL PLAN OF PV TABLE STRUCTURE TYPE-1FOR PV TABLE SIZE 1:50

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

SIZE OF ALL STRUCTURAL MEMBERS SHALL BEE FINALIZED DURING DETAILED DESIGN.

核 准			中国电建 POWERCHINA	华东勘测设计研究院有限公司 HUADONG ENGINEERING CORPORATION LIMITED			
核 定							
审 查			专 业		工程设计资质证书编号: 综合甲级 A133000751	未盖出图专用章本图无效	
校 核			阶 段		工程	子项	
设 计			项目负责			图号	
制 图			专业负责			日期	

0 20 40 60 80 100mm

APPENDIX D – Water Quality Results

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500195131

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **28/02/2023**
Test Requisition Form No: **900196929**
Sample(s) Recieved Date: **26/02/2023**
Date of Analysis: **26/02/2023 - 27/02/2023**

Sample Description ~	Feydhoo (Control)	Maradhoo Feydhoo (Control)	Red Tin Addu	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83236749	83236750	83236751		
Sampled Date ~	09/02/2023 04:00	09/02/2023 04:00	09/02/2023 04:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Pale yellow with particles	Pale yellow with particles	Clear with particles		
Conductivity *	777	705	895	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.1	7.6	7.7	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Temperature	24.7	24.5	24.8	Electrometry	°C
Total Dissolved Solids	389	352	448	Electrometry	mg/L
Total Petroleum Hydrocarbon (TPH)	<0.036 (LoQ 0.036 mg/L)	<0.036 (LoQ 0.036 mg/L)	<0.036 (LoQ 0.036 mg/L)	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by

Nashath

Nashath Ali
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

ilac-MRA eiac مركز الإمارات العالمي للاعتماد Emirates International Accreditation Centre MWSC
LB-TEST-090

WATER QUALITY TEST REPORT
Report No: 500195131

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **28/02/2023**
Test Requisition Form No: **900196929**
Sample(s) Recieved Date: **26/02/2023**
Date of Analysis: **26/02/2023 - 27/02/2023**

Sample Description ~	Hulhumeedhoo (contro)	Feydhoo Harbour Addu	Maradhoo Feydhoo Site	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83236752	83236753	83236754		
Sampled Date ~	09/02/2023 04:00	09/02/2023 04:00	09/02/2023 04:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Pale yellow with particles	Pale yellow with particles		
Conductivity *	442	735	918	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.8	7.7	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Temperature	24.5	24.3	24.7	Electrometry	°C
Total Dissolved Solids	221	367	459	Electrometry	mg/L
Total Petroleum Hydrocarbon (TPH)	<0.036 (LoQ 0.036 mg/L)	<0.036 (LoQ 0.036 mg/L)	<0.036 (LoQ 0.036 mg/L)	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by
Nashath
Nashath Ali
Laboratory Executive

Approved by
Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500192964

Customer Information:
Mauman Abdul Rasheed (A255017)
Sakkeyoge, B. Eydhafushi

B.Eydhafushi B.EYDHAFUS

Report date: **29/09/2022**
Test Requisition Form No: **900195499**
Sample(s) Recieved Date: **25/09/2022**
Date of Analysis: **25/09/2022 - 25/09/2022**

Sample Description ~	S. Hithadhoo (Stadium)	S. Hithadhoo (Harbour)	S. Hulhumeedhoo	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83232381	83232382	83232383		
Sampled Date ~	17/09/2022 10:00	17/09/2022 11:00	17/09/2022 04:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
Conductivity *	749	1685	948	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.3	7.2	7.3	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	0.37	0.85	0.47	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	23.9	24.1	24.1	Electrometry	°C
Total Dissolved Solids	375	843	474	Electrometry	mg/L
Turbidity *	0.251	0.224	0.229	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

مـركـز الإمـارات الـعـالـمـي للاعـتـمـاد
Emirates International Accreditation Centre
LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500192964

Customer Information:
Mauman Abdul Rasheed (A255017)
Sakkeyoge, B. Eydhafushi

B.Eydhafushi B.EYDHAFUS

Report date: **29/09/2022**
Test Requisition Form No: **900195499**
Sample(s) Recieved Date: **25/09/2022**
Date of Analysis: **25/09/2022 - 25/09/2022**

Sample Description ~	S. Feydhoo	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83232384		
Sampled Date ~	17/09/2022 01:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	924	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.3	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	0.45	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.0	Electrometry	°C
Total Dissolved Solids	462	Electrometry	mg/L
Turbidity *	0.310	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************** END OF REPORT **************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194072

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **18/12/2022**
Test Requisition Form No: **900196194**
Sample(s) Recieved Date: **14/12/2022**
Date of Analysis: **14/12/2022 - 15/12/2022**

Sample Description ~	Eydhafushi	Eydhafushi Control	Lh.Hinnavaru GW Control	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83234512	83234513	83234514		
Sampled Date ~	03/12/2022 04:00	03/12/2022 04:00	02/12/2022 04:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear	Clear	Clear with particles		
Conductivity *	640	710	1044	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.6	7.6	7.6	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	0.31	0.35	0.52	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.1	23.8	23.8	Electrometry	°C
Total Dissolved Solids	320	355	522	Electrometry	mg/L
Turbidity *	0.129	0.106	0.122	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Total Petroleum Hydrocarbon (TPH)	0.039	0.170	0.410	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194072

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **18/12/2022**
Test Requisition Form No: **900196194**
Sample(s) Recieved Date: **14/12/2022**
Date of Analysis: **14/12/2022 - 15/12/2022**

Sample Description ~	Lh.Hinnavaru Project location GW	~~N.Magoodhoo Ground Water Location 1 (G)~~	~~N.Magoodhoo Control Ground water~~	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	~~Ground Water~~	~~Ground Water~~		
Sample No	83234515	~~83234517~~	~~83234519~~		
Sampled Date ~	02/12/2022 04:00	~~02/12/2022 08:45~~	~~02/12/2022 08:45~~		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear	~~Clear~~	~~Clear with particles~~		
Conductivity *	2460	~~1064~~	~~1336~~	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.3	~~7.5~~	~~7.3~~	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	1.27	~~0.53~~	~~0.67~~	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	23.8	~~23.8~~	~~23.7~~	Electrometry	°C
Total Dissolved Solids	1231	~~532~~	~~668~~	Electrometry	mg/L
Turbidity *	0.209	~~0.111~~	~~0.145~~	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Total Petroleum Hydrocarbon (TPH)	0.117	~~0.100~~	~~<0.036 (LoQ 0.036 mg/L)~~	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194507

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **11/01/2023**
Test Requisition Form No: **900196476**
Sample(s) Recieved Date: **08/01/2023**
Date of Analysis: **08/01/2023 - 09/01/2023**

Sample Description ~	Klhudhuffushi Kulhi	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235422		
Sampled Date ~	06/01/2023 07:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	11830	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	8.6	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	6.74	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.8	Electrometry	°C
Total Dissolved Solids	5910	Electrometry	mg/L
Turbidity *	1.37	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Total Petroleum Hydrocarbon (TPH)	0.24	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

مـركـز الإمـارات الـعـالـمـي للاعـتـمـاد
Emirates International Accreditation Centre
LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194509

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **11/01/2023**
Test Requisition Form No: **900196476**
Sample(s) Recieved Date: **08/01/2023**
Date of Analysis: **08/01/2023 - 09/01/2023**

Sample Description ~	Kulhudhuffushi Airport	Control - Kulhudhuffushi	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water		
Sample No	83235423	83235424		
Sampled Date ~	06/01/2023 07:30	06/01/2023 08:00		
PARAMETER	**ANALYSIS RESULT**			
Physical Appearance	Clear with particles	Clear with particles		
Conductivity *	2040	956	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	9.1	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	1.04	0.47	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.6	24.3	Electrometry	°C
Total Dissolved Solids	1021	478	Electrometry	mg/L
Total Petroleum Hydrocarbon (TPH)	0.46	0.48	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194504

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **11/01/2023**
Test Requisition Form No: **900196496**
Sample(s) Recieved Date: **10/01/2023**
Date of Analysis: **10/01/2023 - 10/01/2023**

Sample Description ~	Thinadhoo site 1	Thinadhoo site 2	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water		
Sample No	83235466	83235467		
Sampled Date ~	09/01/2023 10:00	09/01/2023 10:00		
PARAMETER	**ANALYSIS RESULT**			
Physical Appearance	Clear with particles	Clear with particles		
Conductivity *	784	351	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.4	8.1	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	0.38	0.17	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.0	24.0	Electrometry	°C
Total Dissolved Solids	392	175.7	Electrometry	mg/L
Turbidity *	<0.1 (LoQ 0.1 NTU)	0.289	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194569

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **17/01/2023**
Test Requisition Form No: **900196533**
Sample(s) Recieved Date: **15/01/2023**
Date of Analysis: **15/01/2023 - 16/01/2023**

Sample Description ~	~~Fuvahmulah FLAT~~	Fuvahmulah House	~~Fuvahmulah Kulhi~~	**TEST METHOD**	**UNIT**
Sample Type ~	~~Ground Water~~	Ground Water	~~Ground Water~~		
Sample No	~~83235555~~	83235556	~~83235557~~		
Sampled Date ~	~~13/01/2023 11:00~~	13/01/2023 11:00	~~13/01/2023 11:00~~		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	~~Clear with particles~~	Clear with particles	~~Clear with particles~~		
Conductivity *	~~557~~	676	~~260~~	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	~~7.4~~	7.4	~~7.8~~	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	~~0.27~~	0.33	~~0.13~~	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	~~24.4~~	24.8	~~24.0~~	Electrometry	°C
Total Dissolved Solids	~~279~~	338	~~130~~	Electrometry	mg/L
Total Petroleum Hydrocarbon (TPH)	~~0.52~~	0.28	~~0.42~~	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194569

Customer Information:
Ismail Ajmal (A138645)
Ma.Fanaaru

Male K

Report date: **17/01/2023**
Test Requisition Form No: **900196533**
Sample(s) Recieved Date: **15/01/2023**
Date of Analysis: **15/01/2023 - 16/01/2023**

Sample Description ~	Fuvahmulah Airport	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235558		
Sampled Date ~	13/01/2023 11:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	332	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.0	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Salinity	0.16	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	‰
Temperature	24.1	Electrometry	°C
Total Dissolved Solids	166.2	Electrometry	mg/L
Total Petroleum Hydrocarbon (TPH)	0.41	UV Fluorescence	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************** END OF REPORT **************************

APPENDIX E – Glare Assessments

GLARE ASSESSMENT REPORT

FUVAHMULA AIRPORT

Prepared by	**Parvaneh**
Date of preparation	**02.05.2023**
Checked/Approved	**Babak Behbahani**
Doc No./Revision	**PEN023-2/0**

Table of Contents

EXECUTIVE SUMMARY

Mega First Power Industries Sdn Bhd plans to install a solar plant in the Fuvahmula airport in Maldives and engaged **Parvaneh** Energy to perform glare and glint analysis for the project.

Parvaneh utilises Forge Solar's GlareGauge analysis tool in order to carry out the analysis which corresponds to the United States (US) Federal Aviation Administration's (FAA) 2021 technical guidance.

The project includes an east-west runway, approach paths from west and east and a control tower. The assessment is performed for the observation points and examined all the possible occurrences.

The results of this study show that with the proposed arrangement of the solar arrays, glare from the project is not expected to impact the ATCT cab with reference to the FFA 2021 policy. Therefore, no mitigative action is needed for the project to address glare at the receptor locations.

INTRODUCTION

Aa part of ASPIRE 11.393MW Solar Power Complex, a total of 2 MW solar project is planned to be installed there Fuvahmula airport. In order to evaluate the potential hazard for the pilots and air-traffic control personnel a glare study is performed by the consultant.

PURPOSE OF THE STUDY

A comprehensive assessment is carried out in order to scrutinize any negative effect of the installation on the observation points which are caused by the panels' reflections. The study scrutinizes location and time of the glare occurrence and any possible potential impact.

Assessment is performed according to the technical requirement of U.S Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, 2021.

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step

PROJECT DESCRIPTION

SITE LOCATION

Fuvahmula airport is located in north of Fuvahmula island, Maldives with a runway of 1100 meters and 30 meters width. The aerodrome has two approach paths from the sides. Figure 1 depict the site location. Annex II and annex III present the aerodrome instrument approach chart and OLS chart respectively.

Figure 1 Fuvahmula Airport location

SITE LAYOUT

Solar panel installation is being carried out in four PV arrays both sides of the runway as demonstrated in Figure 2. PV arrays is being installed in two phases which are highlighted with the blue color for the current phase and green color for the future expansion.

Figure 2 Fuvahmula site general layout

INSTALLATION

Installation of the panels is being done according to the installation detail as provided in Annex IV. The elevation of the tables from the ground is 1 meter. Table installation will be type 2 and the title of the panels will be 10 degrees. Modules orientation/azimuth are defined in Table 1.

The tables are fixed-mounted and no tracking set up is available.

The utilised module type is JA solar 540 wp with antireflection coating.

Table 1 PV Arrays installation

	Installation tilt	Orientation
PV Array 1	10°	202°
PV Array 2	10°	201°
PV Array 22	10°	201°

RECEPTORS AND OBSTACLES

Based on the communication with client and the airport operator below receptor are identified as below:

Table 2 List of the Receptors

Receptor	Location	Observation Height	Type
Air Traffic Control Tower	-0.30868 73.43491	9.85 meters	Observation Point (OP)
Pilot cockpit	approach path from 111°		Flight Path receptor (FP)
Pilot cockpit	approach path from 291°		Flight Path receptor (FP)

According to the site layout, it can be observed that there is no obstacle between the panels and the observation points.

Note: At the moment, firefighting building is used as the control tower. However, the future control tower is used in the study based on the client instruction.

METHODOLOGY AND STUDY

OUTLOOK

This study is based on the solar glare and the regulatory policies of FAA., with the effective date of May 11, 2021.

Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration.

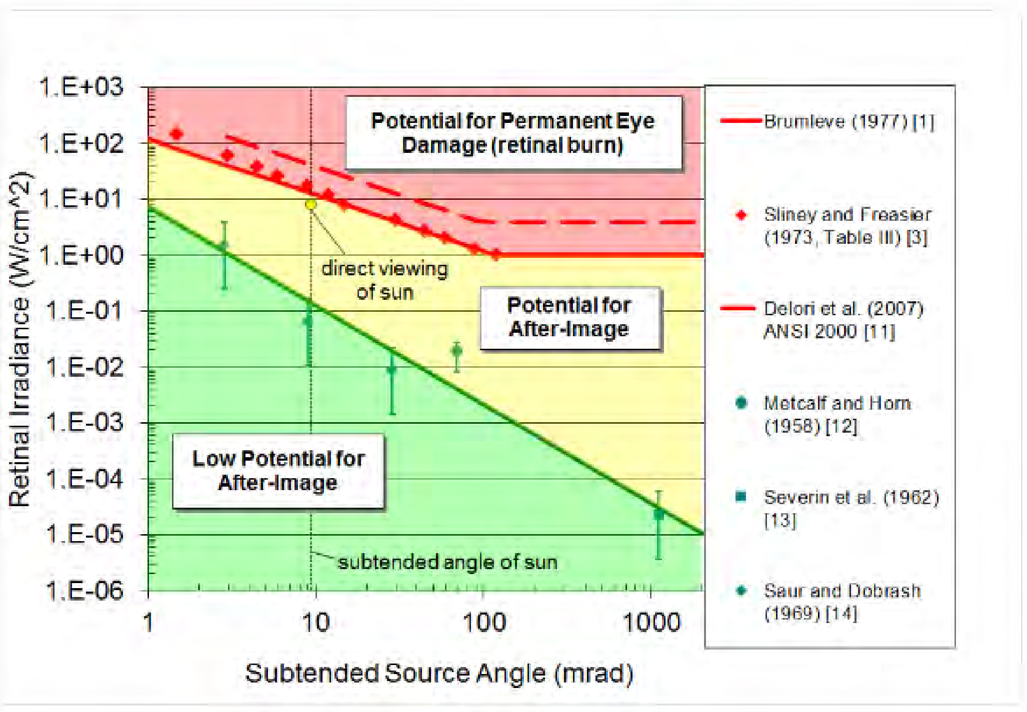


Figure 3 Glare hazard plot defines ocular impact as function of retinal irradiance and subtended source angle

The ocular impact of solar glare is quantified into three categories:

- Green - low potential to cause after-image (flash blindness)
- Yellow - potential to cause temporary after-image
- Red - potential to cause retinal burn (permanent eye damage)

These categories assume a typical blink response in the observer.

Note:

In this study the FAA policy 2021 is utilised. The important change from 2013 version is to evaluate the possible glare only on ATCT cab, therefore there is no more requirement to adjust the solar arrays to reduce the glares on the pilot cockpits while approaching the aerodrome.

The relevant section of the policy is reproduced here as reference; “Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab”

ASSUMPTIONS & LIMITATIONS

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

2. Result data files and plots are retained for two years after analysis completion. Files must be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the approximate total heights of the PV vertices. For increased accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the

height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.

8. The algorithm does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modelling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

RESULTS AND CONCLUSION

The results of the study determines that current installation will have no glare impact on the ACTC and is in compliance with the reference requirement. Details of the results with regards to the requirements of the FAA policy 2021 is provided as Annex I.

For information, Annex V is enclosed to provide complete overview of the site situation.

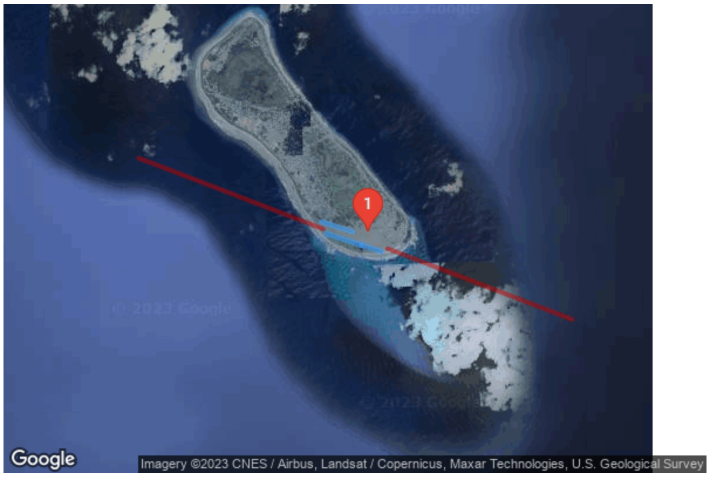
FORGESOLAR GLARE ANALYSIS

Project: **Fuvahmulah airport**
Site configuration: **Fuvahmullah-1**

Client: Mega First Power Industries Sdn Bhd

Created 17 Apr, 2023
Updated 02 May, 2023
Time-step 1 minute
Timezone offset UTC5
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Category 1 MW to 5 MW
Site ID 88463.15469

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Imagery ©2023 CNES / Airbus, Landsat / Copernicus, Maxar Technologies, U.S. Geological Survey

Summary of Results Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	202.0	7,220	120.3	7,401	123.3	1,910,000.0
PV array 2	10.0	201.0	2,503	41.7	657	10.9	2,868,000.0
PV array 22	10.0	201.0	3,672	61.2	459	7.7	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	8,185	136.4	7,876	131.3
FP 2	5,210	86.8	641	10.7
1-ATCT	0	0.0	0	0.0

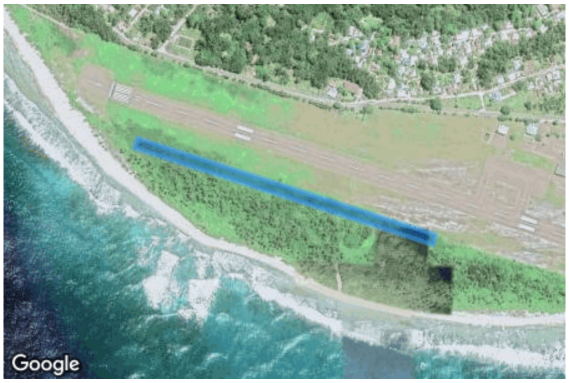
Component Data

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 202.0°
Rated power: 800.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.307078	73.427992	10.09	1.00	11.09
2	-0.307200	73.427950	10.33	1.00	11.33
3	-0.308690	73.432550	3.87	1.00	4.87
4	-0.308580	73.432600	3.38	1.00	4.38

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 201.0°
Rated power: 1200.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.308792	73.428664	7.06	1.00	8.06
2	-0.308964	73.428608	5.93	1.00	6.93
3	-0.310625	73.433747	5.77	1.00	6.77
4	-0.310450	73.433786	5.07	1.00	6.07

Name: PV array 22

Axis tracking: Fixed (no rotation)

Tilt: 10.0°

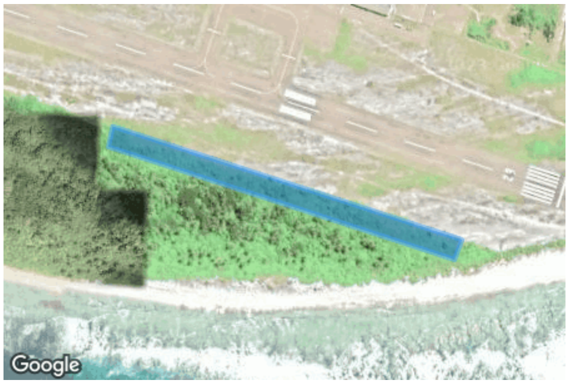
Orientation: 201.0°

Rated power: -

Panel material: Smooth glass with AR coating

Reflectivity: Vary with sun

Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.310450	73.433787	6.09	1.00	7.09
2	-0.310625	73.433750	6.24	1.00	7.24
3	-0.311590	73.436722	5.10	1.00	6.10
4	-0.311420	73.436788	5.63	1.00	6.63

Flight Path Receptors

Name: FP 1

Description:

Threshold height: 15 m

Direction: 111.0°

Glide slope: 3.0°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-0.308186	73.428203	7.13	15.24	22.37
Two-mile	-0.297825	73.401179	0.00	191.05	191.05

Name: FP 2
Description:
Threshold height: 15 m
Direction: 291.0°
Glide slope: 3.0°
Pilot view restricted? Yes
Vertical view: 30.0°
Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	-0.311075	73.437656	5.57	15.24	20.81
Two-mile	-0.321436	73.464680	0.00	189.50	189.50

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-0.308684	73.434906	3.94	9.85

Map image of 1-ATCT

Glare Analysis Results

Summary of Results Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	202.0	7,220	120.3	7,401	123.3	1,910,000.0
PV array 2	10.0	201.0	2,503	41.7	657	10.9	2,868,000.0
PV array 22	10.0	201.0	3,672	61.2	459	7.7	-

Total glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	8,185	136.4	7,876	131.3
FP 2	5,210	86.8	641	10.7
1-ATCT	0	0.0	0	0.0

PV: PV array 1 potential temporary after-image

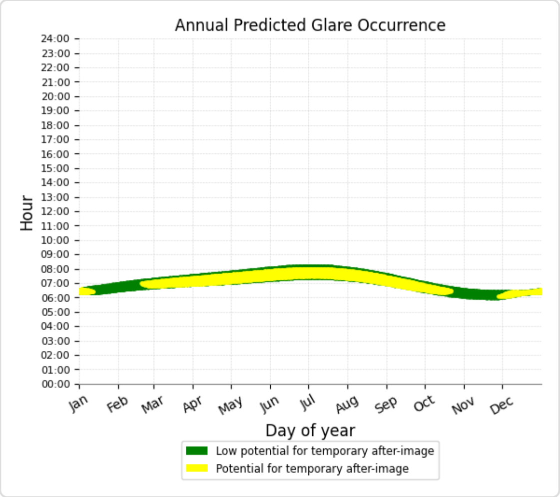
Receptor results ordered by category of glare

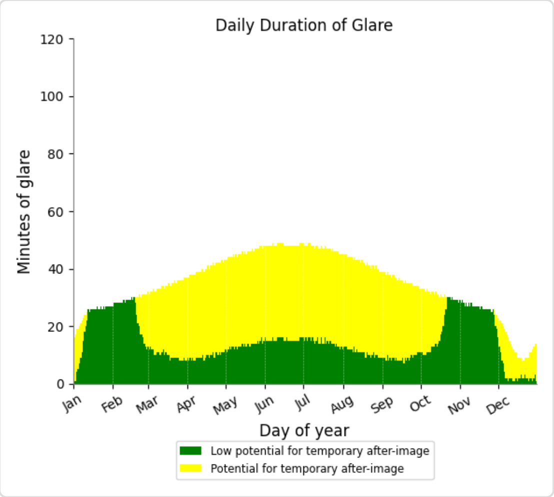
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	5,322	88.7	7,401	123.3
FP 2	1,898	31.6	0	0.0
1-ATCT	0	0.0	0	0.0

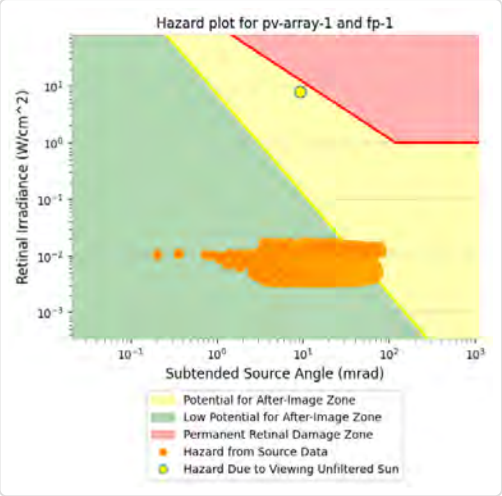
PV array 1 and FP: FP 1

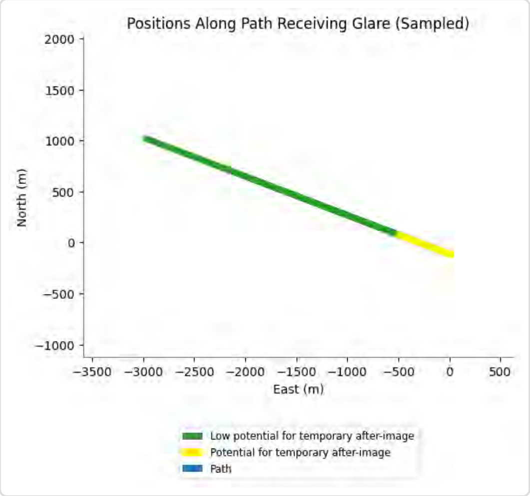
Yellow glare: 7,401 min.

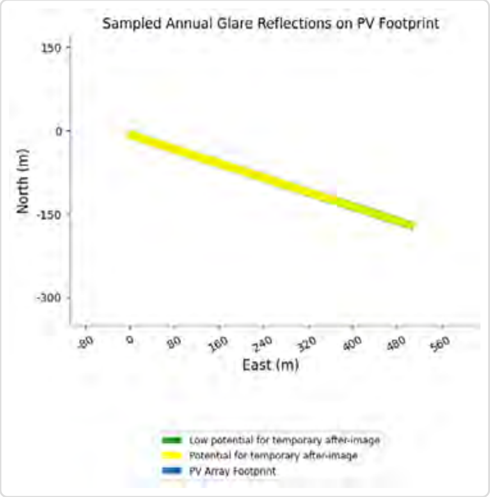
Green glare: 5,322 min.

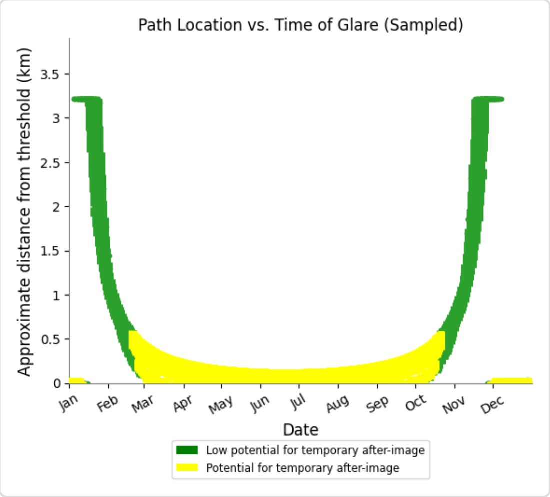








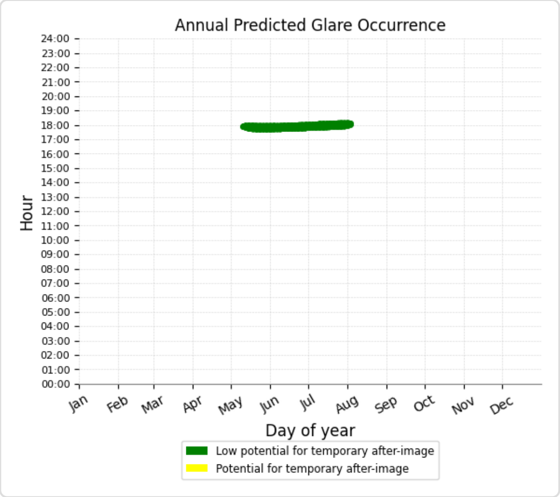


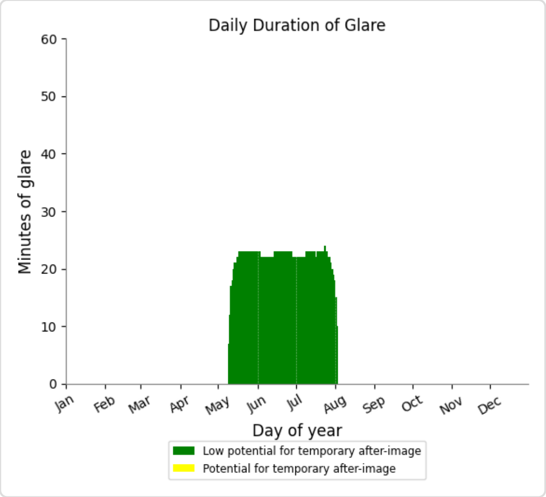


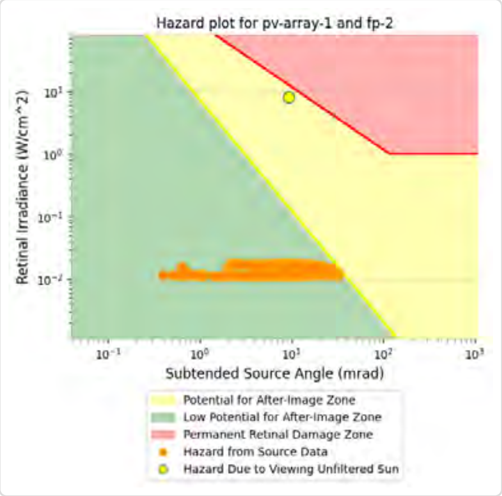
PV array 1 and FP: FP 2

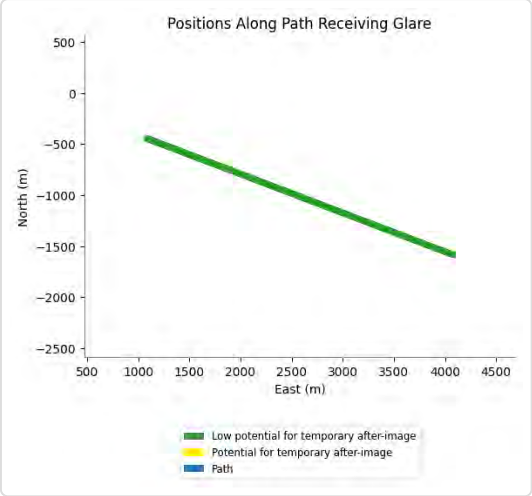
Yellow glare: none

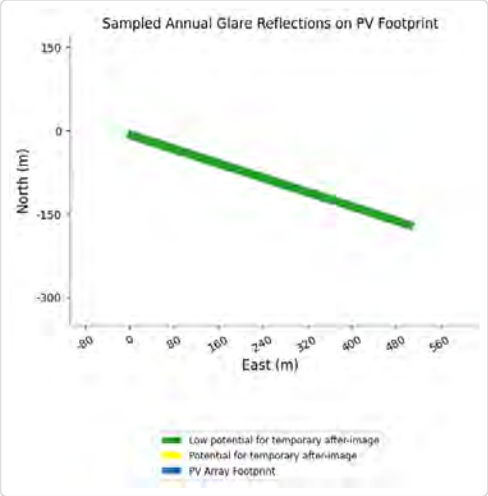
Green glare: 1,898 min.

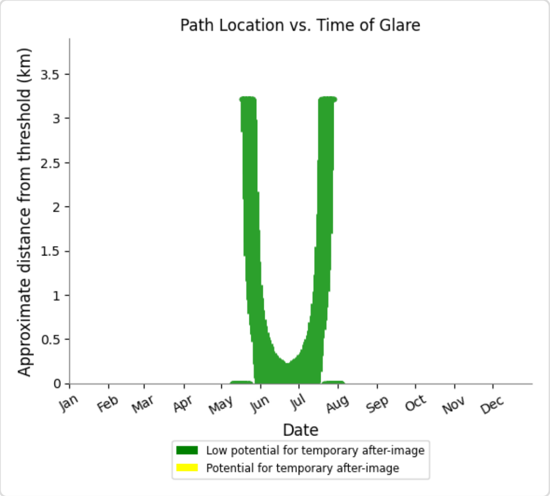

Annual Predicted Glare Occurrence


Daily Duration of Glare


Hazard plot for pv-array-1 and fp-2


Positions Along Path Receiving Glare


Sampled Annual Glare Reflections on PV Footprint


Path Location vs. Time of Glare

PV array 1 and 1-ATCT

No glare found

PV: PV array 2 potential temporary after-image

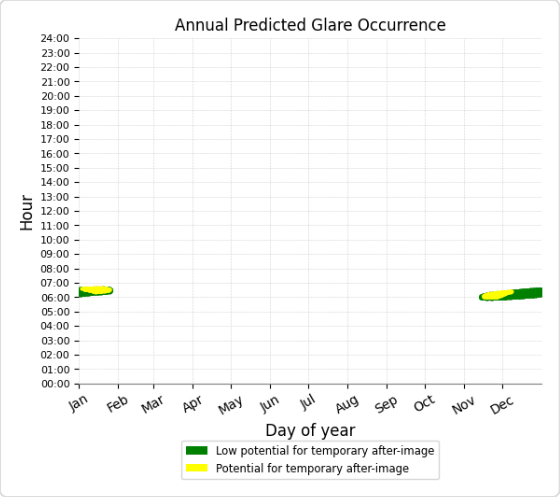
Receptor results ordered by category of glare

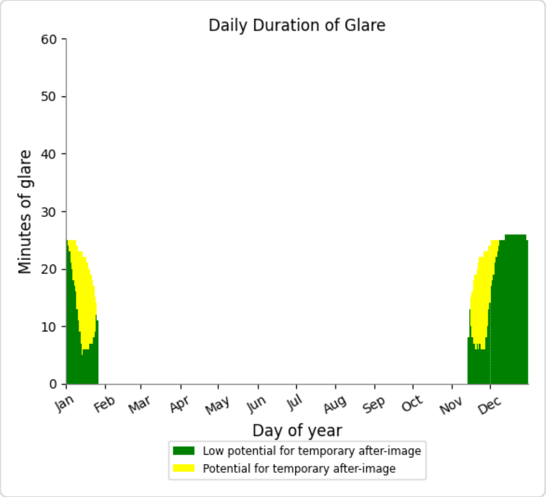
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
FP 1	1,209	20.1	475	7.9
FP 2	1,294	21.6	182	3.0
1-ATCT	0	0.0	0	0.0

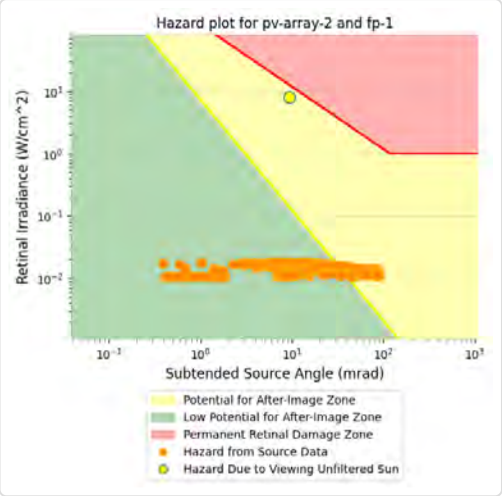
PV array 2 and FP: FP 1

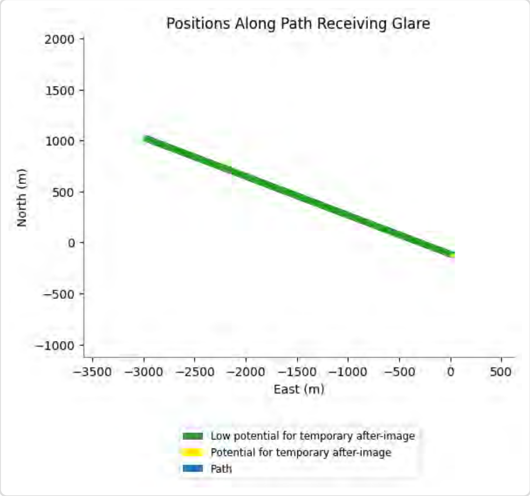
Yellow glare: 475 min.

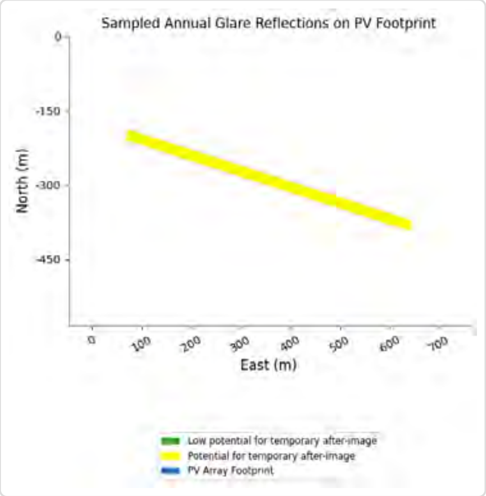
Green glare: 1,209 min.

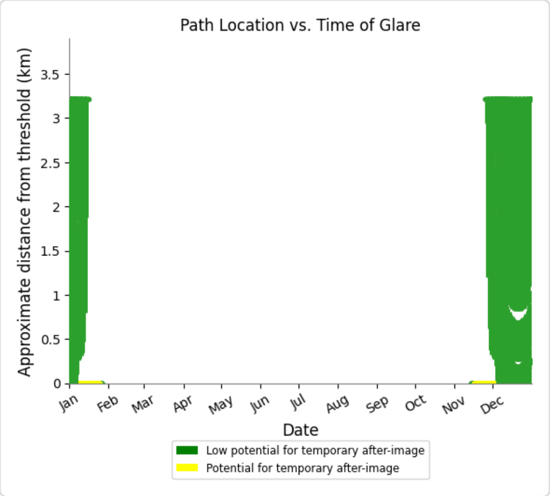

Annual Predicted Glare Occurrence


Daily Duration of Glare


Hazard plot for pv-array-2 and fp-1


Positions Along Path Receiving Glare

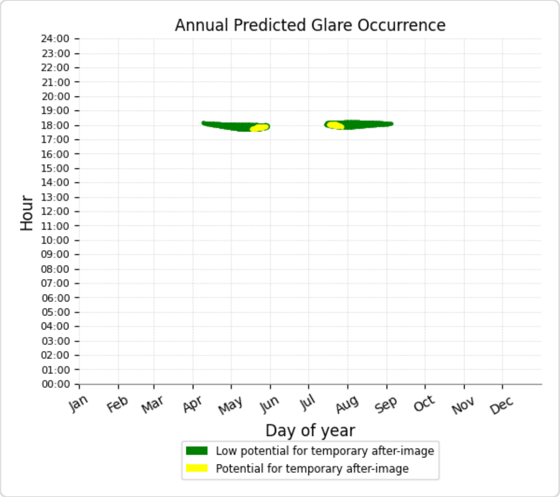

Sampled Annual Glare Reflections on PV Footprint

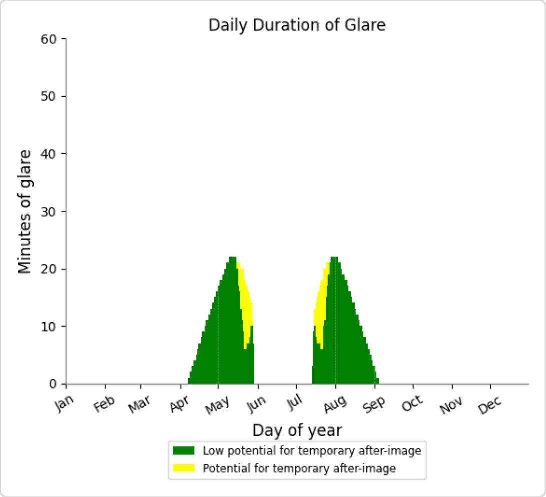

Path Location vs. Time of Glare

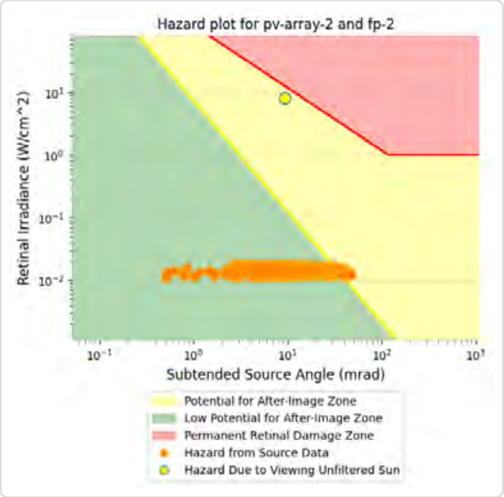
PV array 2 and FP: FP 2

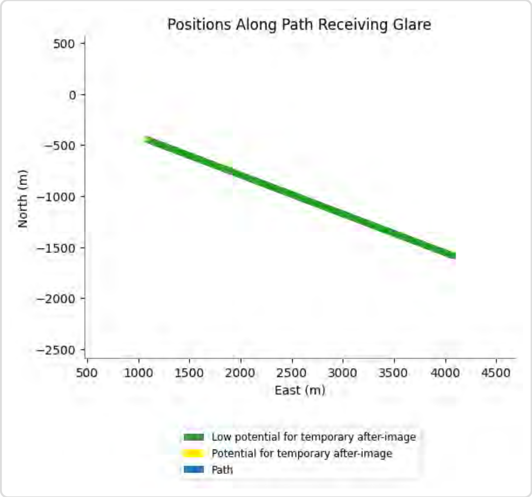
Yellow glare: 182 min.

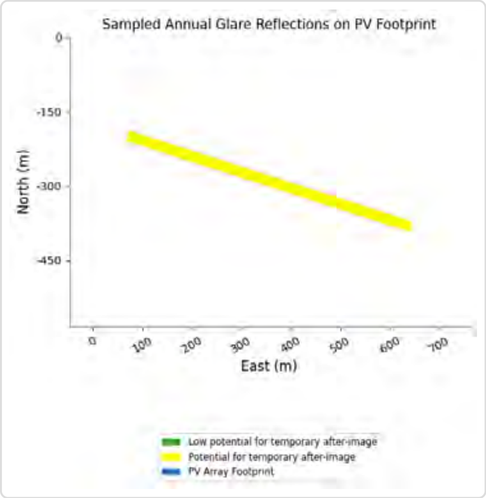
Green glare: 1,294 min.

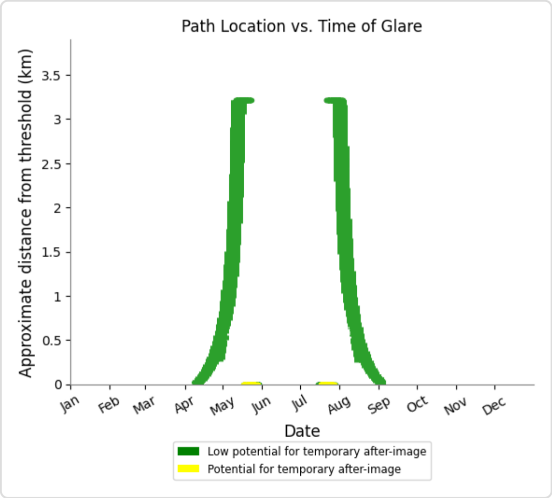












PV array 2 and 1-ATCT

No glare found

PV: PV array 22 potential temporary after-image

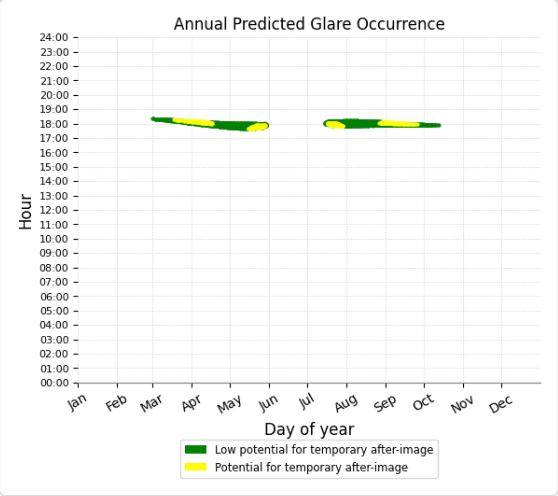
Receptor results ordered by category of glare

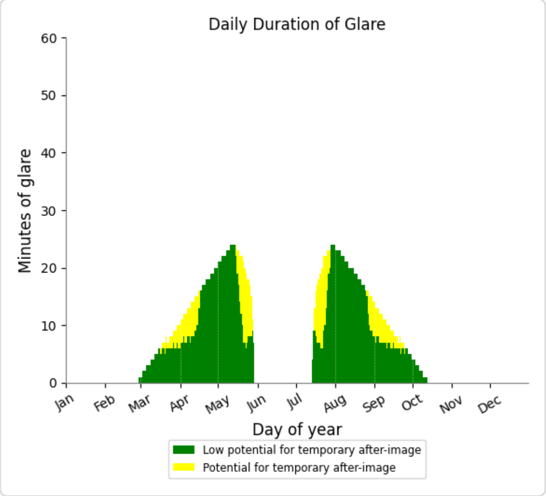
Receptor	**Annual Green Glare**		**Annual Yellow Glare**	
	min	**hr**	**min**	**hr**
FP 2	2,018	33.6	459	7.7
FP 1	1,654	27.6	0	0.0
1-ATCT	0	0.0	0	0.0

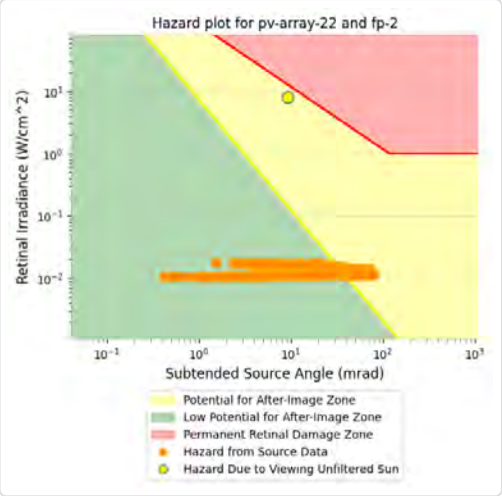
PV array 22 and FP: FP 2

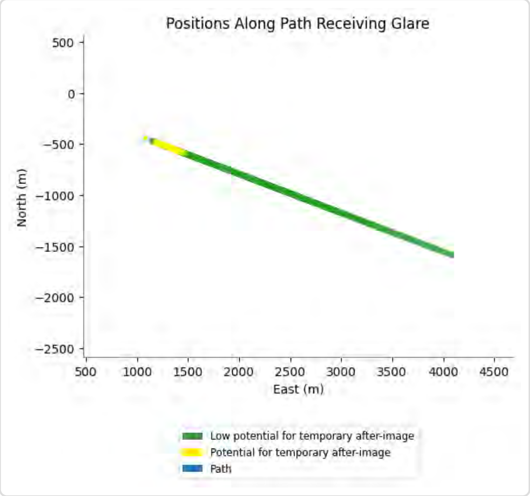
Yellow glare: 459 min.

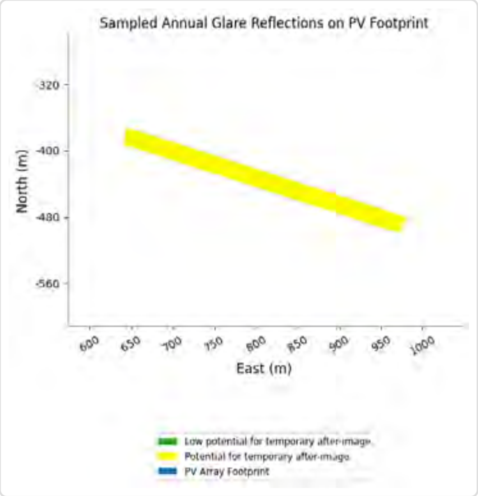
Green glare: 2,018 min.

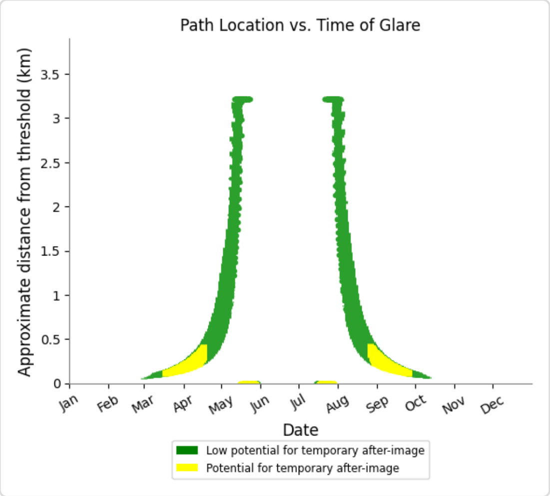






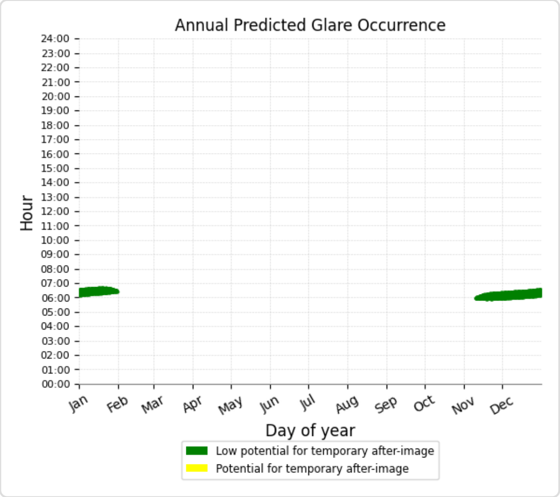


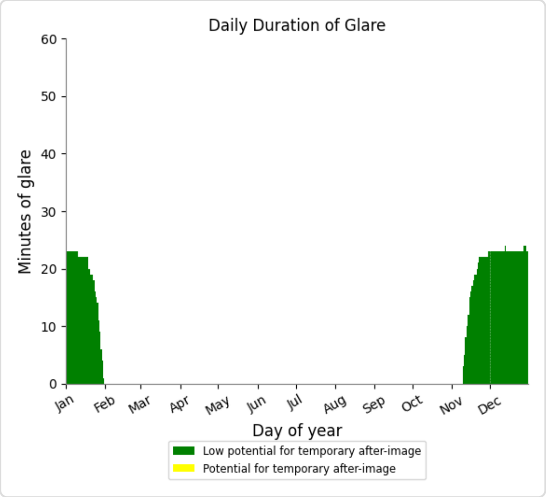


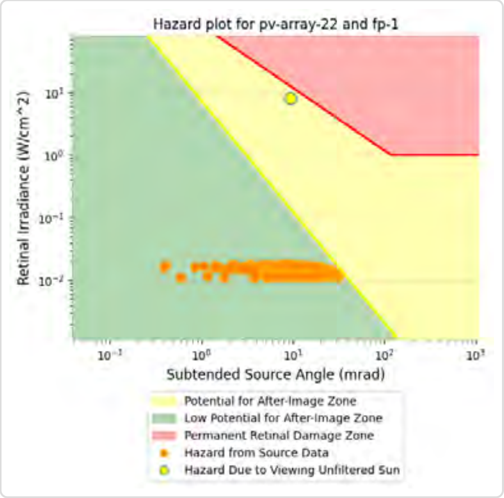


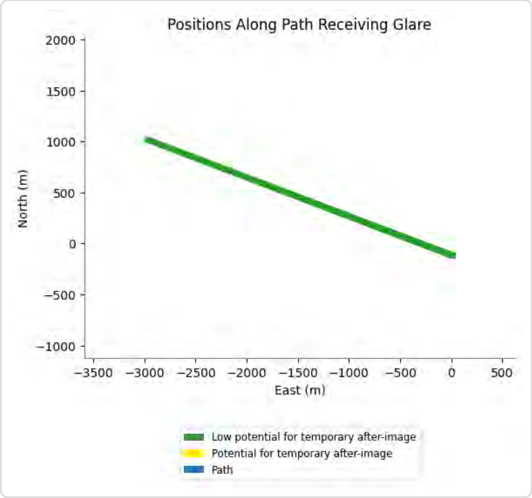
PV array 22 and FP: FP 1

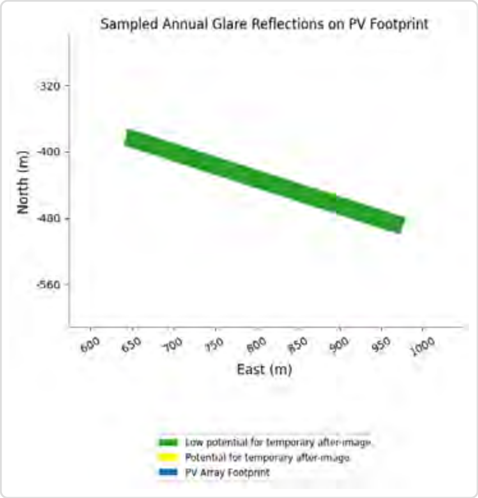
Yellow glare: none
Green glare: 1,654 min.

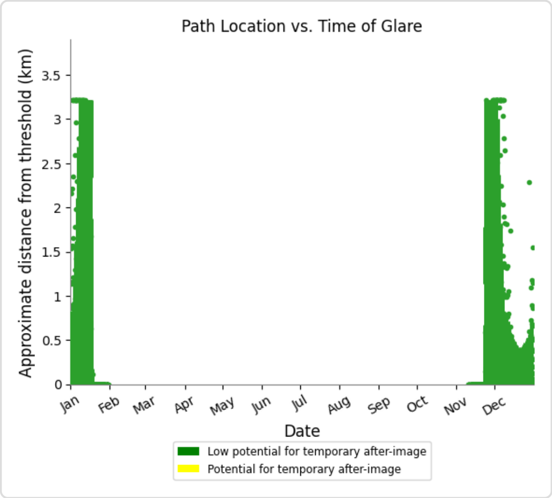












PV array 22 and 1-ATCT

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

INSTRUMENT APPROACH CHART

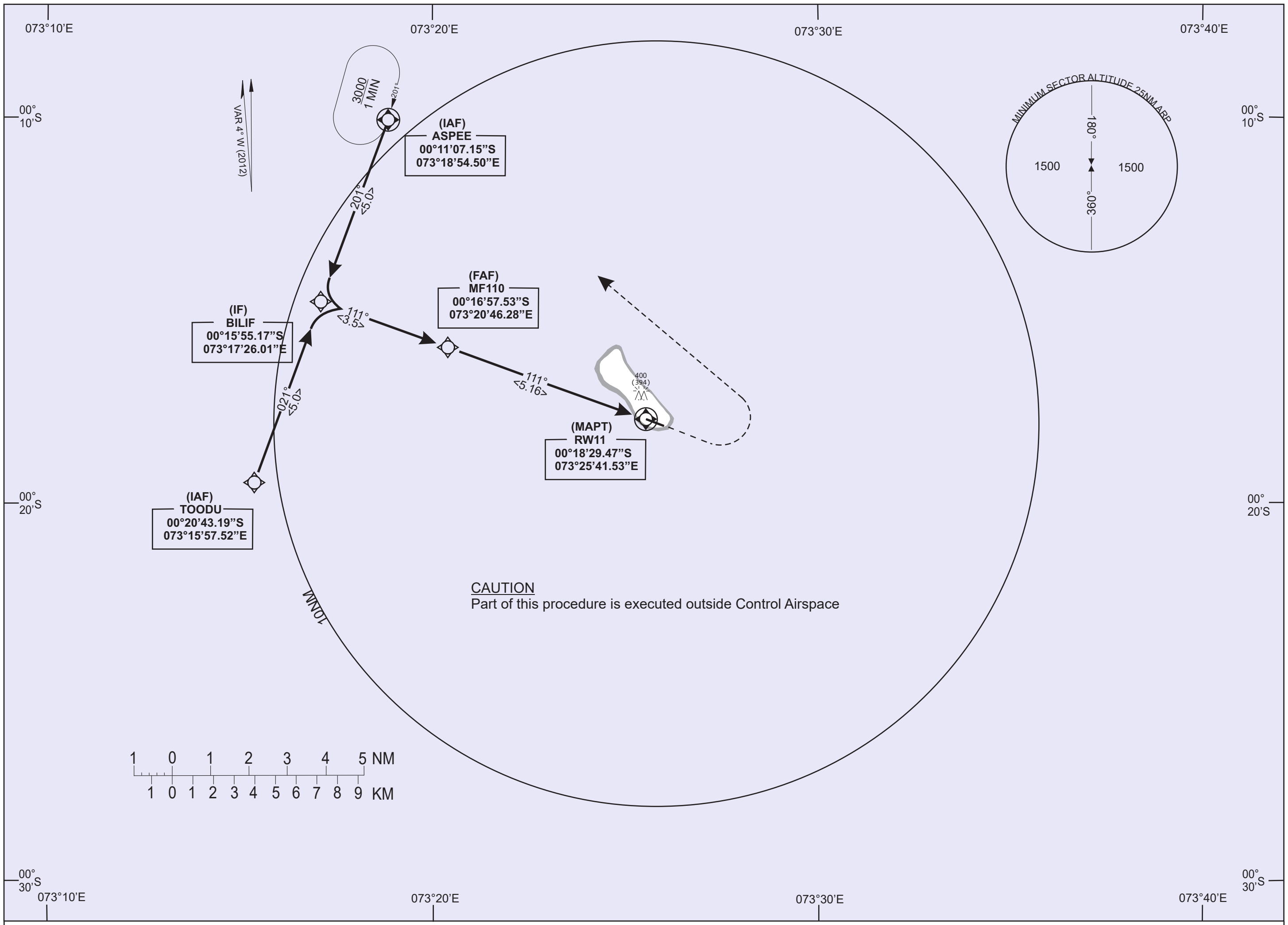
ELEV 6ft
HEIGHT RELATED TO
THR RWY 11 - ELEV 6ft
MIN TEMP -15°

BEARINGS ARE MAGNETIC
ALTITUDE, ELEVATION AND
HEIGHTS ARE IN FEET

TOWER: 118.15

FUVAH-MULAH AIRPORT

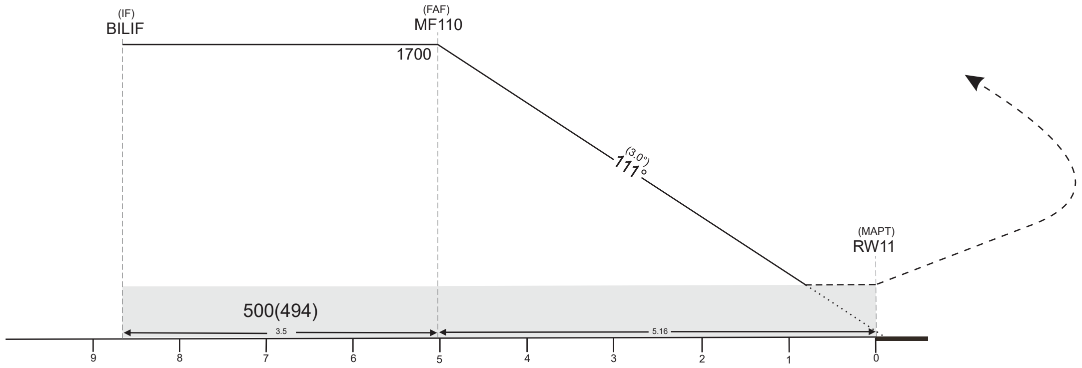
RNAV (GNSS) RWY 11



CAUTION
Part of this procedure is executed outside Control Airspace

RNP 0.3 GNSS REQUIRED

MISSED APPROACH
CLIMB STRAIGHT AHEAD TO 3000, TURN LEFT AND PROCEED DIRECT TO ASPEE AND HOLD OR AS DIRECTED BY ATC



AIRCRAFT CATEGORY	A			B	
LNAV/VNAV DA(DH)	540(534)				
LNAV MDA(MDH)	580(574)				
DISTANCE TO THRESHOLD	5	4	3	2	1
ALTITUDE (HEIGHT)	1650 (1644)	1330 (1334)	1020 (1014)	700 (694)	380 (374)

INSTRUMENT APPROACH CHART

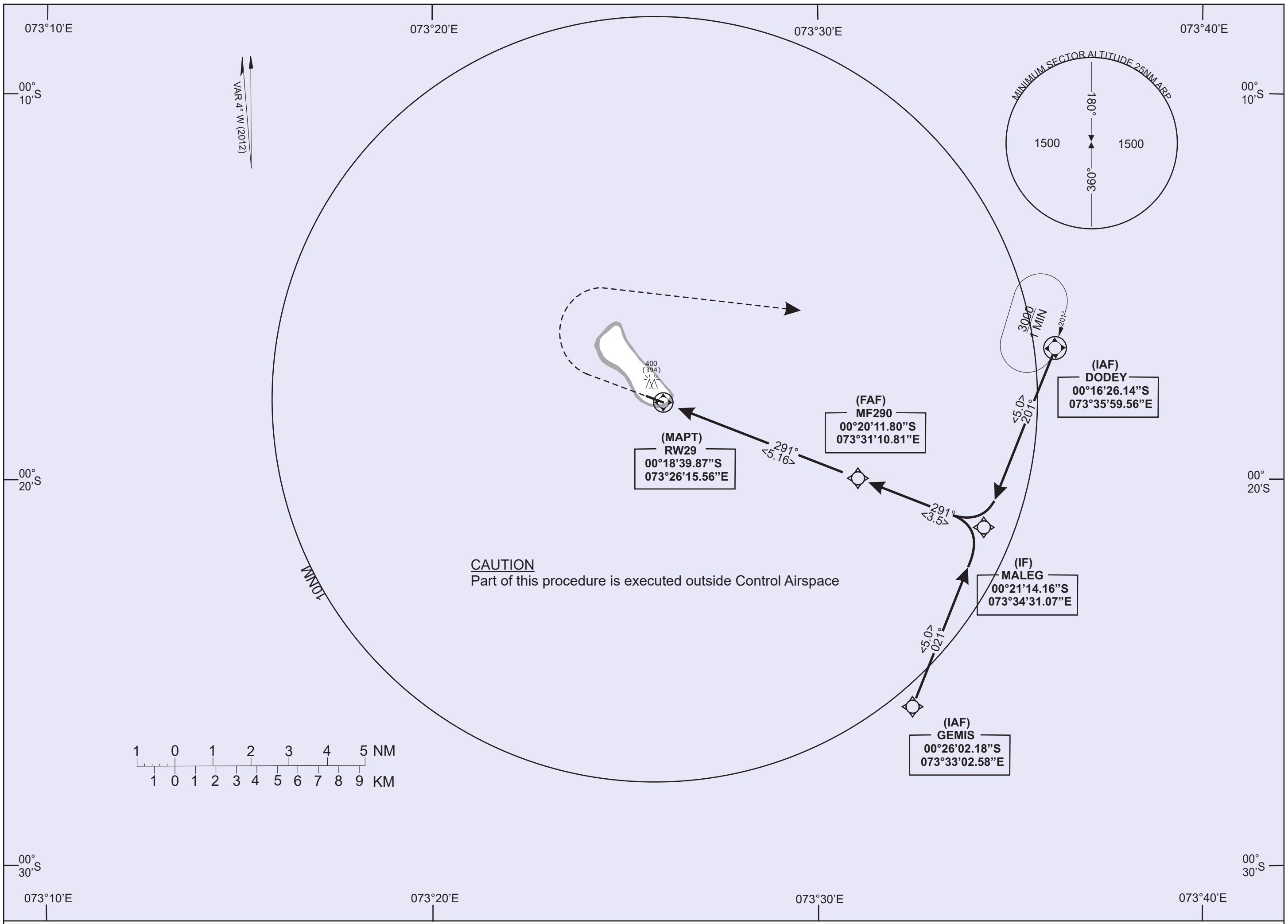
ELEV 6ft
HEIGHT RELATED TO
THR RWY 29 - ELEV 6ft
MIN TEMP -15°

BEARINGS ARE MAGNETIC
ALTITUDE, ELEVATION AND
HEIGHTS ARE IN FEET

TOWER: 118.15

FUVAH-MULAH AIRPORT

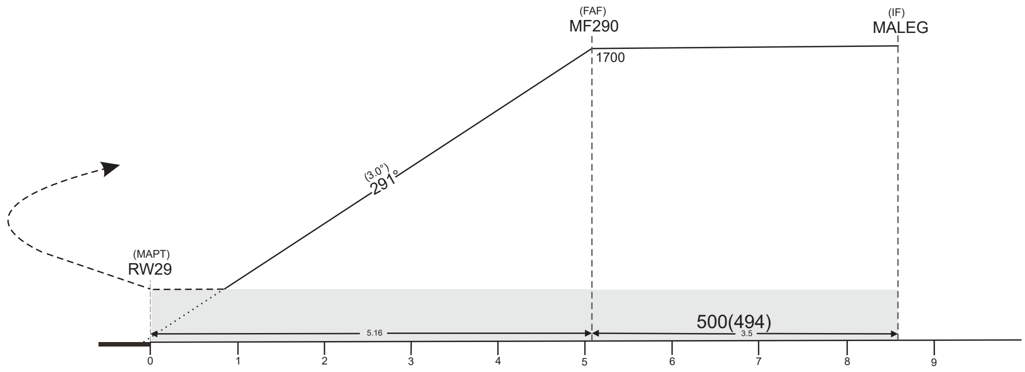
RNAV (GNSS) RWY 29



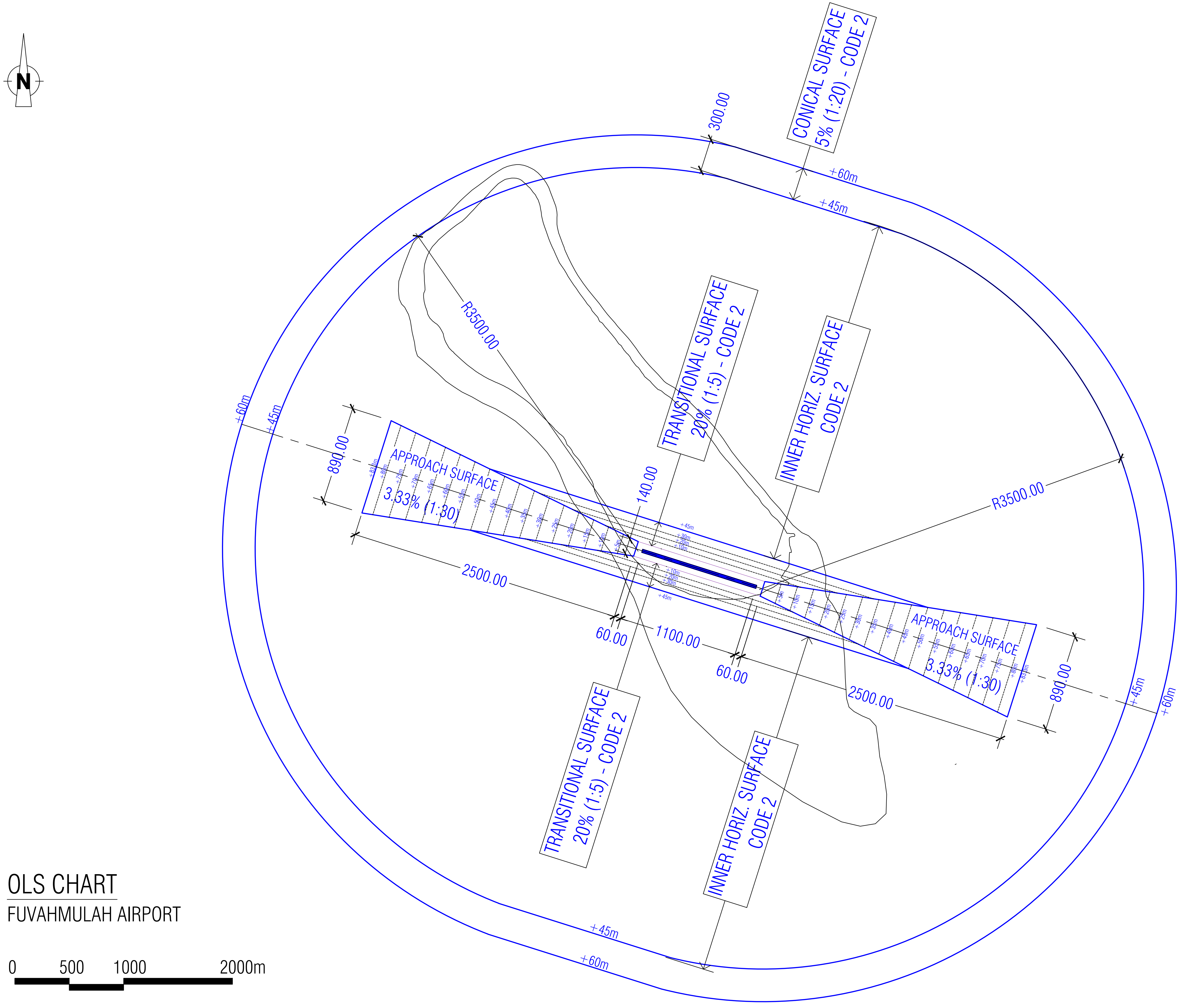
CAUTION
Part of this procedure is executed outside Control Airspace

MISSED APPROACH
CLIMB STRAIGHT AHEAD TO 3000,TURN RIGHT AND PROCEED DIRECT TO DODEY AND HOLD OR AS DIRECTED BY ATC

RNP 0.3 GNSS REQUIRED



AIRCRAFT CATEGORY	A		B	
LNAV/VNAV DA(DH)	330(324)			
LNAV MDA(MDH)	500(494)			
DISTANCE TO THRESHOLD	5	4	3	2	1
ALTITUDE (HEIGHT)	1650 (1644)	1330 (1334)	1020 (1014)	700 (694)	380 (374)



OLS CHART

FUVAHMULAH AIRPORT

GENERAL NOTES

RUNWAY WIDTH: 30m

NO.	REVISION/ ISSUE	DATE
00	ISSUE 1	25.08.20

MALDIVES CIVIL
AVIATION AUTHORITY

2nd FLOOR, VELAANAAGE | AMEER AHMED
MAGU | MALE' | 20096 | REPUBLIC OF MALDIVES
TEL: +960 3027244 | FAX: +960 3323039 |
WEBSITE: WWW.CAA.GOV.MV

DRAWING TITLE: OLS CHART

AERODROME: FUVAHMULAH AIRPORT
FVM/ VRMR

CODE: 2C

DRAWN BY: H.S

CHECKED: F.R

PAPER: A3

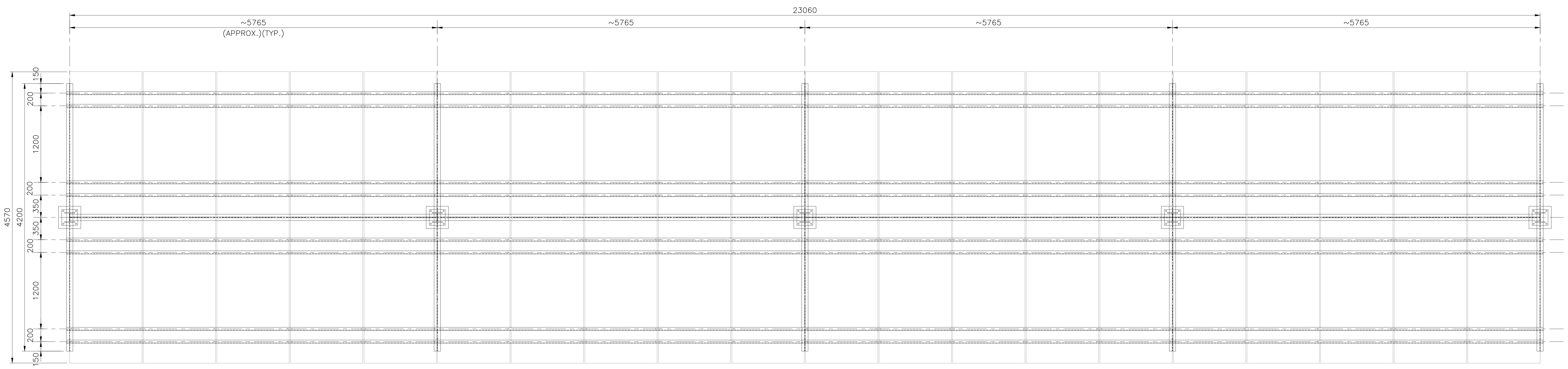
DATE: 26 AUG 2020

SCALE: NTS

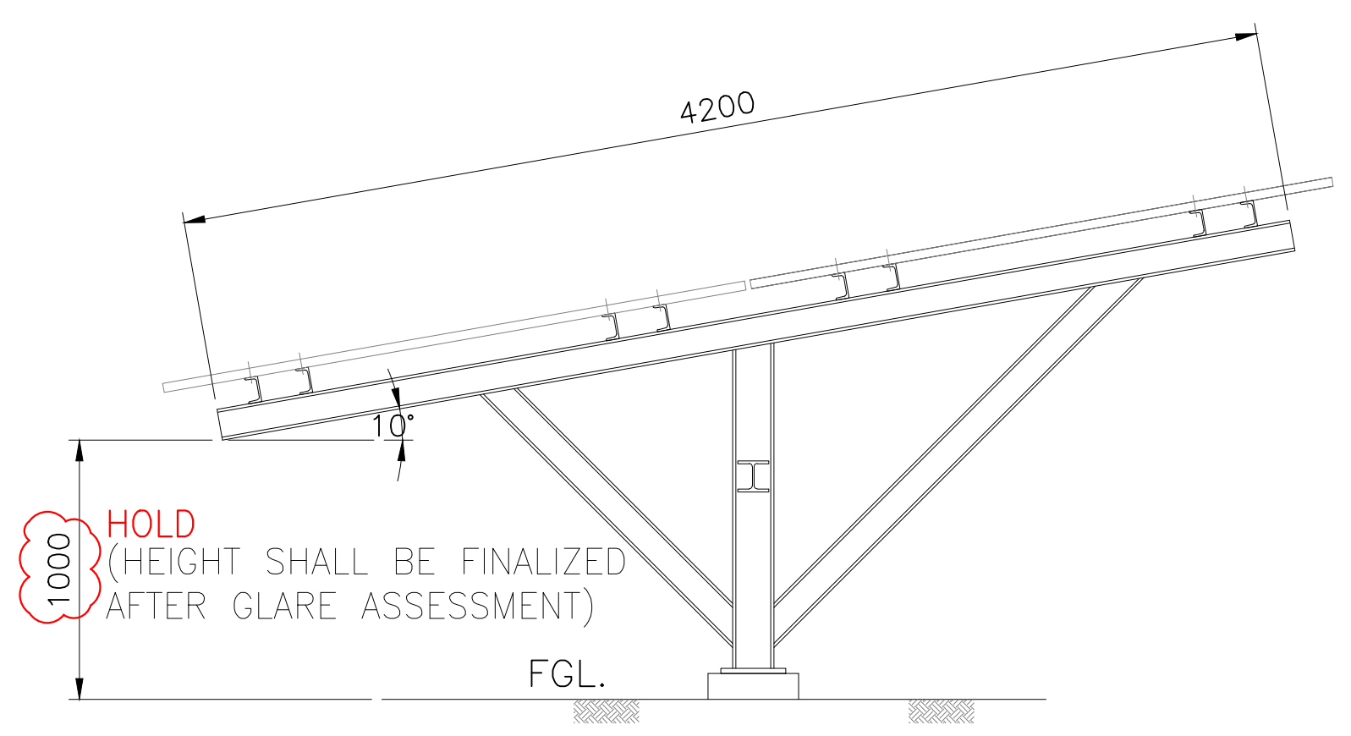
SHEET

C01

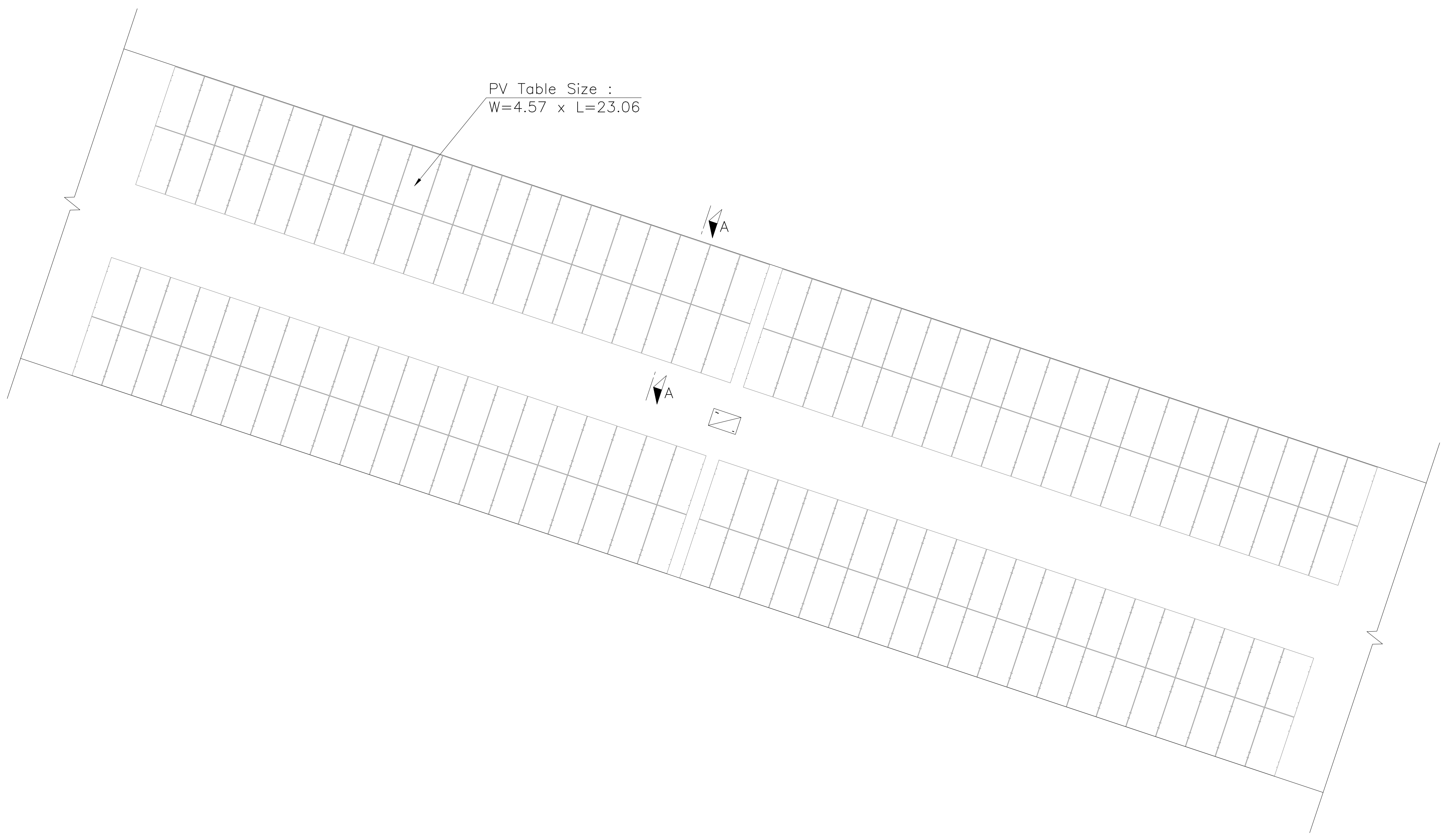
REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR KULHUDHUFFUSHI AIRPORT	–



TYPICAL PLAN OF PV TABLE STRUCTURE TYPE–2
FOR PV TABLE SIZE 4570x23060



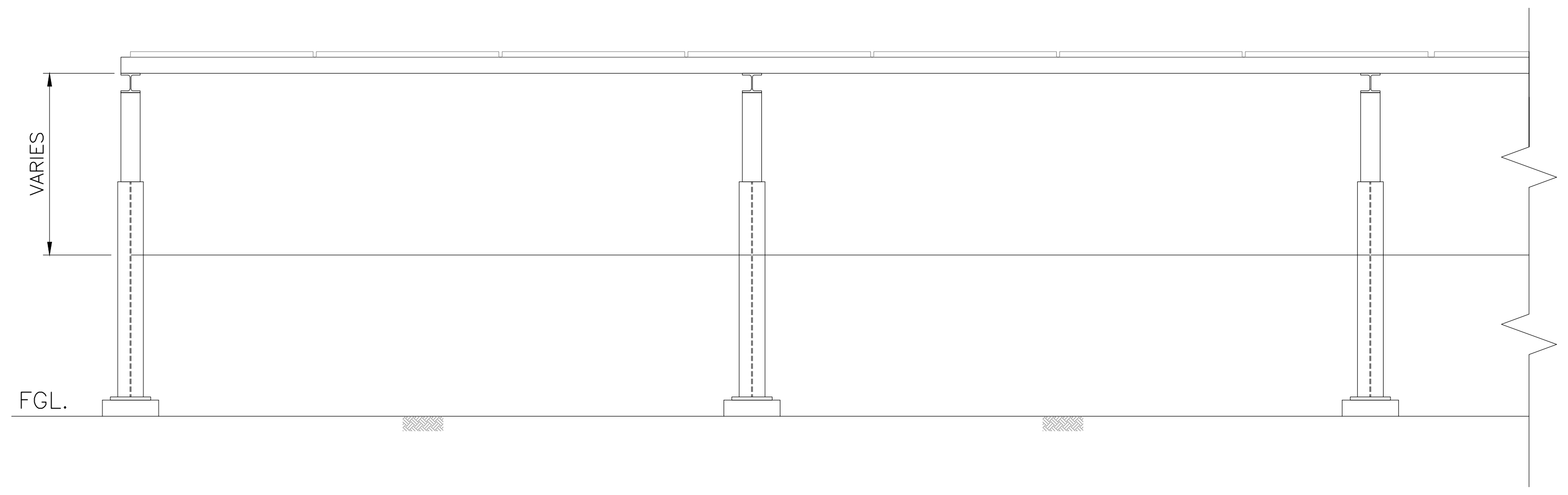
SECTION A–A
SHORTER SIDE ELEVATION



SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.



LONGER SIDE ELEVATION

PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

SECTION: CIVIL SCALE: AS SHOWN	PAGE: 1/1	CONCEPTUAL PV STRUCTURE DRAWING FOR KULHUDHUFFUSHI AIRPORT(GROUND MOUNTED)

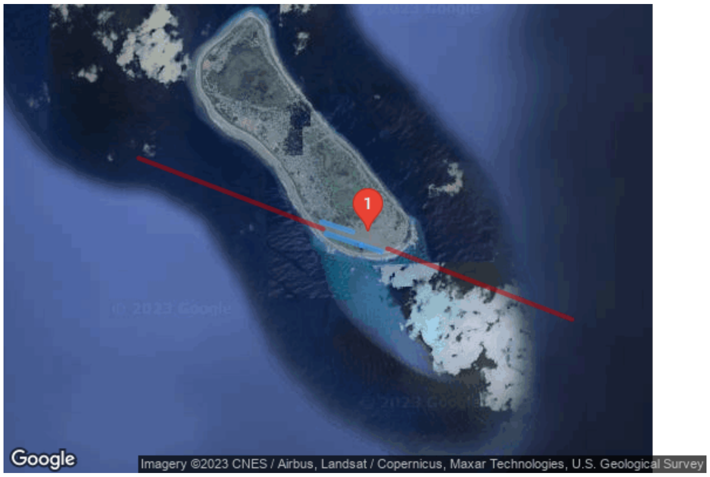
FORGESOLAR GLARE ANALYSIS

Project: **Fuvahmulah airport**
Site configuration: **Fuvahmullah-1**

Client: Mega First Power Industries Sdn Bhd

Created 17 Apr, 2023
Updated 02 May, 2023
Time-step 1 minute
Timezone offset UTC5
Minimum sun altitude 0.0 deg
DNI peaks at 1,000.0 W/m^2
Site ID 88463.15469

Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Imagery ©2023 CNES / Airbus, Landsat / Copernicus, Maxar Technologies, U.S. Geological Survey

Glare Policy Adherence

The following table estimates the policy adherence of this glare analysis according to the **2021** U.S. Federal Aviation Administration Policy:

Review of Solar Energy System Projects on Federally-Obligated Airports

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step.

ForgeSolar is not affiliated with the U.S. FAA and does not represent or speak officially for the U.S. FAA. ForgeSolar cannot approve or deny projects - results are informational only. Contact the relevant airport and FAA district office for information on policy and requirements.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

The referenced policy can be read at https://www.federalregister.gov/d/2021-09862

Component Data

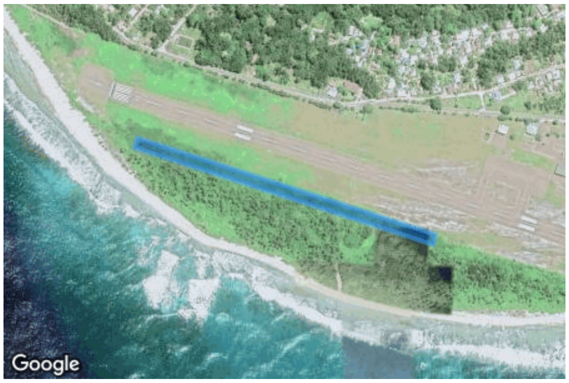
This report includes results for PV arrays and Observation Point ("OP") receptors marked as ATCTs. Components that are not pertinent to the policy, such as routes, flight paths, and vertical surfaces, are excluded.

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 202.0°
Rated power: 800.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

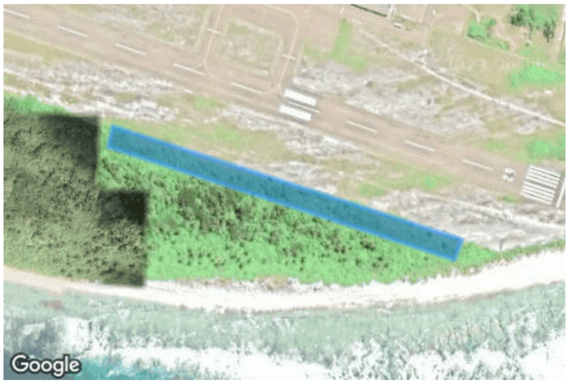
Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.307078	73.427992	10.09	1.00	11.09
2	-0.307200	73.427950	10.33	1.00	11.33
3	-0.308690	73.432550	3.87	1.00	4.87
4	-0.308580	73.432600	3.38	1.00	4.38

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 201.0°
Rated power: 1200.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.308792	73.428664	7.06	1.00	8.06
2	-0.308964	73.428608	5.93	1.00	6.93
3	-0.310625	73.433747	5.77	1.00	6.77
4	-0.310450	73.433786	5.07	1.00	6.07

Name: PV array 22
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 201.0°
Rated power: -
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material



Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	-0.310450	73.433787	6.09	1.00	7.09
2	-0.310625	73.433750	6.24	1.00	7.24
3	-0.311590	73.436722	5.10	1.00	6.10
4	-0.311420	73.436788	5.63	1.00	6.63

Observation Point ATCT Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	-0.308684	73.434906	3.94	9.85

Map image of 1-ATCT

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	202.0	0	0.0	0	0.0	1,910,000.0
PV array 2	10.0	201.0	0	0.0	0	0.0	2,868,000.0
PV array 22	10.0	201.0	0	0.0	0	0.0	-

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV: PV array 1

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV array 1 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV: PV array 2

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV array 2 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV: PV array 22

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV array 22 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

GLARE ASSESSMENT REPORT

KULHUDHUFFUSHI AIRPORT

Prepared by	**Parvaneh**
Date of preparation	**24.04.2023**
Checked/Approved	**Babak Behbahani**
Doc No./Revision	**PEN023-1/0**

Table of Contents

Annex I	Forgesolar results according to FAA policy 2021
Annex II	Aerodrome Instrument Approach Chart
Annex III	OLS Chart
Annex IV	PV Arrays Installation Detail
Annex V	Forgesolar Complete results (For information)

EXECUTIVE SUMMARY

Mega First Power Industries Sdn Bhd plans to install a solar plant in the Kulhudhuffushi airport in Maldives and engaged **Parvaneh** Energy to perform glare and glint analysis for the project.

Parvaneh utilises Forge Solar's GlareGauge analysis tool in order to carry out the analysis which corresponds to the United States (US) Federal Aviation Administration's (FAA) 2021 technical guidance.

The project includes an east-west runway, approach paths from west and east and a control tower. The assessment is performed for the observation points and examined all the possible occurrences.

The results of this study show that with the proposed arrangement of the solar arrays, glare from the project is not expected to impact the ATCT cab with reference to the FFA 2021 policy. Therefore, no mitigative action is needed for the project to address glare at the receptor locations.

INTRODUCTION

Aa part of ASPIRE 11.393MW Solar Power Complex, a total of 2.2 MW solar project is planned to be installed there Kulhudhuffushi airport. In order to evaluate the potential hazard for the pilots and air-traffic control personnel a glare study is performed by the consultant.

PURPOSE OF THE STUDY

A comprehensive assessment is carried out in order to scrutinize any negative effect of the installation on the observation points which are caused by the panels' reflections. The study scrutinizes location and time of the glare occurrence and any possible potential impact.

Assessment is performed according to the technical requirement of U.S Federal Aviation Administration Policy: Review of Solar Energy System Projects on Federally-Obligated Airports, 2021.

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step

PROJECT DESCRIPTION

SITE LOCATION

Kulhudhuffushi airport is located in north of Kulhudhuffushi island, Maldives with a runway of 1200 meters and 30 meters width. The aerodrome has two approach paths from the sides. Figure 1 depict the site location. Annex II and annex III present the aerodrome instrument approach chart and OLS chart respectively.

Figure 1 Kulhudhuffushi Airport location

SITE LAYOUT

Solar panel installation is being carried out in four PV arrays both sides of the runway as demonstrated in Figure 2. PV arrays is being installed in two phases which are highlighted with the blue color for the current phase and green color for the future expansion.

Figure 2 **Kulhudhuffushi** *site general layout*

INSTALLATION

Installation of the panels is being done according to the installation detail as provided in Annex IV. The elevation of the tables from the ground is 1 meter. Table installation will be type 2 and the title of the panels will be 10 degrees. Modules orientation/azimuth are defined in Table 1.

The tables are fixed-mounted and no tracking set up is available.

The utilised module type is JA solar 540 wp with antireflection coating.

Table 1 PV Arrays installation

	Installation tilt	Orientation
PV Array 1	10^{o}	24^{o}
PV Array 12	10^{o}	24^{o}
PV Array 2	10^{o}	32^{o}
PV Array 21	10^{o}	32^{o}

RECEPTORS AND OBSTACLES

Based on the communication with client and the airport operator below receptor are identified as below:

Table 2 List of the Receptors

Receptor	Location	Observation Height	Type
Air Traffic Control Tower	6.6304 73.06596	9.85 meters	Observation Point (OP)
Pilot cockpit	approach path from 114.9°		Flight Path receptor (FP)
Pilot cockpit	approach path from 294°		Flight Path receptor (FP)

According to the site layout, it can be observed that there is no obstacle between the panels and the observation points.

Note: At the moment, firefighting building is used as the control tower. However, the future control tower is used in the study based on the client instruction.

METHODOLOGY AND STUDY

OUTLOOK

This study is based on the solar glare and the regulatory policies of FAA., with the effective date of May 11, 2021.

Glint is typically defined as a momentary flash of bright light, often caused by a reflection off a moving source. A typical example of glint is a momentary solar reflection from a moving car. Glare is defined as a continuous source of bright light. Glare is generally associated with stationary objects, which, due to the slow relative movement of the sun, reflect sunlight for a longer duration.

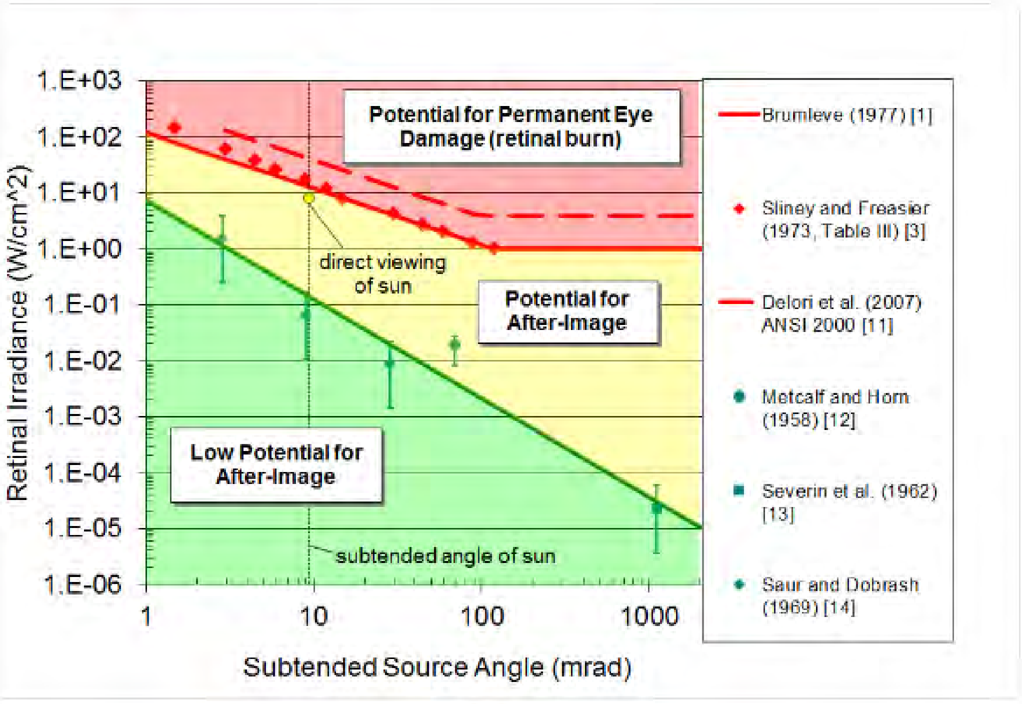


Figure 3 Glare hazard plot defines ocular impact as function of retinal irradiance and subtended source angle

The ocular impact of solar glare is quantified into three categories:

- Green - low potential to cause after-image (flash blindness)
- Yellow - potential to cause temporary after-image
- Red - potential to cause retinal burn (permanent eye damage)

These categories assume a typical blink response in the observer.

Note:

In this study the FAA policy 2021 is utilised. The important change from 2013 version is to evaluate the possible glare only on ATCT cab, therefore there is no more requirement to adjust the solar arrays to reduce the glares on the pilot cockpits while approaching the aerodrome.

The relevant section of the policy is reproduced here as reference; “Initially, FAA believed that solar energy systems could introduce a novel glint and glare effect to pilots on final approach. FAA has subsequently concluded that in most cases, the glint and glare from solar energy systems to pilots on final approach is similar to glint and glare pilots routinely experience from water bodies, glass-façade buildings, parking lots, and similar features. However, FAA has continued to receive reports of potential glint and glare from on-airport solar energy systems on personnel working in ATCT cabs. Therefore, FAA has determined the scope of agency policy should be focused on the impact of on-airport solar energy systems to federally-obligated towered airports, specifically the airport's ATCT cab”

ASSUMPTIONS & LIMITATIONS

Summary of assumptions and abstractions required by the SGHAT/ForgeSolar analysis methodology

1. Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.

2. Result data files and plots are retained for two years after analysis completion. Files must be downloaded and saved if additional persistence is required.
3. The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
4. Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
5. Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
6. The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
7. The algorithm assumes that the PV array is aligned with a plane defined by the approximate total heights of the PV vertices. For increased accuracy, the user should perform runs using minimum and maximum values for the vertex heights to bound the

height of the plane containing the solar array. Doing so will expand the range of observed solar glare when compared to results using a single height value.

8. The algorithm does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
9. The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
10. The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
11. The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modelling methods.
12. Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
13. Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.

RESULTS AND CONCLUSION

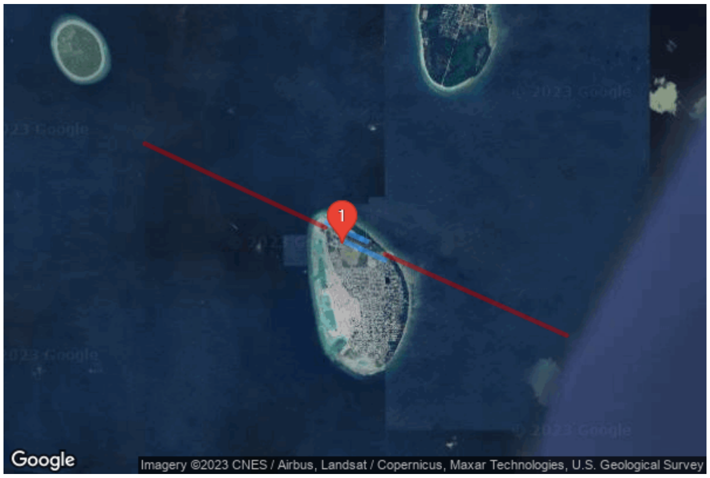
The results of the study determines that current installation will have no glare impact on the ACTC and is in compliance with the reference requirement. Details of the results with regards to the requirements of the FAA policy 2021 is provided as Annex I.

For information, Annex V is enclosed to provide complete overview of the site situation.

FORGESOLAR GLARE ANALYSIS

Project: **Kulhudhuffushi Airport**
Site configuration: **Kulhudhuffushi Airport**

Created 17 Apr, 2023
Updated 24 Apr, 2023
Time-step 1 minute
Timezone offset UTC5
Site ID 88468.15481
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Glare Policy Adherence

The following table estimates the policy adherence of this glare analysis according to the **2021** U.S. Federal Aviation Administration Policy:

Review of Solar Energy System Projects on Federally-Obligated Airports

This policy may require the following criteria be met for solar energy systems on airport property:

- No glare of any kind for Air Traffic Control Tower(s) ("ATCT") at cab height.
- Default analysis and observer characteristics, including 1-minute time step.

ForgeSolar is not affiliated with the U.S. FAA and does not represent or speak officially for the U.S. FAA. ForgeSolar cannot approve or deny projects - results are informational only. Contact the relevant airport and FAA district office for information on policy and requirements.

COMPONENT	STATUS	DESCRIPTION
Analysis parameters	PASS	Analysis time interval and eye characteristics used are acceptable
ATCT(s)	PASS	Receptor(s) marked as ATCT do not receive glare

The referenced policy can be read at https://www.federalregister.gov/d/2021-09862

Component Data

This report includes results for PV arrays and Observation Point ("OP") receptors marked as ATCTs. Components that are not pertinent to the policy, such as routes, flight paths, and vertical surfaces, are excluded.

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 24.0°
Rated power: 1190.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.633540	73.063610	1.79	1.00	2.79
2	6.633430	73.063530	1.85	1.00	2.85
3	6.631070	73.068680	4.41	1.00	5.41
4	6.631180	73.068750	4.32	1.00	5.32

Name: PV array 11
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 24.0°
Rated power: 180.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.631181	73.068750	4.62	1.00	5.62
2	6.631071	73.068680	4.79	1.00	5.79
3	6.630690	73.069501	3.51	1.00	4.51
4	6.630810	73.069560	3.88	1.00	4.88

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 32.0°
Rated power: 430.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.630710	73.066410	1.78	1.00	2.78
2	6.630610	73.066370	1.71	1.00	2.71
3	6.629635	73.068500	0.48	1.00	1.48
4	6.629727	73.068551	0.70	1.00	1.70

Name: PV array 22
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 32.0°
Rated power: 575.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.629725	73.068552	0.70	1.00	1.70
2	6.629636	73.068500	0.51	1.00	1.51
3	6.627980	73.072110	6.56	1.00	7.56
4	6.628080	73.072150	6.29	1.00	7.29

Observation Point ATCT Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	6.630404	73.065957	1.99	9.85

Map image of 1-ATCT

Glare Analysis Results

Summary of Results No glare predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	24.0	0	0.0	0	0.0	2,780,000.0
PV array 11	10.0	24.0	0	0.0	0	0.0	420,800.0
PV array 2	10.0	32.0	0	0.0	0	0.0	1,006,000.0
PV array 22	10.0	32.0	0	0.0	0	0.0	1,345,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV: PV array 1

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV array 1 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV: PV array 11

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
1-ATCT	0	0.0	0	0.0

PV array 11 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV: PV array 2

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
1-ATCT	0	0.0	0	0.0

PV array 2 and 1-ATCT

Receptor type: ATCT Observation Point

No glare found

PV: PV array 22

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
1-ATCT	0	0.0	0	0.0

PV array 22 and 1-ATCT

Receptor type: ATCT Observation Point

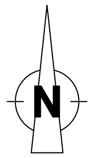
No glare found

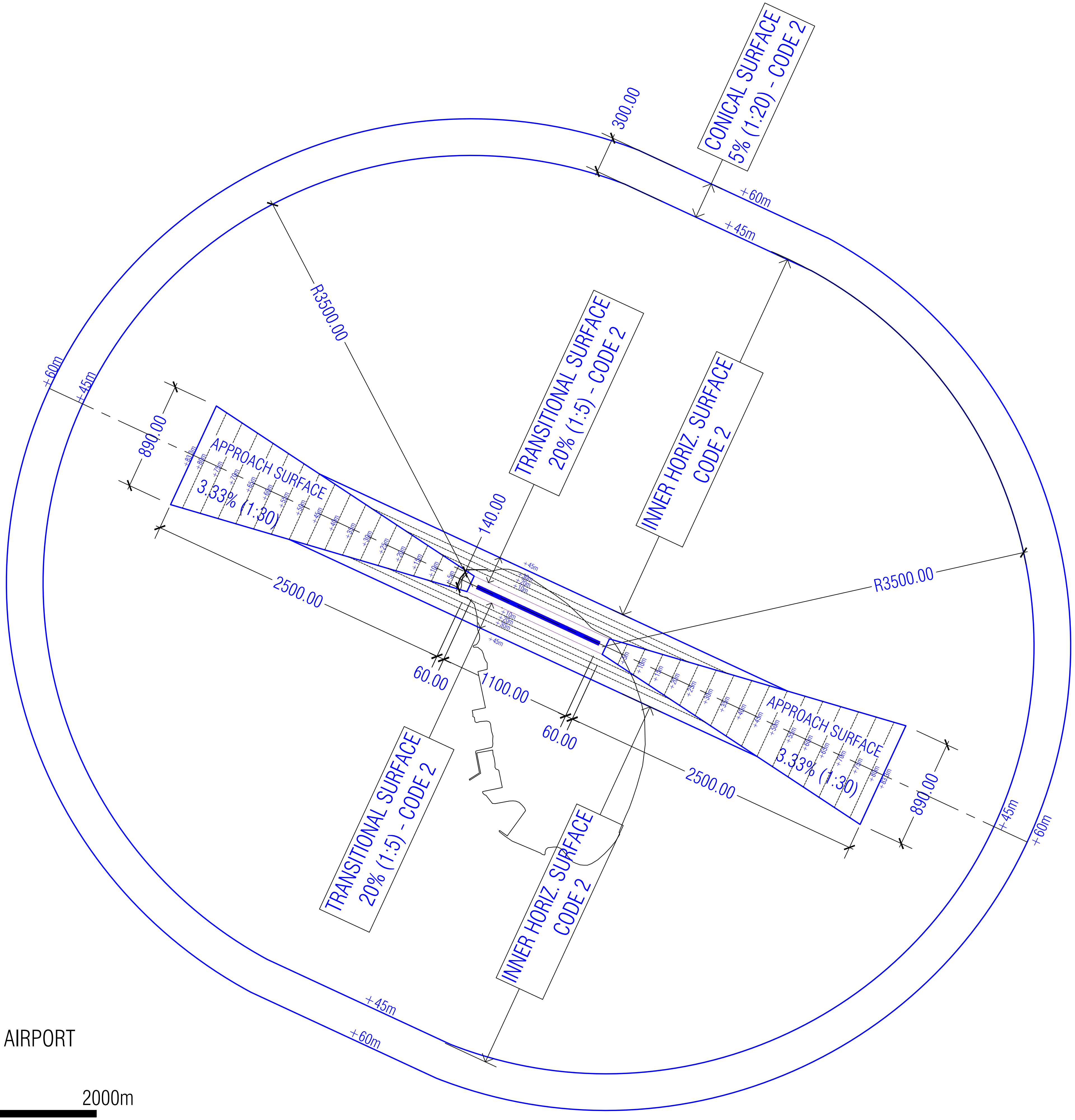
Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians





OLS CHART

KULHUDHUFFUSHI AIRPORT

GENERAL NOTES

RUNWAY WIDTH: 30m

NO.	REVISION/ ISSUE	DATE
00	ISSUE 1	25.08.20

MALDIVES CIVIL
AVIATION AUTHORITY

2nd FLOOR, VELAANAAGE | AMEER AHMED
MAGU | MALE' | 20096 | REPUBLIC OF MALDIVES
TEL: +960 3027244 | FAX: +960 3323039 |
WEBSITE: WWW.CAA.GOV.MV

DRAWING TITLE: OLS CHART

AERODROME: KULHUDHUFFUSHI AIRPORT
HDK/ VRBK

CODE: 2C

DRAWN BY: H.S

CHECKED: F.R

PAPER: A3

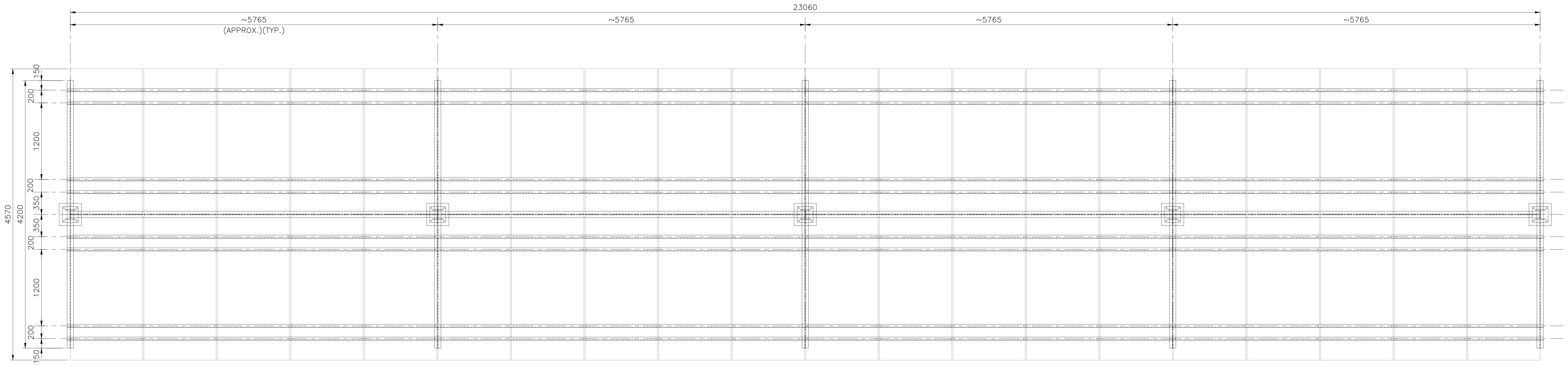
DATE: 26 AUG 2020

SCALE: NTS

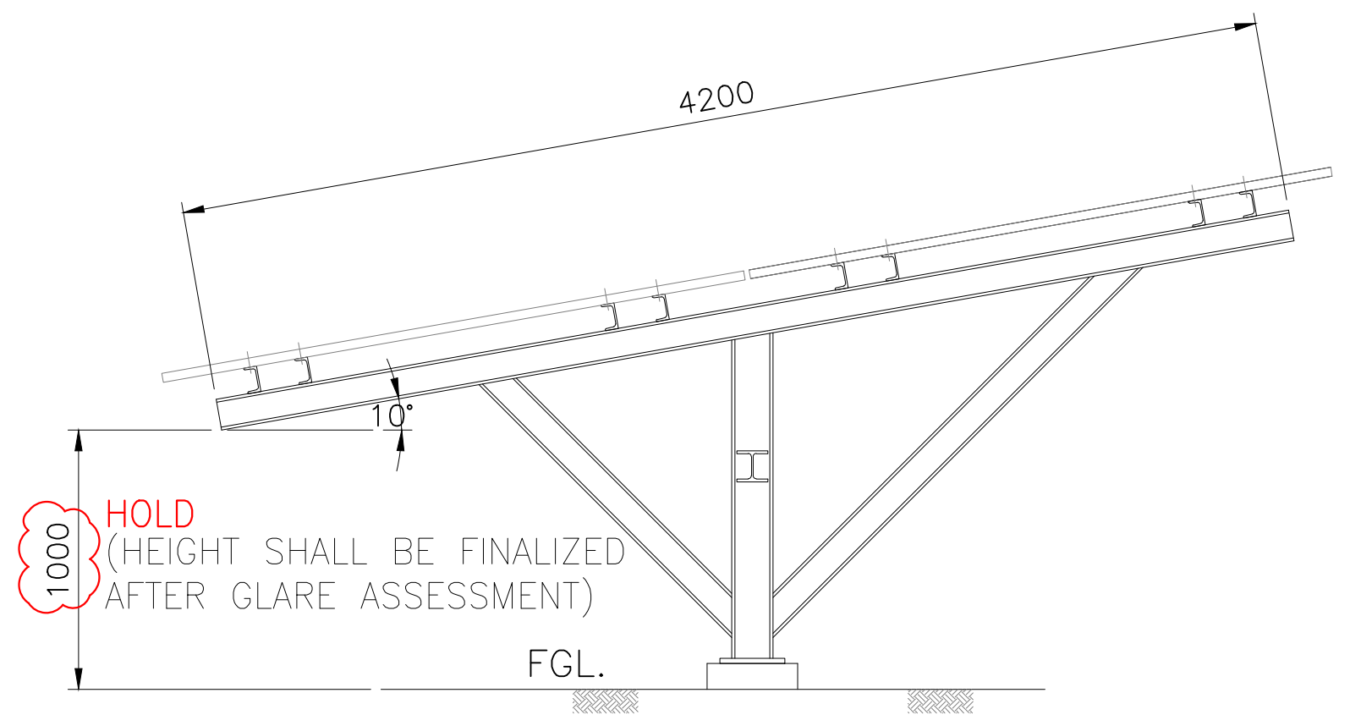
SHEET

C01

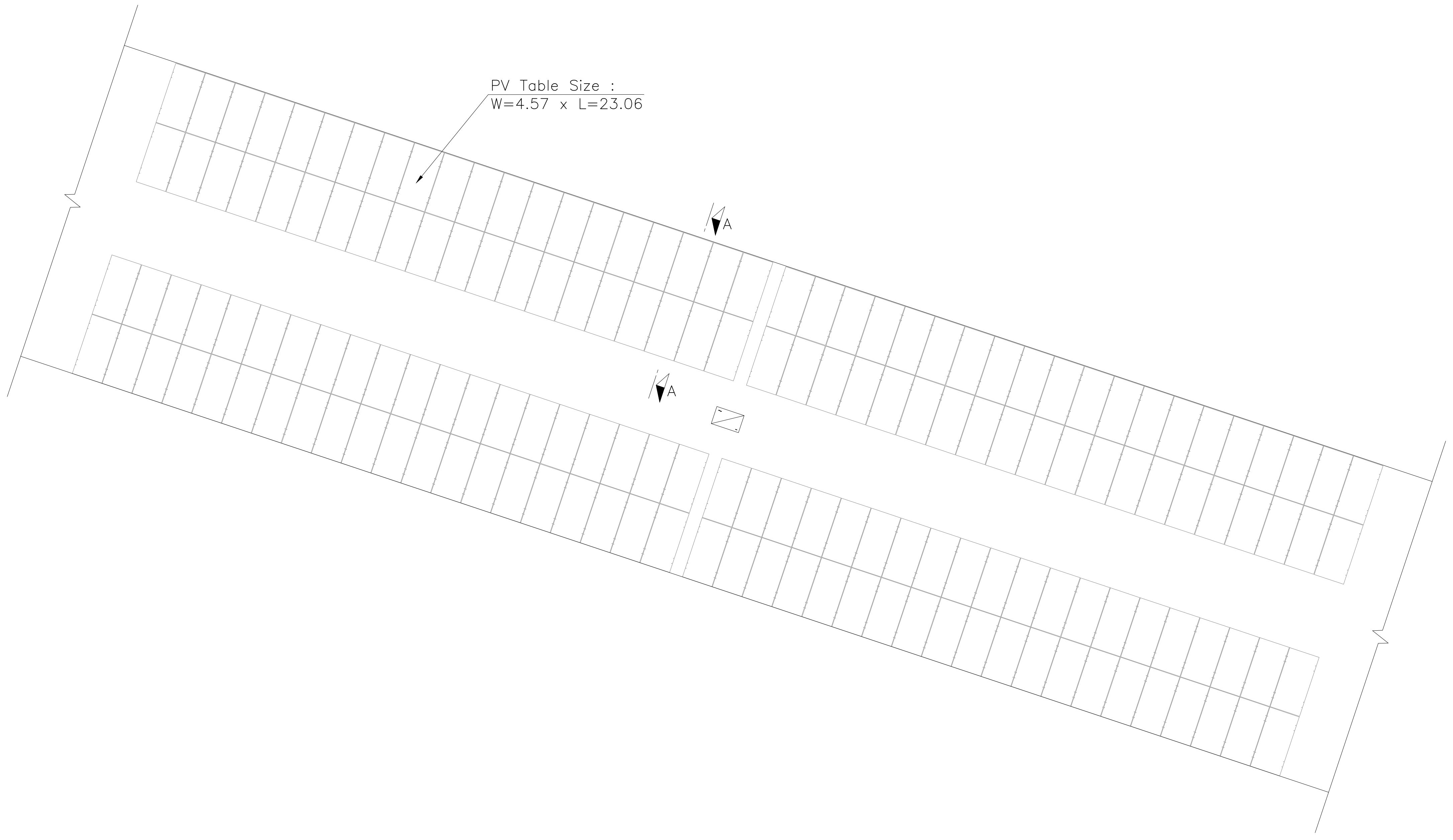
REFERENCE DRAWINGS	
DESCRIPTION	DWG. NO.
PV LAYOUT FOR KULHUDHUFFUSHI AIRPORT	–



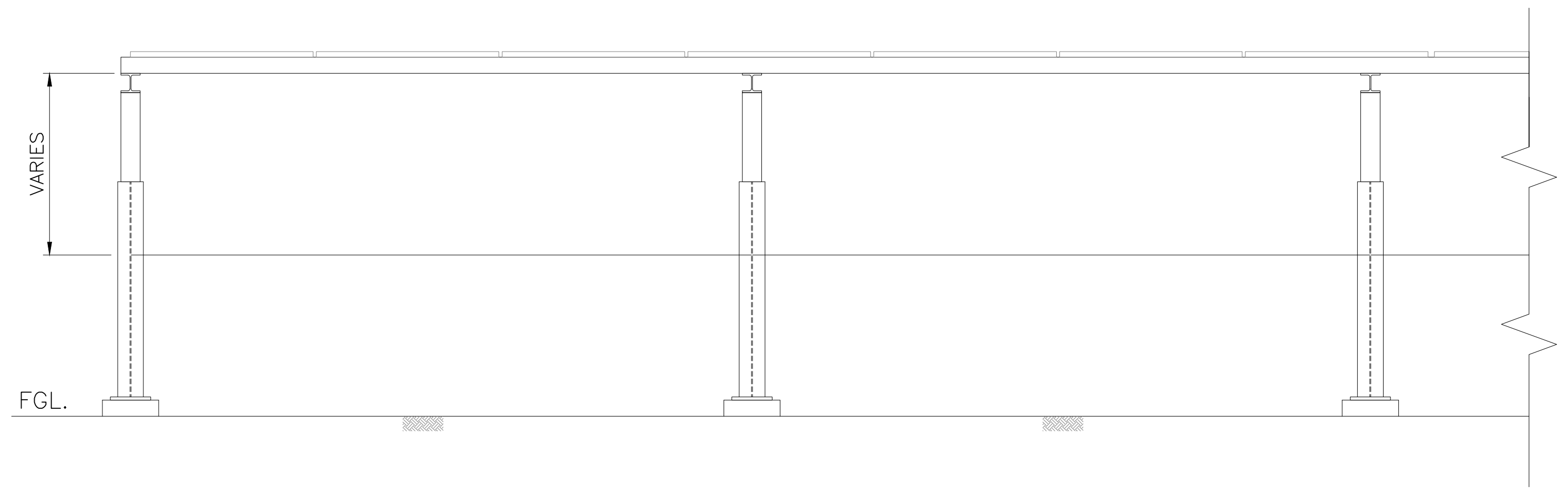
TYPICAL PLAN OF PV TABLE STRUCTURE TYPE–2
FOR PV TABLE SIZE 4570x23060



SECTION A–A
SHORTER SIDE ELEVATION



PV PART LAYOUT
NOTE: REFER OVERALL PV LAYOUT
FOR COMPLETE SCHEME



LONGER SIDE ELEVATION

SIZE OF ALL STRUCTURAL MEMBERS SHALL BE FINALIZED DURING DETAILED DESIGN.

LEGENDS:

FGL.	FINISHED GROUND LEVEL.
RL.	ROAD LEVEL.
TYP.	TYPICAL.

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE STATED.

PROJECT:
ACCELERATING SUSTAINABLE PRIVATE INVESTMENT IN RENEWABLE ENERGY (ASPIRE).

OWNER:
MEGA FIRST POWER INDUSTRIES SDN. BHD. (MALAYSIA).

OWNER'S ENGINEER:
ADVANCED CONSULTING ENGINEERS SDN BHD

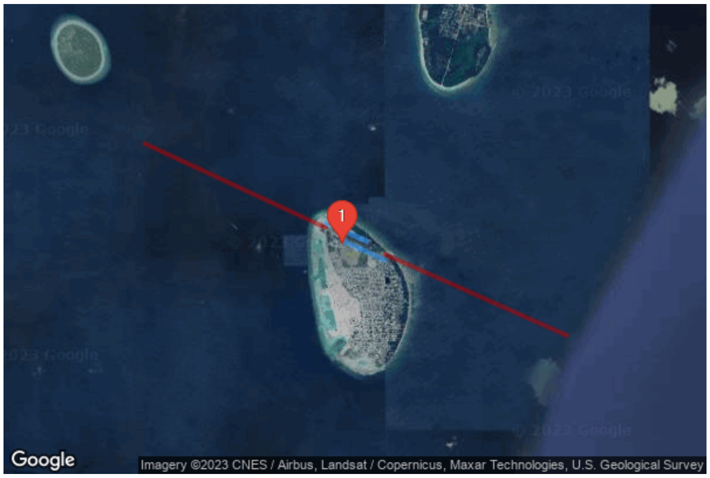
CONTRACTOR:
SINOHYDRO CORPORATION LIMITED.

SECTION: CIVIL	PAGE:	CONCEPTUAL PV STRUCTURE DRAWING FOR KULHUDHUFFUSHI AIRPORT(GROUND MOUNTED)
SCALE: AS SHOWN	1/1	

FORGESOLAR GLARE ANALYSIS

Project: **Kulhudhuffushi Airport**
Site configuration: **Kulhudhuffushi Airport**

Created 17 Apr, 2023
Updated 24 Apr, 2023
Time-step 1 minute
Timezone offset UTC5
Site ID 88468.15481
Category 1 MW to 5 MW
DNI peaks at 1,000.0 W/m^2
Ocular transmission coefficient 0.5
Pupil diameter 0.002 m
Eye focal length 0.017 m
Sun subtended angle 9.3 mrad
PV analysis methodology V2



Summary of Results

Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	24.0	3,590	59.8	1,080	18.0	2,780,000.0
PV array 11	10.0	24.0	2,329	38.8	0	0.0	420,800.0
PV array 2	10.0	32.0	3,969	66.2	0	0.0	1,006,000.0
PV array 22	10.0	32.0	6,891	114.8	5,738	95.6	1,345,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	6,674	111.2	977	16.3
FP 2	10,105	168.4	5,841	97.3
1-ATCT	0	0.0	0	0.0

Component Data

PV Arrays

Name: PV array 1
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 24.0°
Rated power: 1190.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.633540	73.063610	1.79	1.00	2.79
2	6.633430	73.063530	1.85	1.00	2.85
3	6.631070	73.068680	4.41	1.00	5.41
4	6.631180	73.068750	4.32	1.00	5.32

Name: PV array 11
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 24.0°
Rated power: 180.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.631181	73.068750	4.62	1.00	5.62
2	6.631071	73.068680	4.79	1.00	5.79
3	6.630690	73.069501	3.51	1.00	4.51
4	6.630810	73.069560	3.88	1.00	4.88

Name: PV array 2
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 32.0°
Rated power: 430.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.630710	73.066410	1.78	1.00	2.78
2	6.630610	73.066370	1.71	1.00	2.71
3	6.629635	73.068500	0.48	1.00	1.48
4	6.629727	73.068551	0.70	1.00	1.70

Name: PV array 22
Axis tracking: Fixed (no rotation)
Tilt: 10.0°
Orientation: 32.0°
Rated power: 575.0 kW
Panel material: Smooth glass with AR coating
Reflectivity: Vary with sun
Slope error: correlate with material

Vertex	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
1	6.629725	73.068552	0.70	1.00	1.70
2	6.629636	73.068500	0.51	1.00	1.51
3	6.627980	73.072110	6.56	1.00	7.56
4	6.628080	73.072150	6.29	1.00	7.29

Flight Path Receptors

Name: FP 1

Description:

Threshold height: 15 m

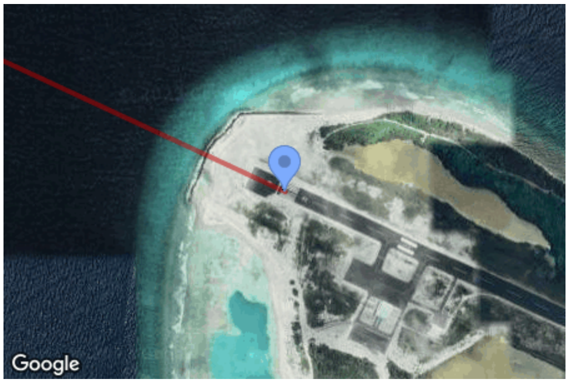
Direction: 114.9°

Glide slope: 3.3°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°



Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	6.632770	73.063378	1.26	15.24	16.50
Two-mile	6.644943	73.036945	0.00	202.09	202.09

Name: FP 2

Description:

Threshold height: 15 m

Direction: 294.0°

Glide slope: 3.3°

Pilot view restricted? Yes

Vertical view: 30.0°

Azimuthal view: 50.0°

Point	Latitude (°)	Longitude (°)	Ground elevation (m)	Height above ground (m)	Total elevation (m)
Threshold	6.628880	73.072150	3.99	15.24	19.23
Two-mile	6.617106	73.098766	0.00	204.82	204.82

Discrete Observation Point Receptors

Name	ID	Latitude (°)	Longitude (°)	Elevation (m)	Height (m)
1-ATCT	1	6.630404	73.065957	1.99	9.85

Map image of 1-ATCT

Glare Analysis Results

Summary of Results Glare with potential for temporary after-image predicted

PV Array	Tilt	Orient	Annual Green Glare		Annual Yellow Glare		Energy
	°	°	min	hr	min	hr	kWh
PV array 1	10.0	24.0	3,590	59.8	1,080	18.0	2,780,000.0
PV array 11	10.0	24.0	2,329	38.8	0	0.0	420,800.0
PV array 2	10.0	32.0	3,969	66.2	0	0.0	1,006,000.0
PV array 22	10.0	32.0	6,891	114.8	5,738	95.6	1,345,000.0

Total annual glare received by each receptor; may include duplicate times of glare from multiple reflective surfaces.

Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	6,674	111.2	977	16.3
FP 2	10,105	168.4	5,841	97.3
1-ATCT	0	0.0	0	0.0

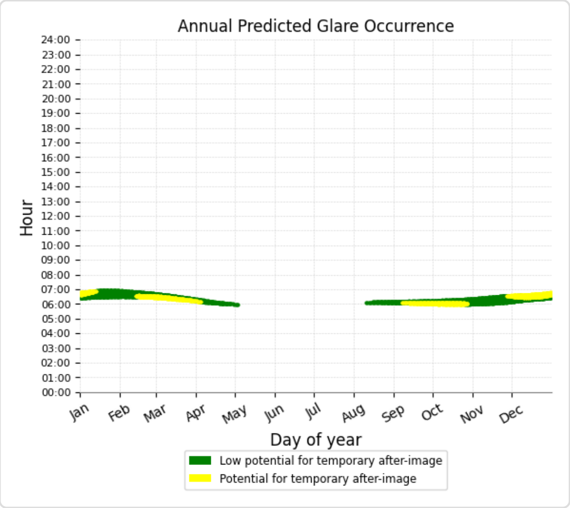
PV: PV array 1 potential temporary after-image

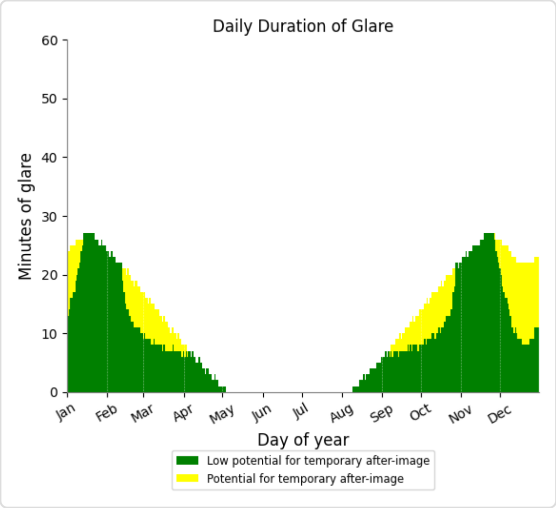
Receptor results ordered by category of glare

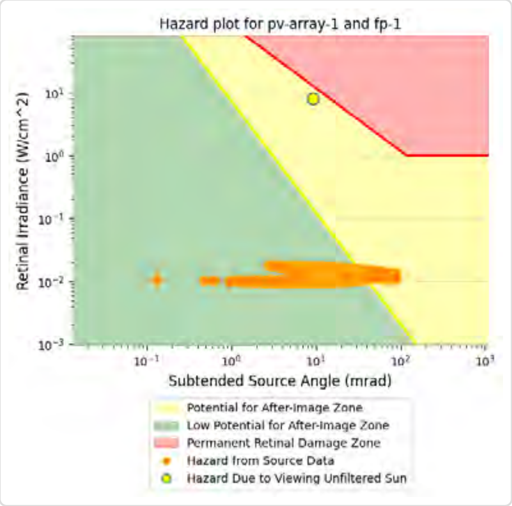
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	3,326	55.4	977	16.3
FP 2	264	4.4	103	1.7
1-ATCT	0	0.0	0	0.0

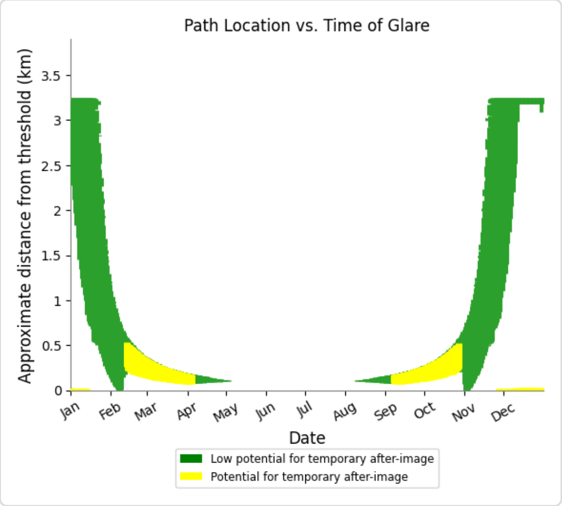
PV array 1 and FP 1

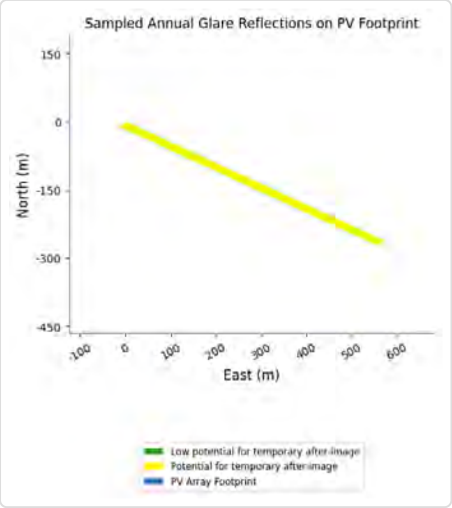
Receptor type: 2-mile Flight Path
977 minutes of yellow glare
3,326 minutes of green glare

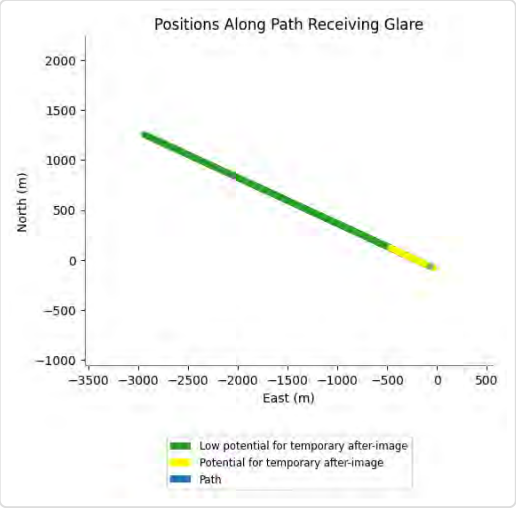

Annual Predicted Glare Occurrence


Daily Duration of Glare


Hazard plot for pv-array-1 and fp-1

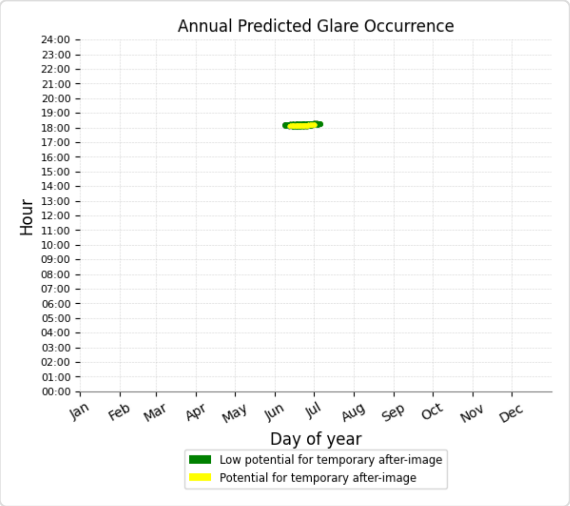

Path Location vs. Time of Glare

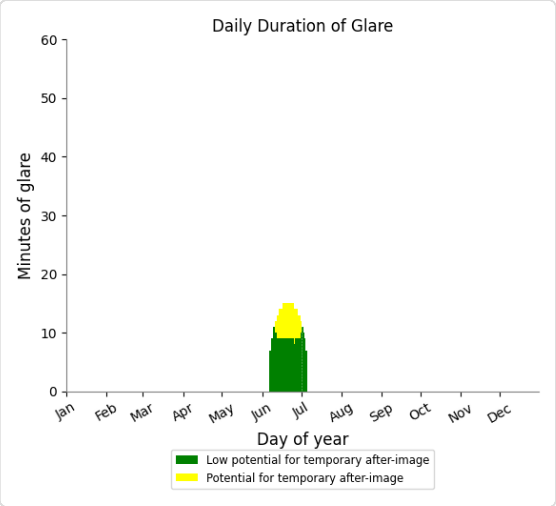

Sampled Annual Glare Reflections on PV Footprint

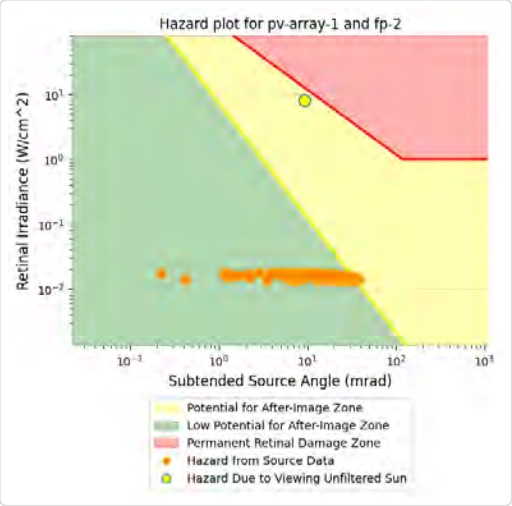

Positions Along Path Receiving Glare

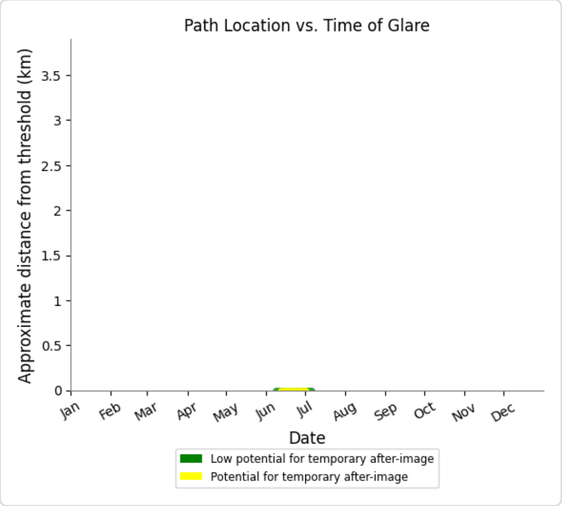
PV array 1 and FP 2

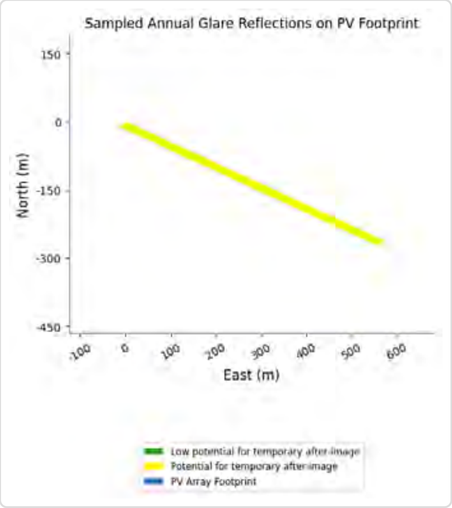
Receptor type: 2-mile Flight Path
103 minutes of yellow glare
264 minutes of green glare

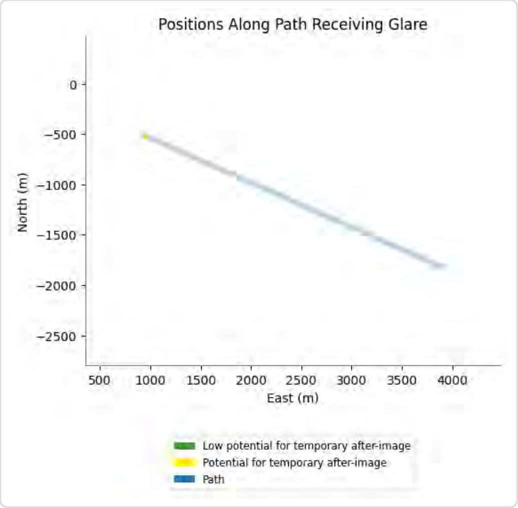

Annual Predicted Glare Occurrence


Daily Duration of Glare


Hazard plot for pv-array-1 and fp-2


Path Location vs. Time of Glare


Sampled Annual Glare Reflections on PV Footprint


Positions Along Path Receiving Glare

PV array 1 and 1-ATCT

Receptor type: Observation Point

No glare found

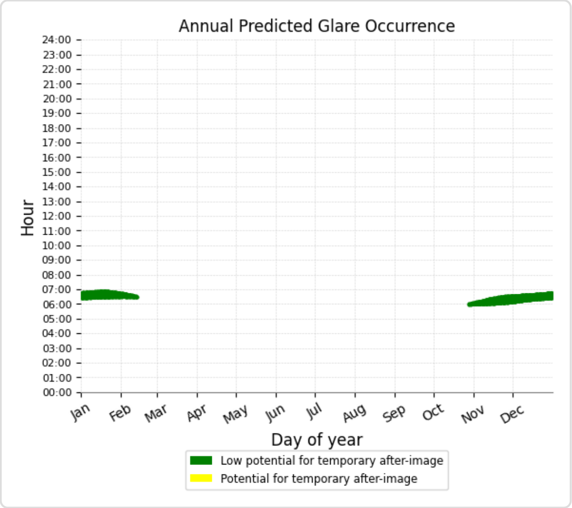
PV: PV array 11 low potential for temporary after-image

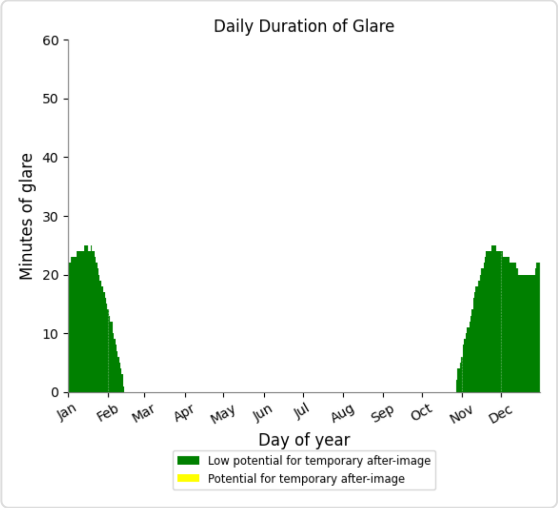
Receptor results ordered by category of glare

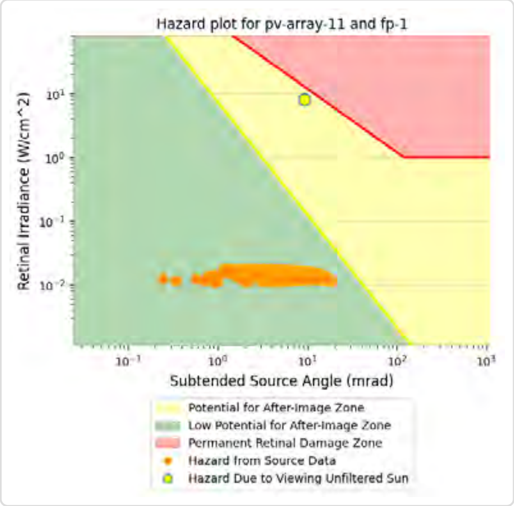
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	hr	min	hr
FP 1	2,025	33.8	0	0.0
FP 2	304	5.1	0	0.0
1-ATCT	0	0.0	0	0.0

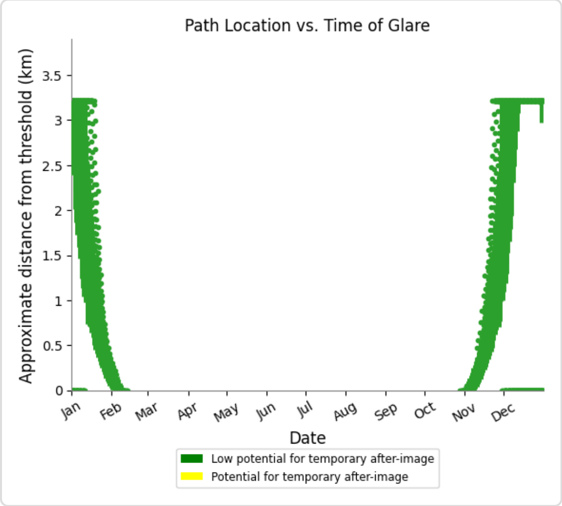
PV array 11 and FP 1

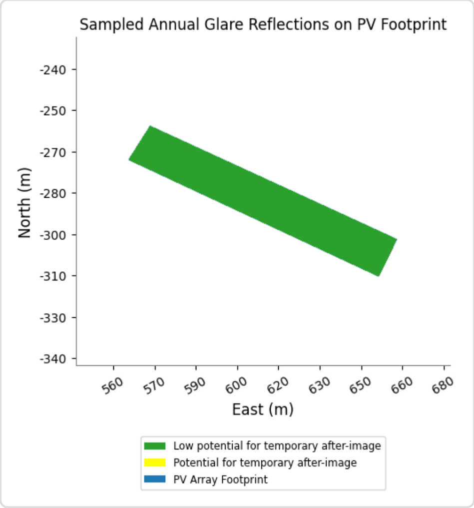
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
2,025 minutes of green glare

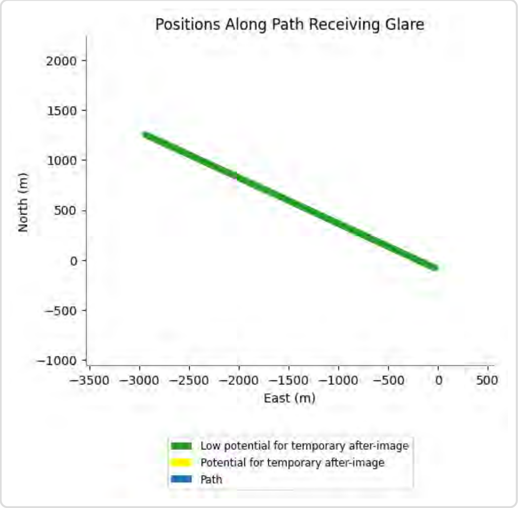






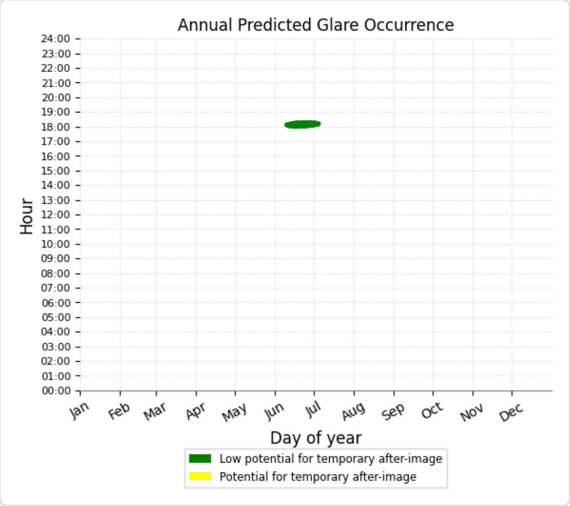


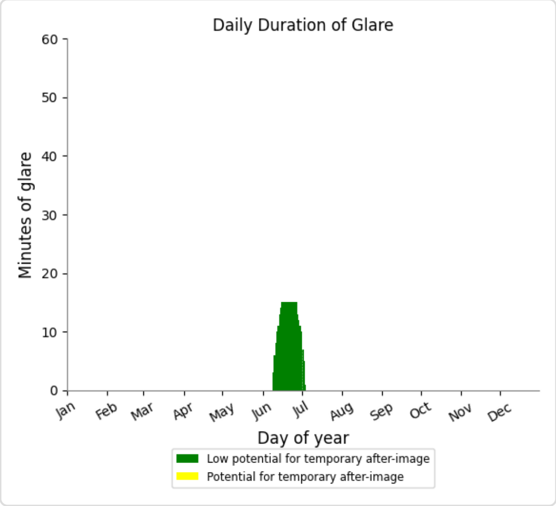


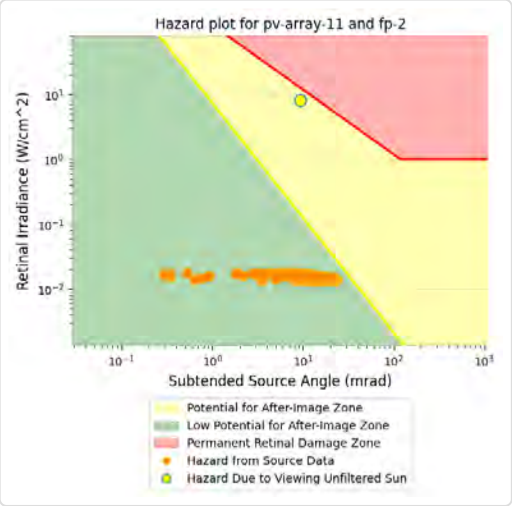


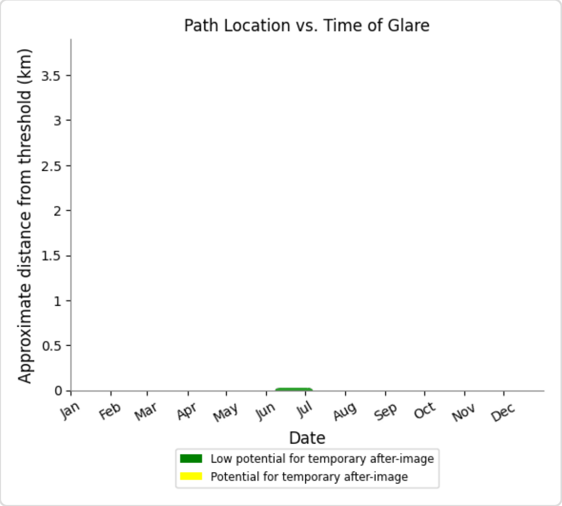
PV array 11 and FP 2

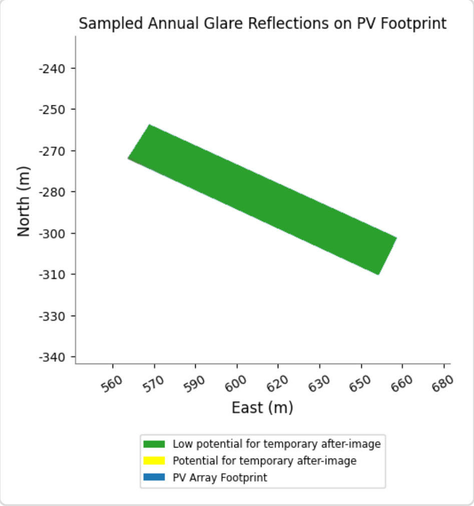
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
304 minutes of green glare

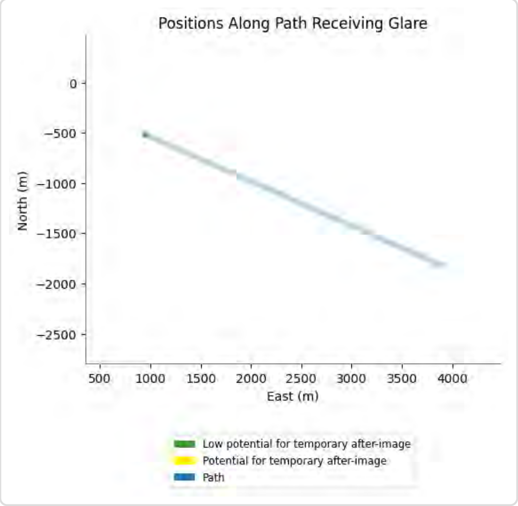












PV array 11 and 1-ATCT

Receptor type: Observation Point

No glare found

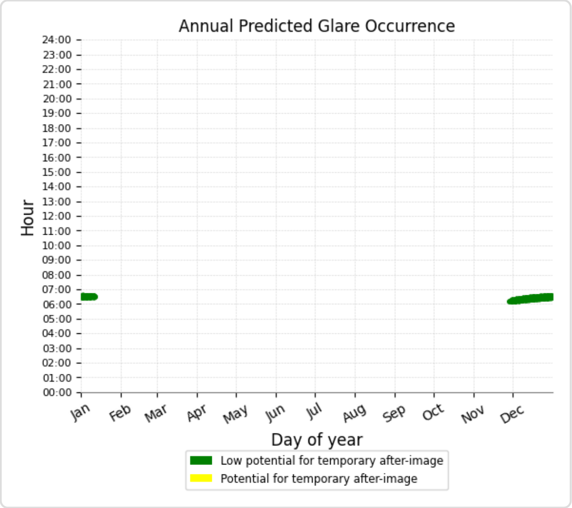
PV: PV array 2 low potential for temporary after-image

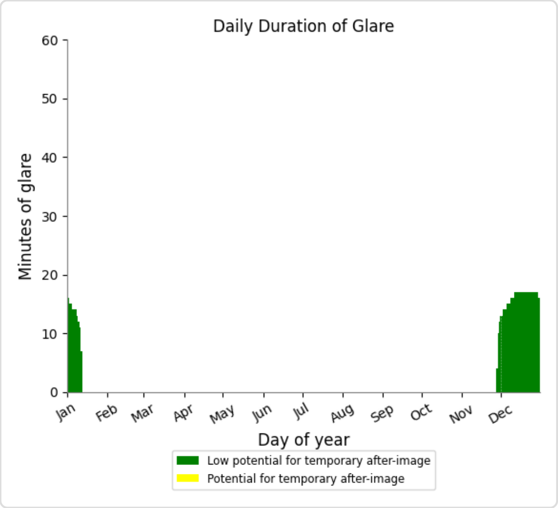
Receptor results ordered by category of glare

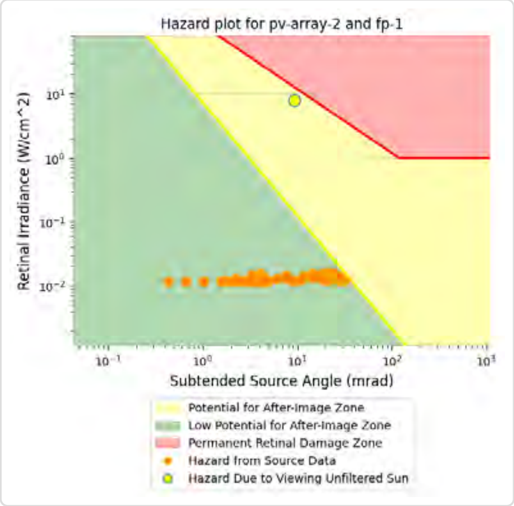
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
FP 1	686	11.4	0	0.0
FP 2	3,283	54.7	0	0.0
1-ATCT	0	0.0	0	0.0

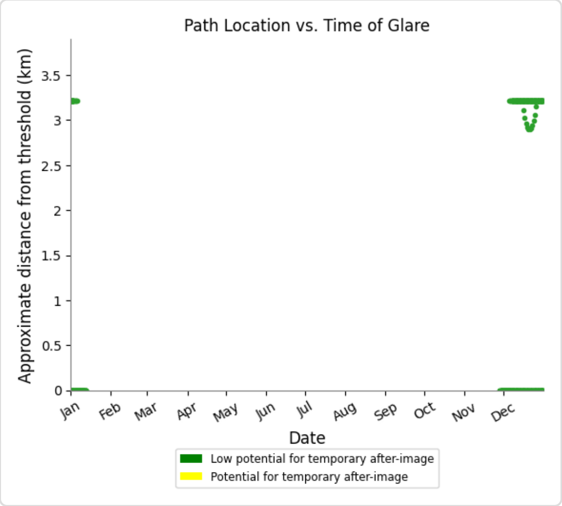
PV array 2 and FP 1

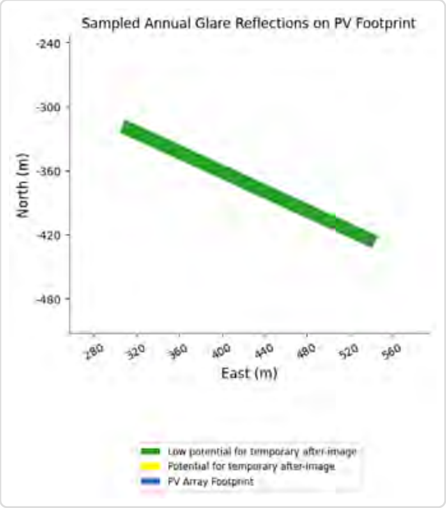
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
686 minutes of green glare

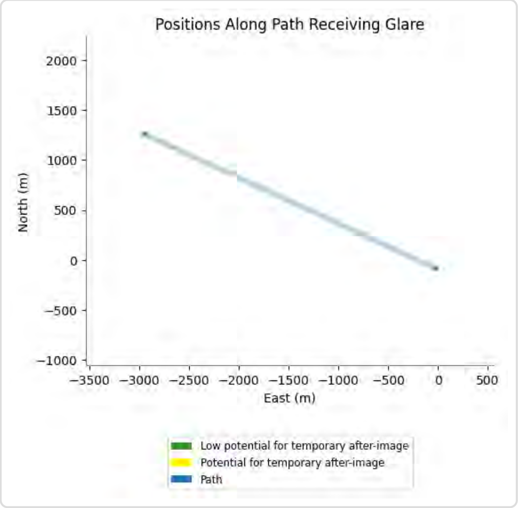






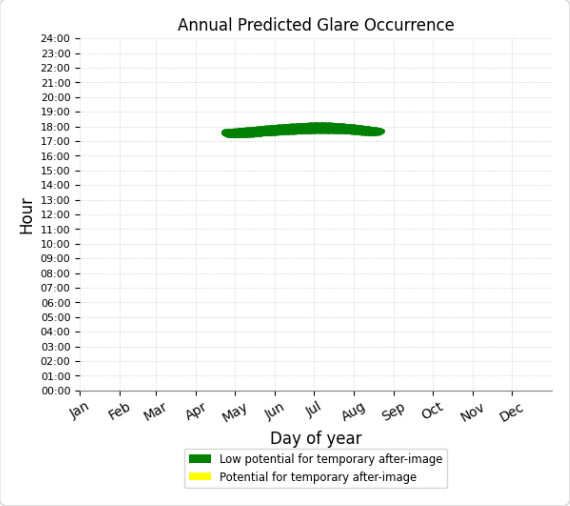


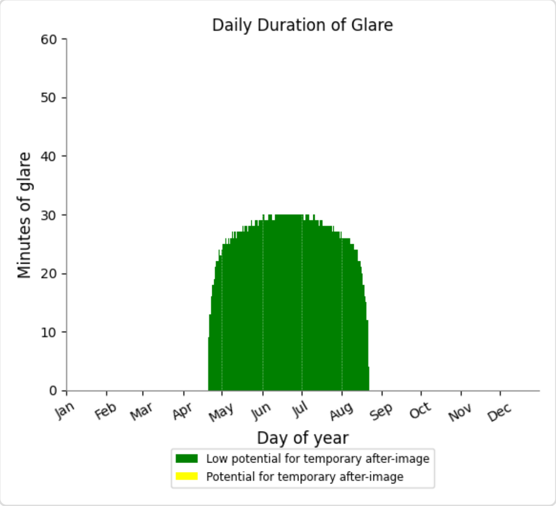


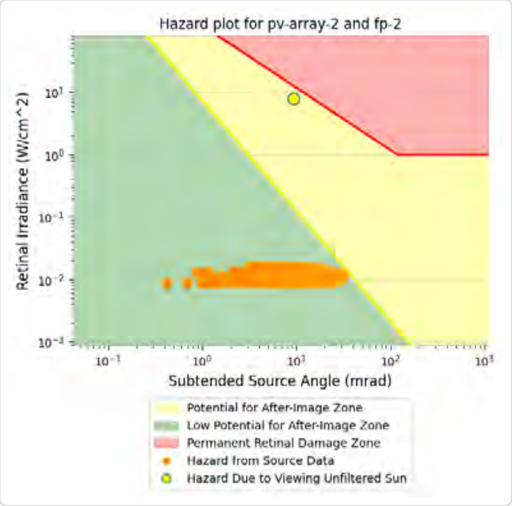


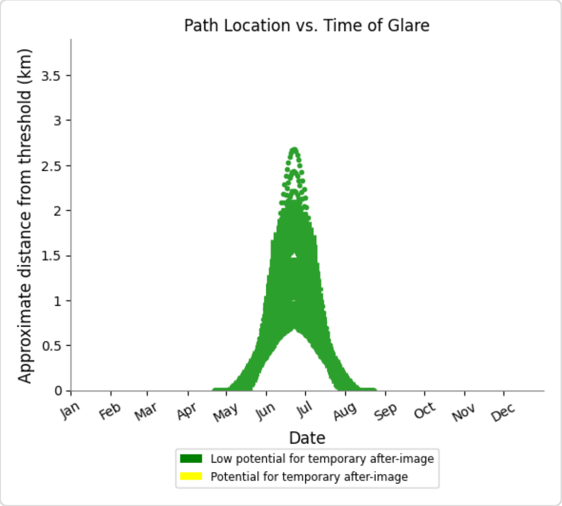
PV array 2 and FP 2

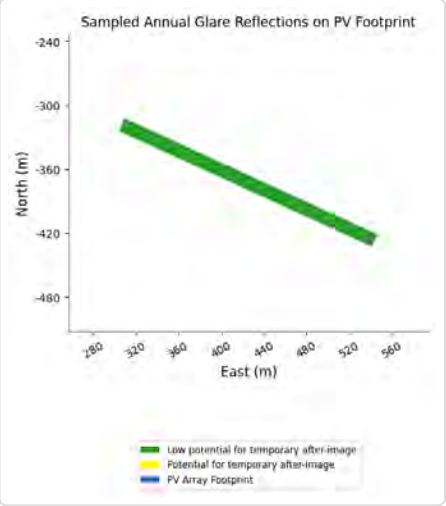
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
3,283 minutes of green glare

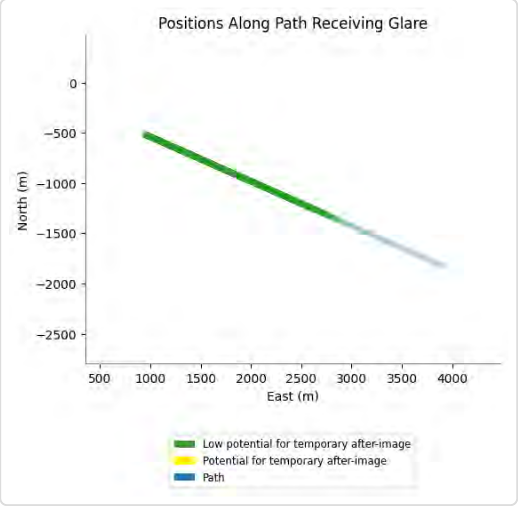












PV array 2 and 1-ATCT

Receptor type: Observation Point

No glare found

PV: PV array 22 potential temporary after-image

Receptor results ordered by category of glare

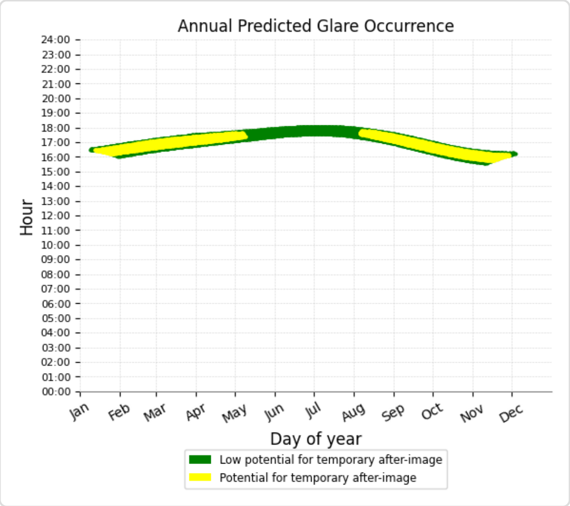
Receptor	Annual Green Glare		Annual Yellow Glare	
	min	**hr**	**min**	**hr**
FP 2	6,254	104.2	5,738	95.6
FP 1	637	10.6	0	0.0
1-ATCT	0	0.0	0	0.0

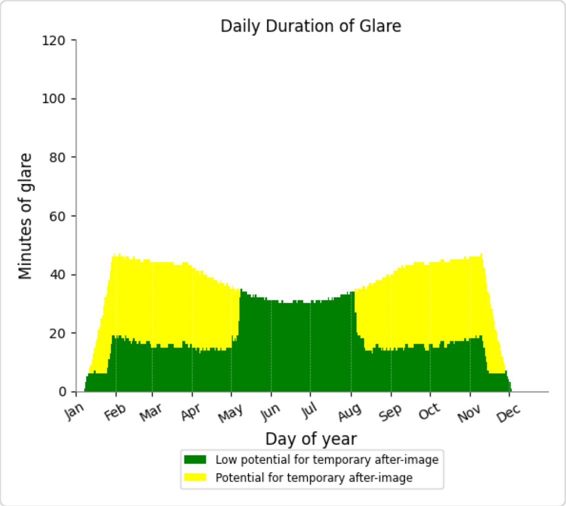
PV array 22 and FP 2

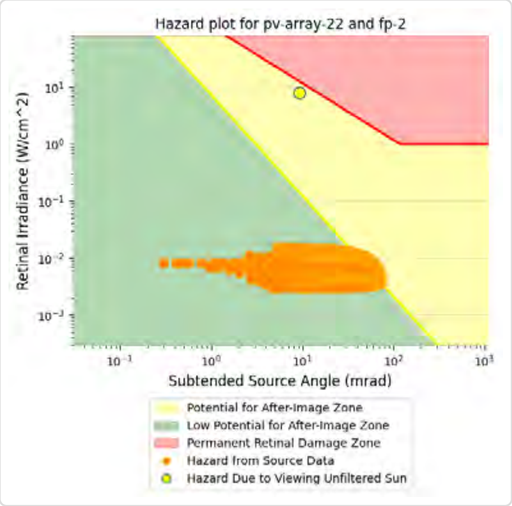
Receptor type: 2-mile Flight Path

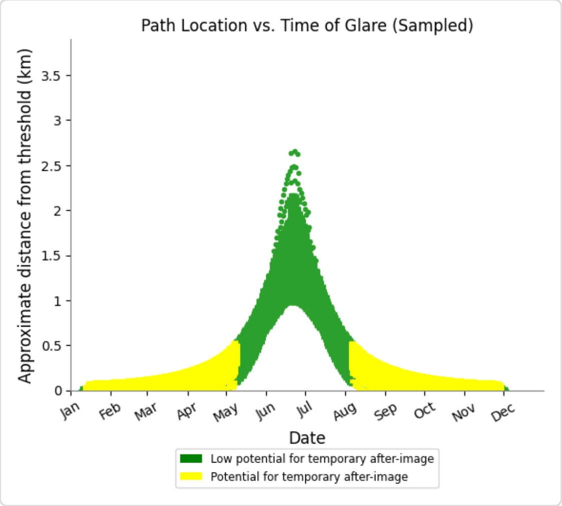
5,738 minutes of yellow glare

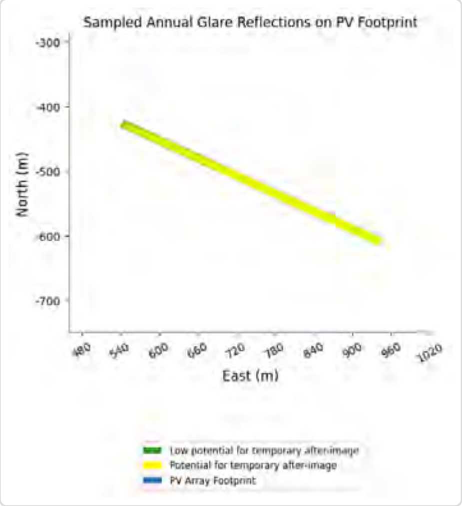
6,254 minutes of green glare

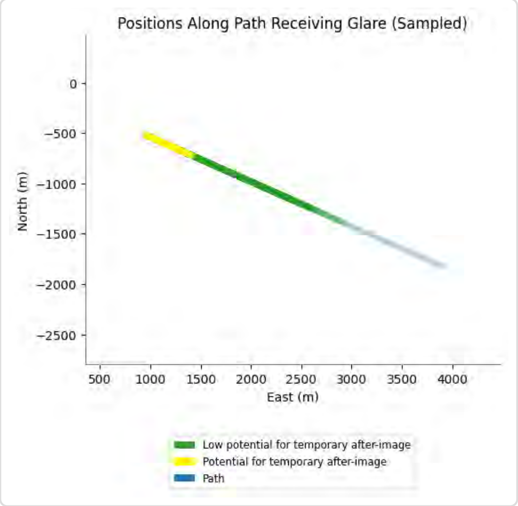






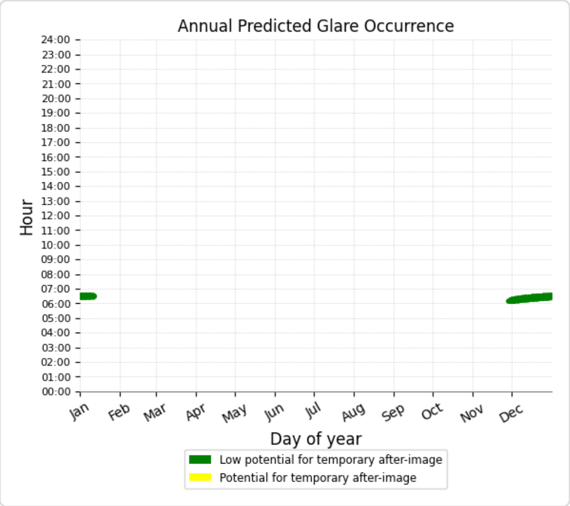


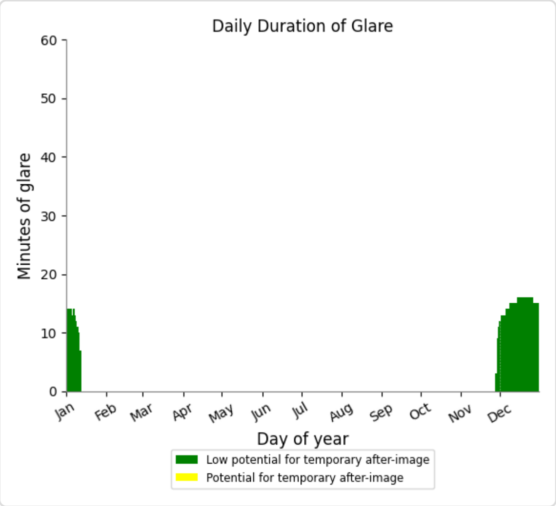


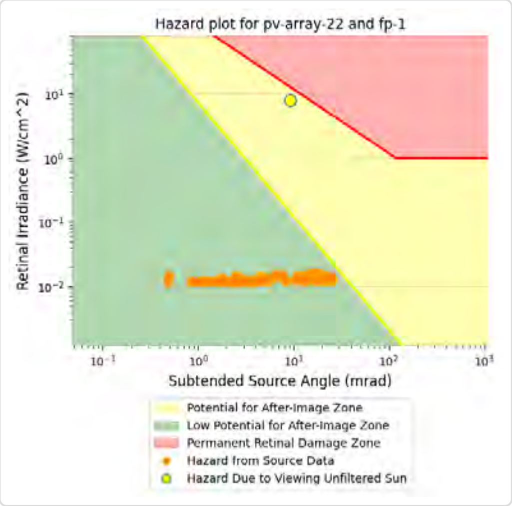


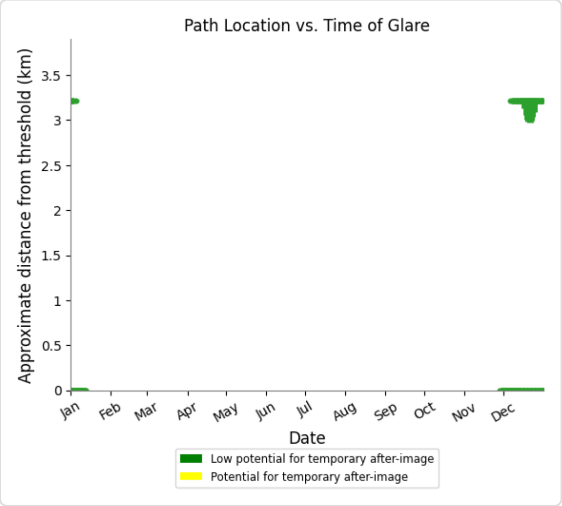
PV array 22 and FP 1

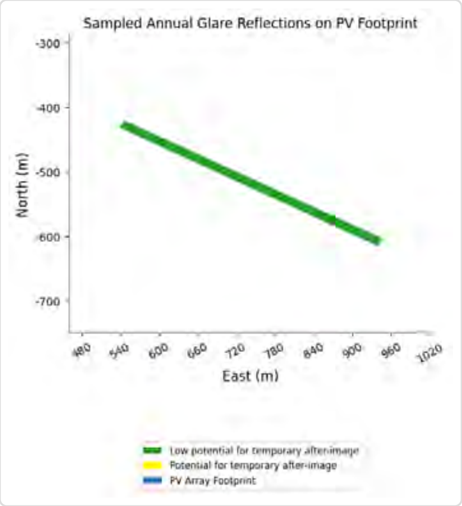
Receptor type: 2-mile Flight Path
0 minutes of yellow glare
637 minutes of green glare

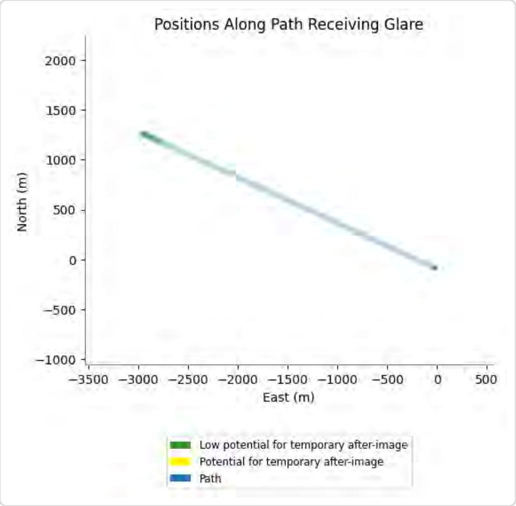

Annual Predicted Glare Occurrence


Daily Duration of Glare


Hazard plot for pv-array-22 and fp-1


Path Location vs. Time of Glare


Sampled Annual Glare Reflections on PV Footprint


Positions Along Path Receiving Glare

PV array 22 and 1-ATCT

Receptor type: Observation Point

No glare found

Assumptions

"Green" glare is glare with low potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
"Yellow" glare is glare with potential to cause an after-image (flash blindness) when observed prior to a typical blink response time.
Times associated with glare are denoted in Standard time. For Daylight Savings, add one hour.
The algorithm does not rigorously represent the detailed geometry of a system; detailed features such as gaps between modules, variable height of the PV array, and support structures may impact actual glare results. However, we have validated our models against several systems, including a PV array causing glare to the air-traffic control tower at Manchester-Boston Regional Airport and several sites in Albuquerque, and the tool accurately predicted the occurrence and intensity of glare at different times and days of the year.
Several V1 calculations utilize the PV array centroid, rather than the actual glare spot location, due to algorithm limitations. This may affect results for large PV footprints. Additional analyses of array sub-sections can provide additional information on expected glare. This primarily affects V1 analyses of path receptors.
Random number computations are utilized by various steps of the annual hazard analysis algorithm. Predicted minutes of glare can vary between runs as a result. This limitation primarily affects analyses of Observation Point receptors, including ATCTs. Note that the SGHAT/ForgeSolar methodology has always relied on an analytical, qualitative approach to accurately determine the overall hazard (i.e. green vs. yellow) of expected glare on an annual basis.
The analysis does not automatically consider obstacles (either man-made or natural) between the observation points and the prescribed solar installation that may obstruct observed glare, such as trees, hills, buildings, etc.
The subtended source angle (glare spot size) is constrained by the PV array footprint size. Partitioning large arrays into smaller sections will reduce the maximum potential subtended angle, potentially impacting results if actual glare spots are larger than the sub-array size. Additional analyses of the combined area of adjacent sub-arrays can provide more information on potential glare hazards. (See previous point on related limitations.)
The variable direct normal irradiance (DNI) feature (if selected) scales the user-prescribed peak DNI using a typical clear-day irradiance profile. This profile has a lower DNI in the mornings and evenings and a maximum at solar noon. The scaling uses a clear-day irradiance profile based on a normalized time relative to sunrise, solar noon, and sunset, which are prescribed by a sun-position algorithm and the latitude and longitude obtained from Google maps. The actual DNI on any given day can be affected by cloud cover, atmospheric attenuation, and other environmental factors.
The ocular hazard predicted by the tool depends on a number of environmental, optical, and human factors, which can be uncertain. We provide input fields and typical ranges of values for these factors so that the user can vary these parameters to see if they have an impact on the results. The speed of SGHAT allows expedited sensitivity and parametric analyses.
The system output calculation is a DNI-based approximation that assumes clear, sunny skies year-round. It should not be used in place of more rigorous modeling methods.
Hazard zone boundaries shown in the Glare Hazard plot are an approximation and visual aid based on aggregated research data. Actual ocular impact outcomes encompass a continuous, not discrete, spectrum.
Glare locations displayed on receptor plots are approximate. Actual glare-spot locations may differ.
Refer to the Help page at **www.forgesolar.com/help/** for assumptions and limitations not listed here.

Default glare analysis parameters and observer eye characteristics (for reference only):

- Analysis time interval: 1 minute
- Ocular transmission coefficient: 0.5
- Pupil diameter: 0.002 meters
- Eye focal length: 0.017 meters
- Sun subtended angle: 9.3 milliradians

APPENDIX F – Environmentally Significant and Protected Areas


Eydhafushi
Protected Area within 10 km
Legend
10 km
B. Anga Faru Area
DH. Dhigali Haa and Dhigili Giri
Eydhafushi
B. Anga Faru Area
DH. Dhigali Haa and Dhigili Giri
Eydhafushi
Google Earth
Image Landsat / Copernicus
6 mi
N

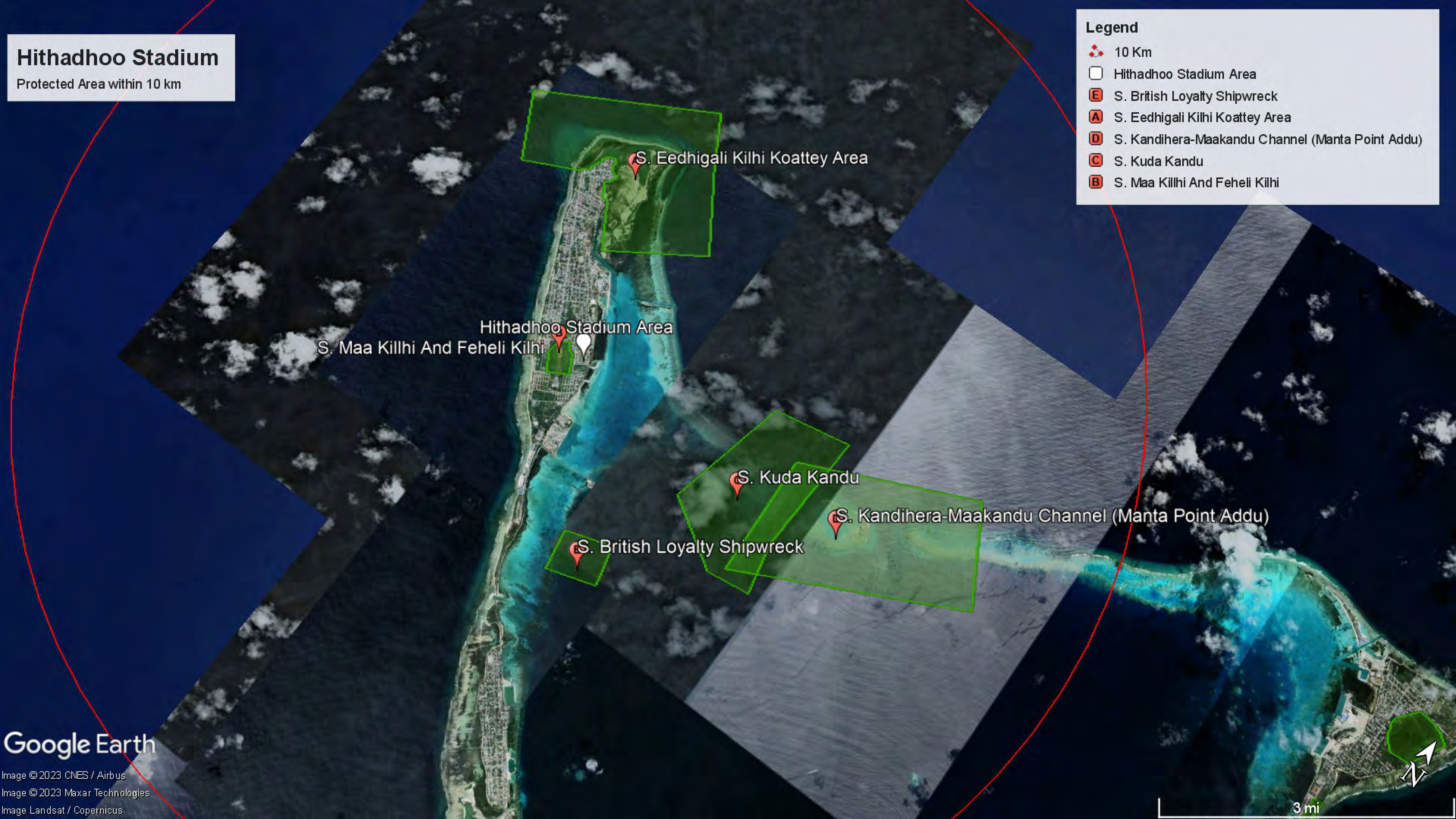
Feydhoo Harbor

Protected Area within 10 km

Fuvahmulah

Protected Area within 10 km


Hinnavaru
Protected Areas within 10km
Legend
10 km
Hinnavaru
C LH. Anemone Thila
D LH. Dhashugirifinolhu
B LH. Fushifaru Region
A LH. Kuredhi Kanduolhi (Kuredhu Express)
LH. Kuredhi Kanduolhi (Kuredhu Express)
LH. Fushifaru Region
Hinnavaru
LH. Anemone Thila
LH. Dhashugirifinolhu
Google Earth
Image Landsat / Copernicus
N
4 mi



Hithadhoo Stadium

Protected Area within 10 km

Image © 2023 CNES / Airbus
Image © 2023 Maxar Technologies
Image Landsat / Copernicus

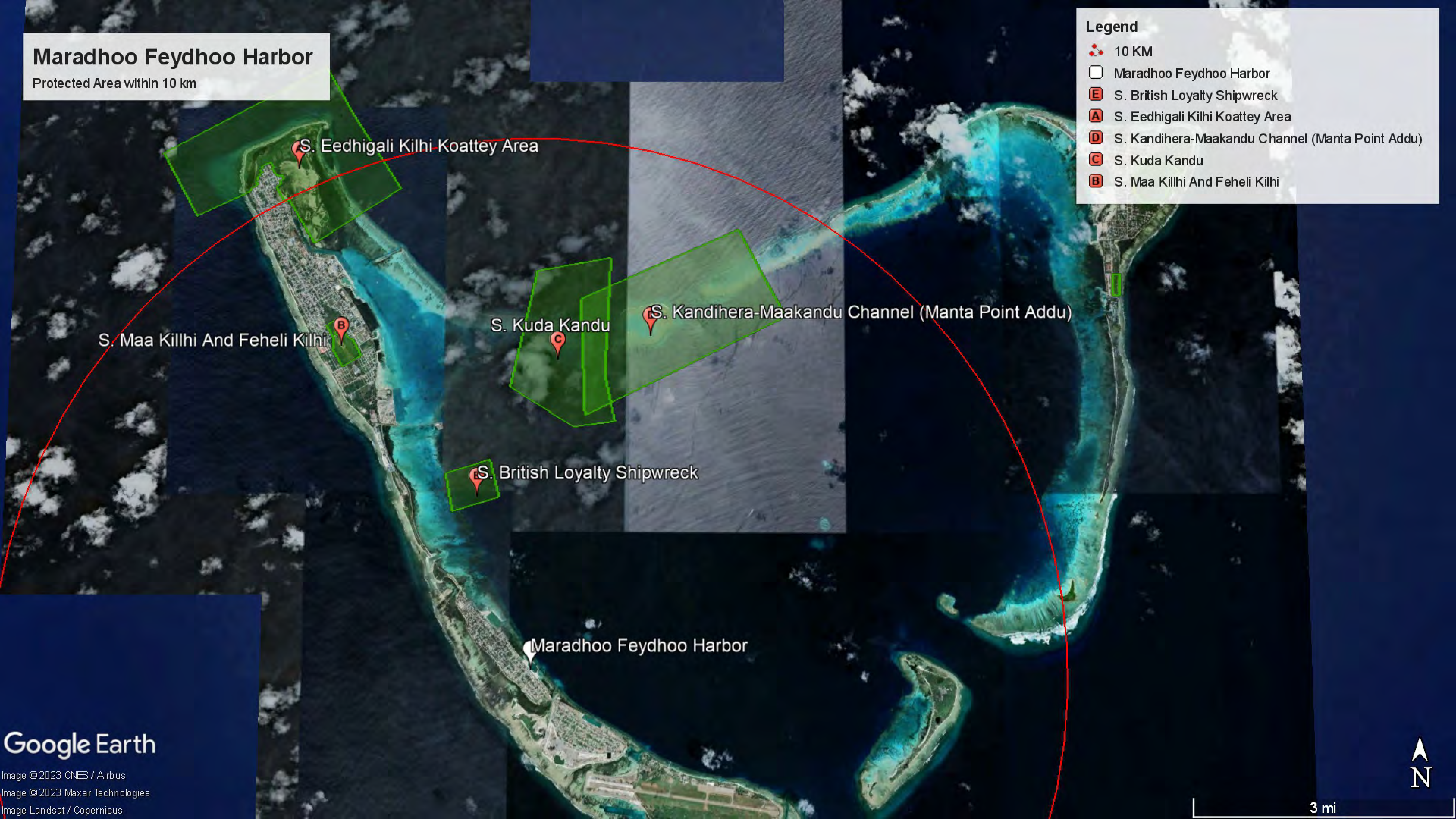
Hulhumeedhoo

Protected Area within 10 km

Kulhudhuffushi
Protected Area within 10 km

Maradhoo Feydhoo Harbor

Protected Area within 10 km



Kulhudhuffushi

Nearest Sensitive Area

Image © 2023 CNES / Airbus

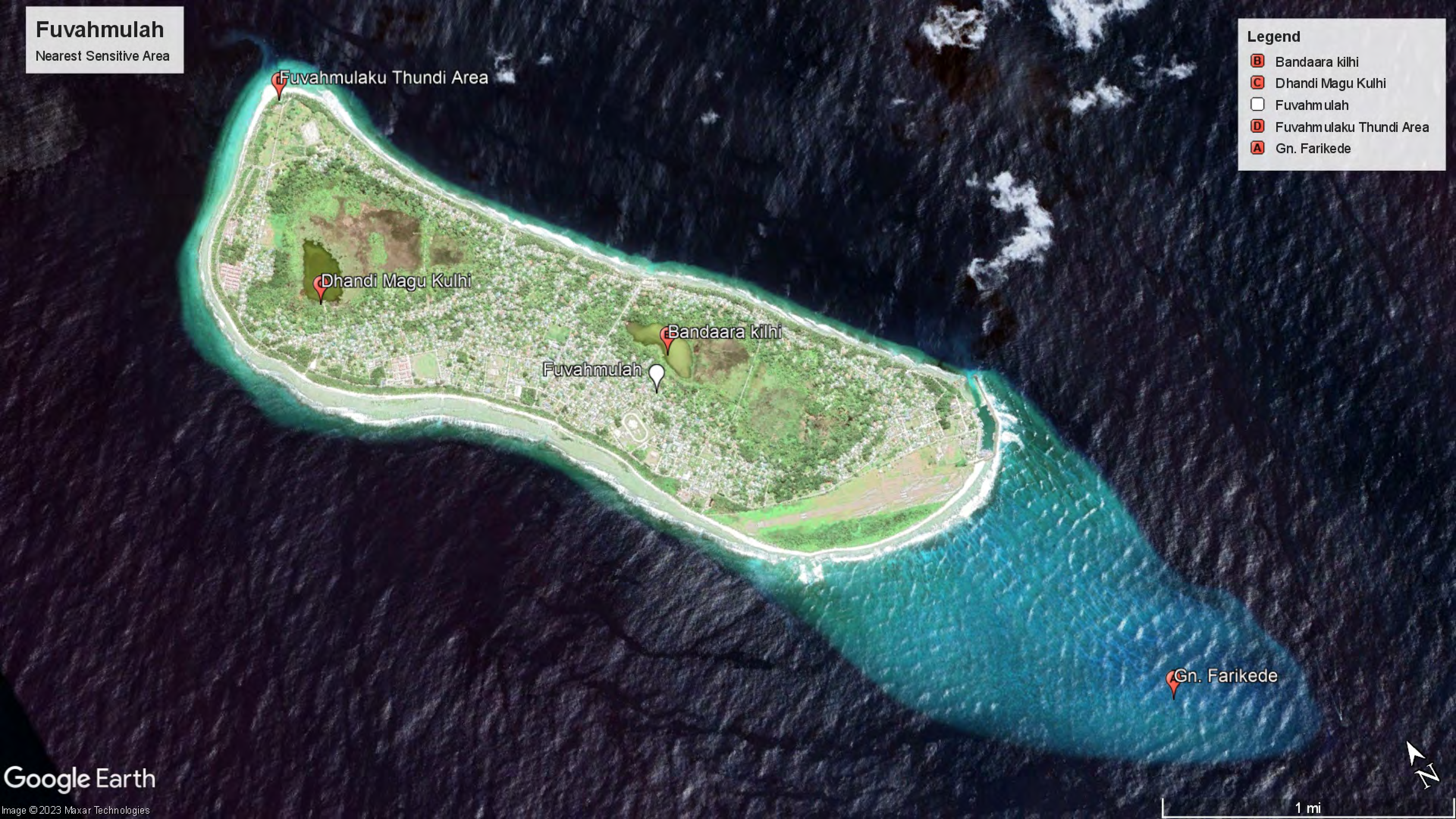

Eydhafushi
Nearest Sensitive Areas
Legend
☐ Eydhafushi
B Maddoo
A Nelivaru Finolhu
Nelivaru Finolhu
Eydhafushi
Maddoo
Google Earth
Image © 2023 CNES / Airbus
1 mi
N

Hinnavaru

Nearest Sensitive Area

Thinadhoo

Nearest Sensitive Area


Fuvahmulah
Nearest Sensitive Area
Legend
B Bandaara kilhi
C Dhandi Magu Kulhi
Fuvahmulah
D Fuvahmulaku Thundi Area
A Gn. Farikede
Fuvahmulaku Thundi Area
Dhandi Magu Kulhi
Bandaara kilhi
Fuvahmulah
Gn. Farikede
Google Earth
Image © 2023 Maxar Technologies
1 mi
N

Hulhumeedhoo

Sensitive Areas near the location

Image © 2023 CNES / Airbus
Image © 2023 Maxar Technologies
Image Landsat / Copernicus

Addu Hithadhoo Stadium
Sensitive Areas in the location
Legend
C British Loyalty Wreck
A Hithadhoo Seagrass beds
☐ Hithadhoo Stadium Area
E Kandihera Heraa-gandu
D Kuda Kandu
F Maa Kandu
B Maamendhoo Kulhi
Hithadhoo Seagrass beds
Hithadhoo Stadium Area
Maamendhoo Kulhi
Kuda Kandu
Kandihera Heraa-gandu
Maa Kandu
British Loyalty Wreck
N
2 mi
Google Earth
Image Landsat / Copernicus
Image © 2023 Maxar Technologies

APPENDIX G – Commitment Letter

MFPI
Mega First Power Industries Sdn Bhd

Date: 05th May 2023

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Male', Republic of Maldives

Subject: Environmental Social Impact Assessment for the Proposed Installation of 11.3 MW Solar PV Systems in Addu City, Eydhafushi, Fuvahmulah City, Hinnavaru, Thinadhoo, and Kulhudhuffushi City. (203-ECA/PRIV/2022/647)

Dear Sir,

As the proponent of the above mentioned project, we confirm that we have read the report and to the best of our knowledge all non-technical information provided in the report is accurate and complete.

We also hereby confirm our commitment to undertake the mitigation and monitoring measures as stated in the Environmental Impact Assessment.

Sincerely,

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

GOH CHIN SAN

Authorised Representative,
Mega First Power Industries Sdn. Bhd.
JV with
Powerchina Huadong Engineering Corporation

APPENDIX H – Site Handover Agreements

LICENSE AGREEMENT
FOR THE INSTALLATION OF GROUND MOUNTED SOLAR PANELS

BETWEEN

ADDU CITY COUNCIL

(MALDIVES)

("LICENSOR")

– AND –

MEGA FIRST POWER INDUSTRIES Sdn. Bhd. (MALAYSIA)

IN JOINT VENTURE WITH

POWERCHINA HUADONG ENGINEERING CORPORATION LIMITED (CHINA)

("LICENSEE")

AGREEMENT NUMBER: (AGR)426-AA/438/2022/1

DATE: JULY 24, 2022

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and entered into as of the *24th July 2022* by and between:

1. **Addu City Council**, a local council of the Government of Maldives, established under Act Number: 7/2010 (Decentralization Act of Maldives) with its offices at Medhe-aari Magu, Hithadhoo, Addu City ("Licensor"); and

2. **Mega First Power Industries Sdn. Bhd. (MFPI)** a limited liability company, company registration number: 199601020584 (392936-W) , organized and existing under the laws of Malaysia, with its principal office located at A-12-01, Level 12, Block A, PJ8, No. 23, Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia, and **Powerchina Huadong Engineering Corporation Limited (HDEC)** a limited liability company with Unified Social Credit Code: 91330000142920718C, organized and existing under the laws of Peoples Republic of China, with its principal office located at No. 22, ChaoWang Road Hangzhou 310014, Zhejiang Province, The People's Republic of China (**MFPI** and **HDEC** will be jointly and severally liable, and collectively will be hereinafter referred to as the "Licensee").

WHEREAS:

A. The Government (as defined in the PPA), with support from the Strategic Climate Fund and International Development Association, has initiated a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) for inviting private sector generators to develop [roof top and ground mounted] solar photovoltaic projects in Maldives on a DBFOOT (i.e. design, build, finance, own, operate and transfer) basis. The electrical energy generated from such projects is proposed to be purchased by a Government owned utility under a long-term power purchase agreement.

B. The Government had invited bids from interested independent power producers, *vide* RFP (as defined in the PPA) dated June 17th, 2021 for setting up solar power projects on Government-owned buildings and public spaces identified and facilitated by the Government in the RFP.

C. The Licensee had submitted a Proposal (as defined in the PPA) in response to the RFP, and has been selected by the Government *vide* Letter of Acceptance, dated February 17th, 2022 to develop a solar PV power project. Accordingly, the Licensee desires to construct, own and operate grid connected solar PV electric generating facilities situated at the roof top of Government owned buildings and on such other public spaces identified on selected islands, with a total electric capacity not less than 11 MW.

D. FENAKA (as defined in the PPA) is the identified state utility under the ASPIRE program for purchase of the Electric Energy (as defined in the PPA) generated by the Seller.

E. The Licensee has entered into a Power Purchase Agreement, dated 29th March 2022 ("PPA") with FENAKA to set forth the mechanism for sale and purchase of the Electric Energy generated by the Licensee and other mutual rights and the obligations of the Licensee and FENAKA.

F. Government also proposes to support the Project, the details of which have been prescribed in the Implementation Agreement (as defined in the PPA), setting forth mutual rights and obligations of the Licensee and the Government, executed between the Licensee and the Government.

G. The Licensee was the successful bidder, and among the locations identified in the RFP are locations situated in Hithadhoo, Feydhoo, Maradhoo-Feydhoo and Hulhudhoo-Meedhoo of Addu City (together with adequate space for setting up a control room for the Instant Facility (as defined herein below)), the description of which is detailed in Exhibit A ("Site(s)").

H. The Licensee intends to incorporate and establish, in accordance with Applicable Laws, a company to develop the Project ("Project Company") and upon its incorporation, the Parties intend to amend this Agreement to add the Project Company as a party to this Agreement such that the Project Company will be jointly and severally liable with the Licensee for all of the Licensee's obligations under this Agreement.

I. The Licensee has agreed to enter in to this Agreement with the Licensor for the purpose of developing the Project at the respective Sites as set out in Exhibit A, subject to and in accordance with the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual promises and covenants of each Party to the other contained in this Agreement and for other good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

ARTICLE 1
DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Agreement, unless the context otherwise requires, any term defined in Article 1.1 of the PPA but not defined herein shall have throughout this Agreement the meaning set forth against that term in the PPA, and the following terms shall have the meanings set forth below:

"**Access Rights**" has the meaning set forth in Article 6.6 hereof.

"**Agreement**" has the meaning set forth in the Preamble hereof.

"Applicable Law" means any and all statutes, laws, municipal charter provisions, regulations, ordinances, rules, mandates, judgements, orders, decrees, Permits and Approvals, codes or license requirements, or other governmental requirements or restrictions or any interpretation or administration of any of the foregoing by any Governmental Authority, that apply to either Party under this Agreement, whether now or hereafter in effect.

"**Defect**" has the meaning set forth in Article 5.5hereof.

"**Dispute Notice**" has the meaning set forth in Article 13.2 hereof.

"**Dispute**" has the meaning set forth in Article 13.2 hereof.

"**Emergency**" has the meaning set forth in Article 8.2 hereof.

"**Execution Date**" means the date of signing this Agreement.

"**Expert**" has the meaning set forth in Article 13.3 hereof.

"**Fee**" has the meaning set forth in Article 4.1 hereof.

"FENAKA" has the meaning set forth in Recital D hereof.

"Implementation Agreement" has the meaning set forth in Recital F hereof.

"**Instant Facility**" means the solar PV systems, inverters, and related equipment, systems, components, fixtures, and facilities sharing a common point of interconnection with FENAKA's Electric System, Licensee's Interconnection Facilities relating thereto, the ground mounted canopy structure on top of which the solar panels shall be fixed and other assets, tangible and intangible, that comprise the Facility as set up on the Site(s).

"**Indemnified Party**" has the meaning set forth in Article 10 hereof.

"**Indemnifying Party**" has the meaning set forth in Article 10 hereof.

"**License**" means the license issued to the Licensee by the Licensor to design, build, maintain

SECRETARIAT OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

and operate the Instant Facility at the Site(s) in accordance with the terms and conditions of this Agreement.

"**License Term**" has the meaning set forth in Article 2 hereof.

"**Licensee**" has the meaning set forth in the Preamble hereof.

"**Licensee's Interconnection Facilities**" has the meaning ascribed to the term "Seller's Interconnection Facilities" in Article 1.1 of the PPA.

"**Licensor**" has the meaning set forth in the Preamble hereof.

"**MECCT**" mean the Ministry of Environment, Climate Change and Technology of the Government of the Republic of Maldives or any successor thereto.

"**PPA**" has the meaning set forth in Recital E hereof.

"**Possession Date**" has the meaning set forth in Article 3 hereof.

"**Reference Rate**" mean the rate notified by the Maldives Monetary Authority for 364 Days Treasury Bills, on the Day that is two (2) Business Days prior to the day on which interest shall begin to be calculated hereunder, subject to a maximum of five percent (5%).

"**Site(s)**" means the public spaces on Hithadhoo, Feydhoo, Maradhoo-Feydhoo and Hulhudhoo-Meedhoo of Addu City chosen as the sites for developing the Project, more fully described in Exhibit A herein.

"**SIAC**" means Singapore International Arbitration Centre.

"**Taxes**" means any tax applicable in the Maldives, including any tax on income, excise duty, customs duty, value added tax, sales tax, good and services tax and other local tax, cess, any impost or surcharge of like nature, any interest, penalties and other sums in relation on the income, goods, material, equipment and services rendered by either Party, and charged, levied or imposed by a Government instrumentality.

"**Transfer**" means in relation to a property, the sale, gift, pledge, assignment, transfer, transfer of any interest in trust, encumbrance, or alienation or disposition in any manner whatsoever, voluntarily or involuntarily, including, any attachment, assignment for the benefit of creditors against the owner of a property or appointment of a custodian, liquidator or receiver in relation to the property.

"**URA**" means the Utility Regulatory Authority established under Law No. 26/2020 (Utility Regulatory Authority Act).

1.2 Interpretations

In this Agreement:

(a) any reference to any statute or statutory provision shall include:

SECRETARIAT OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

   (i) all subordinate legislation made from time to time under that provision (whether or not amended, modified, re-enacted or consolidated);

   (ii) such provision as from time to time amended, modified, re-enacted or consolidated (whether before or after the date of this Agreement) and (to the extent liability thereunder may exist or can arise) shall include any past statutory provision (as from time to time amended, modified, re-enacted or consolidated), which the provision referred to has directly or indirectly replaced;

(b) reference to any Party under this Agreement shall also include its successors, administrators, legal representatives, and permitted assigns as the case may be;

(c) heading to Articles and paragraphs are for information only, and shall not form part of the operative provisions of this Agreement and be ignored in construing the same;

(d) references to Articles and schedules are to Articles and schedules to this Agreement. All of these form part of the operative provisions of this Agreement and references to this Agreement shall, unless the context otherwise requires, include references to the Articles and schedules;

(e) unless the contrary is expressly stated, no Article in this Agreement limits the extent or application of another Article;

(f) any reference to books, files, records or other information or any of them means books, files, records or other information or any of them in any form or in whatever medium held including paper, electronically stored data, magnetic media, film and microfilm;

(g) "in writing" includes any communication made by letter or facsimile;

(h) the words "*include*", "*including*", "*inter alia*" and "*in particular*" shall be construed as being by way of illustration or emphasis only and shall not be construed as, nor shall they take effect as, limiting the generality of any preceding words;

(i) the words "*directly or indirectly*" mean directly or indirectly through one or more intermediary persons or through contractual or other legal arrangements, and "direct or indirect" shall have the correlative meanings;

(j) the expression "*this Article*" shall, unless followed by reference to a specific provision, be deemed to refer to the whole Article (not merely the sub-Article, paragraph or other provision) in which the expression occurs;

(k) the terms '*hereof*', '*herein*', '*hereby*', '*hereto*' and derivative or similar words shall, unless followed by a reference to a specific provision of the Agreement, be deemed to refer to this entire Agreement;

(l) when any number of Days are prescribed in this Agreement, same shall be reckoned exclusively of the first and inclusively of the last Day, unless the last Day does not fall on a Business Day, in which case the last Day shall be the next succeeding Day which is a Business Day;

SECRETARIATE OF THE ADDU CITY COUNCIL

(m) time is of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended, such extended time shall also be of the essence;

(n) a reference to any agreement is a reference to that agreement and all schedules, appendices and the like incorporated therein, as the same may be amended, modified, supplemented, waived, varied, added to, substituted, replaced, renewed or extended from time to time;

(o) all provisions of this Agreement shall be interpreted and construed in accordance with their meanings, and not strictly for or against either Party, regardless of which Party may have drafted this Agreement or a specific provision;

(p) grammatical variations of defined words shall be construed in accordance with the relevant definition(s);

(q) references to the singular number shall include references to the plural number and vice versa; and

(r) words denoting one gender shall include all genders.

SECRETARIATE OF THE ADDU CITY COUNCIL

ARTICLE 2
LICENSE TERM

The term of this Agreement shall enter into full force and effect on the Execution Date and shall expire upon the expiry of the PPA or upon an earlier termination of the PPA ("License Term").

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

ARTICLE 3
GRANT OF LICENSE

Subject to the Licensee's compliance with its obligations in this Agreement, the Licensor hereby grants and the Licensee hereby accepts the License, to design, build, maintain and operate the Instant Facility on the Site(s), for the duration of the License Term, unless terminated earlier in accordance with the terms herein contained. The Licensor shall provide to the Licensee, access to the Site(s) on a Day mutually agreed between the Parties (the "Possession Date"), which Day shall not be later than 31st July 2022. The Licensee undertakes and covenants that the Site(s) shall only be used for the purposes of designing, building, maintaining and operating the Instant Facility in accordance with the terms and conditions herein mentioned, and for no other purpose. The Licensee shall not have exclusive possession of the Site(s) and nothing contained herein shall be construed as creating any rights, interest, easement, tenancy or sub-tenancy in favor of the Licensee in or over the Site(s) other than the permissive right of use herein granted.

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, M

ARTICLE 4
CONSIDERATION

4.1 In consideration of the grant of the License over the Site(s) to develop the Project and the grant of Access Rights, the Licensee shall pay to the Licensor, an annual fee at the rate of Rufiyaa Eight (MVR 8) per square meter (of the area of the Site(s)) per year ("Fee"). The Fee shall be paid on or before the 01st Day of January of each year during the License Term. Parties acknowledge that this Agreement is being entered into towards fulfillment of the Maldives' obligations to the Licensee under the Implementation Agreement, and in consideration, *inter alia*, of the Licensee's obligation to develop the Project and sell Electric Energy to FENAKA, which collectively with the Fee is acknowledged by the Parties to constitute adequate consideration for the grant of the License over the Site(s) and the grant of Access Rights under this Agreement. Accordingly, Parties undertake that neither Party shall question the validity of this Agreement for want or adequacy of consideration

4.2 The Licensee shall commence payment of the Fee starting from 01st Day of January 2023.

4.3 The Licensee shall pay the Fee by online remittance (electronic funds transfer) or by way of demand draft drawn in favor of the Licensor payable at Addu City, Republic of Maldives. In the event the payment is made by way of online remittance, the Licensee shall provide proof of such remittance to the Licensor within 02 (two) days of such remittance and all the charges in relation to transfer of payments to the Licensor's account shall be borne by the Licensee.

SECRETARIATE OF THE ADDU CITY COUNCIL

ARTICLE 5
TAXES AND INSURANCE

5.1 Taxes in Relation to Site(s)

During the License Term, the Licensor shall be liable to bear and pay on its sole account any and all Taxes in relation to the Site(s).

5.2 Taxes in Relation to Instant Facility

Any Tax imposed by a Governmental Authority, with respect to the design, construction, financing, ownership, erection, installation, maintenance and operation of the Instant Facility and/ or on account of the income generated from the operation of the Instant Facility, shall be borne by the Licensee. To the extent possible under Applicable Law, the Licensee shall make such payments directly to the relevant Governmental Authority. In the event that any Tax that is payable by the Licensee is paid by the Licensor, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.3 Taxes on Fee

The Fee shall be paid by the Licensee without any deductions whatsoever, save and except the deduction of tax at source, if applicable. The liability for payment of any Taxes as applicable on the Fee shall be borne by the Licensee, even if the same is payable by the Licensor in accordance with the Applicable Law.

5.4 Commercial General Liability Insurance for Damage to the Site(s)

The Licensee shall procure and maintain commercial general liability insurance, employer's liability, worker's compensation , professional liability (with any exclusions subject to the prior written approval of the Licensor) up to the overall limit set out in Schedule 4 of the PPA, and within such commercial general liability insurance the Licensee shall also insure against liability for personal injury and damage to the Site(s) or damage to any third party properties therein, arising directly out of the installation of the Instant Facility or its use, in standard form, which shall include operations and blanket contractual liability coverage which insures performance by the Licensee of the indemnity provisions of this Agreement. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date.

5.5 Comprehensive "All Risks" Insurance of the Instant Facility

The Licensee, at its cost, shall within the overall limit set out in Schedule 4 of the PPA, procure and maintain comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility against fire, accident, burglary, vandalism, machinery breakdown, earth movement such as earthquake, volcanic eruptions and subsidence, hurricane/ windstorms, flood including

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALD

tsunami, debris removal, ordinance or law, extra expense and terrorism. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date. Upon failure by the Licensee to procure and maintain such comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility, and the occurrence of any such event that renders the Site(s) untenable for use by the Licensor (a "Defect") and other users, the Licensee shall cure such Defect at its own cost, within thirty (30) Days of the occurrence of the Defect. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to obtain the required insurance. In the event that the Licensor obtains required insurance for the Site, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. The Licensor shall be entitled to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.6 The Licensee shall, at its own cost, ensure that any insurance policy required to be maintained by it in accordance with this Article 5 is renewed before the expiry of such insurance policy. Such insurance policy shall also comply with the other requirements stated in Schedule 4 of the PPA, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee. The insurance policies referenced herein shall be taken out in the names of the Licensor and the Licensee for the full value of their respective rights and interests provided that the premiums incurred by the Licensee in complying with this clause will not be unreasonable. The Licensor shall, at the cost of the Licensee, provide all reasonable necessary assistance and cooperation to the Licensee for the renewal of such insurance policy by the Licensee. The proceeds of any Proceeds of any insurance claim are to be applied towards the replacement, repair and/or reinstatement of the Site(s) and/or the Instant Facility.

5.7 On the occurrence of a partial or total loss or an event which, in the reasonable opinion of the Licensee would result in a claim against the insurance policies taken by the Licensee in respect of the Instant Facility, the Licensee shall forthwith and in any case not later than two (2) Days from the date of occurrence of loss or event inform the Licensor of the same.

CJ

ARTICLE 6
LICENSEE'S RIGHTS AND COVENANTS

6.1 The Licensee shall provide a copy of the duly executed PPA to the Licensor within fifteen (15) Days of the Execution Date.

6.2 The Licensee hereby represents and warrants that it has inspected or has caused an inspection of the Site(s) to be done, and has satisfied itself on the suitability of the Site(s) for the Instant Facility, and shall accept the possession of the Site(s) on an "as is where is" basis, on the Possession Date.

6.3 The Licensee shall be solely responsible for (a) all costs and the performance of all tasks required for installation, operation and maintenance of the Instant Facility at the Site(s) including costs related to preparation of the Site(s) before installation, costs related to capital improvement, removal, replacement and expansion of the Instant Facility; (b) ensuring that the design, construction, financing, ownership, maintenance and operation of the Instant Facility are in compliance with Good Engineering and Operating Practices, Codes and Standards, and Applicable Law, including those relating to safety norms, public health and environment; (c) ensuring that the performance of the tasks required for installation, operation and maintenance of the Instant Facility does not cause any damage to the Site(s), and to any public property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; (d) obtaining all Permits and Approvals required for the Licensee's use of the Site(s); and (e) bearing all risk of loss in case of a theft, damage, casualty, condemnation or confiscation of the Instant Facility.

6.4 The Licensee agrees that any matter raised in relation to the installation, maintenance and operation of the Instant Facility by any person, shall be addressed as per the Environment and Social Impact Assessment (ESIA) and the Grievance Redress Mechanism (GRM), developed pursuant to the Environmental and Social Management Framework (defined in the PPA) relating to ASPIRE.

6.5 The Licensor may, if in the event the Licensee is unable to attend to any issue in accordance with the GRM, upon giving 24 hour written notice, resolve such issues or remedy any damages or defects as maybe specified in the notice, and make such repairs thereto as the Licensor deems appropriate. Should the Licensor effect repairs, the Licensee shall pay to the Licensor the amount of such repairs reasonably incurred by the Licensor upon submission to the Licensee of an invoice with supporting documents showing the cost incurred by the Licensor for such repairs which shall be calculated at a fair and reasonable market rate.

6.6 During the License Term, the Licensee shall have the following rights ("Access Rights") in relation to the Site(s):

(a) right to erect temporary structures, such as a scaffolding or similar structures at the Site(s) as may be reasonably required for the purpose of carrying out the construction and erection of the Instant Facility and/ or for the maintenance of the Instant Facility, provided that (i) the Licensee shall use all reasonable efforts to minimize the impact thereof on the normal use of the space

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

3

where the Site(s) is located, by the public and (ii) the Licensee shall obtain prior written approval of the Licensor in respect of such temporary structures and all approvals required under Applicable Law;

(b) right to use such ways, paths and passages as are reasonably necessary for the purpose of access to and egress from the Site(s), with or without workmen and for transporting, loading and unloading necessary tools, equipment and materials, provided that (i) the Licensor may in consultation with the Licensee and for a reasonable cause require the Licensee to change the route of any means of access to or egress from the Site(s) and may change the area over which any of the Access Rights are exercised; and (ii) the use of such ways, paths and passages shall not obstruct the general use of the space where the Site(s) is located by the public, provided that where the Licensee's use of the path, ways and passages will result in an obstruction of the use of such space by the public, such obstruction shall be done only after obtaining a prior written approval from the Licensor, and shall be only for a reasonable period of time as agreed with the Licensor, consistent with Good Engineering and Operating Practices.

Provided that the Licensee shall provide the Licensor at least thirty (30) Days before the commencement of the construction of the Instant Facility, or a related activity, a schedule of construction of the Instant Facility. Upon receipt of such schedule of construction from the Licensee, the Licensor shall within five (5) Business Days respond with such reasonable changes to the schedule of construction, if any, as it may require, failing which the Licensor shall be deemed to have accepted the schedule of construction. If the Licensor requests any changes to the schedule of construction, the Licensee shall modify its schedule of construction after incorporating such reasonable changes suggested by the Licensor, and notify the finalized schedule of construction at least five (5) Days prior to the commencement of construction.

6.7 The Licensee shall have right to use utilities such as electricity and water for the purpose of construction, installation, erection, operation and maintenance of the Instant Facility, at the cost of the Licensee. The Licensee shall install separate meters for recording the consumption of electricity and water by the Licensee at the Site(s). The Licensee shall pay by the due date the meter installation and hire charges and also the bills for consumption of electricity and water in the Site(s) as recorded in the meters to the relevant utility companies and provide a copy of the proof of such payment to the Licensor within fifteen (15) Business Days from such payment for its records. In addition, the Licensee shall arrange at its own cost other facilities such as telephone services and other similar facilities, and pay directly to the third-party services providers for such services availed by it.

6.8 Subject to <u>Article 5</u> hereof, the Licensee may make its own arrangements for and take reasonable measures, in consultation with the Licensor for the protection and security of the Instant Facility.

6.9 The Licensee shall have the right to construct ground mounted canopy structures and such other supporting structures as necessary which forms part of the Instant Facility, and shall have the right from time to time, both before and after the Commercial Operation Date, and at the Licensee's sole cost and expense, to make such additions, alterations or changes to such structures, as are reasonably required in compliance with the provisions of this Agreement, Applicable Law, Good Engineering and Operating Practices and Codes and Standards; provided that: (a) the Licensee shall not cause any damage to the Site(s), and to any public

SECRETARIAT THE ADDU CITY COUNCIL ADDU, MA

3

9

property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, low voltage, medium voltage, and high voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; and (b) the Licensee shall obtain the prior written approval of the Licensor, and such prior written approval shall not be unreasonably withheld, in respect of any such construction, additions, alterations or changes, except if such construction, additions, alterations or changes are cosmetic in nature and/ or are part of the day to day maintenance and repair of the Instant Facility; and (c) the Licensee shall provide to the Licensor a certificate from a civil engineer and/or architect having the requisite competence under Applicable Law for issuing such certificates, and acceptable to the Licensor and such acceptance shall not be unreasonably withheld, and which certificate shall certify that the proposed constructions, additions, alterations, or changes are in compliance with the Applicable Law, required for the construction of the Instant Facility.

6. 10 The Licensee shall be solely responsible for day to day operation and maintenance of the Instant Facility, including without limitation the obligation to promptly make or pay (as determined by the Licensor) for, any repairs to any part or whole of the Site(s), to the extent damage is caused by the Licensee, its employees, officers, agents, contractors or subcontractors, during the License Term.

6.11 In complying with its obligations under Article 6.9, the Licensee shall to the extent possible give five (5) Business Days prior written notice for all repair and maintenance work of the Instant Facility or the Site(s) so as not to restrict public use of the space in which the Site(s) is located. Upon such request for repair and maintenance work, the Licensor shall respond to such request within five (5) Business Days. If the Licensor does not respond to such request within five (5) Business Days, such request shall be deemed approved by the Licensor. The Licensee shall ensure that all such work undertaken must be completed in all respects in a timely manner.

6.12 At all times, the Licensee shall:

(a) take due care to ensure that no damage is caused to any property on the Site(s) and the space belonging to or used by the Licensor, the public or other users of such space;

(b) not cause inconvenience to the Licensor, and other users of the space in which the Site(s) is located as is reasonably practicable, except that the Licensor agrees that the exercise of the Access Right granted under Article 6.6(a) hereof may cause temporary obstruction and/ or interference with the normal use of such space and that such inconvenience shall not be deemed to be a violation of the Licensee's obligations under this Article 6.11(b).

6.13 In the event, there is any damage to the Site(s) and/or to the space where the Site(s) is located, and to any public property or to any property of a third party therein, including but not limited to any damage to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, water and sewerage mains, fiber-optic cables and telecommunication service lines, by reason of the Licensee exercising an Access Right or other rights under this Agreement, the Licensee shall make good such damage (to the reasonable satisfaction of the Licensor) at its own cost.

6.14 The Licensee shall provide a list to the Licensor (or to any officer of the Licensor designated

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

by the Licensor for this purpose), of the employees, agents, sub-contractors, and other representatives of the Licensee who shall be entitled to enter upon the Site(s), and shall ensure that the Access Rights granted hereunder are exercised by such employees, agents, sub-contractors, and other representatives, subject to the reasonable conditions for entry and exit to the Site imposed by the Licensor, and having regard to the public safety, and the safety of the Site(s).

6.15 The Licensee shall, as promptly as possible, notify the Licensor of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s) and/ or the Instant Facility, and that in the Licensee's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety.

6.16 The Licensee shall consult with the Licensor and obtain Licensor's approval in relation to design of the Instant Facility (including with respect to its placement within the Site(s) and technical specifications) and obtain written approval from the Licensor in case of any alteration to the design of the Instant Facility.

SECRETARIAT OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

9

ARTICLE 7
OWNERSHIP OF THE INSTANT FACILITY

7.1 The Licensee shall be the exclusive owner and operator of the Instant Facility, including any part thereof, installed by the Licensee.

7.2 The Licensee acknowledges and agrees that, notwithstanding that the Instant Facility is a fixture on the Site(s), the Licensee shall have no right, title or interest in the Site(s) except as that of a Licensee as per the terms set out in this Agreement. The Licensee shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on the Site(s) or the Access Rights or any interest therein, and the Licensor will not suffer in any manner out of Licensee's use of the Site(s) whereby the estate, rights and interests of the Licensor in the Site(s) or any part thereof might be impaired, except in accordance with and subject to the provisions of this Agreement.

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDI

ARTICLE 8
LICENSOR'S COVENANTS

8.1 The Licensor shall take all reasonable efforts not to cause any interference with the effective operation of the Instant Facility, including any interference with the Licensee's right to receive continuous and uninterrupted passage of light at all times across the Site(s) or have access to the Site(s) and the Instant Facility.

8.2 The Licensor shall, as promptly as possible, notify the Licensee of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s), and that in the Licensor's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety. The Licensor and FENAKA shall have the right (but not the obligation), to the extent permitted by Applicable Law, to enter into the Site(s) for the sole purpose of responding to any dangerous condition posing risk to, the Site(s), the Instant Facility, public health or public safety ("<u>Emergency</u>"); provided that any actions taken by the Licensor upon such entry shall be limited to those reasonably necessary to respond to the risks posed. The Licensee shall respond to any such Emergency as promptly as possible, and take all measures necessary to address the condition that gave rise to the Emergency. The Licensee shall not be required to bear the costs associated with an Emergency related to the Site(s) that are not caused by the Licensee and does not affect the Instant Facility.

8.3 The Licensor shall reasonably cooperate with the Licensee, at the Licensee's cost, so that the Licensee can procure all Permits and Approvals for design, engineering, construction, financing, operations, maintenance and deconstruction of the Instant Facility, and meet its obligations under this Agreement and the PPA.

8.4 The Licensor agrees and undertakes that this Agreement and the Access Rights shall run with the Site(s) and shall survive any Transfer of the Site(s). The Licensor shall give the Licensee at least six (6) Calendar Months written notice prior to any Transfer of all or a portion of the Site(s) identifying the transferee, the portion of the Site(s) to be transferred and the proposed date of Transfer. In the event of Transfer by any way or form of the Site(s), the Licensor shall cause the proposed transferee to execute an agreement identical in terms and conditions as that of this Agreement with the Licensee, for a term equal to the License Term outstanding at the date of such Transfer.

8.5 The Licensor recognizes the need of the Licensee to finance the Project by mortgage of the Instant Facility, accordingly, the Licensor shall reasonably cooperate with the Licensee in creation of charge on the Instant Facility in favor of the lenders to the Project, at the cost of the Licensee, including through furnishing such documents and certificates as may be reasonably requested by the Licensee's lenders.

8.6 The Licensor shall not, directly or indirectly, cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on or with respect to the Site(s), except with the prior written consent of the Licensee, which consent shall not be unreasonably withheld.

8.7 Subject to the terms and conditions of this Agreement and the Licensee's compliance with all

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MAL

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

SECRETARIAT OF THE ADDU CITY COUNCIL

ADDU, MALDIVES

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 **Licensor's Representations and Warranties**

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a local council, duly established and validly existing under the constitution and laws of Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

  (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or
  (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 **Representations and Warranties of the Licensee**

Licensee hereby represents and warrants as of the date hereof that:

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

(a) the Licensee is a company duly organized and validly existing under the relevant jurisdiction specified in the Preamble of this Agreement, and has full legal right, power and authority under Applicable Law to enter into and perform its obligations under this Agreement;

(b) the Licensee has duly authorized the execution and delivery of this Agreement. This Agreement has been duly executed and delivered by the Licensee and will constitute a legal, valid and binding obligation of the Licensee, enforceable against the Licensee in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other laws affecting creditors rights generally;

(c) neither the execution nor the delivery by the Licensee of this Agreement nor the performance by the Licensee of its obligations hereunder: (i) will conflict with, violate, or result in a breach of any Applicable Law of Maldives; or (ii) conflicts with, violates, or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of [incorporation/ registration] of the Licensee), or instrument to which Licensee is a party or by which Licensee or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or instrument;

(d) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensee, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensee in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensee of its obligations hereunder or under such an agreement or instrument.

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

SECRETARIATE OF THE ADDU CITY COUNCIL

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 Licensor's Representations and Warranties

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a local council, duly established and validly existing under the constitution and laws of Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

  (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or

  (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 Representations and Warranties of the Licensee

Licensee hereby represents and warrants as of the date hereof that:

SECRETARIATE OF THE ADDU CITY COUNCIL

ARTICLE 10
INDEMNIFICATION

The Licensee (also an "Indemnifying Party") shall indemnify and hold harmless the Licensor and its employees, officers, agents, contractors, professional advisors and representatives (each an "Indemnified Party") from and against all liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, that may be imposed upon or incurred by or asserted against the Licensor or any of its employees, officers, agents, contractors, professional advisors, representatives, by reason of any of the following occurrences during the License Term, except to the extent such liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, are caused by either (i) gross negligence or intentional wrongful acts of the Indemnified Party or (ii) failure or other breach by the Indemnified Party to perform any of its obligations under Applicable Law or Permits and Approvals:

(a) any breach by the Licensee of its obligations, covenants, representations or warranties contained in this Agreement;

(b) any negligence on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees in connection with the use of the Site(s) or in designing, construction, financing, ownership and operation of the Instant Facility or the Project; or

(c) any failure on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees to comply with Applicable Law that require compliance by the Licensee or any of its agents, contractors, servants, employees, subtenants, licensees or invitees in connection with the Site(s) and its use, or design, construction, financing, ownership and operation of the Instant Facility, or the Project.

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

ARTICLE 11
FORCE MAJEURE EVENT

11.1 Adoption of provisions of PPA

Provisions of Article 12.4, Article 12.5 and Article 12.6 of the PPA shall *mutatis mutandis* apply to this Agreement, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee.

11.2 Effects of Force Majeure Events

Without prejudice to the rights or obligations of the Government or FENAKA under the Implementation Agreement or the PPA,

(a) if the Force Majeure Event results in loss of the Site(s) or the Instant Facility, either Party shall have the right to terminate this Agreement in accordance with the provisions of Article 12.1(a) of this Agreement; or

(b) if a Force Majeure Event subsists for more than one hundred and eighty (180) Days and the PPA is terminated in accordance with Article 13.5. or Article 13.6, as the case may be, of the PPA, either Party may terminate this Agreement in accordance with Article 12.1(b) and Article 12.2, hereof.

ARTICLE 12
TERMINATION

12.1 Events of Termination

This Agreement shall terminate in the following circumstances:

(a) If occurrence of a Force Majeure Event results in loss of the Site(s), either Party shall have the right to terminate this Agreement in accordance with Article 11.2(a), by a notice in writing to the other Party, with the termination being effective from fifteen (15) Days from the date of such notice.

(b) Upon termination of the PPA, whether on account of expiry of the Contract Term, or otherwise, and whether in respect of the Project as a whole or in respect of the Instant Facility, either Party shall have the right to terminate this Agreement with effect from the date of termination of the PPA.

(c) If the Government issues or is deemed to have issued a Concurrence Notice under Article 4.2(c)(iii) of the Implementation Agreement, either Party may terminate this Agreement.

(d) If an Expert (as defined under the Implementation Agreement) determines in accordance with Article 4.2(c)(x) of the Implementation Agreement that the Site(s) is unavailable for use of the Licensee, the Agreement shall terminate with effect from the date of such determination or such other date as such Expert may determine.

12.2 Consequences of Termination

(a) If the Agreement terminates in accordance with Article 12.1(b) but on account of expiry of the Contract Term and FENAKA chooses to purchase the Instant Facility in accordance with Article 2.2 of the PPA, the Licensor shall transfer the License provided for in this Agreement in favor of FENAKA on such terms and conditions as FENAKA and Licensor may agree in writing.

(b) If the Agreement terminates in accordance with Article 12.1(a), or Article 12.1(b) but on account of

(i) expiry of the Contract Term and FENAKA chooses not to purchase the Instant Facility in accordance with Article 2.2 of the PPA,

(ii) termination of the PPA in accordance with Article 13.3(a) or Article 13.3(c) of the PPA, and FENAKA chooses not to exercise its right under Article 13.3(d) of the PPA to purchase the Project or the Instant Facility, or

(iii) termination of the PPA in accordance with Article 13.5(a) or Article 13.5(b) (where the PPA is terminated by the Seller, thereof) of the PPA,

the Licensee shall within one hundred and eighty (180) Days, decommission the entire Instant Facility set up at the Site(s), remove all its assets from the Site(s), and vacate and hand over

SECRETARIAT OF THE ADDU CITY COUNCIL ADDU, MALDIVES

peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

(c) If the Agreement terminates in accordance with Article 12.1(b) but on account of,

  (i) termination of the PPA in accordance with Article 13.4(c), Article 13.4(d), Article 13.6(a) or Article 13.6(c) of the PPA,

  (ii) termination of the PPA by FENAKA in accordance with Article 13.5(b) of the PPA,

Licensor shall execute a license over the Site(s) in favor of the FENAKA simultaneously with the purchase of the Instant Facility by FENAKA, on terms and conditions substantially similar to those contained in this Agreement, unless FENAKA and the Licensor agree otherwise.

(d) If the Agreement terminates in accordance with Article 12.1(c) or Article 12.1(d), the Licensee shall relocate the Instant Facility to the alternative Site(s), promptly upon execution of the license agreement for the alternative Site(s), but in no event later than one hundred and eighty (180) Days, and vacate and hand over peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

ARTICLE 13
DISPUTE RESOLUTION

13.1 Continued Performance

Each Party shall continue to perform its obligations under this Agreement (including any payment obligations) pending resolution of any dispute pursuant to this Article 13. Provided that, if the dispute is with respect to any payments, neither Party shall be required to make such disputed payment(s) to the other Party so long as such dispute has been referred to the process for resolution pursuant to this Article 13; provided, that to the extent any amounts owed to either Party by the other Party are not disputed and can be segregated from amounts with respect to which there is a dispute, such undisputed amounts shall, in good faith, be identified by the Parties and paid as required by this Agreement. To the extent that any disputed amount was withheld from a Party, and such Party is ultimately found to be entitled to all or any portion of such disputed amount pursuant to this Article 13, then such Party shall be entitled to the payment of interest on any withheld amount, at an annual rate equal to Reference Rate, from the original due date for payment of such amount until the payment of such disputed amount.

13.2 Negotiation

If any dispute, controversy or claim arises under or relates to this Agreement or the breach, termination or validity thereof (the "Dispute"), such Dispute shall be referred by each Party to its designated senior officer for resolution upon five (5) Days written notice from either Party (the "Dispute Notice"). The Parties agree to attempt to resolve all Disputes promptly and equitably and to provide each other with reasonable access during regular business hours to any and all non-privileged records, information and data pertaining to any such Dispute.

13.3 Expert Determination

(a) A dispute may be referred to an expert (the "Expert") in accordance with this Article 13.3 if:

  (i) the Parties are not able to agree under Article 13.2 (*Negotiation*) on an amicable resolution to such dispute; and

  (ii) this Agreement expressly provides that such dispute shall be referred to an Expert or the Parties agree in writing that such dispute shall be referred to an Expert.

(b) Any Party to such a Dispute may initiate an Expert reference under this Article 13.3 by proposing to the other Party to the dispute the name of the Expert. If the other Party does not agree to the name suggested by the Party making the reference, and the Parties are otherwise unable to agree on the name of an Expert, either Party may apply to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the Expert for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, an

SECRETARIATE OF THE ADDU CITY COUNCIL

Expert for the matter in Dispute.

(c) The Parties shall request that the Expert determine the referred dispute, within thirty (30) Days of receiving the reference, or in such additional time as may be reasonably required by the Expert to determine the Dispute, which shall not be more than one hundred and eighty (180) Days of receiving the reference.

(d) The Expert shall act as an expert and not as an arbitrator.

(e) The Parties shall have the right to make representations and submissions to the Expert. There shall be no formal hearing.

(f) The Expert shall have power to request any Party to provide him/her with such statements (which shall be written unless otherwise specifically required) or documents or information within their control as he may determine necessary and the Parties shall comply with any such request in accordance with the timeframes set out by the Expert or in the absence of such timeframes, in a timely manner as required to enable the Expert to determine the Dispute within the timeframe set forth in Article 13.3(c).

(g) The Expert shall give his/her decision to the Parties to the Dispute in writing and his/her decision, which shall promptly be given effect to by such Parties, shall be final and binding (save in the case of fraud or manifest error) on them.

(h) If the Expert decides that a sum is due and payable by one Party to another Party then:

- (i) any such sum shall be due and payable within seven (7) Days of receipt by the Parties of written notice of such decision, unless the Expert decides otherwise; and
- (ii) interest shall accrue at the rate of Reference Rate, compounded annually, from the date expiry of the period mentioned in Article 13.3(h)(i); provided that if the sum specified in Article 13.3(h)(i) includes any interest, no interest shall be payable on such interest.

(i) The fees of the Expert and any other costs of and incidental to the reference to Expert determination shall be payable by such Party to the Dispute as the Expert may determine but, in the absence of any such determination, by the Parties to the Dispute in equal shares.

13.4 Arbitration

(a) Selection of Arbitrators

If the Parties are unable to resolve their Disputes through negotiation within thirty (30) Days of the Dispute Notice, either Party may initiate proceedings to submit the Dispute for arbitration. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:

- (i) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply

to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute.

(ii) Where the Parties do not agree that the dispute concerns a technical matter, the Parties may agree to appoint a sole arbitrator mutually agreed by them or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, each Party shall appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) Days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC.

(iii) If, in a dispute subject to Article 13.4(a)(ii) above, one Party fails to appoint its arbitrator within thirty (30) Days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.

(b) Rules of Procedure

Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the SIAC as in force on the date of this Agreement.

(c) Substitute Arbitrators

If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator.

(d) Nationality and Qualifications of Arbitrators

Each arbitrator appointed pursuant to Article 13.4(a)(i) to Article 13.4(a)(iii) shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of Maldives or the home country of the Licensee. For the purposes of this Clause, "home country" means any of:

(i) the country of incorporation of the Licensee or their parent companies;
(ii) the country in which Licensee's principal place of business is located;
(iii) the country of nationality of a majority of the Licensee's shareholders; or
(iv) where the Licensee is a joint venture between two or more Persons, the country of incorporation, nationality or place of business of the partners or shareholders of such joint venture.

SECRETARIATE OF THE ADDU CITY COUNCIL

(e) Miscellaneous

In any arbitration proceeding hereunder:

(i) proceedings shall, unless otherwise agreed by the Parties, be held in Singapore;

(ii) the English language shall be the official language for all purposes; and

(iii) the decision of the sole arbitrator or of a majority of the arbitrators shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

13.6 Governing Law, Jurisdiction and Service of Process

(a) Governing Law

This Agreement shall be governed by, and construed in accordance with, the laws of Maldives.

(b) Jurisdiction

Subject to Article 13.3 and Article 13.4, each of the Parties consents to submit itself to the exclusive jurisdiction of the courts located in the Maldives in relation to recognition of any arbitral award, with respect to any Dispute that arises under this Agreement.

(c) Service of Process

Subject to the rules of SIAC for the purposes of arbitration, each Party agrees that service of any process, summons, notice or document hand delivered or sent by certified mail, return receipt requested, to such Party's respective address set forth in Article 14.4 will be effective service of process for any action, suit or proceeding with respect to any matters to which it has submitted to arbitration as set forth in Article 13.4.

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

ARTICLE 14
MISCELLANEOUS PROVISIONS

14.1 Assignment

Licensee shall not assign or otherwise transfer this Agreement, except (i) for the collateral assignment to any lenders (only if such lenders are independent third party financial institutions) in connection with the provision of any financing for the Instant Facility, or (ii) to any Person who is a bona fide transferee of the PPA (in accordance with the terms of the PPA), subject to the transferee undertaking to comply with the obligations of the Licensee under the PPA, this Agreement, and the Escrow Agreement.

14.2 Further Assurances

Each Party agrees to, and shall use all reasonable efforts to, provide such information, execute and deliver any instruments and documents and take such action as may be necessary or reasonably requested or required by the other Party which are not inconsistent with the provisions of this Agreement and which do not involve the assumption of obligations other than those provided for in this Agreement in order to give full force and effect to this Agreement and to carry out its intent.

14.3 Relationship of Parties

Except as otherwise explicitly provided herein, neither Party to this Agreement shall have any responsibility whatsoever with respect to services provided or contractual obligations assumed by the other Party and nothing in this Agreement shall be deemed to constitute either Party a partner, agent or legal representative of the other Party or to create any fiduciary relationship between or among the Parties.

14.4 Notices

Any notices required to be given hereunder shall be deemed delivered when (i) sent by facsimile upon electronic confirmation of successful transmission; (ii) delivered to an express courier service nationally recognized in Maldives that provides a receipt of delivery, (iii) sent by email, upon dispatch and the receipt of a delivery confirmation, provided that email shall be used as a mode of notice and communication only for non-material day-to-day matters; (iv)when delivered by personal delivery, in each case addressed to the following persons or such other persons as the Parties may designate in writing:

(a) If to the Licensor:
Name: Ali Nizar
Designation: Mayor
Address: Secretariat of Addu City Council
Email: secretariat@adducity.gov.mv
Fax: 6885002
with a copy to:

FENAKA
Name: Ahmed Saeed Mohamed
Designation: Managing Director
Address: FENAKA Corporation Limited, Port Complex Building, 7th Floor, Hilaalee Magu, Male' 20207
Email: ahmed.saeed@fenaka.mv
Copied to: maasha@fenaka.mv

and

MECCT
Name: Mr. Ajwad Musthafa
Designation: Permanent Secretary
Address: Ministry of Environment, Cliimate Change and Technology Green Building, Handhuvaree Hingun, Male', 20392, Republic of Maldives
Email: ajwad.mustafa@environment.gov.mv

(b) If to the Licensee:

Name: Mr. Goh Chin San
Designation:
Managing Director of Mega First Solar (Maldives) Consortium Pvt Ltd
Authorised Representative of Mega First Power Industries Sdn Bhd
Address: A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Email: chinsan.goh@mega-first.com
Copied to: shadhah.shahid@mega-first.com, kok.cw@mega-first.com

14.5 Costs and Expenses

All costs, expenses, including any cost of documentation, reasonable attorney fees, court fee, and stamp fee, relating to creation and maintenance of the license on the Site(s), including execution of this Agreement, shall be borne by the Licensee.

14.6 Confidentiality

The Parties shall at all times keep confidential information acquired in consequence of this Agreement, except for information which the receiving Party already knows or receives from third parties or which the receiving Party may be entitled or bound to disclose under compulsion of Applicable Law or where requested by regulatory agencies or to their professional advisers, investments partners and other parties where reasonably necessary for the performance of their obligations under this Agreement. For the avoidance of doubt, the obligations in this Article shall not apply to information in the public domain or information which the Parties own or acquired lawfully from others and which may be freely disclosed to others without breach of any obligation of confidence

SECRETARIAT OF THE ADDU CITY COUNCIL

2

14.7 Waiver

No waiver of any provision of this Agreement shall be effective against a Party except as expressly set forth in a writing signed by such Party. The waiver by either Party of a default or a breach by the other Party of any provision of this Agreement shall not operate or be construed to operate as a waiver of any subsequent default or breach. The making or the acceptance of a payment by either Party with knowledge of the existence of a default or breach shall not operate or be construed to operate as a waiver of any subsequent default or breach.

14.8 Survival

Notwithstanding anything provided herein to the contrary, Article 12.2 (*Consequences of Termination*), Article 13 (*Dispute Resolution*) and Article 14 (*Miscellaneous*), shall survive the termination of this Agreement.

14.9 Third Party Rights

Nothing herein is intended to or should be construed to create any rights of any kind whatsoever in third persons not parties to this Agreement, except in favor of the Government, FENAKA, and the World Bank.

14.10 Counterparts

This Agreement and any amendment hereto may be executed and delivered in one or more counterparts and by different Parties in separate counterparts. All of such counterparts shall constitute one and the same agreement and shall become effective (unless otherwise therein provided) when one or more counterparts have been signed by each Party and delivered to the other Party. Delivery of this Agreement by facsimile transmission or electronic email shall be as effective as delivery of a manually executed counterpart.

14.11 Severability

In the event that any provision of this Agreement shall, for any reason, be determined to be invalid, illegal, or unenforceable in any respect, the Parties shall negotiate in good faith and agree to such amendments, modifications, or supplements to this Agreement, or such other appropriate actions, as shall, to the maximum extent practicable in light of such determination, implement and give effect to the intentions of the Parties as reflected herein, and the other provisions of this Agreement shall, as so amended, modified, supplemented, or otherwise affected by such action, remain in full force and effect.

14.12 Entire Agreement

All prior agreements, negotiations, representations, and understandings with respect to the subject matter hereof, are hereby superseded. No amendment, modification, or change to this Agreement or its Exhibit shall be effective unless the same shall be in writing, duly executed, authorized and approved by the Parties. In the event of any conflict between the terms and conditions of this Agreement and that of any Exhibit or other document referenced herein, this Agreement shall govern and control.

SECRETARIAT OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

IN WITNESS WHEREOF, the Licensor and Licensee have caused this Agreement to be executed as on the date and the year first set forth above.

For and on behalf of the LICENSOR

....
Mohamed Shuaau
Deputy Mayor
Secretariat of Addu City Council,
Seenu Atoll, Hithadhoo, Addu City, Republic of Maldives

In the presence of;

....
Mariyam Azleema
Assistant council Executive
Secretariat of Addu City Council,
Seenu Atoll, Hithadhoo, Addu City, Republic of Maldives

....
Mohamed Luthfy
Assistant council Executive
Secretariat of Addu City Council,
Seenu Atoll, Hithadhoo, Addu City, Republic of Maldives

For and on behalf of the LICENSEE

....
Goh Chin San
Authorised Representative
Mega First Power Industries Sdn. Bhd.
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia.

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

....
Song Qing Guo
General Manager
Powerchina Huadong Engineering Corporation
Limited
22, ChaoWang Road Hangzhou, Zhejiang
Province, 310014
The People's Republic of China

3301034012942

In the presence of;

....
Khoo Teng Keat
Executive Director
Mega First Corporation Berhad
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia

....
Chen Ting
Chief Representative in Sri Lanka
Sinohydro Corporation Limited
22, Chegongzhuang West Road, Haidian District
Beijing 100048 The People's Republic of China

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Site 1.1: Feydhoo Harbor area

Area: 6,870 m^2
Installation Tilt: 10°
Installation Orientation: 26.4°

SECRETARIAT OF THE ADDU CITY COUNCIL

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Site 1.2: Maradhoo Feydhoo Harbour

Area: 4,500 m^2

Tilt: TBD

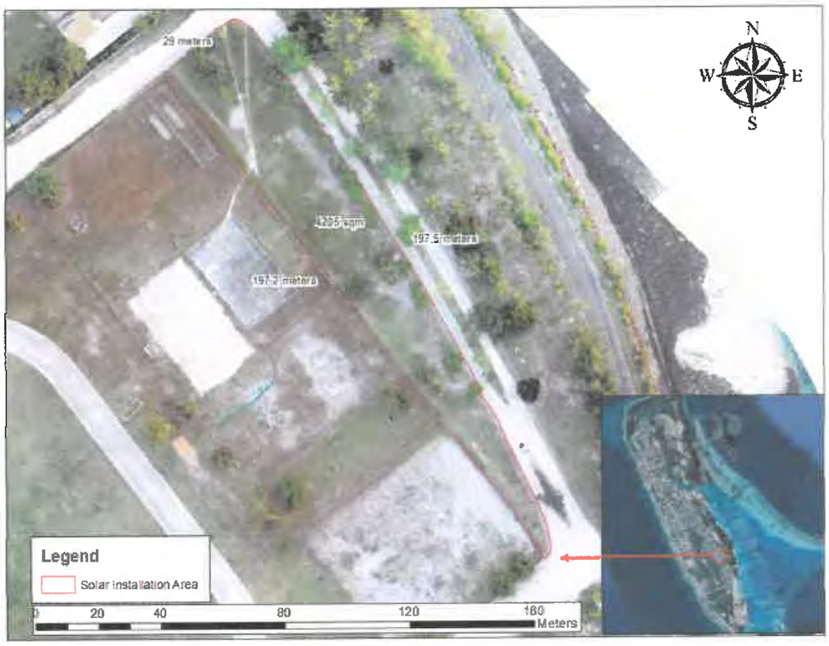
Orientation: TBD

SECRETARIATE OF THE ADDU CITY COUNCIL

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Site 1.3: Hithadhoo Stadium (2 arrays)



Area: 7665 m^2
Tilt: TBD
Orientation: TBD

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

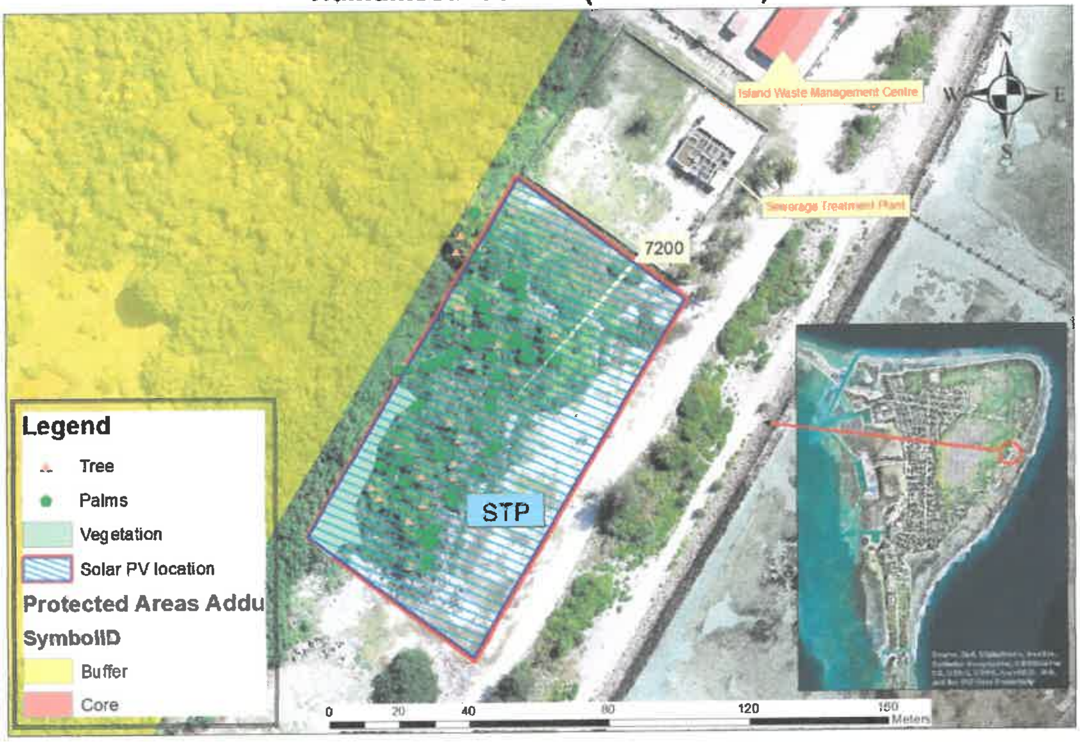
2

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Site 2.1: Hulhudhoo-Meedhoo STP (3 arrays)

Hulhumeedhoo STP (ASPIRE Site)



Area: 7200 m^2

Installation Tilt: 10°

Installation Orientation: 30°

SECRETARIATE OF THE ADDU CITY COUNCIL
ADDU, MALDIVES

3

LICENSE AGREEMENT

FOR THE INSTALLATION OF GROUND MOUNTED SOLAR PANELS

BETWEEN

REGIONAL AIRPORTS COMPANY LIMITED

(MALDIVES)

("LICENSOR")

– AND –

MEGA FIRST POWER INDUSTRIES Sdn. Bhd. (MALAYSIA)

IN JOINT VENTURE WITH

POWERCHINA HUADONG ENGINEERING CORPORATION LIMITED (CHINA)

("LICENSEE")

AGREEMENT NUMBER: RACL/22/PRO/07

DATE: AUGUST 2, 2022

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

REGIONAL AIRPORTS COMPANY LTD
0845/2021

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and entered into as of the 2nd August 2022 by and between:

1. **REGIONAL AIRPORTS COMPANY LIMITED**, a state owned limited liability company established under Presidential Decree Number: 05/2020 (30th September 2020) and bearing its Registration Number: **C-0045/2021**, and having its registered address and principal place of business at H.Suez, 6th Floor, Ameeru Ahmed Magu, Malé, Republic of Maldives (Licensor"); and

2. **Mega First Power Industries Sdn. Bhd. (MFPI)** a limited liability company, company registration number: 199601020584 (392936-W) , organized and existing under the laws of Malaysia, with its principal office located at A-12-01, Level 12, Block A, PJ8, No. 23, Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia, and **Powerchina Huadong Engineering Corporation Limited (HDEC)** a limited liability company with Unified Social Credit Code: 91330000142920718C, organized and existing under the laws of Peoples Republic of China, with its principal office located at No. 22, ChaoWang Road Hangzhou 310014, Zhejiang Province, The People's Republic of China (**MFPI** and **HDEC** will be jointly and severally liable, and collectively will be hereinafter referred to as the "Licensee").

WHEREAS:

A. The Government (as defined in the PPA), with support from the Strategic Climate Fund and International Development Association, has initiated a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) for inviting private sector generators to develop [roof top and ground mounted] solar photovoltaic projects in Maldives on a DBFOOT (i.e. design, build, finance, own, operate and transfer) basis. The electrical energy generated from such projects is proposed to be purchased by a Government owned utility under a long-term power purchase agreement.

B. The Government had invited bids from interested independent power producers, *vide* RFP (as defined in the PPA) dated June 17th, 2021 for setting up solar power projects on Government-owned buildings and public spaces identified and facilitated by the Government in the RFP.

C. The Licensee had submitted a Proposal (as defined in the PPA) in response to the RFP, and has been selected by the Government *vide* Letter of Acceptance, dated February 17th, 2022 to develop a solar PV power project. Accordingly, the Licensee desires to construct, own and operate grid connected solar PV electric generating facilities situated at the roof top of Government owned buildings and on such other public spaces identified on selected islands, with a total electric capacity not less than 11 MW.

D. FENAKA (as defined in the PPA) is the identified state utility under the ASPIRE program for purchase of the Electric Energy (as defined in the PPA) generated by the Seller.

E. The Licensee has entered into a Power Purchase Agreement, dated 29th March 2022 ("PPA")

0045/2021

with FENAKA to set forth the mechanism for sale and purchase of the Electric Energy generated by the Licensee and other mutual rights and the obligations of the Licensee and FENAKA.

F. Government also proposes to support the Project, the details of which have been prescribed in the Implementation Agreement (as defined in the PPA), setting forth mutual rights and obligations of the Licensee and the Government, executed between the Licensee and the Government.

G. The Licensee was the successful bidder, and the locations identified in the RFP and situated in Fuvahmulah Airport and Kulhudhuhfushi Airport (both Airports managed and operated by the Licensor) of Fuvahmulah City and Kulhudhuhfushi City respectively (together with adequate space for setting up a control room for the Instant Facility (as defined herein below)), the description of which is detailed in Exhibit A ("Site(s)").

H. The Licensee intends to incorporate and establish, in accordance with Applicable Laws, a company to develop the Project ("Project Company") and upon its incorporation, the Parties intend to amend this Agreement to add the Project Company as a party to this Agreement such that the Project Company will be jointly and severally liable with the Licensee for all of the Licensee's obligations under this Agreement.

I. The Licensee has agreed to enter in to this Agreement with the Licensor for the purpose of developing the Project at the respective Site(s) as set out in Exhibit A, subject to and in accordance with the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual promises and covenants of each Party to the other contained in this Agreement and for other good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 1
DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Agreement, unless the context otherwise requires, any term defined in Article 1.1 of the PPA but not defined herein shall have throughout this Agreement the meaning set forth against that term in the PPA, and the following terms shall have the meanings set forth below:

"**Access Rights**" has the meaning set forth in Article 6.6 hereof.

"**Agreement**" has the meaning set forth in the Preamble hereof.

"Applicable Law" means any and all statutes, laws, municipal charter provisions, regulations, ordinances, rules, mandates, judgements, orders, decrees, Permits and Approvals, codes or license requirements, or other governmental requirements or restrictions or any interpretation or administration of any of the foregoing by any Governmental Authority, that apply to either Party under this Agreement, whether now or hereafter in effect.

"**Defect**" has the meaning set forth in Article 5.5hereof.

"**Dispute Notice**" has the meaning set forth in Article 13.2 hereof.

"**Dispute**" has the meaning set forth in Article 13.2 hereof.

"**Emergency**" has the meaning set forth in Article 8.2 hereof.

"**Execution Date**" means the date of signing this Agreement.

"**Expert**" has the meaning set forth in Article 13.3 hereof.

"**Fee**" has the meaning set forth in Article 4.1 hereof.

"FENAKA" has the meaning set forth in Recital D hereof.

"Implementation Agreement" has the meaning set forth in Recital F hereof.

"**Instant Facility**" means the solar PV systems, inverters, and related equipment, systems, components, fixtures, and facilities sharing a common point of interconnection with FENAKA's Electric System, Licensee's Interconnection Facilities relating thereto, the ground mounted canopy structure on top of which the solar panels shall be fixed and other assets, tangible and intangible, that comprise the Facility as set up on the Site(s).

"**Indemnified Party**" has the meaning set forth in Article 10 hereof.

"**Indemnifying Party**" has the meaning set forth in Article 10 hereof.

REGIONAL AIRPORTS COMPANY LTD

4

“**License**” means the license issued to the Licensee by the Licensor to design, build, maintain and operate the Instant Facility at the Site(s) in accordance with the terms and conditions of this Agreement.

“**License Term**” has the meaning set forth in Article 2 hereof.

“**Licensee**” has the meaning set forth in the Preamble hereof.

“**Licensee’s Interconnection Facilities**” has the meaning ascribed to the term “Seller’s Interconnection Facilities” in Article 1.1 of the PPA.

“**Licensor**” has the meaning set forth in the Preamble hereof.

“MECCT” mean the Ministry of Environment, Climate Change and Technology of the Government of the Republic of Maldives or any successor thereto.

“**PPA**” has the meaning set forth in Recital E hereof.

“**Possession Date**” has the meaning set forth in Article 3 hereof.

“Reference Rate” mean the rate notified by the Maldives Monetary Authority for 364 Days Treasury Bills, on the Day that is two (2) Business Days prior to the day on which interest shall begin to be calculated hereunder, subject to a maximum of five percent (5%).

“**Site(s)**” means the spaces on Fuvahmulah Airport and Kulhudhuhfushi Airport chosen as the sites for developing the Project, more fully described in Exhibit A herein.

“SIAC” means Singapore International Arbitration Centre.

“Taxes” means any tax applicable in the Maldives, including any tax on income, excise duty, customs duty, value added tax, sales tax, good and services tax and other local tax, cess, any impost or surcharge of like nature, any interest, penalties and other sums in relation on the income, goods, material, equipment and services rendered by either Party, and charged, levied or imposed by a Government instrumentality.

“**Transfer**” means in relation to a property, the sale, gift, pledge, assignment, transfer, transfer of any interest in trust, encumbrance, or alienation or disposition in any manner whatsoever, voluntarily or involuntarily, including, any attachment, assignment for the benefit of creditors against the owner of a property or appointment of a custodian, liquidator or receiver in relation to the property.

“URA” means the Utility Regulatory Authority established under Law No. 26/2020 (Utility Regulatory Authority Act).

1.2 Interpretations

In this Agreement:

(a) any reference to any statute or statutory provision shall include:

  (i) all subordinate legislation made from time to time under that provision (whether or not amended, modified, re-enacted or consolidated);

  (ii) such provision as from time to time amended, modified, re-enacted or consolidated (whether before or after the date of this Agreement) and (to the extent liability thereunder may exist or can arise) shall include any past statutory provision (as from time to time amended, modified, re-enacted or consolidated), which the provision referred to has directly or indirectly replaced;

(b) reference to any Party under this Agreement shall also include its successors, administrators, legal representatives, and permitted assigns as the case may be;

(c) heading to Articles and paragraphs are for information only, and shall not form part of the operative provisions of this Agreement and be ignored in construing the same;

(d) references to Articles and schedules are to Articles and schedules to this Agreement. All of these form part of the operative provisions of this Agreement and references to this Agreement shall, unless the context otherwise requires, include references to the Articles and schedules;

(e) unless the contrary is expressly stated, no Article in this Agreement limits the extent or application of another Article;

(f) any reference to books, files, records or other information or any of them means books, files, records or other information or any of them in any form or in whatever medium held including paper, electronically stored data, magnetic media, film and microfilm;

(g) "in writing" includes any communication made by letter or facsimile;

(h) the words "*include*", "*including*", "*inter alia*" and "*in particular*" shall be construed as being by way of illustration or emphasis only and shall not be construed as, nor shall they take effect as, limiting the generality of any preceding words;

(i) the words "*directly or indirectly*" mean directly or indirectly through one or more intermediary persons or through contractual or other legal arrangements, and "direct or indirect" shall have the correlative meanings;

(j) the expression "*this Article*" shall, unless followed by reference to a specific provision, be deemed to refer to the whole Article (not merely the sub-Article, paragraph or other provision) in which the expression occurs;

(k) the terms '*hereof*', '*herein*', '*hereby*', '*hereto*' and derivative or similar words shall, unless followed by a reference to a specific provision of the Agreement, be deemed to refer to this entire Agreement;

(l) when any number of Days are prescribed in this Agreement, same shall be reckoned exclusively of the first and inclusively of the last Day, unless the last Day does not fall on a Business Day, in which case the last Day shall be the next succeeding Day which is a Business Day;

(m) time is of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended, such extended time shall also be of the essence;

(n) a reference to any agreement is a reference to that agreement and all schedules, appendices and the like incorporated therein, as the same may be amended, modified, supplemented, waived, varied, added to, substituted, replaced, renewed or extended from time to time;

(o) all provisions of this Agreement shall be interpreted and construed in accordance with their meanings, and not strictly for or against either Party, regardless of which Party may have drafted this Agreement or a specific provision;

(p) grammatical variations of defined words shall be construed in accordance with the relevant definition(s);

(q) references to the singular number shall include references to the plural number and vice versa; and

(r) words denoting one gender shall include all genders.

ARTICLE 2
LICENSE TERM

The term of this Agreement shall enter into full force and effect on the Execution Date and shall expire upon the expiry of the PPA or upon an earlier termination of the PPA ("License Term").

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 3
GRANT OF LICENSE

Subject to the Licensee's compliance with its obligations in this Agreement, the Licensor hereby grants and the Licensee hereby accepts the License, to design, build, maintain and operate the Instant Facility on the Site(s), for the duration of the License Term, unless terminated earlier in accordance with the terms herein contained. The Licensor shall provide to the Licensee, access to the Site(s) on a Day mutually agreed between the Parties (the "Possession Date"), which Day shall not be later than 31st July 2022. The Licensee undertakes and covenants that the Site(s) shall only be used for the purposes of designing, building, maintaining and operating the Instant Facility in accordance with the terms and conditions herein mentioned, and for no other purpose. The Licensee shall not have exclusive possession of the Site(s) and nothing contained herein shall be construed as creating any rights, interest, easement, tenancy or sub-tenancy in favor of the Licensee in or over the Site(s) other than the permissive right of use herein granted.

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 4
CONSIDERATION

4.1 In consideration of the grant of the License over the Site(s) to develop the Project and the grant of Access Rights, the Licensee shall pay to the Licensor, an annual fee at the rate of Rufiyaa Eight (MVR 8) per square meter (of the area of the Site(s)) per year ("Fee"). The Fee shall be paid on or before the 01st Day of January of each year during the License Term. Parties acknowledge that this Agreement is being entered into towards fulfillment of the Maldives' obligations to the Licensee under the Implementation Agreement, and in consideration, *inter alia*, of the Licensee's obligation to develop the Project and sell Electric Energy to FENAKA, which collectively with the Fee is acknowledged by the Parties to constitute adequate consideration for the grant of the License over the Site(s) and the grant of Access Rights under this Agreement. Accordingly, Parties undertake that neither Party shall question the validity of this Agreement for want or adequacy of consideration

4.2 The Licensee shall commence payment of the Fee starting from 01st Day of January 2023

4.3 The Licensee shall pay the Fee by online remittance (electronic funds transfer) or by way of demand draft drawn in favor of the Licensor payable at Male', Republic of Maldives. In the event the payment is made by way of online remittance, the Licensee shall provide proof of such remittance to the Licensor within 02 (two) days of such remittance and all the charges in relation to transfer of payments to the Licensor's account shall be borne by the Licensee.

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 5
TAXES AND INSURANCE

5.1 Taxes in Relation to Site(s)

During the License Term, the Licensor shall be liable to bear and pay on its sole account any and all Taxes in relation to the Site(s).

5.2 Taxes in Relation to Instant Facility

Any Tax imposed by a Governmental Authority, with respect to the design, construction, financing, ownership, erection, installation, maintenance and operation of the Instant Facility and/ or on account of the income generated from the operation of the Instant Facility, shall be borne by the Licensee. To the extent possible under Applicable Law, the Licensee shall make such payments directly to the relevant Governmental Authority. In the event that any Tax that is payable by the Licensee is paid by the Licensor, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.3 Taxes on Fee

The Fee shall be paid by the Licensee without any deductions whatsoever, save and except the deduction of tax at source, if applicable. The liability for payment of any Taxes as applicable on the Fee shall be borne by the Licensee, even if the same is payable by the Licensor in accordance with the Applicable Law.

5.4 Commercial General Liability Insurance for Damage to the Site(s)

The Licensee shall procure and maintain commercial general liability insurance, employer's liability, worker's compensation , professional liability (with any exclusions subject to the prior written approval of the Licensor) up to the overall limit set out in Schedule 4 of the PPA, and within such commercial general liability insurance the Licensee shall also insure against liability for personal injury and damage to the Site(s) or damage to any third party properties therein, arising directly out of the installation of the Instant Facility or its use, in standard form, which shall include operations and blanket contractual liability coverage which insures performance by the Licensee of the indemnity provisions of this Agreement. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date.

5.5 Comprehensive "All Risks" Insurance of the Instant Facility

The Licensee, at its cost, shall within the overall limit set out in Schedule 4 of the PPA, procure and maintain comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility against fire, accident, burglary, vandalism, machinery breakdown, earth movement such as earthquake, volcanic eruptions and subsidence, hurricane/ windstorms, flood including

REGIONAL AIRPORTS COMPANY LTD

tsunami, debris removal, ordinance or law, extra expense and terrorism. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date. Upon failure by the Licensee to procure and maintain such comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility, and the occurrence of any such event that renders the Site(s) untenable for use by the Licensor (a "Defect") and other users, the Licensee shall cure such Defect at its own cost, within thirty (30) Days of the occurrence of the Defect. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to obtain the required insurance. In the event that the Licensor obtains required insurance for the Site, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. The Licensor shall be entitled to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.6 The Licensee shall, at its own cost, ensure that any insurance policy required to be maintained by it in accordance with this Article 5 is renewed before the expiry of such insurance policy. Such insurance policy shall also comply with the other requirements stated in Schedule 4 of the PPA, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee. The insurance policies referenced herein shall be taken out in the names of the Licensor and the Licensee for the full value of their respective rights and interests provided that the premiums incurred by the Licensee in complying with this clause will not be unreasonable. The Licensor shall, at the cost of the Licensee, provide all reasonable necessary assistance and cooperation to the Licensee for the renewal of such insurance policy by the Licensee. The proceeds of any Proceeds of any insurance claim are to be applied towards the replacement, repair and/or reinstatement of the Site(s) and/or the Instant Facility.

5.7 On the occurrence of a partial or total loss or an event which, in the reasonable opinion of the Licensee would result in a claim against the insurance policies taken by the Licensee in respect of the Instant Facility, the Licensee shall forthwith and in any case not later than two (2) Days from the date of occurrence of loss or event inform the Licensor of the same.

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 6
LICENSEE'S RIGHTS AND COVENANTS

6.1 The Licensee shall provide a copy of the duly executed PPA to the Licensor within fifteen (15) Days of the Execution Date.

6.2 The Licensee hereby represents and warrants that it has inspected or has caused an inspection of the Site(s) to be done, and has satisfied itself on the suitability of the Site(s) for the Instant Facility, and shall accept the possession of the Site(s) on an "as is where is" basis, on the Possession Date.

6.3 The Licensee shall be solely responsible for (a) all costs and the performance of all tasks required for installation, operation and maintenance of the Instant Facility at the Site(s) including costs related to preparation of the Site(s) before installation, costs related to capital improvement, removal, replacement and expansion of the Instant Facility; (b) ensuring that the design, construction, financing, ownership, maintenance and operation of the Instant Facility are in compliance with Good Engineering and Operating Practices, Codes and Standards, and Applicable Law, including those relating to safety norms, public health and environment; (c) ensuring that the performance of the tasks required for installation, operation and maintenance of the Instant Facility does not cause any damage to the Site(s), and to any public property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; (d) obtaining all Permits and Approvals required for the Licensee's use of the Site(s); and (e) bearing all risk of loss in case of a theft, damage, casualty, condemnation or confiscation of the Instant Facility.

6.4 The Licensee agrees that any matter raised in relation to the installation, maintenance and operation of the Instant Facility by any person, shall be addressed as per the Environment and Social Impact Assessment (ESIA) and the Grievance Redress Mechanism (GRM), developed pursuant to the Environmental and Social Management Framework (defined in the PPA) relating to ASPIRE.

6.5 The Licensor may, if in the event the Licensee is unable to attend to any issue in accordance with the GRM, upon giving 24 hour written notice, resolve such issues or remedy any damages or defects as maybe specified in the notice, and make such repairs thereto as the Licensor deems appropriate. Should the Licensor effect repairs, the Licensee shall pay to the Licensor the amount of such repairs reasonably incurred by the Licensor upon submission to the Licensee of an invoice with supporting documents showing the cost incurred by the Licensor for such repairs which shall be calculated at a fair and reasonable market rate.

6.6 During the License Term, the Licensee shall have the following rights ("<u>Access Rights</u>") in relation to the Site(s):

(a) right to erect temporary structures, such as a scaffolding or similar structures at the Site(s) as may be reasonably required for the purpose of carrying out the construction and erection of the Instant Facility and/ or for the maintenance of the Instant Facility, provided that (i) the Licensee shall use all reasonable efforts to minimize the impact thereof on the normal use of the space

REGIONAL AIRPORTS COMPANY LTD

where the Site(s) is located, by the public and (ii) the Licensee shall obtain prior written approval of the Licensor in respect of such temporary structures and all approvals required under Applicable Law;

(b) right to use such ways, paths and passages as are reasonably necessary for the purpose of access to and egress from the Site(s), with or without workmen and for transporting, loading and unloading necessary tools, equipment and materials, provided that (i) the Licensor may in consultation with the Licensee and for a reasonable cause require the Licensee to change the route of any means of access to or egress from the Site(s) and may change the area over which any of the Access Rights are exercised; and (ii) the use of such ways, paths and passages shall not obstruct the general use of the space where the Site(s) is located by the public, provided that where the Licensee's use of the path, ways and passages will result in an obstruction of the use of such space by the public, such obstruction shall be done only after obtaining a prior written approval from the Licensor, and shall be only for a reasonable period of time as agreed with the Licensor, consistent with Good Engineering and Operating Practices.

Provided that the Licensee shall provide the Licensor at least thirty (30) Days before the commencement of the construction of the Instant Facility, or a related activity, a schedule of construction of the Instant Facility. Upon receipt of such schedule of construction from the Licensee, the Licensor shall within five (5) Business Days respond with such reasonable changes to the schedule of construction, if any, as it may require, failing which the Licensor shall be deemed to have accepted the schedule of construction. If the Licensor requests any changes to the schedule of construction, the Licensee shall modify its schedule of construction after incorporating such reasonable changes suggested by the Licensor, and notify the finalized schedule of construction at least five (5) Days prior to the commencement of construction.

6.7 The Licensee shall have right to use utilities such as electricity and water for the purpose of construction, installation, erection, operation and maintenance of the Instant Facility, at the cost of the Licensee. The Licensee shall install separate meters for recording the consumption of electricity and water by the Licensee at the Site(s). The Licensee shall pay by the due date the meter installation and hire charges and also the bills for consumption of electricity and water in the Site(s) as recorded in the meters to the relevant utility companies and provide a copy of the proof of such payment to the Licensor within fifteen (15) Business Days from such payment for its records. In addition, the Licensee shall arrange at its own cost other facilities such as telephone services and other similar facilities, and pay directly to the third-party services providers for such services availed by it.

6.8 Subject to Article 5 hereof, the Licensee may make its own arrangements for and take reasonable measures, in consultation with the Licensor for the protection and security of the Instant Facility.

6.9 The Licensee shall have the right to construct ground mounted canopy structures and such other supporting structures as necessary which forms part of the Instant Facility, and shall have the right from time to time, both before and after the Commercial Operation Date, and at the Licensee's sole cost and expense, to make such additions, alterations or changes to such structures, as are reasonably required in compliance with the provisions of this Agreement, Applicable Law, Good Engineering and Operating Practices and Codes and Standards; provided that: (a) the Licensee shall not cause any damage to the Site(s), and to any public

REGIONAL AIRPORTS COMPANY LTD

property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, low voltage, medium voltage, and high voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; and (b) the Licensee shall obtain the prior written approval of the Licensor, and such prior written approval shall not be unreasonably withheld, in respect of any such construction, additions, alterations or changes, except if such construction, additions, alterations or changes are cosmetic in nature and/ or are part of the day to day maintenance and repair of the Instant Facility; and (c) the Licensee shall provide to the Licensor a certificate from a civil engineer and/or architect having the requisite competence under Applicable Law for issuing such certificates, and acceptable to the Licensor and such acceptance shall not be unreasonably withheld, and which certificate shall certify that the proposed constructions, additions, alterations, or changes are in compliance with the Applicable Law, required for the construction of the Instant Facility.

6. 10 The Licensee shall be solely responsible for day to day operation and maintenance of the Instant Facility, including without limitation the obligation to promptly make or pay (as determined by the Licensor) for, any repairs to any part or whole of the Site(s), to the extent damage is caused by the Licensee, its employees, officers, agents, contractors or subcontractors, during the License Term.

6.11 In complying with its obligations under Article 6.9, the Licensee shall to the extent possible give five (5) Business Days prior written notice for all repair and maintenance work of the Instant Facility or the Site(s) so as not to restrict public use of the space in which the Site(s) is located. Upon such request for repair and maintenance work, the Licensor shall respond to such request within five (5) Business Days. If the Licensor does not respond to such request within five (5) Business Days, such request shall be deemed approved by the Licensor. The Licensee shall ensure that all such work undertaken must be completed in all respects in a timely manner.

6.12 At all times, the Licensee shall:

(a) take due care to ensure that no damage is caused to any property on the Site(s) and the space belonging to or used by the Licensor, the public or other users of such space;

(b) not cause inconvenience to the Licensor, and other users of the space in which the Site(s) is located as is reasonably practicable, except that the Licensor agrees that the exercise of the Access Right granted under Article 6.6(a) hereof may cause temporary obstruction and/ or interference with the normal use of such space and that such inconvenience shall not be deemed to be a violation of the Licensee's obligations under this Article 6.11(b).

6.13 In the event, there is any damage to the Site(s) and/or to the space where the Site(s) is located, and to any public property or to any property of a third party therein, including but not limited to any damage to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, water and sewerage mains, fiber-optic cables and telecommunication service lines, by reason of the Licensee exercising an Access Right or other rights under this Agreement, the Licensee shall make good such damage (to the reasonable satisfaction of the Licensor) at its own cost.

6.14 The Licensee shall provide a list to the Licensor (or to any officer of the Licensor designated

REGIONAL AIRPORTS COMPANY LTD

by the Licensor for this purpose), of the employees, agents, sub-contractors, and other representatives of the Licensee who shall be entitled to enter upon the Site(s), and shall ensure that the Access Rights granted hereunder are exercised by such employees, agents, sub-contractors, and other representatives, subject to the reasonable conditions for entry and exit to the Site imposed by the Licensor, and having regard to the public safety, and the safety of the Site(s).

6.15 The Licensee shall, as promptly as possible, notify the Licensor of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s) and/ or the Instant Facility, and that in the Licensee's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety.

6.16 The Licensee shall consult with the Licensor and obtain Licensor's approval in relation to design of the Instant Facility (including with respect to its placement within the Site(s) and technical specifications) and obtain written approval from the Licensor in case of any alteration to the design of the Instant Facility.

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 7
OWNERSHIP OF THE INSTANT FACILITY

7.1 The Licensee shall be the exclusive owner and operator of the Instant Facility, including any part thereof, installed by the Licensee.

7.2 The Licensee acknowledges and agrees that, notwithstanding that the Instant Facility is a fixture on the Site(s), the Licensee shall have no right, title or interest in the Site(s) except as that of a Licensee as per the terms set out in this Agreement. The Licensee shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on the Site(s) or the Access Rights or any interest therein, and the Licensor will not suffer in any manner out of Licensee's use of the Site(s) whereby the estate, rights and interests of the Licensor in the Site(s) or any part thereof might be impaired, except in accordance with and subject to the provisions of this Agreement.

REGIONAL AIRPORTS COMPANY LTD
C-0845182

ARTICLE 8
LICENSOR'S COVENANTS

8.1 The Licensor shall take all reasonable efforts not to cause any interference with the effective operation of the Instant Facility, including any interference with the Licensee's right to receive continuous and uninterrupted passage of light at all times across the Site(s) or have access to the Site(s) and the Instant Facility.

8.2 The Licensor shall, as promptly as possible, notify the Licensee of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s), and that in the Licensor's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety. The Licensor and FENAKA shall have the right (but not the obligation), to the extent permitted by Applicable Law, to enter into the Site(s) for the sole purpose of responding to any dangerous condition posing risk to, the Site(s), the Instant Facility, public health or public safety ("Emergency"); provided that any actions taken by the Licensor upon such entry shall be limited to those reasonably necessary to respond to the risks posed. The Licensee shall respond to any such Emergency as promptly as possible, and take all measures necessary to address the condition that gave rise to the Emergency. The Licensee shall not be required to bear the costs associated with an Emergency related to the Site(s) that are not caused by the Licensee and does not affect the Instant Facility.

8.3 The Licensor shall reasonably cooperate with the Licensee, at the Licensee's cost, so that the Licensee can procure all Permits and Approvals for design, engineering, construction, financing, operations, maintenance and deconstruction of the Instant Facility, and meet its obligations under this Agreement and the PPA.

8.4 The Licensor agrees and undertakes that this Agreement and the Access Rights shall run with the Site(s) and shall survive any Transfer of the Site(s). The Licensor shall give the Licensee at least six (6) Calendar Months written notice prior to any Transfer of all or a portion of the Site(s) identifying the transferee, the portion of the Site(s) to be transferred and the proposed date of Transfer. In the event of Transfer by any way or form of the Site(s), the Licensor shall cause the proposed transferee to execute an agreement identical in terms and conditions as that of this Agreement with the Licensee, for a term equal to the License Term outstanding at the date of such Transfer.

8.5 The Licensor recognizes the need of the Licensee to finance the Project by mortgage of the Instant Facility, accordingly, the Licensor shall reasonably cooperate with the Licensee in creation of charge on the Instant Facility in favor of the lenders to the Project, at the cost of the Licensee, including through furnishing such documents and certificates as may be reasonably requested by the Licensee's lenders.

8.6 The Licensor shall not, directly or indirectly, cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on or with respect to the Site(s), except with the prior written consent of the Licensee, which consent shall not be unreasonably withheld.

8.7 Subject to the terms and conditions of this Agreement and the Licensee's compliance with all

REGIONAL AIRPORTS COMPANY LTD
C-0045/20

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 **Licensor's Representations and Warranties**

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a company, duly established and validly existing under the constitution and laws of Maldives, is duly qualified to conduct business in Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

   (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or
   (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of incorporation/ registration of the Licensor) or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 **Representations and Warranties of the Licensee**

REGIONAL AIRPORTS COMPANY LTD

Licensee hereby represents and warrants as of the date hereof that:

(a) the Licensee is a company duly organized and validly existing under the relevant jurisdiction specified in the Preamble of this Agreement, and has full legal right, power and authority under Applicable Law to enter into and perform its obligations under this Agreement;

(b) the Licensee has duly authorized the execution and delivery of this Agreement. This Agreement has been duly executed and delivered by the Licensee and will constitute a legal, valid and binding obligation of the Licensee, enforceable against the Licensee in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other laws affecting creditors rights generally;

(c) neither the execution nor the delivery by the Licensee of this Agreement nor the performance by the Licensee of its obligations hereunder: (i) will conflict with, violate, or result in a breach of any Applicable Law of Maldives; or (ii) conflicts with, violates, or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of [incorporation/ registration] of the Licensee), or instrument to which Licensee is a party or by which Licensee or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or instrument;

(d) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensee, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensee in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensee of its obligations hereunder or under such an agreement or instrument.

REGIONAL AIRPORTS COMPANY LTD
C-0845/2021

ARTICLE 10
INDEMNIFICATION

The Licensee (also an "Indemnifying Party") shall indemnify and hold harmless the Licensor and its employees, officers, agents, contractors, professional advisors and representatives (each an "Indemnified Party") from and against all liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, that may be imposed upon or incurred by or asserted against the Licensor or any of its employees, officers, agents, contractors, professional advisors, representatives, by reason of any of the following occurrences during the License Term, except to the extent such liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, are caused by either (i) gross negligence or intentional wrongful acts of the Indemnified Party or (ii) failure or other breach by the Indemnified Party to perform any of its obligations under Applicable Law or Permits and Approvals:

(a) any breach by the Licensee of its obligations, covenants, representations or warranties contained in this Agreement;

(b) any negligence on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees in connection with the use of the Site(s) or in designing, construction, financing, ownership and operation of the Instant Facility or the Project; or

(c) any failure on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees to comply with Applicable Law that require compliance by the Licensee or any of its agents, contractors, servants, employees, subtenants, licensees or invitees in connection with the Site(s) and its use, or design, construction, financing, ownership and operation of the Instant Facility, or the Project.

REGIONAL AIRPORTS COMPANY LTD
C-8845/202

ARTICLE 11
FORCE MAJEURE EVENT

11.1 Adoption of provisions of PPA

Provisions of Article 12.4, Article 12.5 and Article 12.6 of the PPA shall *mutatis mutandis* apply to this Agreement, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee.

11.2 Effects of Force Majeure Events

Without prejudice to the rights or obligations of the Government or FENAKA under the Implementation Agreement or the PPA,

(a) if the Force Majeure Event results in loss of the Site(s) or the Instant Facility, either Party shall have the right to terminate this Agreement in accordance with the provisions of Article 12.1(a) of this Agreement; or

(b) if a Force Majeure Event subsists for more than one hundred and eighty (180) Days and the PPA is terminated in accordance with Article 13.5, or Article 13.6, as the case may be, of the PPA, either Party may terminate this Agreement in accordance with Article 12.1(b) and Article 12.2, hereof.

ARTICLE 12
TERMINATION

12.1 Events of Termination

This Agreement shall terminate in the following circumstances:

(a) If occurrence of a Force Majeure Event results in loss of the Site(s), either Party shall have the right to terminate this Agreement in accordance with Article 11.2(a), by a notice in writing to the other Party, with the termination being effective from fifteen (15) Days from the date of such notice.

(b) Upon termination of the PPA, whether on account of expiry of the Contract Term, or otherwise, and whether in respect of the Project as a whole or in respect of the Instant Facility, either Party shall have the right to terminate this Agreement with effect from the date of termination of the PPA.

(c) If the Government issues or is deemed to have issued a Concurrence Notice under Article 4.2(c)(iii) of the Implementation Agreement, either Party may terminate this Agreement.

(d) If an Expert (as defined under the Implementation Agreement) determines in accordance with Article 4.2(c)(x) of the Implementation Agreement that the Site(s) is unavailable for use of the Licensee, the Agreement shall terminate with effect from the date of such determination or such other date as such Expert may determine.

12.2 Consequences of Termination

(a) If the Agreement terminates in accordance with Article 12.1(b) but on account of expiry of the Contract Term and FENAKA chooses to purchase the Instant Facility in accordance with Article 2.2 of the PPA, the Licensor shall transfer the License provided for in this Agreement in favor of FENAKA on such terms and conditions as FENAKA and Licensor may agree in writing.

(b) If the Agreement terminates in accordance with Article 12.1(a), or Article 12.1(b) but on account of

(i) expiry of the Contract Term and FENAKA chooses not to purchase the Instant Facility in accordance with Article 2.2 of the PPA,

(ii) termination of the PPA in accordance with Article 13.3(a) or Article 13.3(c) of the PPA, and FENAKA chooses not to exercise its right under Article 13.3(d) of the PPA to purchase the Project or the Instant Facility, or

(iii) termination of the PPA in accordance with Article 13.5(a) or Article 13.5(b) (where the PPA is terminated by the Seller, thereof) of the PPA,

the Licensee shall within one hundred and eighty (180) Days, decommission the entire Instant Facility set up at the Site(s), remove all its assets from the Site(s), and vacate and hand over

REGIONAL AIRPORTS COMPANY LTD

peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

(c) If the Agreement terminates in accordance with Article 12.1(b) but on account of,

   (i) termination of the PPA in accordance with Article 13.4(c), Article 13.4(d), Article 13.6(a) or Article 13.6(c) of the PPA,

   (ii) termination of the PPA by FENAKA in accordance with Article 13.5(b) of the PPA,

Licensor shall execute a license over the Site(s) in favor of the FENAKA simultaneously with the purchase of the Instant Facility by FENAKA, on terms and conditions substantially similar to those contained in this Agreement, unless FENAKA and the Licensor agree otherwise.

(d) If the Agreement terminates in accordance with Article 12.1(c) or Article 12.1(d), the Licensee shall relocate the Instant Facility to the alternative Site(s), promptly upon execution of the license agreement for the alternative Site(s), but in no event later than one hundred and eighty (180) Days, and vacate and hand over peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

REGIONAL AIRPORTS COMPANY LTD

ARTICLE 13
DISPUTE RESOLUTION

13.1 Continued Performance

Each Party shall continue to perform its obligations under this Agreement (including any payment obligations) pending resolution of any dispute pursuant to this Article 13. Provided that, if the dispute is with respect to any payments, neither Party shall be required to make such disputed payment(s) to the other Party so long as such dispute has been referred to the process for resolution pursuant to this Article 13; provided, that to the extent any amounts owed to either Party by the other Party are not disputed and can be segregated from amounts with respect to which there is a dispute, such undisputed amounts shall, in good faith, be identified by the Parties and paid as required by this Agreement. To the extent that any disputed amount was withheld from a Party, and such Party is ultimately found to be entitled to all or any portion of such disputed amount pursuant to this Article 13, then such Party shall be entitled to the payment of interest on any withheld amount, at an annual rate equal to Reference Rate, from the original due date for payment of such amount until the payment of such disputed amount.

13.2 Negotiation

If any dispute, controversy or claim arises under or relates to this Agreement or the breach, termination or validity thereof (the "Dispute"), such Dispute shall be referred by each Party to its designated senior officer for resolution upon five (5) Days written notice from either Party (the "Dispute Notice"). The Parties agree to attempt to resolve all Disputes promptly and equitably and to provide each other with reasonable access during regular business hours to any and all non-privileged records, information and data pertaining to any such Dispute.

13.3 Expert Determination

(a) A dispute may be referred to an expert (the "Expert") in accordance with this Article 13.3 if:

  (i) the Parties are not able to agree under Article 13.2 (*Negotiation*) on an amicable resolution to such dispute; and

  (ii) this Agreement expressly provides that such dispute shall be referred to an Expert or the Parties agree in writing that such dispute shall be referred to an Expert.

(b) Any Party to such a Dispute may initiate an Expert reference under this Article 13.3 by proposing to the other Party to the dispute the name of the Expert. If the other Party does not agree to the name suggested by the Party making the reference, and the Parties are otherwise unable to agree on the name of an Expert, either Party may apply to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the Expert for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, an

Expert for the matter in Dispute.

(c) The Parties shall request that the Expert determine the referred dispute, within thirty (30) Days of receiving the reference, or in such additional time as may be reasonably required by the Expert to determine the Dispute, which shall not be more than one hundred and eighty (180) Days of receiving the reference.

(d) The Expert shall act as an expert and not as an arbitrator.

(e) The Parties shall have the right to make representations and submissions to the Expert. There shall be no formal hearing.

(f) The Expert shall have power to request any Party to provide him/her with such statements (which shall be written unless otherwise specifically required) or documents or information within their control as he may determine necessary and the Parties shall comply with any such request in accordance with the timeframes set out by the Expert or in the absence of such timeframes, in a timely manner as required to enable the Expert to determine the Dispute within the timeframe set forth in Article 13.3(c).

(g) The Expert shall give his/her decision to the Parties to the Dispute in writing and his/her decision, which shall promptly be given effect to by such Parties, shall be final and binding (save in the case of fraud or manifest error) on them.

(h) If the Expert decides that a sum is due and payable by one Party to another Party then:

  (i) any such sum shall be due and payable within seven (7) Days of receipt by the Parties of written notice of such decision, unless the Expert decides otherwise; and

  (ii) interest shall accrue at the rate of Reference Rate, compounded annually, from the date expiry of the period mentioned in Article 13.3(h)(i); provided that if the sum specified in Article 13.3(h)(i) includes any interest, no interest shall be payable on such interest.

(i) The fees of the Expert and any other costs of and incidental to the reference to Expert determination shall be payable by such Party to the Dispute as the Expert may determine but, in the absence of any such determination, by the Parties to the Dispute in equal shares.

13.4 Arbitration

(a) Selection of Arbitrators

If the Parties are unable to resolve their Disputes through negotiation within thirty (30) Days of the Dispute Notice, either Party may initiate proceedings to submit the Dispute for arbitration. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:

  (i) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply

REGIONAL AIRPORTS COMPANY LTD

G

to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute.

(ii) Where the Parties do not agree that the dispute concerns a technical matter, the Parties may agree to appoint a sole arbitrator mutually agreed by them or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, each Party shall appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) Days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC.

(iii) If, in a dispute subject to Article 13.4(a)(ii) above, one Party fails to appoint its arbitrator within thirty (30) Days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.

(b) Rules of Procedure

Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the SIAC as in force on the date of this Agreement.

(c) Substitute Arbitrators

If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator.

(d) Nationality and Qualifications of Arbitrators

Each arbitrator appointed pursuant to Article 13.4(a)(i) to Article 13.4(a)(iii) shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of Maldives or the home country of the Licensee. For the purposes of this Clause, “home country” means any of:

(i) the country of incorporation of the Licensee or their parent companies;
(ii) the country in which Licensee’s principal place of business is located;
(iii) the country of nationality of a majority of the Licensee’s shareholders; or
(iv) where the Licensee is a joint venture between two or more Persons, the country of incorporation, nationality or place of business of the partners or shareholders of such joint venture.

REGIONAL AIRPORTS COMPANY LTD

(e) Miscellaneous

In any arbitration proceeding hereunder:

(i) proceedings shall, unless otherwise agreed by the Parties, be held in Singapore;
(ii) the English language shall be the official language for all purposes; and
(iii) the decision of the sole arbitrator or of a majority of the arbitrators shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

13.6 Governing Law, Jurisdiction and Service of Process

(a) Governing Law

This Agreement shall be governed by, and construed in accordance with, the laws of Maldives.

(b) Jurisdiction

Subject to Article 13.3 and Article 13.4, each of the Parties consents to submit itself to the exclusive jurisdiction of the courts located in the Maldives in relation to recognition of any arbitral award, with respect to any Dispute that arises under this Agreement.

(c) Service of Process

Subject to the rules of SIAC for the purposes of arbitration, each Party agrees that service of any process, summons, notice or document hand delivered or sent by certified mail, return receipt requested, to such Party's respective address set forth in Article 14.4 will be effective service of process for any action, suit or proceeding with respect to any matters to which it has submitted to arbitration as set forth in Article 13.4.

ARTICLE 14
MISCELLANEOUS PROVISIONS

14.1 Assignment

Licensee shall not assign or otherwise transfer this Agreement, except (i) for the collateral assignment to any lenders (only if such lenders are independent third party financial institutions) in connection with the provision of any financing for the Instant Facility, or (ii) to any Person who is a bona fide transferee of the PPA (in accordance with the terms of the PPA), subject to the transferee undertaking to comply with the obligations of the Licensee under the PPA, this Agreement, and the Escrow Agreement.

14.2 Further Assurances

Each Party agrees to, and shall use all reasonable efforts to, provide such information, execute and deliver any instruments and documents and take such action as may be necessary or reasonably requested or required by the other Party which are not inconsistent with the provisions of this Agreement and which do not involve the assumption of obligations other than those provided for in this Agreement in order to give full force and effect to this Agreement and to carry out its intent.

14.3 Relationship of Parties

Except as otherwise explicitly provided herein, neither Party to this Agreement shall have any responsibility whatsoever with respect to services provided or contractual obligations assumed by the other Party and nothing in this Agreement shall be deemed to constitute either Party a partner, agent or legal representative of the other Party or to create any fiduciary relationship between or among the Parties.

14.4 Notices

Any notices required to be given hereunder shall be deemed delivered when (i) sent by facsimile upon electronic confirmation of successful transmission; (ii) delivered to an express courier service nationally recognized in Maldives that provides a receipt of delivery, (iii) sent by email, upon dispatch and the receipt of a delivery confirmation, provided that email shall be used as a mode of notice and communication only for non-material day-to-day matters; (iv)when delivered by personal delivery, in each case addressed to the following persons or such other persons as the Parties may designate in writing:

(a) If to the Licensor:
Name: Mohamed Rizvi
Designation: Managing Director
Address: Regional Airports Company Limited, 6th floor, H. Suaz, Ameer Ahmed Magu, 20095, Male', Republic of Maldives.
Email: rizvi@airports.mv

with a copy to: ahsan@airports.mv

C-0845/2021

FENAKA
Name: Ahmed Saeed Mohamed
Designation: Managing Director
Address: FENAKA Corporation Limited, Port Complex Building, 7th Floor, Hilaalee Magu, Male' 20207
Email: ahmed.saeed@fenaka.mv
Copied to: maasha@fenaka.mv

and

MECCT
Name: Mr. Ajwad Musthafa
Designation: Permanent Secretary
Address: Ministry of Environment, Cliimate Change and Technology Green Building, Handhuvaree Hingun, Male', 20392, Republic of Maldives
Email: ajwad.mustafa@environment.gov.mv

(b) If to the Licensee:

Name: Mr. Goh Chin San
Designation:
Managing Director of Mega First Solar (Maldives) Consortium Pvt Ltd
Authorised Representative of Mega First Power Industries Sdn Bhd
Address: A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Email: chinsan.goh@mega-first.com
Copied to: shadhah.shahid@mega-first.com, kok.cw@mega-first.com

14.5 Costs and Expenses

All costs, expenses, including any cost of documentation, reasonable attorney fees, court fee, and stamp fee, relating to creation and maintenance of the license on the Site(s), including execution of this Agreement, shall be borne by the Licensee.

14.6 Confidentiality

The Parties shall at all times keep confidential information acquired in consequence of this Agreement, except for information which the receiving Party already knows or receives from third parties or which the receiving Party may be entitled or bound to disclose under compulsion of Applicable Law or where requested by regulatory agencies or to their professional advisers, investments partners and other parties where reasonably necessary for the performance of their obligations under this Agreement. For the avoidance of doubt, the obligations in this Article shall not apply to information in the public domain or information which the Parties own or acquired lawfully from others and which may be freely disclosed to others without breach of any obligation of confidence

CJ

14.7 Waiver

No waiver of any provision of this Agreement shall be effective against a Party except as expressly set forth in a writing signed by such Party. The waiver by either Party of a default or a breach by the other Party of any provision of this Agreement shall not operate or be construed to operate as a waiver of any subsequent default or breach. The making or the acceptance of a payment by either Party with knowledge of the existence of a default or breach shall not operate or be construed to operate as a waiver of any subsequent default or breach.

14.8 Survival

Notwithstanding anything provided herein to the contrary, Article 12.2 (*Consequences of Termination*), Article 13 (*Dispute Resolution*) and Article 14 (*Miscellaneous*), shall survive the termination of this Agreement.

14.9 Third Party Rights

Nothing herein is intended to or should be construed to create any rights of any kind whatsoever in third persons not parties to this Agreement, except in favor of the Government, FENAKA, and the World Bank.

14.10 Counterparts

This Agreement and any amendment hereto may be executed and delivered in one or more counterparts and by different Parties in separate counterparts. All of such counterparts shall constitute one and the same agreement and shall become effective (unless otherwise therein provided) when one or more counterparts have been signed by each Party and delivered to the other Party. Delivery of this Agreement by facsimile transmission or electronic email shall be as effective as delivery of a manually executed counterpart.

14.11 Severability

In the event that any provision of this Agreement shall, for any reason, be determined to be invalid, illegal, or unenforceable in any respect, the Parties shall negotiate in good faith and agree to such amendments, modifications, or supplements to this Agreement, or such other appropriate actions, as shall, to the maximum extent practicable in light of such determination, implement and give effect to the intentions of the Parties as reflected herein, and the other provisions of this Agreement shall, as so amended, modified, supplemented, or otherwise affected by such action, remain in full force and effect.

14.12 Entire Agreement

All prior agreements, negotiations, representations, and understandings with respect to the subject matter hereof, are hereby superseded. No amendment, modification, or change to this Agreement or its Exhibit shall be effective unless the same shall be in writing, duly executed, authorized and approved by the Parties. In the event of any conflict between the terms and conditions of this Agreement and that of any Exhibit or other document referenced herein, this Agreement shall govern and control.

REGIONAL AIRPORTS COMPANY LTD
C-0045

IN WITNESS WHEREOF, the Licensor and Licensee have caused this Agreement to be executed as on the date and the year first set forth above.

For and on behalf of the LICENSOR

C-0945/2021

....
Mohamed Rizvi
Managing Director
Regional Airports Company Limited, 6th floor, H. Suez, Ameer Ahmed Magu, 20095, Male', Republic of Maldives.

In the presence of;

....
Ahmed Ibrahim
Chief Operating Officer
Regional Airports Company Limited, 6th floor, H. Suez, Ameer Ahmed Magu, 20095, Male', Republic of Maldives.

For and on behalf of the LICENSEE

....
Goh Chin San
Authorised Representative
Mega First Power Industries Sdn. Bhd.

A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia.

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

....
Song Qing Guo
General Manager
Powerchina Huadong Engineering Corporation Limited
22, ChaoWang Road Hangzhou, Zhejiang
Province, 310014
The People's Republic of China

3301034012942

In the presence of;

....
Khoo Teng Keat
Executive Director
Mega First Corporation Berhad
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia

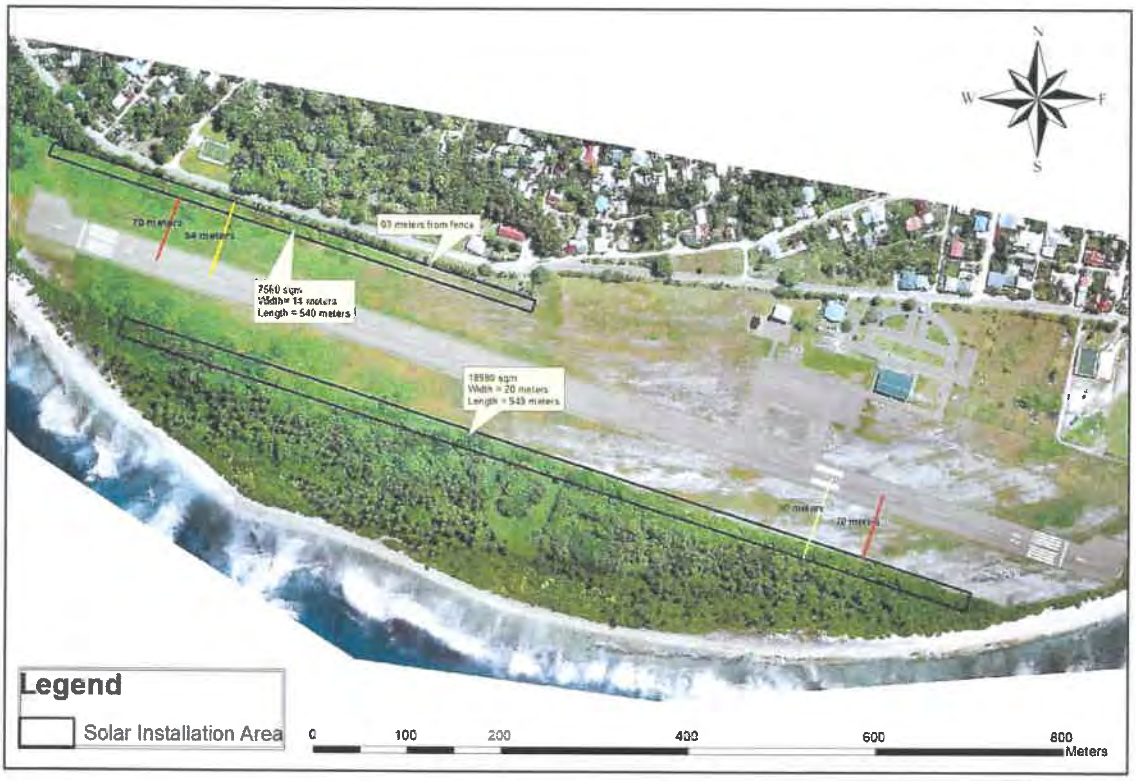
....
Chen Ting
Chief Representative in Sri Lanka
Sinohydro Corporation Limited
22, Chegongzhuang West Road, Haidian District
Beijing 100048 The People's Republic of China

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Note: ***The exact coordinates of the following Sites shall be agreed between the parties on or before the Possession Date following detailed setting out surveys.***

Site 3. Fuvahmulah Airport: Site 3.1: Array Control Tower (N) & Site 3.2: Array Runway South



Area: 7560+18980 m2

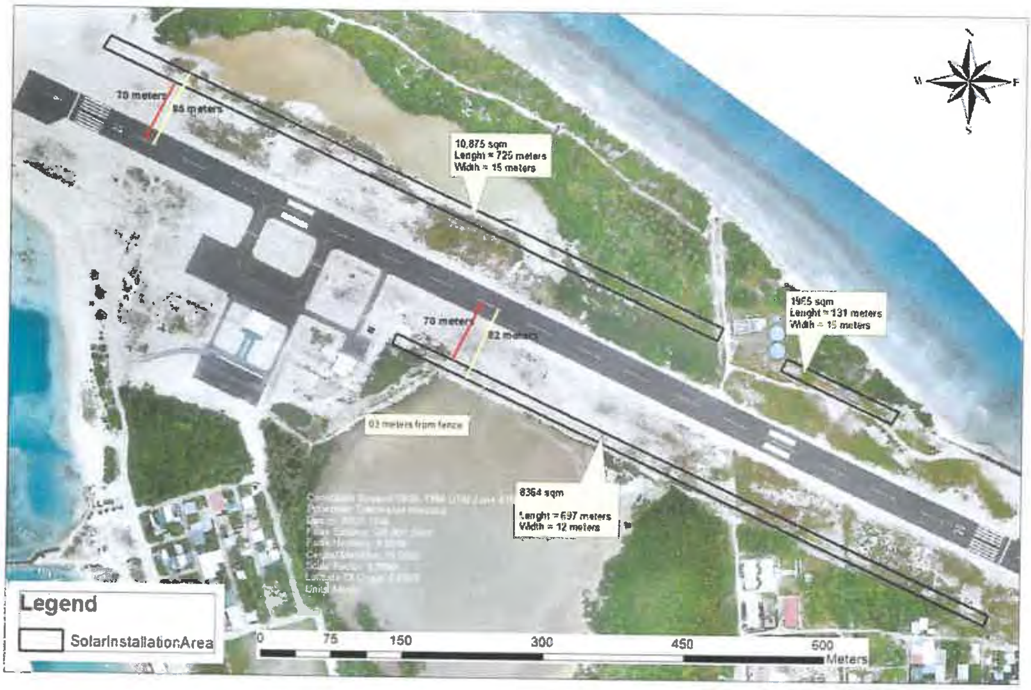
REGIONAL AIRPORTS COMPANY LTD

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Site 7.1&7.2: Kulhudhuffushi Airport: Site 7.1: Array Runway North, & Site 7.2: Array Runway South

Kulhudhuhfushi Airport



Area: 8364+1965+10875 m^2

LICENSE AGREEMENT
FOR THE INSTALLATION OF GROUND MOUNTED SOLAR PANELS

BETWEEN

SOUTH MAALHOSMADULU EYDHAFUSHI ISLAND COUNCIL

(MALDIVES)

(“LICENSOR”)

– AND –

MEGA FIRST POWER INDUSTRIES Sdn. Bhd. (MALAYSIA)

IN JOINT VENTURE WITH

POWERCHINA HUADONG ENGINEERING CORPORATION LIMITED (CHINA)

(“LICENSEE”)

AGREEMENT NUMBER: (AGR)320-FNP/438/2022/1

DATE: APRIL 27, 2022

MEGA FIRST POWER INDUSTRIES SDN. BHD
(Company No. 392936-W)

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and entered into as of the *27th April 2022* by and between:

1. **South Maalhosmadulu Atoll Eydhafushi Island Council,** a local council of the Government of Maldives, established under Act Number: 7/2010 (Decentralization Act of Maldives) with its offices at Secretariat of Eydhafushi Council, South Maalhosmadulu Atoll, Baa Eydhafushi Island, Republic of Maldives ("Licensor"); and

2. **Mega First Power Industries Sdn. Bhd. (MFPI)** a limited liability company, company registration number: 199601020584 (392936-W) , organized and existing under the laws of Malaysia, with its principal office located at A-12-01, Level 12, Block A, PJ8, No. 23, Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia, and **Powerchina Huadong Engineering Corporation Limited (HDEC)** a limited liability company with Unified Social Credit Code: 91330000142920718C, organized and existing under the laws of Peoples Republic of China, with its principal office located at No. 22, ChaoWang Road Hangzhou 310014, Zhejiang Province, The People's Republic of China (**MFPI** and **HDEC** will be jointly and severally liable, and collectively will be hereinafter referred to as the "Licensee").

WHEREAS:

A. The Government (as defined in the PPA), with support from the Strategic Climate Fund and International Development Association, has initiated a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) for inviting private sector generators to develop [roof top and ground mounted] solar photovoltaic projects in Maldives on a DBFOOT (i.e. design, build, finance, own, operate and transfer) basis. The electrical energy generated from such projects is proposed to be purchased by a Government owned utility under a long-term power purchase agreement.

B. The Government had invited bids from interested independent power producers, *vide* RFP (as defined in the PPA) dated June 17th, 2021 for setting up solar power projects on Government-owned buildings and public spaces identified and facilitated by the Government in the RFP.

C. The Licensee had submitted a Proposal (as defined in the PPA) in response to the RFP, and has been selected by the Government *vide* Letter of Acceptance, dated February 17th, 2022 to develop a solar PV power project. Accordingly, the Licensee desires to construct, own and operate grid connected solar PV electric generating facilities situated at the roof top of Government owned buildings and on such other public spaces identified on selected islands, with a total electric capacity not less than 11 MW.

D. FENAKA (as defined in the PPA) is the identified state utility under the ASPIRE program for purchase of the Electric Energy (as defined in the PPA) generated by the Seller.

E. The Licensee has entered into a Power Purchase Agreement, dated 29th March 2022 ("PPA") with FENAKA to set forth the mechanism for sale and purchase of the Electric Energy generated by the Licensee and other mutual rights and the obligations of the Licensee and FENAKA.

F. Government also proposes to support the Project, the details of which have been prescribed in the Implementation Agreement (as defined in the PPA), setting forth mutual rights and obligations of the Licensee and the Government, executed between the Licensee and the Government.

G. The Licensee was the successful bidder, and among the locations identified in the RFP is the location situated in the island of South Maalhosmadulu, Baa. Eydhafushi (together with adequate space for setting up a control room for the Instant Facility (as defined herein below)), the description of which is detailed in Exhibit A ("Site(s)").

H. The Licensee intends to incorporate and establish, in accordance with Applicable Laws, a company to develop the Project ("Project Company") and upon its incorporation, the Parties intend to amend this Agreement to add the Project Company as a party to this Agreement such that the Project Company will be jointly and severally liable with the Licensee for all of the Licensee's obligations under this Agreement.

I. The Licensee has agreed to enter in to this Agreement with the Licensor for the purpose of developing the Project at the respective Sites as set out in Exhibit A, subject to and in accordance with the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual promises and covenants of each Party to the other contained in this Agreement and for other good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

ARTICLE 1
DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Agreement, unless the context otherwise requires, any term defined in Article 1.1 of the PPA but not defined herein shall have throughout this Agreement the meaning set forth against that term in the PPA, and the following terms shall have the meanings set forth below:

"**Access Rights**" has the meaning set forth in Article 6.6 hereof.

"**Agreement**" has the meaning set forth in the Preamble hereof.

"**Applicable Law**" means any and all statutes, laws, municipal charter provisions, regulations, ordinances, rules, mandates, judgements, orders, decrees, Permits and Approvals, codes or license requirements, or other governmental requirements or restrictions or any interpretation or administration of any of the foregoing by any Governmental Authority, that apply to either Party under this Agreement, whether now or hereafter in effect.

"**Defect**" has the meaning set forth in Article 5.5hereof.

"**Dispute Notice**" has the meaning set forth in Article 13.2 hereof.

"**Dispute**" has the meaning set forth in Article 13.2 hereof.

"**Emergency**" has the meaning set forth in Article 8.2 hereof.

"**Execution Date**" means the date of signing this Agreement.

"**Expert**" has the meaning set forth in Article 13.3 hereof.

"**Fee**" has the meaning set forth in Article 4.1 hereof.

"**FENAKA**" has the meaning set forth in Recital D hereof.

"**Implementation Agreement**" has the meaning set forth in Recital F hereof.

"**Instant Facility**" means the solar PV systems, inverters, and related equipment, systems, components, fixtures, and facilities sharing a common point of interconnection with FENAKA's Electric System, Licensee's Interconnection Facilities relating thereto, the ground mounted canopy structure on top of which the solar panels shall be fixed and other assets, tangible and intangible, that comprise the Facility as set up on the Site(s).

"**Indemnified Party**" has the meaning set forth in Article 10 hereof.

"**Indemnifying Party**" has the meaning set forth in Article 10 hereof.

"**License**" means the license issued to the Licensee by the Licensor to design, build, maintain

and operate the Instant Facility at the Site(s) in accordance with the terms and conditions of this Agreement.

"License Term" has the meaning set forth in Article 2 hereof.

"Licensee" has the meaning set forth in the Preamble hereof.

"Licensee's Interconnection Facilities" has the meaning ascribed to the term "Seller's Interconnection Facilities" in Article 1.1 of the PPA.

"Licensor" has the meaning set forth in the Preamble hereof.

"MECCT" mean the Ministry of Environment, Climate Change and Technology of the Government of the Republic of Maldives or any successor thereto.

"PPA" has the meaning set forth in Recital E hereof.

"Possession Date" has the meaning set forth in Article 3 hereof.

"Reference Rate" mean the rate notified by the Maldives Monetary Authority for 364 Days Treasury Bills, on the Day that is two (2) Business Days prior to the day on which interest shall begin to be calculated hereunder, subject to a maximum of five percent (5%).

"Site(s)" means the public spaces on the island of South Maalhosmadulu, Baa Eydhafushi chosen as the sites for developing the Project, more fully described in Exhibit A herein.

"SIAC" means Singapore International Arbitration Centre.

"Taxes" means any tax applicable in the Maldives, including any tax on income, excise duty, customs duty, value added tax, sales tax, good and services tax and other local tax, cess, any impost or surcharge of like nature, any interest, penalties and other sums in relation on the income, goods, material, equipment and services rendered by either Party, and charged, levied or imposed by a Government instrumentality.

"Transfer" means in relation to a property, the sale, gift, pledge, assignment, transfer, transfer of any interest in trust, encumbrance, or alienation or disposition in any manner whatsoever, voluntarily or involuntarily, including, any attachment, assignment for the benefit of creditors against the owner of a property or appointment of a custodian, liquidator or receiver in relation to the property.

"URA" means the Utility Regulatory Authority established under Law No. 26/2020 (Utility Regulatory Authority Act).

1.2 Interpretations

In this Agreement:

(a) any reference to any statute or statutory provision shall include:

(i) all subordinate legislation made from time to time under that provision (whether or not amended, modified, re-enacted or consolidated);

(ii) such provision as from time to time amended, modified, re-enacted or consolidated (whether before or after the date of this Agreement) and (to the extent liability thereunder may exist or can arise) shall include any past statutory provision (as from time to time amended, modified, re-enacted or consolidated), which the provision referred to has directly or indirectly replaced;

(b) reference to any Party under this Agreement shall also include its successors, administrators, legal representatives, and permitted assigns as the case may be;

(c) heading to Articles and paragraphs are for information only, and shall not form part of the operative provisions of this Agreement and be ignored in construing the same;

(d) references to Articles and schedules are to Articles and schedules to this Agreement. All of these form part of the operative provisions of this Agreement and references to this Agreement shall, unless the context otherwise requires, include references to the Articles and schedules;

(e) unless the contrary is expressly stated, no Article in this Agreement limits the extent or application of another Article;

(f) any reference to books, files, records or other information or any of them means books, files, records or other information or any of them in any form or in whatever medium held including paper, electronically stored data, magnetic media, film and microfilm;

(g) "in writing" includes any communication made by letter or facsimile;

(h) the words "*include*", "*including*", "*inter alia*" and "*in particular*" shall be construed as being by way of illustration or emphasis only and shall not be construed as, nor shall they take effect as, limiting the generality of any preceding words;

(i) the words "*directly or indirectly*" mean directly or indirectly through one or more intermediary persons or through contractual or other legal arrangements, and "direct or indirect" shall have the correlative meanings;

(j) the expression "*this Article*" shall, unless followed by reference to a specific provision, be deemed to refer to the whole Article (not merely the sub-Article, paragraph or other provision) in which the expression occurs;

(k) the terms '*hereof*', '*herein*', '*hereby*', '*hereto*' and derivative or similar words shall, unless followed by a reference to a specific provision of the Agreement, be deemed to refer to this entire Agreement;

(l) when any number of Days are prescribed in this Agreement, same shall be reckoned exclusively of the first and inclusively of the last Day, unless the last Day does not fall on a Business Day, in which case the last Day shall be the next succeeding Day which is a Business Day;

(m) time is of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended, such extended time shall also be of the essence;

(n) a reference to any agreement is a reference to that agreement and all schedules, appendices and the like incorporated therein, as the same may be amended, modified, supplemented, waived, varied, added to, substituted, replaced, renewed or extended from time to time;

(o) all provisions of this Agreement shall be interpreted and construed in accordance with their meanings, and not strictly for or against either Party, regardless of which Party may have drafted this Agreement or a specific provision;

(p) grammatical variations of defined words shall be construed in accordance with the relevant definition(s);

(q) references to the singular number shall include references to the plural number and vice versa; and

(r) words denoting one gender shall include all genders.

ARTICLE 2
LICENSE TERM

The term of this Agreement shall enter into full force and effect on the Execution Date and shall expire upon the expiry of the PPA or upon an earlier termination of the PPA ("License Term").

ARTICLE 3
GRANT OF LICENSE

Subject to the Licensee's compliance with its obligations in this Agreement, the Licensor hereby grants and the Licensee hereby accepts the License, to design, build, maintain and operate the Instant Facility on the Site(s), for the duration of the License Term, unless terminated earlier in accordance with the terms herein contained. The Licensor shall provide to the Licensee, access to the Site(s) on a Day mutually agreed between the Parties (the "Possession Date"), which Day shall not be later than 31st July 2022. The Licensee undertakes and covenants that the Site(s) shall only be used for the purposes of designing, building, maintaining and operating the Instant Facility in accordance with the terms and conditions herein mentioned, and for no other purpose. The Licensee shall not have exclusive possession of the Site(s) and nothing contained herein shall be construed as creating any rights, interest, easement, tenancy or sub-tenancy in favor of the Licensee in or over the Site(s) other than the permissive right of use herein granted.

ARTICLE 4
CONSIDERATION

4.1 In consideration of the grant of the License over the Site(s) to develop the Project and the grant of Access Rights, the Licensee shall pay to the Licensor, an annual fee at the rate of Rufiyaa Eight (MVR 8) per square meter (of the area of the Site(s)) per year ("Fee"). The Fee shall be paid on or before the 01st Day of January of each year during the License Term. Parties acknowledge that this Agreement is being entered into towards fulfillment of the Maldives' obligations to the Licensee under the Implementation Agreement, and in consideration, *inter alia*, of the Licensee's obligation to develop the Project and sell Electric Energy to FENAKA, which collectively with the Fee is acknowledged by the Parties to constitute adequate consideration for the grant of the License over the Site(s) and the grant of Access Rights under this Agreement. Accordingly, Parties undertake that neither Party shall question the validity of this Agreement for want or adequacy of consideration

4.2 The Licensee shall commence payment of the Fee starting from 01st Day of January 2023.

4.3 The Licensee shall pay the Fee by online remittance (electronic funds transfer) or by way of demand draft drawn in favor of the Licensor payable at South Maalhosmadulu, Baa. Eydhafushi, Republic of Maldives. In the event the payment is made by way of online remittance, the Licensee shall provide proof of such remittance to the Licensor within 02 (two) days of such remittance and all the charges in relation to transfer of payments to the Licensor's account shall be borne by the Licensee.

ARTICLE 5
TAXES AND INSURANCE

5.1 **Taxes in Relation to Site(s)**

During the License Term, the Licensor shall be liable to bear and pay on its sole account any and all Taxes in relation to the Site(s).

5.2 **Taxes in Relation to Instant Facility**

Any Tax imposed by a Governmental Authority, with respect to the design, construction, financing, ownership, erection, installation, maintenance and operation of the Instant Facility and/ or on account of the income generated from the operation of the Instant Facility, shall be borne by the Licensee. To the extent possible under Applicable Law, the Licensee shall make such payments directly to the relevant Governmental Authority. In the event that any Tax that is payable by the Licensee is paid by the Licensor, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.3 **Taxes on Fee**

The Fee shall be paid by the Licensee without any deductions whatsoever, save and except the deduction of tax at source, if applicable. The liability for payment of any Taxes as applicable on the Fee shall be borne by the Licensee, even if the same is payable by the Licensor in accordance with the Applicable Law.

5.4 **Commercial General Liability Insurance for Damage to the Site(s)**

The Licensee shall procure and maintain commercial general liability insurance, employer's liability, worker's compensation , professional liability (with any exclusions subject to the prior written approval of the Licensor) up to the overall limit set out in Schedule 4 of the PPA, and within such commercial general liability insurance the Licensee shall also insure against liability for personal injury and damage to the Site(s) or damage to any third party properties therein, arising directly out of the installation of the Instant Facility or its use, in standard form, which shall include operations and blanket contractual liability coverage which insures performance by the Licensee of the indemnity provisions of this Agreement. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date.

5.5 **Comprehensive "All Risks" Insurance of the Instant Facility**

The Licensee, at its cost, shall within the overall limit set out in Schedule 4 of the PPA, procure and maintain comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility against fire, accident, burglary, vandalism, machinery breakdown, earth movement such as earthquake, volcanic eruptions and subsidence, hurricane/ windstorms, flood including

G

tsunami, debris removal, ordinance or law, extra expense and terrorism. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date. Upon failure by the Licensee to procure and maintain such comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility, and the occurrence of any such event that renders the Site(s) untenable for use by the Licensor (a "Defect") and other users, the Licensee shall cure such Defect at its own cost, within thirty (30) Days of the occurrence of the Defect. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to obtain the required insurance. In the event that the Licensor obtains required insurance for the Site, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. The Licensor shall be entitled to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.6 The Licensee shall, at its own cost, ensure that any insurance policy required to be maintained by it in accordance with this Article 5 is renewed before the expiry of such insurance policy. Such insurance policy shall also comply with the other requirements stated in Schedule 4 of the PPA, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee. The insurance policies referenced herein shall be taken out in the names of the Licensor and the Licensee for the full value of their respective rights and interests provided that the premiums incurred by the Licensee in complying with this clause will not be unreasonable. The Licensor shall, at the cost of the Licensee, provide all reasonable necessary assistance and cooperation to the Licensee for the renewal of such insurance policy by the Licensee. The proceeds of any Proceeds of any insurance claim are to be applied towards the replacement, repair and/or reinstatement of the Site(s) and/or the Instant Facility.

5.7 On the occurrence of a partial or total loss or an event which, in the reasonable opinion of the Licensee would result in a claim against the insurance policies taken by the Licensee in respect of the Instant Facility, the Licensee shall forthwith and in any case not later than two (2) Days from the date of occurrence of loss or event inform the Licensor of the same.

ARTICLE 6
LICENSEE'S RIGHTS AND COVENANTS

6.1 The Licensee shall provide a copy of the duly executed PPA to the Licensor within fifteen (15) Days of the Execution Date.

6.2 The Licensee hereby represents and warrants that it has inspected or has caused an inspection of the Site(s) to be done, and has satisfied itself on the suitability of the Site(s) for the Instant Facility, and shall accept the possession of the Site(s) on an "as is where is" basis, on the Possession Date.

6.3 The Licensee shall be solely responsible for (a) all costs and the performance of all tasks required for installation, operation and maintenance of the Instant Facility at the Site(s) including costs related to preparation of the Site(s) before installation, costs related to capital improvement, removal, replacement and expansion of the Instant Facility; (b) ensuring that the design, construction, financing, ownership, maintenance and operation of the Instant Facility are in compliance with Good Engineering and Operating Practices, Codes and Standards, and Applicable Law, including those relating to safety norms, public health and environment; (c) ensuring that the performance of the tasks required for installation, operation and maintenance of the Instant Facility does not cause any damage to the Site(s), and to any public property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; (d) obtaining all Permits and Approvals required for the Licensee's use of the Site(s); and (e) bearing all risk of loss in case of a theft, damage, casualty, condemnation or confiscation of the Instant Facility.

6.4 The Licensee agrees that any matter raised in relation to the installation, maintenance and operation of the Instant Facility by any person, shall be addressed as per the Environment and Social Impact Assessment (ESIA) and the Grievance Redress Mechanism (GRM), developed pursuant to the Environmental and Social Management Framework (defined in the PPA) relating to ASPIRE.

6.5 The Licensor may, if in the event the Licensee is unable to attend to any issue in accordance with the GRM, upon giving 24 hour written notice, resolve such issues or remedy any damages or defects as maybe specified in the notice, and make such repairs thereto as the Licensor deems appropriate. Should the Licensor effect repairs, the Licensee shall pay to the Licensor the amount of such repairs reasonably incurred by the Licensor upon submission to the Licensee of an invoice with supporting documents showing the cost incurred by the Licensor for such repairs which shall be calculated at a fair and reasonable market rate.

6.6 During the License Term, the Licensee shall have the following rights ("Access Rights") in relation to the Site(s):

(a) right to erect temporary structures, such as a scaffolding or similar structures at the Site(s) as may be reasonably required for the purpose of carrying out the construction and erection of the Instant Facility and/ or for the maintenance of the Instant Facility, provided that (i) the Licensee shall use all reasonable efforts to minimize the impact thereof on the normal use of the space

where the Site(s) is located, by the public and (ii) the Licensee shall obtain prior written approval of the Licensor in respect of such temporary structures and all approvals required under Applicable Law;

(b) right to use such ways, paths and passages as are reasonably necessary for the purpose of access to and egress from the Site(s), with or without workmen and for transporting, loading and unloading necessary tools, equipment and materials, provided that (i) the Licensor may in consultation with the Licensee and for a reasonable cause require the Licensee to change the route of any means of access to or egress from the Site(s) and may change the area over which any of the Access Rights are exercised; and (ii) the use of such ways, paths and passages shall not obstruct the general use of the space where the Site(s) is located by the public, provided that where the Licensee's use of the path, ways and passages will result in an obstruction of the use of such space by the public, such obstruction shall be done only after obtaining a prior written approval from the Licensor, and shall be only for a reasonable period of time as agreed with the Licensor, consistent with Good Engineering and Operating Practices.

Provided that the Licensee shall provide the Licensor at least thirty (30) Days before the commencement of the construction of the Instant Facility, or a related activity, a schedule of construction of the Instant Facility. Upon receipt of such schedule of construction from the Licensee, the Licensor shall within five (5) Business Days respond with such reasonable changes to the schedule of construction, if any, as it may require, failing which the Licensor shall be deemed to have accepted the schedule of construction. If the Licensor requests any changes to the schedule of construction, the Licensee shall modify its schedule of construction after incorporating such reasonable changes suggested by the Licensor, and notify the finalized schedule of construction at least five (5) Days prior to the commencement of construction.

6.7 The Licensee shall have right to use utilities such as electricity and water for the purpose of construction, installation, erection, operation and maintenance of the Instant Facility, at the cost of the Licensee. The Licensee shall install separate meters for recording the consumption of electricity and water by the Licensee at the Site(s). The Licensee shall pay by the due date the meter installation and hire charges and also the bills for consumption of electricity and water in the Site(s) as recorded in the meters to the relevant utility companies and provide a copy of the proof of such payment to the Licensor within fifteen (15) Business Days from such payment for its records. In addition, the Licensee shall arrange at its own cost other facilities such as telephone services and other similar facilities, and pay directly to the third-party services providers for such services availed by it.

6.8 Subject to Article 5 hereof, the Licensee may make its own arrangements for and take reasonable measures, in consultation with the Licensor for the protection and security of the Instant Facility.

6.9 The Licensee shall have the right to construct ground mounted canopy structures and such other supporting structures as necessary which forms part of the Instant Facility, and shall have the right from time to time, both before and after the Commercial Operation Date, and at the Licensee's sole cost and expense, to make such additions, alterations or changes to such structures, as are reasonably required in compliance with the provisions of this Agreement, Applicable Law, Good Engineering and Operating Practices and Codes and Standards; provided that: (a) the Licensee shall not cause any damage to the Site(s), and to any public

property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, low voltage, medium voltage, and high voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; and (b) the Licensee shall obtain the prior written approval of the Licensor, and such prior written approval shall not be unreasonably withheld, in respect of any such construction, additions, alterations or changes, except if such construction, additions, alterations or changes are cosmetic in nature and/ or are part of the day to day maintenance and repair of the Instant Facility; and (c) the Licensee shall provide to the Licensor a certificate from a civil engineer and/or architect having the requisite competence under Applicable Law for issuing such certificates, and acceptable to the Licensor and such acceptance shall not be unreasonably withheld, and which certificate shall certify that the proposed constructions, additions, alterations, or changes are in compliance with the Applicable Law, required for the construction of the Instant Facility.

6. 10 The Licensee shall be solely responsible for day to day operation and maintenance of the Instant Facility, including without limitation the obligation to promptly make or pay (as determined by the Licensor) for, any repairs to any part or whole of the Site(s), to the extent damage is caused by the Licensee, its employees, officers, agents, contractors or subcontractors, during the License Term.

6.11 In complying with its obligations under Article 6.9, the Licensee shall to the extent possible give five (5) Business Days prior written notice for all repair and maintenance work of the Instant Facility or the Site(s) so as not to restrict public use of the space in which the Site(s) is located. Upon such request for repair and maintenance work, the Licensor shall respond to such request within five (5) Business Days. If the Licensor does not respond to such request within five (5) Business Days, such request shall be deemed approved by the Licensor. The Licensee shall ensure that all such work undertaken must be completed in all respects in a timely manner.

6.12 At all times, the Licensee shall:

(a) take due care to ensure that no damage is caused to any property on the Site(s) and the space belonging to or used by the Licensor, the public or other users of such space;

(b) not cause inconvenience to the Licensor, and other users of the space in which the Site(s) is located as is reasonably practicable, except that the Licensor agrees that the exercise of the Access Right granted under Article 6.6(a) hereof may cause temporary obstruction and/ or interference with the normal use of such space and that such inconvenience shall not be deemed to be a violation of the Licensee's obligations under this Article 6.11(b).

6.13 In the event, there is any damage to the Site(s) and/or to the space where the Site(s) is located, and to any public property or to any property of a third party therein, including but not limited to any damage to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, water and sewerage mains, fiber-optic cables and telecommunication service lines, by reason of the Licensee exercising an Access Right or other rights under this Agreement, the Licensee shall make good such damage (to the reasonable satisfaction of the Licensor) at its own cost.

6.14 The Licensee shall provide a list to the Licensor (or to any officer of the Licensor designated

by the Licensor for this purpose), of the employees, agents, sub-contractors, and other representatives of the Licensee who shall be entitled to enter upon the Site(s), and shall ensure that the Access Rights granted hereunder are exercised by such employees, agents, sub-contractors, and other representatives, subject to the reasonable conditions for entry and exit to the Site imposed by the Licensor, and having regard to the public safety, and the safety of the Site(s).

6.15 The Licensee shall, as promptly as possible, notify the Licensor of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s) and/ or the Instant Facility, and that in the Licensee's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety.

6.16 The Licensee shall consult with the Licensor and obtain Licensor's approval in relation to design of the Instant Facility (including with respect to its placement within the Site(s) and technical specifications) and obtain written approval from the Licensor in case of any alteration to the design of the Instant Facility.

ARTICLE 7
OWNERSHIP OF THE INSTANT FACILITY

7.1 The Licensee shall be the exclusive owner and operator of the Instant Facility, including any part thereof, installed by the Licensee.

7.2 The Licensee acknowledges and agrees that, notwithstanding that the Instant Facility is a fixture on the Site(s), the Licensee shall have no right, title or interest in the Site(s) except as that of a Licensee as per the terms set out in this Agreement. The Licensee shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on the Site(s) or the Access Rights or any interest therein, and the Licensor will not suffer in any manner out of Licensee's use of the Site(s) whereby the estate, rights and interests of the Licensor in the Site(s) or any part thereof might be impaired, except in accordance with and subject to the provisions of this Agreement.

ARTICLE 8
LICENSOR'S COVENANTS

8.1 The Licensor shall take all reasonable efforts not to cause any interference with the effective operation of the Instant Facility, including any interference with the Licensee's right to receive continuous and uninterrupted passage of light at all times across the Site(s) or have access to the Site(s) and the Instant Facility.

8.2 The Licensor shall, as promptly as possible, notify the Licensee of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s), and that in the Licensor's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety. The Licensor and FENAKA shall have the right (but not the obligation), to the extent permitted by Applicable Law, to enter into the Site(s) for the sole purpose of responding to any dangerous condition posing risk to, the Site(s), the Instant Facility, public health or public safety ("Emergency"); provided that any actions taken by the Licensor upon such entry shall be limited to those reasonably necessary to respond to the risks posed. The Licensee shall respond to any such Emergency as promptly as possible, and take all measures necessary to address the condition that gave rise to the Emergency. The Licensee shall not be required to bear the costs associated with an Emergency related to the Site(s) that are not caused by the Licensee and does not affect the Instant Facility.

8.3 The Licensor shall reasonably cooperate with the Licensee, at the Licensee's cost, so that the Licensee can procure all Permits and Approvals for design, engineering, construction, financing, operations, maintenance and deconstruction of the Instant Facility, and meet its obligations under this Agreement and the PPA.

8.4 The Licensor agrees and undertakes that this Agreement and the Access Rights shall run with the Site(s) and shall survive any Transfer of the Site(s). The Licensor shall give the Licensee at least six (6) Calendar Months written notice prior to any Transfer of all or a portion of the Site(s) identifying the transferee, the portion of the Site(s) to be transferred and the proposed date of Transfer. In the event of Transfer by any way or form of the Site(s), the Licensor shall cause the proposed transferee to execute an agreement identical in terms and conditions as that of this Agreement with the Licensee, for a term equal to the License Term outstanding at the date of such Transfer.

8.5 The Licensor recognizes the need of the Licensee to finance the Project by mortgage of the Instant Facility, accordingly, the Licensor shall reasonably cooperate with the Licensee in creation of charge on the Instant Facility in favor of the lenders to the Project, at the cost of the Licensee, including through furnishing such documents and certificates as may be reasonably requested by the Licensee's lenders.

8.6 The Licensor shall not, directly or indirectly, cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on or with respect to the Site(s), except with the prior written consent of the Licensee, which consent shall not be unreasonably withheld.

8.7 Subject to the terms and conditions of this Agreement and the Licensee's compliance with all

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

CS

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 **Licensor's Representations and Warranties**

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a local council, duly established and validly existing under the constitution and laws of Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

- (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or
- (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 **Representations and Warranties of the Licensee**

Licensee hereby represents and warrants as of the date hereof that:

(a) the Licensee is a company duly organized and validly existing under the relevant jurisdiction specified in the Preamble of this Agreement, and has full legal right, power and authority under Applicable Law to enter into and perform its obligations under this Agreement;

(b) the Licensee has duly authorized the execution and delivery of this Agreement. This Agreement has been duly executed and delivered by the Licensee and will constitute a legal, valid and binding obligation of the Licensee, enforceable against the Licensee in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other laws affecting creditors rights generally;

(c) neither the execution nor the delivery by the Licensee of this Agreement nor the performance by the Licensee of its obligations hereunder: (i) will conflict with, violate, or result in a breach of any Applicable Law of Maldives; or (ii) conflicts with, violates, or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of [incorporation/ registration] of the Licensee), or instrument to which Licensee is a party or by which Licensee or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or instrument;

(d) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensee, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensee in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensee of its obligations hereunder or under such an agreement or instrument.

ARTICLE 10
INDEMNIFICATION

The Licensee (also an "Indemnifying Party") shall indemnify and hold harmless the Licensor and its employees, officers, agents, contractors, professional advisors and representatives (each an "Indemnified Party") from and against all liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, that may be imposed upon or incurred by or asserted against the Licensor or any of its employees, officers, agents, contractors, professional advisors, representatives, by reason of any of the following occurrences during the License Term, except to the extent such liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, are caused by either (i) gross negligence or intentional wrongful acts of the Indemnified Party or (ii) failure or other breach by the Indemnified Party to perform any of its obligations under Applicable Law or Permits and Approvals:

(a) any breach by the Licensee of its obligations, covenants, representations or warranties contained in this Agreement;

(b) any negligence on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees in connection with the use of the Site(s) or in designing, construction, financing, ownership and operation of the Instant Facility or the Project; or

(c) any failure on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees to comply with Applicable Law that require compliance by the Licensee or any of its agents, contractors, servants, employees, subtenants, licensees or invitees in connection with the Site(s) and its use, or design, construction, financing, ownership and operation of the Instant Facility, or the Project.

ARTICLE 11
FORCE MAJEURE EVENT

11.1 Adoption of provisions of PPA

Provisions of Article 12.4, Article 12.5 and Article 12.6 of the PPA shall *mutatis mutandis* apply to this Agreement, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee.

11.2 Effects of Force Majeure Events

Without prejudice to the rights or obligations of the Government or FENAKA under the Implementation Agreement or the PPA,

(a) if the Force Majeure Event results in loss of the Site(s) or the Instant Facility, either Party shall have the right to terminate this Agreement in accordance with the provisions of Article 12.1(a) of this Agreement; or

(b) if a Force Majeure Event subsists for more than one hundred and eighty (180) Days and the PPA is terminated in accordance with Article 13.5, or Article 13.6, as the case may be, of the PPA, either Party may terminate this Agreement in accordance with Article 12.1(b) and Article 12.2, hereof.

ARTICLE 12
TERMINATION

12.1 Events of Termination

This Agreement shall terminate in the following circumstances:

(a) If occurrence of a Force Majeure Event results in loss of the Site(s), either Party shall have the right to terminate this Agreement in accordance with Article 11.2(a), by a notice in writing to the other Party, with the termination being effective from fifteen (15) Days from the date of such notice.

(b) Upon termination of the PPA, whether on account of expiry of the Contract Term, or otherwise, and whether in respect of the Project as a whole or in respect of the Instant Facility, either Party shall have the right to terminate this Agreement with effect from the date of termination of the PPA.

(c) If the Government issues or is deemed to have issued a Concurrence Notice under Article 4.2(c)(iii) of the Implementation Agreement, either Party may terminate this Agreement.

(d) If an Expert (as defined under the Implementation Agreement) determines in accordance with Article 4.2(c)(x) of the Implementation Agreement that the Site(s) is unavailable for use of the Licensee, the Agreement shall terminate with effect from the date of such determination or such other date as such Expert may determine.

12.2 Consequences of Termination

(a) If the Agreement terminates in accordance with Article 12.1(b) but on account of expiry of the Contract Term and FENAKA chooses to purchase the Instant Facility in accordance with Article 2.2 of the PPA, the Licensor shall transfer the License provided for in this Agreement in favor of FENAKA on such terms and conditions as FENAKA and Licensor may agree in writing.

(b) If the Agreement terminates in accordance with Article 12.1(a), or Article 12.1(b) but on account of

(i) expiry of the Contract Term and FENAKA chooses not to purchase the Instant Facility in accordance with Article 2.2 of the PPA,

(ii) termination of the PPA in accordance with Article 13.3(a) or Article 13.3(c) of the PPA, and FENAKA chooses not to exercise its right under Article 13.3(d) of the PPA to purchase the Project or the Instant Facility, or

(iii) termination of the PPA in accordance with Article 13.5(a) or Article 13.5(b) (where the PPA is terminated by the Seller, thereof) of the PPA,

the Licensee shall within one hundred and eighty (180) Days, decommission the entire Instant Facility set up at the Site(s), remove all its assets from the Site(s), and vacate and hand over

peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

(c) If the Agreement terminates in accordance with Article 12.1(b) but on account of,

(i) termination of the PPA in accordance with Article 13.4(c), Article 13.4(d), Article 13.6(a) or Article 13.6(c) of the PPA,

(ii) termination of the PPA by FENAKA in accordance with Article 13.5(b) of the PPA,

Licensor shall execute a license over the Site(s) in favor of the FENAKA simultaneously with the purchase of the Instant Facility by FENAKA, on terms and conditions substantially similar to those contained in this Agreement, unless FENAKA and the Licensor agree otherwise.

(d) If the Agreement terminates in accordance with Article 12.1(c) or Article 12.1(d), the Licensee shall relocate the Instant Facility to the alternative Site(s), promptly upon execution of the license agreement for the alternative Site(s), but in no event later than one hundred and eighty (180) Days, and vacate and hand over peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

ARTICLE 13
DISPUTE RESOLUTION

13.1 Continued Performance

Each Party shall continue to perform its obligations under this Agreement (including any payment obligations) pending resolution of any dispute pursuant to this Article 13. Provided that, if the dispute is with respect to any payments, neither Party shall be required to make such disputed payment(s) to the other Party so long as such dispute has been referred to the process for resolution pursuant to this Article 13; provided, that to the extent any amounts owed to either Party by the other Party are not disputed and can be segregated from amounts with respect to which there is a dispute, such undisputed amounts shall, in good faith, be identified by the Parties and paid as required by this Agreement. To the extent that any disputed amount was withheld from a Party, and such Party is ultimately found to be entitled to all or any portion of such disputed amount pursuant to this Article 13, then such Party shall be entitled to the payment of interest on any withheld amount, at an annual rate equal to Reference Rate, from the original due date for payment of such amount until the payment of such disputed amount.

13.2 Negotiation

If any dispute, controversy or claim arises under or relates to this Agreement or the breach, termination or validity thereof (the "Dispute"), such Dispute shall be referred by each Party to its designated senior officer for resolution upon five (5) Days written notice from either Party (the "Dispute Notice"). The Parties agree to attempt to resolve all Disputes promptly and equitably and to provide each other with reasonable access during regular business hours to any and all non-privileged records, information and data pertaining to any such Dispute.

13.3 Expert Determination

(a) A dispute may be referred to an expert (the "Expert") in accordance with this Article 13.3 if:

(i) the Parties are not able to agree under Article 13.2 (*Negotiation*) on an amicable resolution to such dispute; and

(ii) this Agreement expressly provides that such dispute shall be referred to an Expert or the Parties agree in writing that such dispute shall be referred to an Expert.

(b) Any Party to such a Dispute may initiate an Expert reference under this Article 13.3 by proposing to the other Party to the dispute the name of the Expert. If the other Party does not agree to the name suggested by the Party making the reference, and the Parties are otherwise unable to agree on the name of an Expert, either Party may apply to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the Expert for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, an

Expert for the matter in Dispute.

(c) The Parties shall request that the Expert determine the referred dispute, within thirty (30) Days of receiving the reference, or in such additional time as may be reasonably required by the Expert to determine the Dispute, which shall not be more than one hundred and eighty (180) Days of receiving the reference.

(d) The Expert shall act as an expert and not as an arbitrator.

(e) The Parties shall have the right to make representations and submissions to the Expert. There shall be no formal hearing.

(f) The Expert shall have power to request any Party to provide him/her with such statements (which shall be written unless otherwise specifically required) or documents or information within their control as he may determine necessary and the Parties shall comply with any such request in accordance with the timeframes set out by the Expert or in the absence of such timeframes, in a timely manner as required to enable the Expert to determine the Dispute within the timeframe set forth in Article 13.3(c).

(g) The Expert shall give his/her decision to the Parties to the Dispute in writing and his/her decision, which shall promptly be given effect to by such Parties, shall be final and binding (save in the case of fraud or manifest error) on them.

(h) If the Expert decides that a sum is due and payable by one Party to another Party then:

   (i) any such sum shall be due and payable within seven (7) Days of receipt by the Parties of written notice of such decision, unless the Expert decides otherwise; and

   (ii) interest shall accrue at the rate of Reference Rate, compounded annually, from the date expiry of the period mentioned in Article 13.3(h)(i); provided that if the sum specified in Article 13.3(h)(i) includes any interest, no interest shall be payable on such interest.

(i) The fees of the Expert and any other costs of and incidental to the reference to Expert determination shall be payable by such Party to the Dispute as the Expert may determine but, in the absence of any such determination, by the Parties to the Dispute in equal shares.

13.4 Arbitration

(a) Selection of Arbitrators

If the Parties are unable to resolve their Disputes through negotiation within thirty (30) Days of the Dispute Notice, either Party may initiate proceedings to submit the Dispute for arbitration. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:

   (i) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply

Cs

to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute.

(ii) Where the Parties do not agree that the dispute concerns a technical matter, the Parties may agree to appoint a sole arbitrator mutually agreed by them or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, each Party shall appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) Days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC.

(iii) If, in a dispute subject to Article 13.4(a)(ii) above, one Party fails to appoint its arbitrator within thirty (30) Days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.

(b) Rules of Procedure

Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the SIAC as in force on the date of this Agreement.

(c) Substitute Arbitrators

If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator.

(d) Nationality and Qualifications of Arbitrators

Each arbitrator appointed pursuant to Article 13.4(a)(i) to Article 13.4(a)(iii) shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of Maldives or the home country of the Licensee. For the purposes of this Clause, "home country" means any of:

(i) the country of incorporation of the Licensee or their parent companies;
(ii) the country in which Licensee's principal place of business is located;
(iii) the country of nationality of a majority of the Licensee's shareholders; or
(iv) where the Licensee is a joint venture between two or more Persons, the country of incorporation, nationality or place of business of the partners or shareholders of such joint venture.

(e) Miscellaneous

In any arbitration proceeding hereunder:

(i) proceedings shall, unless otherwise agreed by the Parties, be held in Singapore;

(ii) the English language shall be the official language for all purposes; and

(iii) the decision of the sole arbitrator or of a majority of the arbitrators shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

13.6 Governing Law, Jurisdiction and Service of Process

(a) Governing Law

This Agreement shall be governed by, and construed in accordance with, the laws of Maldives.

(b) Jurisdiction

Subject to Article 13.3 and Article 13.4, each of the Parties consents to submit itself to the exclusive jurisdiction of the courts located in the Maldives in relation to recognition of any arbitral award, with respect to any Dispute that arises under this Agreement.

(c) Service of Process

Subject to the rules of SIAC for the purposes of arbitration, each Party agrees that service of any process, summons, notice or document and delivered or sent by certified mail, return receipt requested, to such Party's respective address set forth in Article 14.4 will be effective service of process for any action, suit or proceeding with respect to any matters to which it has submitted to arbitration as set forth in Article 13.4.

ARTICLE 14
MISCELLANEOUS PROVISIONS

14.1 Assignment

Licensee shall not assign or otherwise transfer this Agreement, except (i) for the collateral assignment to any lenders (only if such lenders are independent third party financial institutions) in connection with the provision of any financing for the Instant Facility, or (ii) to any Person who is a bona fide transferee of the PPA (in accordance with the terms of the PPA), subject to the transferee undertaking to comply with the obligations of the Licensee under the PPA, this Agreement, and the Escrow Agreement.

14.2 Further Assurances

Each Party agrees to, and shall use all reasonable efforts to, provide such information, execute and deliver any instruments and documents and take such action as may be necessary or reasonably requested or required by the other Party which are not inconsistent with the provisions of this Agreement and which do not involve the assumption of obligations other than those provided for in this Agreement in order to give full force and effect to this Agreement and to carry out its intent.

14.3 Relationship of Parties

Except as otherwise explicitly provided herein, neither Party to this Agreement shall have any responsibility whatsoever with respect to services provided or contractual obligations assumed by the other Party and nothing in this Agreement shall be deemed to constitute either Party a partner, agent or legal representative of the other Party or to create any fiduciary relationship between or among the Parties.

14.4 Notices

Any notices required to be given hereunder shall be deemed delivered when (i) sent by facsimile upon electronic confirmation of successful transmission; (ii) delivered to an express courier service nationally recognized in Maldives that provides a receipt of delivery, (iii) sent by email, upon dispatch and the receipt of a delivery confirmation, provided that email shall be used as a mode of notice and communication only for non-material day-to-day matters; (iv)when delivered by personal delivery, in each case addressed to the following persons or such other persons as the Parties may designate in writing:

(a) If to the Licensor:
Name: Mohamed Fathih
Designation: Council President
Address: Secretariat of Eydhafushi Council, Baa Eydhafushi, Republic of Maldives
Email: info@eydhafushi.gov.mv
Fax: +960 3018301
with a copy to:

FENAKA
Name: Ahmed Saeed Mohamed
Designation: Managing Director
Address: FENAKA Corporation Limited, Port Complex Building, 7th Floor, Hilaalee Magu, Male' 20207
Email: ahmed.saeed@fenaka.mv
Copied to: maasha@fenaka.mv

and

MECCT
Name: Mr. Ajwad Musthafa
Designation: Permanent Secretary
Address: Ministry of Environment, Cliimate Change and Technology Green Building, Handhuvaree Hingun, Male', 20392, Republic of Maldives
Email: ajwad.mustafa@environment.gov.mv

(b) If to the Licensee:

Name: Mr. Goh Chin San
Designation:
Managing Director of Mega First Solar (Maldives) Consortium Pvt Ltd
Authorised Representative of Mega First Power Industries Sdn Bhd
Address: A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Email: chinsan.goh@mega-first.com
Copied to: shadhah.shahid@mega-first.com, kok.cw@mega-first.com

14.5 Costs and Expenses

All costs, expenses, including any cost of documentation, reasonable attorney fees, court fee, and stamp fee, relating to creation and maintenance of the license on the Site(s), including execution of this Agreement, shall be borne by the Licensee.

14.6 Confidentiality

The Parties shall at all times keep confidential information acquired in consequence of this Agreement, except for information which the receiving Party already knows or receives from third parties or which the receiving Party may be entitled or bound to disclose under compulsion of Applicable Law or where requested by regulatory agencies or to their professional advisers, investments partners and other parties where reasonably necessary for the performance of their obligations under this Agreement. For the avoidance of doubt, the obligations in this Article shall not apply to information in the public domain or information which the Parties own or acquired lawfully from others and which may be freely disclosed to others without breach of any obligation of confidence

14.7 Waiver

No waiver of any provision of this Agreement shall be effective against a Party except as expressly set forth in a writing signed by such Party. The waiver by either Party of a default or a breach by the other Party of any provision of this Agreement shall not operate or be construed to operate as a waiver of any subsequent default or breach. The making or the acceptance of a payment by either Party with knowledge of the existence of a default or breach shall not operate or be construed to operate as a waiver of any subsequent default or breach.

14.8 Survival

Notwithstanding anything provided herein to the contrary, Article 12.2 (*Consequences of Termination*), Article 13 (*Dispute Resolution*) and Article 14 (*Miscellaneous*), shall survive the termination of this Agreement.

14.9 Third Party Rights

Nothing herein is intended to or should be construed to create any rights of any kind whatsoever in third persons not parties to this Agreement, except in favor of the Government, FENAKA, and the World Bank.

14.10 Counterparts

This Agreement and any amendment hereto may be executed and delivered in one or more counterparts and by different Parties in separate counterparts. All of such counterparts shall constitute one and the same agreement and shall become effective (unless otherwise therein provided) when one or more counterparts have been signed by each Party and delivered to the other Party. Delivery of this Agreement by facsimile transmission or electronic email shall be as effective as delivery of a manually executed counterpart.

14.11 Severability

In the event that any provision of this Agreement shall, for any reason, be determined to be invalid, illegal, or unenforceable in any respect, the Parties shall negotiate in good faith and agree to such amendments, modifications, or supplements to this Agreement, or such other appropriate actions, as shall, to the maximum extent practicable in light of such determination, implement and give effect to the intentions of the Parties as reflected herein, and the other provisions of this Agreement shall, as so amended, modified, supplemented, or otherwise affected by such action, remain in full force and effect.

14.12 Entire Agreement

All prior agreements, negotiations, representations, and understandings with respect to the subject matter hereof, are hereby superseded. No amendment, modification, or change to this Agreement or its Exhibit shall be effective unless the same shall be in writing, duly executed, authorized and approved by the Parties. In the event of any conflict between the terms and conditions of this Agreement and that of any Exhibit or other document referenced herein, this Agreement shall govern and control.

IN WITNESS WHEREOF, the Licensor and Licensee have caused this Agreement to be executed as on the date and the year first set forth above.

For and on behalf of the LICENSOR

……………………………
Mohamed Fathih
Council President
Secretariat of Eydhafushi Council
Baa Eydhafushi, Republic of Maldives

In the presence of;

……………………………
Mamnoona Abdulla
Director
Secretariat of Eydhafushi Council
Baa Eydhafushi, Republic of Maldives

……………………………
Ibrahim Shifau
Assistant Finance Officer
Secretariat of Eydhafushi Council
Baa Eydhafushi, Republic of Maldives

For and on behalf of the LICENSEE

……………………………
Goh Chin San
Authorised Representative
Mega First Power Industries Sdn. Bhd.

A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia.

……………………………
Song Qing Guo
General Manager
Powerchina Huadong Engineering Corporation Limited
22, ChaoWang Road Hangzhou, Zhejiang
Province, 310014
The People's Republic of China

3301034012842

MEGA FIRST POWER INDUSTRIES SDN. BHD.
(Company No. 392936-W)

In the presence of;

……………………………
Khoo Teng Keat
Executive Director
Mega First Corporation Berhad
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia

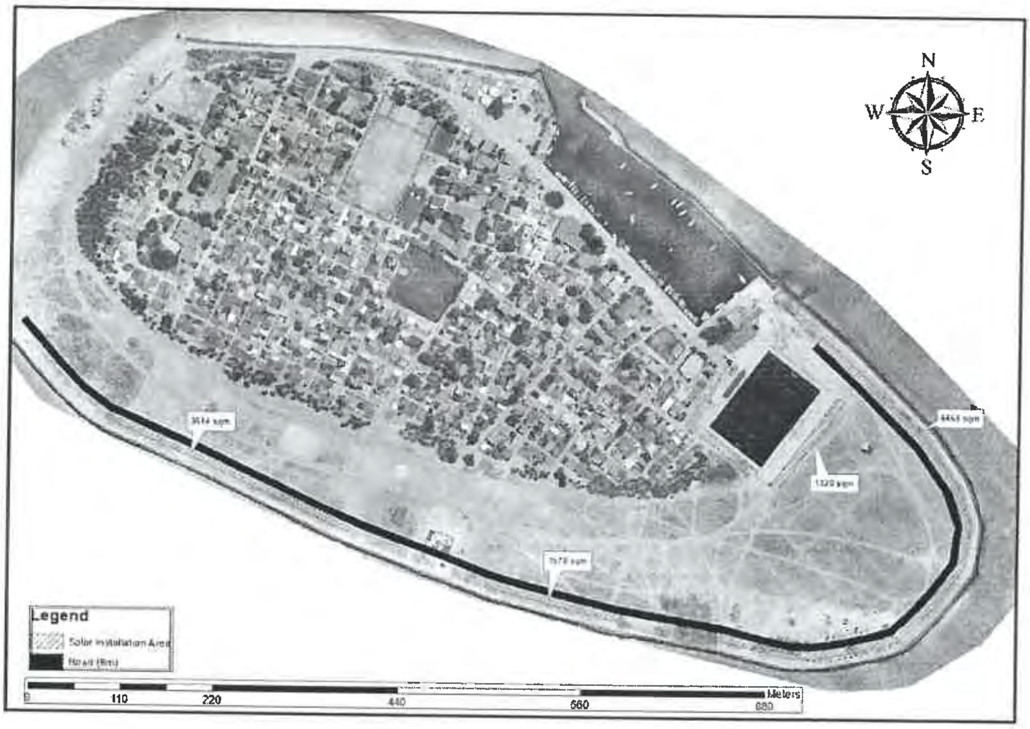
……………………………
Chen Ting
Chief Representative in Sri Lanka
Sinohydro Corporation Limited
22, Chegongzhuang West Road, Haidian District
Beijing 100048 The People's Republic of China

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Note: *The exact coordinates of the following Sites shall be agreed between the parties on or before the Possession Date following detailed setting out surveys.*

Site 6: Eydhafushi Sea-side road



Area: 3614+1320+1578+6658 m^2

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-W)

LICENSE AGREEMENT
FOR THE INSTALLATION OF GROUND MOUNTED SOLAR PANELS

BETWEEN

FAADHIPPOLHU HINNAVARU ISLAND COUNCIL

(MALDIVES)

(“LICENSOR”)

– AND –

MEGA FIRST POWER INDUSTRIES Sdn. Bhd. (MALAYSIA)

IN JOINT VENTURE WITH

POWERCHINA HUADONG ENGINEERING CORPORATION LIMITED (CHINA)

(“LICENSEE”)

AGREEMENT NUMBER: (AGR)326-AD/438/2022/01

DATE: APRIL 27, 2022

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392836-W)

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and entered into as of the *27th April* 2022 by and between:

1. **Faadhippolhu Hinnavaru Island Council**, a local council of the Government of Maldives, established under Act Number: 7/2010 (Decentralization Act of Maldives) with its offices at Secretariat of Faadhippolhu Hinnavaru Council, Road 09, 07010, Faadhippolhu Hinnavaru, Republic of Maldives ("Licensor"); and

2. **Mega First Power Industries Sdn. Bhd. (MFPI)** a limited liability company, company registration number: 199601020584 (392936-W) , organized and existing under the laws of Malaysia, with its principal office located at A-12-01, Level 12, Block A, PJ8, No. 23, Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia, and **Powerchina Huadong Engineering Corporation Limited (HDEC)** a limited liability company with Unified Social Credit Code: 91330000142920718C, organized and existing under the laws of Peoples Republic of China, with its principal office located at No. 22, ChaoWang Road Hangzhou 310014, Zhejiang Province, The People's Republic of China (**MFPI** and **HDEC** will be jointly and severally liable, and collectively will be hereinafter referred to as the "Licensee").

WHEREAS:

A. The Government (as defined in the PPA), with support from the Strategic Climate Fund and International Development Association, has initiated a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) for inviting private sector generators to develop [roof top and ground mounted] solar photovoltaic projects in Maldives on a DBFOOT (i.e. design, build, finance, own, operate and transfer) basis. The electrical energy generated from such projects is proposed to be purchased by a Government owned utility under a long-term power purchase agreement.

B. The Government had invited bids from interested independent power producers, *vide* RFP (as defined in the PPA) dated June 17th, 2021 for setting up solar power projects on Government-owned buildings and public spaces identified and facilitated by the Government in the RFP.

C. The Licensee had submitted a Proposal (as defined in the PPA) in response to the RFP, and has been selected by the Government *vide* Letter of Acceptance, dated February 17th, 2022 to develop a solar PV power project. Accordingly, the Licensee desires to construct, own and operate grid connected solar PV electric generating facilities situated at the roof top of Government owned buildings and on such other public spaces identified on selected islands, with a total electric capacity not less than 11 MW.

D. FENAKA (as defined in the PPA) is the identified state utility under the ASPIRE program for purchase of the Electric Energy (as defined in the PPA) generated by the Seller.

E. The Licensee has entered into a Power Purchase Agreement, dated 29th March 2022 ("PPA") with FENAKA to set forth the mechanism for sale and purchase of the Electric Energy generated by the Licensee and other mutual rights and the obligations of the Licensee and FENAKA.

F. Government also proposes to support the Project, the details of which have been prescribed in the Implementation Agreement (as defined in the PPA), setting forth mutual rights and obligations of the Licensee and the Government, executed between the Licensee and the Government.

G. The Licensee was the successful bidder, and among the locations identified in the RFP is the location situated in the island of Faadhippolhu Hinnavaru (together with adequate space for setting up a control room for the Instant Facility (as defined herein below)), the description of which is detailed in Exhibit A ("Site(s)").

H. The Licensee intends to incorporate and establish, in accordance with Applicable Laws, a company to develop the Project ("Project Company") and upon its incorporation, the Parties intend to amend this Agreement to add the Project Company as a party to this Agreement such that the Project Company will be jointly and severally liable with the Licensee for all of the Licensee's obligations under this Agreement.

I. The Licensee has agreed to enter in to this Agreement with the Licensor for the purpose of developing the Project at the respective Sites as set out in Exhibit A, subject to and in accordance with the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual promises and covenants of each Party to the other contained in this Agreement and for other good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

1

ARTICLE 1
DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Agreement, unless the context otherwise requires, any term defined in Article 1.1 of the PPA but not defined herein shall have throughout this Agreement the meaning set forth against that term in the PPA, and the following terms shall have the meanings set forth below:

"**Access Rights**" has the meaning set forth in Article 6.6 hereof.

"**Agreement**" has the meaning set forth in the Preamble hereof.

"Applicable Law" means any and all statutes, laws, municipal charter provisions, regulations, ordinances, rules, mandates, judgements, orders, decrees, Permits and Approvals, codes or license requirements, or other governmental requirements or restrictions or any interpretation or administration of any of the foregoing by any Governmental Authority, that apply to either Party under this Agreement, whether now or hereafter in effect.

"**Defect**" has the meaning set forth in Article 5.5hereof.

"**Dispute Notice**" has the meaning set forth in Article 13.2 hereof.

"**Dispute**" has the meaning set forth in Article 13.2 hereof.

"**Emergency**" has the meaning set forth in Article 8.2 hereof.

"**Execution Date**" means the date of signing this Agreement.

"**Expert**" has the meaning set forth in Article 13.3 hereof.

"**Fee**" has the meaning set forth in Article 4.1 hereof.

"FENAKA" has the meaning set forth in Recital D hereof.

"Implementation Agreement" has the meaning set forth in Recital F hereof.

"**Instant Facility**" means the solar PV systems, inverters, and related equipment, systems, components, fixtures, and facilities sharing a common point of interconnection with FENAKA's Electric System, Licensee's Interconnection Facilities relating thereto, the ground mounted canopy structure on top of which the solar panels shall be fixed and other assets, tangible and intangible, that comprise the Facility as set up on the Site(s).

"**Indemnified Party**" has the meaning set forth in Article 10 hereof.

"**Indemnifying Party**" has the meaning set forth in Article 10 hereof.

"**License**" means the license issued to the Licensee by the Licensor to design, build, maintain

and operate the Instant Facility at the Site(s) in accordance with the terms and conditions of this Agreement.

“**License Term**” has the meaning set forth in Article 2 hereof.

“**Licensee**” has the meaning set forth in the Preamble hereof.

“**Licensee’s Interconnection Facilities**” has the meaning ascribed to the term “Seller’s Interconnection Facilities” in Article 1.1 of the PPA.

“**Licensor**” has the meaning set forth in the Preamble hereof.

“MECCT” mean the Ministry of Environment, Climate Change and Technology of the Government of the Republic of Maldives or any successor thereto.

“**PPA**” has the meaning set forth in Recital E hereof.

“**Possession Date**” has the meaning set forth in Article 3 hereof.

“Reference Rate” mean the rate notified by the Maldives Monetary Authority for 364 Days Treasury Bills, on the Day that is two (2) Business Days prior to the day on which interest shall begin to be calculated hereunder, subject to a maximum of five percent (5%).

“**Site(s)**” means the public spaces on the island of Faadhippolhu Hinnavaru chosen as the sites for developing the Project, more fully described in Exhibit A herein.

“SIAC” means Singapore International Arbitration Centre.

“Taxes” means any tax applicable in the Maldives, including any tax on income, excise duty, customs duty, value added tax, sales tax, good and services tax and other local tax, cess, any impost or surcharge of like nature, any interest, penalties and other sums in relation on the income, goods, material, equipment and services rendered by either Party, and charged, levied or imposed by a Government instrumentality.

“**Transfer**” means in relation to a property, the sale, gift, pledge, assignment, transfer, transfer of any interest in trust, encumbrance, or alienation or disposition in any manner whatsoever, voluntarily or involuntarily, including, any attachment, assignment for the benefit of creditors against the owner of a property or appointment of a custodian, liquidator or receiver in relation to the property.

“URA” means the Utility Regulatory Authority established under Law No. 26/2020 (Utility Regulatory Authority Act).

1.2 Interpretations

In this Agreement:

(a) any reference to any statute or statutory provision shall include:

(i) all subordinate legislation made from time to time under that provision (whether or not amended, modified, re-enacted or consolidated);

(ii) such provision as from time to time amended, modified, re-enacted or consolidated (whether before or after the date of this Agreement) and (to the extent liability thereunder may exist or can arise) shall include any past statutory provision (as from time to time amended, modified, re-enacted or consolidated), which the provision referred to has directly or indirectly replaced;

(b) reference to any Party under this Agreement shall also include its successors, administrators, legal representatives, and permitted assigns as the case may be;

(c) heading to Articles and paragraphs are for information only, and shall not form part of the operative provisions of this Agreement and be ignored in construing the same;

(d) references to Articles and schedules are to Articles and schedules to this Agreement. All of these form part of the operative provisions of this Agreement and references to this Agreement shall, unless the context otherwise requires, include references to the Articles and schedules;

(e) unless the contrary is expressly stated, no Article in this Agreement limits the extent or application of another Article;

(f) any reference to books, files, records or other information or any of them means books, files, records or other information or any of them in any form or in whatever medium held including paper, electronically stored data, magnetic media, film and microfilm;

(g) "in writing" includes any communication made by letter or facsimile;

(h) the words "*include*", "*including*", "*inter alia*" and "*in particular*" shall be construed as being by way of illustration or emphasis only and shall not be construed as, nor shall they take effect as, limiting the generality of any preceding words;

(i) the words "*directly or indirectly*" mean directly or indirectly through one or more intermediary persons or through contractual or other legal arrangements, and "direct or indirect" shall have the correlative meanings;

(j) the expression "*this Article*" shall, unless followed by reference to a specific provision, be deemed to refer to the whole Article (not merely the sub-Article, paragraph or other provision) in which the expression occurs;

(k) the terms '*hereof*', '*herein*', '*hereby*', '*hereto*' and derivative or similar words shall, unless followed by a reference to a specific provision of the Agreement, be deemed to refer to this entire Agreement;

(l) when any number of Days are prescribed in this Agreement, same shall be reckoned exclusively of the first and inclusively of the last Day, unless the last Day does not fall on a Business Day, in which case the last Day shall be the next succeeding Day which is a Business Day;

(m) time is of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended, such extended time shall also be of the essence;

(n) a reference to any agreement is a reference to that agreement and all schedules, appendices and the like incorporated therein, as the same may be amended, modified, supplemented, waived, varied, added to, substituted, replaced, renewed or extended from time to time;

(o) all provisions of this Agreement shall be interpreted and construed in accordance with their meanings, and not strictly for or against either Party, regardless of which Party may have drafted this Agreement or a specific provision;

(p) grammatical variations of defined words shall be construed in accordance with the relevant definition(s);

(q) references to the singular number shall include references to the plural number and vice versa; and

(r) words denoting one gender shall include all genders.

ARTICLE 2
LICENSE TERM

The term of this Agreement shall enter into full force and effect on the Execution Date and shall expire upon the expiry of the PPA or upon an earlier termination of the PPA ("License Term").

ARTICLE 3
GRANT OF LICENSE

Subject to the Licensee's compliance with its obligations in this Agreement, the Licensor hereby grants and the Licensee hereby accepts the License, to design, build, maintain and operate the Instant Facility on the Site(s), for the duration of the License Term, unless terminated earlier in accordance with the terms herein contained. The Licensor shall provide to the Licensee, access to the Site(s) on a Day mutually agreed between the Parties (the "Possession Date"), which Day shall not be later than 31st July 2022. The Licensee undertakes and covenants that the Site(s) shall only be used for the purposes of designing, building, maintaining and operating the Instant Facility in accordance with the terms and conditions herein mentioned, and for no other purpose. The Licensee shall not have exclusive possession of the Site(s) and nothing contained herein shall be construed as creating any rights, interest, easement, tenancy or sub-tenancy in favor of the Licensee in or over the Site(s) other than the permissive right of use herein granted.

ARTICLE 4
CONSIDERATION

4.1 In consideration of the grant of the License over the Site(s) to develop the Project and the grant of Access Rights, the Licensee shall pay to the Licensor, an annual fee at the rate of Rufiyaa Eight (MVR 8) per square meter (of the area of the Site(s)) per year ("Fee"). The Fee shall be paid on or before the 01st Day of January of each year during the License Term. Parties acknowledge that this Agreement is being entered into towards fulfillment of the Maldives' obligations to the Licensee under the Implementation Agreement, and in consideration, *inter alia*, of the Licensee's obligation to develop the Project and sell Electric Energy to FENAKA, which collectively with the Fee is acknowledged by the Parties to constitute adequate consideration for the grant of the License over the Site(s) and the grant of Access Rights under this Agreement. Accordingly, Parties undertake that neither Party shall question the validity of this Agreement for want or adequacy of consideration

4.2 The Licensee shall commence payment of the Fee starting from 01st Day of January, 2023.

4.3 The Licensee shall pay the Fee by online remittance (electronic funds transfer) or by way of demand draft drawn in favor of the Licensor payable at Faadhippolhu Hinnavaru, Republic of Maldives. In the event the payment is made by way of online remittance, the Licensee shall provide proof of such remittance to the Licensor within 02 (two) days of such remittance and all the charges in relation to transfer of payments to the Licensor's account shall be borne by the Licensee.

ARTICLE 5

TAXES AND INSURANCE

5.1 Taxes in Relation to Site(s)

During the License Term, the Licensor shall be liable to bear and pay on its sole account any and all Taxes in relation to the Site(s).

5.2 Taxes in Relation to Instant Facility

Any Tax imposed by a Governmental Authority, with respect to the design, construction, financing, ownership, erection, installation, maintenance and operation of the Instant Facility and/ or on account of the income generated from the operation of the Instant Facility, shall be borne by the Licensee. To the extent possible under Applicable Law, the Licensee shall make such payments directly to the relevant Governmental Authority. In the event that any Tax that is payable by the Licensee is paid by the Licensor, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.3 Taxes on Fee

The Fee shall be paid by the Licensee without any deductions whatsoever, save and except the deduction of tax at source, if applicable. The liability for payment of any Taxes as applicable on the Fee shall be borne by the Licensee, even if the same is payable by the Licensor in accordance with the Applicable Law.

5.4 Commercial General Liability Insurance for Damage to the Site(s)

The Licensee shall procure and maintain commercial general liability insurance, employer's liability, worker's compensation , professional liability (with any exclusions subject to the prior written approval of the Licensor) up to the overall limit set out in Schedule 4 of the PPA, and within such commercial general liability insurance the Licensee shall also insure against liability for personal injury and damage to the Site(s) or damage to any third party properties therein, arising directly out of the installation of the Instant Facility or its use, in standard form, which shall include operations and blanket contractual liability coverage which insures performance by the Licensee of the indemnity provisions of this Agreement. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date.

5.5 Comprehensive "All Risks" Insurance of the Instant Facility

The Licensee, at its cost, shall within the overall limit set out in Schedule 4 of the PPA, procure and maintain comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility against fire, accident, burglary, vandalism, machinery breakdown, earth movement such as earthquake, volcanic eruptions and subsidence, hurricane/ windstorms, flood including

tsunami, debris removal, ordinance or law, extra expense and terrorism. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date. Upon failure by the Licensee to procure and maintain such comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility, and the occurrence of any such event that renders the Site(s) untenable for use by the Licensor (a "Defect") and other users, the Licensee shall cure such Defect at its own cost, within thirty (30) Days of the occurrence of the Defect. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to obtain the required insurance. In the event that the Licensor obtains required insurance for the Site, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. The Licensor shall be entitled to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.6 The Licensee shall, at its own cost, ensure that any insurance policy required to be maintained by it in accordance with this Article 5 is renewed before the expiry of such insurance policy. Such insurance policy shall also comply with the other requirements stated in Schedule 4 of the PPA, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee. The insurance policies referenced herein shall be taken out in the names of the Licensor and the Licensee for the full value of their respective rights and interests provided that the premiums incurred by the Licensee in complying with this clause will not be unreasonable. The Licensor shall, at the cost of the Licensee, provide all reasonable necessary assistance and cooperation to the Licensee for the renewal of such insurance policy by the Licensee. The proceeds of any Proceeds of any insurance claim are to be applied towards the replacement, repair and/or reinstatement of the Site(s) and/or the Instant Facility.

5.7 On the occurrence of a partial or total loss or an event which, in the reasonable opinion of the Licensee would result in a claim against the insurance policies taken by the Licensee in respect of the Instant Facility, the Licensee shall forthwith and in any case not later than two (2) Days from the date of occurrence of loss or event inform the Licensor of the same.

ARTICLE 6
LICENSEE'S RIGHTS AND COVENANTS

6.1 The Licensee shall provide a copy of the duly executed PPA to the Licensor within fifteen (15) Days of the Execution Date.

6.2 The Licensee hereby represents and warrants that it has inspected or has caused an inspection of the Site(s) to be done, and has satisfied itself on the suitability of the Site(s) for the Instant Facility, and shall accept the possession of the Site(s) on an "as is where is" basis, on the Possession Date.

6.3 The Licensee shall be solely responsible for (a) all costs and the performance of all tasks required for installation, operation and maintenance of the Instant Facility at the Site(s) including costs related to preparation of the Site(s) before installation, costs related to capital improvement, removal, replacement and expansion of the Instant Facility; (b) ensuring that the design, construction, financing, ownership, maintenance and operation of the Instant Facility are in compliance with Good Engineering and Operating Practices, Codes and Standards, and Applicable Law, including those relating to safety norms, public health and environment; (c) ensuring that the performance of the tasks required for installation, operation and maintenance of the Instant Facility does not cause any damage to the Site(s), and to any public property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; (d) obtaining all Permits and Approvals required for the Licensee's use of the Site(s); and (e) bearing all risk of loss in case of a theft, damage, casualty, condemnation or confiscation of the Instant Facility.

6.4 The Licensee agrees that any matter raised in relation to the installation, maintenance and operation of the Instant Facility by any person, shall be addressed as per the Environment and Social Impact Assessment (ESIA) and the Grievance Redress Mechanism (GRM), developed pursuant to the Environmental and Social Management Framework (defined in the PPA) relating to ASPIRE.

6.5 The Licensor may, if in the event the Licensee is unable to attend to any issue in accordance with the GRM, upon giving 24 hour written notice, resolve such issues or remedy any damages or defects as maybe specified in the notice, and make such repairs thereto as the Licensor deems appropriate. Should the Licensor effect repairs, the Licensee shall pay to the Licensor the amount of such repairs reasonably incurred by the Licensor upon submission to the Licensee of an invoice with supporting documents showing the cost incurred by the Licensor for such repairs which shall be calculated at a fair and reasonable market rate.

6.6 During the License Term, the Licensee shall have the following rights ("Access Rights") in relation to the Site(s):

(a) right to erect temporary structures, such as a scaffolding or similar structures at the Site(s) as may be reasonably required for the purpose of carrying out the construction and erection of the Instant Facility and/ or for the maintenance of the Instant Facility, provided that (i) the Licensee shall use all reasonable efforts to minimize the impact thereof on the normal use of the space

where the Site(s) is located, by the public and (ii) the Licensee shall obtain prior written approval of the Licensor in respect of such temporary structures and all approvals required under Applicable Law;

(b) right to use such ways, paths and passages as are reasonably necessary for the purpose of access to and egress from the Site(s), with or without workmen and for transporting, loading and unloading necessary tools, equipment and materials, provided that (i) the Licensor may in consultation with the Licensee and for a reasonable cause require the Licensee to change the route of any means of access to or egress from the Site(s) and may change the area over which any of the Access Rights are exercised; and (ii) the use of such ways, paths and passages shall not obstruct the general use of the space where the Site(s) is located by the public, provided that where the Licensee's use of the path, ways and passages will result in an obstruction of the use of such space by the public, such obstruction shall be done only after obtaining a prior written approval from the Licensor, and shall be only for a reasonable period of time as agreed with the Licensor, consistent with Good Engineering and Operating Practices.

Provided that the Licensee shall provide the Licensor at least thirty (30) Days before the commencement of the construction of the Instant Facility, or a related activity, a schedule of construction of the Instant Facility. Upon receipt of such schedule of construction from the Licensee, the Licensor shall within five (5) Business Days respond with such reasonable changes to the schedule of construction, if any, as it may require, failing which the Licensor shall be deemed to have accepted the schedule of construction. If the Licensor requests any changes to the schedule of construction, the Licensee shall modify its schedule of construction after incorporating such reasonable changes suggested by the Licensor, and notify the finalized schedule of construction at least five (5) Days prior to the commencement of construction.

6.7 The Licensee shall have right to use utilities such as electricity and water for the purpose of construction, installation, erection, operation and maintenance of the Instant Facility, at the cost of the Licensee. The Licensee shall install separate meters for recording the consumption of electricity and water by the Licensee at the Site(s). The Licensee shall pay by the due date the meter installation and hire charges and also the bills for consumption of electricity and water in the Site(s) as recorded in the meters to the relevant utility companies and provide a copy of the proof of such payment to the Licensor within fifteen (15) Business Days from such payment for its records. In addition, the Licensee shall arrange at its own cost other facilities such as telephone services and other similar facilities, and pay directly to the third-party services providers for such services availed by it.

6.8 Subject to Article 5 hereof, the Licensee may make its own arrangements for and take reasonable measures, in consultation with the Licensor for the protection and security of the Instant Facility.

6.9 The Licensee shall have the right to construct ground mounted canopy structures and such other supporting structures as necessary which forms part of the Instant Facility, and shall have the right from time to time, both before and after the Commercial Operation Date, and at the Licensee's sole cost and expense, to make such additions, alterations or changes to such structures, as are reasonably required in compliance with the provisions of this Agreement, Applicable Law, Good Engineering and Operating Practices and Codes and Standards; provided that: (a) the Licensee shall not cause any damage to the Site(s), and to any public

property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, low voltage, medium voltage, and high voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; and (b) the Licensee shall obtain the prior written approval of the Licensor, and such prior written approval shall not be unreasonably withheld, in respect of any such construction, additions, alterations or changes, except if such construction, additions, alterations or changes are cosmetic in nature and/ or are part of the day to day maintenance and repair of the Instant Facility; and (c) the Licensee shall provide to the Licensor a certificate from a civil engineer and/or architect having the requisite competence under Applicable Law for issuing such certificates, and acceptable to the Licensor and such acceptance shall not be unreasonably withheld, and which certificate shall certify that the proposed constructions, additions, alterations, or changes are in compliance with the Applicable Law, required for the construction of the Instant Facility.

6. 10 The Licensee shall be solely responsible for day to day operation and maintenance of the Instant Facility, including without limitation the obligation to promptly make or pay (as determined by the Licensor) for, any repairs to any part or whole of the Site(s), to the extent damage is caused by the Licensee, its employees, officers, agents, contractors or subcontractors, during the License Term.

6.11 In complying with its obligations under Article 6.9, the Licensee shall to the extent possible give five (5) Business Days prior written notice for all repair and maintenance work of the Instant Facility or the Site(s) so as not to restrict public use of the space in which the Site(s) is located. Upon such request for repair and maintenance work, the Licensor shall respond to such request within five (5) Business Days. If the Licensor does not respond to such request within five (5) Business Days, such request shall be deemed approved by the Licensor. The Licensee shall ensure that all such work undertaken must be completed in all respects in a timely manner.

6.12 At all times, the Licensee shall:

(a) take due care to ensure that no damage is caused to any property on the Site(s) and the space belonging to or used by the Licensor, the public or other users of such space;

(b) not cause inconvenience to the Licensor, and other users of the space in which the Site(s) is located as is reasonably practicable, except that the Licensor agrees that the exercise of the Access Right granted under Article 6.6(a) hereof may cause temporary obstruction and/ or interference with the normal use of such space and that such inconvenience shall not be deemed to be a violation of the Licensee's obligations under this Article 6.11(b).

6.13 In the event, there is any damage to the Site(s) and/or to the space where the Site(s) is located, and to any public property or to any property of a third party therein, including but not limited to any damage to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, water and sewerage mains, fiber-optic cables and telecommunication service lines, by reason of the Licensee exercising an Access Right or other rights under this Agreement, the Licensee shall make good such damage (to the reasonable satisfaction of the Licensor) at its own cost.

6.14 The Licensee shall provide a list to the Licensor (or to any officer of the Licensor designated

by the Licensor for this purpose), of the employees, agents, sub-contractors, and other representatives of the Licensee who shall be entitled to enter upon the Site(s), and shall ensure that the Access Rights granted hereunder are exercised by such employees, agents, sub-contractors, and other representatives, subject to the reasonable conditions for entry and exit to the Site imposed by the Licensor, and having regard to the public safety, and the safety of the Site(s).

6.15 The Licensee shall, as promptly as possible, notify the Licensor of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s) and/ or the Instant Facility, and that in the Licensee's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety.

6.16 The Licensee shall consult with the Licensor and obtain Licensor's approval in relation to design of the Instant Facility (including with respect to its placement within the Site(s) and technical specifications) and obtain written approval from the Licensor in case of any alteration to the design of the Instant Facility.

ARTICLE 7
OWNERSHIP OF THE INSTANT FACILITY

7.1 The Licensee shall be the exclusive owner and operator of the Instant Facility, including any part thereof, installed by the Licensee.

7.2 The Licensee acknowledges and agrees that, notwithstanding that the Instant Facility is a fixture on the Site(s), the Licensee shall have no right, title or interest in the Site(s) except as that of a Licensee as per the terms set out in this Agreement. The Licensee shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on the Site(s) or the Access Rights or any interest therein, and the Licensor will not suffer in any manner out of Licensee's use of the Site(s) whereby the estate, rights and interests of the Licensor in the Site(s) or any part thereof might be impaired, except in accordance with and subject to the provisions of this Agreement.

ARTICLE 8
LICENSOR'S COVENANTS

8.1 The Licensor shall take all reasonable efforts not to cause any interference with the effective operation of the Instant Facility, including any interference with the Licensee's right to receive continuous and uninterrupted passage of light at all times across the Site(s) or have access to the Site(s) and the Instant Facility.

8.2 The Licensor shall, as promptly as possible, notify the Licensee of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s), and that in the Licensor's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety. The Licensor and FENAKA shall have the right (but not the obligation), to the extent permitted by Applicable Law, to enter into the Site(s) for the sole purpose of responding to any dangerous condition posing risk to, the Site(s), the Instant Facility, public health or public safety ("Emergency"); provided that any actions taken by the Licensor upon such entry shall be limited to those reasonably necessary to respond to the risks posed. The Licensee shall respond to any such Emergency as promptly as possible, and take all measures necessary to address the condition that gave rise to the Emergency. The Licensee shall not be required to bear the costs associated with an Emergency related to the Site(s) that are not caused by the Licensee and does not affect the Instant Facility.

8.3 The Licensor shall reasonably cooperate with the Licensee, at the Licensee's cost, so that the Licensee can procure all Permits and Approvals for design, engineering, construction, financing, operations, maintenance and deconstruction of the Instant Facility, and meet its obligations under this Agreement and the PPA.

8.4 The Licensor agrees and undertakes that this Agreement and the Access Rights shall run with the Site(s) and shall survive any Transfer of the Site(s). The Licensor shall give the Licensee at least six (6) Calendar Months written notice prior to any Transfer of all or a portion of the Site(s) identifying the transferee, the portion of the Site(s) to be transferred and the proposed date of Transfer. In the event of Transfer by any way or form of the Site(s), the Licensor shall cause the proposed transferee to execute an agreement identical in terms and conditions as that of this Agreement with the Licensee, for a term equal to the License Term outstanding at the date of such Transfer.

8.5 The Licensor recognizes the need of the Licensee to finance the Project by mortgage of the Instant Facility, accordingly, the Licensor shall reasonably cooperate with the Licensee in creation of charge on the Instant Facility in favor of the lenders to the Project, at the cost of the Licensee, including through furnishing such documents and certificates as may be reasonably requested by the Licensee's lenders.

8.6 The Licensor shall not, directly or indirectly, cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on or with respect to the Site(s), except with the prior written consent of the Licensee, which consent shall not be unreasonably withheld.

8.7 Subject to the terms and conditions of this Agreement and the Licensee's compliance with all

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 **Licensor's Representations and Warranties**

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a local council, duly established and validly existing under the constitution and laws of Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

  (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or
  (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 **Representations and Warranties of the Licensee**

Licensee hereby represents and warrants as of the date hereof that:

(a) the Licensee is a company duly organized and validly existing under the relevant jurisdiction specified in the Preamble of this Agreement, and has full legal right, power and authority under Applicable Law to enter into and perform its obligations under this Agreement;

(b) the Licensee has duly authorized the execution and delivery of this Agreement. This Agreement has been duly executed and delivered by the Licensee and will constitute a legal, valid and binding obligation of the Licensee, enforceable against the Licensee in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other laws affecting creditors rights generally;

(c) neither the execution nor the delivery by the Licensee of this Agreement nor the performance by the Licensee of its obligations hereunder: (i) will conflict with, violate, or result in a breach of any Applicable Law of Maldives; or (ii) conflicts with, violates, or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of [incorporation/ registration] of the Licensee), or instrument to which Licensee is a party or by which Licensee or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or instrument;

(d) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensee, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensee in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensee of its obligations hereunder or under such an agreement or instrument.

ARTICLE 10
INDEMNIFICATION

The Licensee (also an "Indemnifying Party") shall indemnify and hold harmless the Licensor and its employees, officers, agents, contractors, professional advisors and representatives (each an "Indemnified Party") from and against all liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, that may be imposed upon or incurred by or asserted against the Licensor or any of its employees, officers, agents, contractors, professional advisors, representatives, by reason of any of the following occurrences during the License Term, except to the extent such liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, are caused by either (i) gross negligence or intentional wrongful acts of the Indemnified Party or (ii) failure or other breach by the Indemnified Party to perform any of its obligations under Applicable Law or Permits and Approvals:

(a) any breach by the Licensee of its obligations, covenants, representations or warranties contained in this Agreement;

(b) any negligence on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees in connection with the use of the Site(s) or in designing, construction, financing, ownership and operation of the Instant Facility or the Project; or

(c) any failure on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees to comply with Applicable Law that require compliance by the Licensee or any of its agents, contractors, servants, employees, subtenants, licensees or invitees in connection with the Site(s) and its use, or design, construction, financing, ownership and operation of the Instant Facility, or the Project.

ARTICLE 11
FORCE MAJEURE EVENT

11.1 Adoption of provisions of PPA

Provisions of Article 12.4, Article 12.5 and Article 12.6 of the PPA shall *mutatis mutandis* apply to this Agreement, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee.

11.2 Effects of Force Majeure Events

Without prejudice to the rights or obligations of the Government or FENAKA under the Implementation Agreement or the PPA,

(a) if the Force Majeure Event results in loss of the Site(s) or the Instant Facility, either Party shall have the right to terminate this Agreement in accordance with the provisions of Article 12.1(a) of this Agreement; or

(b) if a Force Majeure Event subsists for more than one hundred and eighty (180) Days and the PPA is terminated in accordance with Article 13.5, or Article 13.6, as the case may be, of the PPA, either Party may terminate this Agreement in accordance with Article 12.1(b) and Article 12.2, hereof.

ARTICLE 12
TERMINATION

12.1 Events of Termination

This Agreement shall terminate in the following circumstances:

(a) If occurrence of a Force Majeure Event results in loss of the Site(s), either Party shall have the right to terminate this Agreement in accordance with Article 11.2(a), by a notice in writing to the other Party, with the termination being effective from fifteen (15) Days from the date of such notice.

(b) Upon termination of the PPA, whether on account of expiry of the Contract Term, or otherwise, and whether in respect of the Project as a whole or in respect of the Instant Facility, either Party shall have the right to terminate this Agreement with effect from the date of termination of the PPA.

(c) If the Government issues or is deemed to have issued a Concurrence Notice under Article 4.2(c)(iii) of the Implementation Agreement, either Party may terminate this Agreement.

(d) If an Expert (as defined under the Implementation Agreement) determines in accordance with Article 4.2(c)(x) of the Implementation Agreement that the Site(s) is unavailable for use of the Licensee, the Agreement shall terminate with effect from the date of such determination or such other date as such Expert may determine.

12.2 Consequences of Termination

(a) If the Agreement terminates in accordance with Article 12.1(b) but on account of expiry of the Contract Term and FENAKA chooses to purchase the Instant Facility in accordance with Article 2.2 of the PPA, the Licensor shall transfer the License provided for in this Agreement in favor of FENAKA on such terms and conditions as FENAKA and Licensor may agree in writing.

(b) If the Agreement terminates in accordance with Article 12.1(a), or Article 12.1(b) but on account of

(i) expiry of the Contract Term and FENAKA chooses not to purchase the Instant Facility in accordance with Article 2.2 of the PPA,

(ii) termination of the PPA in accordance with Article 13.3(a) or Article 13.3(c) of the PPA, and FENAKA chooses not to exercise its right under Article 13.3(d) of the PPA to purchase the Project or the Instant Facility, or

(iii) termination of the PPA in accordance with Article 13.5(a) or Article 13.5(b) (where the PPA is terminated by the Seller, thereof) of the PPA,

the Licensee shall within one hundred and eighty (180) Days, decommission the entire Instant Facility set up at the Site(s), remove all its assets from the Site(s), and vacate and hand over

peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

(c) If the Agreement terminates in accordance with Article 12.1(b) but on account of,

(i) termination of the PPA in accordance with Article 13.4(c), Article 13.4(d), Article 13.6(a) or Article 13.6(c) of the PPA,

(ii) termination of the PPA by FENAKA in accordance with Article 13.5(b) of the PPA,

Licensor shall execute a license over the Site(s) in favor of the FENAKA simultaneously with the purchase of the Instant Facility by FENAKA, on terms and conditions substantially similar to those contained in this Agreement, unless FENAKA and the Licensor agree otherwise.

(d) If the Agreement terminates in accordance with Article 12.1(c) or Article 12.1(d), the Licensee shall relocate the Instant Facility to the alternative Site(s), promptly upon execution of the license agreement for the alternative Site(s), but in no event later than one hundred and eighty (180) Days, and vacate and hand over peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

ARTICLE 13
DISPUTE RESOLUTION

13.1 Continued Performance

Each Party shall continue to perform its obligations under this Agreement (including any payment obligations) pending resolution of any dispute pursuant to this Article 13. Provided that, if the dispute is with respect to any payments, neither Party shall be required to make such disputed payment(s) to the other Party so long as such dispute has been referred to the process for resolution pursuant to this Article 13; provided, that to the extent any amounts owed to either Party by the other Party are not disputed and can be segregated from amounts with respect to which there is a dispute, such undisputed amounts shall, in good faith, be identified by the Parties and paid as required by this Agreement. To the extent that any disputed amount was withheld from a Party, and such Party is ultimately found to be entitled to all or any portion of such disputed amount pursuant to this Article 13, then such Party shall be entitled to the payment of interest on any withheld amount, at an annual rate equal to Reference Rate, from the original due date for payment of such amount until the payment of such disputed amount.

13.2 Negotiation

If any dispute, controversy or claim arises under or relates to this Agreement or the breach, termination or validity thereof (the "Dispute"), such Dispute shall be referred by each Party to its designated senior officer for resolution upon five (5) Days written notice from either Party (the "Dispute Notice"). The Parties agree to attempt to resolve all Disputes promptly and equitably and to provide each other with reasonable access during regular business hours to any and all non-privileged records, information and data pertaining to any such Dispute.

13.3 Expert Determination

(a) A dispute may be referred to an expert (the "Expert") in accordance with this Article 13.3 if:

(i) the Parties are not able to agree under Article 13.2 (*Negotiation*) on an amicable resolution to such dispute; and

(ii) this Agreement expressly provides that such dispute shall be referred to an Expert or the Parties agree in writing that such dispute shall be referred to an Expert.

(b) Any Party to such a Dispute may initiate an Expert reference under this Article 13.3 by proposing to the other Party to the dispute the name of the Expert. If the other Party does not agree to the name suggested by the Party making the reference, and the Parties are otherwise unable to agree on the name of an Expert, either Party may apply to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the Expert for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, an

Expert for the matter in Dispute.

(c) The Parties shall request that the Expert determine the referred dispute, within thirty (30) Days of receiving the reference, or in such additional time as may be reasonably required by the Expert to determine the Dispute, which shall not be more than one hundred and eighty (180) Days of receiving the reference.

(d) The Expert shall act as an expert and not as an arbitrator.

(e) The Parties shall have the right to make representations and submissions to the Expert. There shall be no formal hearing.

(f) The Expert shall have power to request any Party to provide him/her with such statements (which shall be written unless otherwise specifically required) or documents or information within their control as he may determine necessary and the Parties shall comply with any such request in accordance with the timeframes set out by the Expert or in the absence of such timeframes, in a timely manner as required to enable the Expert to determine the Dispute within the timeframe set forth in Article 13.3(c).

(g) The Expert shall give his/her decision to the Parties to the Dispute in writing and his/her decision, which shall promptly be given effect to by such Parties, shall be final and binding (save in the case of fraud or manifest error) on them.

(h) If the Expert decides that a sum is due and payable by one Party to another Party then:

(i) any such sum shall be due and payable within seven (7) Days of receipt by the Parties of written notice of such decision, unless the Expert decides otherwise; and

(ii) interest shall accrue at the rate of Reference Rate, compounded annually, from the date expiry of the period mentioned in Article 13.3(h)(i); provided that if the sum specified in Article 13.3(h)(i) includes any interest, no interest shall be payable on such interest.

(i) The fees of the Expert and any other costs of and incidental to the reference to Expert determination shall be payable by such Party to the Dispute as the Expert may determine but, in the absence of any such determination, by the Parties to the Dispute in equal shares.

13.4 Arbitration

(a) Selection of Arbitrators

If the Parties are unable to resolve their Disputes through negotiation within thirty (30) Days of the Dispute Notice, either Party may initiate proceedings to submit the Dispute for arbitration. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:

(i) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply

to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute.

(ii) Where the Parties do not agree that the dispute concerns a technical matter, the Parties may agree to appoint a sole arbitrator mutually agreed by them or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, each Party shall appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) Days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC.

(iii) If, in a dispute subject to Article 13.4(a)(ii) above, one Party fails to appoint its arbitrator within thirty (30) Days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.

(b) Rules of Procedure

Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the SIAC as in force on the date of this Agreement.

(c) Substitute Arbitrators

If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator.

(d) Nationality and Qualifications of Arbitrators

Each arbitrator appointed pursuant to Article 13.4(a)(i) to Article 13.4(a)(iii) shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of Maldives or the home country of the Licensee. For the purposes of this Clause, "home country" means any of:

(i) the country of incorporation of the Licensee or their parent companies;
(ii) the country in which Licensee's principal place of business is located;
(iii) the country of nationality of a majority of the Licensee's shareholders; or
(iv) where the Licensee is a joint venture between two or more Persons, the country of incorporation, nationality or place of business of the partners or shareholders of such joint venture.

(e) Miscellaneous

In any arbitration proceeding hereunder:

- (i) proceedings shall, unless otherwise agreed by the Parties, be held in Singapore;
- (ii) the English language shall be the official language for all purposes; and
- (iii) the decision of the sole arbitrator or of a majority of the arbitrators shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

13.6 Governing Law, Jurisdiction and Service of Process

(a) Governing Law

This Agreement shall be governed by, and construed in accordance with, the laws of Maldives.

(b) Jurisdiction

Subject to Article 13.3 and Article 13.4, each of the Parties consents to submit itself to the exclusive jurisdiction of the courts located in the Maldives in relation to recognition of any arbitral award, with respect to any Dispute that arises under this Agreement.

(c) Service of Process

Subject to the rules of SIAC for the purposes of arbitration, each Party agrees that service of any process, summons, notice or document hand delivered or sent by certified mail, return receipt requested, to such Party's respective address set forth in Article 14.4 will be effective service of process for any action, suit or proceeding with respect to any matters to which it has submitted to arbitration as set forth in Article 13.4.

ARTICLE 14
MISCELLANEOUS PROVISIONS

14.1 Assignment

Licensee shall not assign or otherwise transfer this Agreement, except (i) for the collateral assignment to any lenders (only if such lenders are independent third party financial institutions) in connection with the provision of any financing for the Instant Facility, or (ii) to any Person who is a bona fide transferee of the PPA (in accordance with the terms of the PPA), subject to the transferee undertaking to comply with the obligations of the Licensee under the PPA, this Agreement, and the Escrow Agreement.

14.2 Further Assurances

Each Party agrees to, and shall use all reasonable efforts to, provide such information, execute and deliver any instruments and documents and take such action as may be necessary or reasonably requested or required by the other Party which are not inconsistent with the provisions of this Agreement and which do not involve the assumption of obligations other than those provided for in this Agreement in order to give full force and effect to this Agreement and to carry out its intent.

14.3 Relationship of Parties

Except as otherwise explicitly provided herein, neither Party to this Agreement shall have any responsibility whatsoever with respect to services provided or contractual obligations assumed by the other Party and nothing in this Agreement shall be deemed to constitute either Party a partner, agent or legal representative of the other Party or to create any fiduciary relationship between or among the Parties.

14.4 Notices

Any notices required to be given hereunder shall be deemed delivered when (i) sent by facsimile upon electronic confirmation of successful transmission; (ii) delivered to an express courier service nationally recognized in Maldives that provides a receipt of delivery, (iii) sent by email, upon dispatch and the receipt of a delivery confirmation, provided that email shall be used as a mode of notice and communication only for non-material day-to-day matters; (iv)when delivered by personal delivery, in each case addressed to the following persons or such other persons as the Parties may designate in writing:

(a) If to the Licensor:
Name: Hassan Shafiu
Designation: Council President
Address: Secretariat of Faadhippolhu Hinnavaru Council, Road 09, 07010, Lh. Hinnavaru, Republic of Maldives
Email: hinn.office@gmail.com
Fax: +960 3018301
with a copy to:

FENAKA
Name: Ahmed Saeed Mohamed
Designation: Managing Director
Address: FENAKA Corporation Limited, Port Complex Building, 7th Floor, Hilaalee Magu, Male' 20207
Email: ahmed.saeed@fenaka.mv
Copied to: maasha@fenaka.mv

and

MECCT
Name: Mr. Ajwad Musthafa
Designation: Permanent Secretary
Address: Ministry of Environment, Cliimate Change and Technology Green Building, Handhuvaree Hingun, Male', 20392, Republic of Maldives
Email: ajwad.mustafa@environment.gov.mv

(b) If to the Licensee:

Name: Mr. Goh Chin San
Designation:
Managing Director of Mega First Solar (Maldives) Consortium Pvt Ltd
Authorised Representative of Mega First Power Industries Sdn Bhd
Address: A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Email: chinsan.goh@mega-first.com
Copied to: shadhah.shahid@mega-first.com, kok.cw@mega-first.com

14.5 Costs and Expenses

All costs, expenses, including any cost of documentation, reasonable attorney fees, court fee, and stamp fee, relating to creation and maintenance of the license on the Site(s), including execution of this Agreement, shall be borne by the Licensee.

14.6 Confidentiality

The Parties shall at all times keep confidential information acquired in consequence of this Agreement, except for information which the receiving Party already knows or receives from third parties or which the receiving Party may be entitled or bound to disclose under compulsion of Applicable Law or where requested by regulatory agencies or to their professional advisers, investments partners and other parties where reasonably necessary for the performance of their obligations under this Agreement. For the avoidance of doubt, the obligations in this Article shall not apply to information in the public domain or information which the Parties own or acquired lawfully from others and which may be freely disclosed to others without breach of any obligation of confidence

14.7 Waiver

No waiver of any provision of this Agreement shall be effective against a Party except as expressly set forth in a writing signed by such Party. The waiver by either Party of a default or a breach by the other Party of any provision of this Agreement shall not operate or be construed to operate as a waiver of any subsequent default or breach. The making or the acceptance of a payment by either Party with knowledge of the existence of a default or breach shall not operate or be construed to operate as a waiver of any subsequent default or breach.

14.8 Survival

Notwithstanding anything provided herein to the contrary, Article 12.2 (*Consequences of Termination*), Article 13 (*Dispute Resolution*) and Article 14 (*Miscellaneous*), shall survive the termination of this Agreement.

14.9 Third Party Rights

Nothing herein is intended to or should be construed to create any rights of any kind whatsoever in third persons not parties to this Agreement, except in favor of the Government, FENAKA, and the World Bank.

14.10 Counterparts

This Agreement and any amendment hereto may be executed and delivered in one or more counterparts and by different Parties in separate counterparts. All of such counterparts shall constitute one and the same agreement and shall become effective (unless otherwise therein provided) when one or more counterparts have been signed by each Party and delivered to the other Party. Delivery of this Agreement by facsimile transmission or electronic email shall be as effective as delivery of a manually executed counterpart.

14.11 Severability

In the event that any provision of this Agreement shall, for any reason, be determined to be invalid, illegal, or unenforceable in any respect, the Parties shall negotiate in good faith and agree to such amendments, modifications, or supplements to this Agreement, or such other appropriate actions, as shall, to the maximum extent practicable in light of such determination, implement and give effect to the intentions of the Parties as reflected herein, and the other provisions of this Agreement shall, as so amended, modified, supplemented, or otherwise affected by such action, remain in full force and effect.

14.12 Entire Agreement

All prior agreements, negotiations, representations, and understandings with respect to the subject matter hereof, are hereby superseded. No amendment, modification, or change to this Agreement or its Exhibit shall be effective unless the same shall be in writing, duly executed, authorized and approved by the Parties. In the event of any conflict between the terms and conditions of this Agreement and that of any Exhibit or other document referenced herein, this Agreement shall govern and control.

IN WITNESS WHEREOF, the Licensor and Licensee have caused this Agreement to be executed as on the date and the year first set forth above.

For and on behalf of the LICENSOR

....
Hassan Shafiu
Council President
Secretariat of Faadhippolhu Hinnavaru Council,
Road 09, 07010, Lh. Hinnavaru, Republic of Maldives

In the presence of;

....
Ahmed Abdulla
Council Vice President
Secretariat of Faadhippolhu Hinnavaru Council,
Road 09, 07010, Lh. Hinnavaru, Republic of Maldives

For and on behalf of the LICENSEE

....
Goh Chin San
Authorised Representative
Mega First Power Industries Sdn. Bhd.

A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392936-M)

In the presence of;

....
Khoo Teng Keat
Executive Director
Mega First Corporation Berhad
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia

....
Song Qing Guo
General Manager
Powerchina Huadong Engineering Corporation Limited
22, ChaoWang Road Hangzhou, Zhejiang Province, 310014
The People's Republic of China

3301034012842

....
Chen Ting
Chief Representative in Sri Lanka
Sinohydro Corporation Limited
22, Chegongzhuang West Road, Haidian District
Beijing 100048 The People's Republic of China

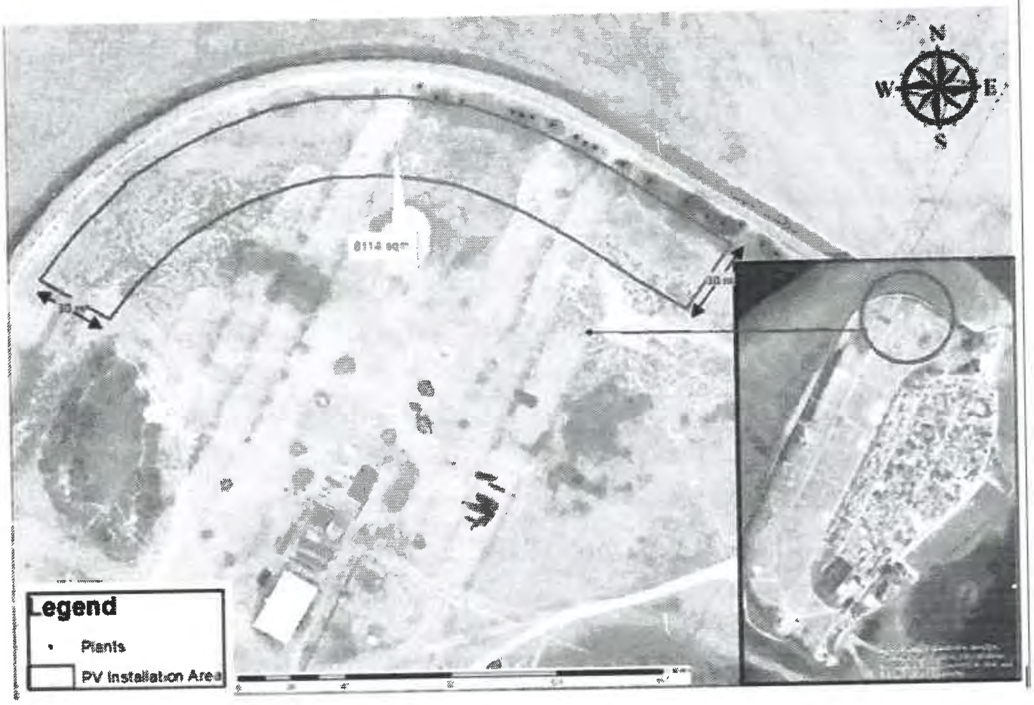
EXHIBIT A

DESCRIPTION OF THE SITE(S)

Note: *The exact coordinates of the following Site shall be agreed between the parties on or before the Possession Date following detailed setting out surveys.*

Site 5.1 Hinnavaru Public Beach Area

Hinnavaru (ASPIRE Site)



Area: 8114 m^2

Array1:

Installation Tilt: 10°

Installation Orientation: 119°

Array2:

Installation Tilt: 10°

Installation Orientation: 149°

Array3:

Installation Tilt: 10°

Installation Orientation: 181°

Array4:

Installation Tilt: 10°

Installation Orientation: 211°

LICENSE AGREEMENT
FOR THE INSTALLATION OF GROUND MOUNTED SOLAR PANELS

BETWEEN

SOUTH HUVADHU ATOLL THINADHOO ISLAND COUNCIL

(MALDIVES)

("LICENSOR")

– AND –

MEGA FIRST POWER INDUSTRIES Sdn. Bhd. (MALAYSIA)

IN JOINT VENTURE WITH

POWERCHINA HUADONG ENGINEERING CORPORATION LIMITED (CHINA)

("LICENSEE")

AGREEMENT NUMBER: (AGR)415/415/2022/1

DATE: APRIL 27, 2022

MEGA FIRST POWER INDUSTRIES SDN. BHD
(Company No. 392936-W)

SECRETARIAT OF THE THINADHOO COUNCIL

LICENSE AGREEMENT

This License Agreement ("Agreement") is made and entered into as of the *27th April 2022* by and between:

1. **South Huvadhu Atoll Thiandhoo Island Council**, a local council of the Government of Maldives, established under Act Number: 7/2010 (Decentralization Act of Maldives) with its offices at Secretariat of Thinadhoo Council, South Huvadhu Atoll, Gaafu Dhaalu Thinadhoo Island, Republic of Maldives ("Licensor"); and

2. **Mega First Power Industries Sdn. Bhd. (MFPI)** a limited liability company, company registration number: 199601020584 (392936-W) , organized and existing under the laws of Malaysia, with its principal office located at A-12-01, Level 12, Block A, PJ8, No. 23, Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia, and **Powerchina Huadong Engineering Corporation Limited (HDEC)** a limited liability company with Unified Social Credit Code: 91330000142920718C, organized and existing under the laws of Peoples Republic of China, with its principal office located at No. 22, ChaoWang Road Hangzhou 310014, Zhejiang Province, The People's Republic of China (**MFPI** and **HDEC** will be jointly and severally liable, and collectively will be hereinafter referred to as the "Licensee").

WHEREAS:

A. The Government (as defined in the PPA), with support from the Strategic Climate Fund and International Development Association, has initiated a program called Accelerating Sustainable Private Investment in Renewable Energy (ASPIRE) for inviting private sector generators to develop [roof top and ground mounted] solar photovoltaic projects in Maldives on a DBFOOT (i.e. design, build, finance, own, operate and transfer) basis. The electrical energy generated from such projects is proposed to be purchased by a Government owned utility under a long-term power purchase agreement.

B. The Government had invited bids from interested independent power producers, *vide* RFP (as defined in the PPA) dated June 17th, 2021 for setting up solar power projects on Government-owned buildings and public spaces identified and facilitated by the Government in the RFP.

C. The Licensee had submitted a Proposal (as defined in the PPA) in response to the RFP, and has been selected by the Government *vide* Letter of Acceptance, dated February 17th, 2022 to develop a solar PV power project. Accordingly, the Licensee desires to construct, own and operate grid connected solar PV electric generating facilities situated at the roof top of Government owned buildings and on such other public spaces identified on selected islands, with a total electric capacity not less than 11 MW.

D. FENAKA (as defined in the PPA) is the identified state utility under the ASPIRE program for purchase of the Electric Energy (as defined in the PPA) generated by the Seller.

E. The Licensee has entered into a Power Purchase Agreement, dated 29th March 2022 ("PPA") with FENAKA to set forth the mechanism for sale and purchase of the Electric Energy generated by the Licensee and other mutual rights and the obligations of the Licensee and FENAKA.

F. Government also proposes to support the Project, the details of which have been prescribed in the Implementation Agreement (as defined in the PPA), setting forth mutual rights and obligations of the Licensee and the Government, executed between the Licensee and the Government.

G. The Licensee was the successful bidder, and among the locations identified in the RFP is the location situated in the island of South Huvadhu Atoll Thinadhoo (together with adequate space for setting up a control room for the Instant Facility (as defined herein below)), the description of which is detailed in Exhibit A ("Site(s)").

H. The Licensee intends to incorporate and establish, in accordance with Applicable Laws, a company to develop the Project ("Project Company") and upon its incorporation, the Parties intend to amend this Agreement to add the Project Company as a party to this Agreement such that the Project Company will be jointly and severally liable with the Licensee for all of the Licensee's obligations under this Agreement.

I. The Licensee has agreed to enter in to this Agreement with the Licensor for the purpose of developing the Project at the respective Sites as set out in Exhibit A, subject to and in accordance with the terms and conditions set forth in this Agreement.

NOW, THEREFORE, in consideration of the mutual promises and covenants of each Party to the other contained in this Agreement and for other good and valuable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties agree as follows:

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 1
DEFINITIONS AND INTERPRETATIONS

1.1 Definitions

In this Agreement, unless the context otherwise requires, any term defined in Article 1.1 of the PPA but not defined herein shall have throughout this Agreement the meaning set forth against that term in the PPA, and the following terms shall have the meanings set forth below:

"Access Rights" has the meaning set forth in Article 6.6 hereof.

"Agreement" has the meaning set forth in the Preamble hereof.

"Applicable Law" means any and all statutes, laws, municipal charter provisions, regulations, ordinances, rules, mandates, judgements, orders, decrees, Permits and Approvals, codes or license requirements, or other governmental requirements or restrictions or any interpretation or administration of any of the foregoing by any Governmental Authority, that apply to either Party under this Agreement, whether now or hereafter in effect.

"Defect" has the meaning set forth in Article 5.5hereof.

"Dispute Notice" has the meaning set forth in Article 13.2 hereof.

"Dispute" has the meaning set forth in Article 13.2 hereof.

"Emergency" has the meaning set forth in Article 8.2 hereof.

"Execution Date" means the date of signing this Agreement.

"Expert" has the meaning set forth in Article 13.3 hereof.

"Fee" has the meaning set forth in Article 4.1 hereof.

"FENAKA" has the meaning set forth in Recital D hereof.

"Implementation Agreement" has the meaning set forth in Recital F hereof.

"Instant Facility" means the solar PV systems, inverters, and related equipment, systems, components, fixtures, and facilities sharing a common point of interconnection with FENAKA's Electric System, Licensee's Interconnection Facilities relating thereto, the ground mounted canopy structure on top of which the solar panels shall be fixed and other assets, tangible and intangible, that comprise the Facility as set up on the Site(s).

"Indemnified Party" has the meaning set forth in Article 10 hereof.

"Indemnifying Party" has the meaning set forth in Article 10 hereof.

"License" means the license issued to the Licensee by the Licensor to design, build, maintain

SECRETARIAT OF THE THIMADHOO COUNCIL

2

and operate the Instant Facility at the Site(s) in accordance with the terms and conditions of this Agreement.

"**License Term**" has the meaning set forth in Article 2 hereof.

"**Licensee**" has the meaning set forth in the Preamble hereof.

"**Licensee's Interconnection Facilities**" has the meaning ascribed to the term "Seller's Interconnection Facilities" in Article 1.1 of the PPA.

"**Licensor**" has the meaning set forth in the Preamble hereof.

"**MECCT**" mean the Ministry of Environment, Climate Change and Technology of the Government of the Republic of Maldives or any successor thereto.

"**PPA**" has the meaning set forth in Recital E hereof.

"**Possession Date**" has the meaning set forth in Article 3 hereof.

"**Reference Rate**" mean the rate notified by the Maldives Monetary Authority for 364 Days Treasury Bills, on the Day that is two (2) Business Days prior to the day on which interest shall begin to be calculated hereunder, subject to a maximum of five percent (5%).

"**Site(s)**" means the public spaces on the island of South Huvadhu Atoll Thinadhoo chosen as the sites for developing the Project, more fully described in Exhibit A herein.

"**SIAC**" means Singapore International Arbitration Centre.

"**Taxes**" means any tax applicable in the Maldives, including any tax on income, excise duty, customs duty, value added tax, sales tax, good and services tax and other local tax, cess, any impost or surcharge of like nature, any interest, penalties and other sums in relation on the income, goods, material, equipment and services rendered by either Party, and charged, levied or imposed by a Government instrumentality.

"**Transfer**" means in relation to a property, the sale, gift, pledge, assignment, transfer, transfer of any interest in trust, encumbrance, or alienation or disposition in any manner whatsoever, voluntarily or involuntarily, including, any attachment, assignment for the benefit of creditors against the owner of a property or appointment of a custodian, liquidator or receiver in relation to the property.

"**URA**" means the Utility Regulatory Authority established under Law No. 26/2020 (Utility Regulatory Authority Act).

1.2 Interpretations

In this Agreement:

(a) any reference to any statute or statutory provision shall include:

(i) all subordinate legislation made from time to time under that provision (whether or not amended, modified, re-enacted or consolidated);

(ii) such provision as from time to time amended, modified, re-enacted or consolidated (whether before or after the date of this Agreement) and (to the extent liability thereunder may exist or can arise) shall include any past statutory provision (as from time to time amended, modified, re-enacted or consolidated), which the provision referred to has directly or indirectly replaced;

(b) reference to any Party under this Agreement shall also include its successors, administrators, legal representatives, and permitted assigns as the case may be;

(c) heading to Articles and paragraphs are for information only, and shall not form part of the operative provisions of this Agreement and be ignored in construing the same;

(d) references to Articles and schedules are to Articles and schedules to this Agreement. All of these form part of the operative provisions of this Agreement and references to this Agreement shall, unless the context otherwise requires, include references to the Articles and schedules;

(e) unless the contrary is expressly stated, no Article in this Agreement limits the extent or application of another Article;

(f) any reference to books, files, records or other information or any of them means books, files, records or other information or any of them in any form or in whatever medium held including paper, electronically stored data, magnetic media, film and microfilm;

(g) "in writing" includes any communication made by letter or facsimile;

(h) the words "*include*", "*including*", "*inter alia*" and "*in particular*" shall be construed as being by way of illustration or emphasis only and shall not be construed as, nor shall they take effect as, limiting the generality of any preceding words;

(i) the words "*directly or indirectly*" mean directly or indirectly through one or more intermediary persons or through contractual or other legal arrangements, and "direct or indirect" shall have the correlative meanings;

(j) the expression "*this Article*" shall, unless followed by reference to a specific provision, be deemed to refer to the whole Article (not merely the sub-Article, paragraph or other provision) in which the expression occurs;

(k) the terms '*hereof*', '*herein*', '*hereby*', '*hereto*' and derivative or similar words shall, unless followed by a reference to a specific provision of the Agreement, be deemed to refer to this entire Agreement;

(l) when any number of Days are prescribed in this Agreement, same shall be reckoned exclusively of the first and inclusively of the last Day, unless the last Day does not fall on a Business Day, in which case the last Day shall be the next succeeding Day which is a Business Day;

(m) time is of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended, such extended time shall also be of the essence;

(n) a reference to any agreement is a reference to that agreement and all schedules, appendices and the like incorporated therein, as the same may be amended, modified, supplemented, waived, varied, added to, substituted, replaced, renewed or extended from time to time;

(o) all provisions of this Agreement shall be interpreted and construed in accordance with their meanings, and not strictly for or against either Party, regardless of which Party may have drafted this Agreement or a specific provision;

(p) grammatical variations of defined words shall be construed in accordance with the relevant definition(s);

(q) references to the singular number shall include references to the plural number and vice versa; and

(r) words denoting one gender shall include all genders.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 2
LICENSE TERM

The term of this Agreement shall enter into full force and effect on the Execution Date and shall expire upon the expiry of the PPA or upon an earlier termination of the PPA ("License Term").

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 3
GRANT OF LICENSE

Subject to the Licensee's compliance with its obligations in this Agreement, the Licensor hereby grants and the Licensee hereby accepts the License, to design, build, maintain and operate the Instant Facility on the Site(s), for the duration of the License Term, unless terminated earlier in accordance with the terms herein contained. The Licensor shall provide to the Licensee, access to the Site(s) on a Day mutually agreed between the Parties (the "Possession Date"), which Day shall not be later than 31st July 2022. The Licensee undertakes and covenants that the Site(s) shall only be used for the purposes of designing, building, maintaining and operating the Instant Facility in accordance with the terms and conditions herein mentioned, and for no other purpose. The Licensee shall not have exclusive possession of the Site(s) and nothing contained herein shall be construed as creating any rights, interest, easement, tenancy or sub-tenancy in favor of the Licensee in or over the Site(s) other than the permissive right of use herein granted.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 4
CONSIDERATION

4.1 In consideration of the grant of the License over the Site(s) to develop the Project and the grant of Access Rights, the Licensee shall pay to the Licensor, an annual fee at the rate of Rufiyaa Eight (MVR 8) per square meter (of the area of the Site(s)) per year ("Fee"). The Fee shall be paid on or before the 01st Day of January of each year during the License Term. Parties acknowledge that this Agreement is being entered into towards fulfillment of the Maldives' obligations to the Licensee under the Implementation Agreement, and in consideration, *inter alia*, of the Licensee's obligation to develop the Project and sell Electric Energy to FENAKA, which collectively with the Fee is acknowledged by the Parties to constitute adequate consideration for the grant of the License over the Site(s) and the grant of Access Rights under this Agreement. Accordingly, Parties undertake that neither Party shall question the validity of this Agreement for want or adequacy of consideration

4.2 The Licensee shall commence payment of the Fee starting from 01st Day of January 2023.

4.3 The Licensee shall pay the Fee by online remittance (electronic funds transfer) or by way of demand draft drawn in favor of the Licensor payable at South Huvadhu Atoll Gaafu Dhaalu Thinadhoo, Republic of Maldives. In the event the payment is made by way of online remittance, the Licensee shall provide proof of such remittance to the Licensor within 02 (two) days of such remittance and all the charges in relation to transfer of payments to the Licensor's account shall be borne by the Licensee.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 5
TAXES AND INSURANCE

5.1 Taxes in Relation to Site(s)

During the License Term, the Licensor shall be liable to bear and pay on its sole account any and all Taxes in relation to the Site(s).

5.2 Taxes in Relation to Instant Facility

Any Tax imposed by a Governmental Authority, with respect to the design, construction, financing, ownership, erection, installation, maintenance and operation of the Instant Facility and/ or on account of the income generated from the operation of the Instant Facility, shall be borne by the Licensee. To the extent possible under Applicable Law, the Licensee shall make such payments directly to the relevant Governmental Authority. In the event that any Tax that is payable by the Licensee is paid by the Licensor, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.3 Taxes on Fee

The Fee shall be paid by the Licensee without any deductions whatsoever, save and except the deduction of tax at source, if applicable. The liability for payment of any Taxes as applicable on the Fee shall be borne by the Licensee, even if the same is payable by the Licensor in accordance with the Applicable Law.

5.4 Commercial General Liability Insurance for Damage to the Site(s)

The Licensee shall procure and maintain commercial general liability insurance, employer's liability, worker's compensation , professional liability (with any exclusions subject to the prior written approval of the Licensor) up to the overall limit set out in Schedule 4 of the PPA, and within such commercial general liability insurance the Licensee shall also insure against liability for personal injury and damage to the Site(s) or damage to any third party properties therein, arising directly out of the installation of the Instant Facility or its use, in standard form, which shall include operations and blanket contractual liability coverage which insures performance by the Licensee of the indemnity provisions of this Agreement. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date.

5.5 Comprehensive "All Risks" Insurance of the Instant Facility

The Licensee, at its cost, shall within the overall limit set out in Schedule 4 of the PPA, procure and maintain comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility against fire, accident, burglary, vandalism, machinery breakdown, earth movement such as earthquake, volcanic eruptions and subsidence, hurricane/ windstorms, flood including

SECRETARIAT OF THE THINADHOO COUNCIL

2

tsunami, debris removal, ordinance or law, extra expense and terrorism. The Licensee shall provide the Licensor a copy of the insurance so obtained by it within thirty (30) Days of the Possession Date. Upon failure by the Licensee to procure and maintain such comprehensive "all risks" insurance policy in respect of the Site(s) and the Instant Facility, and the occurrence of any such event that renders the Site(s) untenable for use by the Licensor (a "Defect") and other users, the Licensee shall cure such Defect at its own cost, within thirty (30) Days of the occurrence of the Defect. Failure to do so by the Licensee within the period specified herein shall entitle the Licensor to obtain the required insurance. In the event that the Licensor obtains required insurance for the Site, the Licensee shall reimburse the same to the Licensor upon the Licensor submitting proof of payment of the same to Licensee within a period of fifteen (15) Days from the date of submission of such proof of payment. The Licensor shall be entitled to interest on the amount claimed, at an annual rate equal to the Reference Rate, from the original due date for payment of such amount until the payment of such amount.

5.6 The Licensee shall, at its own cost, ensure that any insurance policy required to be maintained by it in accordance with this Article 5 is renewed before the expiry of such insurance policy. Such insurance policy shall also comply with the other requirements stated in Schedule 4 of the PPA, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee. The insurance policies referenced herein shall be taken out in the names of the Licensor and the Licensee for the full value of their respective rights and interests provided that the premiums incurred by the Licensee in complying with this clause will not be unreasonable. The Licensor shall, at the cost of the Licensee, provide all reasonable necessary assistance and cooperation to the Licensee for the renewal of such insurance policy by the Licensee. The proceeds of any Proceeds of any insurance claim are to be applied towards the replacement, repair and/or reinstatement of the Site(s) and/or the Instant Facility.

5.7 On the occurrence of a partial or total loss or an event which, in the reasonable opinion of the Licensee would result in a claim against the insurance policies taken by the Licensee in respect of the Instant Facility, the Licensee shall forthwith and in any case not later than two (2) Days from the date of occurrence of loss or event inform the Licensor of the same.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 6
LICENSEE'S RIGHTS AND COVENANTS

6.1 The Licensee shall provide a copy of the duly executed PPA to the Licensor within fifteen (15) Days of the Execution Date.

6.2 The Licensee hereby represents and warrants that it has inspected or has caused an inspection of the Site(s) to be done, and has satisfied itself on the suitability of the Site(s) for the Instant Facility, and shall accept the possession of the Site(s) on an "as is where is" basis, on the Possession Date.

6.3 The Licensee shall be solely responsible for (a) all costs and the performance of all tasks required for installation, operation and maintenance of the Instant Facility at the Site(s) including costs related to preparation of the Site(s) before installation, costs related to capital improvement, removal, replacement and expansion of the Instant Facility; (b) ensuring that the design, construction, financing, ownership, maintenance and operation of the Instant Facility are in compliance with Good Engineering and Operating Practices, Codes and Standards, and Applicable Law, including those relating to safety norms, public health and environment; (c) ensuring that the performance of the tasks required for installation, operation and maintenance of the Instant Facility does not cause any damage to the Site(s), and to any public property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; (d) obtaining all Permits and Approvals required for the Licensee's use of the Site(s); and (e) bearing all risk of loss in case of a theft, damage, casualty, condemnation or confiscation of the Instant Facility.

6.4 The Licensee agrees that any matter raised in relation to the installation, maintenance and operation of the Instant Facility by any person, shall be addressed as per the Environment and Social Impact Assessment (ESIA) and the Grievance Redress Mechanism (GRM), developed pursuant to the Environmental and Social Management Framework (defined in the PPA) relating to ASPIRE.

6.5 The Licensor may, if in the event the Licensee is unable to attend to any issue in accordance with the GRM, upon giving 24 hour written notice, resolve such issues or remedy any damages or defects as maybe specified in the notice, and make such repairs thereto as the Licensor deems appropriate. Should the Licensor effect repairs, the Licensee shall pay to the Licensor the amount of such repairs reasonably incurred by the Licensor upon submission to the Licensee of an invoice with supporting documents showing the cost incurred by the Licensor for such repairs which shall be calculated at a fair and reasonable market rate.

6.6 During the License Term, the Licensee shall have the following rights ("Access Rights") in relation to the Site(s):

(a) right to erect temporary structures, such as a scaffolding or similar structures at the Site(s) as may be reasonably required for the purpose of carrying out the construction and erection of the Instant Facility and/ or for the maintenance of the Instant Facility, provided that (i) the Licensee shall use all reasonable efforts to minimize the impact thereof on the normal use of the space

SECRETARIAT OF THE THINADHOO COUNCIL

where the Site(s) is located, by the public and (ii) the Licensee shall obtain prior written approval of the Licensor in respect of such temporary structures and all approvals required under Applicable Law;

(b) right to use such ways, paths and passages as are reasonably necessary for the purpose of access to and egress from the Site(s), with or without workmen and for transporting, loading and unloading necessary tools, equipment and materials, provided that (i) the Licensor may in consultation with the Licensee and for a reasonable cause require the Licensee to change the route of any means of access to or egress from the Site(s) and may change the area over which any of the Access Rights are exercised; and (ii) the use of such ways, paths and passages shall not obstruct the general use of the space where the Site(s) is located by the public, provided that where the Licensee's use of the path, ways and passages will result in an obstruction of the use of such space by the public, such obstruction shall be done only after obtaining a prior written approval from the Licensor, and shall be only for a reasonable period of time as agreed with the Licensor, consistent with Good Engineering and Operating Practices.

Provided that the Licensee shall provide the Licensor at least thirty (30) Days before the commencement of the construction of the Instant Facility, or a related activity, a schedule of construction of the Instant Facility. Upon receipt of such schedule of construction from the Licensee, the Licensor shall within five (5) Business Days respond with such reasonable changes to the schedule of construction, if any, as it may require, failing which the Licensor shall be deemed to have accepted the schedule of construction. If the Licensor requests any changes to the schedule of construction, the Licensee shall modify its schedule of construction after incorporating such reasonable changes suggested by the Licensor, and notify the finalized schedule of construction at least five (5) Days prior to the commencement of construction.

6.7 The Licensee shall have right to use utilities such as electricity and water for the purpose of construction, installation, erection, operation and maintenance of the Instant Facility, at the cost of the Licensee. The Licensee shall install separate meters for recording the consumption of electricity and water by the Licensee at the Site(s). The Licensee shall pay by the due date the meter installation and hire charges and also the bills for consumption of electricity and water in the Site(s) as recorded in the meters to the relevant utility companies and provide a copy of the proof of such payment to the Licensor within fifteen (15) Business Days from such payment for its records. In addition, the Licensee shall arrange at its own cost other facilities such as telephone services and other similar facilities, and pay directly to the third-party services providers for such services availed by it.

6.8 Subject to Article 5 hereof, the Licensee may make its own arrangements for and take reasonable measures, in consultation with the Licensor for the protection and security of the Instant Facility.

6.9 The Licensee shall have the right to construct ground mounted canopy structures and such other supporting structures as necessary which forms part of the Instant Facility, and shall have the right from time to time, both before and after the Commercial Operation Date, and at the Licensee's sole cost and expense, to make such additions, alterations or changes to such structures, as are reasonably required in compliance with the provisions of this Agreement, Applicable Law, Good Engineering and Operating Practices and Codes and Standards; provided that: (a) the Licensee shall not cause any damage to the Site(s), and to any public

SECRETARIAT OF THE THINADHOO COUNCIL
SOUTH HUVADHUATHOLHU, MALDIVES

property or to any property of a third party therein, including but not limited to (where applicable) revetments, light posts, security cameras, road signs, low voltage, medium voltage, and high voltage cables, sewerage and water mains, fiber-optic cables and telecommunication service lines; and (b) the Licensee shall obtain the prior written approval of the Licensor, and such prior written approval shall not be unreasonably withheld, in respect of any such construction, additions, alterations or changes, except if such construction, additions, alterations or changes are cosmetic in nature and/ or are part of the day to day maintenance and repair of the Instant Facility; and (c) the Licensee shall provide to the Licensor a certificate from a civil engineer and/or architect having the requisite competence under Applicable Law for issuing such certificates, and acceptable to the Licensor and such acceptance shall not be unreasonably withheld, and which certificate shall certify that the proposed constructions, additions, alterations, or changes are in compliance with the Applicable Law, required for the construction of the Instant Facility.

6. 10 The Licensee shall be solely responsible for day to day operation and maintenance of the Instant Facility, including without limitation the obligation to promptly make or pay (as determined by the Licensor) for, any repairs to any part or whole of the Site(s), to the extent damage is caused by the Licensee, its employees, officers, agents, contractors or subcontractors, during the License Term.

6.11 In complying with its obligations under Article 6.9, the Licensee shall to the extent possible give five (5) Business Days prior written notice for all repair and maintenance work of the Instant Facility or the Site(s) so as not to restrict public use of the space in which the Site(s) is located. Upon such request for repair and maintenance work, the Licensor shall respond to such request within five (5) Business Days. If the Licensor does not respond to such request within five (5) Business Days, such request shall be deemed approved by the Licensor. The Licensee shall ensure that all such work undertaken must be completed in all respects in a timely manner.

6.12 At all times, the Licensee shall:

(a) take due care to ensure that no damage is caused to any property on the Site(s) and the space belonging to or used by the Licensor, the public or other users of such space;

(b) not cause inconvenience to the Licensor, and other users of the space in which the Site(s) is located as is reasonably practicable, except that the Licensor agrees that the exercise of the Access Right granted under Article 6.6(a) hereof may cause temporary obstruction and/ or interference with the normal use of such space and that such inconvenience shall not be deemed to be a violation of the Licensee's obligations under this Article 6.11(b).

6.13 In the event, there is any damage to the Site(s) and/or to the space where the Site(s) is located, and to any public property or to any property of a third party therein, including but not limited to any damage to (where applicable) revetments, light posts, security cameras, road signs, high, medium and low voltage cables, water and sewerage mains, fiber-optic cables and telecommunication service lines, by reason of the Licensee exercising an Access Right or other rights under this Agreement, the Licensee shall make good such damage (to the reasonable satisfaction of the Licensor) at its own cost.

6.14 The Licensee shall provide a list to the Licensor (or to any officer of the Licensor designated

SECRETARIAT OF THE THINADHOO COUNCIL

by the Licensor for this purpose), of the employees, agents, sub-contractors, and other representatives of the Licensee who shall be entitled to enter upon the Site(s), and shall ensure that the Access Rights granted hereunder are exercised by such employees, agents, sub-contractors, and other representatives, subject to the reasonable conditions for entry and exit to the Site imposed by the Licensor, and having regard to the public safety, and the safety of the Site(s).

6.15 The Licensee shall, as promptly as possible, notify the Licensor of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s) and/ or the Instant Facility, and that in the Licensee's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety.

6.16 The Licensee shall consult with the Licensor and obtain Licensor's approval in relation to design of the Instant Facility (including with respect to its placement within the Site(s) and technical specifications) and obtain written approval from the Licensor in case of any alteration to the design of the Instant Facility.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 7
OWNERSHIP OF THE INSTANT FACILITY

7.1 The Licensee shall be the exclusive owner and operator of the Instant Facility, including any part thereof, installed by the Licensee.

7.2 The Licensee acknowledges and agrees that, notwithstanding that the Instant Facility is a fixture on the Site(s), the Licensee shall have no right, title or interest in the Site(s) except as that of a Licensee as per the terms set out in this Agreement. The Licensee shall not directly or indirectly cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on the Site(s) or the Access Rights or any interest therein, and the Licensor will not suffer in any manner out of Licensee's use of the Site(s) whereby the estate, rights and interests of the Licensor in the Site(s) or any part thereof might be impaired, except in accordance with and subject to the provisions of this Agreement.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 8
LICENSOR'S COVENANTS

8.1 The Licensor shall take all reasonable efforts not to cause any interference with the effective operation of the Instant Facility, including any interference with the Licensee's right to receive continuous and uninterrupted passage of light at all times across the Site(s) or have access to the Site(s) and the Instant Facility.

8.2 The Licensor shall, as promptly as possible, notify the Licensee of the occurrence of any event or the existence of any condition or circumstance that it becomes aware of, in relation to the Site(s), and that in the Licensor's reasonable judgment, poses an imminent threat or hazard to the safety of the Site(s), the Instant Facility, public health or public safety. The Licensor and FENAKA shall have the right (but not the obligation), to the extent permitted by Applicable Law, to enter into the Site(s) for the sole purpose of responding to any dangerous condition posing risk to, the Site(s), the Instant Facility, public health or public safety ("Emergency"); provided that any actions taken by the Licensor upon such entry shall be limited to those reasonably necessary to respond to the risks posed. The Licensee shall respond to any such Emergency as promptly as possible, and take all measures necessary to address the condition that gave rise to the Emergency. The Licensee shall not be required to bear the costs associated with an Emergency related to the Site(s) that are not caused by the Licensee and does not affect the Instant Facility.

8.3 The Licensor shall reasonably cooperate with the Licensee, at the Licensee's cost, so that the Licensee can procure all Permits and Approvals for design, engineering, construction, financing, operations, maintenance and deconstruction of the Instant Facility, and meet its obligations under this Agreement and the PPA.

8.4 The Licensor agrees and undertakes that this Agreement and the Access Rights shall run with the Site(s) and shall survive any Transfer of the Site(s). The Licensor shall give the Licensee at least six (6) Calendar Months written notice prior to any Transfer of all or a portion of the Site(s) identifying the transferee, the portion of the Site(s) to be transferred and the proposed date of Transfer. In the event of Transfer by any way or form of the Site(s), the Licensor shall cause the proposed transferee to execute an agreement identical in terms and conditions as that of this Agreement with the Licensee, for a term equal to the License Term outstanding at the date of such Transfer.

8.5 The Licensor recognizes the need of the Licensee to finance the Project by mortgage of the Instant Facility, accordingly, the Licensor shall reasonably cooperate with the Licensee in creation of charge on the Instant Facility in favor of the lenders to the Project, at the cost of the Licensee, including through furnishing such documents and certificates as may be reasonably requested by the Licensee's lenders.

8.6 The Licensor shall not, directly or indirectly, cause, create, incur, assume or suffer to exist any mortgage, pledge, lien, charge, security interest, encumbrance or claim, on or with respect to the Site(s), except with the prior written consent of the Licensee, which consent shall not be unreasonably withheld.

8.7 Subject to the terms and conditions of this Agreement and the Licensee's compliance with all

SECRETARIAT OF THE THINADHOO COUNCIL

provisions contained in this Agreement, and without prejudice to the rights of other users of the Site(s), the Licensor consents that the Licensee shall have quiet, unimpeded and peaceful access to the Site(s) and/or the Instant Facility throughout the License Term.

8.8 Except in the event of an Emergency, the Licensor will not initiate or conduct activities that it knows, or is reasonably expected to know to cause damage, impair or otherwise adversely affect the Instant Facility or its functioning without the Licensee's prior written consent, which consent shall not be unreasonably withheld or delayed.

8.9 Subject to the obligation of the Licensee under Article 6.9, the Licensor shall maintain and carry out at its own cost all major or structural repairs, modifications, or improvements, to the Site(s) at its own cost. Except in Emergencies, the Licensor shall give the Licensee at least fifteen (15) Days' notice in writing prior to commencing any such major or structural repairs, modifications, or improvements.

8.10 Third Party Rights

The Licensor and the Licensee hereby agrees to permit FENAKA, the World Bank, MECCT and URA the reasonable right of ingress and egress, consistent with safe operation of the Instant Facility, over the Site(s), to the extent:

(a) FENAKA deems such ingress and egress reasonably necessary in order to examine, test, calibrate, coordinate, operate, maintain, or repair any interconnection equipment involved in the parallel operation of the Facilities and FENAKA's Electric System, including the Metering Devices and any FENAKA meteorological equipment; provided that except in the event of actual or pending Electric System Emergency, or as otherwise provided in the Interconnection Requirements, as applicable, FENAKA shall give reasonable prior notice to the Licensee and Licensor prior to such ingress or egress, or

(b) World Bank deems such ingress and egress reasonably necessary in order to exercise its rights under any agreements with Maldives, FENAKA or the Licensee.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 9
REPRESENTATIONS AND WARRANTIES

9.1 Licensor's Representations and Warranties

The Licensor hereby represents and warrants to the Licensee, as of the date hereof, that:

(a) the Licensor has the right to, and is sufficiently authorized to grant a License with respect to the Site(s) as provided for in this Agreement;

(b) the Site(s) is free from all encumbrances or any other form of charge or claim that would hinder the Licensee from using the Site(s);

(c) there is no pending or threatened action which affects or is likely to affect the interest or right of the Licensor in or to the Site(s);

(d) the Licensor is a local council, duly established and validly existing under the constitution and laws of Maldives, and has full legal right, power and authority to enter into and perform its obligations under this Agreement;

(e) the Licensor has duly authorized the execution and delivery of this Agreement in accordance with Applicable Law. This Agreement has been duly executed and delivered by the Licensor and constitutes the legal, valid and binding obligation of the Licensor enforceable against the Licensor in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other Applicable Law affecting creditors rights generally;

(f) neither the execution nor the delivery by the Licensor of this Agreement nor the performance by the Licensor of its obligations hereunder:

  (i) will conflict with, violate, or result in a breach of any Applicable Law applicable to the Licensor; or

  (ii) conflicts with, violates or results in a breach of any term or condition of any judgment, decree, franchise, agreement or instrument to which the Licensor is a party or by which the Licensor or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or installment.

(g) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensor, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensor in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensor of its obligations hereunder or under any such other agreement or instrument.

9.2 Representations and Warranties of the Licensee

Licensee hereby represents and warrants as of the date hereof that:

SECRETARIAT OF THE THINADHOO COUNCIL

(a) the Licensee is a company duly organized and validly existing under the relevant jurisdiction specified in the Preamble of this Agreement, and has full legal right, power and authority under Applicable Law to enter into and perform its obligations under this Agreement;

(b) the Licensee has duly authorized the execution and delivery of this Agreement. This Agreement has been duly executed and delivered by the Licensee and will constitute a legal, valid and binding obligation of the Licensee, enforceable against the Licensee in accordance with its terms except insofar as such enforcement may be affected by bankruptcy, insolvency, moratorium, and other laws affecting creditors rights generally;

(c) neither the execution nor the delivery by the Licensee of this Agreement nor the performance by the Licensee of its obligations hereunder: (i) will conflict with, violate, or result in a breach of any Applicable Law of Maldives; or (ii) conflicts with, violates, or results in a breach of any term or condition of any judgment, decree, franchise, agreement (including the certificate of [incorporation/ registration] of the Licensee), or instrument to which Licensee is a party or by which Licensee or any of its properties or assets are bound, or constitutes a default under any such judgment, decree, agreement or instrument;

(d) there is no action, suit, or other proceeding as of the date hereof at law or in equity, before or by any Governmental Authority, pending or, to its knowledge, threatened against the Licensee, which is likely to result in an unfavorable decision, ruling, or finding which will materially and adversely affect the validity or enforceability of this Agreement or any agreement or instrument entered into by the Licensee in connection with the transaction contemplated hereby, or which will materially and adversely affect the performance by the Licensee of its obligations hereunder or under such an agreement or instrument.

SECRETARIAT OF THE THINADHOO COUNCIL
SOUTH HUVADHUMATHOLHU, MALDIVES

ARTICLE 10
INDEMNIFICATION

The Licensee (also an "Indemnifying Party") shall indemnify and hold harmless the Licensor and its employees, officers, agents, contractors, professional advisors and representatives (each an "Indemnified Party") from and against all liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, that may be imposed upon or incurred by or asserted against the Licensor or any of its employees, officers, agents, contractors, professional advisors, representatives, by reason of any of the following occurrences during the License Term, except to the extent such liabilities, losses, damages, penalties, costs, and expenses, including reasonable attorneys' fees, are caused by either (i) gross negligence or intentional wrongful acts of the Indemnified Party or (ii) failure or other breach by the Indemnified Party to perform any of its obligations under Applicable Law or Permits and Approvals:

(a) any breach by the Licensee of its obligations, covenants, representations or warranties contained in this Agreement;

(b) any negligence on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees in connection with the use of the Site(s) or in designing, construction, financing, ownership and operation of the Instant Facility or the Project; or

(c) any failure on the part of the Licensee or any of its agents, contractors, servants, employees, licensees or invitees to comply with Applicable Law that require compliance by the Licensee or any of its agents, contractors, servants, employees, subtenants, licensees or invitees in connection with the Site(s) and its use, or design, construction, financing, ownership and operation of the Instant Facility, or the Project.

SECRETARIAT OF THE THINADHOO COUNCIL
SOUTH HUVADHUATHOLHU, MALDIVES

G

ARTICLE 11
FORCE MAJEURE EVENT

11.1 <u>Adoption of provisions of PPA</u>

Provisions of <u>Article 12.4</u>, <u>Article 12.5</u> and <u>Article 12.6</u> of the PPA shall *mutatis mutandis* apply to this Agreement, with the modification that all references to FENAKA therein shall be read as Licensor, and all references to the Seller therein shall be read as the Licensee.

11.2 <u>Effects of Force Majeure Events</u>

Without prejudice to the rights or obligations of the Government or FENAKA under the Implementation Agreement or the PPA,

(a) if the Force Majeure Event results in loss of the Site(s) or the Instant Facility, either Party shall have the right to terminate this Agreement in accordance with the provisions of <u>Article 12.1(a)</u> of this Agreement; or

(b) if a Force Majeure Event subsists for more than one hundred and eighty (180) Days and the PPA is terminated in accordance with <u>Article 13.5</u>, or <u>Article 13.6</u>, as the case may be, of the PPA, either Party may terminate this Agreement in accordance with <u>Article 12.1(b)</u> and <u>Article 12.2</u>, hereof.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 12
TERMINATION

12.1 Events of Termination

This Agreement shall terminate in the following circumstances:

(a) If occurrence of a Force Majeure Event results in loss of the Site(s), either Party shall have the right to terminate this Agreement in accordance with Article 11.2(a), by a notice in writing to the other Party, with the termination being effective from fifteen (15) Days from the date of such notice.

(b) Upon termination of the PPA, whether on account of expiry of the Contract Term, or otherwise, and whether in respect of the Project as a whole or in respect of the Instant Facility, either Party shall have the right to terminate this Agreement with effect from the date of termination of the PPA.

(c) If the Government issues or is deemed to have issued a Concurrence Notice under Article 4.2(c)(iii) of the Implementation Agreement, either Party may terminate this Agreement.

(d) If an Expert (as defined under the Implementation Agreement) determines in accordance with Article 4.2(c)(x) of the Implementation Agreement that the Site(s) is unavailable for use of the Licensee, the Agreement shall terminate with effect from the date of such determination or such other date as such Expert may determine.

12.2 Consequences of Termination

(a) If the Agreement terminates in accordance with Article 12.1(b) but on account of expiry of the Contract Term and FENAKA chooses to purchase the Instant Facility in accordance with Article 2.2 of the PPA, the Licensor shall transfer the License provided for in this Agreement in favor of FENAKA on such terms and conditions as FENAKA and Licensor may agree in writing.

(b) If the Agreement terminates in accordance with Article 12.1(a), or Article 12.1(b) but on account of

(i) expiry of the Contract Term and FENAKA chooses not to purchase the Instant Facility in accordance with Article 2.2 of the PPA,

(ii) termination of the PPA in accordance with Article 13.3(a) or Article 13.3(c) of the PPA, and FENAKA chooses not to exercise its right under Article 13.3(d) of the PPA to purchase the Project or the Instant Facility, or

(iii) termination of the PPA in accordance with Article 13.5(a) or Article 13.5(b) (where the PPA is terminated by the Seller, thereof) of the PPA,

the Licensee shall within one hundred and eighty (180) Days, decommission the entire Instant Facility set up at the Site(s), remove all its assets from the Site(s), and vacate and hand over

SECRETARIAT OF THE THINADHOO COUNCIL

peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

(c) If the Agreement terminates in accordance with Article 12.1(b) but on account of,

- (i) termination of the PPA in accordance with Article 13.4(c), Article 13.4(d), Article 13.6(a) or Article 13.6(c) of the PPA,
- (ii) termination of the PPA by FENAKA in accordance with Article 13.5(b) of the PPA,

Licensor shall execute a license over the Site(s) in favor of the FENAKA simultaneously with the purchase of the Instant Facility by FENAKA, on terms and conditions substantially similar to those contained in this Agreement, unless FENAKA and the Licensor agree otherwise.

(d) If the Agreement terminates in accordance with Article 12.1(c) or Article 12.1(d), the Licensee shall relocate the Instant Facility to the alternative Site(s), promptly upon execution of the license agreement for the alternative Site(s), but in no event later than one hundred and eighty (180) Days, and vacate and hand over peaceful possession of the Site(s) to the Licensor in a condition approximately original to that existing at the Possession Date, subject to normal wear and tear caused due to installation of Instant Facility or otherwise, failing which the Licensor shall be entitled to recover as damages (i) the cost of performing any work required to be (but not) done by the Licensee (towards decommission of the Instant Facility, and removal of all assets of the Licensee from the Site(s) before handing over the vacant possession of the Site(s) to the Licensor) under this Agreement at the time of vacating the Site(s), and (ii) the cost of restoring the Site(s) to approximately the original condition of the Site(s) as of the Possession Date of this Agreement, subject to exception for normal wear and tear.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 13
DISPUTE RESOLUTION

13.1 Continued Performance

Each Party shall continue to perform its obligations under this Agreement (including any payment obligations) pending resolution of any dispute pursuant to this Article 13. Provided that, if the dispute is with respect to any payments, neither Party shall be required to make such disputed payment(s) to the other Party so long as such dispute has been referred to the process for resolution pursuant to this Article 13; provided, that to the extent any amounts owed to either Party by the other Party are not disputed and can be segregated from amounts with respect to which there is a dispute, such undisputed amounts shall, in good faith, be identified by the Parties and paid as required by this Agreement. To the extent that any disputed amount was withheld from a Party, and such Party is ultimately found to be entitled to all or any portion of such disputed amount pursuant to this Article 13, then such Party shall be entitled to the payment of interest on any withheld amount, at an annual rate equal to Reference Rate, from the original due date for payment of such amount until the payment of such disputed amount.

13.2 Negotiation

If any dispute, controversy or claim arises under or relates to this Agreement or the breach, termination or validity thereof (the "Dispute"), such Dispute shall be referred by each Party to its designated senior officer for resolution upon five (5) Days written notice from either Party (the "Dispute Notice"). The Parties agree to attempt to resolve all Disputes promptly and equitably and to provide each other with reasonable access during regular business hours to any and all non-privileged records, information and data pertaining to any such Dispute.

13.3 Expert Determination

(a) A dispute may be referred to an expert (the "Expert") in accordance with this Article 13.3 if:

  (i) the Parties are not able to agree under Article 13.2 (*Negotiation*) on an amicable resolution to such dispute; and

  (ii) this Agreement expressly provides that such dispute shall be referred to an Expert or the Parties agree in writing that such dispute shall be referred to an Expert.

(b) Any Party to such a Dispute may initiate an Expert reference under this Article 13.3 by proposing to the other Party to the dispute the name of the Expert. If the other Party does not agree to the name suggested by the Party making the reference, and the Parties are otherwise unable to agree on the name of an Expert, either Party may apply to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the Expert for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, an

SECRETARIAT OF THE THINADHOO COUNCIL

Expert for the matter in Dispute.

(c) The Parties shall request that the Expert determine the referred dispute, within thirty (30) Days of receiving the reference, or in such additional time as may be reasonably required by the Expert to determine the Dispute, which shall not be more than one hundred and eighty (180) Days of receiving the reference.

(d) The Expert shall act as an expert and not as an arbitrator.

(e) The Parties shall have the right to make representations and submissions to the Expert. There shall be no formal hearing.

(f) The Expert shall have power to request any Party to provide him/her with such statements (which shall be written unless otherwise specifically required) or documents or information within their control as he may determine necessary and the Parties shall comply with any such request in accordance with the timeframes set out by the Expert or in the absence of such timeframes, in a timely manner as required to enable the Expert to determine the Dispute within the timeframe set forth in Article 13.3(c).

(g) The Expert shall give his/her decision to the Parties to the Dispute in writing and his/her decision, which shall promptly be given effect to by such Parties, shall be final and binding (save in the case of fraud or manifest error) on them.

(h) If the Expert decides that a sum is due and payable by one Party to another Party then:

  (i) any such sum shall be due and payable within seven (7) Days of receipt by the Parties of written notice of such decision, unless the Expert decides otherwise; and

  (ii) interest shall accrue at the rate of Reference Rate, compounded annually, from the date expiry of the period mentioned in Article 13.3(h)(i); provided that if the sum specified in Article 13.3(h)(i) includes any interest, no interest shall be payable on such interest.

(i) The fees of the Expert and any other costs of and incidental to the reference to Expert determination shall be payable by such Party to the Dispute as the Expert may determine but, in the absence of any such determination, by the Parties to the Dispute in equal shares.

13.4 Arbitration

(a) Selection of Arbitrators

If the Parties are unable to resolve their Disputes through negotiation within thirty (30) Days of the Dispute Notice, either Party may initiate proceedings to submit the Dispute for arbitration. Each dispute submitted by a Party to arbitration shall be heard by a sole arbitrator or an arbitration panel composed of three (3) arbitrators, in accordance with the following provisions:

  (i) Where the Parties agree that the dispute concerns a technical matter, they may agree to appoint a sole arbitrator or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, either Party may apply

to *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* for a list of not fewer than five (5) nominees and, on receipt of such list, the Parties shall alternately strike names therefrom, and the last remaining nominee on the list shall be the sole arbitrator for the matter in dispute. If the last remaining nominee has not been determined in this manner within sixty (60) Days of the date of the list, *Federation Internationale des Ingenieurs-Conseil (FIDIC) of Lausanne, Switzerland* shall appoint, upon the request of either Party and from such list or otherwise, a sole arbitrator for the matter in dispute.

(ii) Where the Parties do not agree that the dispute concerns a technical matter, the Parties may agree to appoint a sole arbitrator mutually agreed by them or, failing agreement on the identity of such sole arbitrator within thirty (30) Days after receipt by the other Party of the proposal of a name for such an appointment by the Party who initiated the proceedings, each Party shall appoint one (1) arbitrator, and these two arbitrators shall jointly appoint a third arbitrator, who shall chair the arbitration panel. If the arbitrators named by the Parties do not succeed in appointing a third arbitrator within thirty (30) Days after the latter of the two (2) arbitrators named by the Parties has been appointed, the third arbitrator shall, at the request of either Party, be appointed by SIAC.

(iii) If, in a dispute subject to Article 13.4(a)(ii) above, one Party fails to appoint its arbitrator within thirty (30) Days after the other Party has appointed its arbitrator, the Party which has named an arbitrator may apply to the SIAC to appoint a sole arbitrator for the matter in dispute, and the arbitrator appointed pursuant to such application shall be the sole arbitrator for that dispute.

(b) Rules of Procedure

Except as otherwise stated herein, arbitration proceedings shall be conducted in accordance with the rules of procedure for arbitration of the SIAC as in force on the date of this Agreement.

(c) Substitute Arbitrators

If for any reason an arbitrator is unable to perform his/her function, a substitute shall be appointed in the same manner as the original arbitrator.

(d) Nationality and Qualifications of Arbitrators

Each arbitrator appointed pursuant to Article 13.4(a)(i) to Article 13.4(a)(iii) shall be an internationally recognized legal or technical expert with extensive experience in relation to the matter in dispute and shall not be a national of Maldives or the home country of the Licensee. For the purposes of this Clause, "home country" means any of:

(i) the country of incorporation of the Licensee or their parent companies;
(ii) the country in which Licensee's principal place of business is located;
(iii) the country of nationality of a majority of the Licensee's shareholders; or
(iv) where the Licensee is a joint venture between two or more Persons, the country of incorporation, nationality or place of business of the partners or shareholders of such joint venture.

SECRETARIAT OF THE THINADHOO COUNCIL

(e) Miscellaneous

In any arbitration proceeding hereunder:

- (i) proceedings shall, unless otherwise agreed by the Parties, be held in Singapore;
- (ii) the English language shall be the official language for all purposes; and
- (iii) the decision of the sole arbitrator or of a majority of the arbitrators shall be final and binding and shall be enforceable in any court of competent jurisdiction, and the Parties hereby waive any objections to or claims of immunity in respect of such enforcement.

13.6 Governing Law, Jurisdiction and Service of Process

(a) Governing Law

This Agreement shall be governed by, and construed in accordance with, the laws of Maldives.

(b) Jurisdiction

Subject to Article 13.3 and Article 13.4, each of the Parties consents to submit itself to the exclusive jurisdiction of the courts located in the Maldives in relation to recognition of any arbitral award, with respect to any Dispute that arises under this Agreement.

(c) Service of Process

Subject to the rules of SIAC for the purposes of arbitration, each Party agrees that service of any process, summons, notice or document hand delivered or sent by certified mail, return receipt requested, to such Party's respective address set forth in Article 14.4 will be effective service of process for any action, suit or proceeding with respect to any matters to which it has submitted to arbitration as set forth in Article 13.4.

SECRETARIAT OF THE THINADHOO COUNCIL

ARTICLE 14
MISCELLANEOUS PROVISIONS

14.1 Assignment

Licensee shall not assign or otherwise transfer this Agreement, except (i) for the collateral assignment to any lenders (only if such lenders are independent third party financial institutions) in connection with the provision of any financing for the Instant Facility, or (ii) to any Person who is a bona fide transferee of the PPA (in accordance with the terms of the PPA), subject to the transferee undertaking to comply with the obligations of the Licensee under the PPA, this Agreement, and the Escrow Agreement.

14.2 Further Assurances

Each Party agrees to, and shall use all reasonable efforts to, provide such information, execute and deliver any instruments and documents and take such action as may be necessary or reasonably requested or required by the other Party which are not inconsistent with the provisions of this Agreement and which do not involve the assumption of obligations other than those provided for in this Agreement in order to give full force and effect to this Agreement and to carry out its intent.

14.3 Relationship of Parties

Except as otherwise explicitly provided herein, neither Party to this Agreement shall have any responsibility whatsoever with respect to services provided or contractual obligations assumed by the other Party and nothing in this Agreement shall be deemed to constitute either Party a partner, agent or legal representative of the other Party or to create any fiduciary relationship between or among the Parties.

14.4 Notices

Any notices required to be given hereunder shall be deemed delivered when (i) sent by facsimile upon electronic confirmation of successful transmission; (ii) delivered to an express courier service nationally recognized in Maldives that provides a receipt of delivery, (iii) sent by email, upon dispatch and the receipt of a delivery confirmation, provided that email shall be used as a mode of notice and communication only for non-material day-to-day matters; (iv)when delivered by personal delivery, in each case addressed to the following persons or such other persons as the Parties may designate in writing:

(a) If to the Licensor:
Name: Saudh Ali
Designation: Council President
Address: Secretariat of Thinadhoo Council, South Huvadhu Atoll, G.Dh Thinadhoo Island, Republic of Maldives
Email: info@thinadhoo.gov.mv
Fax: +960 6841018
with a copy to:

FENAKA
Name: Ahmed Saeed Mohamed
Designation: Managing Director
Address: FENAKA Corporation Limited, Port Complex Building, 7th Floor, Hilaalee Magu, Male' 20207
Email: ahmed.saeed@fenaka.mv
Copied to: maasha@fenaka.mv

and

MECCT
Name: Mr. Ajwad Musthafa
Designation: Permanent Secretary
Address: Ministry of Environment, Cliimate Change and Technology Green Building, Handhuvaree Hingun, Male', 20392, Republic of Maldives
Email: ajwad.mustafa@environment.gov.mv

(b) If to the Licensee:

Name: Mr. Goh Chin San
Designation:
Managing Director of Mega First Solar (Maldives) Consortium Pvt Ltd
Authorised Representative of Mega First Power Industries Sdn Bhd
Address: A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat, Seksyen 8, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia.
Email: chinsan.goh@mega-first.com
Copied to: shadhah.shahid@mega-first.com, kok.cw@mega-first.com

14.5 Costs and Expenses

All costs, expenses, including any cost of documentation, reasonable attorney fees, court fee, and stamp fee, relating to creation and maintenance of the license on the Site(s), including execution of this Agreement, shall be borne by the Licensee.

14.6 Confidentiality

The Parties shall at all times keep confidential information acquired in consequence of this Agreement, except for information which the receiving Party already knows or receives from third parties or which the receiving Party may be entitled or bound to disclose under compulsion of Applicable Law or where requested by regulatory agencies or to their professional advisers, investments partners and other parties where reasonably necessary for the performance of their obligations under this Agreement. For the avoidance of doubt, the obligations in this Article shall not apply to information in the public domain or information which the Parties own or acquired lawfully from others and which may be freely disclosed to others without breach of any obligation of confidence

14.7 Waiver

No waiver of any provision of this Agreement shall be effective against a Party except as expressly set forth in a writing signed by such Party. The waiver by either Party of a default or a breach by the other Party of any provision of this Agreement shall not operate or be construed to operate as a waiver of any subsequent default or breach. The making or the acceptance of a payment by either Party with knowledge of the existence of a default or breach shall not operate or be construed to operate as a waiver of any subsequent default or breach.

14.8 Survival

Notwithstanding anything provided herein to the contrary, Article 12.2 (*Consequences of Termination*), Article 13 (*Dispute Resolution*) and Article 14 (*Miscellaneous*), shall survive the termination of this Agreement.

14.9 Third Party Rights

Nothing herein is intended to or should be construed to create any rights of any kind whatsoever in third persons not parties to this Agreement, except in favor of the Government, FENAKA, and the World Bank.

14.10 Counterparts

This Agreement and any amendment hereto may be executed and delivered in one or more counterparts and by different Parties in separate counterparts. All of such counterparts shall constitute one and the same agreement and shall become effective (unless otherwise therein provided) when one or more counterparts have been signed by each Party and delivered to the other Party. Delivery of this Agreement by facsimile transmission or electronic email shall be as effective as delivery of a manually executed counterpart.

14.11 Severability

In the event that any provision of this Agreement shall, for any reason, be determined to be invalid, illegal, or unenforceable in any respect, the Parties shall negotiate in good faith and agree to such amendments, modifications, or supplements to this Agreement, or such other appropriate actions, as shall, to the maximum extent practicable in light of such determination, implement and give effect to the intentions of the Parties as reflected herein, and the other provisions of this Agreement shall, as so amended, modified, supplemented, or otherwise affected by such action, remain in full force and effect.

14.12 Entire Agreement

All prior agreements, negotiations, representations, and understandings with respect to the subject matter hereof, are hereby superseded. No amendment, modification, or change to this Agreement or its Exhibit shall be effective unless the same shall be in writing, duly executed, authorized and approved by the Parties. In the event of any conflict between the terms and conditions of this Agreement and that of any Exhibit or other document referenced herein, this Agreement shall govern and control.

IN WITNESS WHEREOF, the Licensor and Licensee have caused this Agreement to be executed as on the date and the year first set forth above.

For and on behalf of the LICENSOR

………………………………
Saud Ali
Council President
Secretariat of Thinadhoo Council,
South Huvadhu Atoll, G.Dh Thinadhoo Island, Republic of Maldives

In the presence of;

………………………………
Mohamed Shareef
Secretary General
Secretariat of Thinadhoo Council,
South Huvadhu Atoll, G.Dh Thinadhoo Island,
Republic of Maldives

………………………………
Ibrahim Ali
Assistant Council Executive
Secretariat of Thinadhoo Council,
South Huvadhu Atoll, G.Dh Thinadhoo Island,
Republic of Maldives

For and on behalf of the LICENSEE

………………………………
Goh Chin San
Authorised Representative
Mega First Power Industries Sdn. Bhd.

A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia.

MEGA FIRST POWER INDUSTRIES SDN BHD
(Company No. 392838-W)

In the presence of;

………………………………
Khoo Teng Keat
Executive Director
Mega First Corporation Berhad
A-12-01, Level 12, Block A, PJ8, No. 23 Jalan Barat,
Seksyen 8, 46050 Petaling Jaya, Selangor Darul
Ehsan, Malaysia

………………………………
Song Qing Guo
General Manager
Powerchina Huadong Engineering Corporation
Limited
22, ChaoWang Road Hangzhou, Zhejiang
Province, 310014
The People's Republic of China

3301034012942

………………………………
Chen Ting
Chief Representative in Sri Lanka
Sinohydro Corporation Limited
22, Chegongzhuang West Road, Haidian District
Beijing 100048 The People's Republic of China

EXHIBIT A

DESCRIPTION OF THE SITE(S)

Note: *The exact coordinates of the following Site shall be agreed between the parties on or before the Possession Date following detailed setting out surveys.*

Site 4: Thinadhoo West Beach Side

Thinadhoo (ASPIRE Site)

Area: 26458 m^2

Installation Tilt: 10°

Installation Orientation: 180.9°

SECRETARIAT OF THE THINADHOO COUNCIL
SOUTH HUVADHUATHOLHU, MALDIVES

APPENDIX I – Geotechnical Assessment Report

sidco

FEBRUARY 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
HDh. Kulhudhuffushi Airport Area

CLIENT

HDEC

中国电建
POWERCHINA

Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out between 14th January and 6th February 2023 in Hdh. Kulhudhuffushi for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Borehole / Standard Penetration Test (SPT)
2. Dynamic Cone Penetration (DCP) tests
3. Mackintosh Probe
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. BS 5930:2015+A1:2020 Code of practice for ground investigation
2. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
3. BS EN ISO 17892-4:2016 Determination of particle size distribution
4. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
5. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

Hdh. Kulhudhuffushi (Kulhudhuffushi City is situated on the eastern side peripheral reef of Thiladhunmathi Atoll at geographic coordinates of N6º 37’ 24” and E73º 04’ 10”, approximately 275 km north of Malé City.

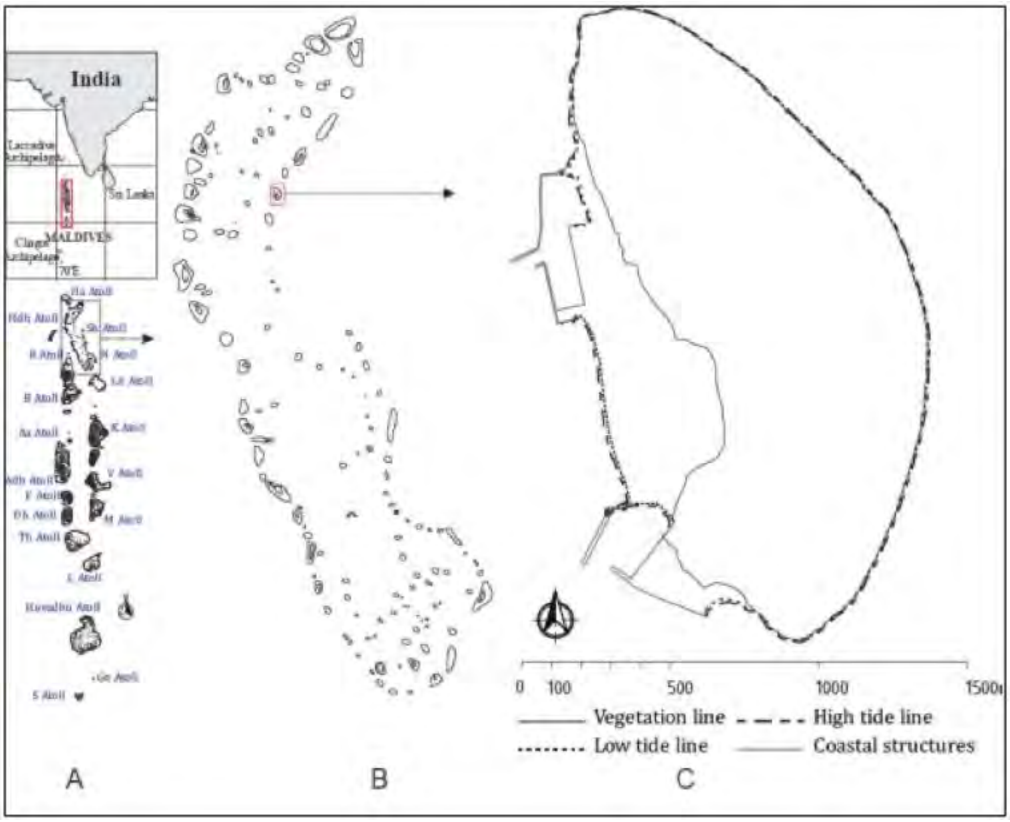


Figure 1: Location of Kulhudhuffushi (MHI 2016)

Originally the island’s land size was 200 ha, however and additional 35 ha was added to the island by reclamation of shallow lagoon on the western side reef flat. Additionally, part of Kulhudhuffushi mangrove and east side of the lagoon was reclaimed to build Kulhudhuffushi airport. The length and width of Kulhudhuffushi land are 2.53 km and 0.9 km respectively. Kulhudhuffushi is approximately 275 km away from Malé. Kulhudhuffushi is on separate peripheral reef typical to the most of islands in the north.

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed roads for development have a flat terrain and the ground elevation is between 1 and 1.5 meters.

Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands that was dredged from deep sea to reclaim the land. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

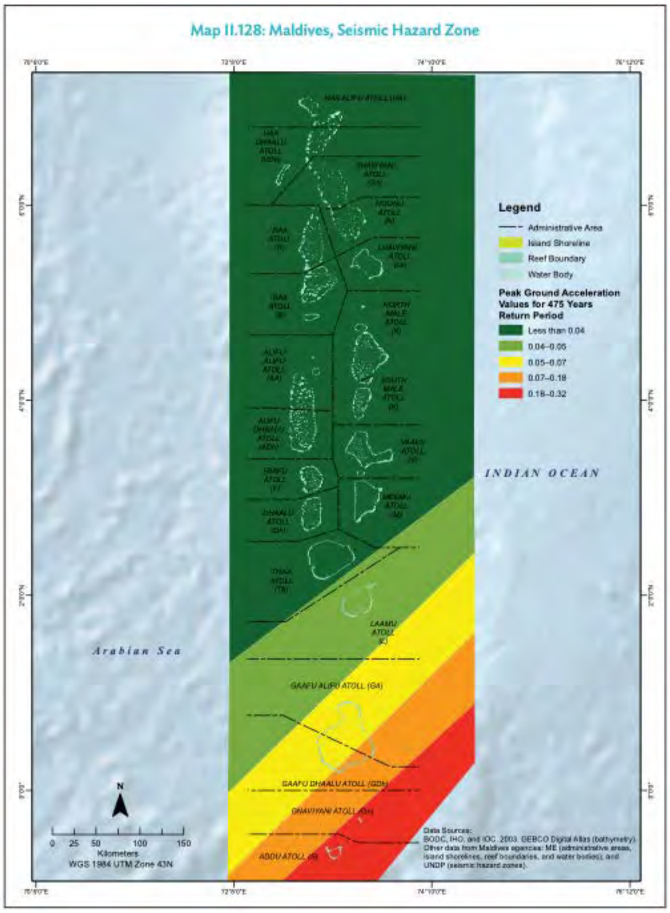
In Kulhudhuffushi, the western side of the lagoon has been modified by construction of a commercial port, local harbour, and reclamation of land. The reef system around the island slopes to the deep ocean on the eastern side and exposed to strong waves. The reef slopes to the atoll inner lagoon on the western side and is protected from the strong waves coming from the deep ocean.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP

2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.



Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry). Other data from Maldives agencies: ME (administrative areas, island shorelines, reef boundaries, and water bodies); and UNDP (seismic hazard zones).

Figure 2: Seismic Hazard Zone (ADB 2020)

Kulhudhuffushi is located north of Maldives where peak ground acceleration value for 475 years return period is less than 0.04.

2.4 RAINFALL

Rainfall data and other meteorological data are not available for Kulhudhuffushi. The weather station in Hdh. Hanimaadhoo (located at 6.75º N and 73.17º E) is the closest where the meteorological data are available and is representative of the weather conditions of northern part of Maldives.

Hanimaadhoo rainfall data shows a periodic pattern and annual precipitation varies from year to year with an average rainfall of 1785.4 mm and ranging between 1346.5 mm and 2240.5 mm (Zahid 2011).

On average the maximum number of rainy days for the northern region is 154 rainy days per calendar year. According to Zahid (2011), there is a strong correlation between the number of rainy days and the annual rainfall in Hanimaadhoo (CC=0.98).

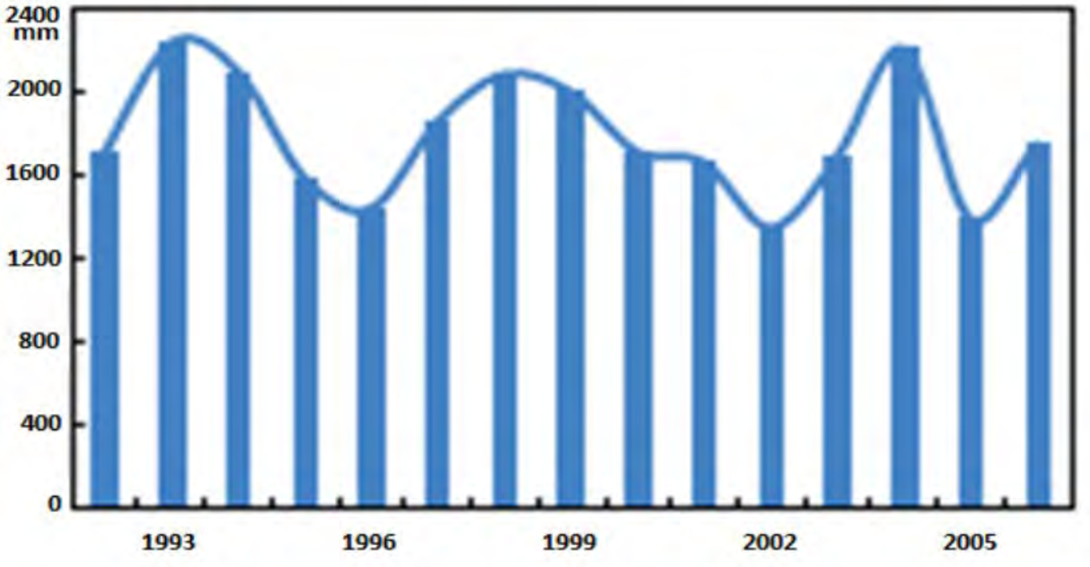


Figure 3: Yearly total rainfall for Hanimaadhoo(Zahid 2011)

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Borehole Investigation / SPT

3.2.1.1 Rotatory Drilling

Boreholes shall be drilled using Rotary drilling machine. Borehole with the nominal diameter of 76 mm were be drilled using rotary drill rig. Drilling was carried out using rotary boring machine Figure 4. A metal drill bit as a cutting tool would be attached at the lower end of the drilling rods and circulated mud water pumped through the hollow rods into the bottom of borehole to stabilize the borehole and wash out the cuttings to ground surface.

Drilling was done using clear water/ bentonite water as drilling fluid. The return water from the borehole carried out the sludge and become muddy. This muddy water was kept in the surface pit and later pumped into the hole through drill rods as drilling fluid. Water would be changed when the muddy water turned too thick. As the whole circulating process was running in a closed system, no spillage and contamination of muddy water occurred throughout the drilling time.

Figure 4: Rotatory drilling machine used for boring and SPT

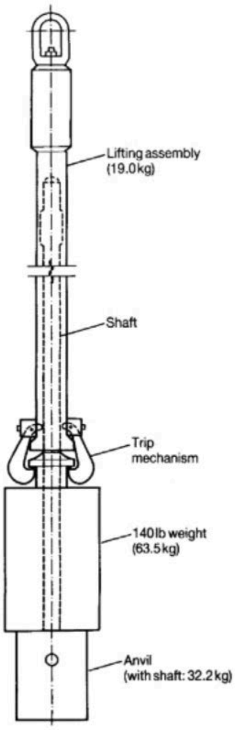


Figure 5: SPT Trip Hammer schematic diagram

Total of 2 boreholes were drilled, one on each site for the solar PV installation.

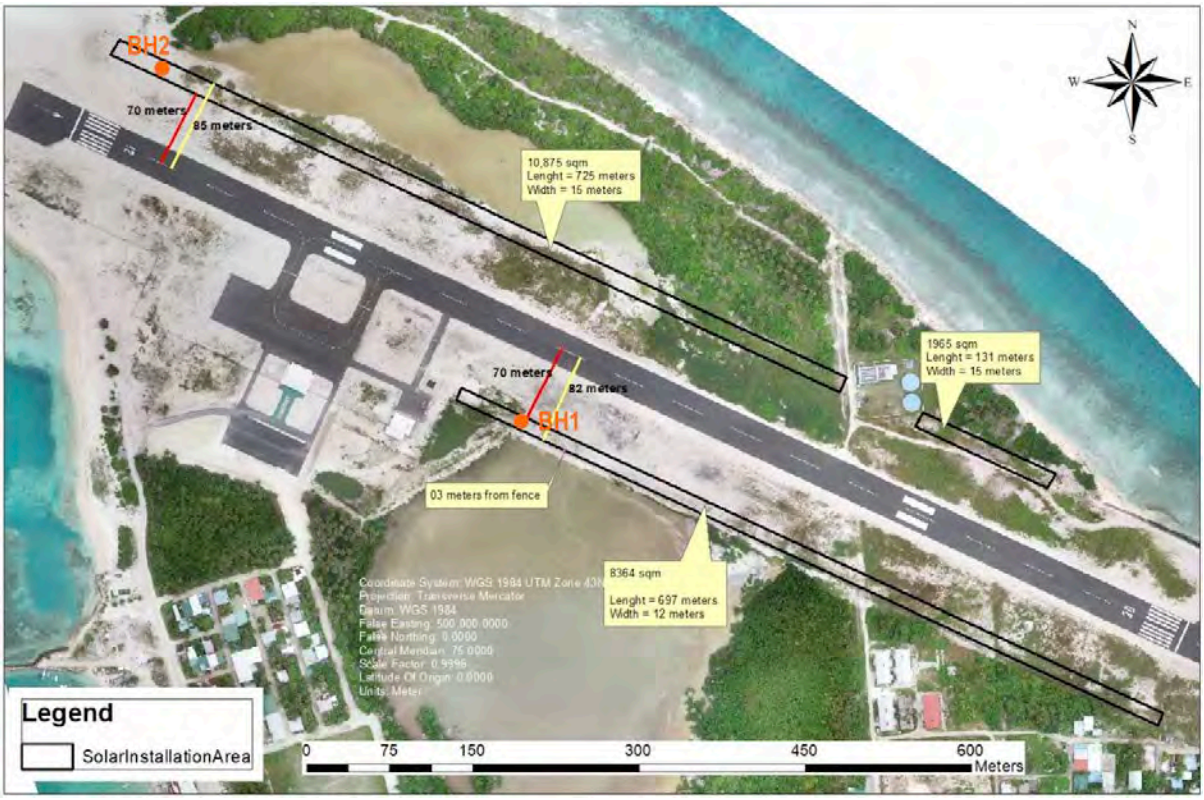


Figure 6: Borehole numbers and locations

3.2.1.2 Standard Penetration Test (SPT)

The 'Standard Penetration Test, commonly known as the 'SPT', was carried out in a borehole, by driving a standard 50mm O.D x 60mm long thick wall 'split spoon' sampler using repeated blows of a 63.5 kg hammer free falling through 750mm. Automatic Trip Hammer was used to do SPT test. It is designed to hammer Split Spoon Sampler with standard 63.5 kg weight with exact height of 760 mm fall. It eliminates the human error of measurement and lifting the weight and then dropping on split tube sampler. The split spoon is lowered to the bottom of the hole, and is then driven 450 mm taking SPT number for every 150 mm. At the end of driving, the split spoon is pulled from the base of the hole, and the sample is preserved in an airtight container.

The penetration resistance (N) is the number of blows required to drive the split spoon for the last 300mm of penetration. The penetration resistance during the first 150 mm of penetration is ignored, because the soil is considered to have been disturbed by the action of boring the hole.

Upon completion of test, the sampler was removed and dissembled to provide a disturbed but representative sample. These SPT samples and other disturbed samples from all soil strata were kept properly sealed, labelled, and packed in plastic bag for verification in preparing this report. The "N" values are indicated in the logs of boring. Corrected N values $(N_1)_{60}$ are also included in the logs.

The SPT tests were conducted at 1 m interval up to 3 m and then every 1.5 m intervals up to refusal.

Field log sheets will contain the soil description based on field observation, depth, and type of samples

3.2.2 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

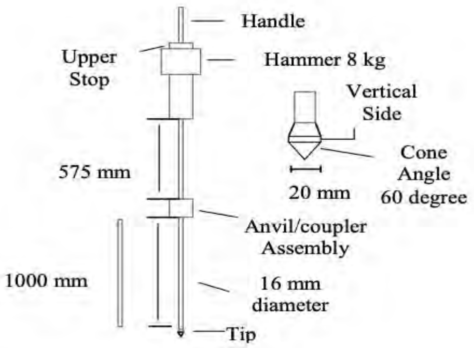


Figure 7: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.3 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.
6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.

7. The data is then plotted number of blows against depth.

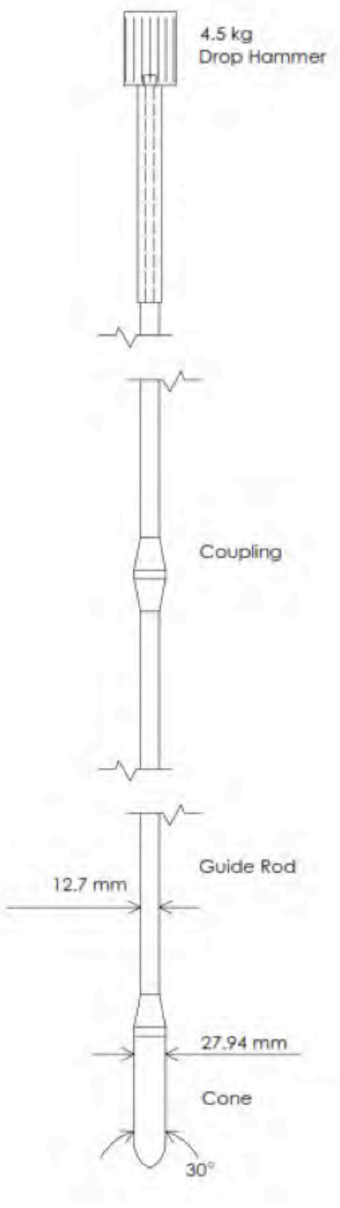


Figure 8: Schematic diagram of Mackintosh Probe

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

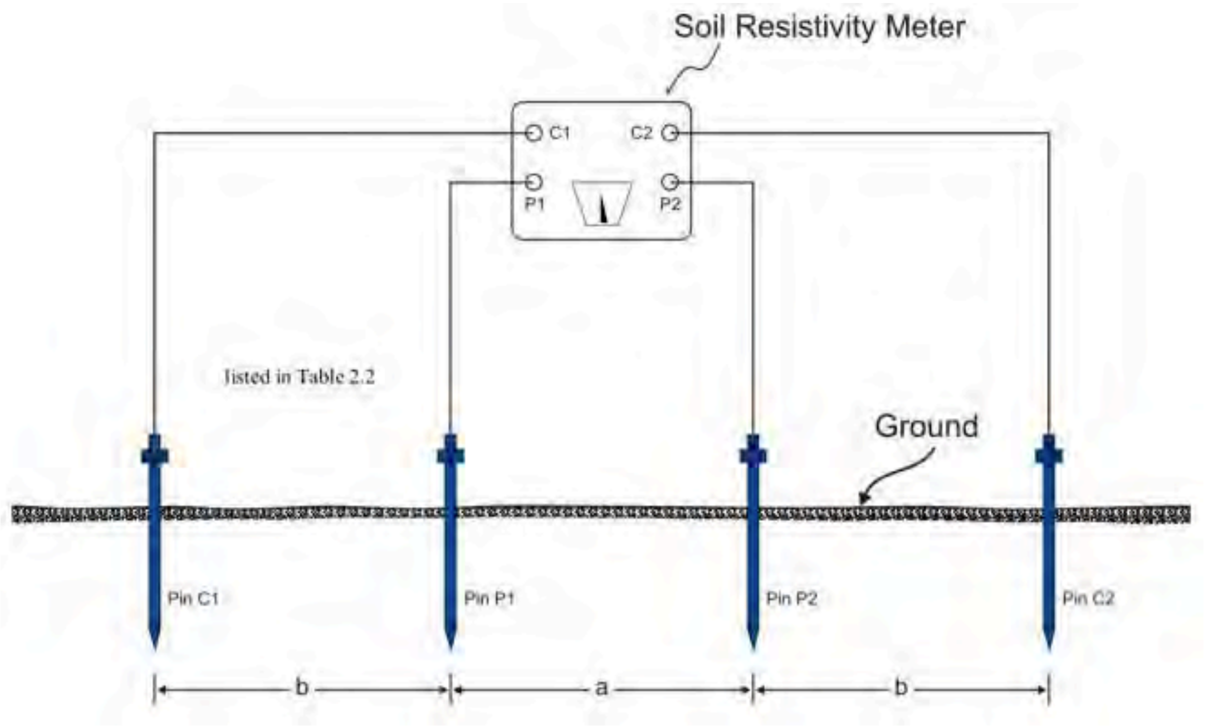


Figure 9: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi\ AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 10: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W $m^{-1}{}^{o}C^{-1}$). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 11: TLS-100 Portable Thermal Conductivity Meter

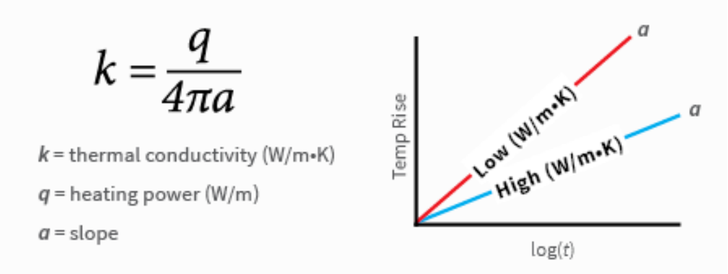


Figure 12: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\gamma_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 13.

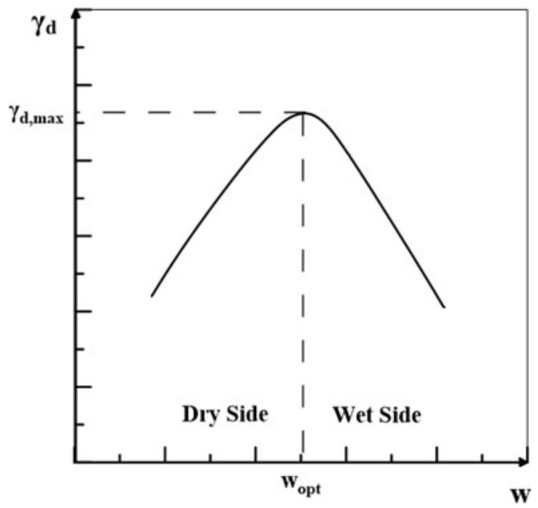


Figure 13: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 14, highest strength of a soil is achieved dry of optimum moisture content of a soil.

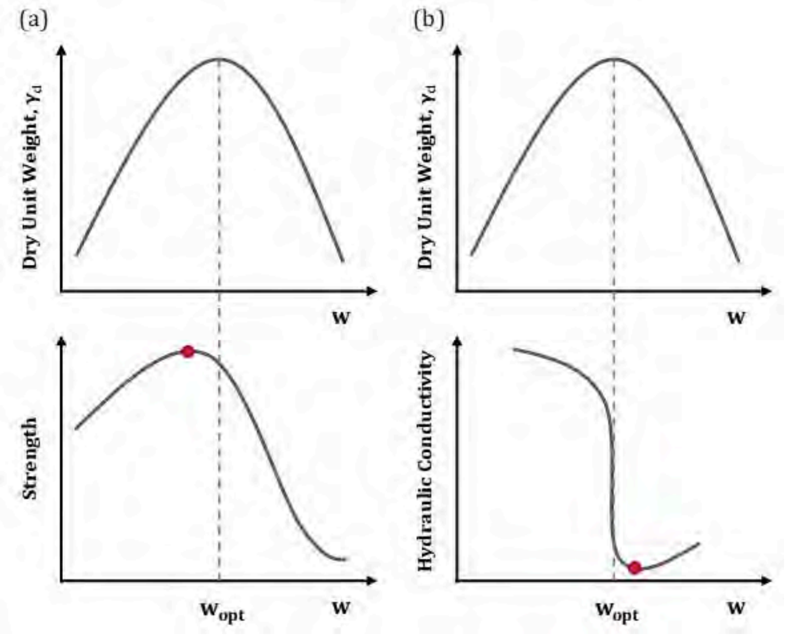


Figure 14: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Results and discussions

4.1.1 Standard Penetration Test (SPT)

4.1.1.1 SPT N Corrections

According to Skempton (1986) that the penetration resistance would be significantly affected by the energy transmitted by SPT hammer and rod system and argued that SPT N values should be corrected to a common reference energy rating. Skempton (1986) proposed the use of 60% of the free fall energy as the reference energy rating. N_{60} is given as:

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.60}$$

E_m= Hammer efficiency

C_B= Borehole diameter correction

C_S= Sample barrel correction

C_R= Rod length correction

N= N measured

N_{60}= SPT N-value corrected for field procedures and apparatus

Liao and Whitman (1986) proposed overburden correction to Skempton's N60 to consider increasing confinement with depth. This correction was termed as $(N_1)_{60}$ and is given as:

$$(N_1)_{60} = N_{60} \times C_N$$

Where C_N is given as:

$$C_N = 9.78\sqrt{\frac{1}{\sigma_v'}}$$

$\boldsymbol{\sigma}'_v$ is given in kN/m^2

Robertson and Wride (1997) have modified the Skempton's correction factors chart to add the factors proposed by Liao and Whitman (1986).

Table 1: Recommended corrections for SPT N values Robertson and Wride (1997)

Factor	Equipment Variable	Term	Correction
Overburden Pressure		C_N	$(Pa / \sigma'_{vo})^{0.5}$ but $C_N \leq 2$
Energy ratio	Donut Hammer Safety Hammer Automatic Hammer	C_E	0.5 to 1.0 0.7 to 1.2 0.8 to 1.5
Borehole diameter	65 mm to 115 mm 150 mm 200 mm	C_B	1.0 1.05 1.15
Rod length	3 m to 4 m 4 m to 6 m 6 m to 10 m 10m to 30 m >30 m	C_R	0.75 0.85 0.95 1.0 <1.0
Sampling method	Standard sampler Sampler without liners	Cs	1.0 1.1 to 1.3

Below given are the tables with standardised SPT N-values for all 2 boreholes.

Table 2: Borehole 1 SPT N-values corrected

BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.20	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	19	0.7	1	1	0.75	17	17	2.00	33	32
2.00	20	0.7	1	1	0.75	18	26	2.00	35	32
3.00	19	0.7	1	1	0.75	17	33	1.69	28	32
4.50	20	0.7	1	1	0.75	18	44	1.48	26	32
6.00	18	0.7	1	1	0.85	18	55	1.32	24	32
7.50	17	0.7	1	1	0.85	17	65	1.21	20	32
9.00	22	0.7	1	1	0.95	24	76	1.12	27	34
10.50	20	0.7	1	1	0.95	22	87	1.05	23	33
12.00	21	0.7	1	1	0.95	23	97	0.99	23	34
13.50	24	0.7	1	1	0.95	27	108	0.94	25	35
15.00	23	0.7	1	1	0.95	25	119	0.90	23	34

Table 3: Borehole 2 SPT N-values corrected

BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
0.75	20	0.7	1	1	0.75	18	13	2.00	35	32
1.50	23	0.7	1	1	0.75	20	23	2.00	40	33
2.25	25	0.7	1	1	0.75	22	28	1.85	40	33
3.00	21	0.7	1	1	0.75	18	33	1.69	31	32
4.50	20	0.7	1	1	0.85	20	44	1.48	29	33
6.00	21	0.7	1	1	0.85	21	55	1.32	28	33
7.50	18	0.7	1	1	0.95	20	65	1.21	24	33
9.00	21	0.7	1	1	0.95	23	76	1.12	26	34
10.50	16	0.7	1	1	0.95	18	87	1.05	19	32
12.00	14	0.7	1	1	0.95	16	97	0.99	15	32
14.00	20	0.7	1	1	0.95	22	111	0.93	21	33

4.1.1.2 Safe Bearing Capacity (SBC) for Pad Foundation

In a geotechnical investigation, calculating safe bearing capacity is utmost important. In general data from shearing of undisturbed samples, especially triaxial shearing results are considered as an accurate method. However, in non-cohesive soils, like that was found in the project sites, both corrected SPT N values are used to estimate the safe bearing capacity of soil.

4.1.1.3 SBC using $(N_1)_{60}$ values for pad foundation

One of the earliest published relationship between was proposed by Terzaghi and Peck (1967). With the accumulation field data over the time has shown the bearing capacity curves to be overly conservative. To address this Meyerhof (1976) proposed new set of equations for a 25 mm settlement. The equations are given below.

For foundation footing width ≤ 4 ft

$$q_a = \left(\frac{N}{4}\right) K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{6}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

However, the equations proposed by Meyerhof (1976) were also found to be conservative which produce similar safe bearing capacity values as equations proposed by Terzaghi and Peck (1967). Hence, Bowles (1996) adjusted the Meyerhof's equations and proposed the following equations.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{4}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

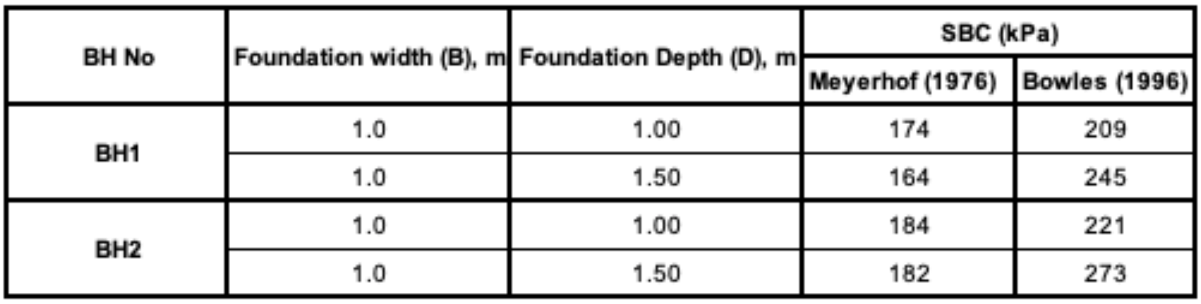
where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 3 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 250 kPa as safe bearing capacity for foundation design.

Table 4:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.



BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	174	209
	1.0	1.50	164	245
BH2	1.0	1.00	184	221
	1.0	1.50	182	273

Since Bowles (1996) showed that Meyerhof (1976) under-estimates the SBC, we have to check settlement of each bearing capacity to determine an allowable bearing capacity.

Since the soil is granular, the settlement in sand is generally the immediate settlement, unless the soil contains very high content of silt. This is because it is unlikely for porewater pressure to build up in granular soil.

Generally shallow foundation is designed for a maximum of 25 mm settlement. The bearing capacities of both Meyerhof's and Bowles' methods are calculated for a settlement limit of 25 mm. The average settlement of normally consolidated sand is calculated using Burland and Burbidge (1985) approach where average settlement is expressed as;

$$S_i = \frac{q_n B^{0.7}}{3}\left(\frac{1.71}{N^{1.4}}\right)$$

Where q_n is the net foundation pressure, B is foundation breadth and N is e $(N)_{60}$. Sine the SBC The above safe bearing capacity do not exceed the settlement limit of 25 mm.

4.1.2 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

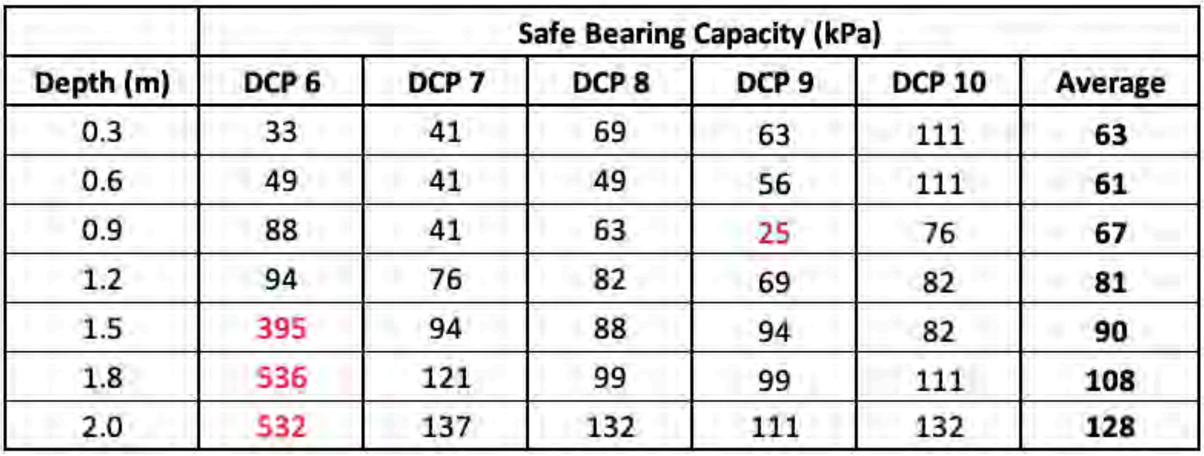
q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

Table 5: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	56	41	69	76	63	**61**
0.6	49	33	69	76	69	**59**
0.9	63	63	63	69	111	**74**
1.2	82	111	137	105	111	**109**
1.5	132	132	111	94	121	**118**
1.8	162	147	121	99	142	**134**
2.0	162	142	127	121	132	**137**

Table 6: Safe Bearing Capacities calculated from DCP readings from North side of Airport runway



	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 6**	**DCP 7**	**DCP 8**	**DCP 9**	**DCP 10**	**Average**
0.3	33	41	69	63	111	**63**
0.6	49	41	49	56	111	**61**
0.9	88	41	63	25	76	**67**
1.2	94	76	82	69	82	**81**
1.5	395	94	88	94	82	**90**
1.8	536	121	99	99	111	**108**
2.0	532	137	132	111	132	**128**

Table 5 (south side) and Table 6 (north side) shows safe bearing capacities calculated for each DCP test at different depths. The values marked in read are abnormal values, hence were not considered when calculating the average. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth. The area was previously a wetland which was reclaimed for the development of the airport. Hence, low safe bearing capacity values.

4.1.3 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550\,(R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

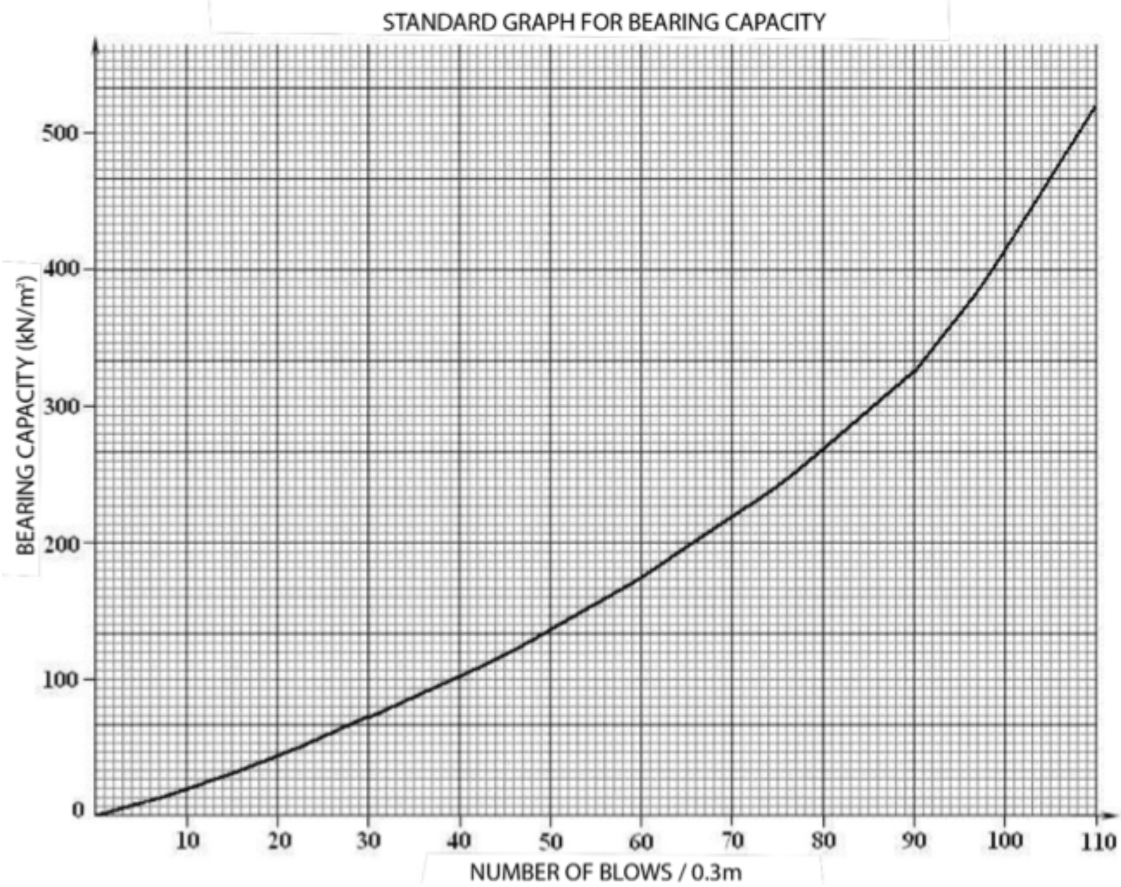


Figure 15: Standard bearing capacity graph for Mackintosh Probe

Table 7 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 7: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1 (south)**	**MP 2 (north)**	**Average**
0.3	81	83	82
0.6	90	90	90
0.9	73	115	94
1.2	86	111	99
1.5	117	120	119
1.8	123	130	127
2.1	132	140	136
2.4	167	167	167
2.7	179	186	183
3	174	189	182
3.3	190	204	197
3.6	202	196	199
3.9	197	205	201
4.2	211	220	216
4.5	231	227	229
4.8	224	-	224
5.1	238	-	238
5.4	256	-	256

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

4.1.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at the north and south side of Hdh. Kulhudhuffushi Airport are provided in the Table 8 and Table 9. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 8: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	65.0	15.0	5.0	2.0	4.0	2.9	6.1
1.0	35.0	25.0	11.0	7.0	7.0	5.1	9.9
2.0	20.0	10.0	29.0	14.0	8.0	10.3	8.7
3.0	27.0	7.0	16.0	9.0	11.0	22.3	7.7
4.5	16.0	4.0	9.0	6.0	23.0	33.4	8.6
6.0	41.0	3.0	5.0	5.0	16.0	23.4	6.6
7.5	12.0	8.0	18.0	12.0	20.0	23.9	6.1
9.0	19.0	13.0	29.0	17.0	12.0	6.0	4.0
10.5	28.0	20.0	12.0	11.0	16.0	6.4	6.6
12.0	21.0	19.0	30.0	12.0	8.0	2.9	7.1
13.5	20.0	5.0	23.0	24.0	18.0	3.5	6.5
15.0	20.0	6.0	23.0	26.0	15.0	4.9	5.1

Table 9: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	54.0	14.0	7.0	4.0	8.0	4.8	8.2
1.0	37.0	24.0	13.0	6.0	8.0	4.6	7.4
2.0	25.0	12.0	27.0	15.0	9.0	4.9	7.1
3.0	31.0	13.0	24.0	12.0	10.0	3.1	6.9
4.5	23.0	6.0	6.0	4.0	21.0	32.1	7.9
6.0	27.0	8.0	5.0	8.0	21.0	21.1	9.9
7.5	18.0	6.0	19.0	16.0	15.0	18.8	7.2
9.0	24.0	14.0	26.0	15.0	10.0	5.3	5.7
10.5	26.0	12.0	22.0	16.0	12.0	3.8	8.2
12.0	20.0	18.0	24.0	16.0	10.0	2.6	9.4
13.5	20.0	5.0	24.0	22.0	20.0	2.8	6.2
15.0	18.0	7.0	25.0	25.0	13.0	5.7	6.3

4.1.5 Direct Shear

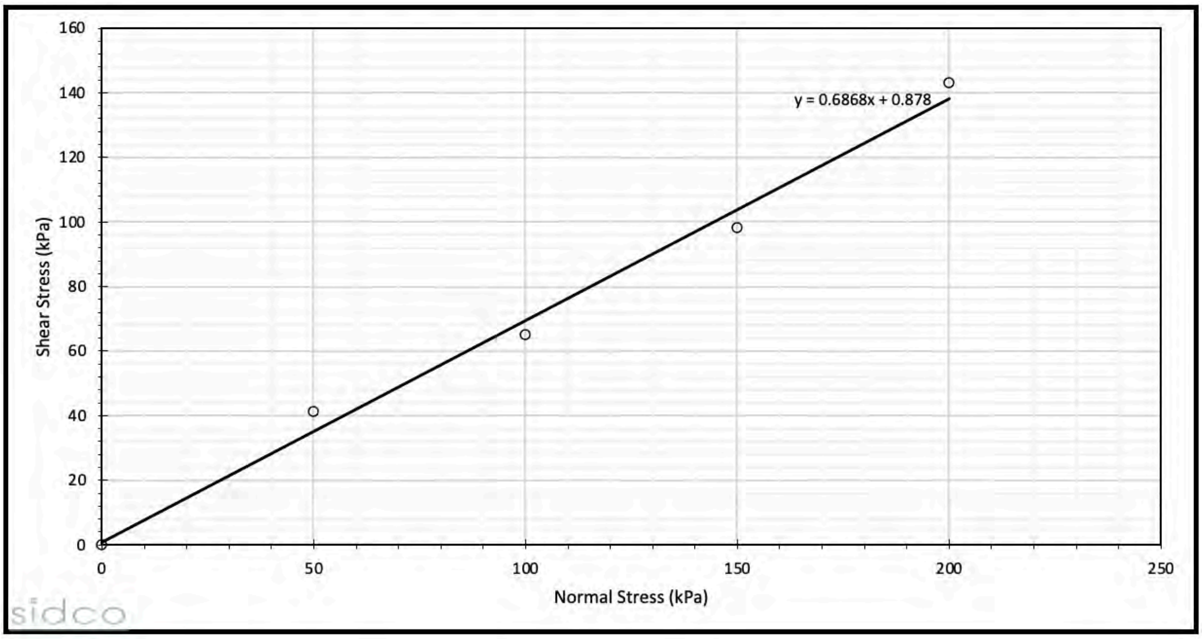


Figure 16: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 35 degrees, which is typical for carbonated sand found in Maldives.

4.1.6 Proctor Compaction Test

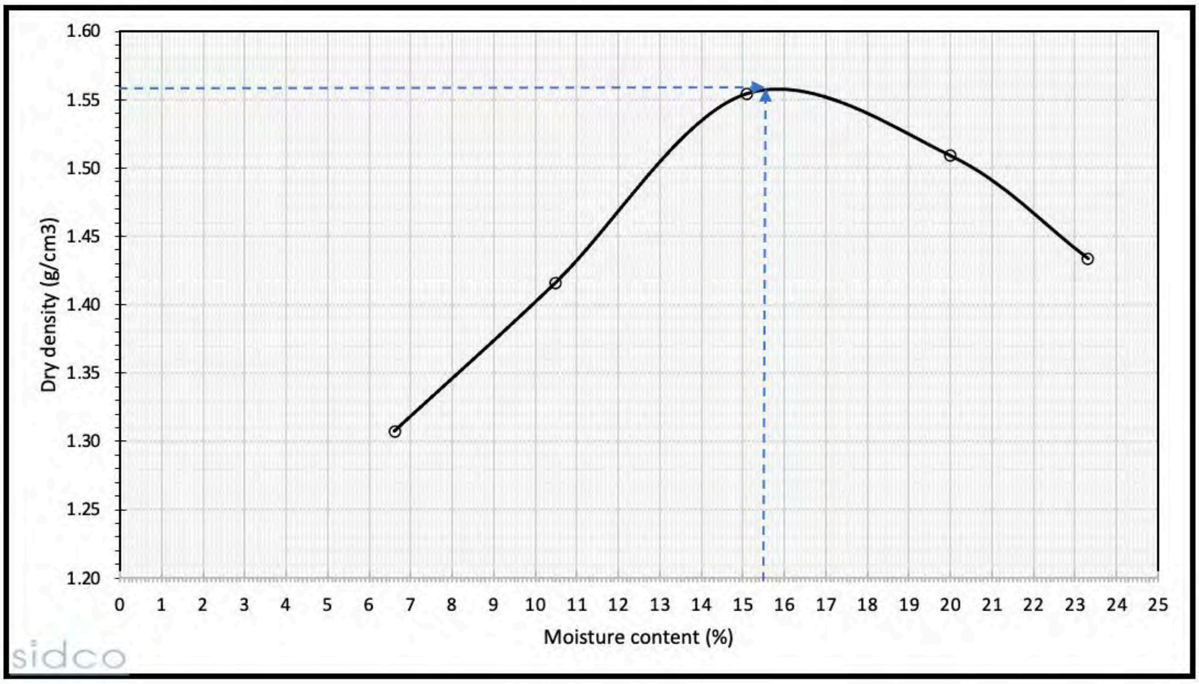
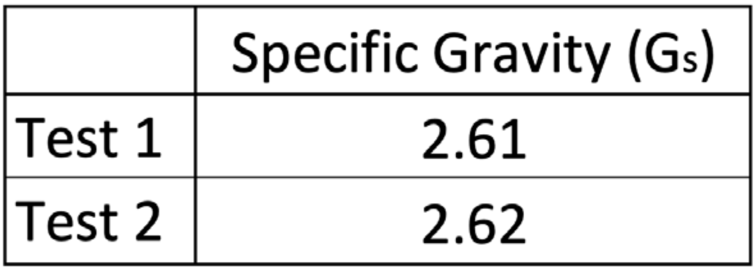


Figure 17: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.56 g/cm^3 and an optimum moisture content of 15.5%.

4.1.7 Specific gravity test

Table 10: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.61
Test 2	2.62

Table 10 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

4.1.8 Electrical Resistivity (ER)

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content.

1. Kulhudhuffushi Airport areas allocated for solar pv installation are green fields and moisture content appears to be very high. High moisture content reduces the resistivity.
2. The temperature is approximately 27 degrees Celsius. Higher temperature decreases the resistivity.
3. The site was previously a freshwater wetland area, which was backfilled. Hence, contains high mineral content. This also reduces the resistivity.

The tables and graphs below show ER test results.

Table 11: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	2.87	18
2	2	1.96	25
3	3	2.27	43
4	4	2.39	60
5	5	2.14	67
6	6	2.00	75
7	7	1.62	71
8	8	1.32	66
9	9	1.09	62
10	10	0.86	54

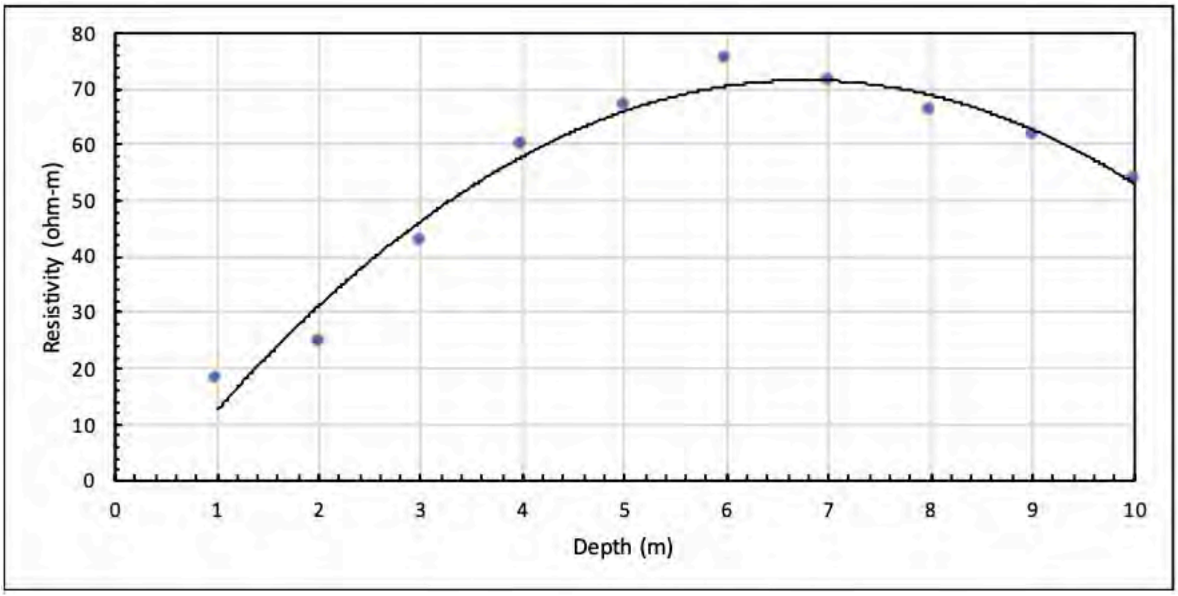


Figure 18: Resistivity graph for Test 1

Table 12: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	3.13	20
2	2	3.79	48
3	3	5.01	94
4	4	4.83	121
5	5	6.85	215
6	6	4.32	163
7	7	3.23	142
8	8	2.67	134
9	9	1.06	60
10	10	0.74	46

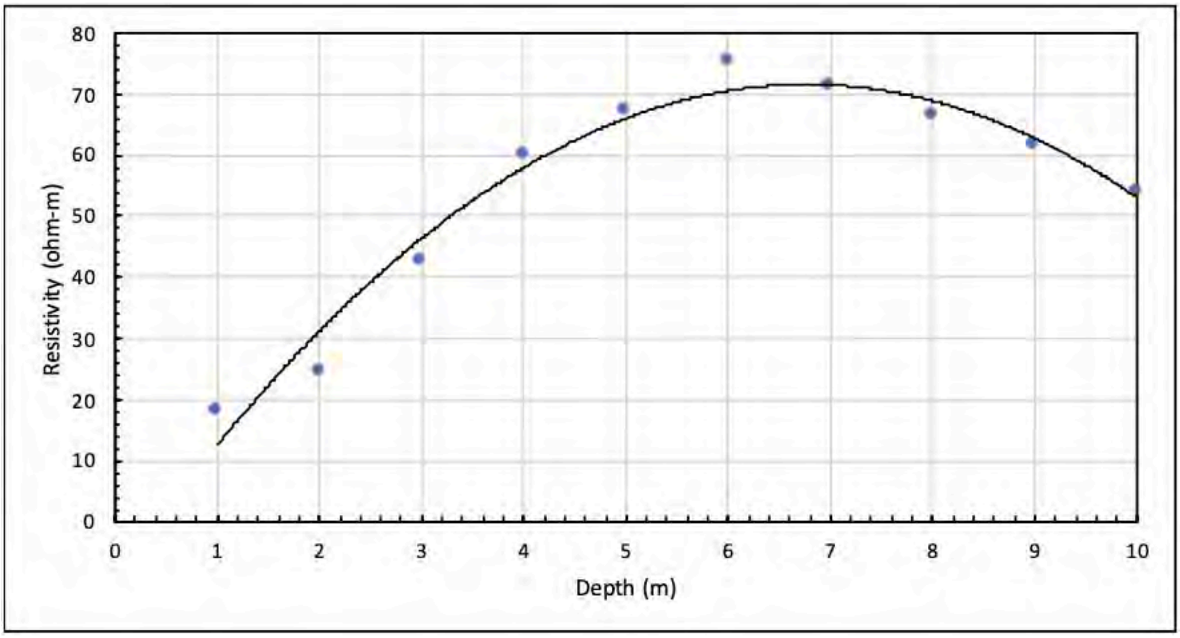


Figure 19: Resistivity graph for Test 2

Resistivity of soil increases up to 6.0 m and then decreases. This could be because the area was previously a freshwater wetland where high mineral content in the top layers which reduces with the depth and then resistivity decreases when salt content increases with the depth. But overall, the 70 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

4.1.9 Thermal Conductivity

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 13: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (^oC)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	27.40	0.438	2.28	200
2	TLS100	27.40	0.581	1.72	200
Average		27.40	0.510	2.00	

The average thermal conductivity is 0.510 W/mK.

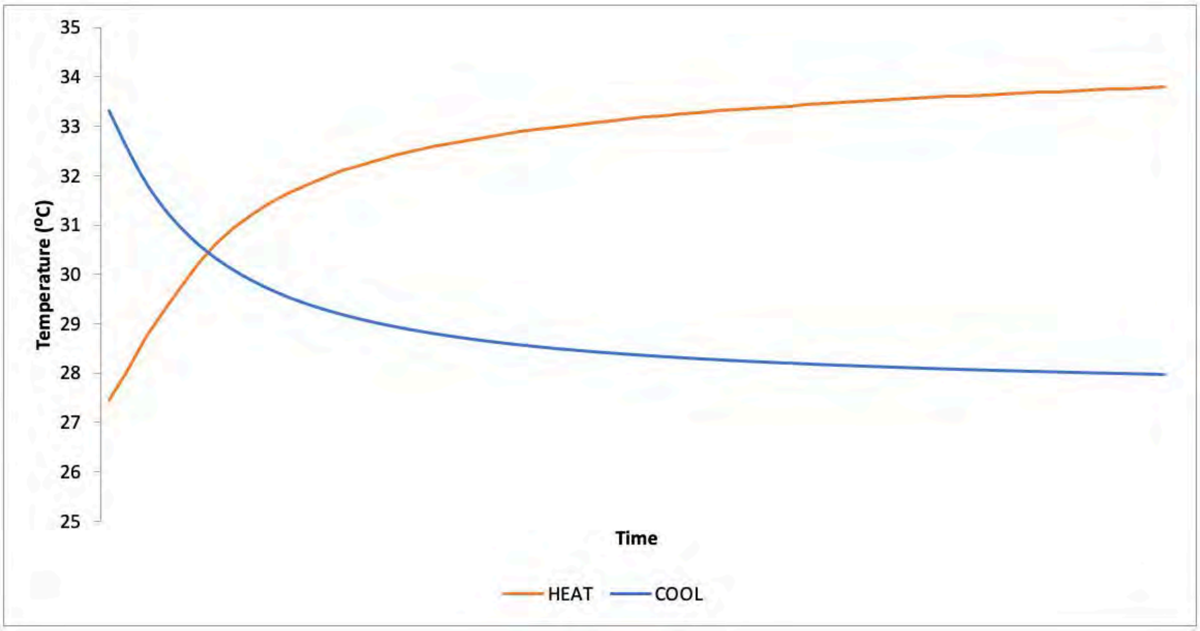


Figure 20: Heat and Colling Curve to TC Test 1 (South side)

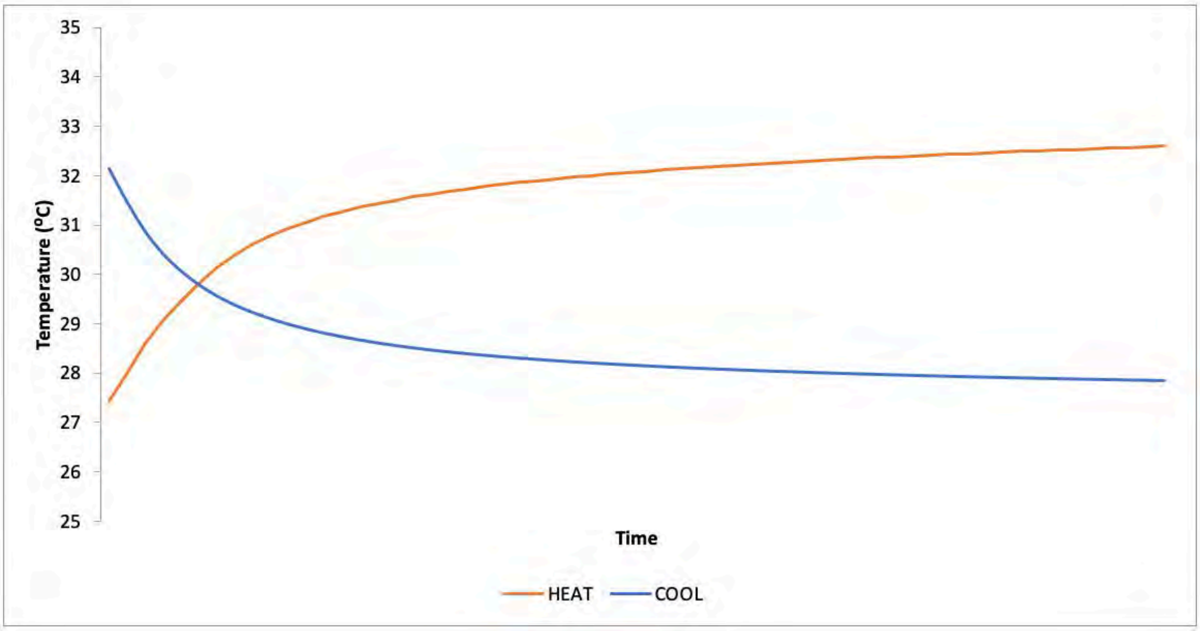


Figure 21: Heat and Colling Curve to TC Test 2

4.1.10 Chemical Analysis of Ground Water

Water samples were collected from. Trial pits and results from water laboratory has not received. But previous water testing in same area shows a conductivity of about 1013 µS/cm with a salinity of 0.50%, Sulphate content of 37 mg/L, Nitrate content of 1.9 mg/L, Chloride content of 95 mg/L. The report will be updated when test results are received.

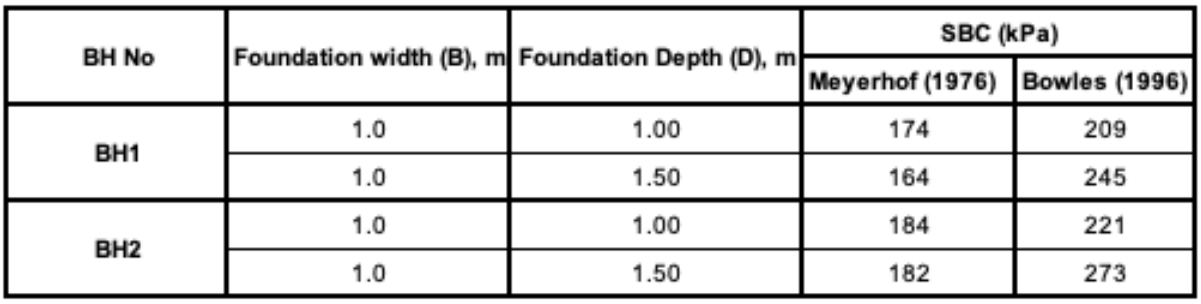
5 Conclusion

5.1 GEOTECHNICAL CONSIDERATIONS

5.1.1 Safe Bearing Capacity

Since the soil is gravelly sand with less than 10% silt content from 0-15 m. The result of SPT is most accurate out of SPT, DCP and MP conducted at the site. Since only 2 borehole/SPT were conducted and 10 DCP tests were carried out, DCP results gives better idea of overall site condition. It was noticed that the further from the runway, the soil was getting softer. This is due to the compaction carried out during airport construction. Hence, DCP results should be looked at while designing, even though safe bearing capacity using SPT N value would be most accurate.

Table 14: Safe bearing capacity for shallow foundation at different depths



BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	174	209
	1.0	1.50	164	245
BH2	1.0	1.00	184	221
	1.0	1.50	182	273

5.1.2 Electrical Resistivity

For grounding design use electrical resistivity of 70 Ohm-m. And consider soil as moderately corrosive for sub-structure design.

5.1.3 Thermal Conductivity

For underground cable design use 0.510 W/mK as thermal conductivity and 2.00 mK/W as thermal resistance.

5.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Kulhudhuffushi is located north of Maldives where peak ground acceleration value is less than 0.04.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.04, S_s is 0.09 and S_1 is 0.025.

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

Bowles, L. E. (1996). Foundation analysis and design, McGraw-hill.

Burland, J. B. and M. C. Burbidge (1985). "Settlement of foundations on sand and gravel." Proceedings of the institution of Civil Engineers 78(6): 1325-1381.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User's Manual for K-100 Models of KSE DCP. USA.

Liao, S. and R. Whitman (1986). "Overburden Correction Factors for SPT in Sand." Journal of Geotechnical Engineering 112: 373-377.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

Meyerhof, G. (1976). "Bearing capacity and settlement of pile foundations (11th Terzaghi Lecture)." Journal of the Geotechnical Engineering Division ASCE 102: 195-228.

MHI (2016). Initial Environmental Examination - MLD: Kulhuduffushi Harbor Expansion Project, Ministry of Housing and Infrastructure, Maldives.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

Robertson, P. and C. E. Wride (1997). "Cyclic liquefaction and its evaluation based on SPT and CPT. Proc. NCEER Work-shop on Evaluation of Liquefaction Resistance of Soils." Report NCEER-97-0022, National Center for Earthquake Engineering Research, SUNY Buffalo, NY.

Skempton, A. W. (1986). "Standard penetration test procedures and the effects in sands of overburden pressure, relative density, particle size, ageing and overconsolidation." Geotechnique 36(3): 425-447.

Terzaghi, K. and R. B. Peck (1967). Soil mechanics in engineering practice. New York, John Wiley & Sons, Inc.

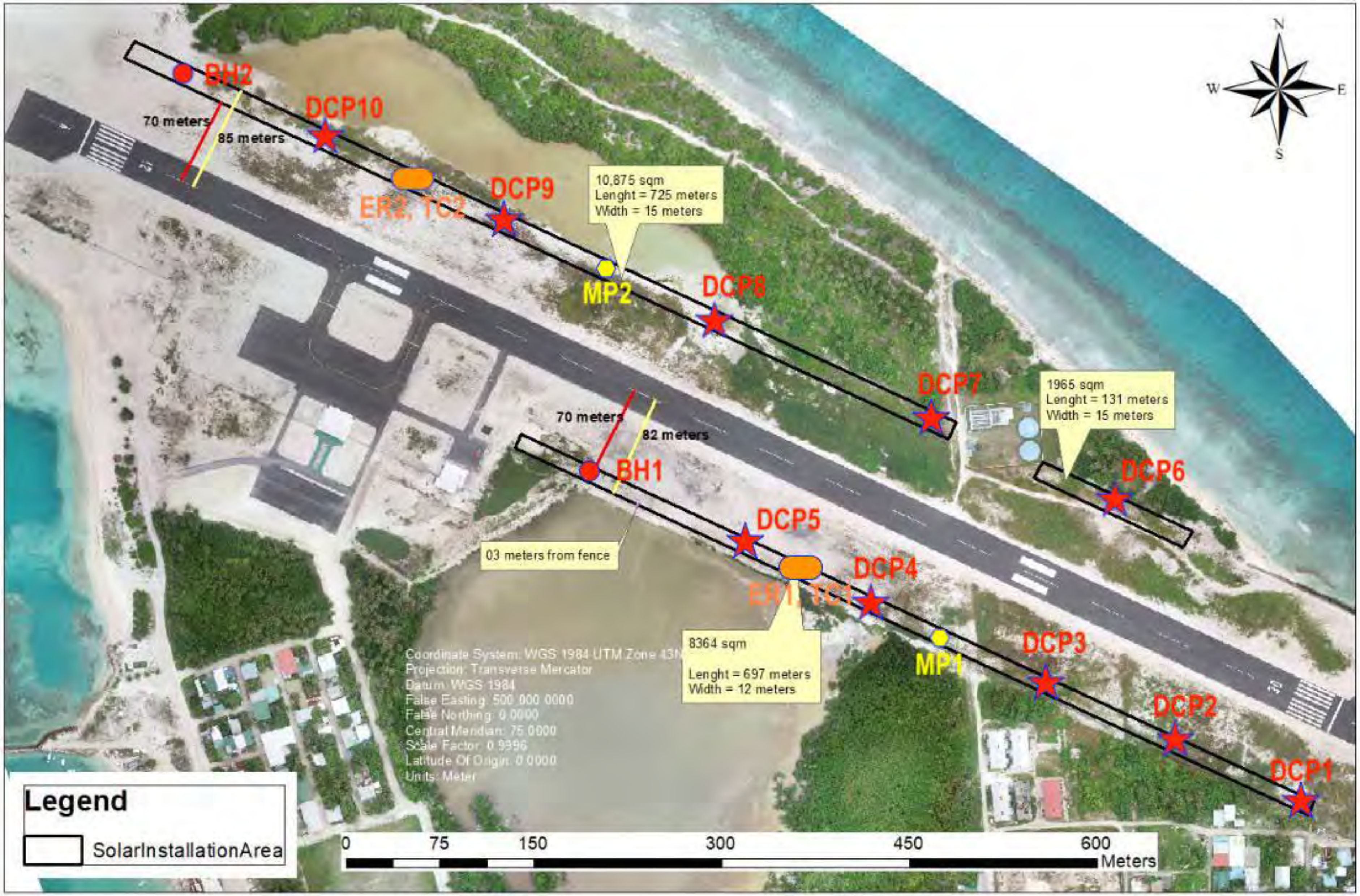
UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES

APPENDIX 1: TEST LOCATIONS

Kulhudhuhfushi Airport



APPENDIX 2: Borehole Logs

sidco
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

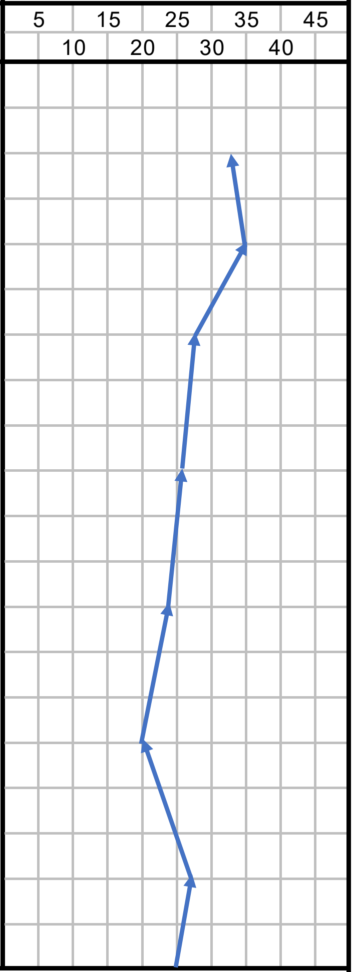
Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - Hdh. Kulhudhuffushi Airport				
Project Number:	2023/HDEC/09	Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill	Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory				

Ground water depth (m)	1.2	Date	Started:	03/09/2022	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	15		Completed	04/09/2022	Hammer Type	Auto tripped hammer		
BH Location	Kulhudhuffushi Airport		Backfilled:	05/09/2022	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N $(N_1)_{60}$
1	SS	D1	▼	Medium dense, off white coral sand with some gravels (compacted backfilled material)	10	9	10	19	33
	SS	D2							
2					11	10	10	20	35
	SS	D3							
3	SS	D4		Medium dense, off white fine sand with some silt	9	9	10	19	28
4									
	SS	D5		Medium dense, off white sand with rock fragments	10	9	10	20	26
5									
6									
	SS	D6			8	9	9	18	24
7									
	SS	D7			9	8	9	17	20
8									
9									
	SS	D8			8	10	12	22	27
10									

Graphical representation of corrected SPT N values



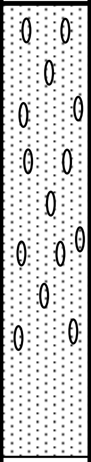
Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

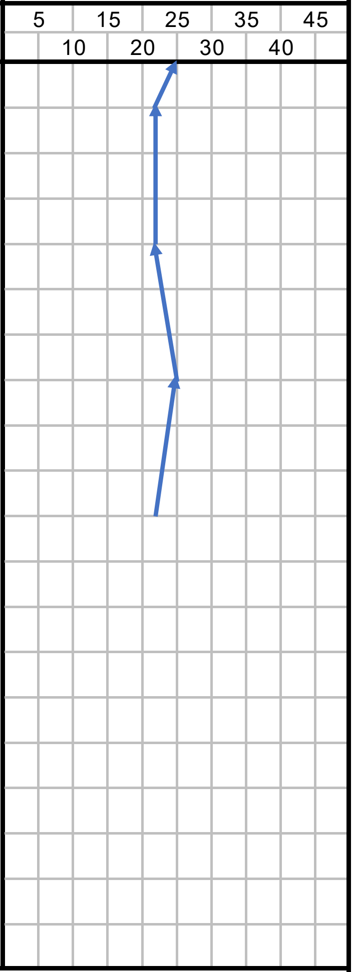
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - Hdh. Kulhudhuffushi Airport						
Project Number:	2023/HDEC/09		Client:	HDEC		BH No.	1
Drill Rig type	Rotatary Drill		Drilling Contractor	SIDCO Pvt Ltd			
Drilling method	Rotatory						
Ground water depth (m)	1.2	Date	Started: 03/09/2022	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	15		Completed 04/09/2022	Hammer Type	Auto tripped hammer		
BH Location	Kulhudhuffushi Airport		Backfilled: 05/09/2022	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60
	SS	D9				10	11	10	20	23
11										
12										
	SS	D10			Medium dense, off white coral sand with weathered coral rock pieces	12	10	11	21	23
13										
						9	11	13	24	25
14										
	SS	D11								
15					**BH ended at 15.0 m**	12	11	12	23	23
16										
17										
18										
19										
20										

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample

▽ Ground water level

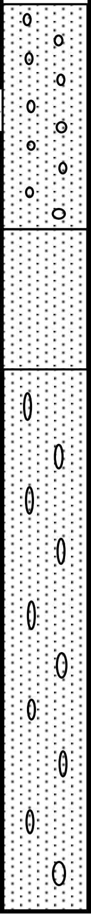
sidco
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

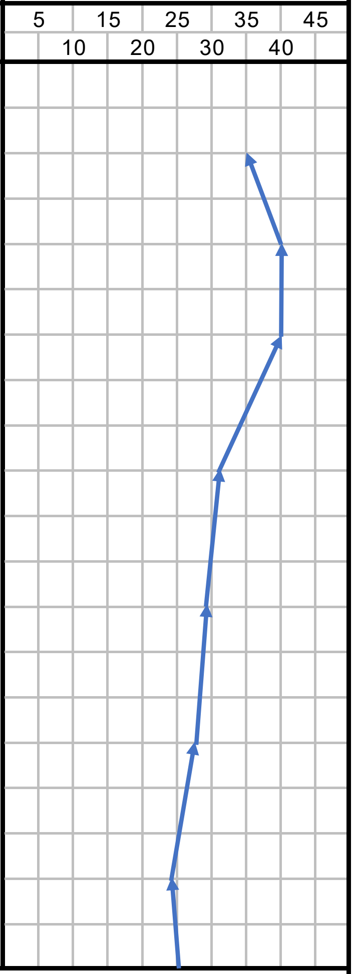
Project:	Aspire - Solar PV Installation Project - Hdh. Kulhudhuffushi Airport						
Project Number:	2023/HDEC/09			Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.2	Date	Started: 03/09/2022	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	15		Completed 04/09/2022	Hammer Type	Auto tripped hammer		
BH Location	Kulhudhuffushi Airport		Backfilled: 05/09/2022	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60
1	SS	D1	▼	Medium dense, off white coral sand with some gravels (compacted backfilled material)	10	10	10	20	35
	SS	D2							
2					11	11	13	23	40
	SS	D3							
3	SS	D4		Medium dense, off white fine sand with some silt	12	13	12	25	40
4									
	SS	D5		Medium dense, off white sand with rock fragments	11	11	10	21	31
5									
6	SS	D6			9	10	10	20	29
7									
	SS	D7			11	10	11	21	28
8									
9	SS	D8			12	8	10	18	24
10									

Graphic Log



Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

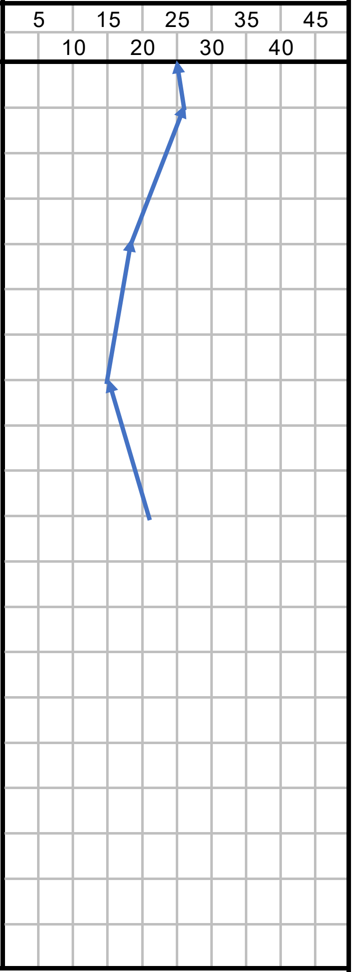
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - Hdh. Kulhudhuffushi Airport						
Project Number:	2023/HDEC/09			Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.2	Date	Started: 03/09/2022	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	15		Completed 04/09/2022	Hammer Type	Auto tripped hammer		
BH Location	Kulhudhuffushi Airport		Backfilled: 05/09/2022	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)$_{60}$
	SS	D9				13	10	11	21	26
11										
12	SS	D10				6	8	8	16	19
					Medium dense, off white coral sand with weathered coral rock pieces					
13										
						8	7	7	14	15
14	SS	D11								
15						9	9	11	20	21
					BH ended at 15.0 m					
16										
17										
18										
19										
20										

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

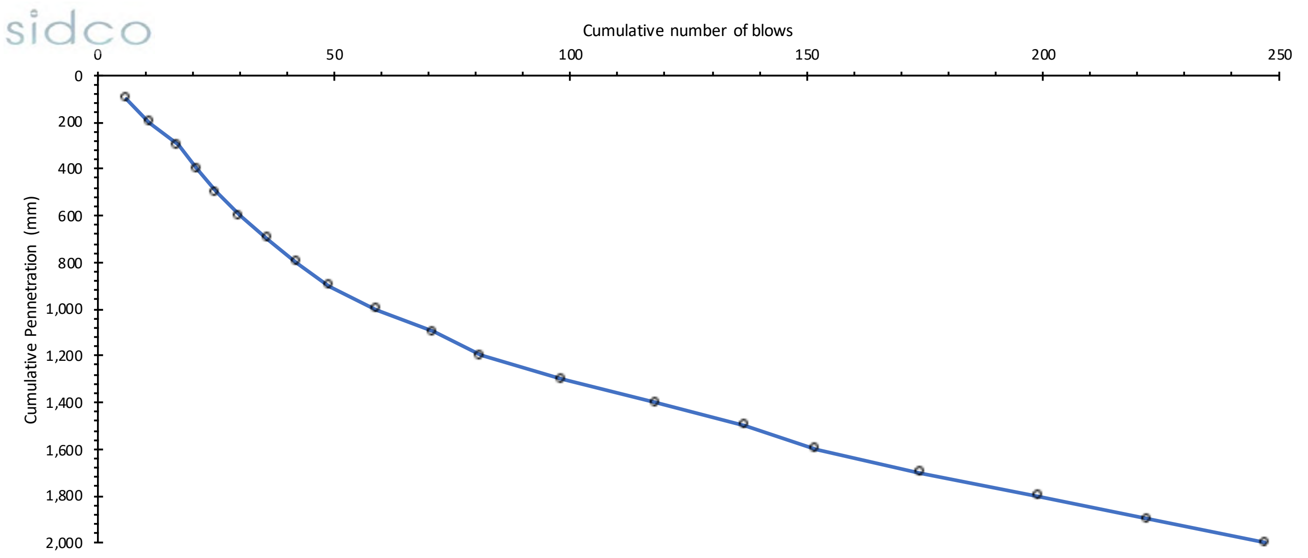
APPENDIX 3: DCP TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	5	11	20.0	10	122	49
200-300	6	17	16.7	13	140	56
300-400	4	21	25.0	8	104	41
400-500	4	25	25.0	8	104	41
500-600	5	30	20.0	10	122	49
600-700	6	36	16.7	13	140	56
700-800	6	42	16.7	13	140	56
800-900	7	49	14.3	15	157	63
900-1000	10	59	10.0	22	205	82
1000-1100	12	71	8.3	27	234	94
1100-1200	10	81	10.0	22	205	82
1200-1300	17	98	5.9	40	304	121
1300-1400	20	118	5.0	48	343	137
1400-1500	19	137	5.3	45	330	132
1500-1600	15	152	6.7	35	277	111
1600-1700	22	174	4.5	54	368	147
1700-1800	25	199	4.0	62	404	162
1800-1900	23	222	4.3	56	380	152
1900-2000	25	247	4.0	62	404	162



SIDCO SOILS LAB

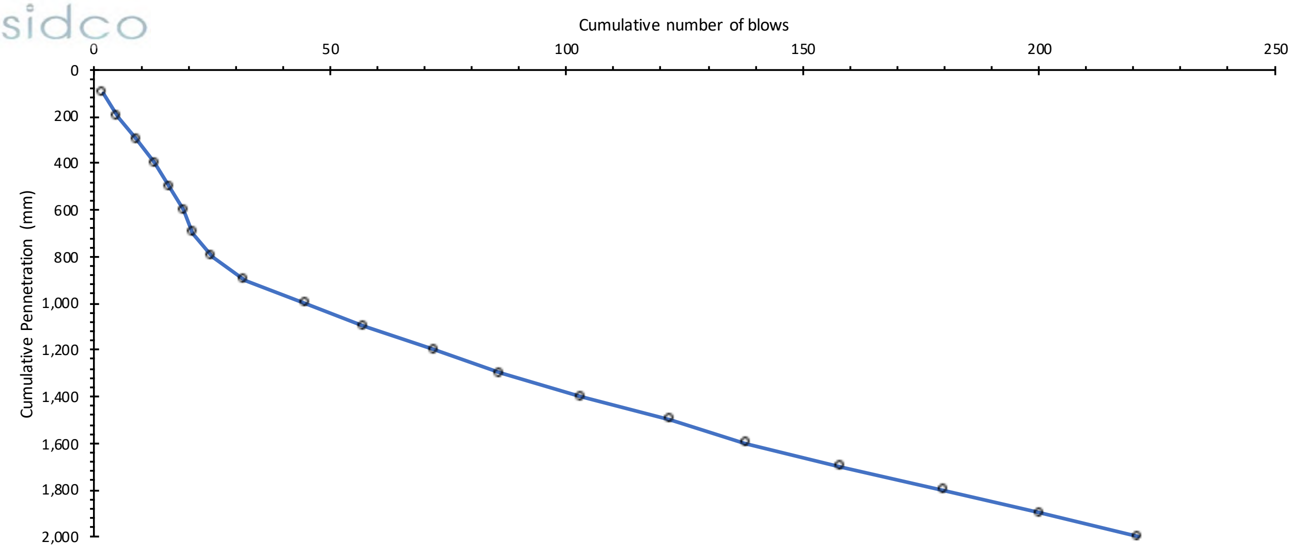
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	2	2	50.0	4	62	25
100-200	3	5	33.3	6	84	33
200-300	4	9	25.0	8	104	41
300-400	4	13	25.0	8	104	41
400-500	3	16	33.3	6	84	33
500-600	3	19	33.3	6	84	33
600-700	2	21	50.0	4	62	25
700-800	4	25	25.0	8	104	41
800-900	7	32	14.3	15	157	63
900-1000	13	45	7.7	30	249	99
1000-1100	12	57	8.3	27	234	94
1100-1200	15	72	6.7	35	277	111
1200-1300	14	86	7.1	32	263	105
1300-1400	17	103	5.9	40	304	121
1400-1500	19	122	5.3	45	330	132
1500-1600	16	138	6.3	37	290	116
1600-1700	20	158	5.0	48	343	137
1700-1800	22	180	4.5	54	368	147
1800-1900	20	200	5.0	48	343	137
1900-2000	21	221	4.8	51	355	142

sidco

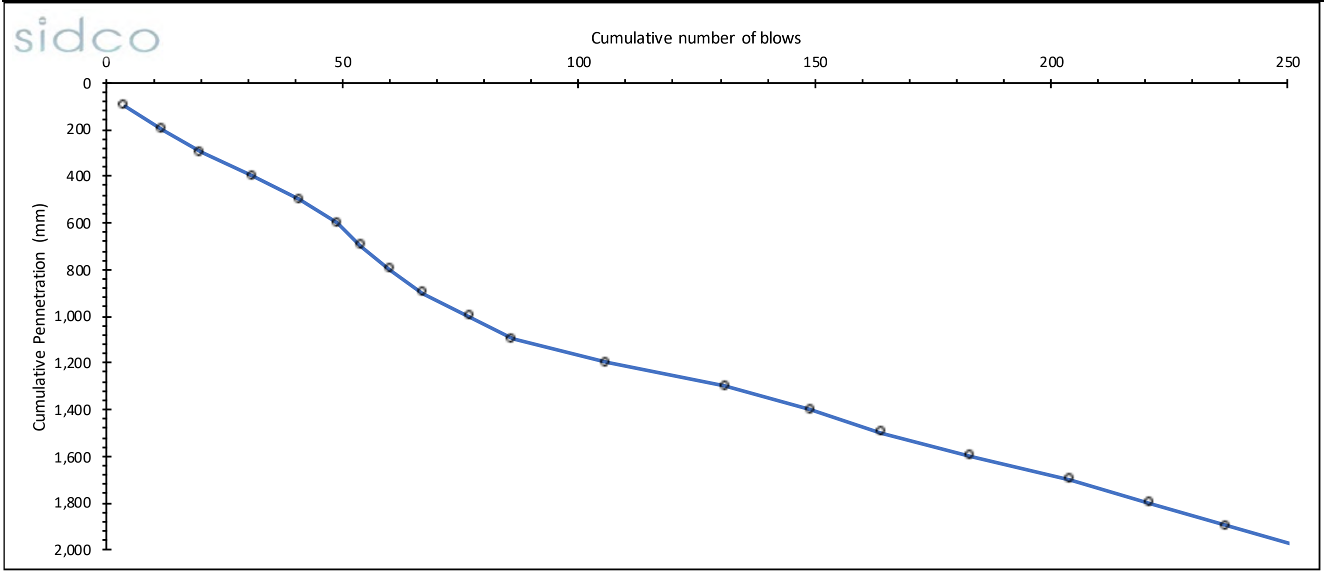


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	8	12	12.5	17	173	69
200-300	8	20	12.5	17	173	69
300-400	11	31	9.1	25	220	88
400-500	10	41	10.0	22	205	82
500-600	8	49	12.5	17	173	69
600-700	5	54	20.0	10	122	49
700-800	6	60	16.7	13	140	56
800-900	7	67	14.3	15	157	63
900-1000	10	77	10.0	22	205	82
1000-1100	9	86	11.1	20	189	76
1100-1200	20	106	5.0	48	343	137
1200-1300	25	131	4.0	62	404	162
1300-1400	18	149	5.6	43	317	127
1400-1500	15	164	6.7	35	277	111
1500-1600	19	183	5.3	45	330	132
1600-1700	21	204	4.8	51	355	142
1700-1800	17	221	5.9	40	304	121
1800-1900	16	237	6.3	37	290	116
1900-2000	18	255	5.6	43	317	127



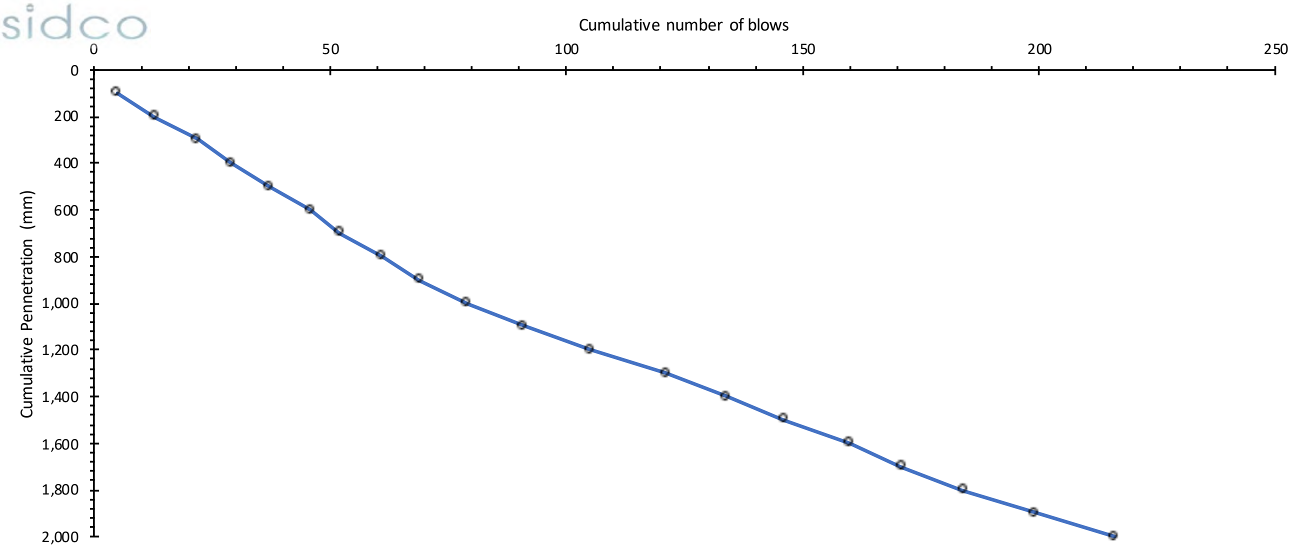
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	Hdh. Kulhudhuffushi		03/02/2023		DCP#	4
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	8	13	12.5	17	173	69
200-300	9	22	11.1	20	189	76
300-400	7	29	14.3	15	157	63
400-500	8	37	12.5	17	173	69
500-600	9	46	11.1	20	189	76
600-700	6	52	16.7	13	140	56
700-800	9	61	11.1	20	189	76
800-900	8	69	12.5	17	173	69
900-1000	10	79	10.0	22	205	82
1000-1100	12	91	8.3	27	234	94
1100-1200	14	105	7.1	32	263	105
1200-1300	16	121	6.3	37	290	116
1300-1400	13	134	7.7	30	249	99
1400-1500	12	146	8.3	27	234	94
1500-1600	14	160	7.1	32	263	105
1600-1700	11	171	9.1	25	220	88
1700-1800	13	184	7.7	30	249	99
1800-1900	15	199	6.7	35	277	111
1900-2000	17	216	5.9	40	304	121

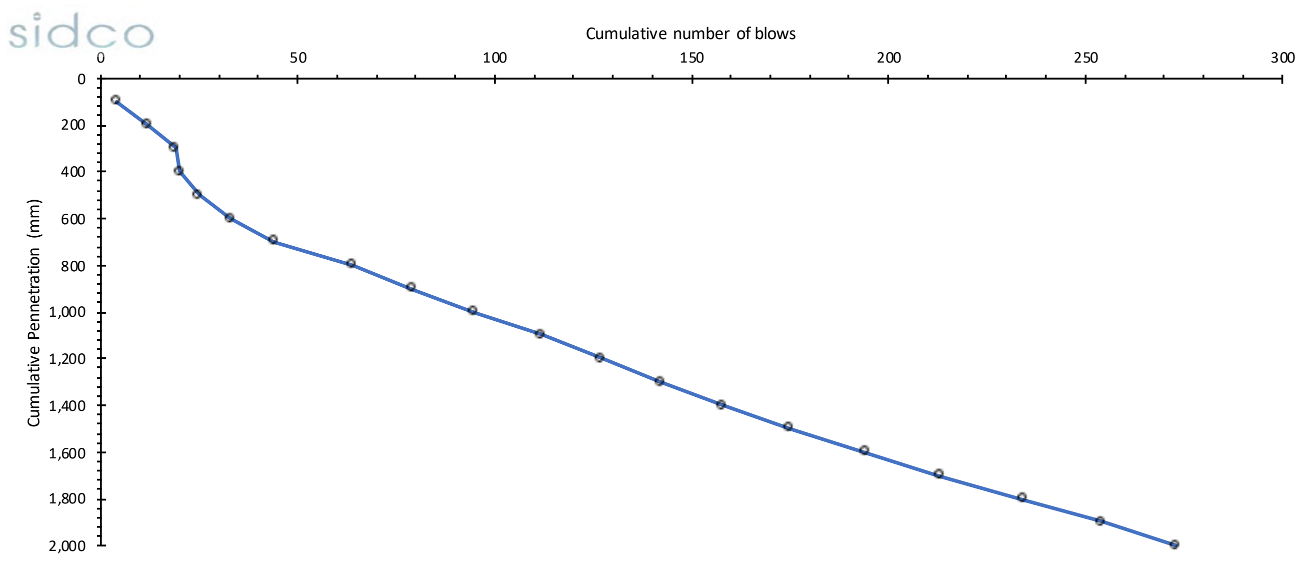


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	Hdh. Kulhudhuffushi		03/02/2023		DCP#	5
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	8	12	12.5	17	173	69
200-300	7	19	14.3	15	157	63
300-400	1	20	100.0	2	37	15
400-500	5	25	20.0	10	122	49
500-600	8	33	12.5	17	173	69
600-700	11	44	9.1	25	220	88
700-800	20	64	5.0	48	343	137
800-900	15	79	6.7	35	277	111
900-1000	16	95	6.3	37	290	116
1000-1100	17	112	5.9	40	304	121
1100-1200	15	127	6.7	35	277	111
1200-1300	15	142	6.7	35	277	111
1300-1400	16	158	6.3	37	290	116
1400-1500	17	175	5.9	40	304	121
1500-1600	19	194	5.3	45	330	132
1600-1700	19	213	5.3	45	330	132
1700-1800	21	234	4.8	51	355	142
1800-1900	20	254	5.0	48	343	137
1900-2000	19	273	5.3	45	330	132

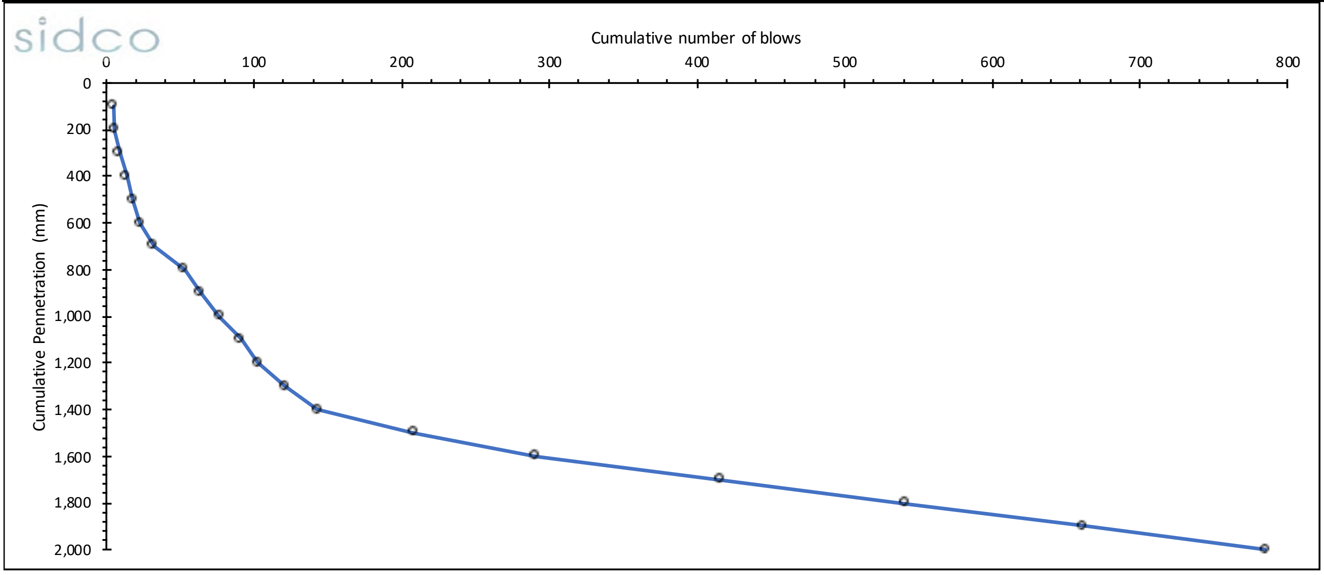


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**6**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	1	6	100.0	2	37	15
200-300	3	9	33.3	6	84	33
300-400	5	14	20.0	10	122	49
400-500	4	18	25.0	8	104	41
500-600	5	23	20.0	10	122	49
600-700	9	32	11.1	20	189	76
700-800	21	53	4.8	51	355	142
800-900	11	64	9.1	25	220	88
900-1000	13	77	7.7	30	249	99
1000-1100	14	91	7.1	32	263	105
1100-1200	12	103	8.3	27	234	94
1200-1300	18	121	5.6	43	317	127
1300-1400	22	143	4.5	54	368	147
1400-1500	65	208	1.5	180	823	329
1500-1600	83	291	1.2	237	987	395
1600-1700	125	416	0.8	375	1339	536
1700-1800	125	541	0.8	375	1339	536
1800-1900	120	661	0.8	358	1299	519
1900-2000	124	785	0.8	372	1331	532

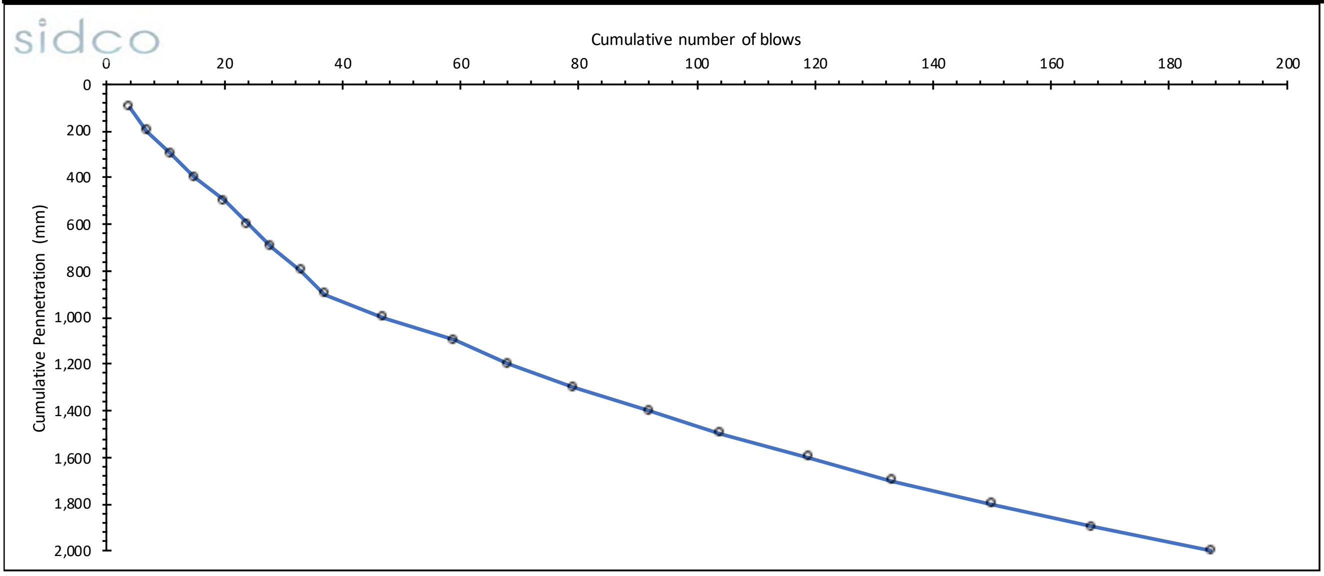


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**7**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	3	7	33.3	6	84	33
200-300	4	11	25.0	8	104	41
300-400	4	15	25.0	8	104	41
400-500	5	20	20.0	10	122	49
500-600	4	24	25.0	8	104	41
600-700	4	28	25.0	8	104	41
700-800	5	33	20.0	10	122	49
800-900	4	37	25.0	8	104	41
900-1000	10	47	10.0	22	205	82
1000-1100	12	59	8.3	27	234	94
1100-1200	9	68	11.1	20	189	76
1200-1300	11	79	9.1	25	220	88
1300-1400	13	92	7.7	30	249	99
1400-1500	12	104	8.3	27	234	94
1500-1600	15	119	6.7	35	277	111
1600-1700	14	133	7.1	32	263	105
1700-1800	17	150	5.9	40	304	121
1800-1900	17	167	5.9	40	304	121
1900-2000	20	187	5.0	48	343	137



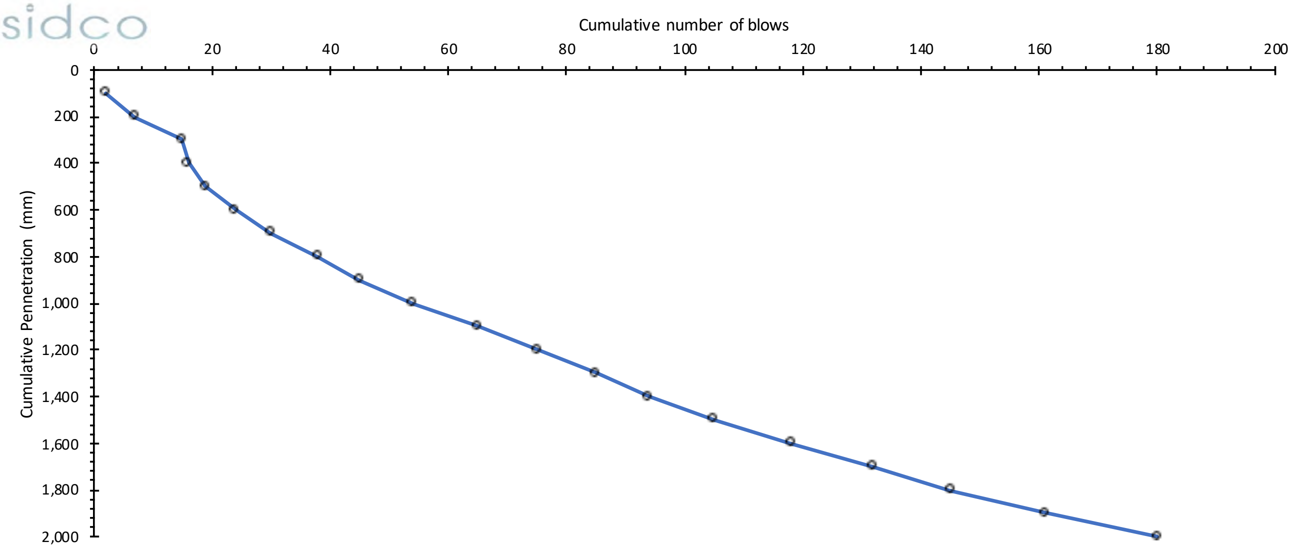
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	Hdh. Kulhudhuffushi		03/02/2023		DCP#	8
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	2	2	50.0	4	62	25
100-200	5	7	20.0	10	122	49
200-300	8	15	12.5	17	173	69
300-400	1	16	100.0	2	37	15
400-500	3	19	33.3	6	84	33
500-600	5	24	20.0	10	122	49
600-700	6	30	16.7	13	140	56
700-800	8	38	12.5	17	173	69
800-900	7	45	14.3	15	157	63
900-1000	9	54	11.1	20	189	76
1000-1100	11	65	9.1	25	220	88
1100-1200	10	75	10.0	22	205	82
1200-1300	10	85	10.0	22	205	82
1300-1400	9	94	11.1	20	189	76
1400-1500	11	105	9.1	25	220	88
1500-1600	13	118	7.7	30	249	99
1600-1700	14	132	7.1	32	263	105
1700-1800	13	145	7.7	30	249	99
1800-1900	16	161	6.3	37	290	116
1900-2000	19	180	5.3	45	330	132



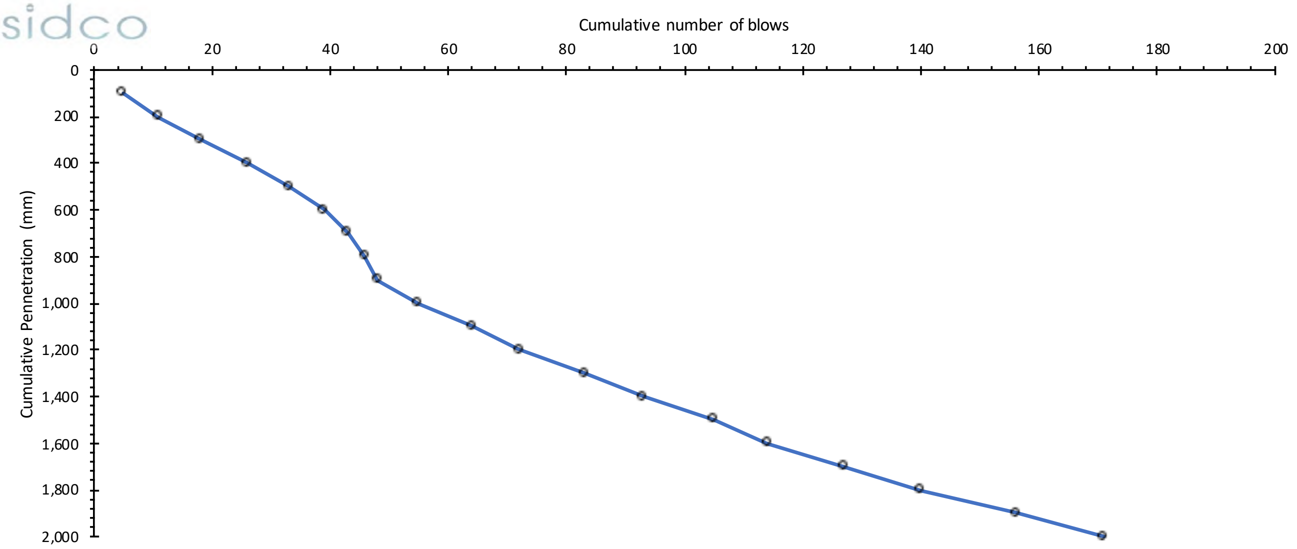
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**9**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	6	11	16.7	13	140	56
200-300	7	18	14.3	15	157	63
300-400	8	26	12.5	17	173	69
400-500	7	33	14.3	15	157	63
500-600	6	39	16.7	13	140	56
600-700	4	43	25.0	8	104	41
700-800	3	46	33.3	6	84	33
800-900	2	48	50.0	4	62	25
900-1000	7	55	14.3	15	157	63
1000-1100	9	64	11.1	20	189	76
1100-1200	8	72	12.5	17	173	69
1200-1300	11	83	9.1	25	220	88
1300-1400	10	93	10.0	22	205	82
1400-1500	12	105	8.3	27	234	94
1500-1600	9	114	11.1	20	189	76
1600-1700	13	127	7.7	30	249	99
1700-1800	13	140	7.7	30	249	99
1800-1900	16	156	6.3	37	290	116
1900-2000	15	171	6.7	35	277	111



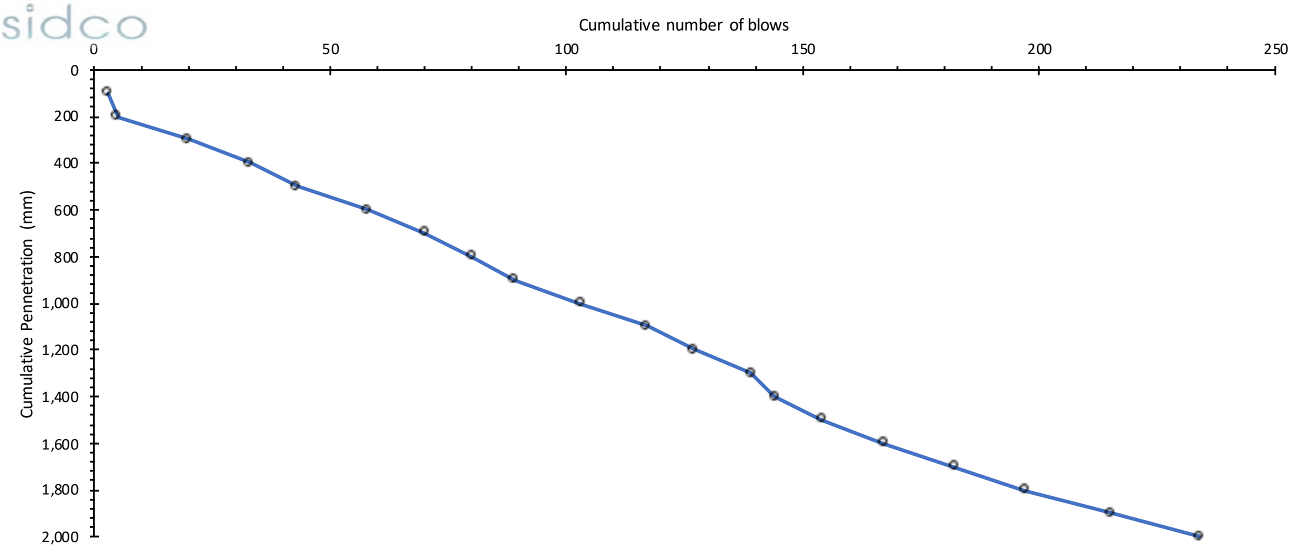
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Hdh. Kulhudhuffushi**		**03/02/2023**		**DCP#**	**10**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	3	3	33.3	6	84	33
100-200	2	5	50.0	4	62	25
200-300	15	20	6.7	35	277	111
300-400	13	33	7.7	30	249	99
400-500	10	43	10.0	22	205	82
500-600	15	58	6.7	35	277	111
600-700	12	70	8.3	27	234	94
700-800	10	80	10.0	22	205	82
800-900	9	89	11.1	20	189	76
900-1000	14	103	7.1	32	263	105
1000-1100	14	117	7.1	32	263	105
1100-1200	10	127	10.0	22	205	82
1200-1300	12	139	8.3	27	234	94
1300-1400	5	144	20.0	10	122	49
1400-1500	10	154	10.0	22	205	82
1500-1600	13	167	7.7	30	249	99
1600-1700	15	182	6.7	35	277	111
1700-1800	15	197	6.7	35	277	111
1800-1900	18	215	5.6	43	317	127
1900-2000	19	234	5.3	45	330	132



APPENDIX 4: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

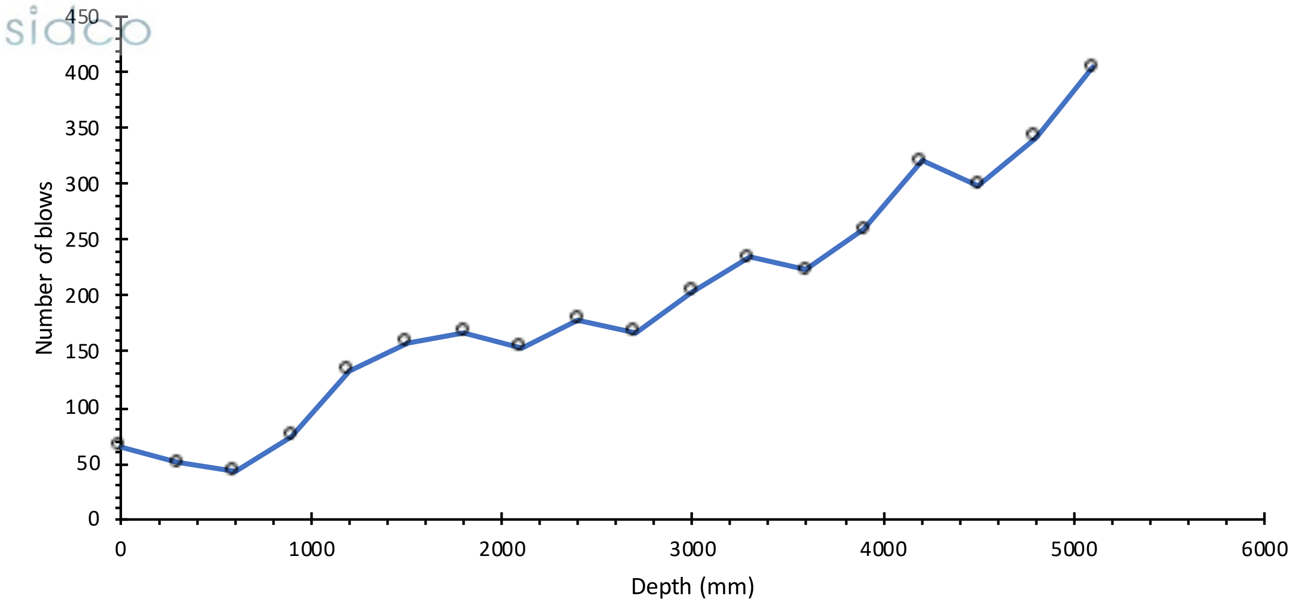
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location: Kulhudhuffushi | **Date:** 03/02/2023 | **MP#** 1

Depth (mm)	Number of Blows, N_{MP}	Cumulative Number of Blows	Bearing Capacity kPa	Bearing Capacity
0-300	65	65	269	107
300-600	51	116	224	90
600-900	43	159	183	73
900-1200	74	233	290	116
1200-1500	134	367	392	157
1500-1800	158	525	423	169
1800-2100	167	692	434	173
2100-2400	154	846	418	167
2400-2700	179	1025	447	179
2700-3000	168	1193	435	174
3000-3300	204	1397	474	190
3300-3600	235	1632	505	202
3600-3900	223	1855	493	197
3900-4200	259	2114	527	211
4200-4500	321	2435	578	231
4500-4800	299	2734	561	224
4800-5100	342	3076	595	238
5100-5400	405	3481	640	256
5400-5700				
5700-6000				



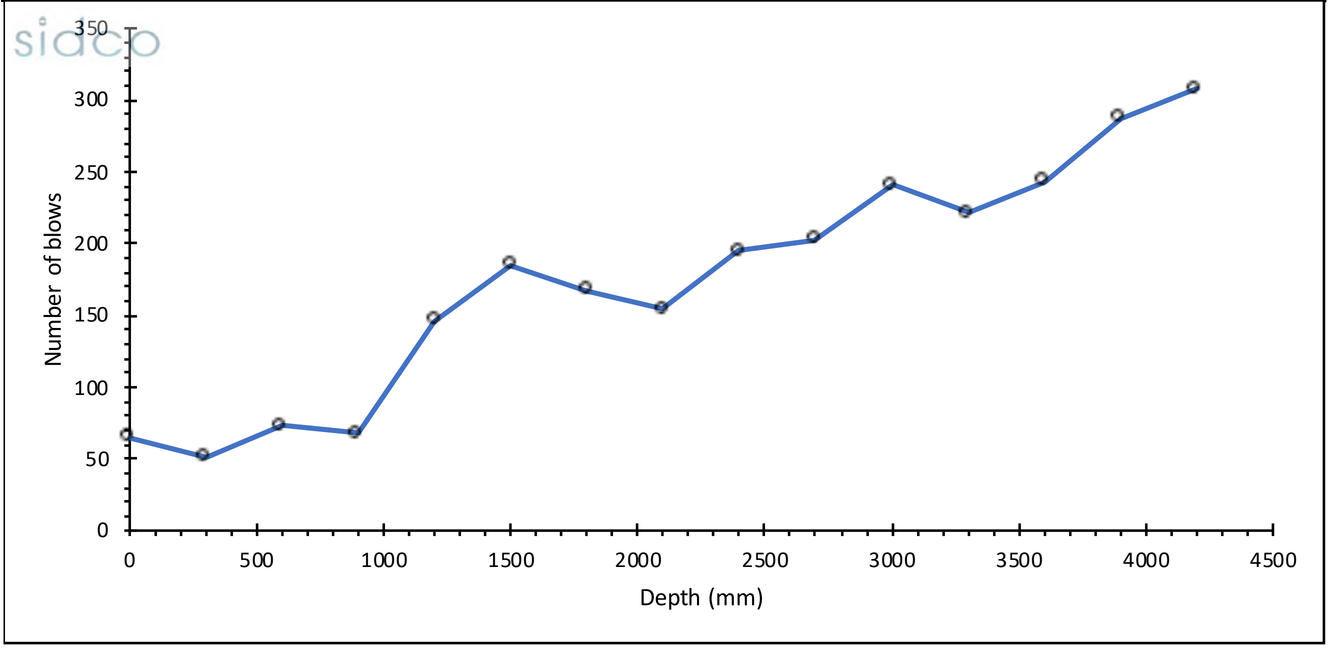
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Kulhudhuffushi**	**Date:**	**03/02/2023**	**MP#**	**2**
Depth (mm)		**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity kPa**
0-300		65	65	269	107
300-600		51	116	224	90
600-900		73	189	288	115
900-1200		68	257	276	111
1200-1500		146	403	408	163
1500-1800		185	588	454	182
1800-2100		167	755	434	173
2100-2400		154	909	418	167
2400-2700		195	1104	465	186
2700-3000		203	1307	473	189
3000-3300		241	1548	510	204
3300-3600		221	1769	491	196
3600-3900		243	2012	512	205
3900-4200		287	2299	551	220
4200-4500		308	2607	568	227
4500-4800		>400 (possibly isolated rock boulder)			
4800-5100					
5100-5400					
5400-5700					
5700-6000					



APPENDIX 5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

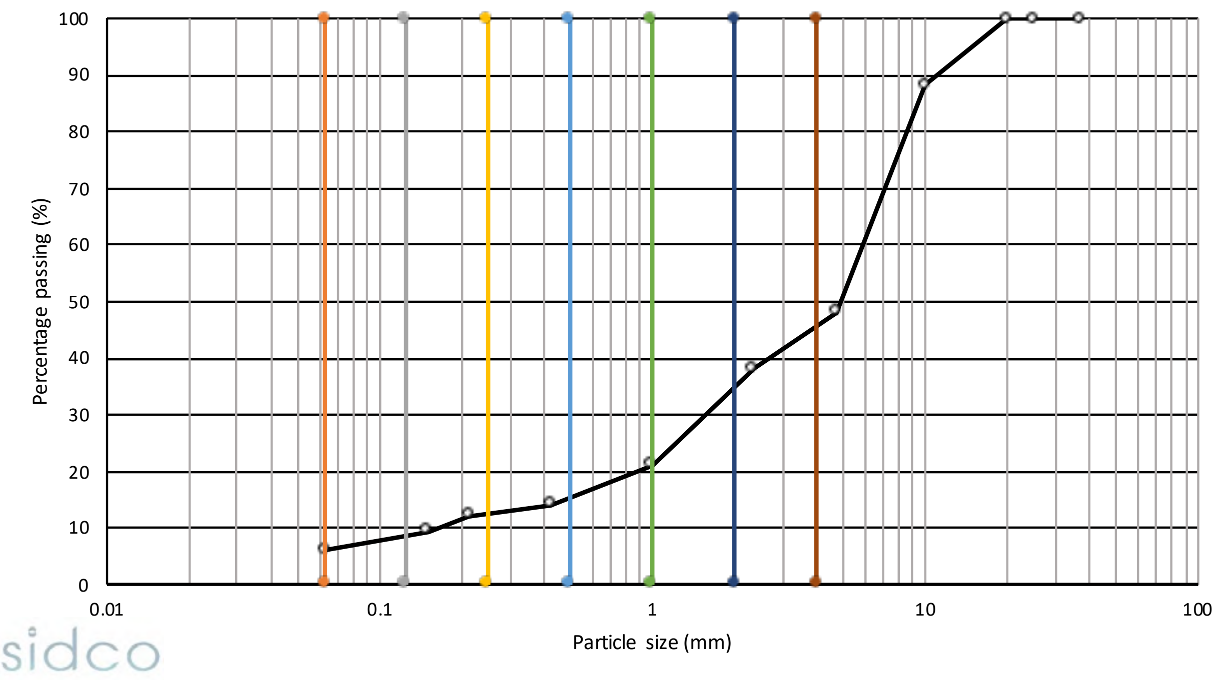
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH1	**Depth (m)**	0.0		**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	212	100.0
2	**25**	0	0	0.0	212	100.0
3	**20**	0	0	0.0	212	100.0
4	**10**	25	25	11.8	187	88.2
5	**4.75**	85	110	51.9	102	48.1
8	**2.36**	21	131	61.8	81	38.2
16	**1**	36	167	78.8	45	21.2
30	**0.425**	15	182	85.8	30	14.2
50	**0.212**	4	186	87.7	26	12.3
100	**0.15**	6	192	90.6	20	9.4
200	**0.063**	7	199	93.9	13	6.1
Total weight sieved through 200 (g)				13		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				212	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.1%	2.9%	4.0%	2.0%	5.0%	15.0%	65.0%

SIDCO PVT LTD

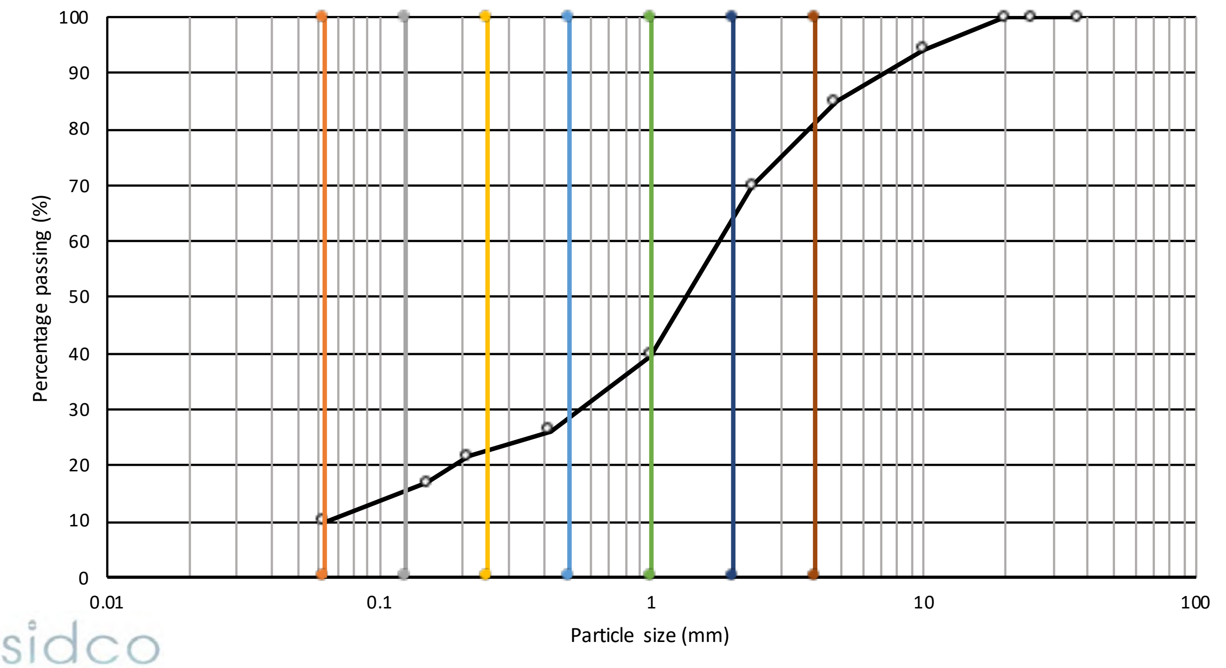
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH1	**Depth (m)**	1.0		**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	172	100.0
2	**25**	0	0	0.0	172	100.0
3	**20**	0	0	0.0	172	100.0
4	**10**	10	10	5.8	162	94.2
5	**4.75**	16	26	15.1	146	84.9
8	**2.36**	26	52	30.2	120	69.8
16	**1**	52	104	60.5	68	39.5
30	**0.425**	23	127	73.8	45	26.2
50	**0.212**	8	135	78.5	37	21.5
100	**0.15**	8	143	83.1	29	16.9
200	**0.063**	12	155	90.1	17	9.9
Total weight sieved through 200 (g)				17		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				172	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
9.9%	5.1%	7.0%	7.0%	11.0%	25.0%	35.0%

SIDCO PVT LTD

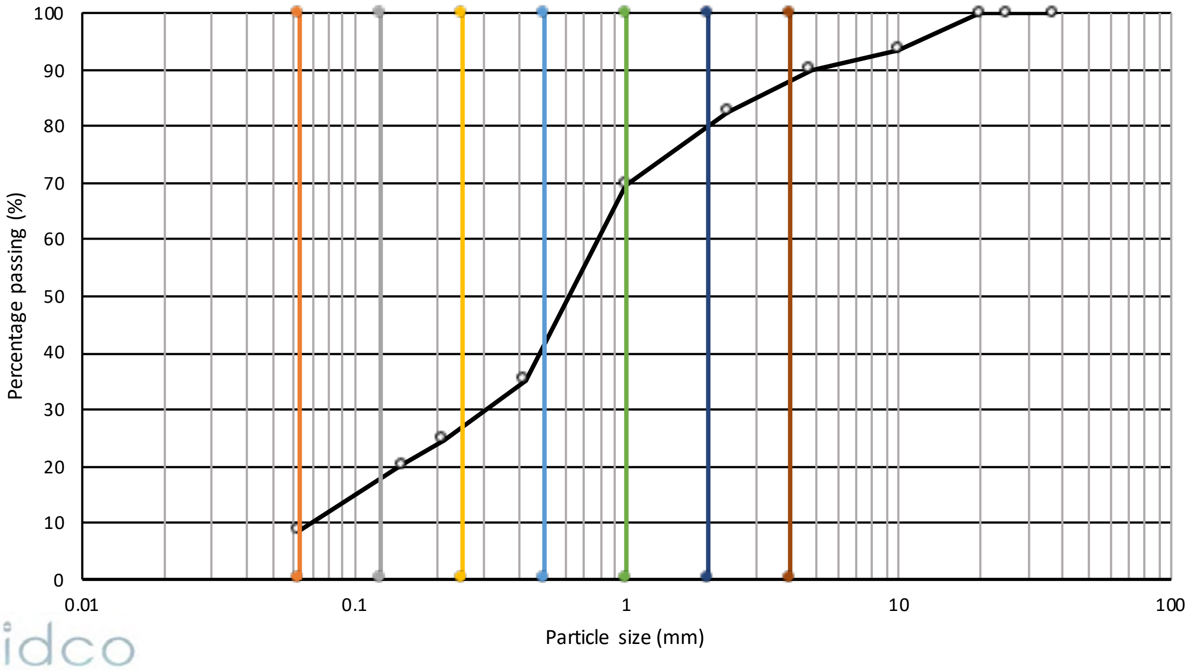
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH1	**Depth (m)**	2.0		**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	218	100.0
2	**25**	0	0	0.0	218	100.0
3	**20**	0	0	0.0	218	100.0
4	**10**	14	14	6.4	204	93.6
5	**4.75**	8	22	10.1	196	89.9
8	**2.36**	16	38	17.4	180	82.6
16	**1**	28	66	30.3	152	69.7
30	**0.425**	75	141	64.7	77	35.3
50	**0.212**	23	164	75.2	54	24.8
100	**0.15**	10	174	79.8	44	20.2
200	**0.063**	25	199	91.3	19	8.7
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				218	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.7%	10.3%	8.0%	14.0%	29.0%	10.0%	20.0%

SIDCO PVT LTD

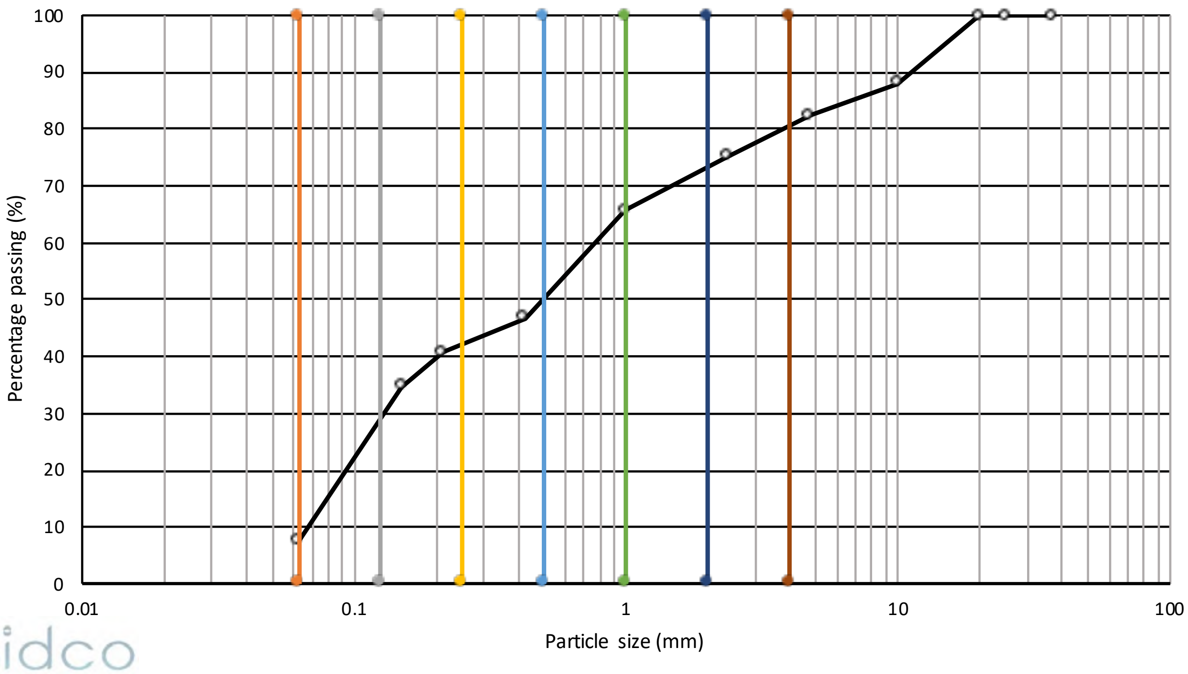
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH1	**Depth (m)**	3.0	**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	233	100.0
2	**25**	0	0	0.0	233	100.0
3	**20**	0	0	0.0	233	100.0
4	**10**	28	28	12.0	205	88.0
5	**4.75**	13	41	17.6	192	82.4
8	**2.36**	17	58	24.9	175	75.1
16	**1**	22	80	34.3	153	65.7
30	**0.425**	44	124	53.2	109	46.8
50	**0.212**	14	138	59.2	95	40.8
100	**0.15**	14	152	65.2	81	34.8
200	**0.063**	63	215	92.3	18	7.7
Total weight sieved through 200 (g)				18		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				233	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.7%	22.3%	11.0%	9.0%	16.0%	7.0%	27.0%

SIDCO PVT LTD

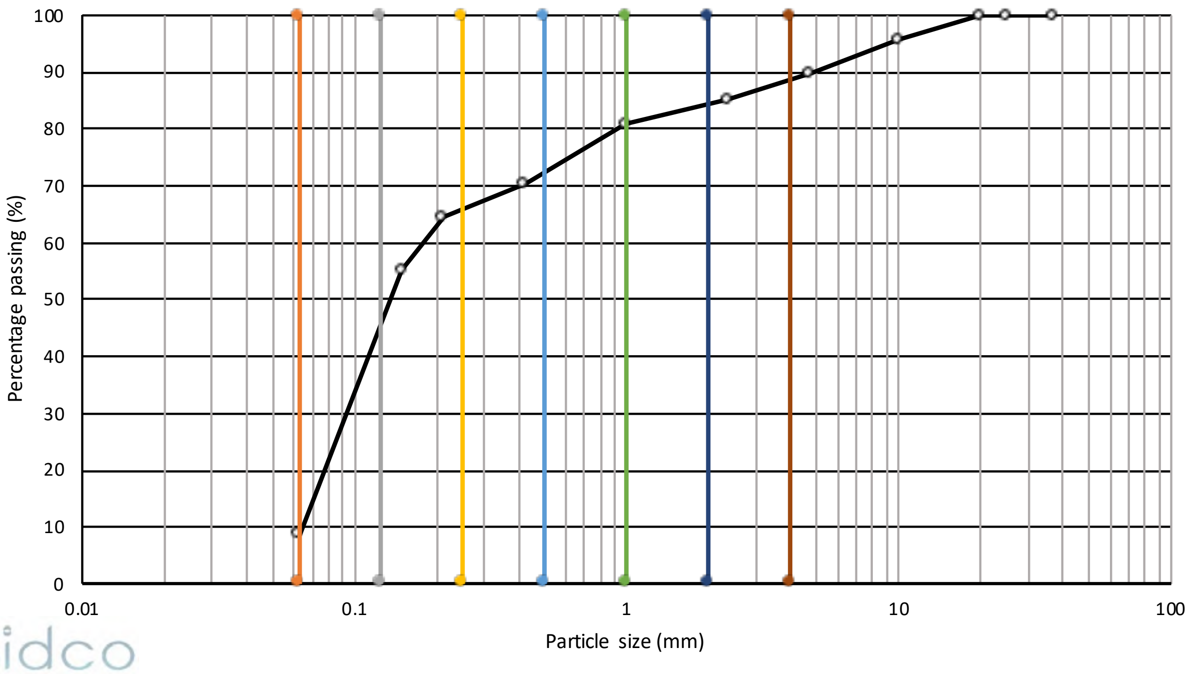
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH1	**Depth (m)**	4.5	**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	256	100.0
2	**25**	0	0	0.0	256	100.0
3	**20**	0	0	0.0	256	100.0
4	**10**	11	11	4.3	245	95.7
5	**4.75**	15	26	10.2	230	89.8
8	**2.36**	12	38	14.8	218	85.2
16	**1**	11	49	19.1	207	80.9
30	**0.425**	27	76	29.7	180	70.3
50	**0.212**	15	91	35.5	165	64.5
100	**0.15**	24	115	44.9	141	55.1
200	**0.063**	119	234	91.4	22	8.6
Total weight sieved through 200 (g)				22		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				256	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.6%	33.4%	23.0%	6.0%	9.0%	4.0%	16.0%

SIDCO PVT LTD

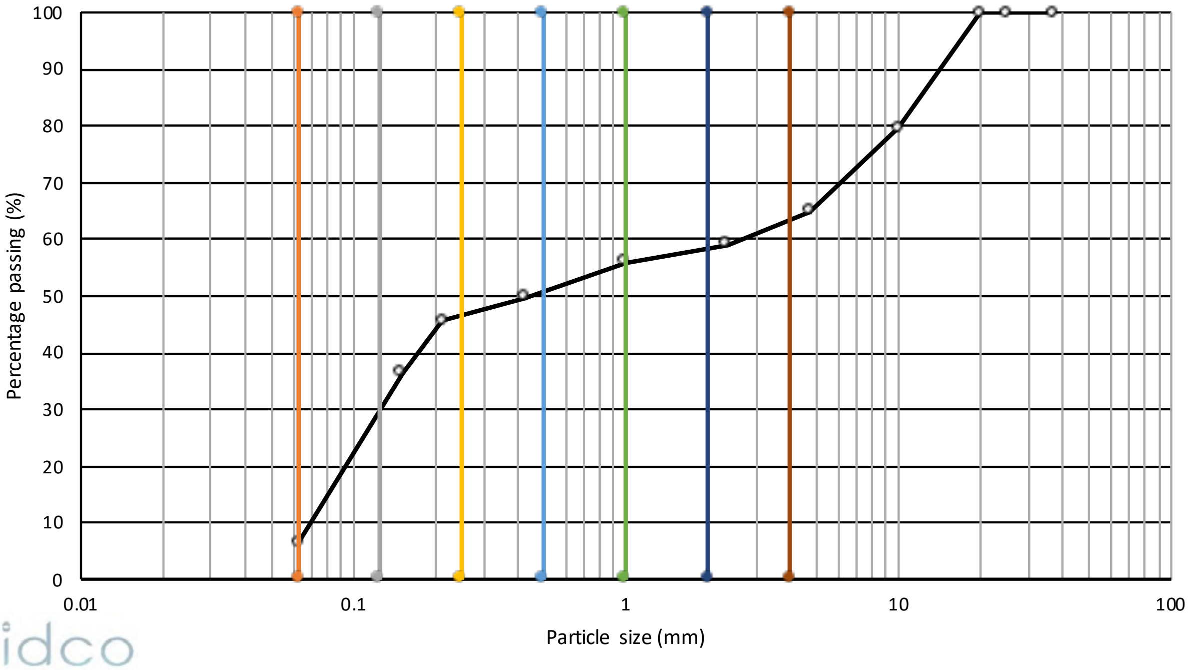
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH1	**Depth (m)**	6.0	**Test #**	**6**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	288	100.0
2	**25**	0	0	0.0	288	100.0
3	**20**	0	0	0.0	288	100.0
4	**10**	59	59	20.5	229	79.5
5	**4.75**	42	101	35.1	187	64.9
8	**2.36**	17	118	41.0	170	59.0
16	**1**	9	127	44.1	161	55.9
30	**0.425**	18	145	50.3	143	49.7
50	**0.212**	12	157	54.5	131	45.5
100	**0.15**	26	183	63.5	105	36.5
200	**0.063**	86	269	93.4	19	6.6
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				288	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.6%	23.4%	16.0%	5.0%	5.0%	3.0%	41.0%

SIDCO PVT LTD

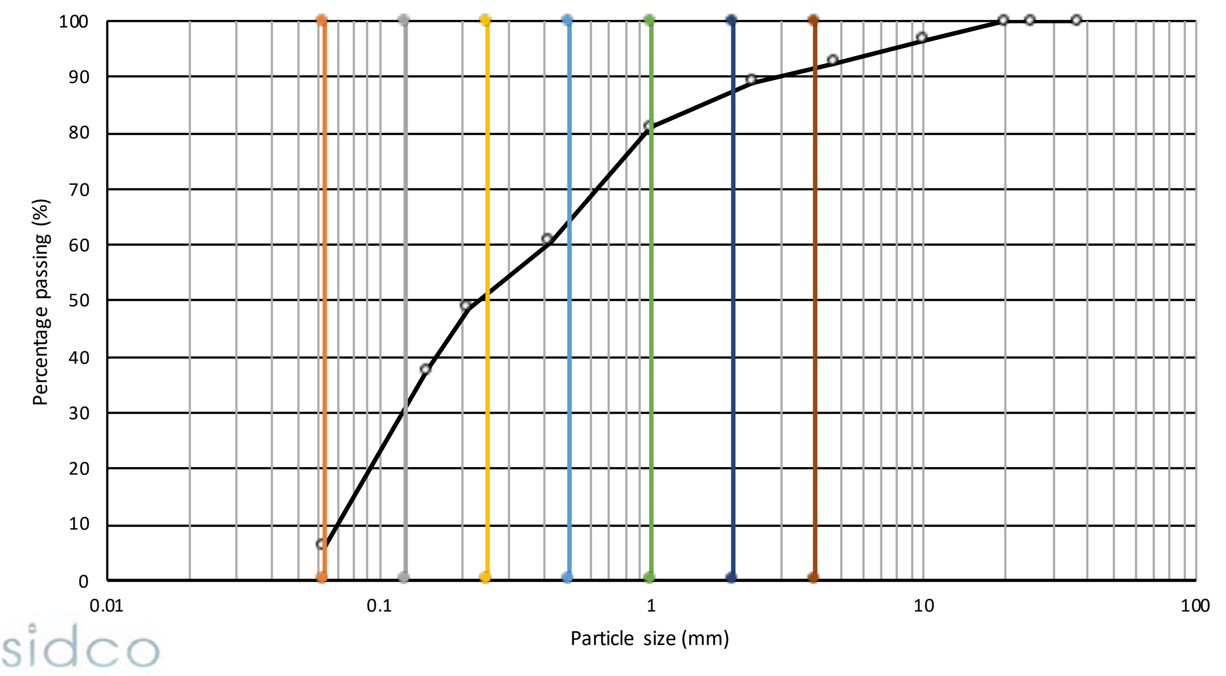
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH1	**Depth (m)**	7.5		**Test #**	**7**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	347	100.0
2	**25**	0	0	0.0	347	100.0
3	**20**	0	0	0.0	347	100.0
4	**10**	12	12	3.5	335	96.5
5	**4.75**	14	26	7.5	321	92.5
8	**2.36**	12	38	11.0	309	89.0
16	**1**	28	66	19.0	281	81.0
30	**0.425**	71	137	39.5	210	60.5
50	**0.212**	41	178	51.3	169	48.7
100	**0.15**	39	217	62.5	130	37.5
200	**0.063**	109	326	93.9	21	6.1
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				347	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.1%	23.9%	20.0%	12.0%	18.0%	8.0%	12.0%

SIDCO PVT LTD

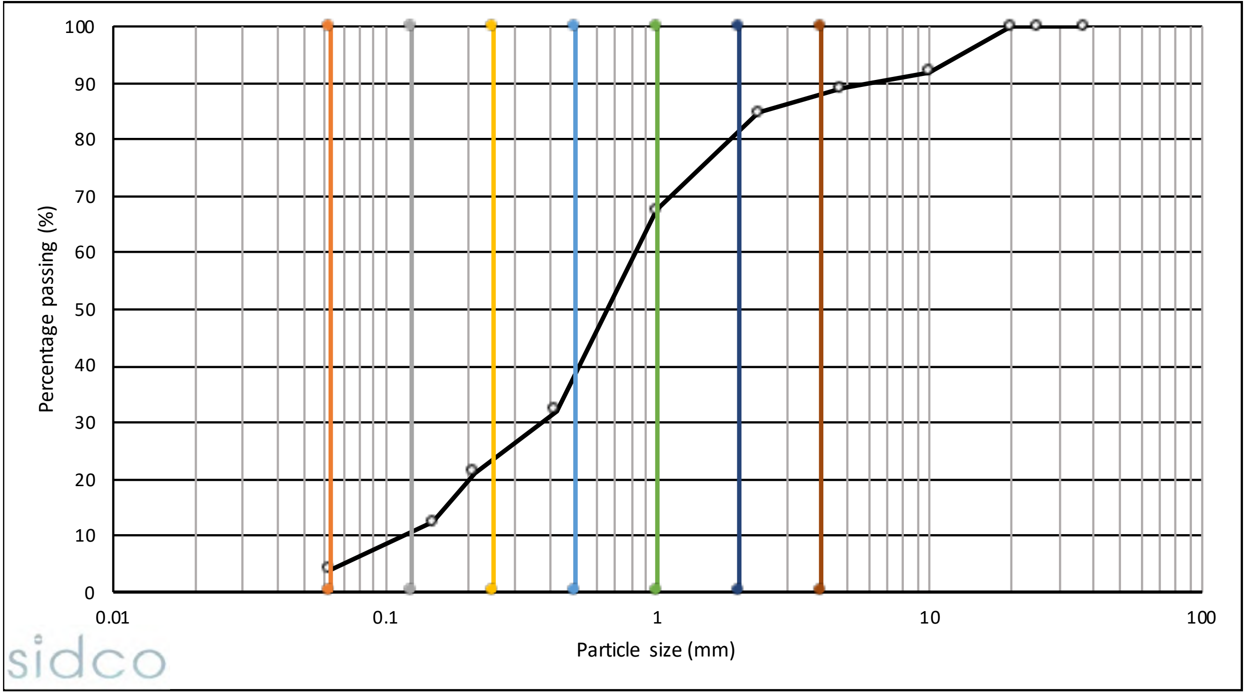
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1	
Date:	12/01/2023	**Tested by:**	SM		
BH1	**Depth (m)**	9.0	**Test #**	**8**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	299	100.0
2	**25**	0	0	0.0	299	100.0
3	**20**	0	0	0.0	299	100.0
4	**10**	24	24	8.0	275	92.0
5	**4.75**	9	33	11.0	266	89.0
8	**2.36**	13	46	15.4	253	84.6
16	**1**	51	97	32.4	202	67.6
30	**0.425**	106	203	67.9	96	32.1
50	**0.212**	33	236	78.9	63	21.1
100	**0.15**	26	262	87.6	37	12.4
200	**0.063**	25	287	96.0	12	4.0
Total weight sieved through 200 (g)				12		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				299	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
4.0%	6.0%	12.0%	17.0%	29.0%	13.0%	19.0%

SIDCO PVT LTD

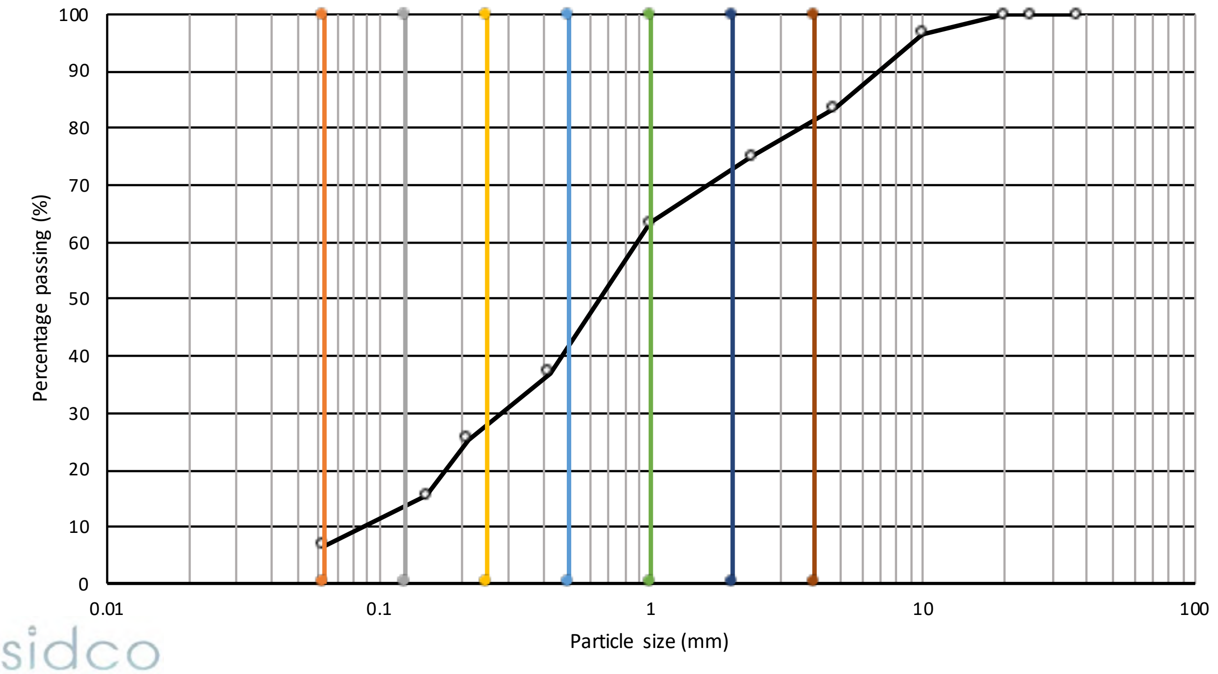
M. Asrafeegee, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH1	**Depth (m)**	10.5	**Test #**	**9**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	316	100.0
2	**25**	0	0	0.0	316	100.0
3	**20**	0	0	0.0	316	100.0
4	**10**	11	11	3.5	305	96.5
5	**4.75**	41	52	16.5	264	83.5
8	**2.36**	27	79	25.0	237	75.0
16	**1**	37	116	36.7	200	63.3
30	**0.425**	83	199	63.0	117	37.0
50	**0.212**	37	236	74.7	80	25.3
100	**0.15**	31	267	84.5	49	15.5
200	**0.063**	28	295	93.4	21	6.6
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				316	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.6%	6.4%	16.0%	11.0%	12.0%	20.0%	28.0%

SIDCO PVT LTD

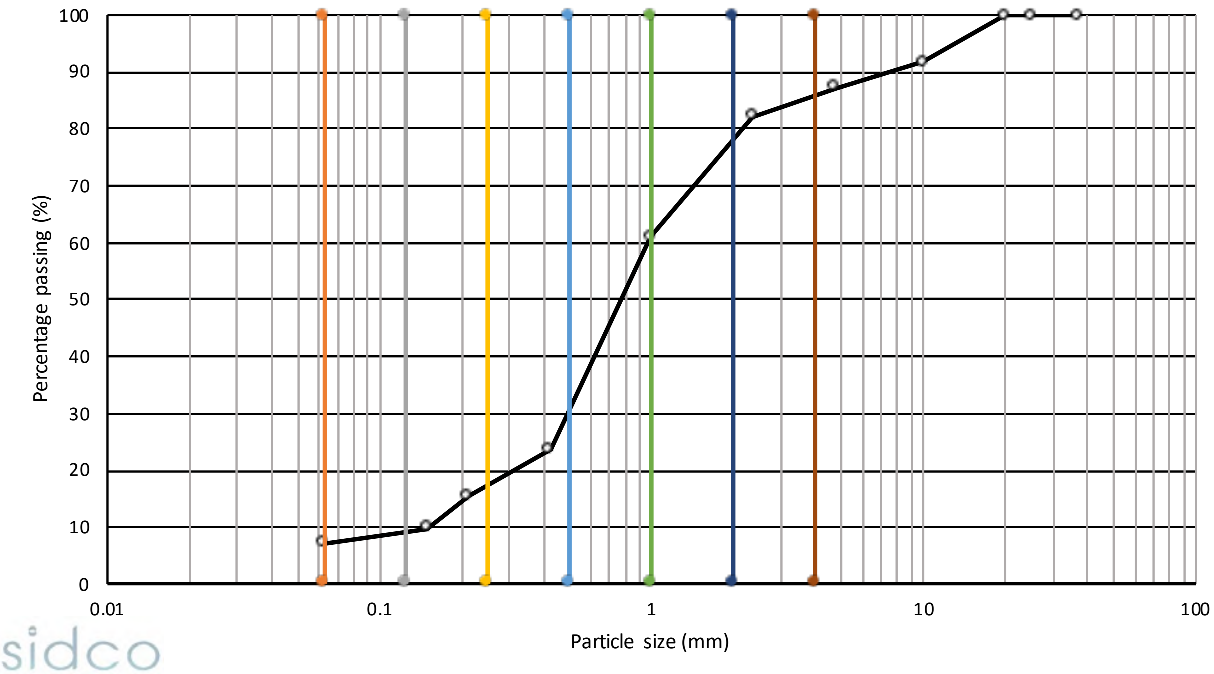
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH1	**Depth (m)**	12.0	**Test #**	**10**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	336	100.0
2	**25**	0	0	0.0	336	100.0
3	**20**	0	0	0.0	336	100.0
4	**10**	28	28	8.3	308	91.7
5	**4.75**	15	43	12.8	293	87.2
8	**2.36**	17	60	17.9	276	82.1
16	**1**	71	131	39.0	205	61.0
30	**0.425**	126	257	76.5	79	23.5
50	**0.212**	27	284	84.5	52	15.5
100	**0.15**	19	303	90.2	33	9.8
200	**0.063**	9	312	92.9	24	7.1
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				336	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.1%	2.9%	8.0%	12.0%	30.0%	19.0%	21.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

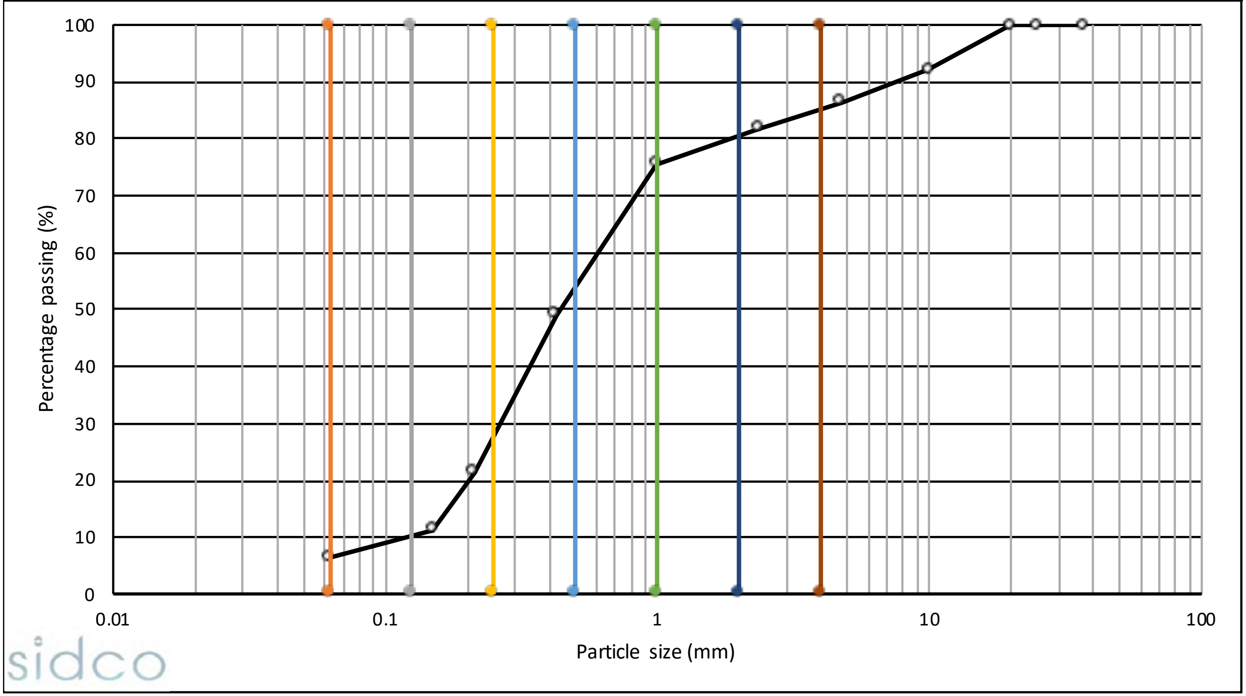
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**		SM	
BH1	**Depth (m)**	13.5		**Test #**	**11**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	369	100.0
2	**25**	0	0	0.0	369	100.0
3	**20**	0	0	0.0	369	100.0
4	**10**	29	29	7.9	340	92.1
5	**4.75**	21	50	13.6	319	86.4
8	**2.36**	17	67	18.2	302	81.8
16	**1**	23	90	24.4	279	75.6
30	**0.425**	98	188	50.9	181	49.1
50	**0.212**	102	290	78.6	79	21.4
100	**0.15**	37	327	88.6	42	11.4
200	**0.063**	18	345	93.5	24	6.5
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				369	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.5%	3.5%	18.0%	24.0%	23.0%	5.0%	20.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

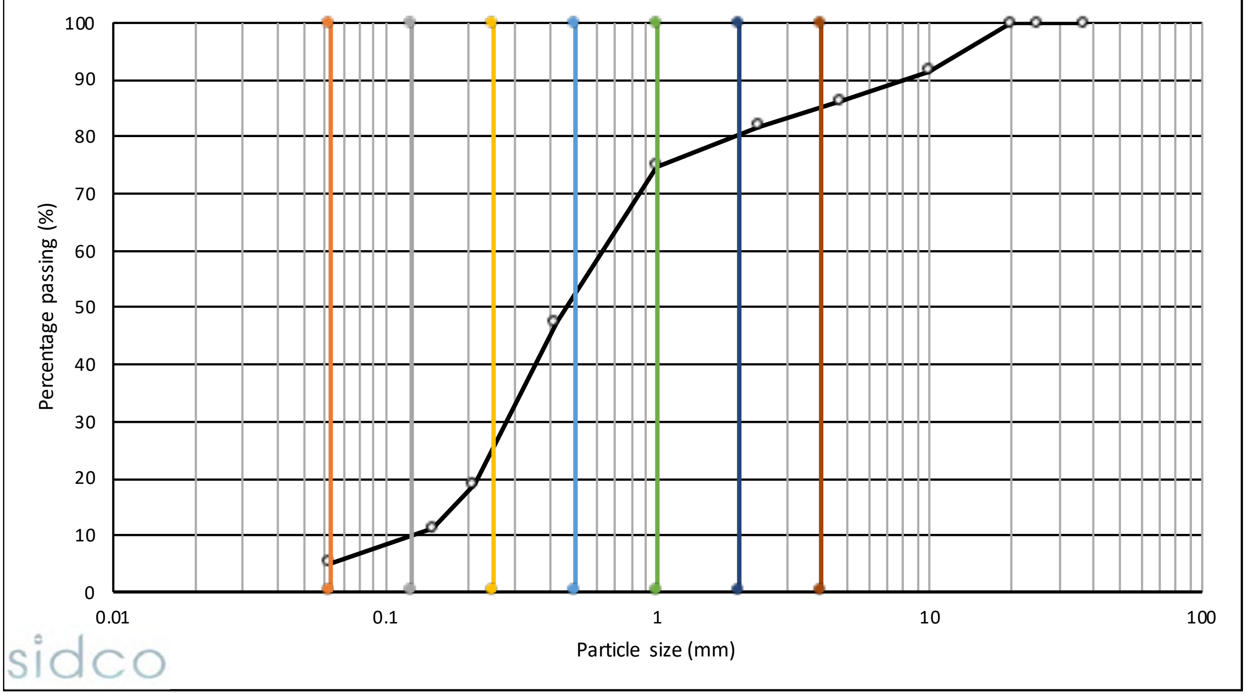
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH1	**Depth (m)**	15.0		**Test #**	**12**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	374	100.0
2	**25**	0	0	0.0	374	100.0
3	**20**	0	0	0.0	374	100.0
4	**10**	32	32	8.6	342	91.4
5	**4.75**	19	51	13.6	323	86.4
8	**2.36**	17	68	18.2	306	81.8
16	**1**	26	94	25.1	280	74.9
30	**0.425**	103	197	52.7	177	47.3
50	**0.212**	106	303	81.0	71	19.0
100	**0.15**	29	332	88.8	42	11.2
200	**0.063**	23	355	94.9	19	5.1
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				374	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.1%	4.9%	15.0%	26.0%	23.0%	6.0%	20.0%

SIDCO PVT LTD

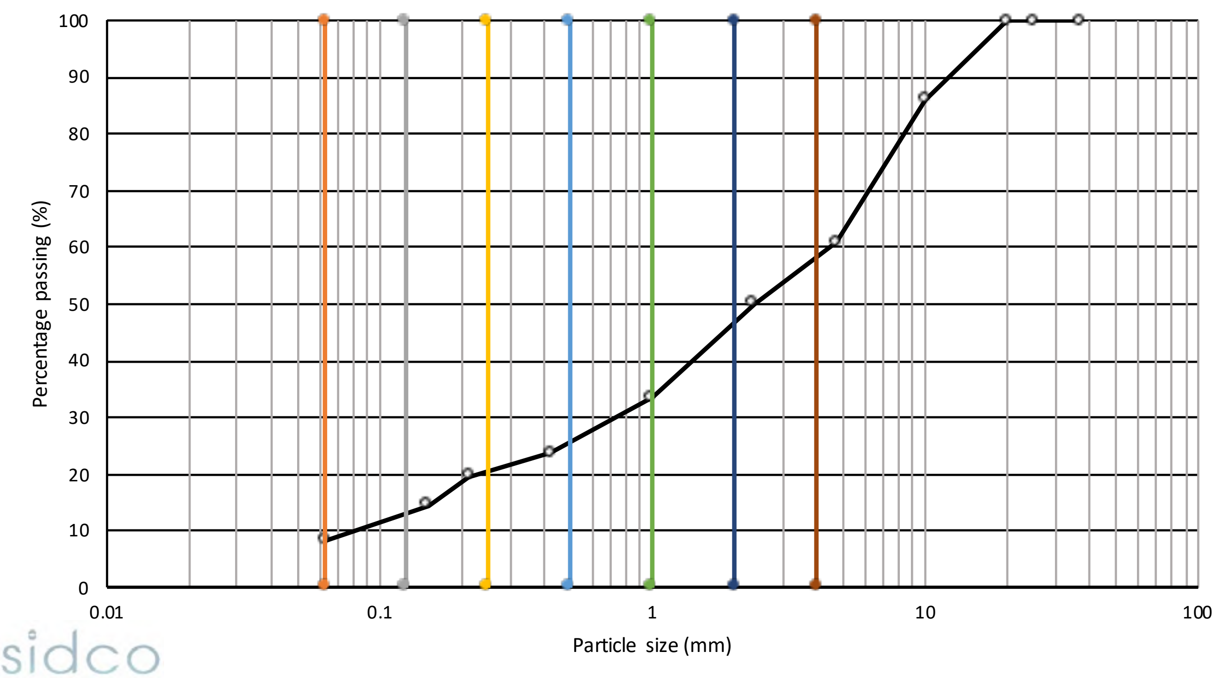
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH2	**Depth (m)**	0.0		**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	194	100.0
2	**25**	0	0	0.0	194	100.0
3	**20**	0	0	0.0	194	100.0
4	**10**	27	27	13.9	167	86.1
5	**4.75**	49	76	39.2	118	60.8
8	**2.36**	21	97	50.0	97	50.0
16	**1**	32	129	66.5	65	33.5
30	**0.425**	19	148	76.3	46	23.7
50	**0.212**	8	156	80.4	38	19.6
100	**0.15**	10	166	85.6	28	14.4
200	**0.063**	12	178	91.8	16	8.2
Total weight sieved through 200 (g)				16		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				194	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.2%	4.8%	8.0%	4.0%	7.0%	14.0%	54.0%

SIDCO PVT LTD

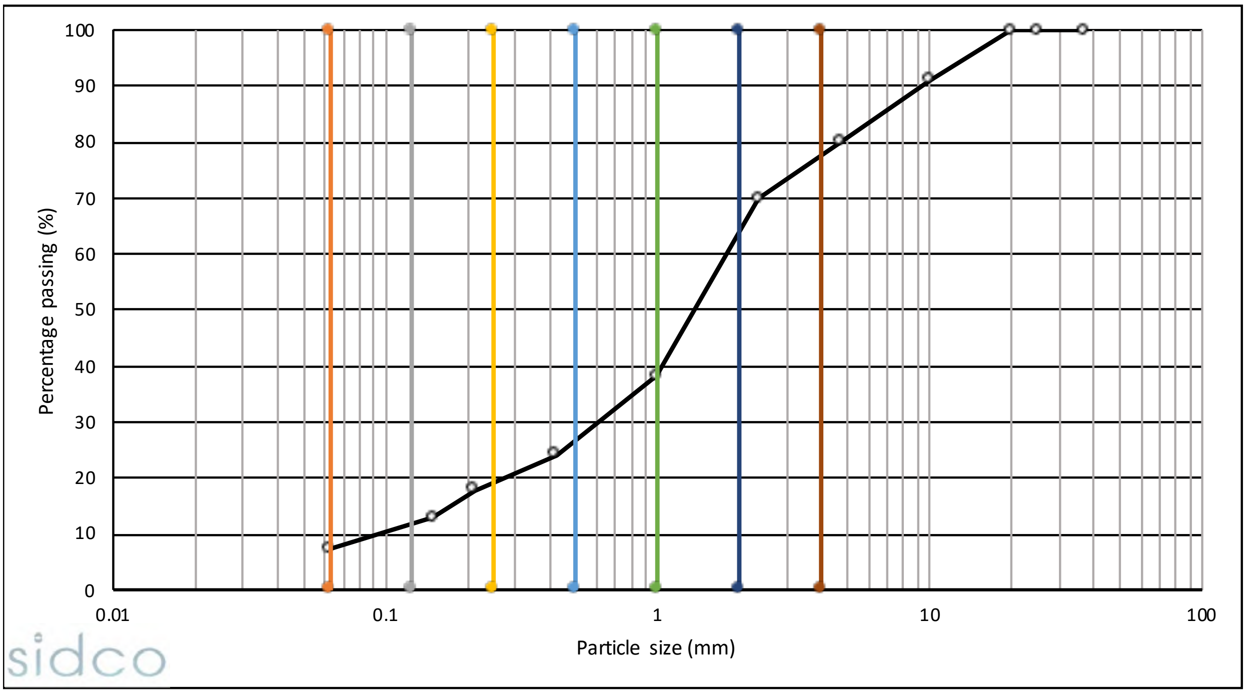
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH2	**Depth (m)**	1.0		**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	202	100.0
2	**25**	0	0	0.0	202	100.0
3	**20**	0	0	0.0	202	100.0
4	**10**	18	18	8.9	184	91.1
5	**4.75**	22	40	19.8	162	80.2
8	**2.36**	21	61	30.2	141	69.8
16	**1**	64	125	61.9	77	38.1
30	**0.425**	28	153	75.7	49	24.3
50	**0.212**	13	166	82.2	36	17.8
100	**0.15**	10	176	87.1	26	12.9
200	**0.063**	11	187	92.6	15	7.4
Total weight sieved through 200 (g)				15		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				202	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.4%	4.6%	8.0%	6.0%	13.0%	24.0%	37.0%

SIDCO PVT LTD

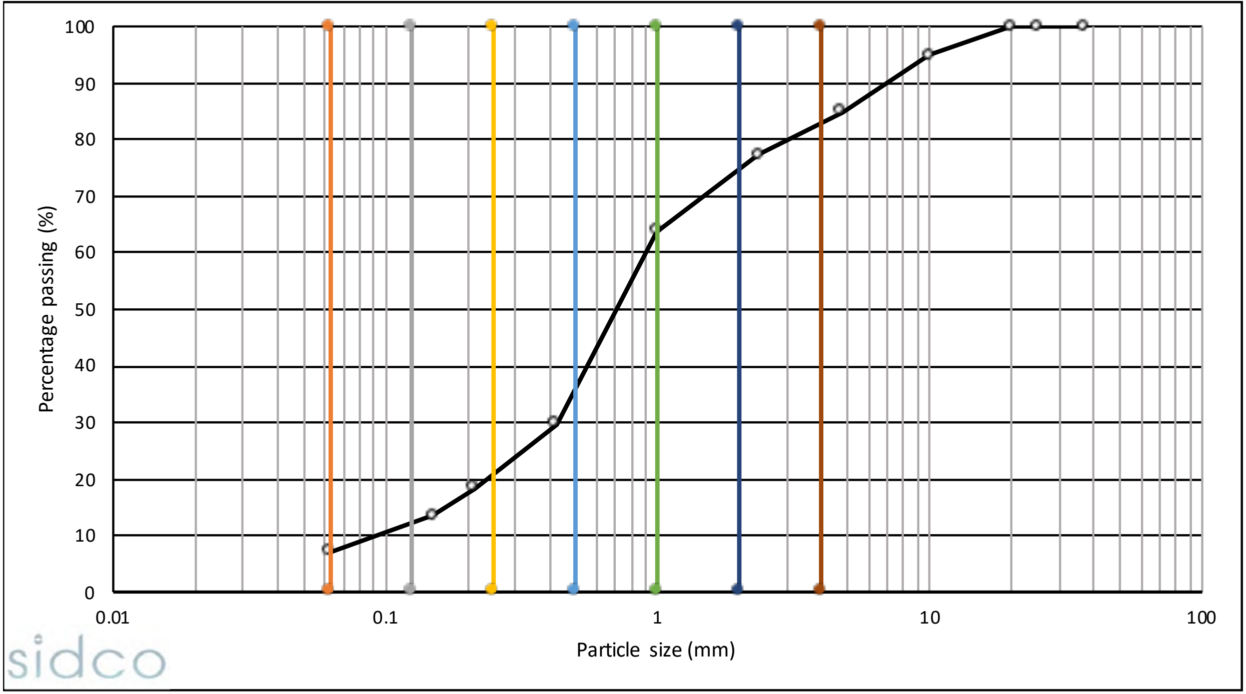
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH2	**Depth (m)**	2.0	**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	238	100.0
2	**25**	0	0	0.0	238	100.0
3	**20**	0	0	0.0	238	100.0
4	**10**	12	12	5.0	226	95.0
5	**4.75**	24	36	15.1	202	84.9
8	**2.36**	18	54	22.7	184	77.3
16	**1**	32	86	36.1	152	63.9
30	**0.425**	81	167	70.2	71	29.8
50	**0.212**	27	194	81.5	44	18.5
100	**0.15**	12	206	86.6	32	13.4
200	**0.063**	15	221	92.9	17	7.1
Total weight sieved through 200 (g)				17		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				238	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.1%	4.9%	9.0%	15.0%	27.0%	12.0%	25.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

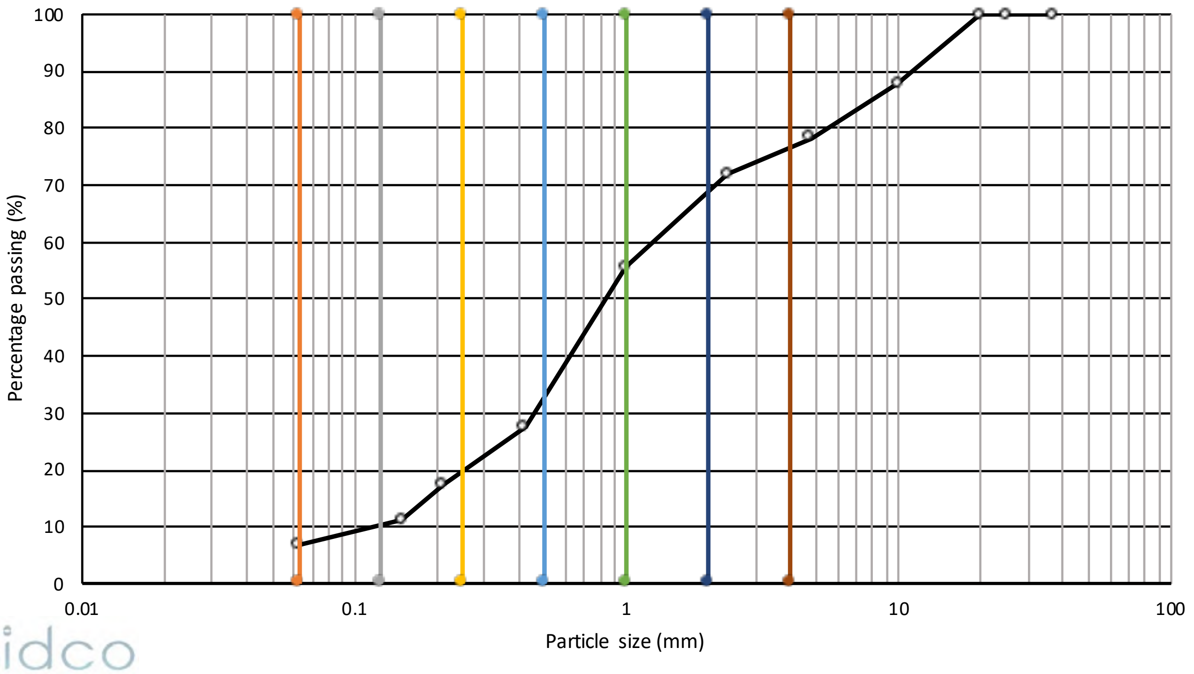
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**		SM	
BH2	**Depth (m)**	3.0		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	189	100.0
2	**25**	0	0	0.0	189	100.0
3	**20**	0	0	0.0	189	100.0
4	**10**	23	23	12.2	166	87.8
5	**4.75**	18	41	21.7	148	78.3
8	**2.36**	12	53	28.0	136	72.0
16	**1**	31	84	44.4	105	55.6
30	**0.425**	53	137	72.5	52	27.5
50	**0.212**	19	156	82.5	33	17.5
100	**0.15**	12	168	88.9	21	11.1
200	**0.063**	8	176	93.1	13	6.9
Total weight sieved through 200 (g)				13		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				189	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.9%	3.1%	10.0%	12.0%	24.0%	13.0%	31.0%

SIDCO PVT LTD

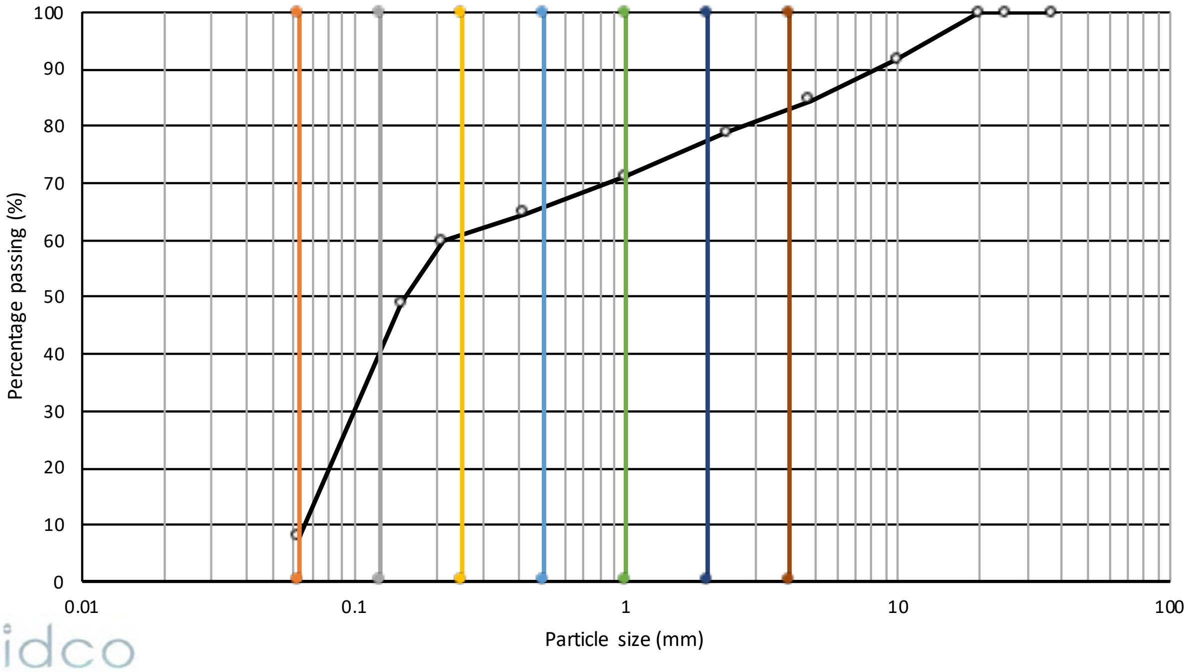
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH2	**Depth (m)**	4.5	**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	266	100.0
2	**25**	0	0	0.0	266	100.0
3	**20**	0	0	0.0	266	100.0
4	**10**	22	22	8.3	244	91.7
5	**4.75**	19	41	15.4	225	84.6
8	**2.36**	15	56	21.1	210	78.9
16	**1**	21	77	28.9	189	71.1
30	**0.425**	17	94	35.3	172	64.7
50	**0.212**	13	107	40.2	159	59.8
100	**0.15**	29	136	51.1	130	48.9
200	**0.063**	109	245	92.1	21	7.9
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				266	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.9%	32.1%	21.0%	4.0%	6.0%	6.0%	23.0%

SIDCO PVT LTD

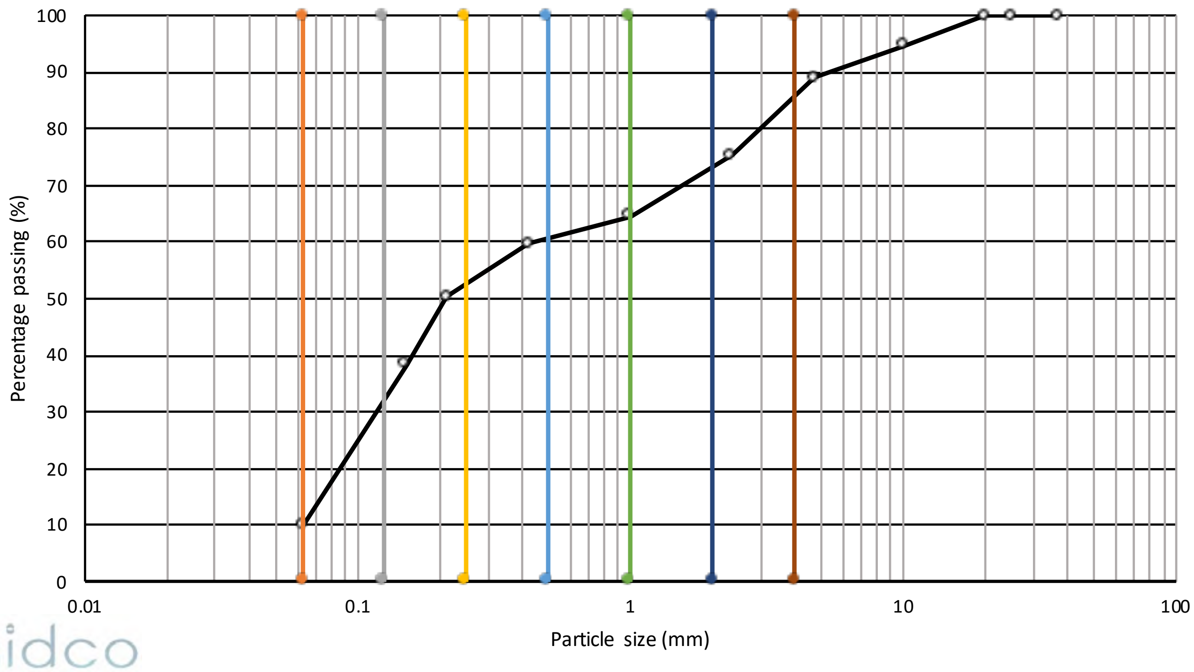
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**		SM	
BH2	**Depth (m)**	6.0		**Test #**	**6**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	243	100.0
2	**25**	0	0	0.0	243	100.0
3	**20**	0	0	0.0	243	100.0
4	**10**	13	13	5.3	230	94.7
5	**4.75**	14	27	11.1	216	88.9
8	**2.36**	33	60	24.7	183	75.3
16	**1**	26	86	35.4	157	64.6
30	**0.425**	12	98	40.3	145	59.7
50	**0.212**	23	121	49.8	122	50.2
100	**0.15**	29	150	61.7	93	38.3
200	**0.063**	69	219	90.1	24	9.9
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				243	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
9.9%	21.1%	21.0%	8.0%	5.0%	8.0%	27.0%

SIDCO PVT LTD

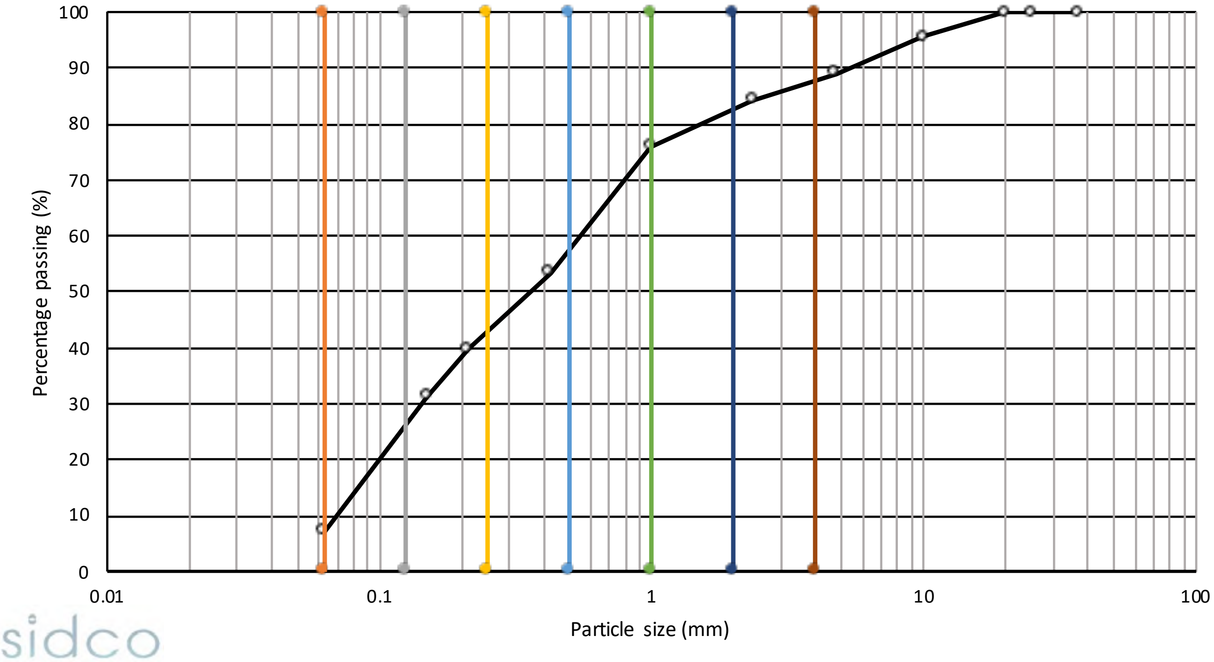
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH2	**Depth (m)**	7.5	**Test #**	**7**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	376	100.0
2	**25**	0	0	0.0	376	100.0
3	**20**	0	0	0.0	376	100.0
4	**10**	17	17	4.5	359	95.5
5	**4.75**	24	41	10.9	335	89.1
8	**2.36**	18	59	15.7	317	84.3
16	**1**	31	90	23.9	286	76.1
30	**0.425**	85	175	46.5	201	53.5
50	**0.212**	51	226	60.1	150	39.9
100	**0.15**	32	258	68.6	118	31.4
200	**0.063**	91	349	92.8	27	7.2
Total weight sieved through 200 (g)				27		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				376	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.2%	18.8%	15.0%	16.0%	19.0%	6.0%	18.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

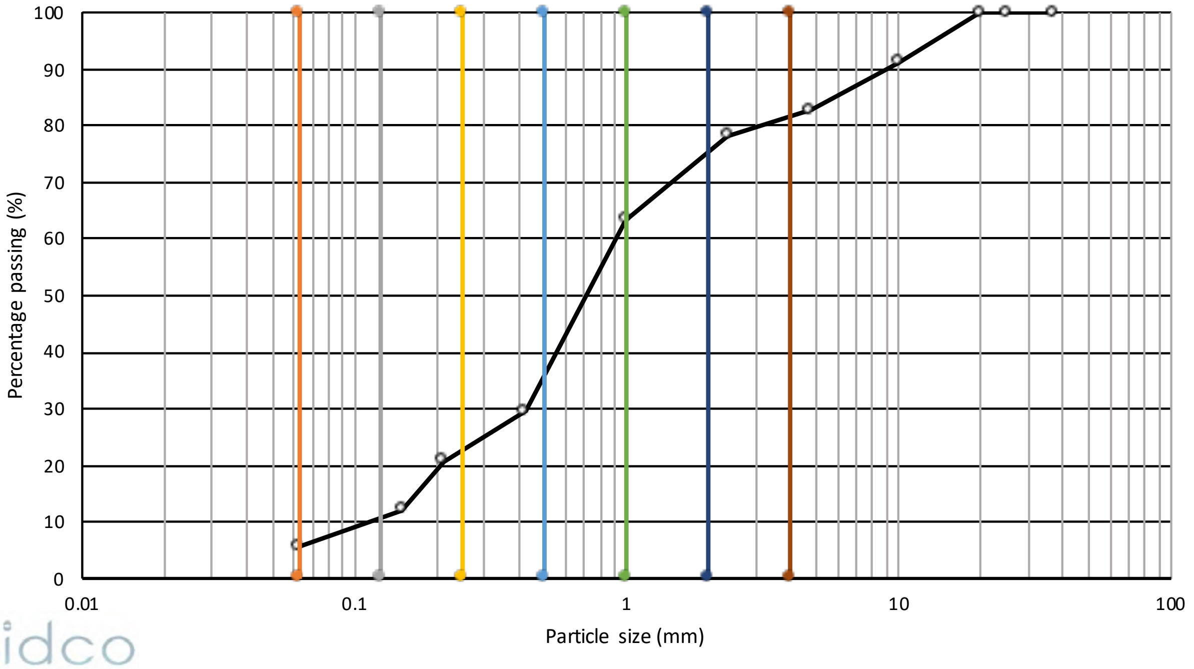
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH2	**Depth (m)**	9.0	**Test #**	**8**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	331	100.0
2	**25**	0	0	0.0	331	100.0
3	**20**	0	0	0.0	331	100.0
4	**10**	29	29	8.8	302	91.2
5	**4.75**	28	57	17.2	274	82.8
8	**2.36**	15	72	21.8	259	78.2
16	**1**	49	121	36.6	210	63.4
30	**0.425**	112	233	70.4	98	29.6
50	**0.212**	29	262	79.2	69	20.8
100	**0.15**	29	291	87.9	40	12.1
200	**0.063**	21	312	94.3	19	5.7
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				331	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.7%	5.3%	10.0%	15.0%	26.0%	14.0%	24.0%

SIDCO PVT LTD

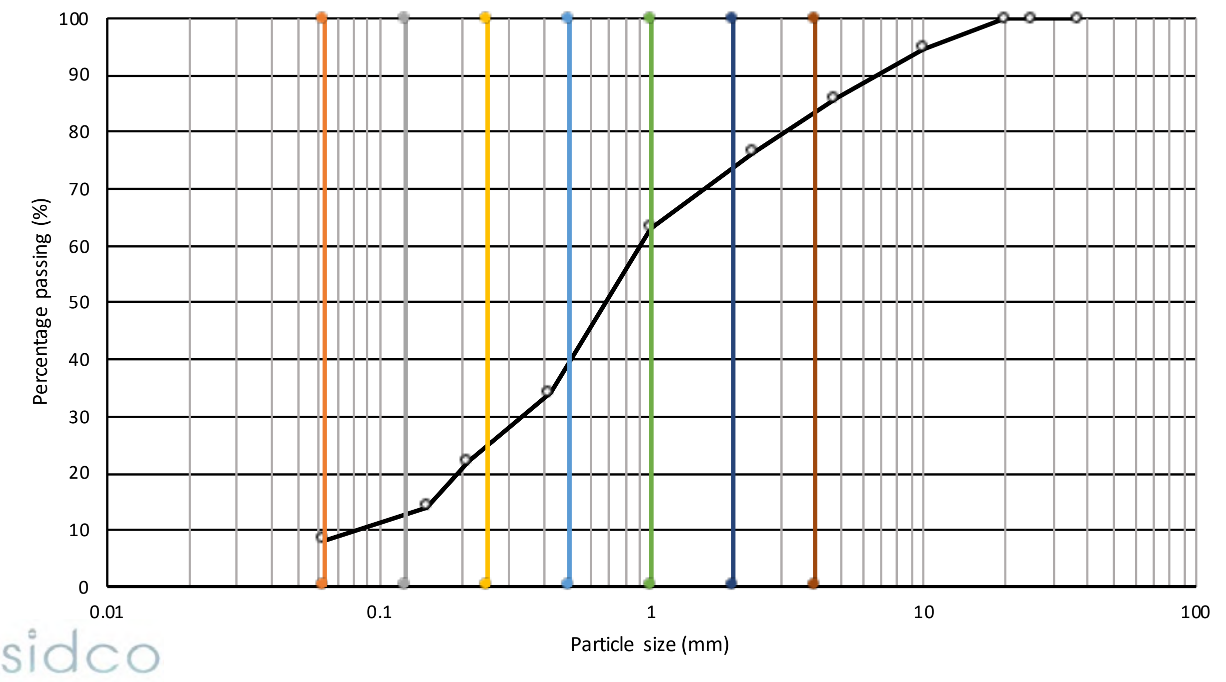
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH2	**Depth (m)**	10.5		**Test #**	**9**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	355	100.0
2	**25**	0	0	0.0	355	100.0
3	**20**	0	0	0.0	355	100.0
4	**10**	19	19	5.4	336	94.6
5	**4.75**	31	50	14.1	305	85.9
8	**2.36**	34	84	23.7	271	76.3
16	**1**	47	131	36.9	224	63.1
30	**0.425**	103	234	65.9	121	34.1
50	**0.212**	43	277	78.0	78	22.0
100	**0.15**	28	305	85.9	50	14.1
200	**0.063**	21	326	91.8	29	8.2
Total weight sieved through 200 (g)				29		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				355	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.2%	3.8%	12.0%	16.0%	22.0%	12.0%	26.0%

SIDCO PVT LTD

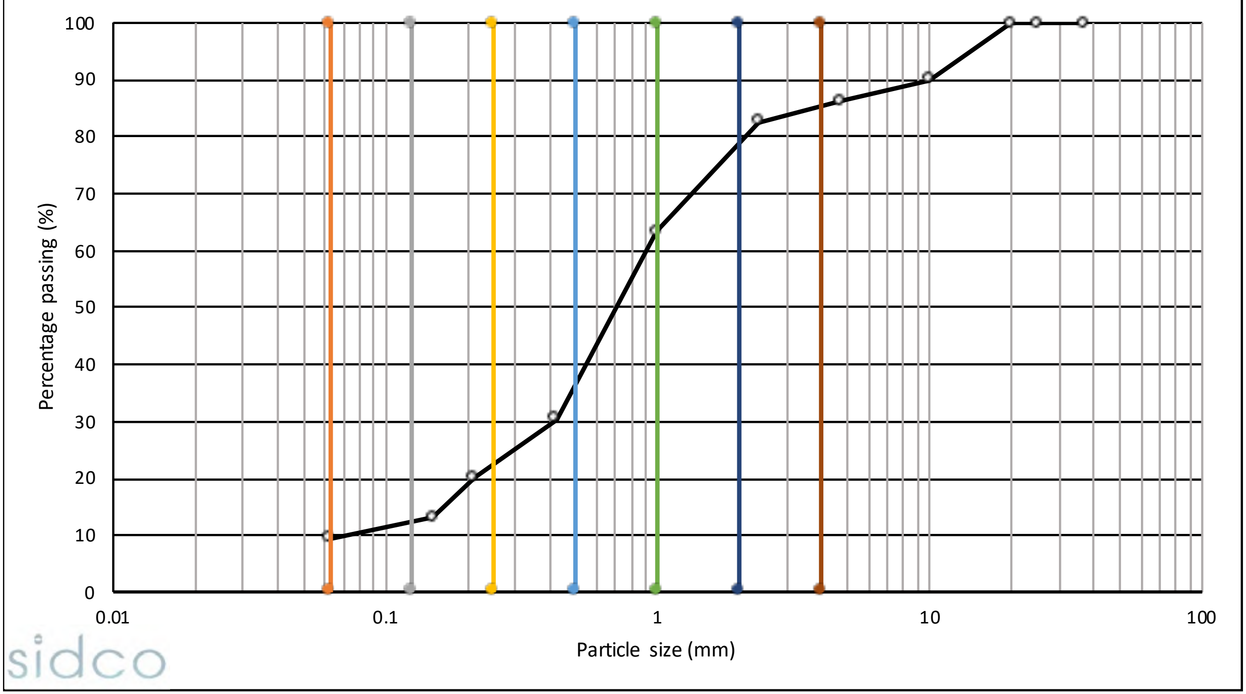
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1	
Date:	12/01/2023	**Tested by:**	SM		
BH2	**Depth (m)**	12.0	**Test #**	**10**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	329	100.0
2	**25**	0	0	0.0	329	100.0
3	**20**	0	0	0.0	329	100.0
4	**10**	33	33	10.0	296	90.0
5	**4.75**	12	45	13.7	284	86.3
8	**2.36**	12	57	17.3	272	82.7
16	**1**	64	121	36.8	208	63.2
30	**0.425**	108	229	69.6	100	30.4
50	**0.212**	34	263	79.9	66	20.1
100	**0.15**	23	286	86.9	43	13.1
200	**0.063**	12	298	90.6	31	9.4
Total weight sieved through 200 (g)				31		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				329	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
9.4%	2.6%	10.0%	16.0%	24.0%	18.0%	20.0%

SIDCO PVT LTD

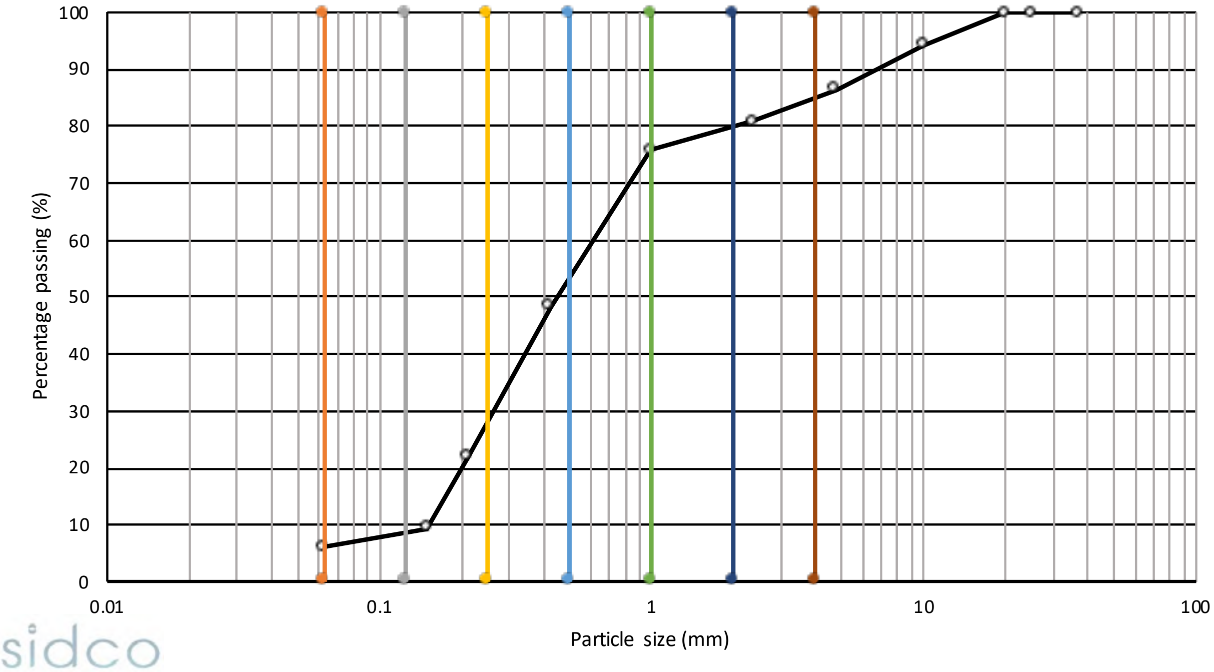
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi		**File #:**	HDEC/2023/1
Date:	12/01/2023	**Tested by:**	SM	
BH2	**Depth (m)**	13.5	**Test #**	**11**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	372	100.0
2	**25**	0	0	0.0	372	100.0
3	**20**	0	0	0.0	372	100.0
4	**10**	21	21	5.6	351	94.4
5	**4.75**	29	50	13.4	322	86.6
8	**2.36**	21	71	19.1	301	80.9
16	**1**	19	90	24.2	282	75.8
30	**0.425**	102	192	51.6	180	48.4
50	**0.212**	98	290	78.0	82	22.0
100	**0.15**	47	337	90.6	35	9.4
200	**0.063**	12	349	93.8	23	6.2
Total weight sieved through 200 (g)				23		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				372	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.2%	2.8%	20.0%	22.0%	24.0%	5.0%	20.0%

SIDCO PVT LTD

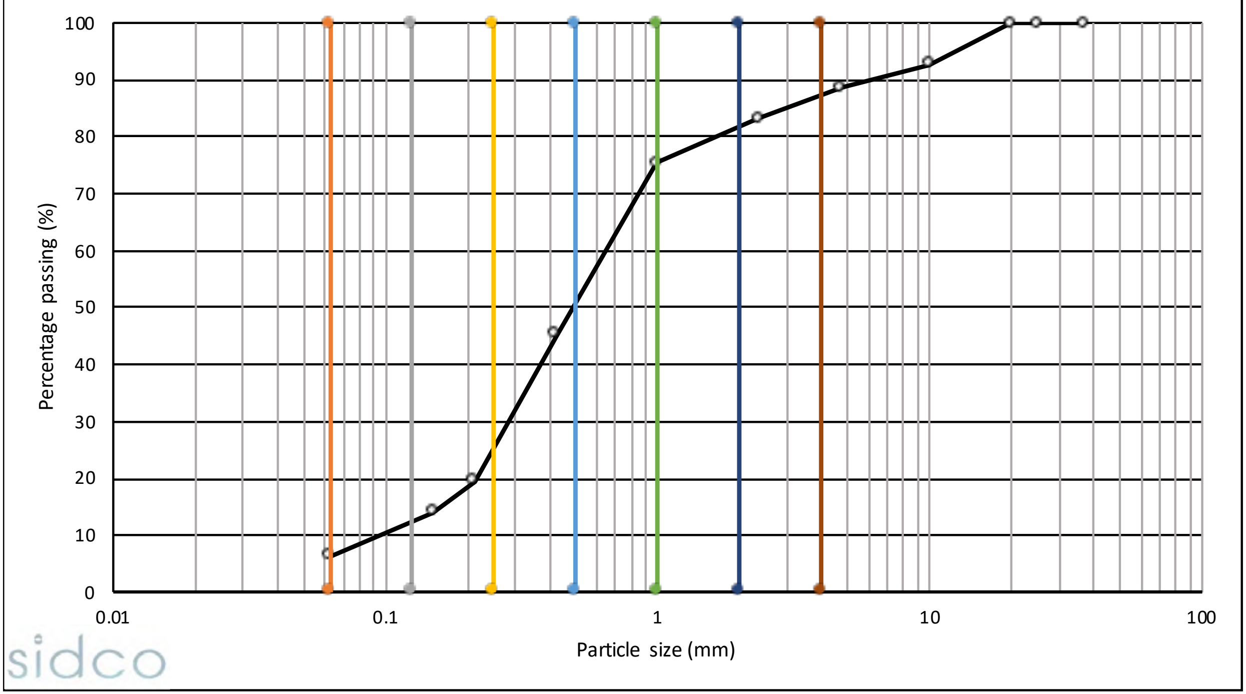
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Hdh. Kulhudhuffushi			**File #:**	HDEC/2023/1
Date:	12/01/2023		**Tested by:**	SM	
BH2	**Depth (m)**	15.0		**Test #**	**12**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	379	100.0
2	**25**	0	0	0.0	379	100.0
3	**20**	0	0	0.0	379	100.0
4	**10**	28	28	7.4	351	92.6
5	**4.75**	15	43	11.3	336	88.7
8	**2.36**	21	64	16.9	315	83.1
16	**1**	29	93	24.5	286	75.5
30	**0.425**	115	208	54.9	171	45.1
50	**0.212**	97	305	80.5	74	19.5
100	**0.15**	21	326	86.0	53	14.0
200	**0.063**	29	355	93.7	24	6.3
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				379	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.3%	5.7%	13.0%	25.0%	25.0%	7.0%	18.0%

APPENDIX 6: PROCTOR TEST RESULT

SIDCO PVT LTD

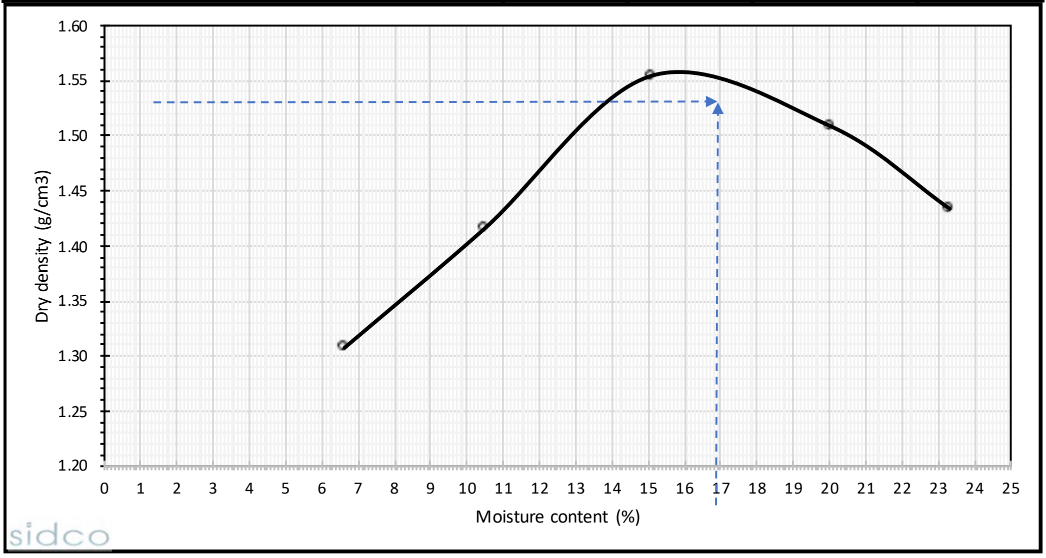
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**Hdh. Kulhudhuffushi**	**Date:**	**14/02/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.61	
Water dennsity, 𝛾w	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4843.00	5013.00	5238.00	5260.00	5217.00
weight of compacted soil, w2-w1 (g)	1394.00	1564.00	1789.00	1811.00	1768.00
Wet density, 𝛾b = ((w2-w1)/v), g/cm3	1.39	1.56	1.79	1.81	1.77
Dry density, 𝛾d = (𝛾b/(1+(w/100))), g/cm3	**1.31**	**1.42**	**1.55**	**1.51**	**1.43**
Void Ratio e = ((Gs𝛾w)/𝛾d-1	2.00	1.84	1.68	1.73	1.82
Moisture content					
Weight of container, g	29.98	30.02	29.89	29.97	30.12
Weight of container + wet soil, g	65.4	71.2	69.3	60.9	67.4
Wet container + dry soil, g	63.21	67.32	64.15	55.72	60.31
Weight of moisture, ww (g)	2.20	3.91	5.17	5.15	7.04
Weight of dry soil, ws (g)	33.23	37.30	34.26	25.75	30.19
Water content, w= ((ww/ws)x100), %	**6.62**	**10.48**	**15.09**	**20.00**	**23.32**



APPENDIX 7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

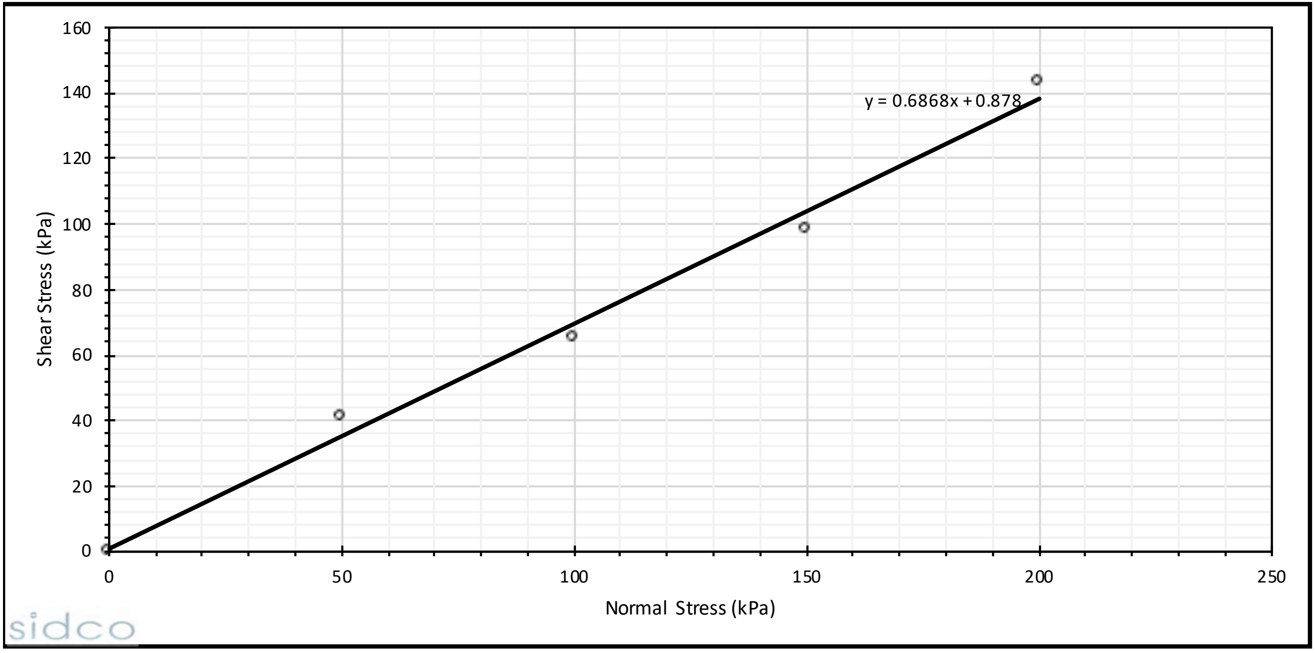
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**Hdh. Kulhudhuffushi**	**Date:**	**15/02/2023**	**Direct Shear**	**1**

Moisture content (%)	8.75%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	34.62	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	41.23
100.00	65.14
150.00	98.23
200.00	143.21



APPENDIX 8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**Kulhudhuffushi**	**Date:**	**16/02/2022**
TEST 1			
Mass of dnesity bottle	W1	30.08	g
Mass of bottle + dry sand	W2	73.65	g
Mass of bottle + dry sand + water	W3	157.83	g
Mass of bottle + water	W4	130.95	g
Specific Gravity	Gs	2.61	

TEST 2

Mass of dnesity bottle	W1	35.01	g
Mass of bottle + dry sand	W2	82.34	g
Mass of bottle + dry sand + water	W3	175.9	g
Mass of bottle + water	W4	146.65	g
Specific Gravity	Gs	2.62	

Avarege Gs		2.61	

APPENDIX 9: SOIL RESITIVITY SURVEY RESULT

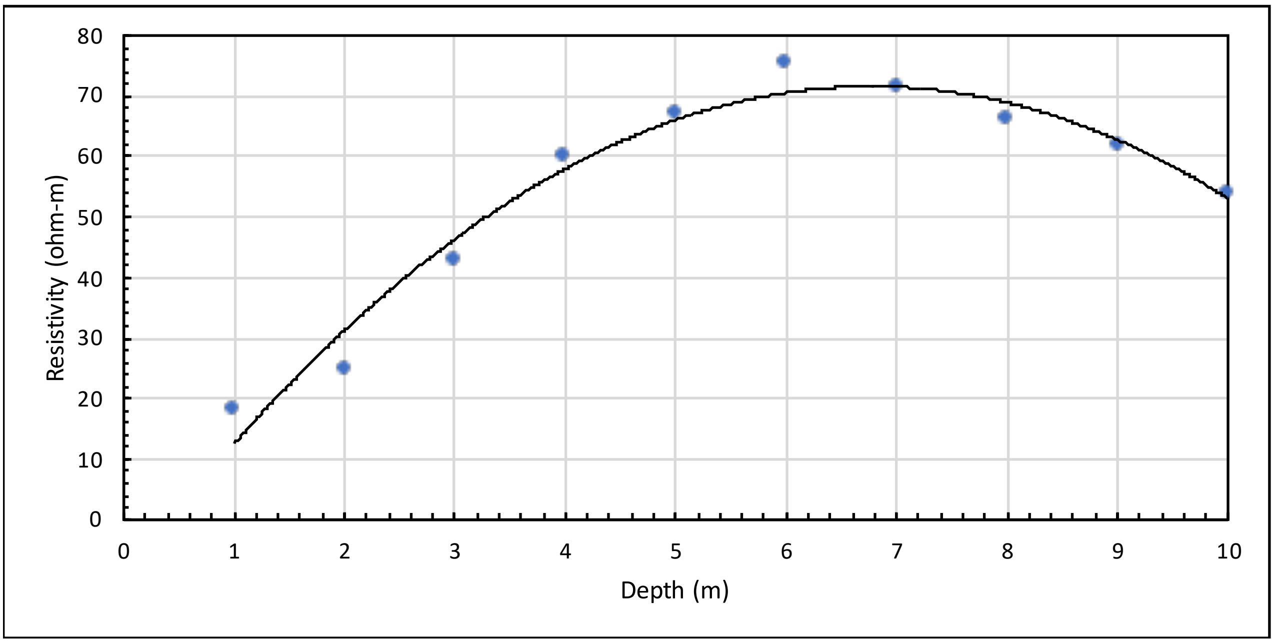
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

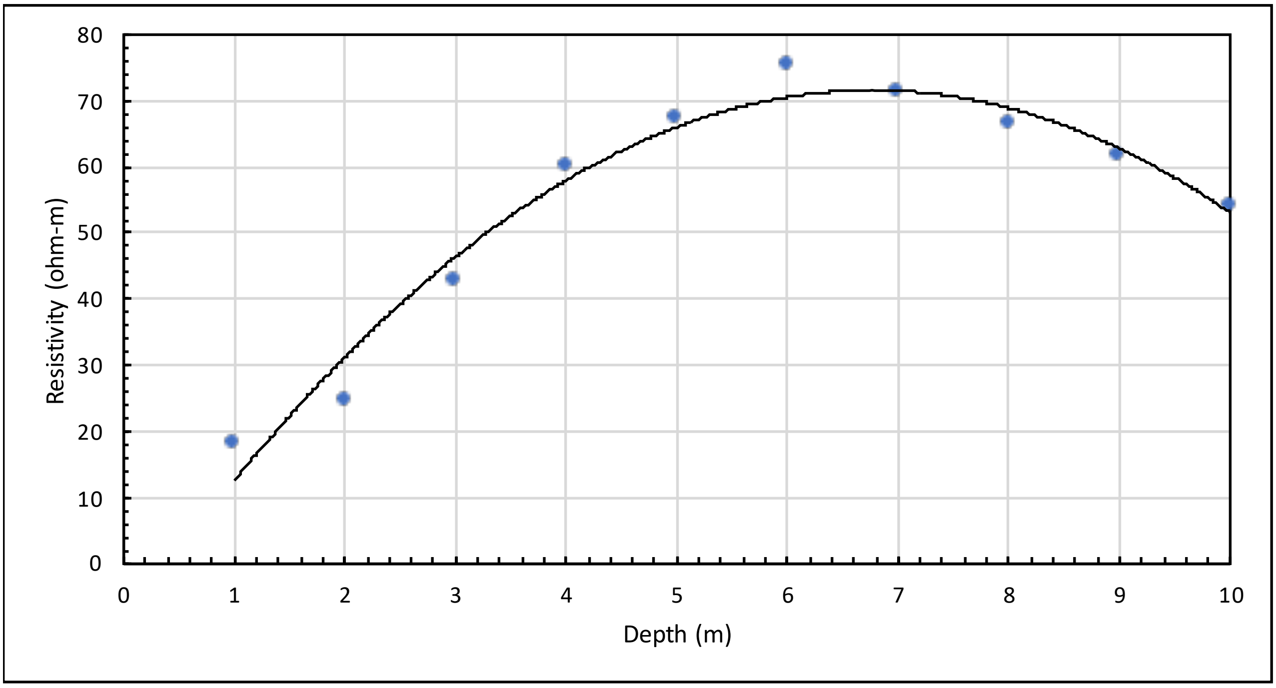
Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	2.87	18
2	2	1.96	25
3	3	2.27	43
4	4	2.39	60
5	5	2.14	67
6	6	2.00	75
7	7	1.62	71
8	8	1.32	66
9	9	1.09	62
10	10	0.86	54



Soil Resistivity Survey - Wenner Method

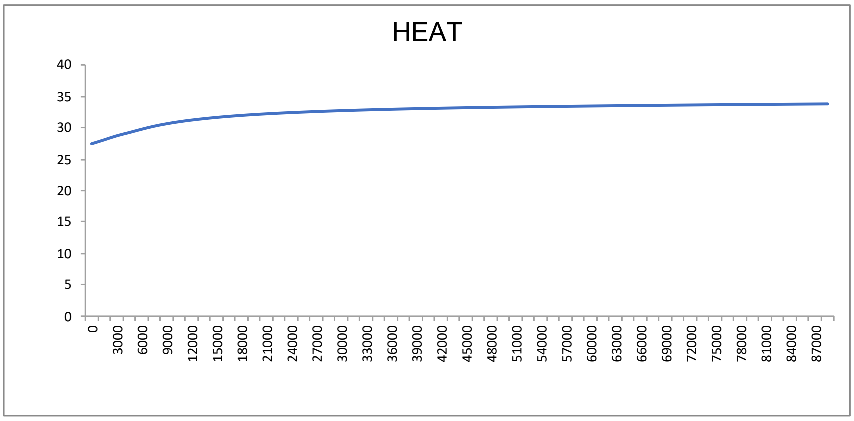
TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	3.13	20
2	2	3.79	48
3	3	5.01	94
4	4	4.83	121
5	5	6.85	215
6	6	4.32	163
7	7	3.23	142
8	8	2.67	134
9	9	1.06	60
10	10	0.74	46

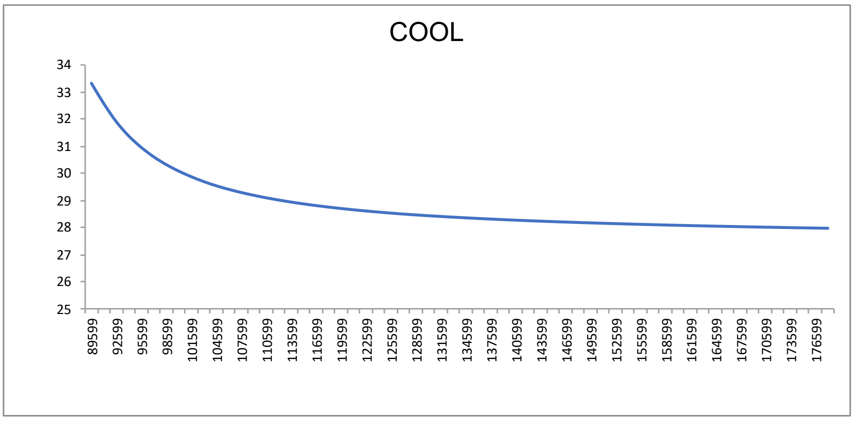


APPENDIX 10: THERMAL CONDUCTIVITY TEST RESULTS

TEST 1

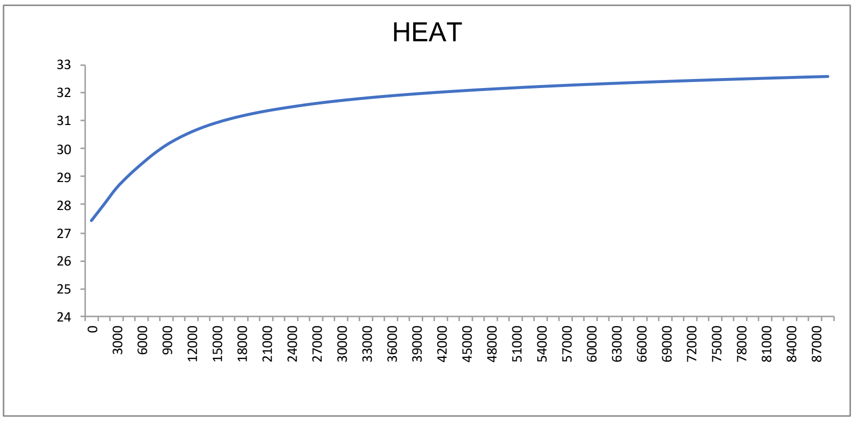
HEAT		COOL	
Time (ms)	T (C)	Time (ms)	T (C)
0	27.444584	89599	33.323586
1500	28.063538	91099	32.568237
3000	28.705793	92599	31.901047
4500	29.222713	94099	31.372805
6000	29.753551	95599	30.953558
7500	30.23682	97099	30.605652
9000	30.626633	98599	30.319881
10500	30.950529	100099	30.080059
12000	31.218166	101599	29.874317
13500	31.443628	103099	29.695549
15000	31.641411	104599	29.540094
16500	31.813633	106099	29.407804
18000	31.963303	107599	29.291571
19500	32.096191	109099	29.18882
21000	32.212872	110599	29.096064
22500	32.317707	112099	29.01375
24000	32.411652	113599	28.938635
25500	32.495979	115099	28.87076
27000	32.576462	116599	28.80934
28500	32.64994	118099	28.752899
30000	32.71698	119599	28.700603
31500	32.778893	121099	28.653349
33000	32.836807	122599	28.609278
34500	32.890301	124099	28.568876
36000	32.940792	125599	28.530516
37500	32.987381	127099	28.495909
39000	33.03093	128599	28.463709
40500	33.072521	130099	28.434278
42000	33.111561	131599	28.406784
43500	33.148338	133099	28.380711
45000	33.18335	134599	28.35622
46500	33.216656	136099	28.332701
48000	33.248039	137599	28.310614
49500	33.277908	139099	28.289509
51000	33.307205	140599	28.270092
52500	33.335083	142099	28.251364
54000	33.361473	143599	28.233345
55500	33.386642	145099	28.216196
57000	33.411686	146599	28.200539
58500	33.434414	148099	28.184816
60000	33.457497	149599	28.169621
61500	33.479183	151099	28.155277
63000	33.500626	152599	28.141859
64500	33.521744	154099	28.128834
66000	33.542336	155599	28.115805
67500	33.563152	157099	28.103497
69000	33.581795	158599	28.091604
70500	33.600979	160099	28.080566
72000	33.619247	161599	28.069773
73500	33.637589	163099	28.059479
75000	33.654728	164599	28.049086
76500	33.671341	166099	28.03968
78000	33.687828	167599	28.029722
79500	33.704174	169099	28.020437
81000	33.719704	170599	28.012039
82500	33.735538	172099	28.003263
84000	33.75013	173599	27.994753
85500	33.764961	175099	27.986629
87000	33.778946	176599	27.978859
88500	33.793159	178099	27.971189

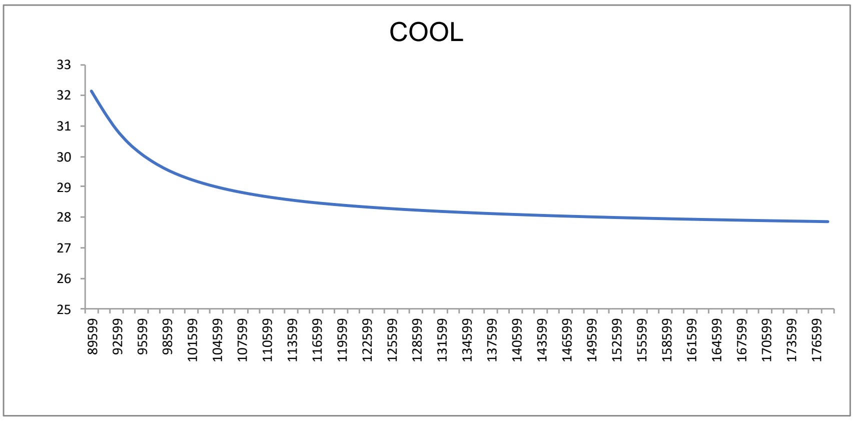




TEST 2

HEAT		COOL	
Time (ms)	T (C)	Time (ms)	T (C)
0	27.432011	89599	32.142841
1500	28.006065	91099	31.474192
3000	28.594048	92599	30.882517
4500	29.053171	94099	30.426664
6000	29.454056	95599	30.079702
7500	29.822807	97099	29.801849
9000	30.137962	98599	29.574219
10500	30.3923	100099	29.390957
12000	30.605171	101599	29.239531
13500	30.785458	103099	29.111025
15000	30.935284	104599	29.000383
16500	31.064278	106099	28.904419
18000	31.174934	107599	28.820543
19500	31.272652	109099	28.746611
21000	31.35829	110599	28.679998
22500	31.434368	112099	28.621313
24000	31.503548	113599	28.568083
25500	31.56937	115099	28.519569
27000	31.628704	116599	28.476526
28500	31.68327	118099	28.438164
30000	31.73328	119599	28.402443
31500	31.779778	121099	28.370064
33000	31.823311	122599	28.339718
34500	31.863968	124099	28.311382
36000	31.902592	125599	28.285196
37500	31.937996	127099	28.260107
39000	31.972111	128599	28.237358
40500	32.004227	130099	28.215553
42000	32.034958	131599	28.194946
43500	32.063271	133099	28.175829
45000	32.09111	134599	28.157391
46500	32.118382	136099	28.139381
48000	32.142776	137599	28.123058
49500	32.167385	139099	28.107464
51000	32.190907	140599	28.092661
52500	32.213604	142099	28.078424
54000	32.235065	143599	28.064529
55500	32.255966	145099	28.051527
57000	32.276279	146599	28.039234
58500	32.296185	148099	28.027573
60000	32.314548	149599	28.015453
61500	32.332981	151099	28.004725
63000	32.35051	152599	27.993767
64500	32.368084	154099	27.98365
66000	32.384464	155599	27.973894
67500	32.400856	157099	27.964291
69000	32.416462	158599	27.955183
70500	32.432091	160099	27.945917
72000	32.44669	161599	27.937708
73500	32.461662	163099	27.929289
75000	32.47644	164599	27.92148
76500	32.489738	166099	27.913799
78000	32.503479	167599	27.905922
79500	32.517315	169099	27.898731
81000	32.530819	170599	27.891388
82500	32.544197	172099	27.884605
84000	32.557037	173599	27.877907
85500	32.570118	175099	27.871653
87000	32.582329	176599	27.865288
88500	32.594814	178099	27.858437





sidco

FEBRUARY 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
GDh. Thinadhoo West Beach

CLIENT
HDEC

中国电建
POWERCHINA

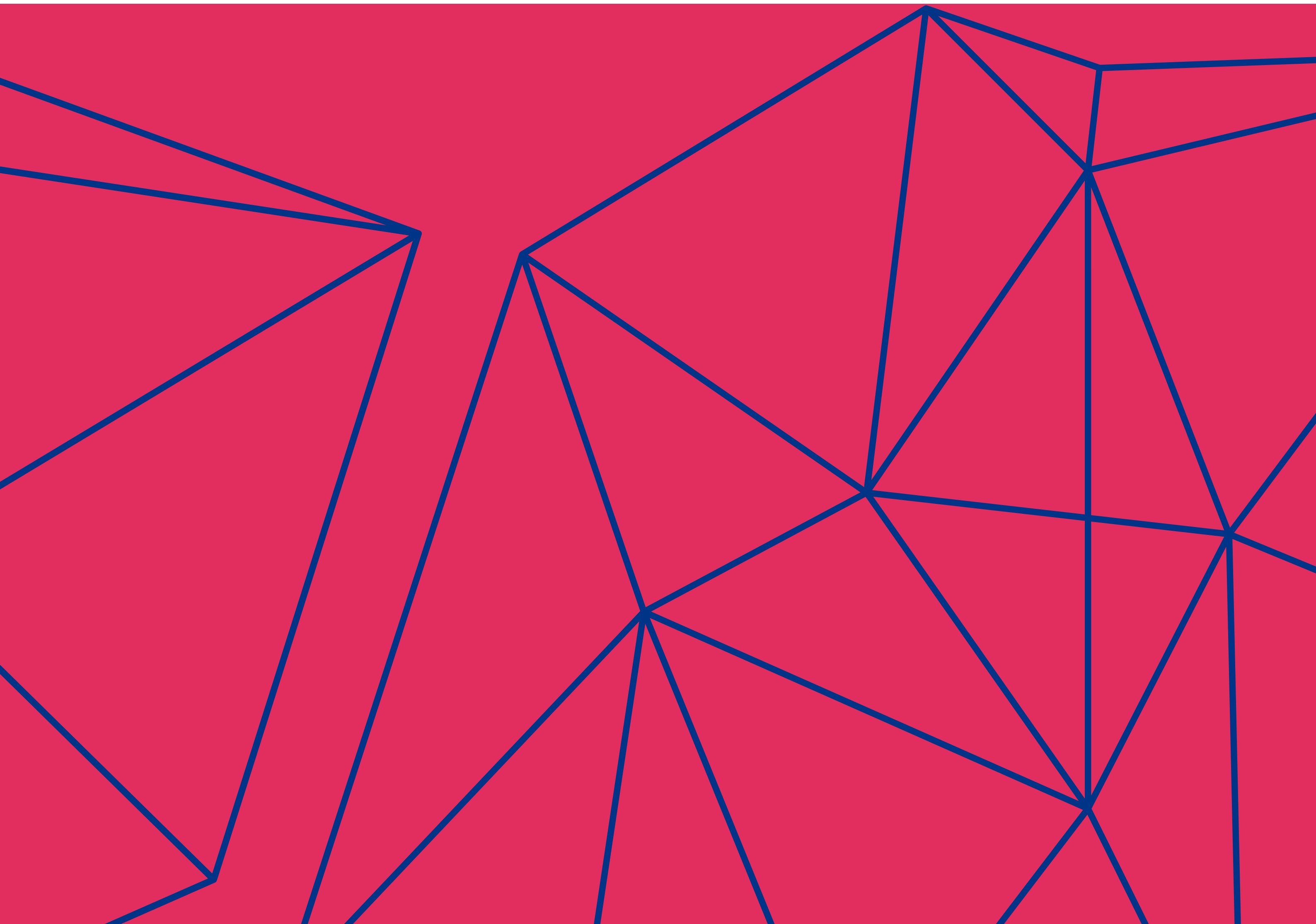


Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out on 26th and 27th January 2023 in GDh. Thinadhoo for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Dynamic Cone Penetration (DCP) tests
2. Mackintosh Probe
3. Trial Pits
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
2. BS EN ISO 17892-4:2016 Determination of particle size distribution
3. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
4. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

GDh. Thinadhoo is the atoll capital island of South Huvadhu Atoll located 407 km south of Male' at approximately 72° 59' 50"E and 0° 31' 49" N. The geographic land area of the island is 174 hectares. The length of the island measures length 2 km and about 0.85 km wide. The population of the Island is 7456.[1]

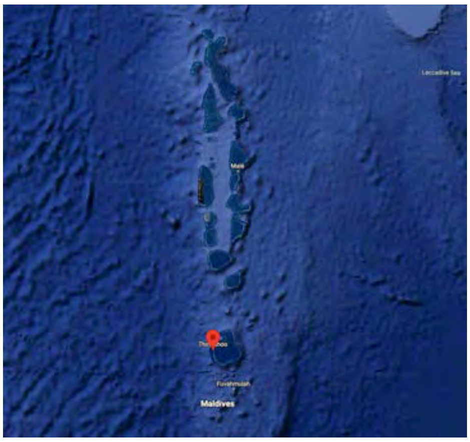


Figure 1: Location of GDh. Thinadhoo (Google Maps)

Figure 2: Drone Photo of Thinadhoo1

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock, and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented

---

[1] https://www.isles.gov.mv/Island/DetailsEn/971

with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed location for development has a flat terrain and the ground elevation is between 1.0 and 2.0 meters.

Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands that was dredged from deep sea to reclaim the land. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain, and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP 2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.

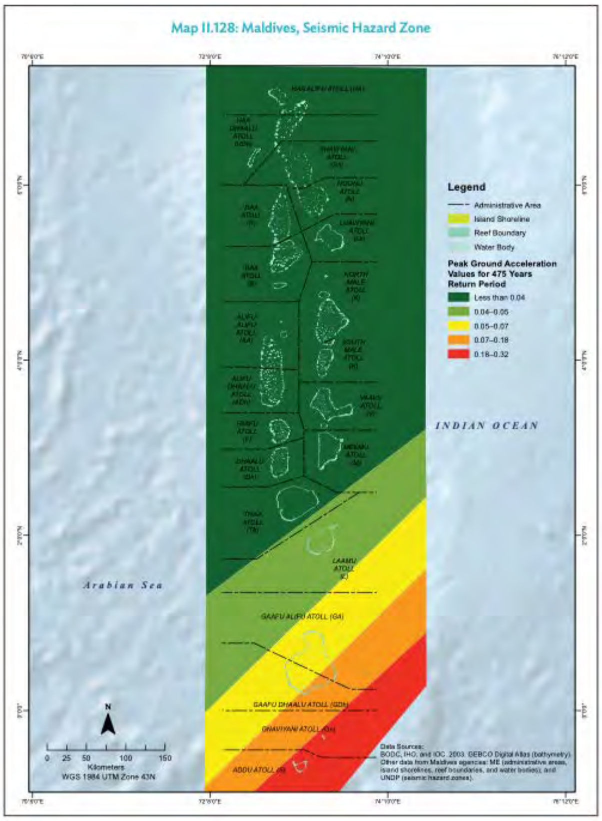


Figure 3: Seismic Hazard Zone (ADB 2020)

Thinadhoo is located north of Maldives where peak ground acceleration value is between 0.05 and 0.07 as in Figure 3.

2.4 RAINFALL

Rainfall data and other meteorological data are not available for Thinadhoo. The closest weather centre is located at Kaadhedhdhoo Airport (located at 00º29’17” N and 72º59’49” E), which is about 3.5 km south of Thinadhoo. Therefore, data from Kaadedhdhoo weather centre is used for the project.

The rainfall pattern in Maldives is influenced by the monsoons, where heavy rainfall in south-west monsoon (*Hulhan’gu*) from May to November followed by a transition period from December to January and dry period in north-east monsoon (*Iruvai*) from January to April with scattered rainfall.

Kaadhedhdhoo rainfall data shows a periodic pattern and annual precipitation varies from year to year with a mean rainfall of 2285.1 mm and ranging between 1814.6 mm and 3059.1 mm (Zahid 2011).

On average the maximum number of rainy days for the northern region is 177 rainy days per calendar year. According to Zahid (2011), there is a strong correlation between the number of rainy days and the annual rainfall in Kaadhedhdhoo (CC=0.69).

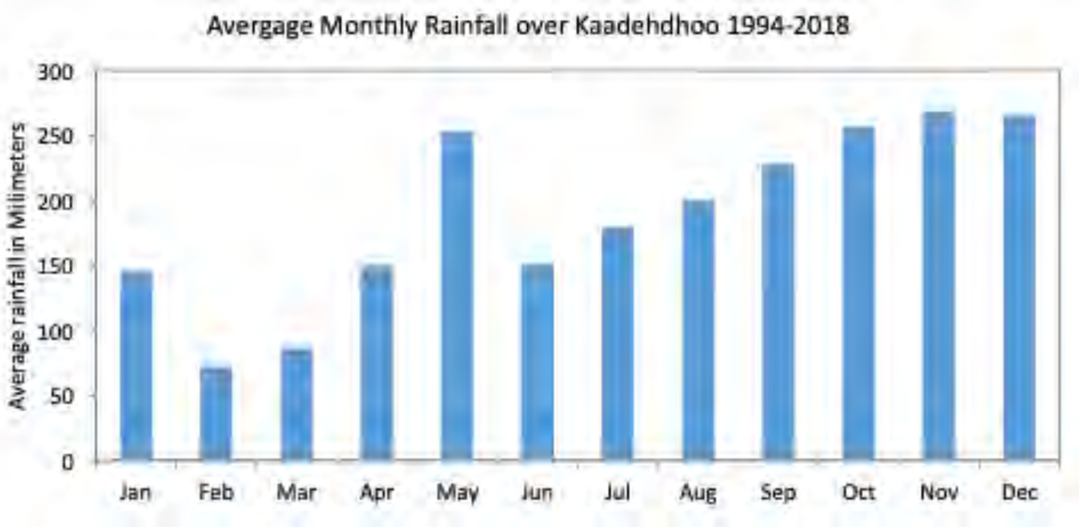


Figure 4: Average Monthly Rainfall over Kaadedhdhoo 1994-2018 (Musthafa 2020)

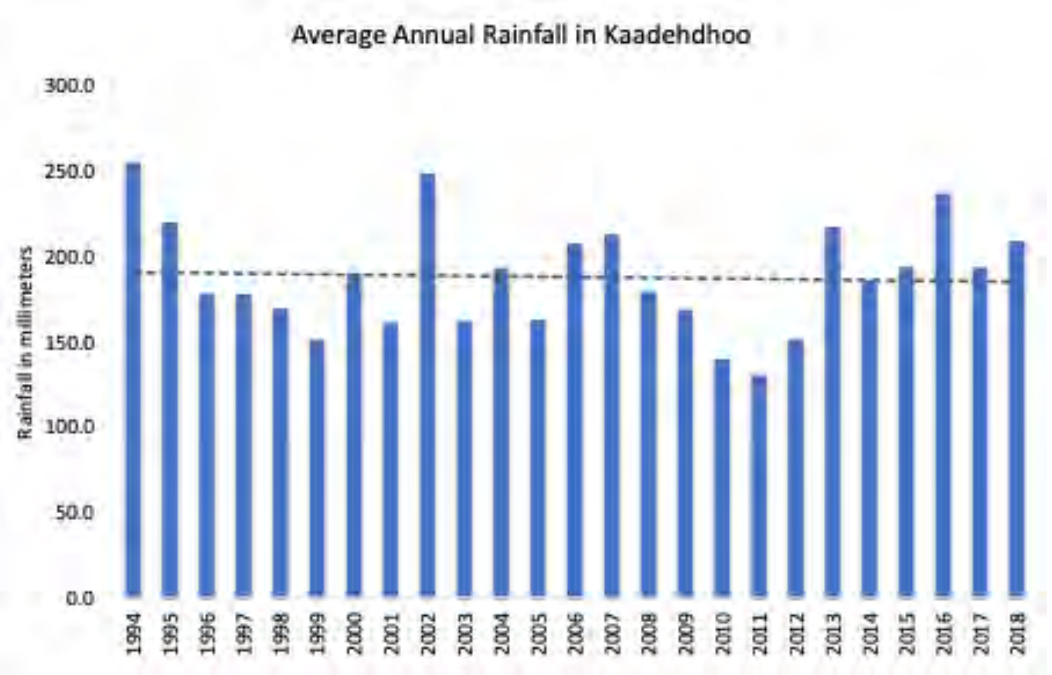


Figure 5: Average Annual Rainfall in Kaadedhdhoo from 1994 to 2018 (Musthafa 2020)

In addition, the trend observed is that the number of rainy days has been decreasing without decreasing annual rainfall. This indicates that more rainfall is received over a shorter period increasing the chances of flooding due to heavy rain.

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

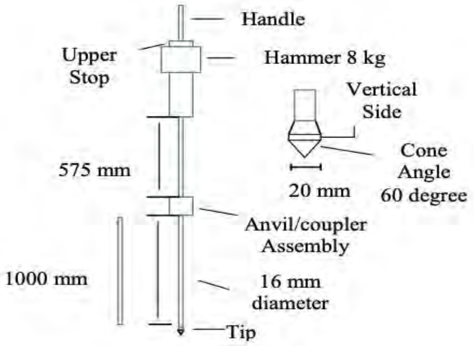


Figure 6: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.2 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.
6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.

7. The data is then plotted number of blows against depth.

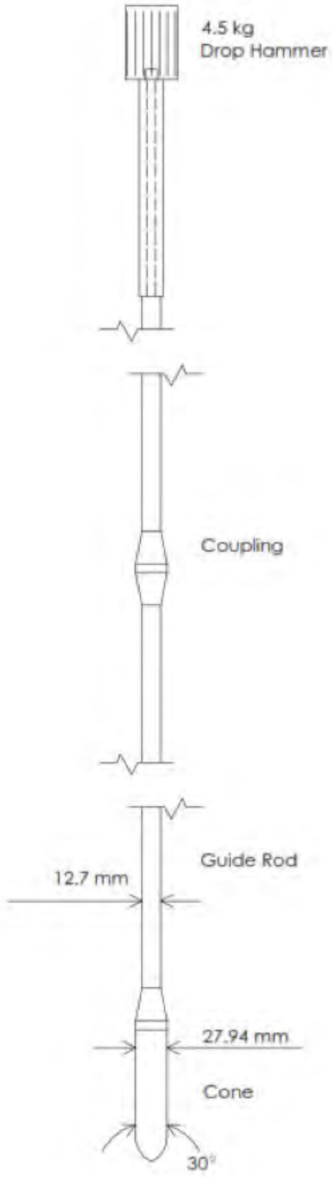


Figure 7: Schematic diagram of Mackintosh Probe

3.2.3 Trial Pits

Two trial pits were made using an excavator. A soil sample was taken at the top, 0.5 m, 1.0 m, 2.0 m and 3.0 m for laboratory investigation of sieve analysis. Photographs and were taken and observation noted to determine soil profile up to 3.0 m.

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

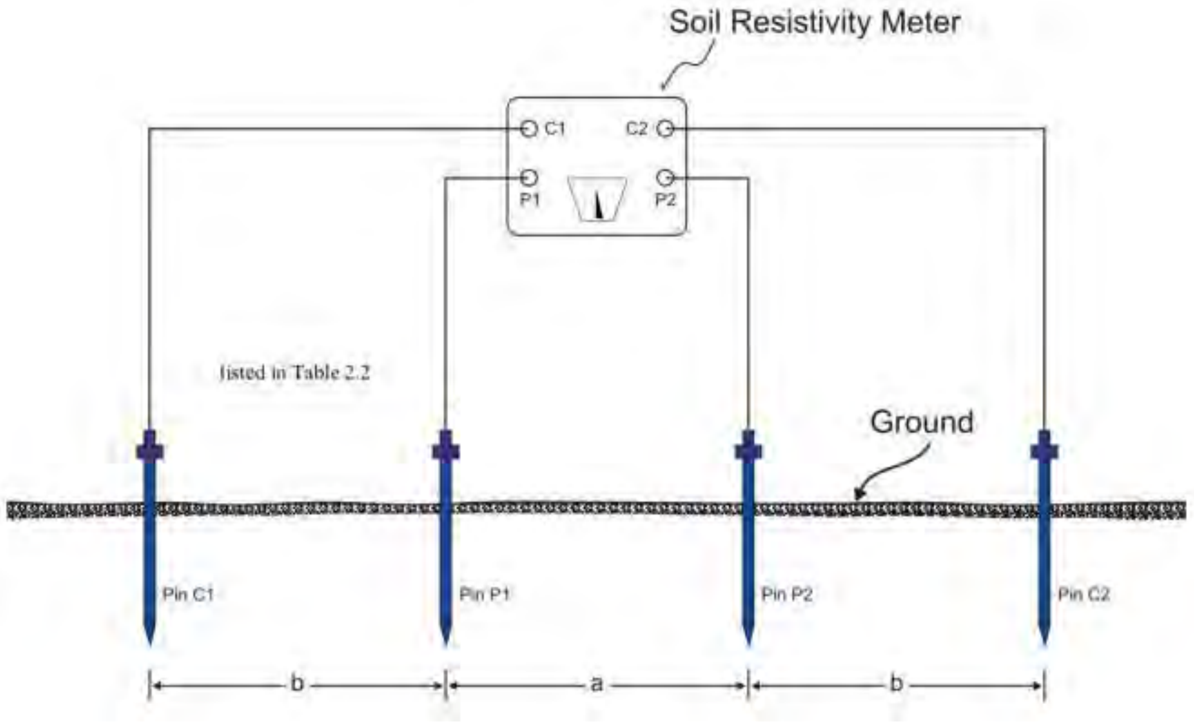


Figure 8: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi\ AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 9: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W $m^{-1o}C^{-1}$). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 10: TLS-100 Portable Thermal Conductivity Meter

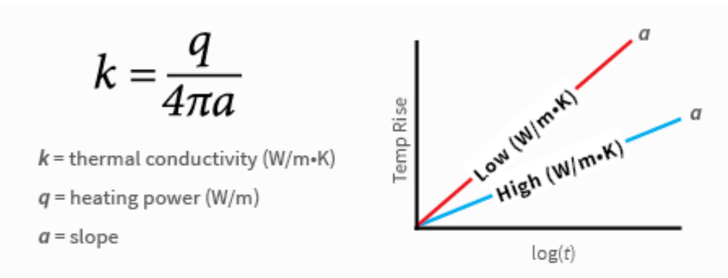


Figure 11: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\gamma_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 12.

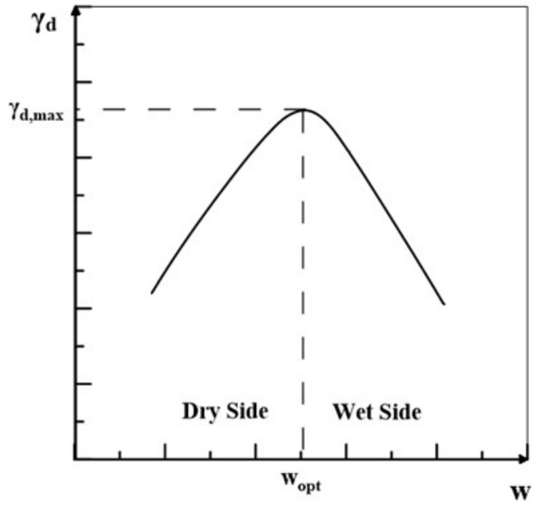


Figure 12: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 13, highest strength of a soil is achieved dry of optimum moisture content of a soil.

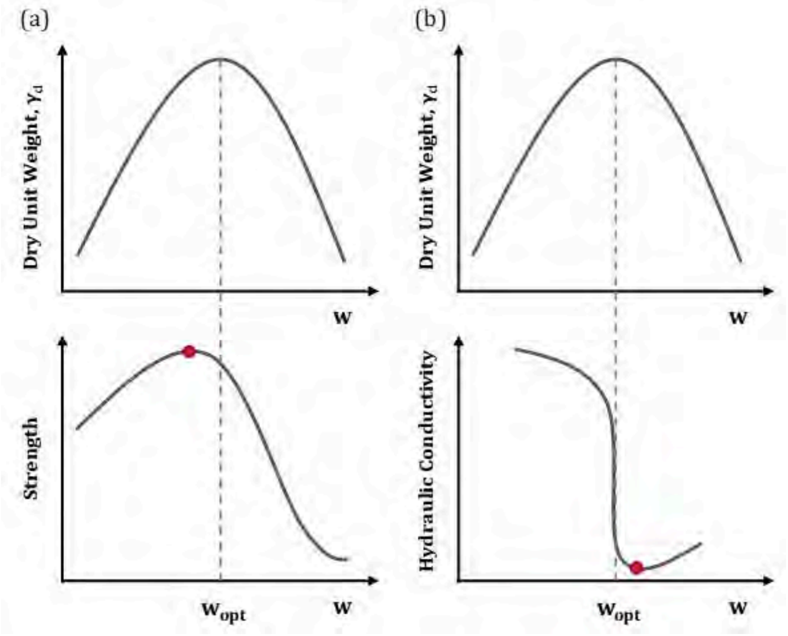


Figure 13: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Results and discussions

4.1.1 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

Table 1: Safe Bearing Capacities calculated from DCP readings

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	129	142	157	111	144	**137**
0.6	153	142	158	144	130	**145**
0.9	158	158	171	154	152	**159**
1.2	157	163	174	162	170	**165**
1.5	162	145	199	168	177	**170**
1.8	222	119	169	147	142	**160**

Table 1 shows safe bearing capacities calculated for each DCP test at different depths. A hard rock layer was encountered at a depth of 1.7-1.8 m. Hence, results are only up to 1.8 m. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

4.1.2 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550\,(R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

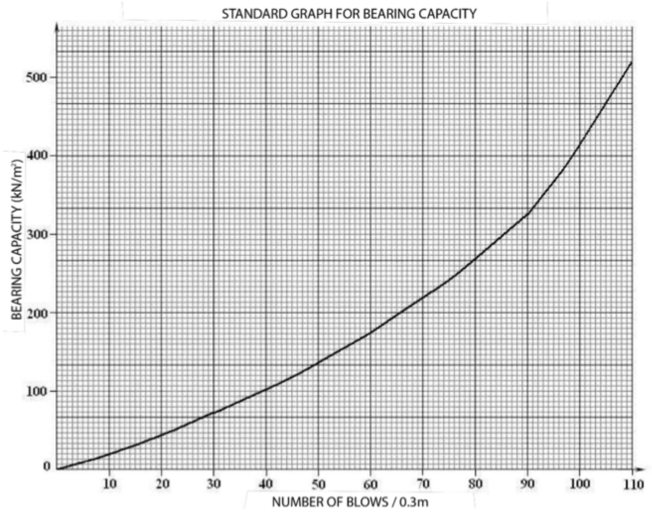
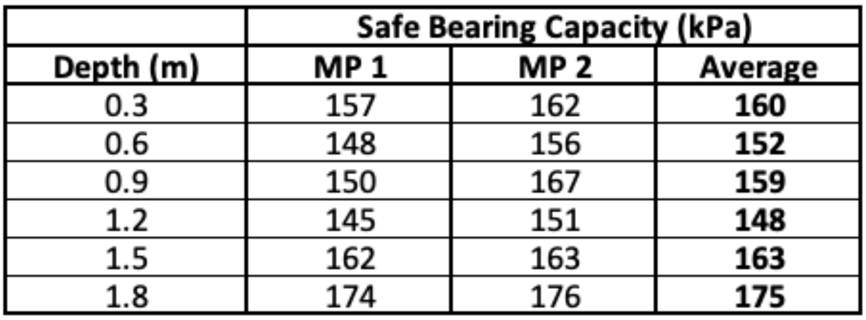


Figure 14: Standard bearing capacity graph for Mackintosh Probe

Table 2 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 2: Safe Bearing Capacity calculated from MP results



	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	157	162	**160**
0.6	148	156	**152**
0.9	150	167	**159**
1.2	145	151	**148**
1.5	162	163	**163**
1.8	174	176	**175**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach hard strata which was found to be at 1.7 m depth. Since the soil is medium dense gravelly sand, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used. In few cases, excavation had to be used to remove rods.

4.1.3 Trial Pits

Trial pits were conducted to get soil samples for testing, measuring water table and to check the soil profile. The trial pits could only be done up to 1.7-1.8 m at the depth a hard rock layer was encountered and could not be excavated deeper.

The two trial pits excavated at two ends of the Thinadhoo West Beach site; soil strata are gravelly sand up to 1.7-1.8 m depth where hard stratum was encountered. The water table was at 1.0 m depth.

The samples collected at 0, 0.5, 1.0, 2.0 and 3.0 were tested in the laboratory for particle size distribution. The results are given in 4.1.4.

As seen in the photo below the soil doesn't change with the depth and is gravelly sand. Since the soil is granular with the significant quantity of gravel, pebbles and stones, it was difficult excavate smoothly because the side of the pit keeps collapsing.

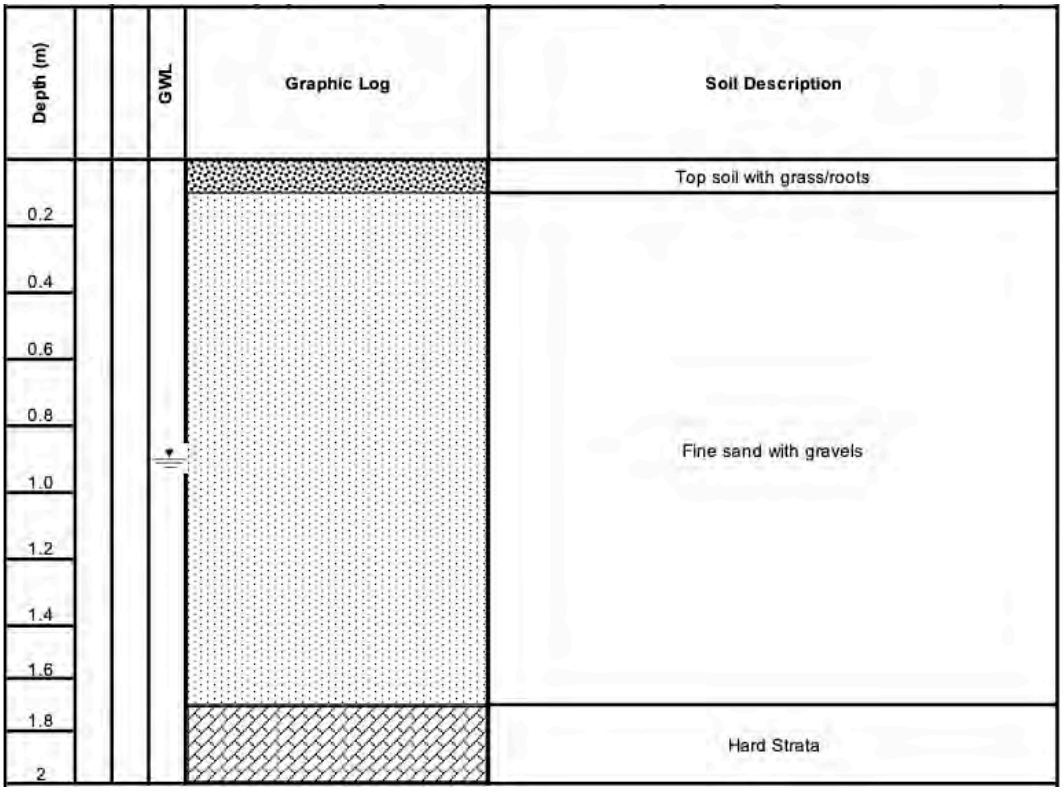


Figure 15: Log for both Trial Pits

4.1.4 Particle size distribution

The trial pits in Thinadhoo West Beach could only be excavated up to 1.7 m due to presence of very hard rock layer. This area was reclaimed as part of shore protection project.

Particle size distribution of samples collected from trial pits at the West Beach of GDh. Thinadhoo. The result shows the sand is gravelly with silt content less than 3.5%, but gravel and larger sizes consist about 1/3 of the soil. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The particle size distribution graphs are included in the appendix.

Table 3: Results of Particle size distribution of samples from Trial Pit 1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	41.0	8.0	15.0	13.0	13.0	6.9	3.1
0.5	28.0	4.0	22.0	16.0	19.0	7.6	3.4
1.0	27.0	3.0	20.0	19.0	21.0	7.3	2.7
1.7	27.0	3.0	20.0	17.0	23.0	7.0	3.0

Table 4: Results of Particle size distribution of samples from Trial Pit 2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	37.0	4.0	23.0	14.0	14.0	6.1	1.9
0.5	33.0	7.0	20.0	14.0	17.0	6.7	2.3
1.0	31.0	19.0	21.0	14.0	8.0	4.8	2.2
1.7	34.0	16.0	21.0	13.0	8.0	4.9	3.1

4.1.5 Direct Shear

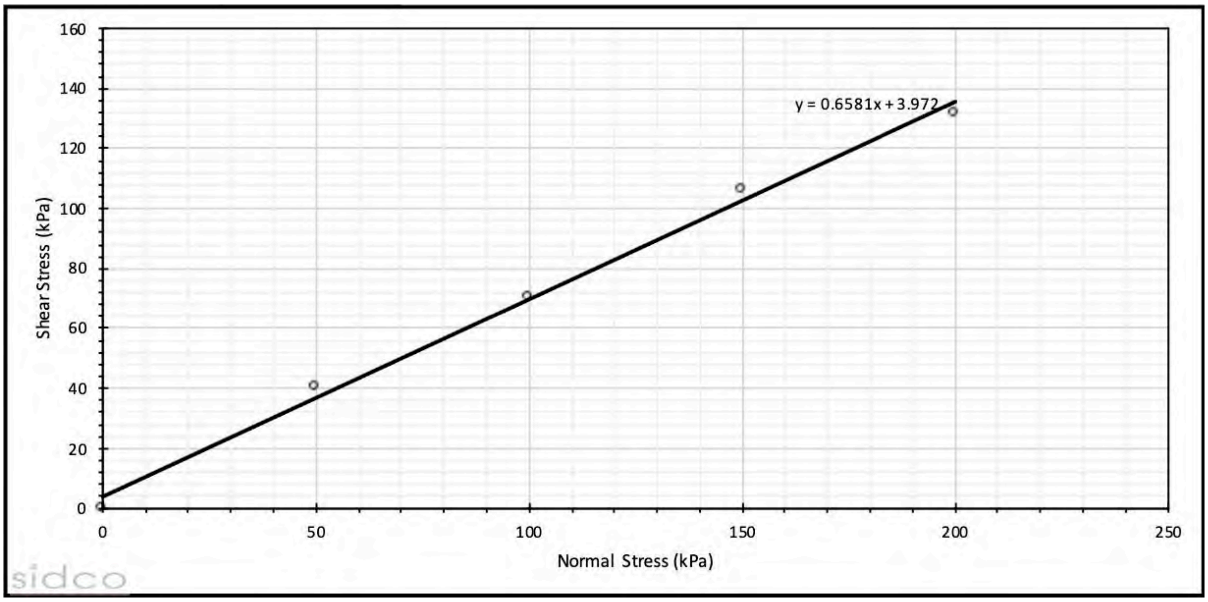


Figure 16: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 34 degrees, which is typical for carbonated sand found in Maldives.

4.1.6 Proctor Compaction Test

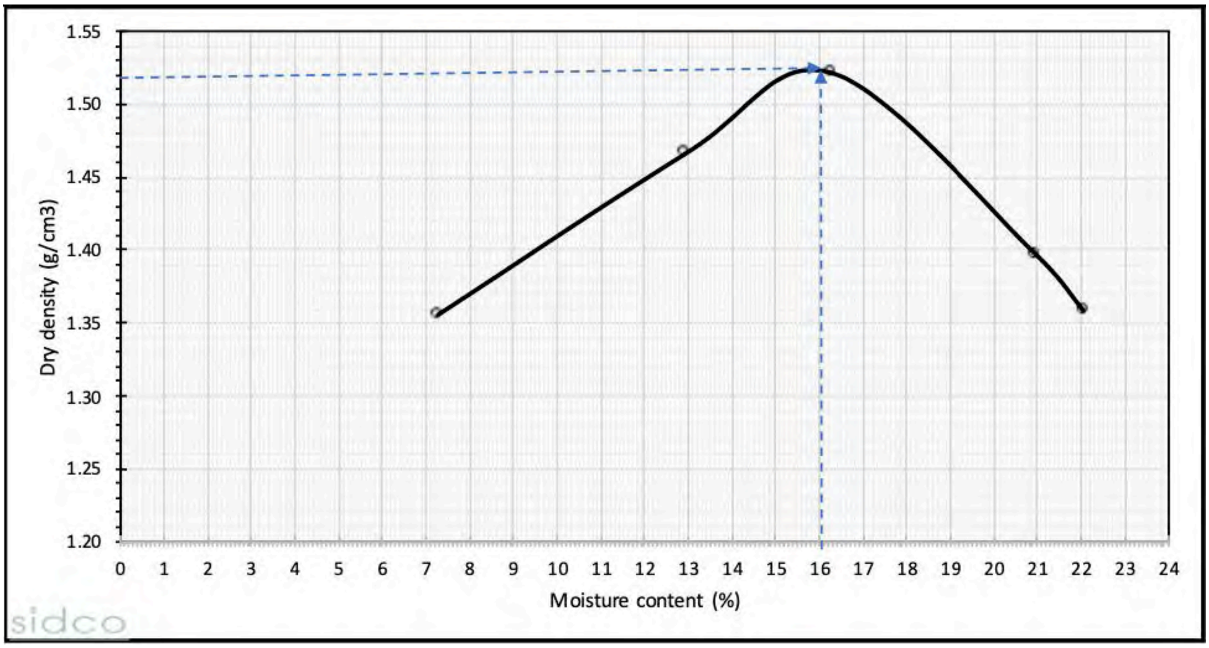
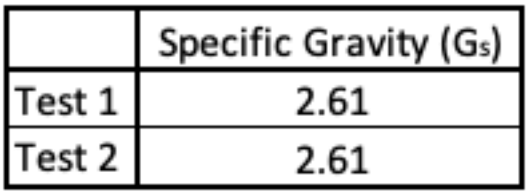


Figure 17: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.52 g/cm^3 and an optimum moisture content of 16%.

4.1.7 Specific gravity test

Table 5: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.61
Test 2	2.61

Table 5 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer. Both tests yield 2.61.

4.1.8 Electrical Resistivity (ER)

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content.

1. Thinadhoo west beach area is covered with weeds and grass and moisture content appears to be very high. High moisture content reduces the resistivity.
2. The temperature is approximately 30 degrees Celsius. Higher temperature decreases the resistivity.
3. The site was previously sea, which was reclaimed. Hence, contains salt. This also reduces the resistivity.

The tables and graphs below show ER test results.

Table 6: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	12.11	76
2	2	5.91	74
3	3	4.01	76
4	4	3.21	81
5	5	2.73	86
6	6	2.16	81
7	7	1.82	80
8	8	1.51	76
9	9	1.24	70
10	10	0.97	61

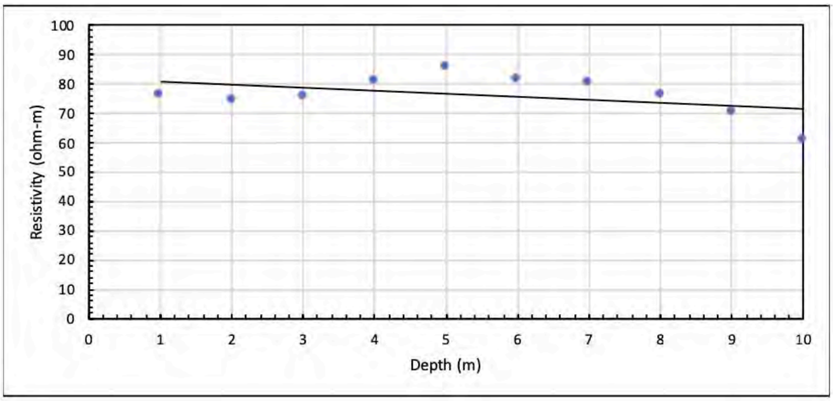


Figure 18: Resistivity graph for Test 1

Table 7: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	11.94	75
2	2	5.60	70
3	3	4.11	77
4	4	3.02	76
5	5	2.41	76
6	6	2.03	76
7	7	1.54	68
8	8	1.25	63
9	9	1.01	57
10	10	0.97	61

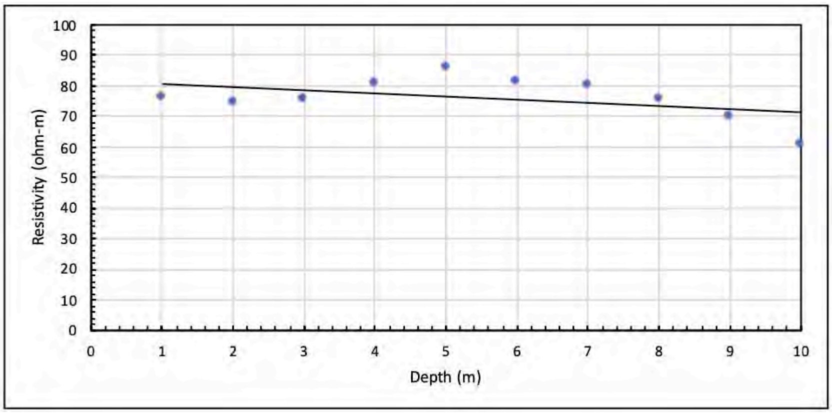


Figure 19: Resistivity graph for Test 2

Resistivity of soil remains overall same with depth. This could be because the presence of rock strata from 1.7 m. But overall, the 75 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

4.1.9 Thermal Conductivity

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 8: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (°C)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	30.10	0.459	2.18	200
2	TLS100	30.20	0.464	2.16	200
Average		30.15	0.462	2.17	

The average thermal conductivity is 0.462 W/mK.

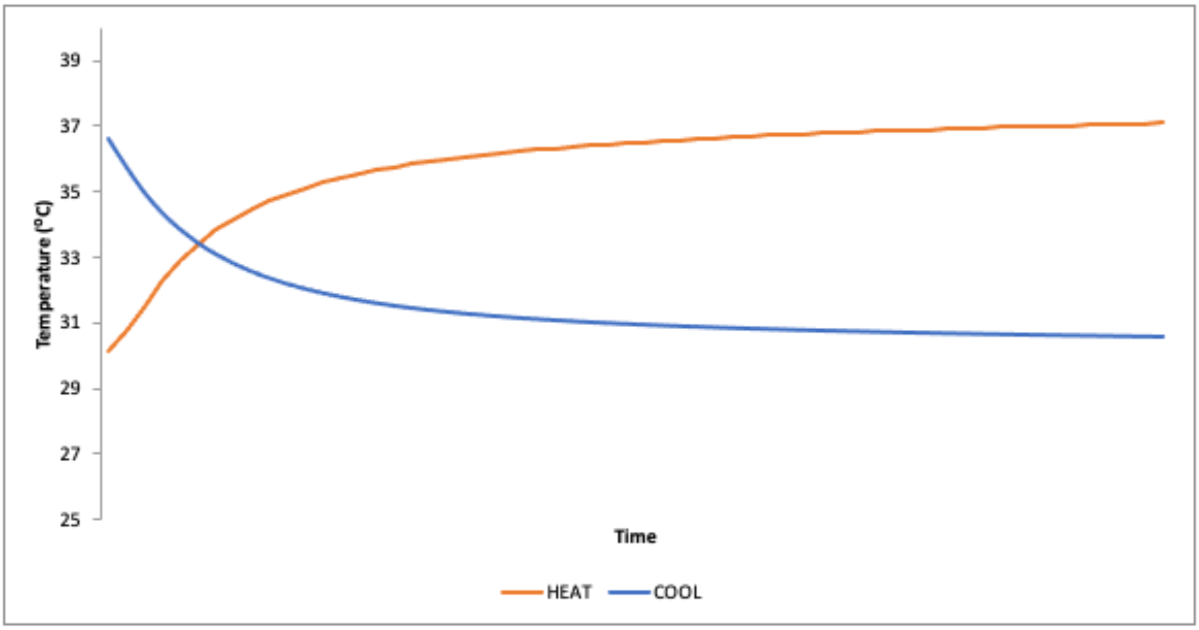


Figure 20: Heat and Colling Curve to TC Test 1

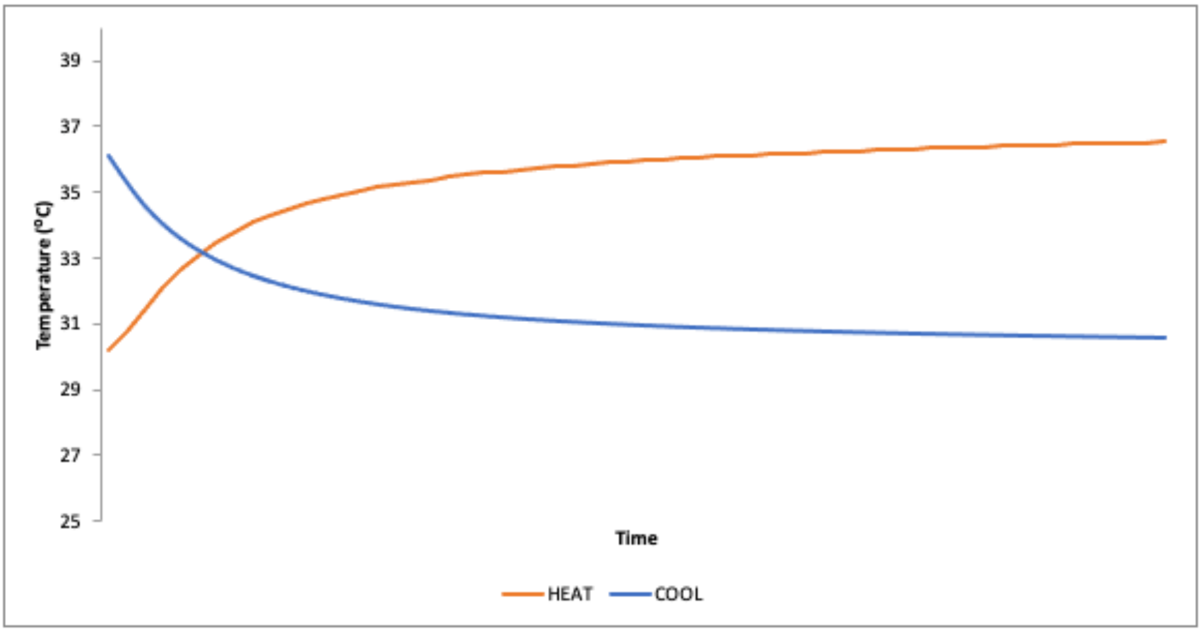


Figure 21: Heat and Colling Curve to TC Test 2

4.1.10 Chemical Analysis of Ground Water

Water samples were collected from. Trial pits and results from water laboratory has not received. But previous water testing in same area shows a conductivity of about 1500 µS/cm with a salinity of 0.69%, Sulphate content of 20 mg/L, Nitrate content of 12 mg/L, Chloride content of 95 mg/L. The report will be updated when test results are received.

5 Conclusion

5.1 GEOTECHNICAL CONSIDERATIONS

5.1.1 Safe Bearing Capacity

Since the soil is gravelly sand, the result of DCP should more accurate and reliable than MP. Hence it is recommended to use the safe bearing capacity in the table below.

Table 9: Safe bearing capacity for shallow foundation at different depths

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	129	142	157	111	144	**137**
0.6	153	142	158	144	130	**145**
0.9	158	158	171	154	152	**159**
1.2	157	163	174	162	170	**165**
1.5	162	145	199	168	177	**170**
1.8	222	119	169	147	142	**160**

5.1.2 Electrical Resistivity

For grounding design use electrical resistivity of 86 Ohm-m. And consider soil as moderately corrosive for sub-structure design.

5.1.3 Thermal Conductivity

For underground cable design use 0.462 W/mK as thermal conductivity and 2.17 mK/W as thermal resistance.

5.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Thinadhoo is located north of Maldives where peak ground acceleration value is between 0.05 and 0.07.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.07, S_s is 0.154 and S_1 is 0.045.

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User's Manual for K-100 Models of KSE DCP. USA.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

Musthafa, A. (2020). Environmental Impact Assessment for the Establishment of Flood Mitigation Measures in Thinadhoo, Gaaf Dhaal Atoll.

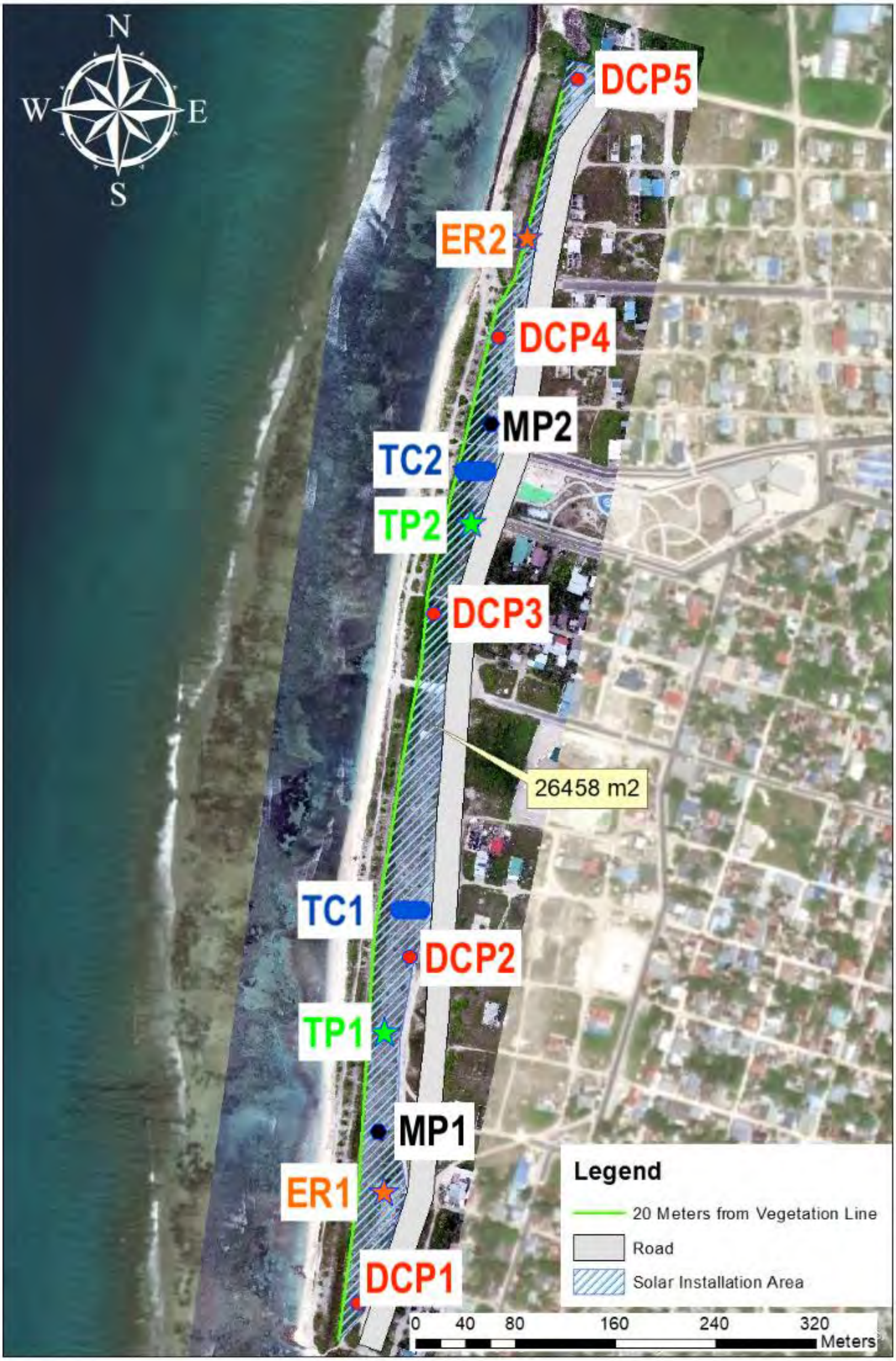
UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES

APPENDIX 1: TEST LOCATIONS

Thinadhoo (ASPIRE Site)



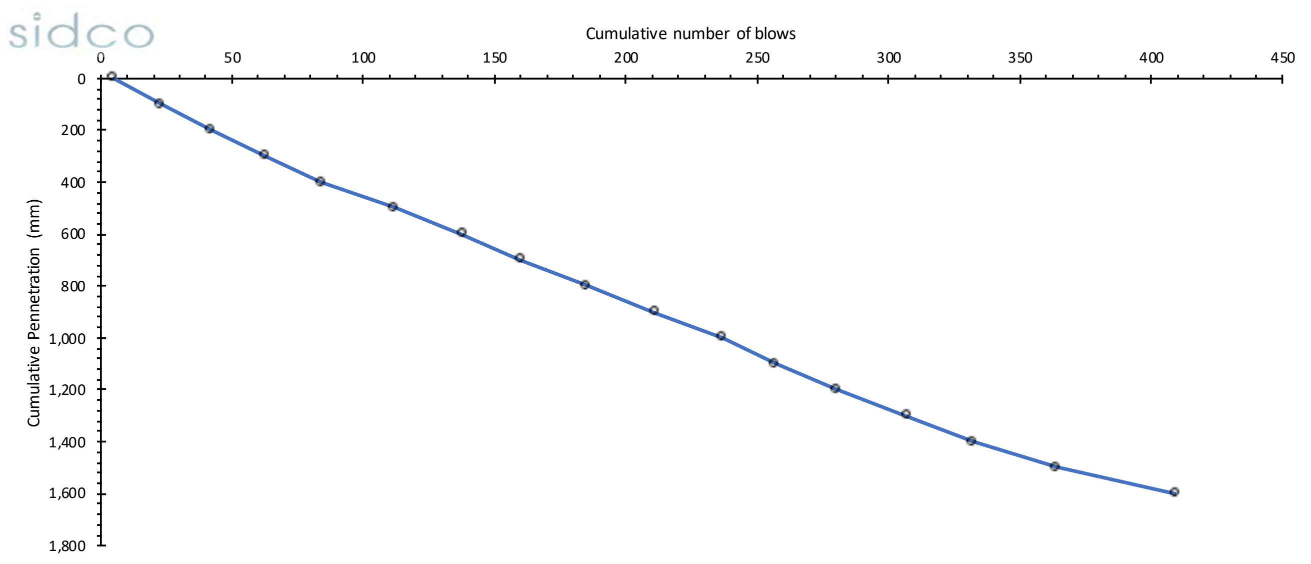
APPENDIX 1: DCP TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Gdh. Thinadhoo, West Beach**		**26/01/2022**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	18	23	5.6	43	317	127
200-300	19	42	5.3	45	330	132
300-400	21	63	4.8	51	355	142
400-500	21	84	4.8	51	355	142
500-600	28	112	3.6	70	440	176
600-700	26	138	3.8	65	416	167
700-800	22	160	4.5	54	368	147
800-900	25	185	4.0	62	404	162
900-1000	26	211	3.8	65	416	167
1000-1100	26	237	3.8	65	416	167
1100-1200	20	257	5.0	48	343	137
1200-1300	23	280	4.3	56	380	152
1300-1400	27	307	3.7	67	428	171
1400-1500	25	332	4.0	62	404	162
1500-1600	32	364	3.1	81	486	194
1600-1700	45	409	2.2	119	626	250
1700-1800	Rebound					
1800-1900						
1900-2000						



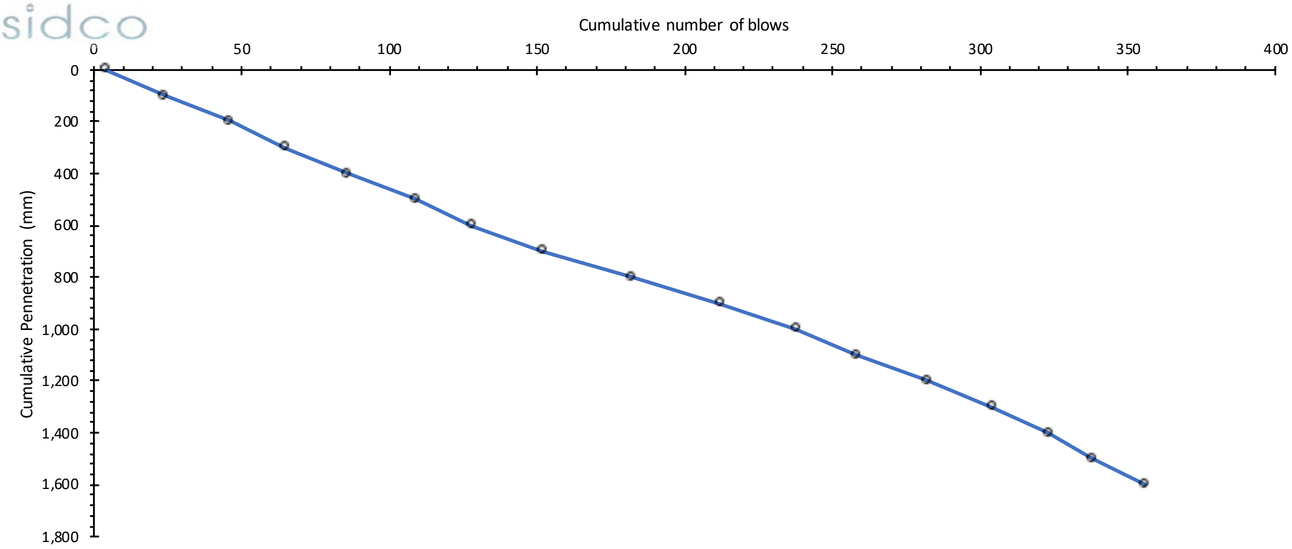
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

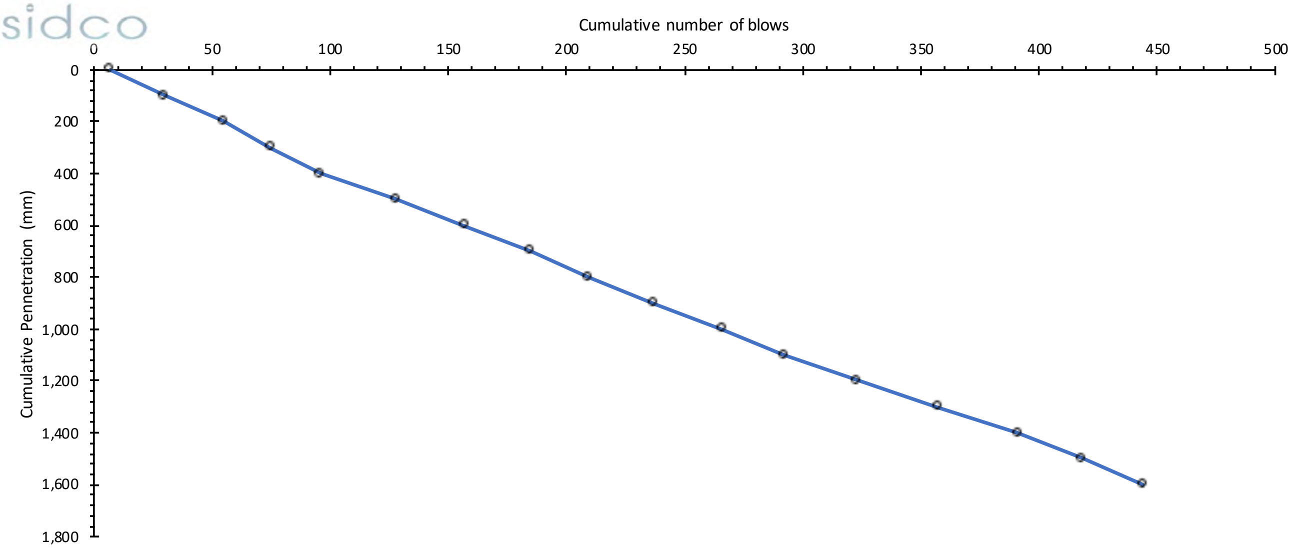
Location:	**Gdh. Thinadhoo, West Beach**		**26/01/2022**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	20	24	5.0	48	343	137
200-300	22	46	4.5	54	368	147
300-400	19	65	5.3	45	330	132
400-500	21	86	4.8	51	355	142
500-600	23	109	4.3	56	380	152
600-700	19	128	5.3	45	330	132
700-800	24	152	4.2	59	392	157
800-900	30	182	3.3	76	463	185
900-1000	30	212	3.3	76	463	185
1000-1100	26	238	3.8	65	416	167
1100-1200	20	258	5.0	48	343	137
1200-1300	24	282	4.2	59	392	157
1300-1400	22	304	4.5	54	368	147
1400-1500	19	323	5.3	45	330	132
1500-1600	15	338	6.7	35	277	111
1600-1700	18	356	5.6	43	317	127
1700-1800	Rebound					
1800-1900						
1900-2000						



SIDCO SOILS LAB
M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Gdh. Thinadhoo, West Beach**		**26/01/2022**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	7	7	14.3	15	157	63
100-200	23	30	4.3	56	380	152
200-300	25	55	4.0	62	404	162
300-400	20	75	5.0	48	343	137
400-500	21	96	4.8	51	355	142
500-600	32	128	3.1	81	486	194
600-700	29	157	3.4	73	452	181
700-800	28	185	3.6	70	440	176
800-900	24	209	4.2	59	392	157
900-1000	28	237	3.6	70	440	176
1000-1100	29	266	3.4	73	452	181
1100-1200	26	292	3.8	65	416	167
1200-1300	31	323	3.2	79	475	190
1300-1400	34	357	2.9	87	508	203
1400-1500	34	391	2.9	87	508	203
1500-1600	27	418	3.7	67	428	171
1600-1700	26	444	3.8	65	416	167
1700-1800	Rebound					
1800-1900						
1900-2000						



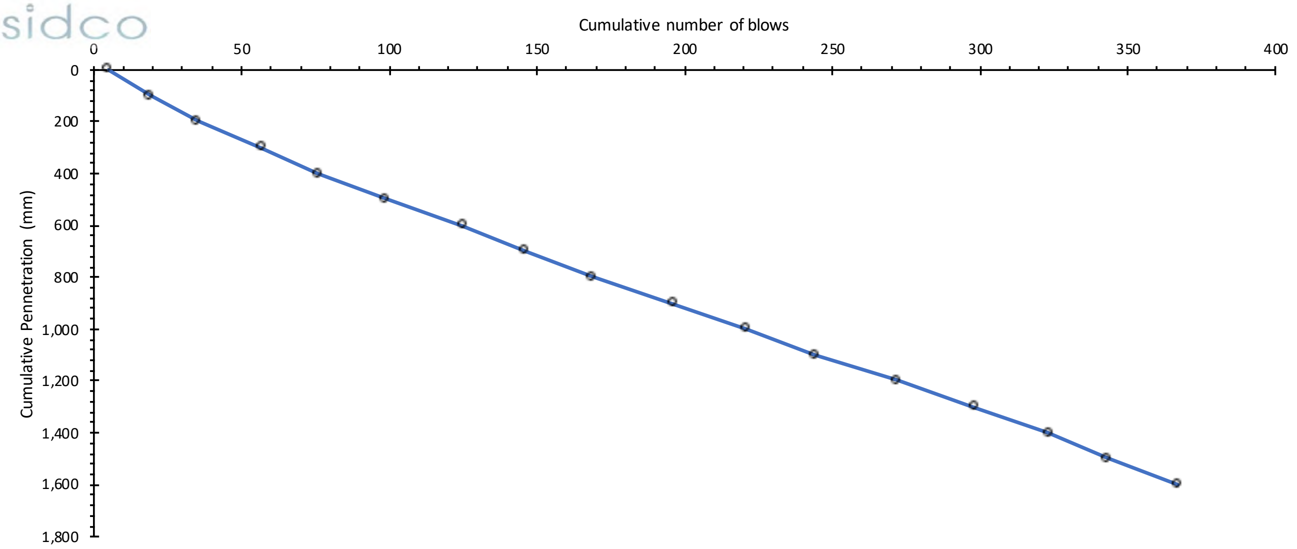
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Gdh. Thinadhoo, West Beach**		**26/01/2022**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	14	19	7.1	32	263	105
200-300	16	35	6.3	37	290	116
300-400	22	57	4.5	54	368	147
400-500	19	76	5.3	45	330	132
500-600	23	99	4.3	56	380	152
600-700	26	125	3.8	65	416	167
700-800	21	146	4.8	51	355	142
800-900	23	169	4.3	56	380	152
900-1000	27	196	3.7	67	428	171
1000-1100	25	221	4.0	62	404	162
1100-1200	23	244	4.3	56	380	152
1200-1300	28	272	3.6	70	440	176
1300-1400	26	298	3.8	65	416	167
1400-1500	25	323	4.0	62	404	162
1500-1600	20	343	5.0	48	343	137
1600-1700	24	367	4.2	59	392	157
1700-1800	Rebound					
1800-1900						
1900-2000						



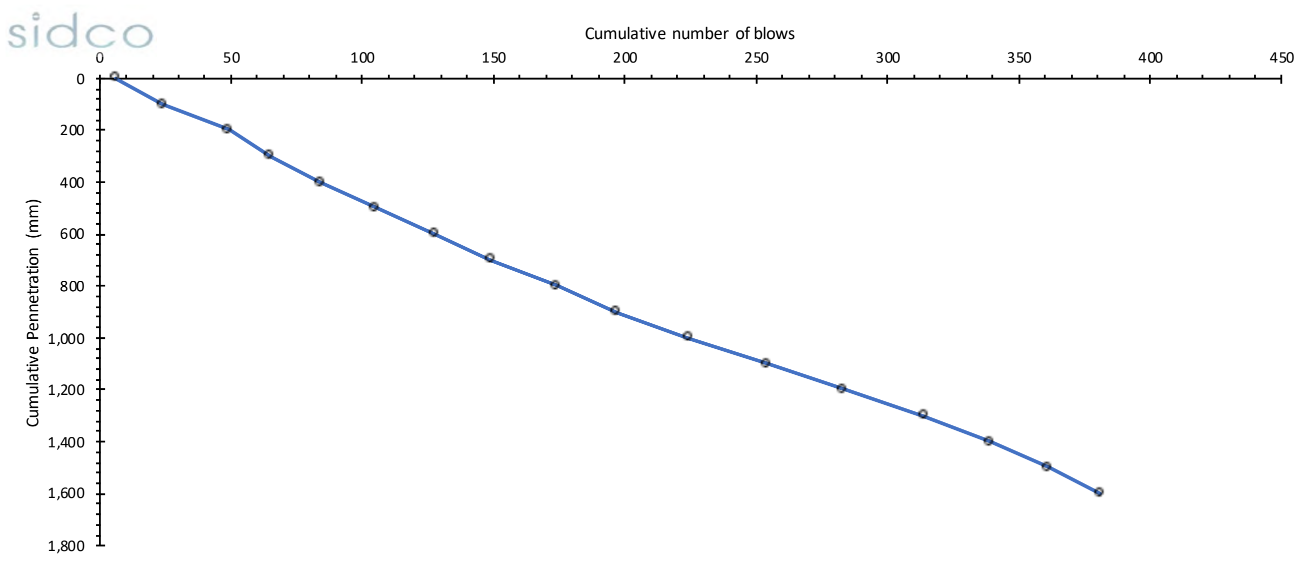
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Gdh. Thinadhoo, West Beach**		**26/01/2022**		**DCP#**	**5**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	18	24	5.6	43	317	127
200-300	25	49	4.0	62	404	162
300-400	16	65	6.3	37	290	116
400-500	19	84	5.3	45	330	132
500-600	21	105	4.8	51	355	142
600-700	23	128	4.3	56	380	152
700-800	21	149	4.8	51	355	142
800-900	25	174	4.0	62	404	162
900-1000	23	197	4.3	56	380	152
1000-1100	27	224	3.7	67	428	171
1100-1200	30	254	3.3	76	463	185
1200-1300	29	283	3.4	73	452	181
1300-1400	31	314	3.2	79	475	190
1400-1500	25	339	4.0	62	404	162
1500-1600	22	361	4.5	54	368	147
1600-1700	20	381	5.0	48	343	137
1700-1800	Rebound					
1800-1900						
1900-2000						



APPENDIX 3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

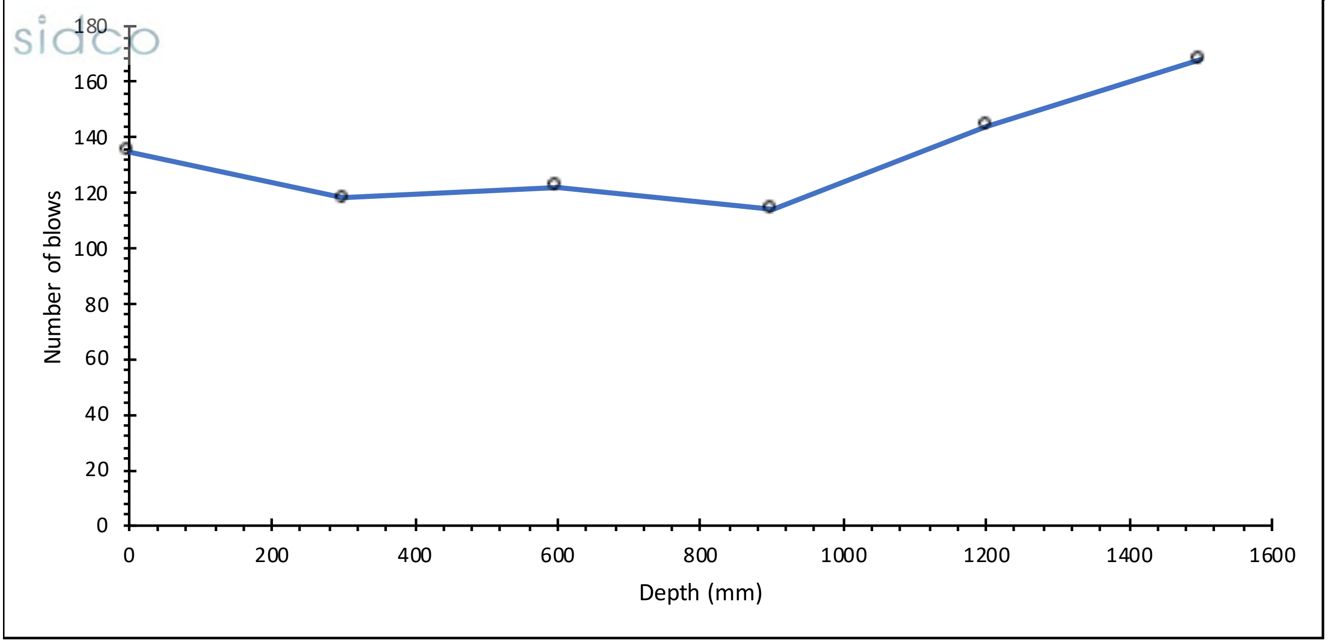
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Gdh. Thinadhoo**	**Date:**	**26/01/2022**	**MP#**	**1**

Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity**
0-300	135	135	394	157
300-600	118	253	370	148
600-900	122	375	375	150
900-1200	114	489	363	145
1200-1500	144	633	405	162
1500-1800	168	801	435	174
1800-2100	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
2100-2400				
2400-2700				
2700-3000				
3000-3300				
3300-3600				
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



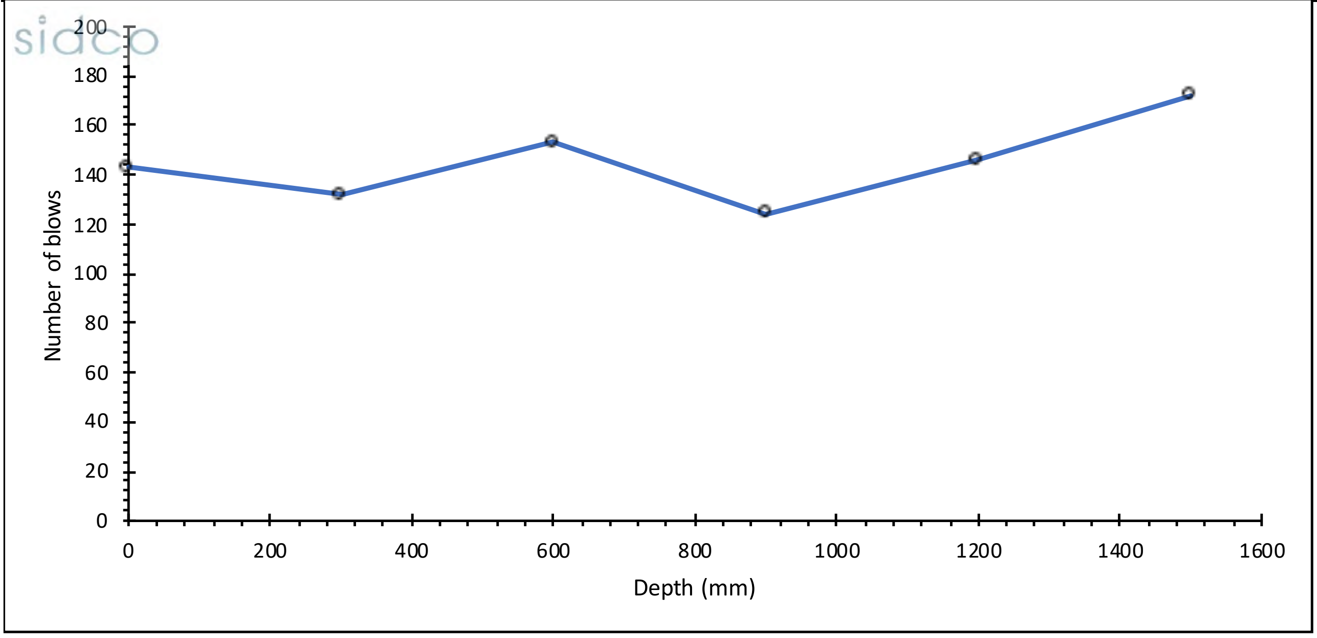
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location: **Gdh. Thinadhoo**	**Date:**	**26/01/2022**	**MP# 1**	**2**
Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity**
0-300	143	143	404	162
300-600	132	275	390	156
600-900	153	428	417	167
900-1200	124	552	378	151
1200-1500	146	698	408	163
1500-1800	172	870	439	176
1800-2100	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
2100-2400				
2400-2700				
2700-3000				
3000-3300				
3300-3600				
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



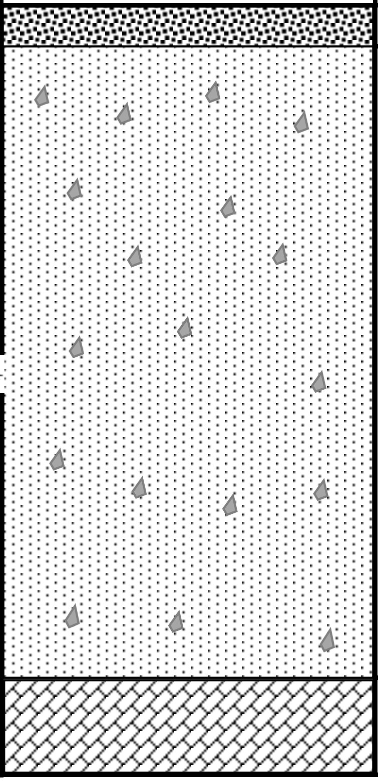
APPENDIX 4: TRIAL PIT LOGS

sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire Project - Solar PV Installation							
Project Number:	HDEC/2023/1				Client:	HDEC		
Equipment	Excavator				Contractor	SIDCO Pvt Ltd		
Ground water depth (m)	0.9	Date	Started:	26/01/2023			Trial Pit	1
Total depth (m)	1.7		Completed	26/01/2023				
BH Location	GDh. Thinadhoo West Beach		Backfilled:	26/01/2023				

Depth (m)			GWL	Graphic Log	Soil Description
0.2					Top soil with grass/roots
0.4					Fine sand with gravels
0.6					
0.8					
1.0			▼		
1.2					
1.4					
1.6					
1.8					Hard Strata
2					

Notes

▼ Ground water level

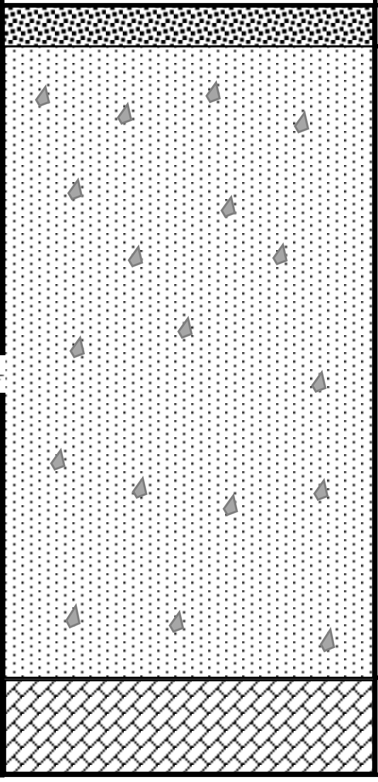
sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project: Aspire Project - Solar PV Installation
Project Number: HDEC/2023/1
Client: HDEC
Equipment Excavator
Contractor SIDCO Pvt Ltd
Ground water depth (m) 0.9
Total depth (m) 1.7
BH Location GDh. Thinadhoo West Beach
Date Started: 26/01/2023
Date Completed 26/01/2023
Date Backfilled: 26/01/2023
Trial Pit 2

Graphic Log



Depth (m)	**GWL**	**Soil Description**
0.2		Top soil with grass/roots
0.4		
0.6		
0.8		
1.0	▼	Fine sand with gravels
1.2		
1.4		
1.6		
1.8		Hard Strata
2		

Notes

▼ Ground water level

APPENDIX 5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

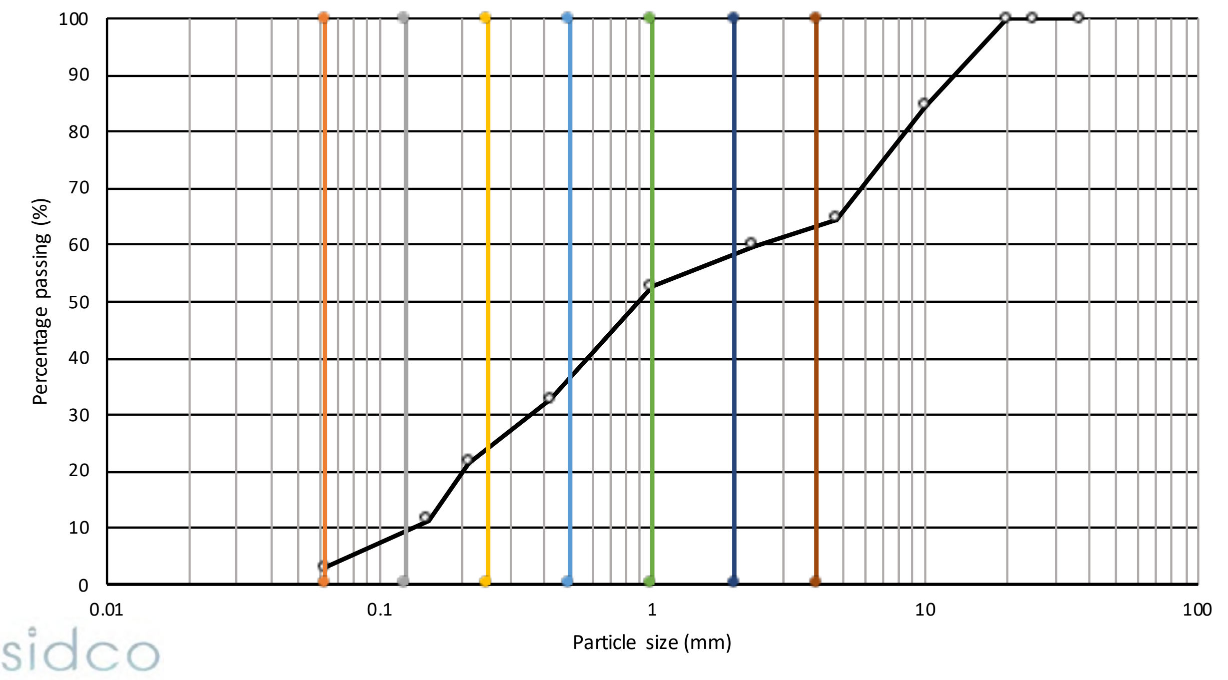
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo		**File #:**	HDEC/2023/1	
Date:	02/02/2022	**Tested by:**	SM		
Trial Pit #1	**Depth (m)**	0.0	**Test #**	**1**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	359	100.0
2	**25**	0	0	0.0	359	100.0
3	**20**	0	0	0.0	359	100.0
4	**10**	56	56	15.6	303	84.4
5	**4.75**	71	127	35.4	232	64.6
8	**2.36**	17	144	40.1	215	59.9
16	**1**	26	170	47.4	189	52.6
30	**0.425**	72	242	67.4	117	32.6
50	**0.212**	40	282	78.6	77	21.4
100	**0.15**	36	318	88.6	41	11.4
200	**0.063**	30	348	96.9	11	3.1
Total weight sieved through 200 (g)				11		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				359	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.1%	6.9%	13.0%	13.0%	15.0%	8.0%	41.0%

SIDCO PVT LTD

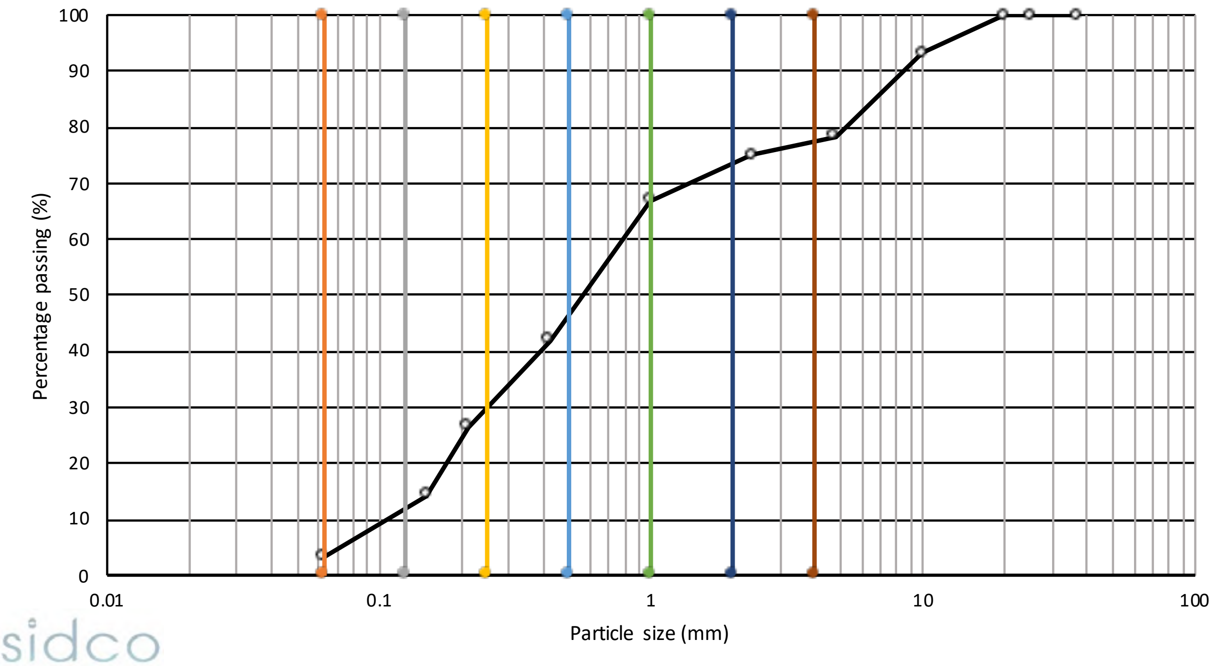
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022		**Tested by:**	SM	
Trial Pit #1	**Depth (m)**	0.5		**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	327	100.0
2	**25**	0	0	0.0	327	100.0
3	**20**	0	0	0.0	327	100.0
4	**10**	22	22	6.7	305	93.3
5	**4.75**	49	71	21.7	256	78.3
8	**2.36**	11	82	25.1	245	74.9
16	**1**	26	108	33.0	219	67.0
30	**0.425**	82	190	58.1	137	41.9
50	**0.212**	50	240	73.4	87	26.6
100	**0.15**	40	280	85.6	47	14.4
200	**0.063**	36	316	96.6	11	3.4
Total weight sieved through 200 (g)				11		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				327	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.4%	7.6%	19.0%	16.0%	22.0%	4.0%	28.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

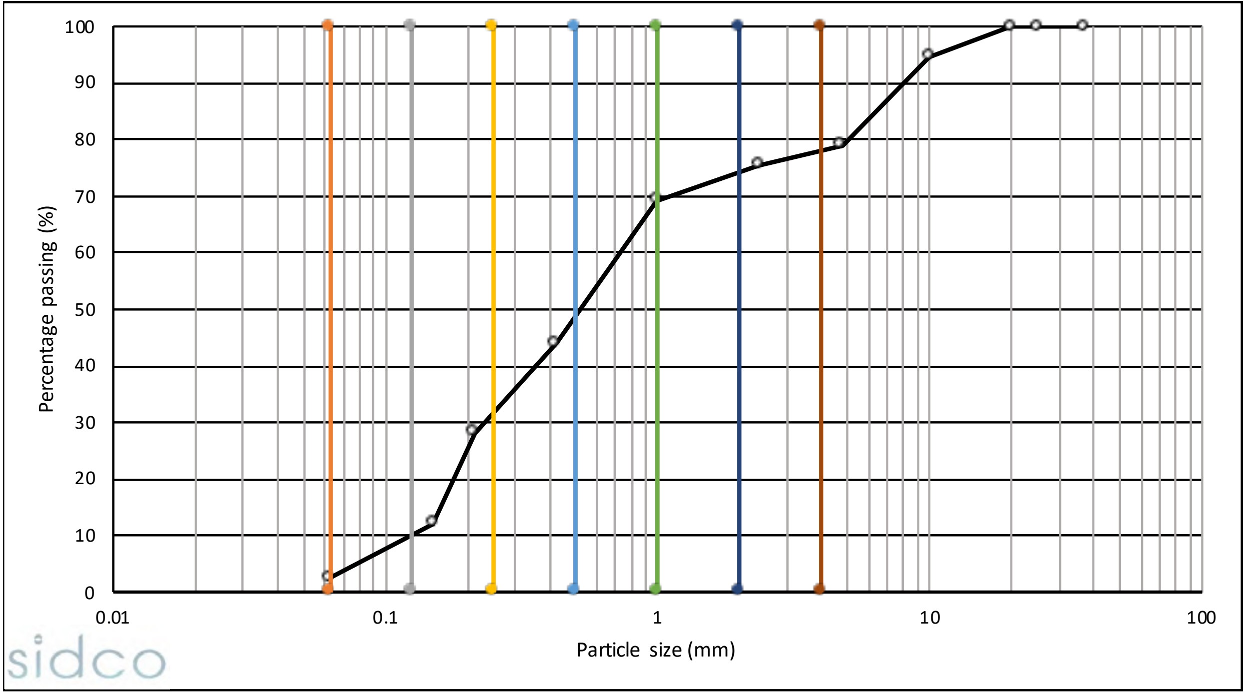
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**	SM		
Trial Pit #1	**Depth (m)**	1.0		**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	338	100.0
2	**25**	0	0	0.0	338	100.0
3	**20**	0	0	0.0	338	100.0
4	**10**	18	18	5.3	320	94.7
5	**4.75**	53	71	21.0	267	79.0
8	**2.36**	12	83	24.6	255	75.4
16	**1**	21	104	30.8	234	69.2
30	**0.425**	85	189	55.9	149	44.1
50	**0.212**	54	243	71.9	95	28.1
100	**0.15**	54	297	87.9	41	12.1
200	**0.063**	32	329	97.3	9	2.7
Total weight sieved through 200 (g)				9		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				338	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.7%	7.3%	21.0%	19.0%	20.0%	3.0%	27.0%

SIDCO PVT LTD

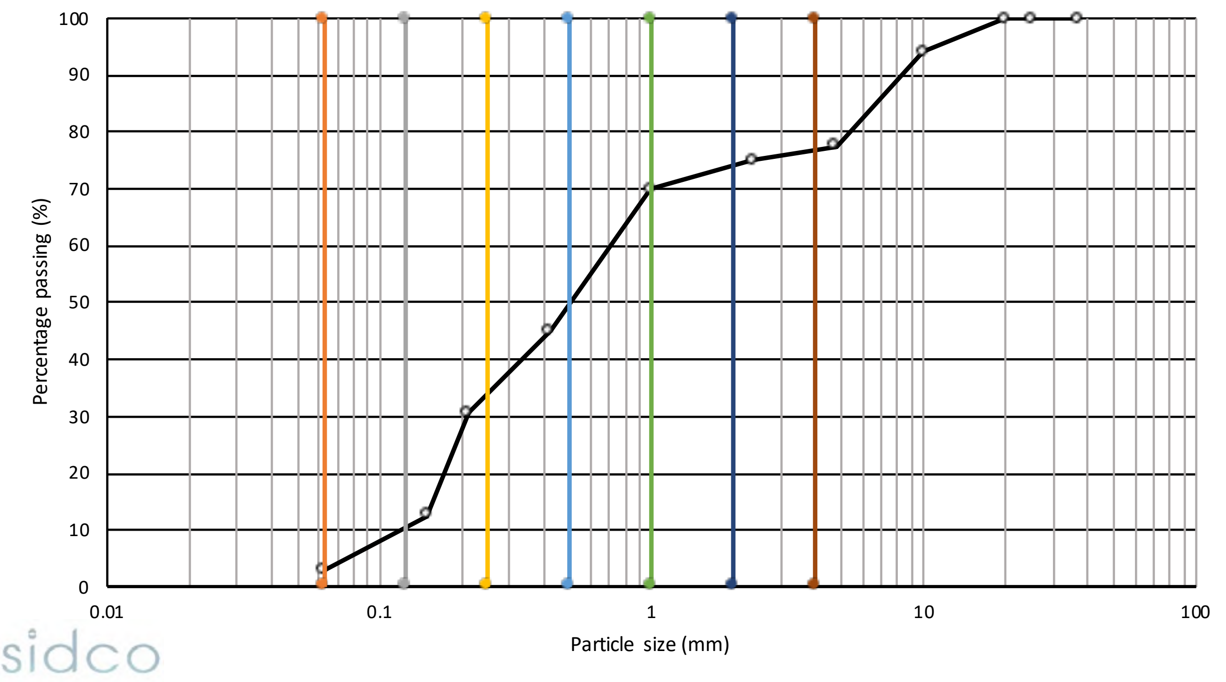
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022		**Tested by:**	SM	
Trial Pit #1	**Depth (m)**	1.7		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	368	100.0
2	**25**	0	0	0.0	368	100.0
3	**20**	0	0	0.0	368	100.0
4	**10**	22	22	6.0	346	94.0
5	**4.75**	61	83	22.6	285	77.4
8	**2.36**	9	92	25.0	276	75.0
16	**1**	19	111	30.2	257	69.8
30	**0.425**	91	202	54.9	166	45.1
50	**0.212**	53	255	69.3	113	30.7
100	**0.15**	67	322	87.5	46	12.5
200	**0.063**	35	357	97.0	11	3.0
Total weight sieved through 200 (g)				11		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				368	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.0%	7.0%	23.0%	17.0%	20.0%	3.0%	27.0%

SIDCO PVT LTD

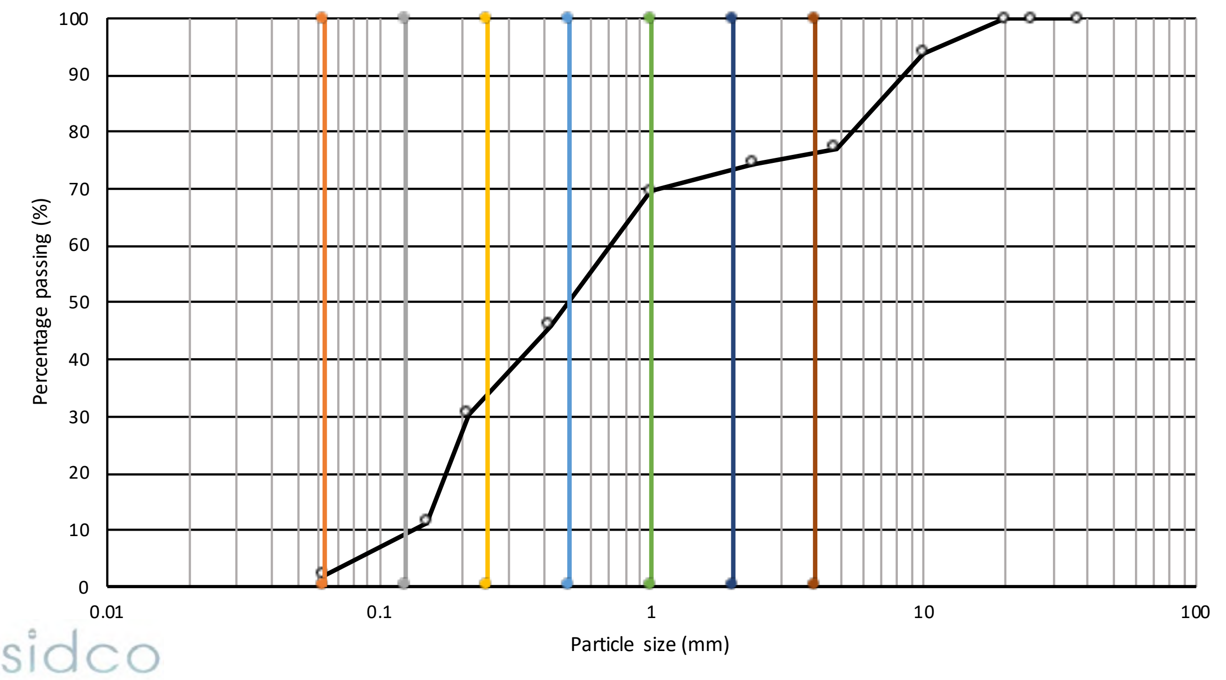
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo		**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**	SM	
Trial Pit #1	**Depth (m)**	3.0	**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	292	100.0
2	**25**	0	0	0.0	292	100.0
3	**20**	0	0	0.0	292	100.0
4	**10**	18	18	6.2	274	93.8
5	**4.75**	49	67	22.9	225	77.1
8	**2.36**	8	75	25.7	217	74.3
16	**1**	14	89	30.5	203	69.5
30	**0.425**	69	158	54.1	134	45.9
50	**0.212**	45	203	69.5	89	30.5
100	**0.15**	56	259	88.7	33	11.3
200	**0.063**	27	286	97.9	6	2.1
Total weight sieved through 200 (g)				6		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				292	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.1%	7.9%	23.0%	17.0%	20.0%	3.0%	27.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

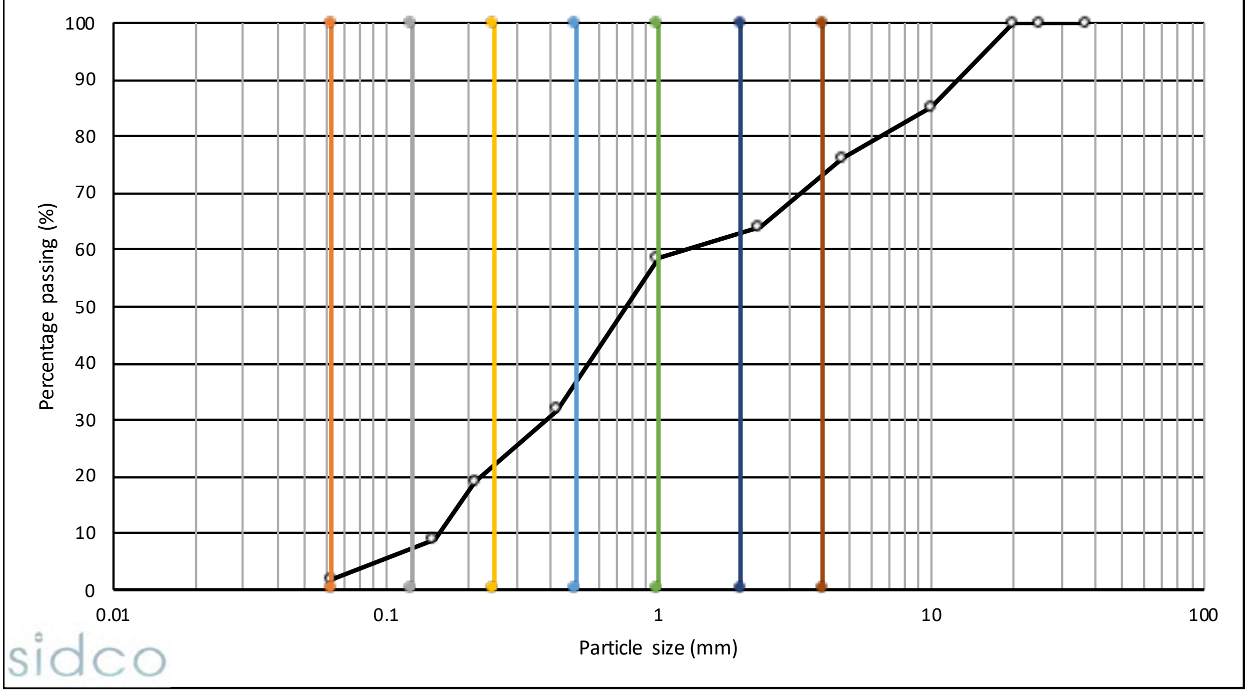
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**		SM	
Trial Pit #2	**Depth (m)**	0.0		**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	375	100.0
2	**25**	0	0	0.0	375	100.0
3	**20**	0	0	0.0	375	100.0
4	**10**	56	56	14.9	319	85.1
5	**4.75**	34	90	24.0	285	76.0
8	**2.36**	45	135	36.0	240	64.0
16	**1**	21	156	41.6	219	58.4
30	**0.425**	100	256	68.3	119	31.7
50	**0.212**	48	304	81.1	71	18.9
100	**0.15**	38	342	91.2	33	8.8
200	**0.063**	26	368	98.1	7	1.9
Total weight sieved through 200 (g)				7		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				375	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.9%	6.1%	14.0%	14.0%	23.0%	4.0%	37.0%

SIDCO PVT LTD

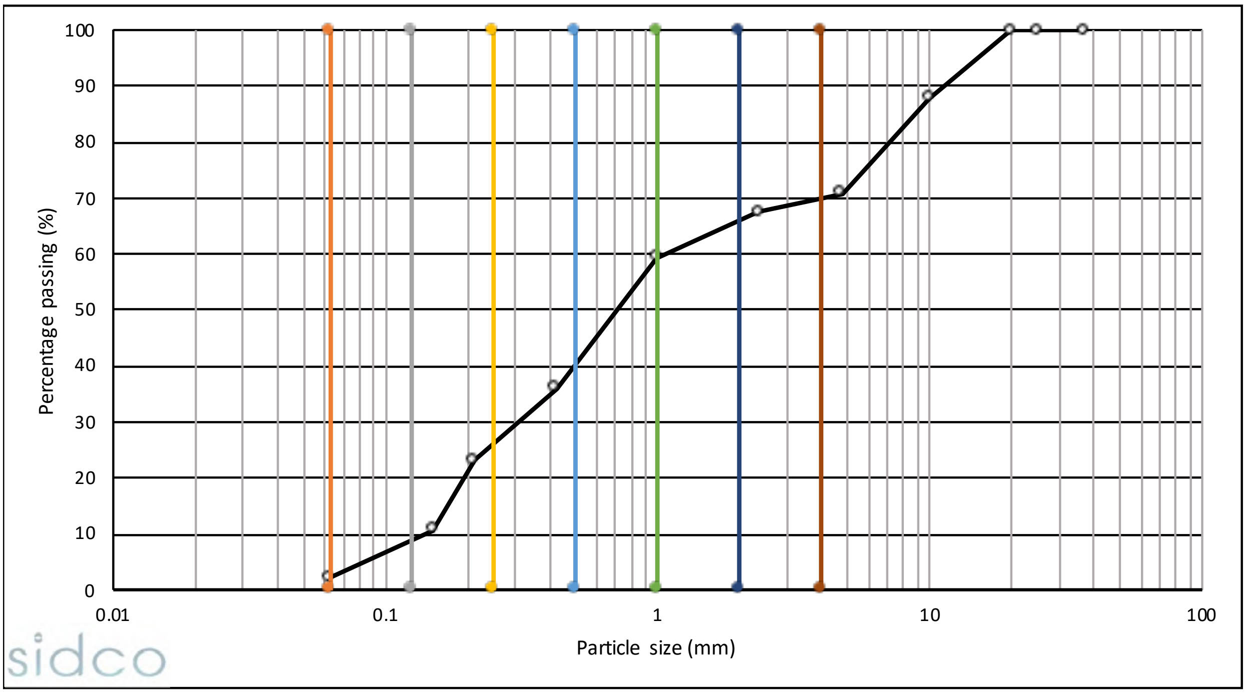
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo		**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**	SM	
Trial Pit #2	**Depth (m)**	0.5	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	388	100.0
2	**25**	0	0	0.0	388	100.0
3	**20**	0	0	0.0	388	100.0
4	**10**	47	47	12.1	341	87.9
5	**4.75**	66	113	29.1	275	70.9
8	**2.36**	13	126	32.5	262	67.5
16	**1**	32	158	40.7	230	59.3
30	**0.425**	90	248	63.9	140	36.1
50	**0.212**	50	298	76.8	90	23.2
100	**0.15**	48	346	89.2	42	10.8
200	**0.063**	33	379	97.7	9	2.3
Total weight sieved through 200 (g)				9		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				388	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.3%	6.7%	17.0%	14.0%	20.0%	7.0%	33.0%

SIDCO PVT LTD

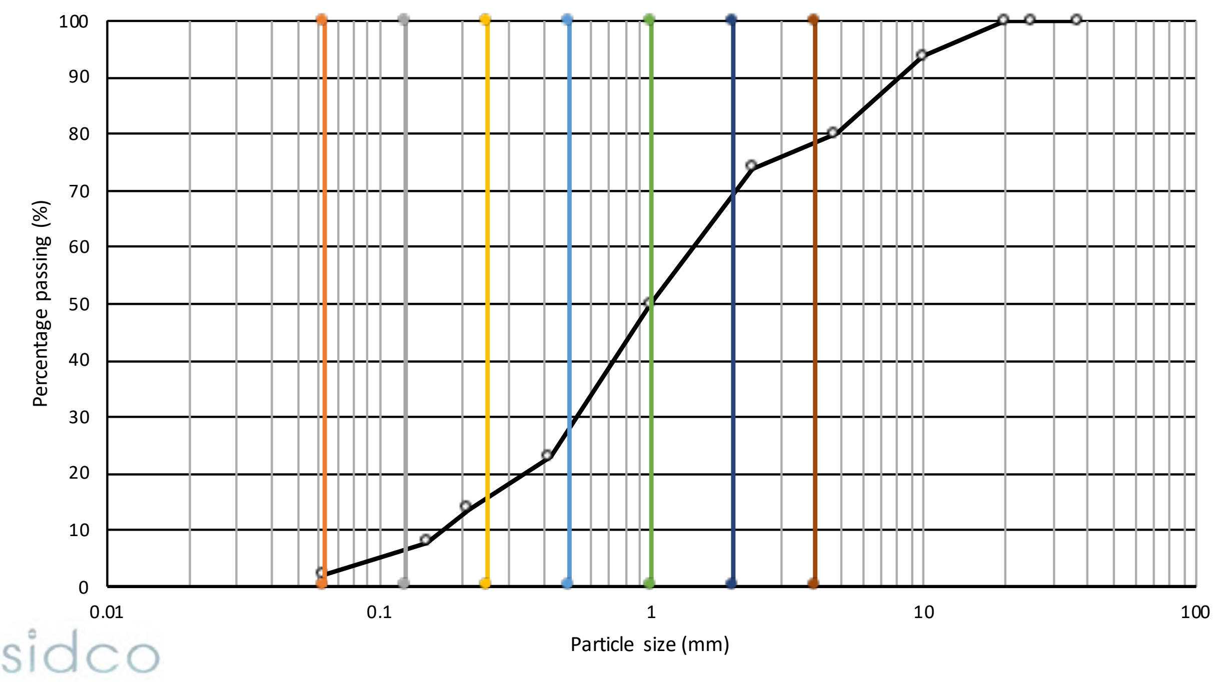
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo		**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**	SM	
Trial Pit #2	**Depth (m)**	1.0	**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	366	100.0
2	**25**	0	0	0.0	366	100.0
3	**20**	0	0	0.0	366	100.0
4	**10**	23	23	6.3	343	93.7
5	**4.75**	50	73	19.9	293	80.1
8	**2.36**	22	95	26.0	271	74.0
16	**1**	88	183	50.0	183	50.0
30	**0.425**	99	282	77.0	84	23.0
50	**0.212**	34	316	86.3	50	13.7
100	**0.15**	21	337	92.1	29	7.9
200	**0.063**	21	358	97.8	8	2.2
Total weight sieved through 200 (g)				8		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				366	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.2%	4.8%	8.0%	14.0%	21.0%	19.0%	31.0%

SIDCO PVT LTD

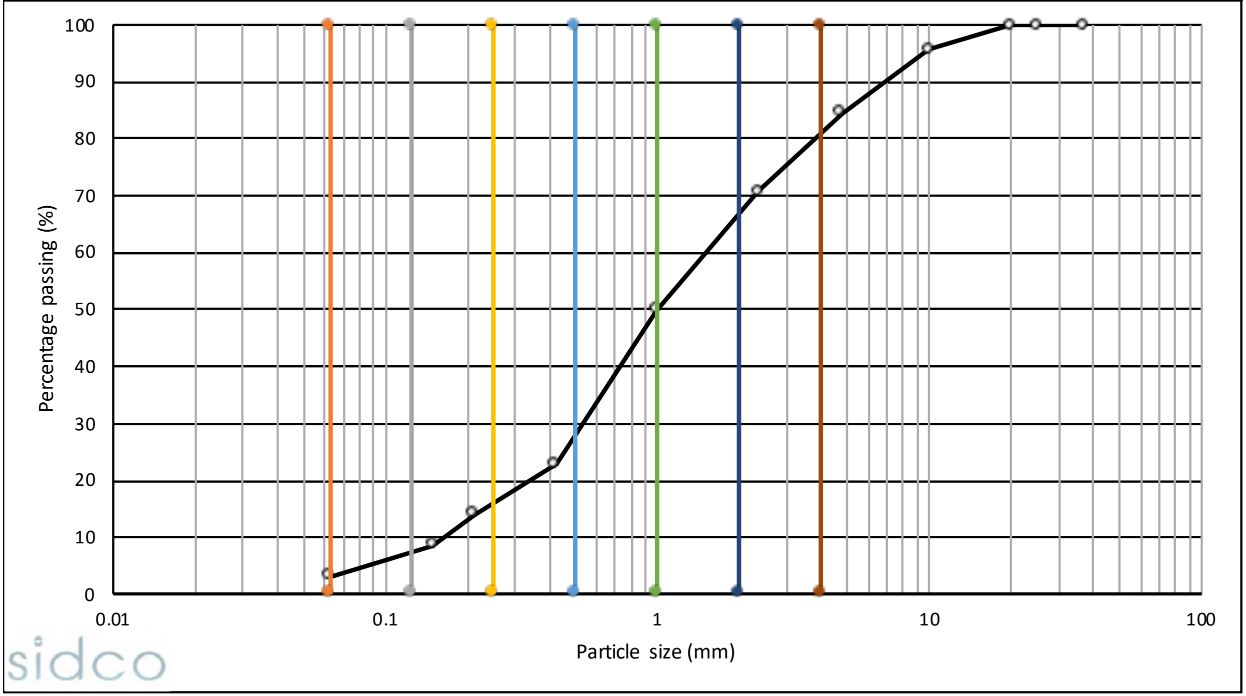
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022	**Tested by:**	SM		
Trial Pit #2	**Depth (m)**	1.7		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing mass (g)	Passing percent (%)
1	**37.5**	0	0	0.0	325	100.0
2	**25**	0	0	0.0	325	100.0
3	**20**	0	0	0.0	325	100.0
4	**10**	14	14	4.3	311	95.7
5	**4.75**	36	50	15.4	275	84.6
8	**2.36**	45	95	29.2	230	70.8
16	**1**	68	163	50.2	162	49.8
30	**0.425**	88	251	77.2	74	22.8
50	**0.212**	28	279	85.8	46	14.2
100	**0.15**	18	297	91.4	28	8.6
200	**0.063**	18	315	96.9	10	3.1
Total weight sieved through 200 (g)				10		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				325	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.1%	4.9%	8.0%	13.0%	21.0%	16.0%	34.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

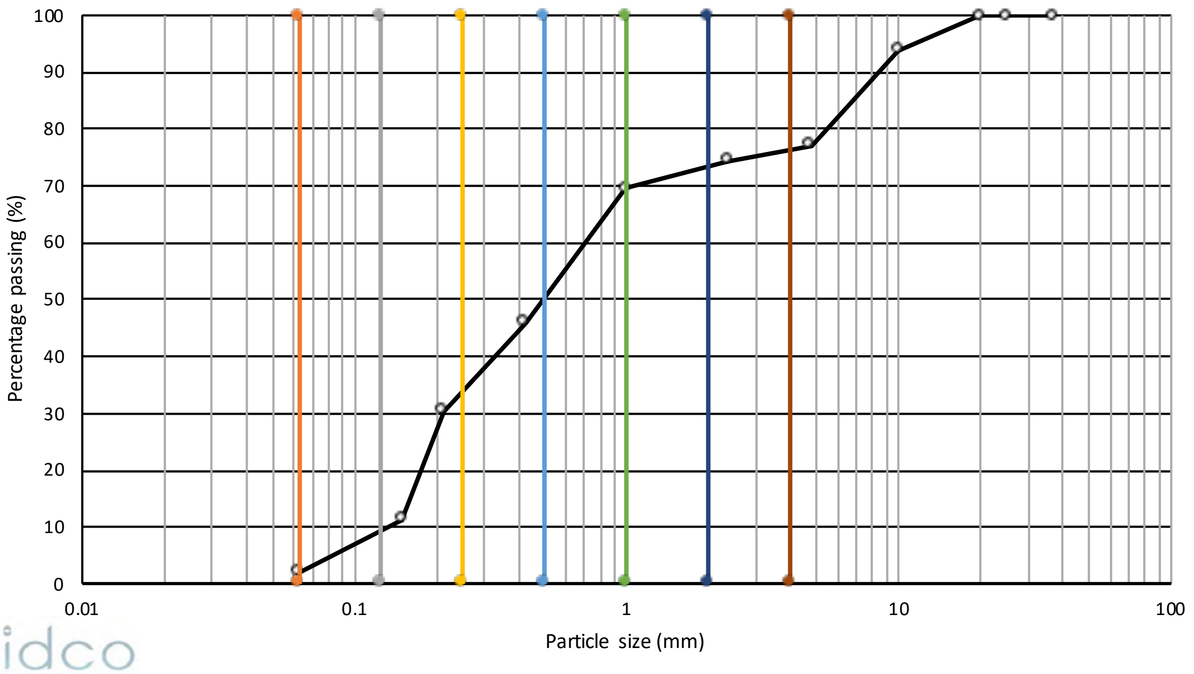
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	Gdh. Thinadhoo			**File #:**	HDEC/2023/1
Date:	02/02/2022		**Tested by:**	SM	
Trial Pit #2	**Depth (m)**	3.0		**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	292	100.0
2	**25**	0	0	0.0	292	100.0
3	**20**	0	0	0.0	292	100.0
4	**10**	18	18	6.2	274	93.8
5	**4.75**	49	67	22.9	225	77.1
8	**2.36**	8	75	25.7	217	74.3
16	**1**	14	89	30.5	203	69.5
30	**0.425**	69	158	54.1	134	45.9
50	**0.212**	45	203	69.5	89	30.5
100	**0.15**	56	259	88.7	33	11.3
200	**0.063**	27	286	97.9	6	2.1
Total weight sieved through 200 (g)				6		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				292	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.1%	7.9%	23.0%	17.0%	20.0%	3.0%	27.0%

APPENDIX 6: PROCTOR TEST RESULT

SIDCO PVT LTD

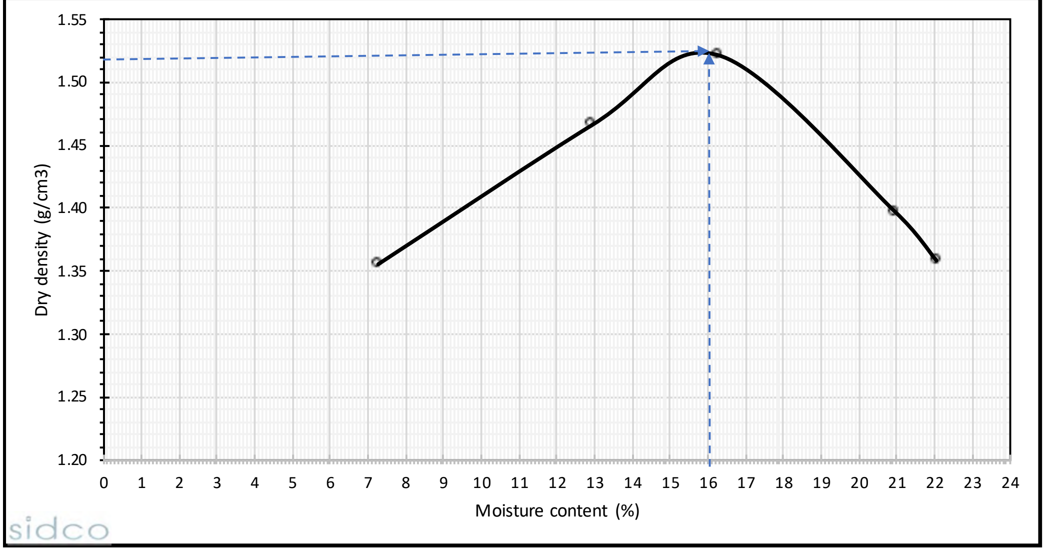
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**GDh. Thinadhoo**	**Date:**	**10/02/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.6	
Water dennsity, 𝜸w	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4903.00	5105.00	5218.00	5139.00	5107.00
weight of compacted soil, w2-w1 (g)	1454.00	1656.00	1769.00	1690.00	1658.00
Wet density, 𝜸b = ((w2-w1)/v), g/cm3	1.45	1.66	1.77	1.69	1.66
Dry density, 𝜸d = (𝜸b/(1+(w/100))), g/cm3	**1.36**	**1.47**	**1.52**	**1.40**	**1.36**
Void Ratio e = ((Gs𝜸w)/𝜸d-1	1.92	1.77	1.71	1.86	1.91
Moisture content					
Weight of container, g	30.09	30.26	30.03	29.99	30.19
Weight of container + wet soil, g	73.2	64.2	75.4	72.2	64.9
Wet container + dry soil, g	70.29	60.32	69.05	64.89	58.63
Weight of moisture, ww (g)	2.92	3.89	6.35	7.31	6.27
Weight of dry soil, ws (g)	40.20	30.06	39.02	34.90	28.44
Water content, w= ((ww/ws)x100), %	**7.26**	**12.94**	**16.27**	**20.95**	**22.05**



APPENDIX 7: DIRECT SHEAR TEST RESULT

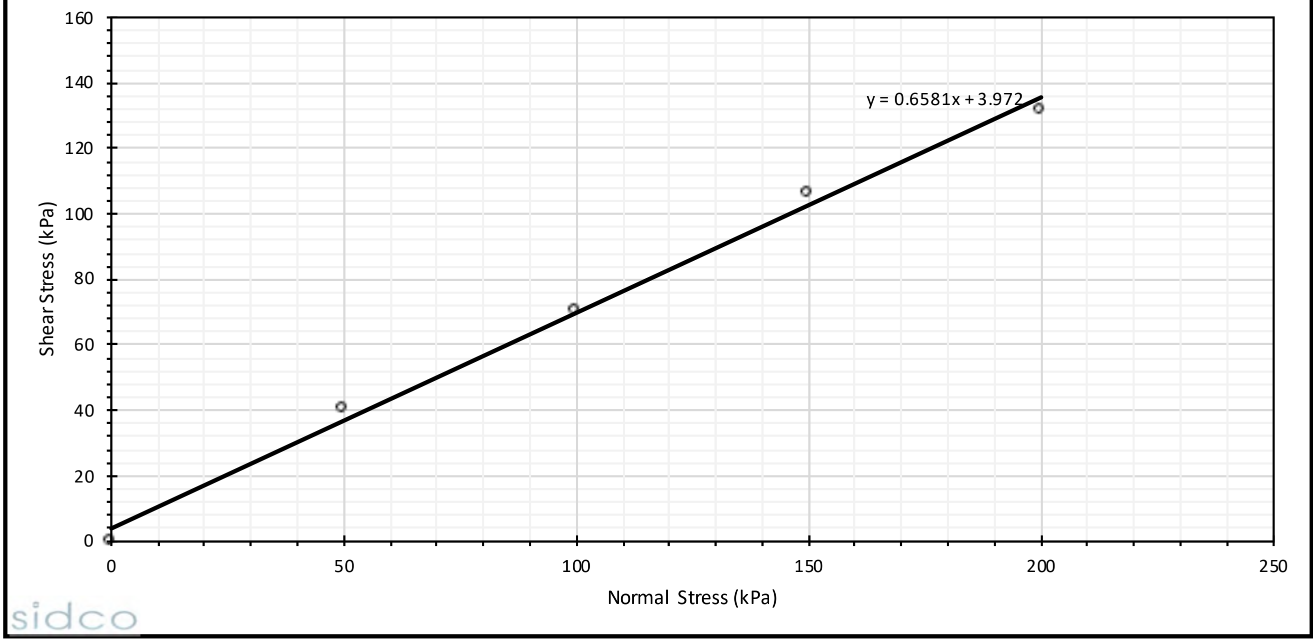
SIDCO PVT LTD
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**GDh. Thinadhoo**	**Date:**	**10/02/2023**	**Direct Shear**	**1**

Moisture content (%)	8.75%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	34.14	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	40.65
100.00	70.23
150.00	106.34
200.00	131.67



APPENDIX 8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	Gdh. Thinadhoo	Date:	26/01/2022
TEST 1			
Mass of dnesity bottle	W1	31.32	g
Mass of bottle + dry sand	W2	60.81	g
Mass of bottle + dry sand + water	W3	149.1	g
Mass of bottle + water	W4	130.92	g
Specific Gravity	Gs	2.61	

TEST 2

Mass of dnesity bottle	W1	35.02	g
Mass of bottle + dry sand	W2	67.14	g
Mass of bottle + dry sand + water	W3	166.5	g
Mass of bottle + water	W4	146.68	g
Specific Gravity	Gs	2.61	

Avarege Gs		2.61	

APPENDIX 9: SOIL RESITIVITY SURVEY RESULT

SIDCO SOILS LAB

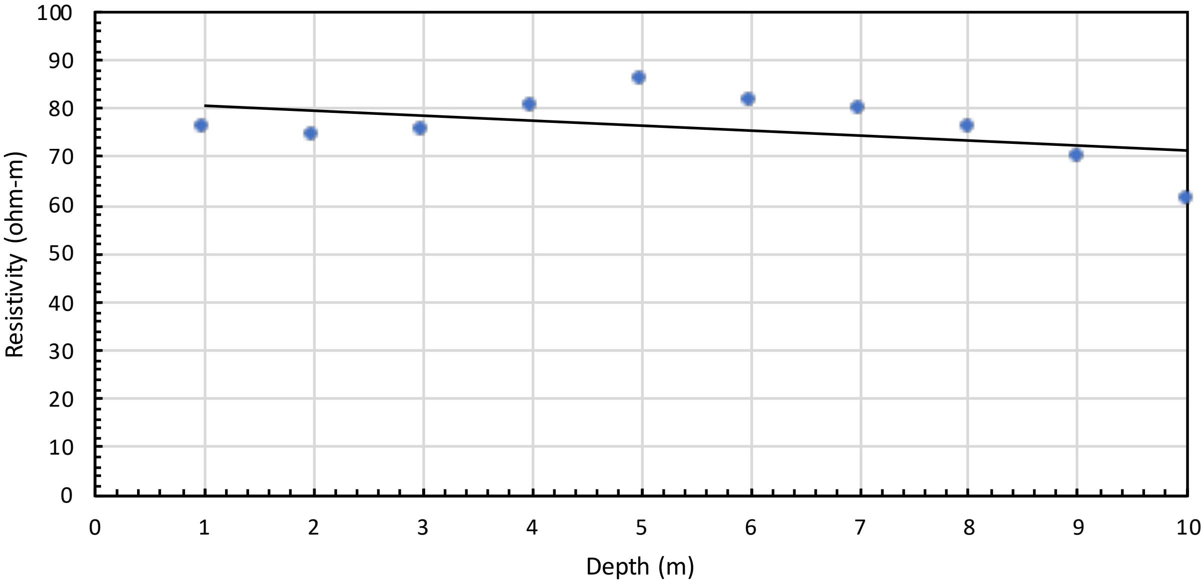
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1

Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	12.11	76
2	2	5.91	74
3	3	4.01	76
4	4	3.21	81
5	5	2.73	86
6	6	2.16	81
7	7	1.82	80
8	8	1.51	76
9	9	1.24	70
10	10	0.97	61



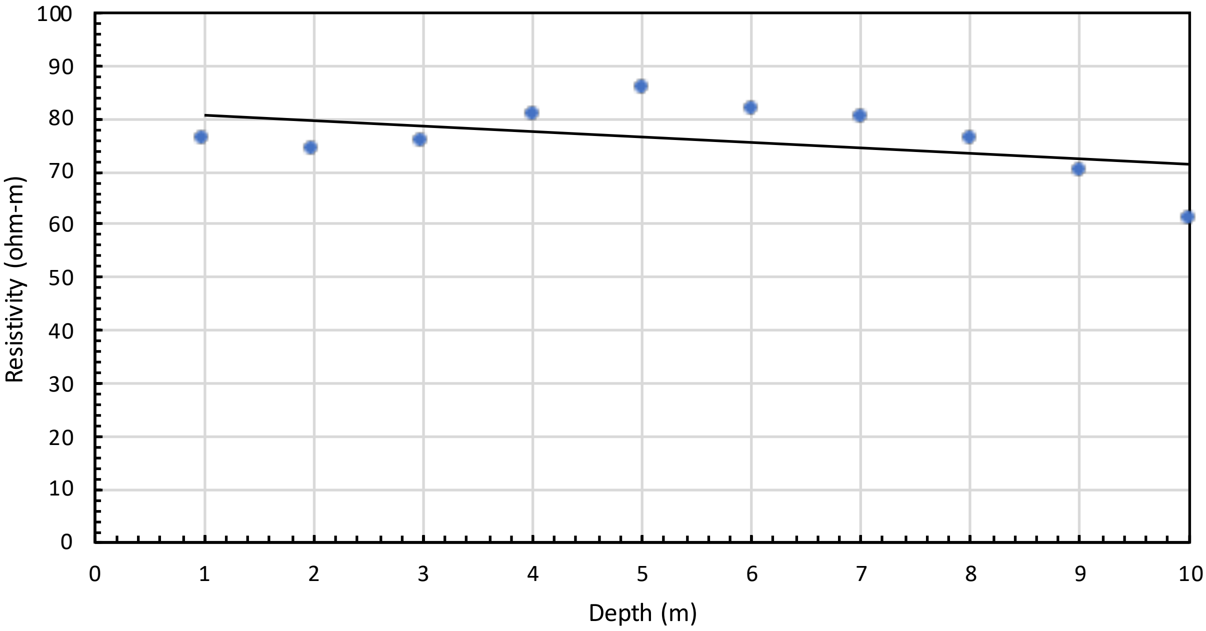
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 2

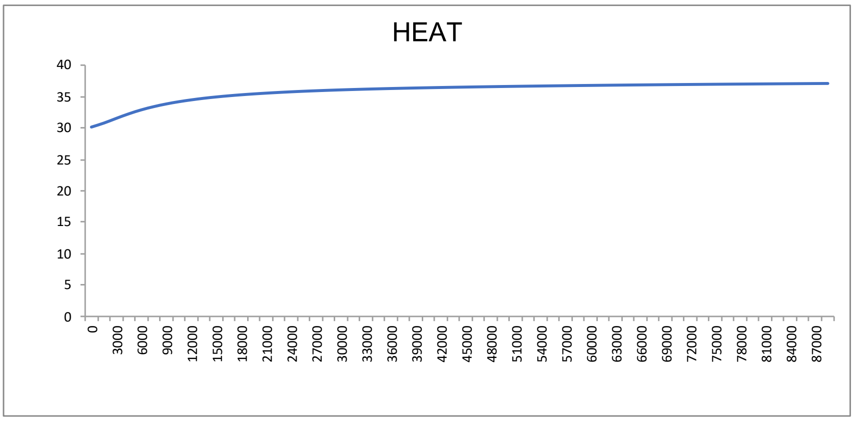
Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	11.94	75
2	2	5.60	70
3	3	4.11	77
4	4	3.02	76
5	5	2.41	76
6	6	2.03	76
7	7	1.54	68
8	8	1.25	63
9	9	1.01	57
10	10	0.97	61

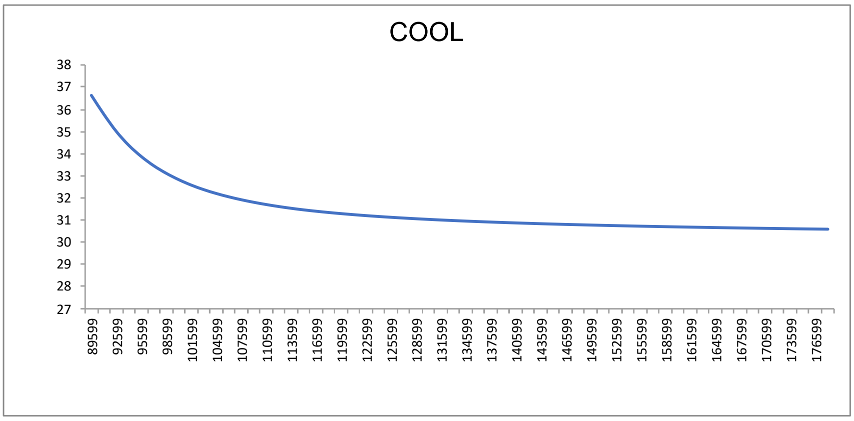


APPENDIX 10: THERMAL CONDUCTIVITY TEST RESULTS

TEST1

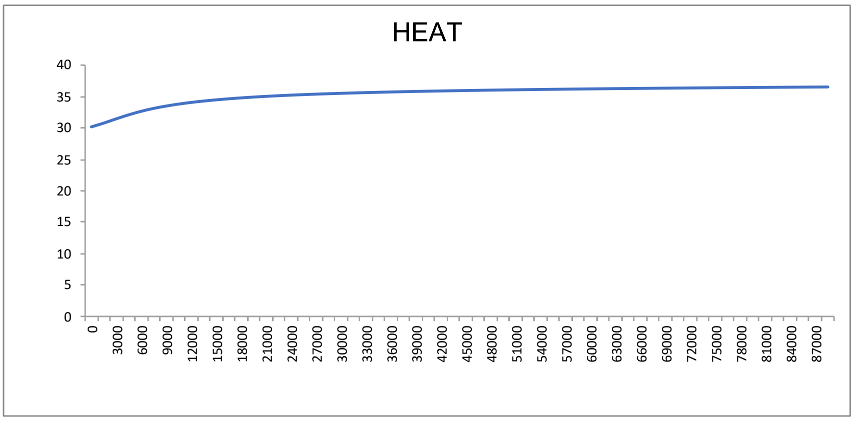
HEAT		COOL	
Time (ms)	T (C)	Time (ms)	T (C)
0	30.143858	89599	36.626713
1500	30.780037	91099	35.771008
3000	31.534462	92599	34.997276
4500	32.256882	94099	34.370827
6000	32.884422	95599	33.867245
7500	33.397285	97099	33.449764
9000	33.825119	98599	33.110218
10500	34.179089	100099	32.823273
12000	34.472576	101599	32.579174
13500	34.727947	103099	32.374722
15000	34.939022	104599	32.201283
16500	35.122913	106099	32.051273
18000	35.282684	107599	31.919899
19500	35.421867	109099	31.804676
21000	35.544899	110599	31.703045
22500	35.656403	112099	31.61298
24000	35.756859	113599	31.532978
25500	35.846615	115099	31.462212
27000	35.925903	116599	31.400162
28500	35.99958	118099	31.343891
30000	36.065945	119599	31.292698
31500	36.126514	121099	31.246078
33000	36.182903	122599	31.202509
34500	36.234001	124099	31.163015
36000	36.281834	125599	31.126678
37500	36.326458	127099	31.092985
39000	36.367882	128599	31.061642
40500	36.406677	130099	31.032696
42000	36.44405	131599	31.004833
43500	36.47924	133099	30.979937
45000	36.512169	134599	30.955309
46500	36.544559	136099	30.933069
48000	36.574375	137599	30.911655
49500	36.603848	139099	30.891911
51000	36.631657	140599	30.872793
52500	36.657776	142099	30.854912
54000	36.682632	143599	30.837267
55500	36.708042	145099	30.821262
57000	36.731152	146599	30.805677
58500	36.754757	148099	30.791315
60000	36.776089	149599	30.777082
61500	36.79763	151099	30.763565
63000	36.817963	152599	30.750353
64500	36.837669	154099	30.737953
66000	36.856167	155599	30.725634
67500	36.874691	157099	30.714569
69000	36.893051	158599	30.703598
70500	36.910164	160099	30.692825
72000	36.92725	161599	30.68265
73500	36.943436	163099	30.672974
75000	36.959763	164599	30.662922
76500	36.975662	166099	30.653847
78000	36.989964	167599	30.644979
79500	37.003868	169099	30.636555
81000	37.01833	170599	30.62785
82500	37.032883	172099	30.620249
84000	37.046417	173599	30.61171
85500	37.060635	175099	30.604065
87000	37.074715	176599	30.597176
88500	37.087311	178099	30.590263

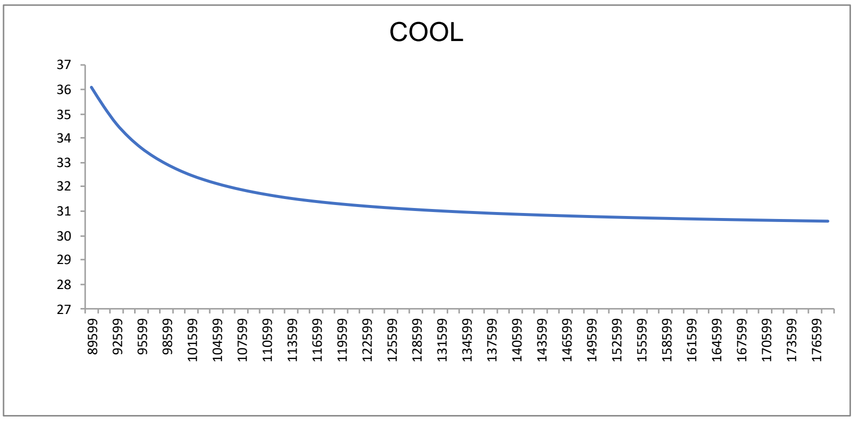




TEST2

HEAT		COOL	
Time (ms)	T (C)	Time (ms)	T (C)
0	30.177149	89599	36.084648
1500	30.782808	91099	35.288338
3000	31.462746	92599	34.585335
4500	32.10009	94099	34.03754
6000	32.659119	95599	33.592819
7500	33.121223	97099	33.235653
9000	33.490818	98599	32.93853
10500	33.80582	100099	32.687176
12000	34.067841	101599	32.473694
13500	34.288307	103099	32.295216
15000	34.476227	104599	32.140221
16500	34.644394	106099	32.005039
18000	34.79147	107599	31.885937
19500	34.920559	109099	31.780308
21000	35.034328	110599	31.686844
22500	35.136314	112099	31.602013
24000	35.227455	113599	31.526127
25500	35.309898	115099	31.459555
27000	35.385143	116599	31.399792
28500	35.452911	118099	31.345219
30000	35.51609	119599	31.295961
31500	35.576115	121099	31.249695
33000	35.631416	122599	31.207935
34500	35.682739	124099	31.168907
36000	35.730812	125599	31.132465
37500	35.77602	127099	31.099266
39000	35.818035	128599	31.068451
40500	35.856964	130099	31.03904
42000	35.894028	131599	31.012291
43500	35.928978	133099	30.986252
45000	35.962387	134599	30.962263
46500	35.993713	136099	30.939777
48000	36.023891	137599	30.917147
49500	36.052814	139099	30.897596
51000	36.080055	140599	30.878666
52500	36.106697	142099	30.860609
54000	36.131302	143599	30.842758
55500	36.155125	145099	30.826729
57000	36.178864	146599	30.811115
58500	36.200901	148099	30.796188
60000	36.222313	149599	30.781595
61500	36.242599	151099	30.768225
63000	36.263126	152599	30.754862
64500	36.28249	154099	30.742205
66000	36.301521	155599	30.729927
67500	36.319214	157099	30.718328
69000	36.336689	158599	30.707804
70500	36.35363	160099	30.69673
72000	36.370564	161599	30.686264
73500	36.386532	163099	30.676325
75000	36.402767	164599	30.666723
76500	36.418201	166099	30.657402
78000	36.432766	167599	30.648502
79500	36.447075	169099	30.639645
81000	36.461983	170599	30.631073
82500	36.475708	172099	30.622379
84000	36.489597	173599	30.615273
85500	36.502831	175099	30.607052
87000	36.515945	176599	30.599749
88500	36.529072	178099	30.592592





MARCH 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
B. Eydhafushi

CLIENT

HDEC

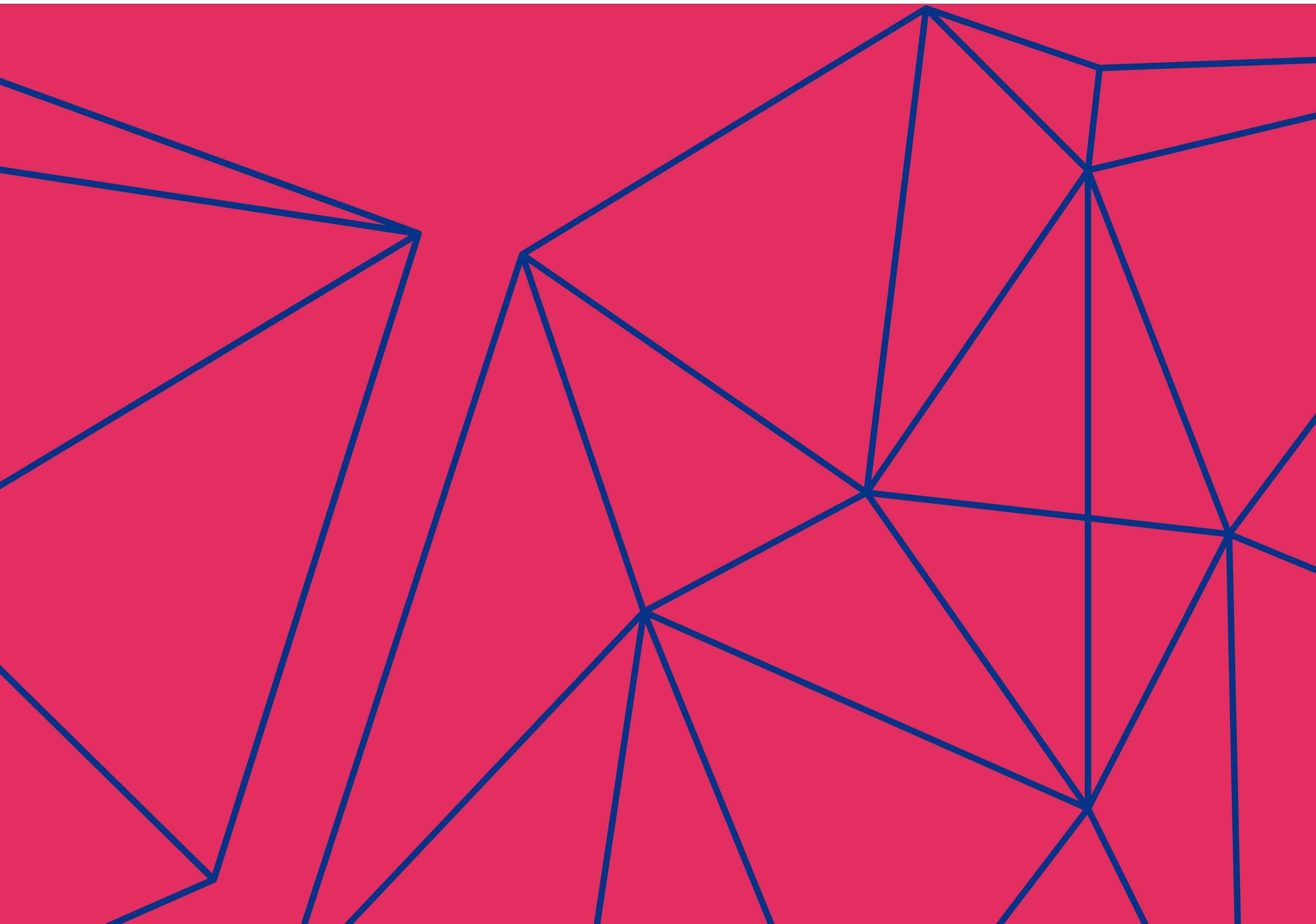


Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out on 22nd and 23rd January 2023 in B. Eydhafushi for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Dynamic Cone Penetration (DCP) tests
2. Mackintosh Probe
3. Trial Pits
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
2. BS EN ISO 17892-4:2016 Determination of particle size distribution
3. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
4. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

B. Eydhafushi is located 113 km north of Male' at 73° 4.222' E and 05° 6.227' N. The geographic land area of the island is 55 hectares. The length of the island measures length 1.22 km and about 0.60 km wide. The population of the Island is 3339.[1]

Figure 1: Location of Lh, Hinnavaru (www.isles.gov.mv)

The island was originally only 30.9 ha, but 25 ha land was added to the west side of the island through reclamation.

The proposed solar PV installation is to be carried out on reclaimed area.

---

[1] https://www.isles.gov.mv/Island/DetailsEn/971

Figure 2: Satellite image of Eydhafushi in 2023 (google maps)

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed roads for development have a flat terrain and the ground elevation is between 1 and 1.5 meters.

Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

In Hinnnavaru, the eastern side of the island has been modified by construction of a local harbour, and western side by reclamation of 33 ha of land.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP 2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.

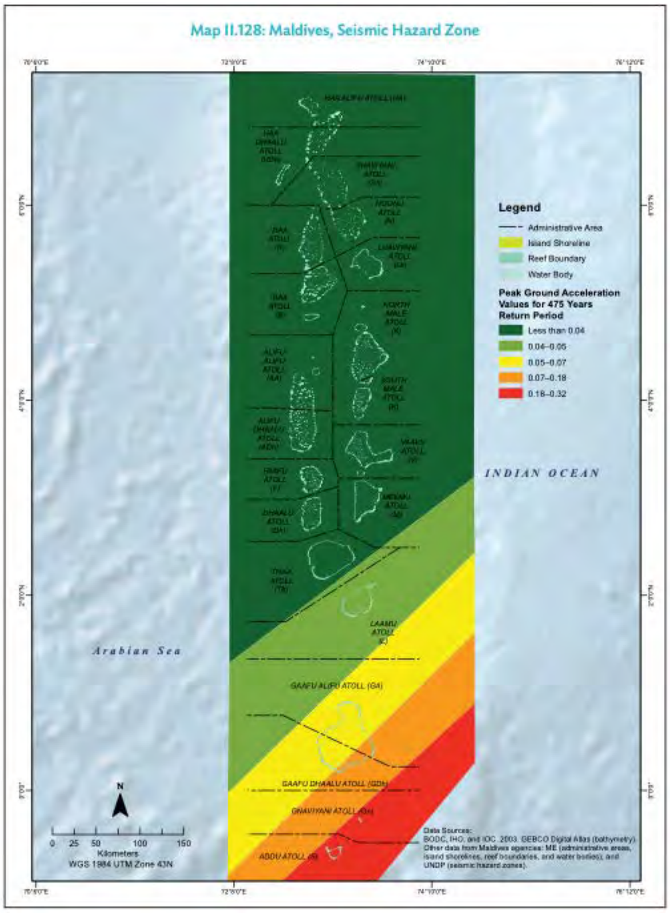


Figure 3: Seismic Hazard Zone (ADB 2020)

Eydhafushi is located north of Maldives where peak ground acceleration value for 475 years return period is less than 0.04.

2.4 RAINFALL

Rainfall data and other meteorological data are not available for Eydhafushi. The closest weather centre is located at Hulhule' (located at 4.1875º N and 73.5292º E) and are available and is representative of the weather conditions of northern part of Maldives.

Hulhulé rainfall data shows a periodic pattern and annual precipitation varies from year to year with an average rainfall of 2003.3 mm and ranging between 1407.0 mm and 2711.2 mm (Zahid 2011).

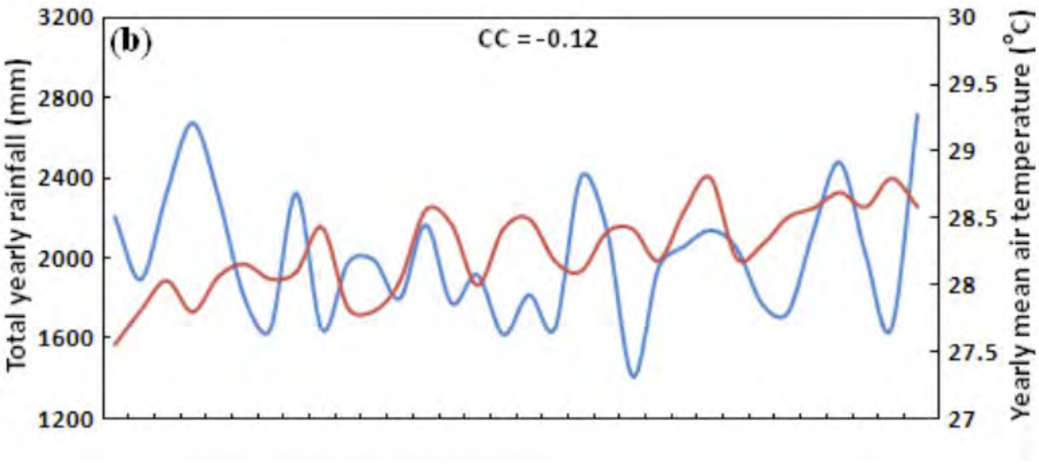


Figure 4: Annual total rainfall and mean air temperature for Hulhule, (Zahid 2011)

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

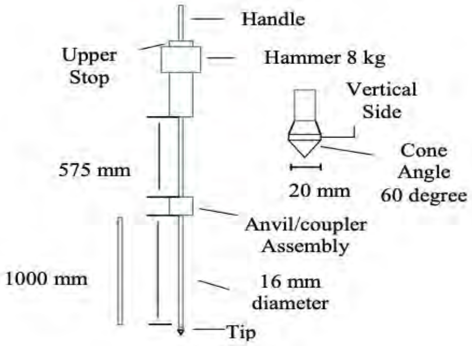


Figure 5: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.2 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.

6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.
7. The data is then plotted number of blows against depth.

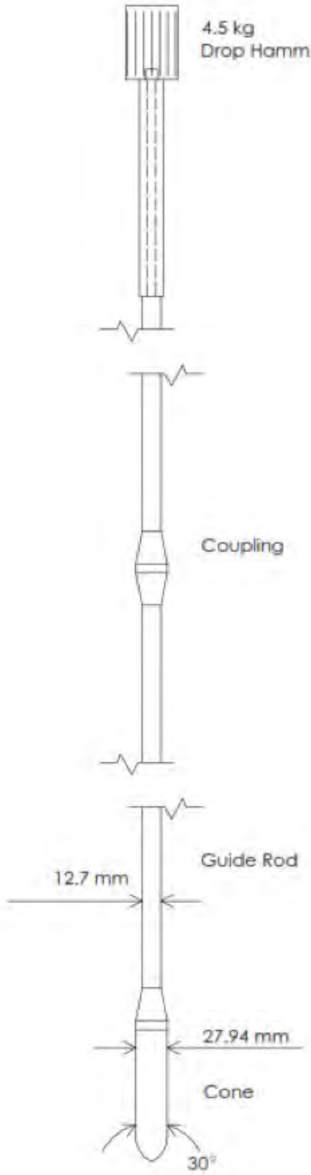


Figure 6: Schematic diagram of Mackintosh Probe

3.2.3 Trial Pits

Two trial pits were made using an excavator. A soil sample was taken at the top, 0.5 m, 1.0 m, 2.0 m and 3.0 m for laboratory investigation of sieve analysis. Photographs and were taken and observation noted to determine soil profile up to 3.0 m.

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

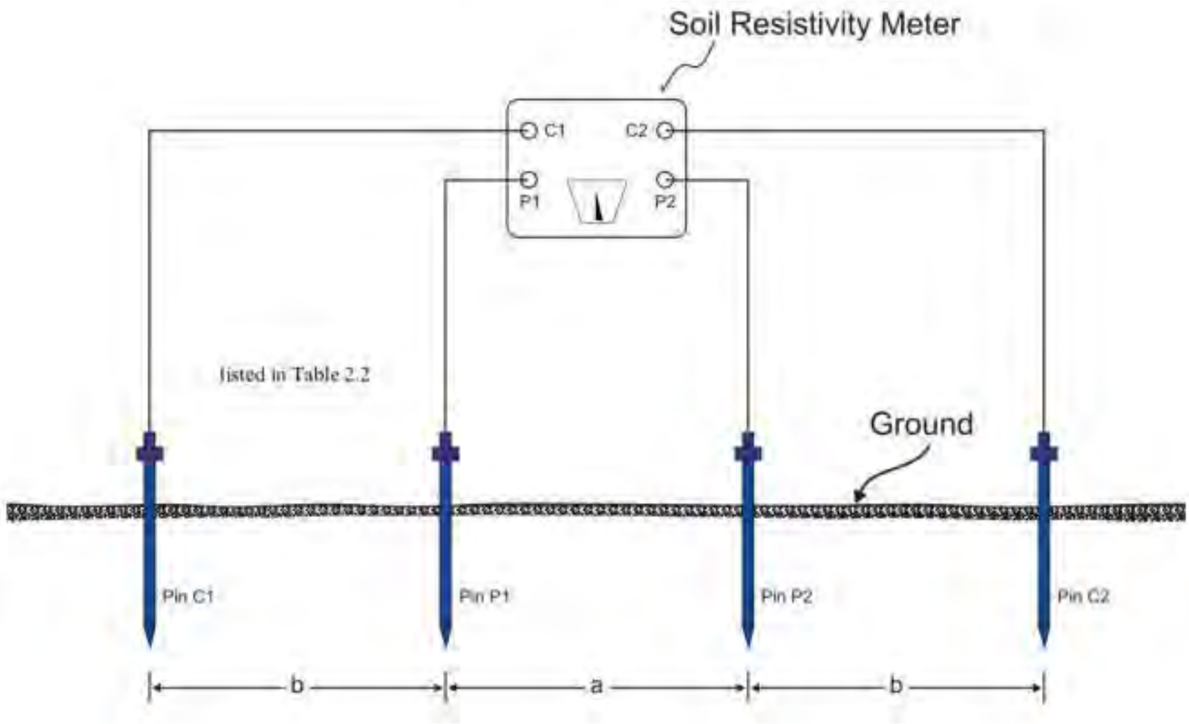


Figure 7: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 8: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W m^{-1}°C^{-1}). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 9: TLS-100 Portable Thermal Conductivity Meter

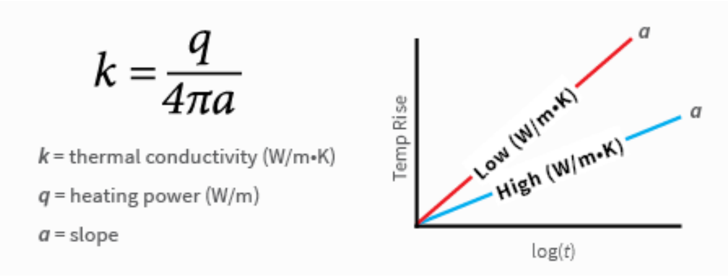


Figure 10: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\boldsymbol{\gamma}_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 11.

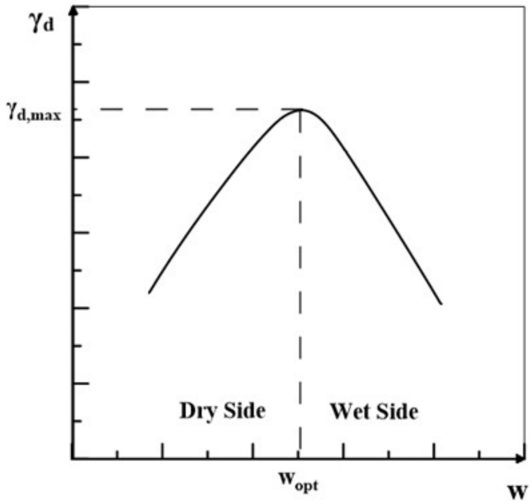


Figure 11: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 12, highest strength of a soil is achieved dry of optimum moisture content of a soil.

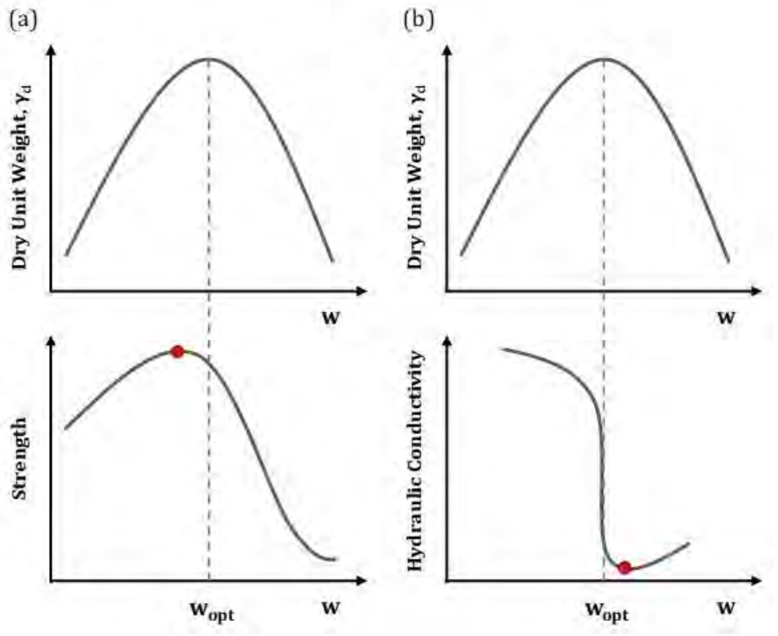


Figure 12: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Results and discussions

4.1.1 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

Table 1: Safe Bearing Capacities calculated from DCP readings

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	76	105	88	76	41	**77**
0.6	99	137	132	132	76	**115**
0.9	152	152	121	132	105	**132**
1.2	116	142	121	116	121	**123**
1.5	116	121	132	116	116	**120**
1.8	127	121	121	121	127	**123**
2.0	132	116	116	137	121	**124**

Table 1 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

4.1.2 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550 (R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

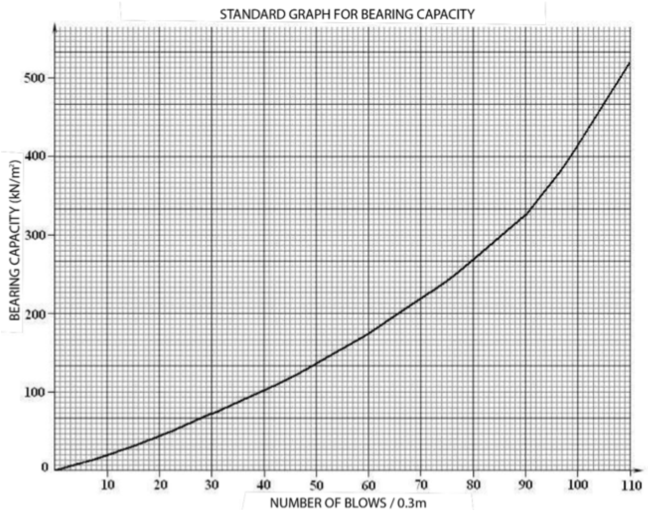


Figure 13: Standard bearing capacity graph for Mackintosh Probe

Table 2 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 2: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	131	97	**114**
0.6	140	138	**139**
0.9	151	150	**151**
1.2	155	147	**151**
1.5	148	154	**151**
1.8	161	159	**160**
2.1	172	166	**169**
2.4	168	163	**166**
2.7	158	171	**165**
3.0	148	174	**161**
3.3	157	177	**167**
3.6	154	188	**171**
3.9	-	186	**186**
4.2	-	182	**182**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum possible depth. Since the soil is medium dense gravelly sand, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used. In few cases, excavation had to be used to remove rods.

4.1.3 Trial Pits

Trial pits were conducted to get soil samples for testing, measuring water table and to check the soil profile.

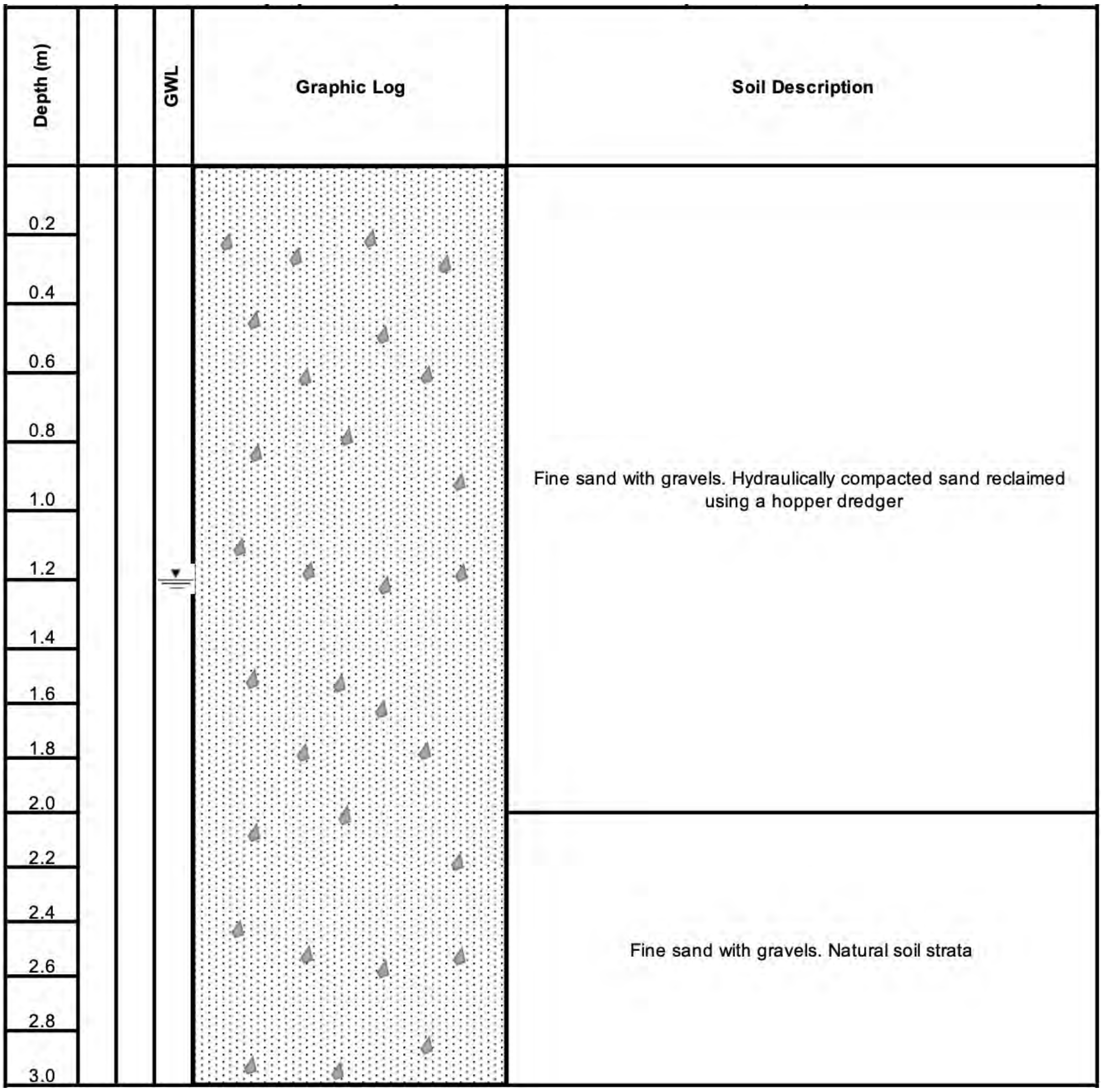
The two trial pits excavated at two ends of the Eydhafushi site; soil strata are gravelly sand up throughout the depth of 3.0 m with the content of gravels and pebbles increases after 1.5 m. The water table was at 1.2 m depth.

The samples collected at 0, 0.5, 1.0, 2.0 and 3.0 were tested in the laboratory for particle size distribution. The results are given in 4.1.4.

As seen in the photo below the soil doesn't change with the depth and is gravelly sand. Since the soil is granular with the significant quantity of gravel, pebbles and stones, it was difficult excavate smoothly because the side of the pit keeps collapsing.

Figure 14: Excavating trial pit 1

Figure 15: Excavating trial pit 2



Fine sand with gravels. Hydraulically compacted sand reclaimed using a hopper dredger

Fine sand with gravels. Natural soil strata

Figure 16: Log for Trial Pit 1

4.1.4 Particle size distribution

Particle size distribution of samples collected from trial pits at B. Eydhafushi site. The result shows the sand is gravelly with silt content less than 2.3 %, but gravel and larger sizes consist about 1/3 of the soil. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The particle size distribution graphs are included in the appendix.

Table 3: Results of Particle size distribution of samples from Trial Pit 1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	25.8	20.2	28.9	12.5	9.8	1.9	0.9
0.5	30.1	19.0	26.6	13.2	9.1	1.2	0.8
1.0	18.4	13.7	30.8	22.0	13.9	0.8	0.4
1.5	13.8	15.7	35.4	21.9	12.2	0.7	0.4
2.0	17.9	18.4	35.5	17.7	8.8	0.5	1.2
2.5	19.9	15.2	30.9	20.4	10.9	0.9	1.9
3.0	23.3	15.3	25.5	21.6	11.8	1.0	1.5

Table 4: Results of Particle size distribution of samples from Trial Pit 2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	17.2	17.5	32.2	17.8	12.1	1.7	1.4
0.5	12.4	14.8	31.8	22.0	16.7	1.6	0.7
1.0	6.5	7.6	28.4	29.4	26.7	0.9	0.5
1.5	5.4	13.0	49.3	22.0	10.0	0.3	0.1
2.0	29.4	16.4	27.0	14.1	10.4	1.7	1.0
2.5	22.6	18.0	29.0	16.5	11.6	1.4	0.8
3.0	29.2	16.4	25.8	12.5	11.7	1.9	2.5

4.1.5 Direct Shear

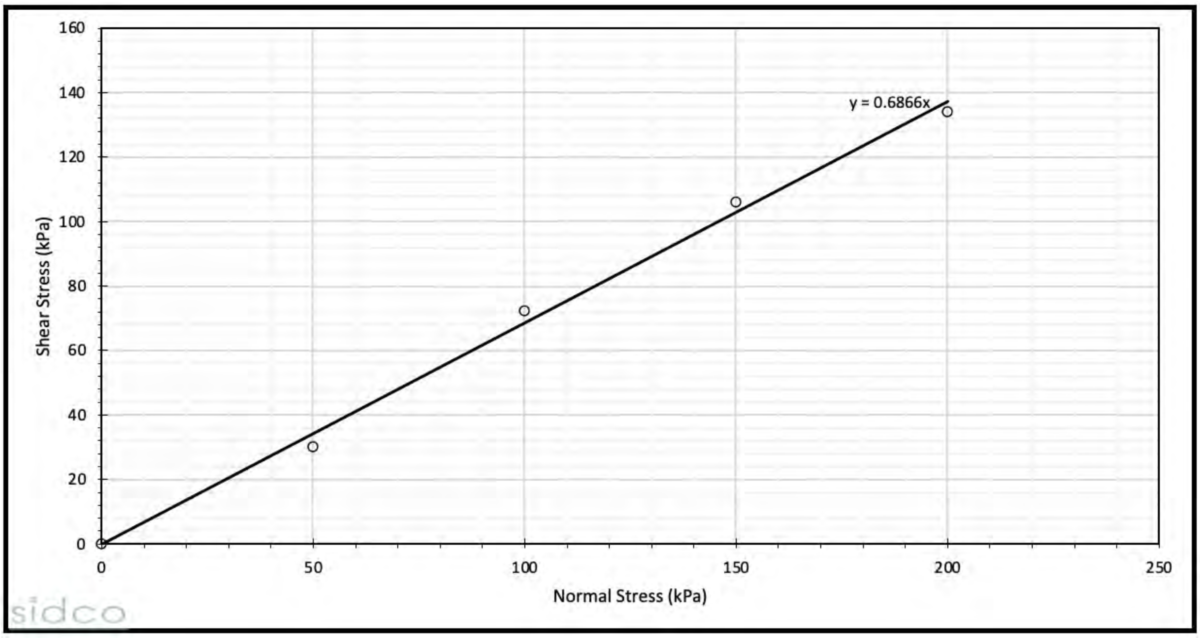


Figure 17: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 34 degrees, which is typical for carbonated sand found in Maldives.

4.1.6 Proctor Compaction Test

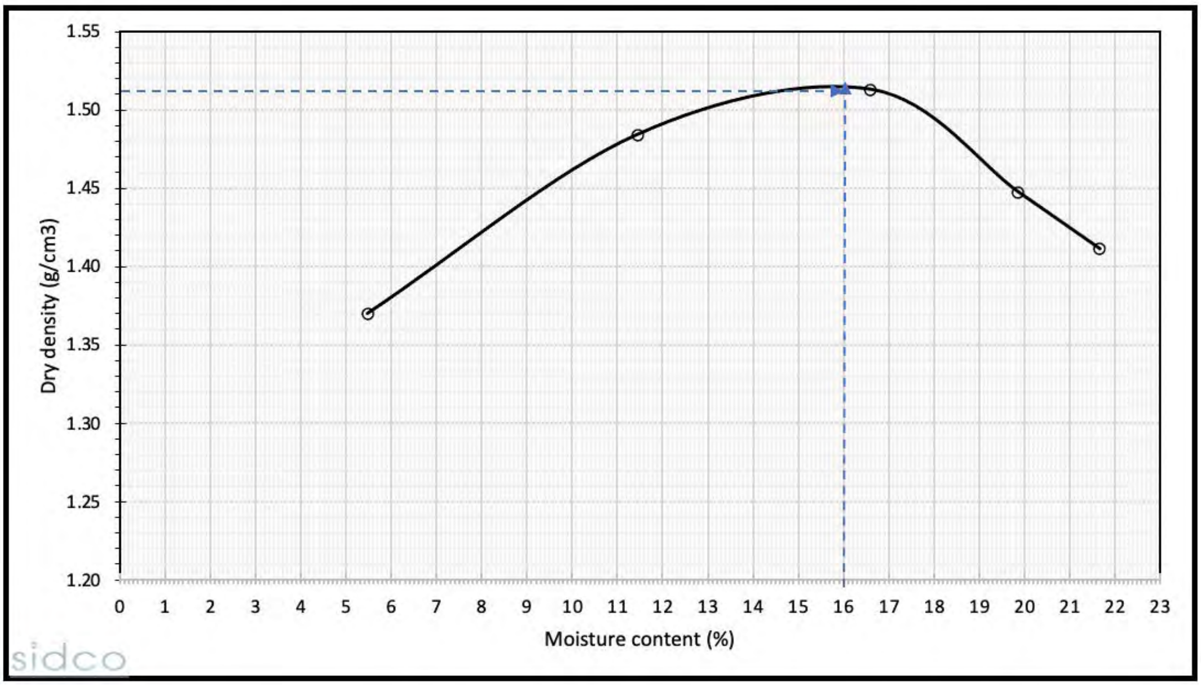
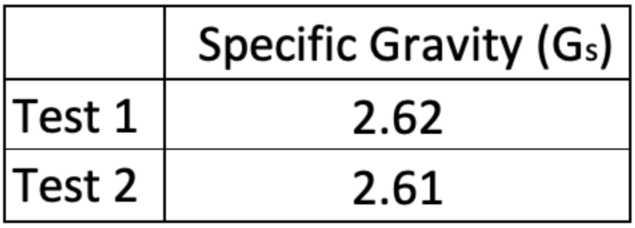


Figure 18: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.51 g/cm^3 and an optimum moisture content of 16%.

4.1.7 Specific gravity test

Table 5: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.62
Test 2	2.61

Table 5 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

4.1.8 Electrical Resistivity (ER)

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content.

1. Eydhafushi project site is a reclaimed area is covered with weeds and grass and moisture content appears to be low. High moisture content reduces the resistivity.
2. The temperature is approximately 34 degrees Celsius. Higher temperature decreases the resistivity.
3. The site was previously sea, which was reclaimed. Hence, contains salt. This also reduces the resistivity.

The tables and graphs below show ER test results.

Table 6: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	14.32	90
2	2	7.43	93
3	3	4.51	85
4	4	3.48	87
5	5	2.81	88
6	6	2.23	84
7	7	1.89	83
8	8	1.67	84
9	9	1.41	80
10	10	1.20	75

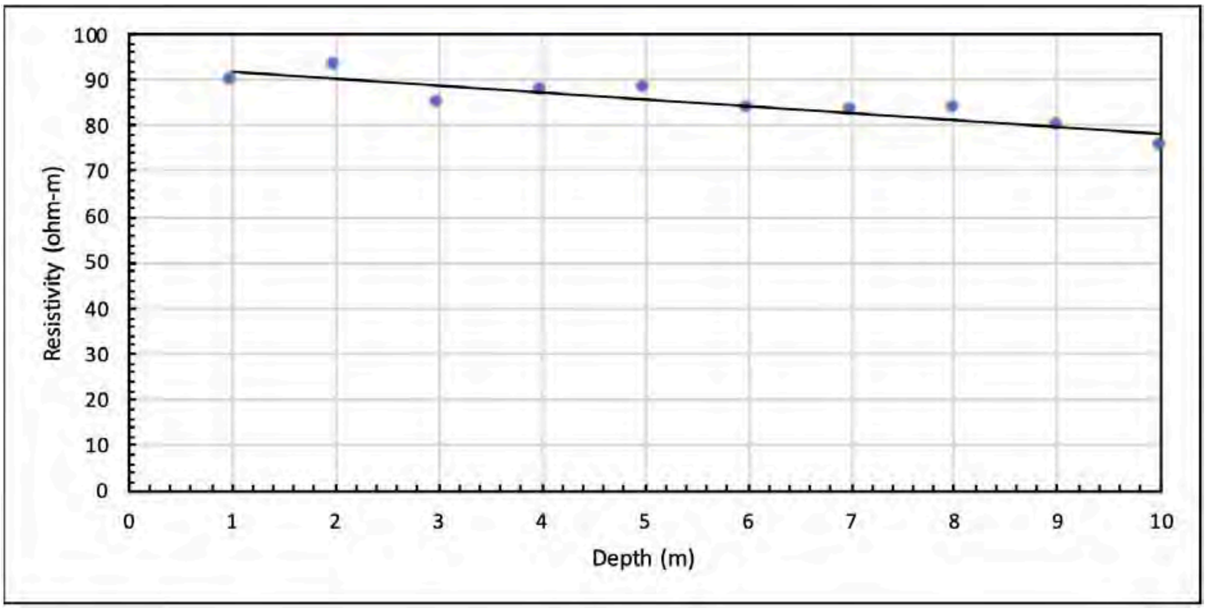


Figure 19: Resistivity graph for Test 1

Table 7: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	16.31	102
2	2	8.64	109
3	3	4.65	88
4	4	3.57	90
5	5	2.96	93
6	6	2.26	85
7	7	1.93	85
8	8	1.60	80
9	9	1.37	77
10	10	1.12	70

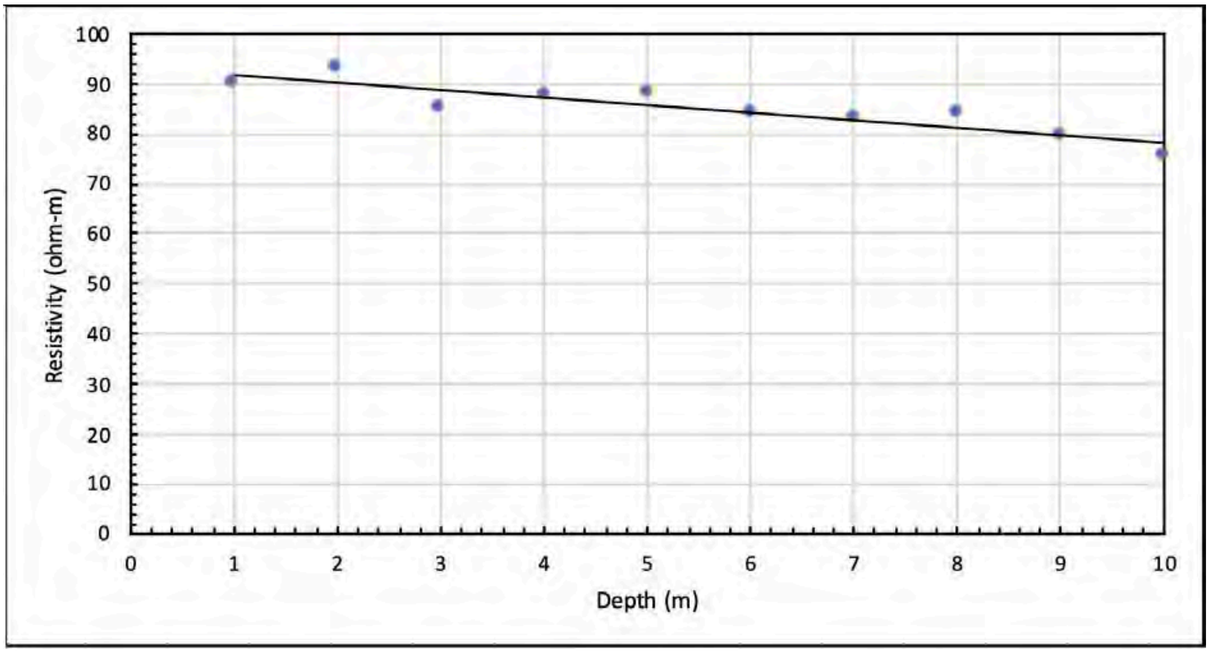


Figure 20: Resistivity graph for Test 2

Resistivity of soil remains between 70 and 110 ohm-m. Overall, the 110 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

4.1.9 Thermal Conductivity

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 8: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (ºC)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	30.60	0.337	2.97	200
2	TLS100	28.60	0.251	3.98	200
Average		29.60	0.294	3.48	

The average thermal conductivity is 0.294 W/mK.

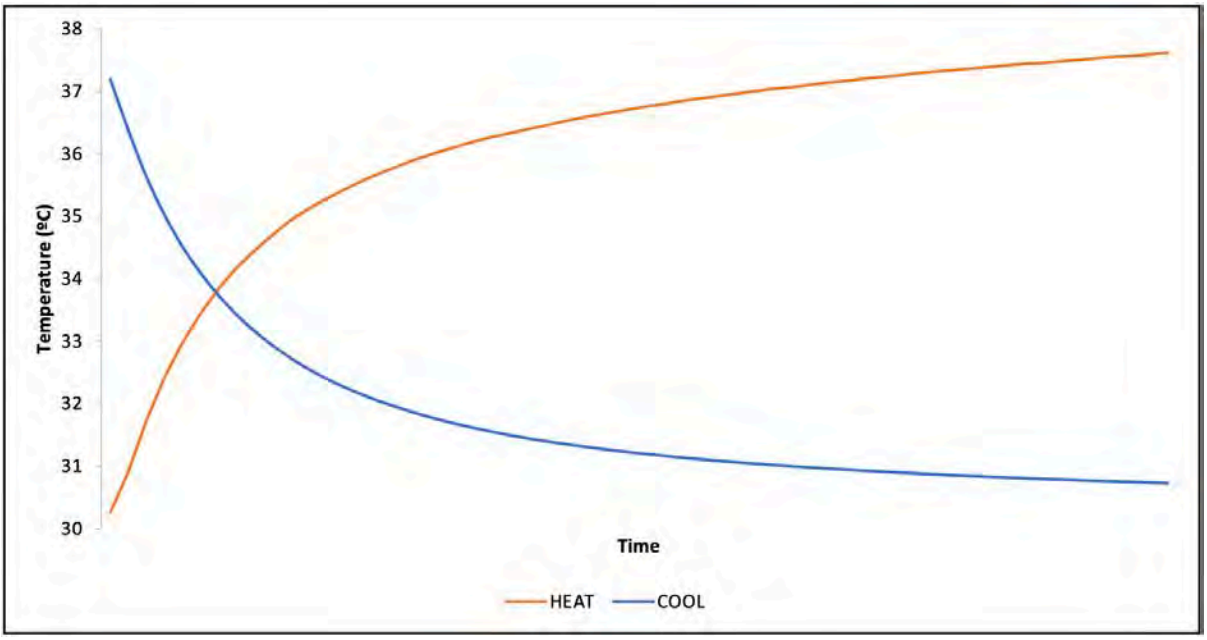


Figure 21: Heat and Colling Curve to TC Test 1

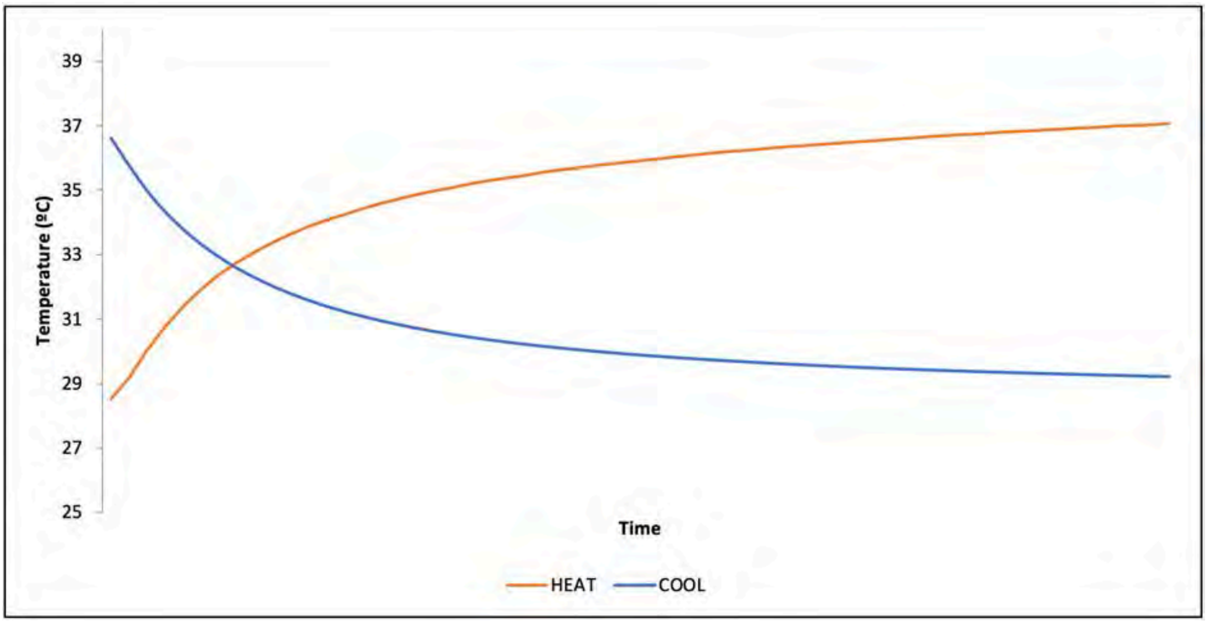
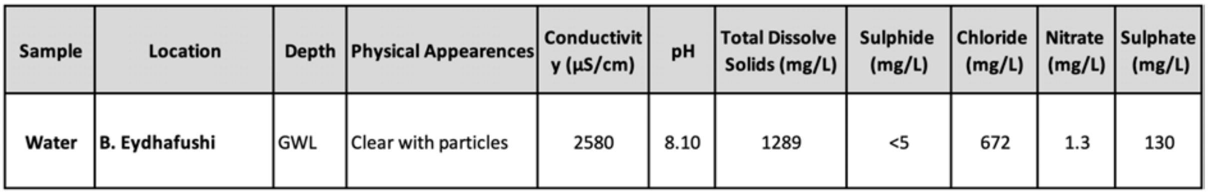


Figure 22: Heat and Colling Curve to TC Test 2

4.1.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 2580 µS/cm with a Sulphate content of 130 mg/L, Nitrate content of 1.3 mg/L, Chloride content of 672 mg/L and Sulphide content of <5 mg/L. The project location is part of reclaimed land in 2014. The ground water at the site has improved since reclamation but remain salty and not portable. Hence, sub-structural concrete will have to be designed to have high quality concrete with low permeability and should be treated with surface sealant like bitumen.

Table 9: Chemical test results of water sample from B. Eydhafushi project site



Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	**B. Eydhafushi**	GWL	Clear with particles	2580	8.10	1289	<5	672	1.3	130

5 Conclusion

5.1 GEOTECHNICAL CONSIDERATIONS

5.1.1 Safe Bearing Capacity

Since the soil is gravelly sand, the result of DCP should more accurate and reliable than MP. Hence it is recommended to use the safe bearing capacity in the table below.

Table 10: Safe bearing capacity for shallow foundation at different depths

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	76	105	88	76	41	**77**
0.6	99	137	132	132	76	**115**
0.9	152	152	121	132	105	**132**
1.2	116	142	121	116	121	**123**
1.5	116	121	132	116	116	**120**
1.8	127	121	121	121	127	**123**
2.0	132	116	116	137	121	**124**

5.1.2 Electrical Resistivity

For grounding design use electrical resistivity of 110 Ohm-m. And consider soil as moderately corrosive for sub-structure design.

5.1.3 Thermal Conductivity

For underground cable design use 0.294 W/mK as thermal conductivity and 3.48 mK/W as thermal resistance.

5.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Eydhafushi is located north of Maldives where peak ground acceleration value is less than 0.04.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.04, S_s is 0.09 and S_1 is 0.025.

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User’s Manual for K-100 Models of KSE DCP. USA.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES

APPENDIX 1: TEST LOCATIONS


S
DCP1
6658 sqm
ER1
1320 sqm
TP1
MP1
TC1
DCP2
DCP3
1578 sqm
DCP4
ER2
TP2
MP2
3614 sqm
TC2
DCP5
Legend
Solar Installation Area
Road (9m)
0
110
220
440
660
880
Meters

APPENDIX 2: DCP TEST RESULTS

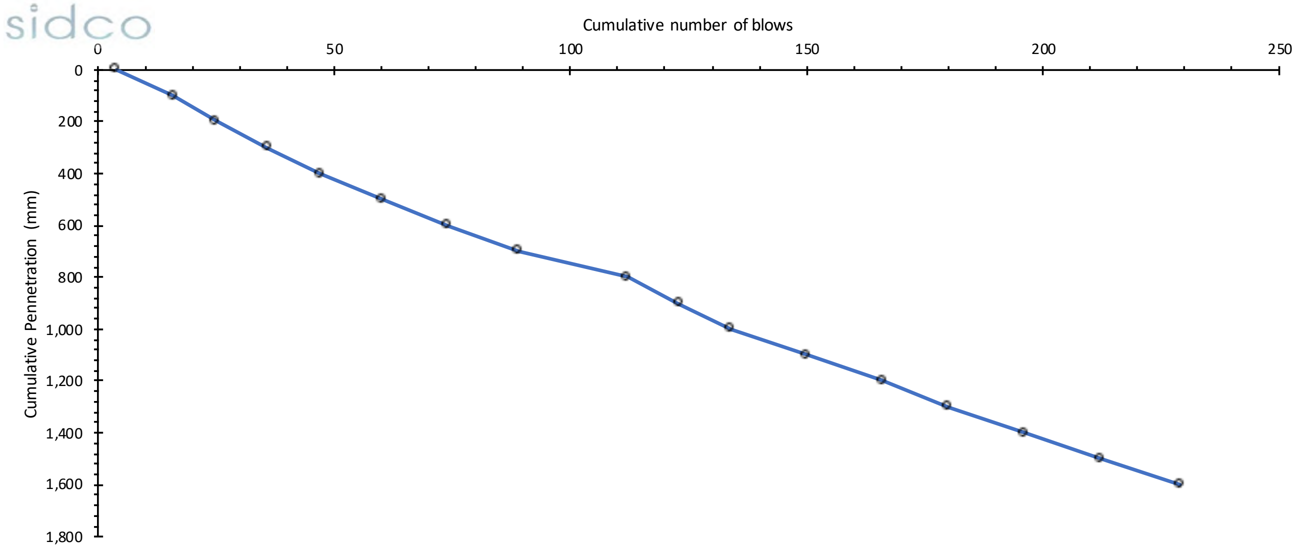
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**B. Eydhafushi**		**22/01/2022**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	12	16	8.3	27	234	94
200-300	9	25	11.1	20	189	76
300-400	11	36	9.1	25	220	88
400-500	11	47	9.1	25	220	88
500-600	13	60	7.7	30	249	99
600-700	14	74	7.1	32	263	105
700-800	15	89	6.7	35	277	111
800-900	23	112	4.3	56	380	152
900-1000	11	123	9.1	25	220	88
1000-1100	11	134	9.1	25	220	88
1100-1200	16	150	6.3	37	290	116
1200-1300	16	166	6.3	37	290	116
1300-1400	14	180	7.1	32	263	105
1400-1500	16	196	6.3	37	290	116
1500-1600	16	212	6.3	37	290	116
1600-1700	17	229	5.9	40	304	121
1700-1800	18	247	5.6	43	317	127
1800-1900	20	267	5.0	48	343	137
1900-2000	19	286	5.3	45	330	132

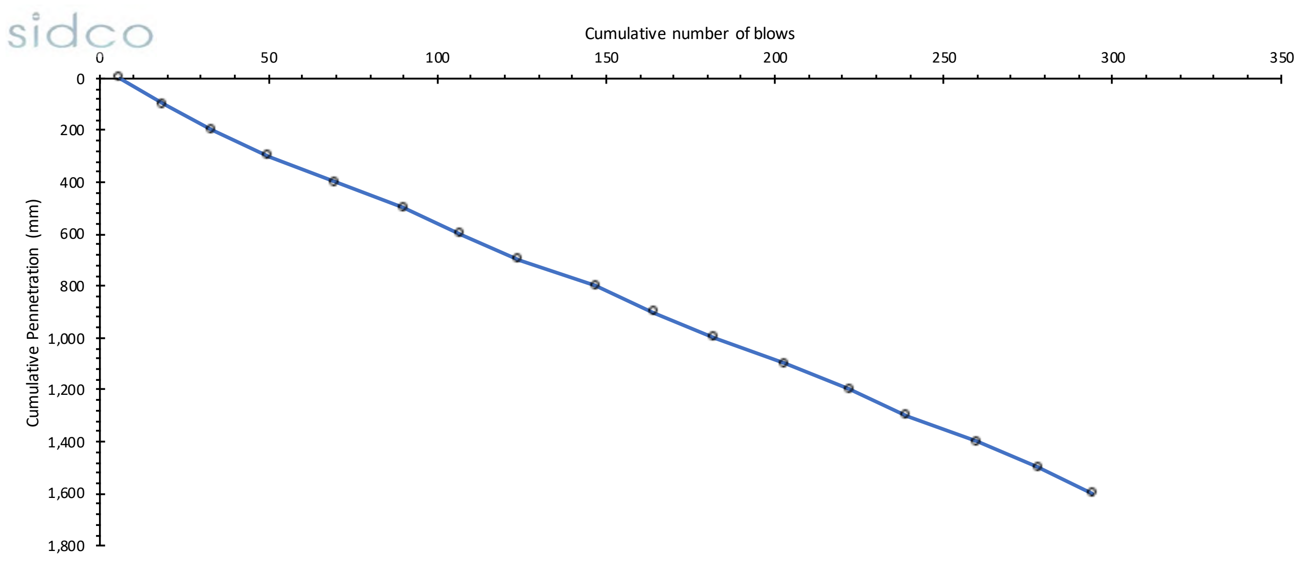


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	B. Eydhafushi		22/01/2022		DCP#	2
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	13	19	7.7	30	249	99
200-300	14	33	7.1	32	263	105
300-400	17	50	5.9	40	304	121
400-500	20	70	5.0	48	343	137
500-600	20	90	5.0	48	343	137
600-700	17	107	5.9	40	304	121
700-800	17	124	5.9	40	304	121
800-900	23	147	4.3	56	380	152
900-1000	17	164	5.9	40	304	121
1000-1100	18	182	5.6	43	317	127
1100-1200	21	203	4.8	51	355	142
1200-1300	19	222	5.3	45	330	132
1300-1400	17	239	5.9	40	304	121
1400-1500	21	260	4.8	51	355	142
1500-1600	18	278	5.6	43	317	127
1600-1700	16	294	6.3	37	290	116
1700-1800	17	311	5.9	40	304	121
1800-1900	16	327	6.3	37	290	116
1900-2000	16	343	6.3	37	290	116

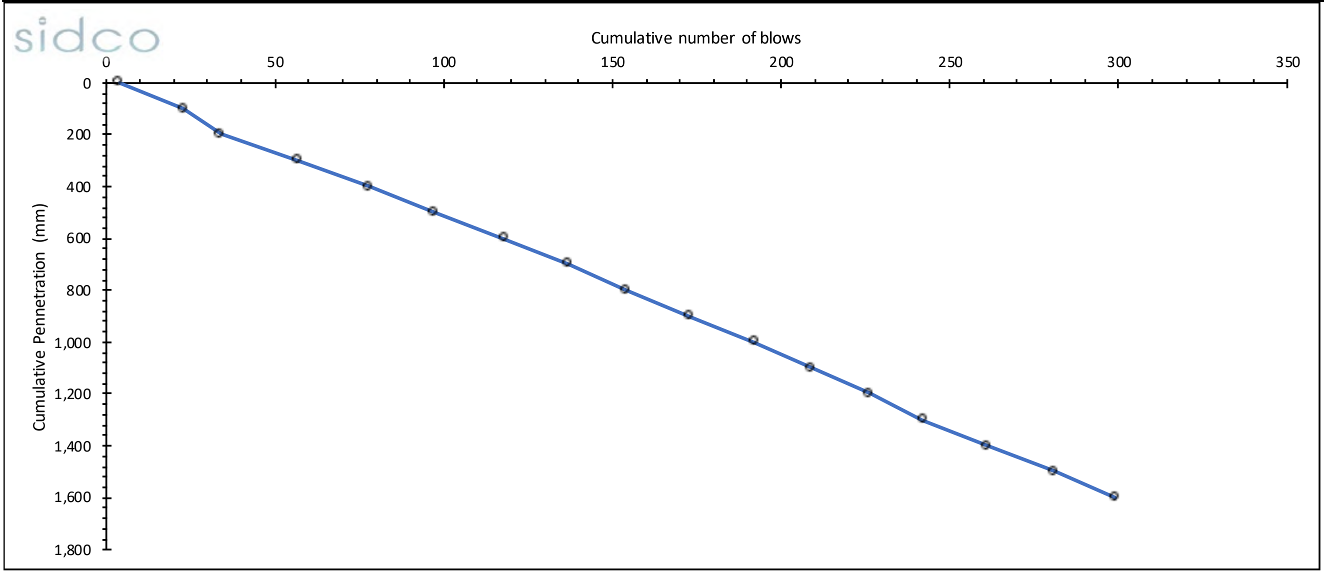


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**B. Eydhafushi**		**22/01/2022**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	19	23	5.3	45	330	132
200-300	11	34	9.1	25	220	88
300-400	23	57	4.3	56	380	152
400-500	21	78	4.8	51	355	142
500-600	19	97	5.3	45	330	132
600-700	21	118	4.8	51	355	142
700-800	19	137	5.3	45	330	132
800-900	17	154	5.9	40	304	121
900-1000	19	173	5.3	45	330	132
1000-1100	19	192	5.3	45	330	132
1100-1200	17	209	5.9	40	304	121
1200-1300	17	226	5.9	40	304	121
1300-1400	16	242	6.3	37	290	116
1400-1500	19	261	5.3	45	330	132
1500-1600	20	281	5.0	48	343	137
1600-1700	18	299	5.6	43	317	127
1700-1800	17	316	5.9	40	304	121
1800-1900	18	334	5.6	43	317	127
1900-2000	16	350	6.3	37	290	116



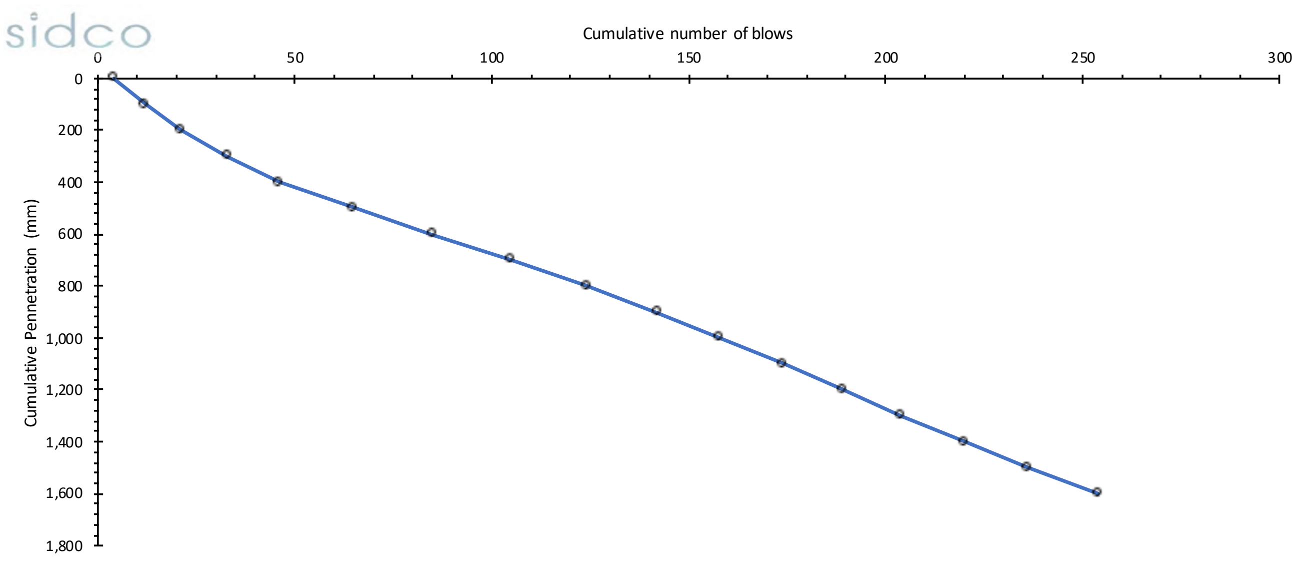
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**B. Eydhafushi**		**22/01/2022**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	8	12	12.5	17	173	69
200-300	9	21	11.1	20	189	76
300-400	12	33	8.3	27	234	94
400-500	13	46	7.7	30	249	99
500-600	19	65	5.3	45	330	132
600-700	20	85	5.0	48	343	137
700-800	20	105	5.0	48	343	137
800-900	19	124	5.3	45	330	132
900-1000	18	142	5.6	43	317	127
1000-1100	16	158	6.3	37	290	116
1100-1200	16	174	6.3	37	290	116
1200-1300	15	189	6.7	35	277	111
1300-1400	15	204	6.7	35	277	111
1400-1500	16	220	6.3	37	290	116
1500-1600	16	236	6.3	37	290	116
1600-1700	18	254	5.6	43	317	127
1700-1800	17	271	5.9	40	304	121
1800-1900	19	290	5.3	45	330	132
1900-2000	20	310	5.0	48	343	137



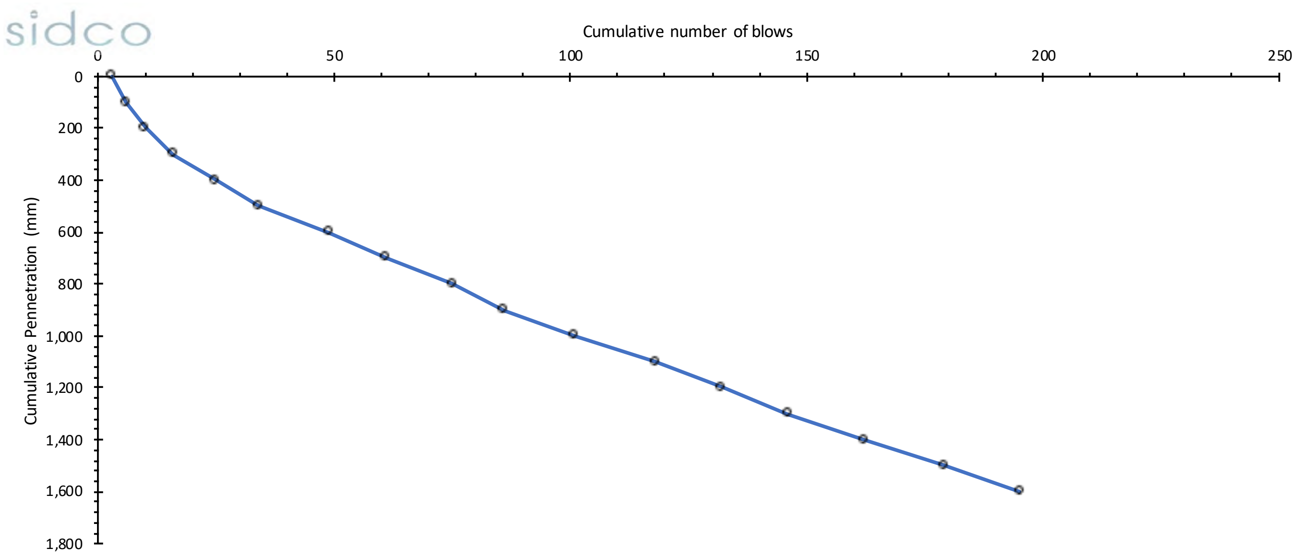
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	B. Eydhafushi		22/01/2022		DCP#	5
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	3	3	33.3	6	84	33
100-200	3	6	33.3	6	84	33
200-300	4	10	25.0	8	104	41
300-400	6	16	16.7	13	140	56
400-500	9	25	11.1	20	189	76
500-600	9	34	11.1	20	189	76
600-700	15	49	6.7	35	277	111
700-800	12	61	8.3	27	234	94
800-900	14	75	7.1	32	263	105
900-1000	11	86	9.1	25	220	88
1000-1100	15	101	6.7	35	277	111
1100-1200	17	118	5.9	40	304	121
1200-1300	14	132	7.1	32	263	105
1300-1400	14	146	7.1	32	263	105
1400-1500	16	162	6.3	37	290	116
1500-1600	17	179	5.9	40	304	121
1600-1700	16	195	6.3	37	290	116
1700-1800	18	213	5.6	43	317	127
1800-1900	19	232	5.3	45	330	132
1900-2000	17	249	5.9	40	304	121



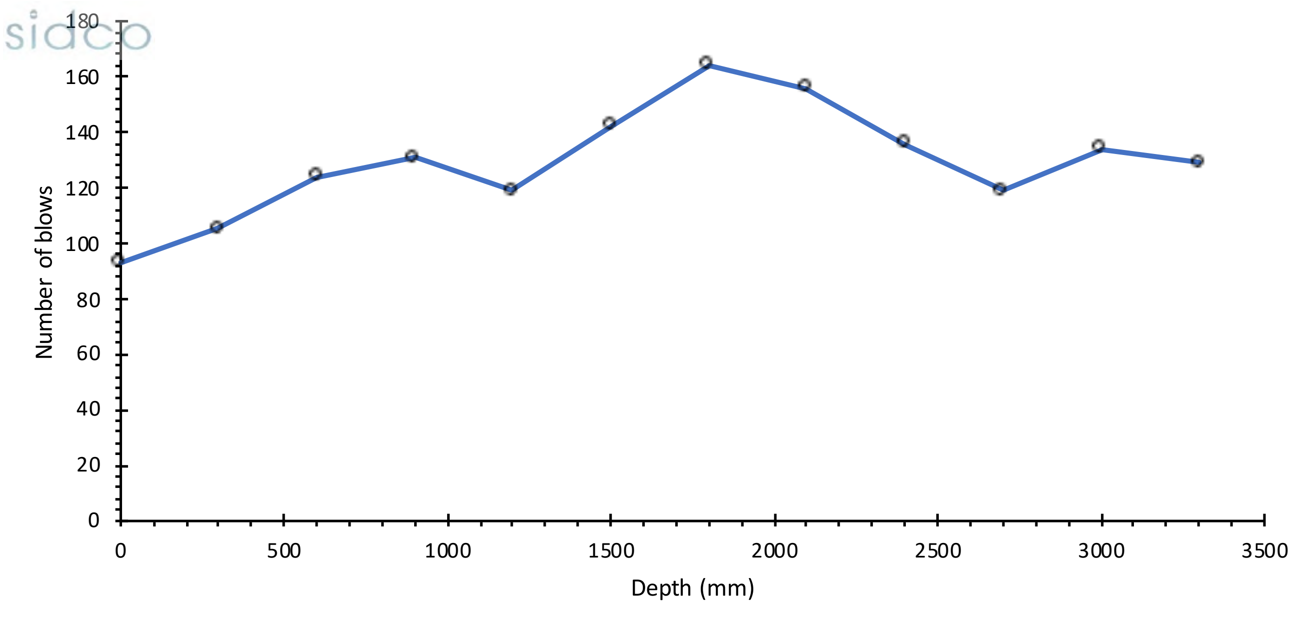
APPENDIX 3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	B. Eydhafushi	Date:	22/01/2022	MP#	1
Depth (mm)		**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity kPa**
0-300		93	93	329	131
300-600		105	198	349	140
600-900		124	322	378	151
900-1200		131	453	388	155
1200-1500		119	572	371	148
1500-1800		142	714	403	161
1800-2100		164	878	430	172
2100-2400		156	1034	421	168
2400-2700		136	1170	395	158
2700-3000		119	1289	371	148
3000-3300		134	1423	392	157
3300-3600		129	1552	385	154
3600-3900		>400 blows per 0.3 m as MP got rebound on a hard rock			
3900-4200					
4200-4500					
4500-4800					
4800-5100					
5100-5400					
5400-5700					
5700-6000					



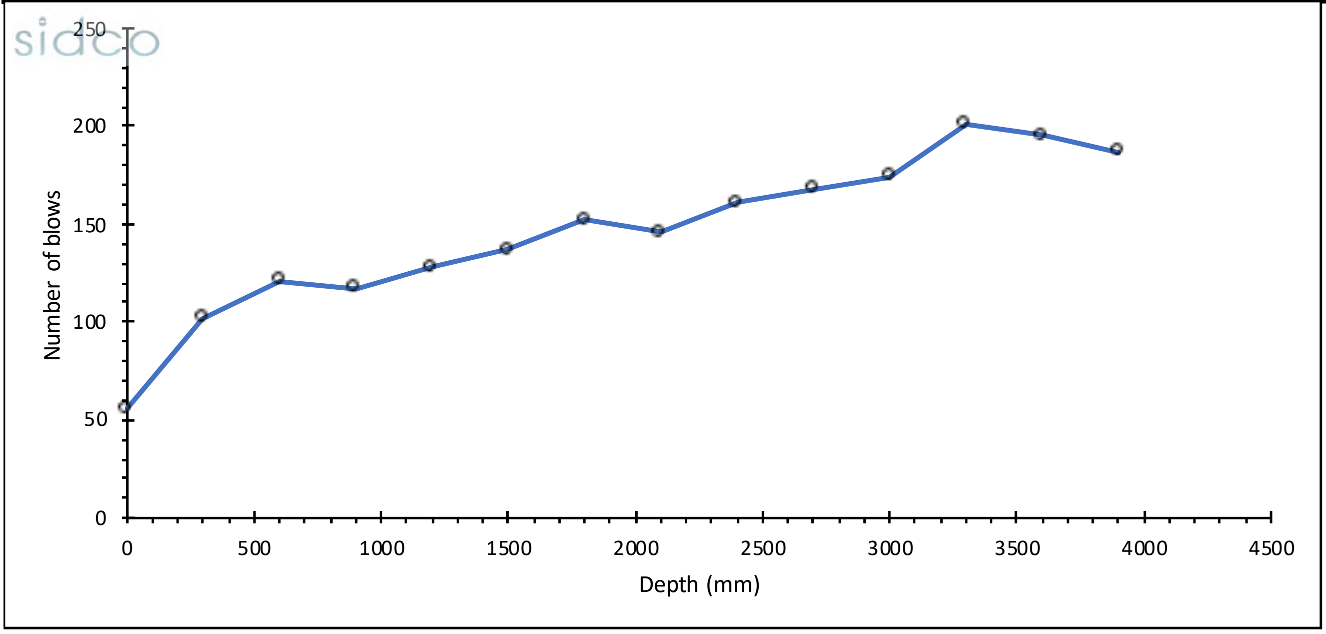
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	B. Eydhafushi	Date:	22/01/2022	MP# 1	2
Depth (mm)		Number of Blows, N_{MP}	Cumulative Number of Blows	Bearing Capacity kPa	Bearing Capacity kPa
0-300		56	56	242	97
300-600		102	158	344	138
600-900		121	279	374	150
900-1200		117	396	368	147
1200-1500		128	524	384	154
1500-1800		137	661	396	159
1800-2100		152	813	416	166
2100-2400		146	959	408	163
2400-2700		161	1120	427	171
2700-3000		168	1288	435	174
3000-3300		174	1462	442	177
3300-3600		201	1663	471	188
3600-3900		195	1858	465	186
3900-4200		187	2045	456	182
4200-4500		>400 blows per 0.3 m as MP got rebound on hard rock			
4500-4800					
4800-5100					
5100-5400					
5400-5700					
5700-6000					



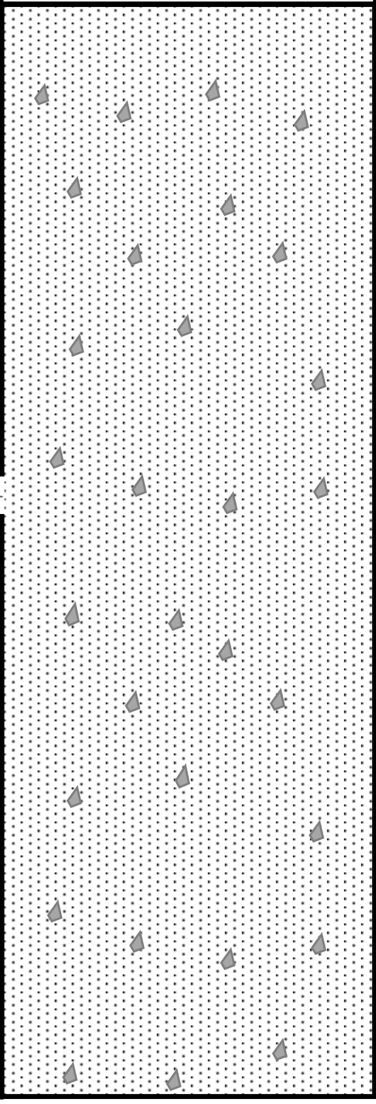
APPENDIX 4: BOREHOLE LOGS

sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire Project - Solar PV Installation - B. Eydhafushi				
Project Number:	HDEC/2023/1	Client:	HDEC		
Equipment	Excavator	Contractor	SIDCO Pvt Ltd		
Ground water depth (m)	1.2	Date: Started:	22/01/2023	Trial Pit	1
Total depth (m)	3.0	Date: Completed	22/01/2023		
Location	Eydhafushi West Side	Date: Backfilled:	22/01/2023		

Depth (m)			GWL	Graphic Log	Soil Description
0.2					Fine sand with gravels. Hydraulically compacted sand reclaimed using a hopper dredger
0.4					
0.6					
0.8					
1.0					
1.2			▼		
1.4					
1.6					
1.8					
2.0					
2.2					Fine sand with gravels. Natural soil strata
2.4					
2.6					
2.8					
3.0					

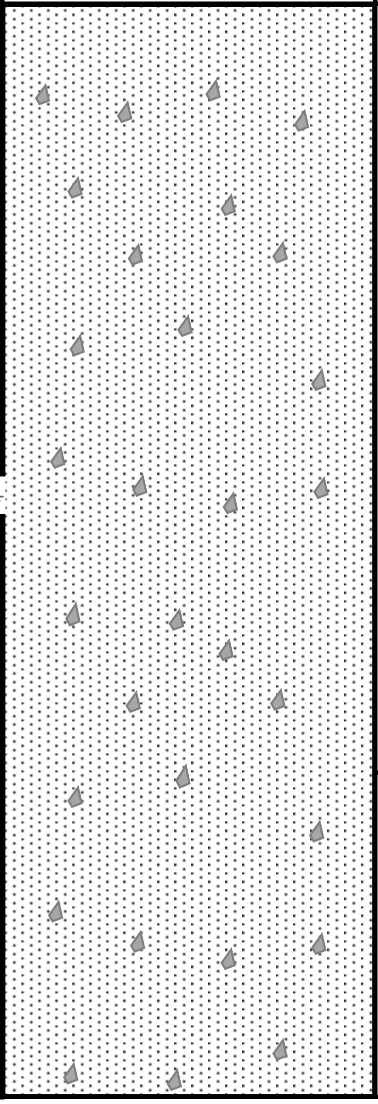
Notes

▼ Ground water level

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire Project - Solar PV Installation - B. Eydhafushi							
Project Number:	HDEC/2023/1				Client:	HDEC		
Equipment	Excavator				Contractor	SIDCO Pvt Ltd		
Ground water depth (m)	1.2	Date	Started:	22/01/2023			Trial Pit	2
Total depth (m)	3.0		Completed	22/01/2023				
Location	Eydhafushi West Side		Backfilled:	22/01/2023				



Depth (m)			GWL	Graphic Log	Soil Description
0.2					Fine sand with gravels. Hydraulically compacted sand reclaimed using a hopper dredger
0.4					
0.6					
0.8					
1.0					
1.2			▼		
1.4					
1.6					
1.8					
2.0					
2.2					Fine sand with gravels. Natural soil strata
2.4					
2.6					
2.8					
3.0					

Notes

▼ Ground water level

APPENDIX 5: RESULTS OF PARTICLE SIZE DISTRIBUTION

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	0.0 m	**Test #**	**TP 1**

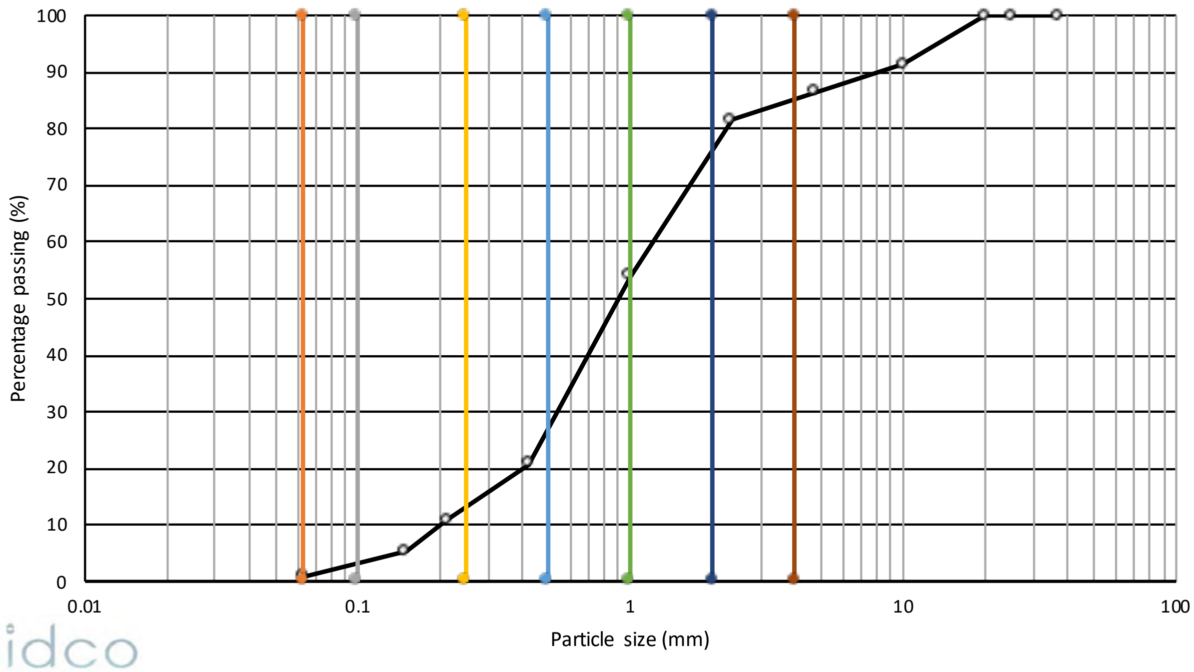
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	397.05	100.0
2	**25**	0	0	0.0	397.05	100.0
3	**20**	0	0	0.0	397.05	100.0
4	**10**	34.73	34.73	8.7	362.32	91.3
5	**4.75**	19.06	54	13.5	343.26	86.5
8	**2.36**	19.87	73.66	18.6	323.39	81.4
16	**1**	109.01	182.67	46.0	214.38	54.0
30	**0.425**	132.18	314.85	79.3	82.2	20.7
50	**0.212**	39.40	354.25	89.2	42.8	10.8
100	**0.15**	21.34	375.59	94.6	21.46	5.4
200	**0.063**	18.06	393.65	99.1	3.4	0.9
Total weight sieved through #200				3.40		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				397	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.9%	1.9%	9.8%	12.5%	28.9%	20.2%	25.8%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

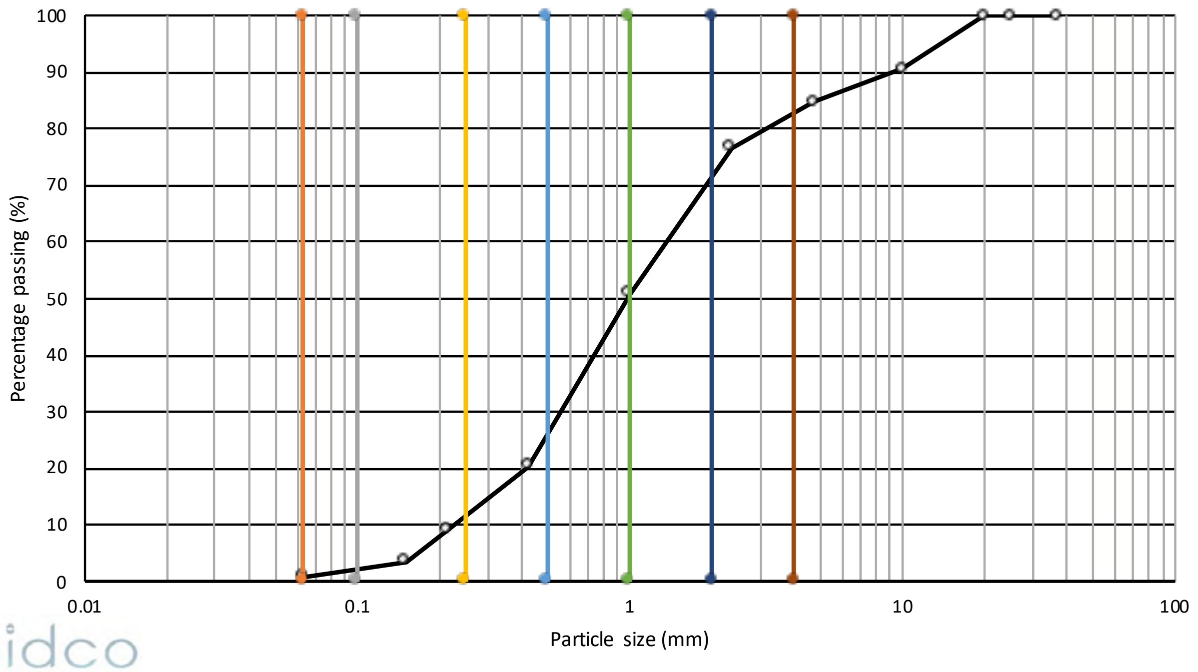
Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023		**Tested by:**	Hewage	
	Depth (m)	0.5m		**Test #**	**TP 1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	426.34	100.0
2	**25**	0	0	0.0	426.34	100.0
3	**20**	0	0	0.0	426.34	100.0
4	**10**	40.27	40.27	9.4	386.07	90.6
5	**4.75**	25.30	66	15.4	360.77	84.6
8	**2.36**	33.56	99.13	23.3	327.21	76.7
16	**1**	110.41	209.54	49.1	216.8	50.9
30	**0.425**	130.33	339.87	79.7	86.47	20.3
50	**0.212**	47.61	387.48	90.9	38.86	9.1
100	**0.15**	23.44	410.92	96.4	15.42	3.6
200	**0.063**	12.07	422.99	99.2	3.35	0.8
Total weight sieved through #200				3.35		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				426	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.8%	1.2%	9.1%	13.2%	26.6%	19.0%	30.1%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

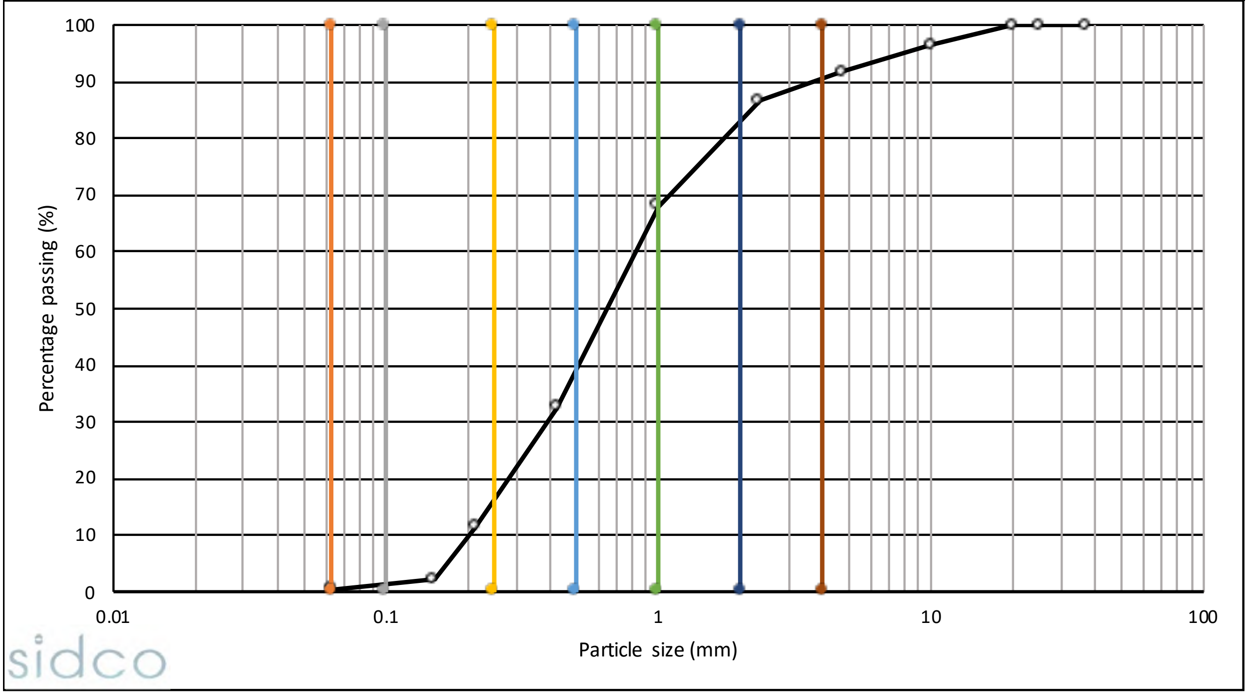
Project:	B. Eydhafushi		**File #:**		
Date:	Monday, 20 March 2023	**Tested by:**	Hewage		
	Depth (m)	1m	**Test #**	**TP 1**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	328.18	100.0
2	**25**	0	0	0.0	328.18	100.0
3	**20**	0	0	0.0	328.18	100.0
4	**10**	11.86	11.86	3.6	316.32	96.4
5	**4.75**	15.70	28	8.4	300.62	91.6
8	**2.36**	16.59	44.15	13.5	284.03	86.5
16	**1**	61.00	105.15	32.0	223.03	68.0
30	**0.425**	116.32	221.47	67.5	106.71	32.5
50	**0.212**	69.58	291.05	88.7	37.13	11.3
100	**0.15**	29.61	320.66	97.7	7.52	2.3
200	**0.063**	6.15	326.81	99.6	1.37	0.4
Total weight sieved through #200				1.37		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				328	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.4%	0.8%	13.9%	22.0%	30.8%	13.7%	18.4%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**		Hewage	
	Depth (m)	1.5m		**Test #**	**TP 1**

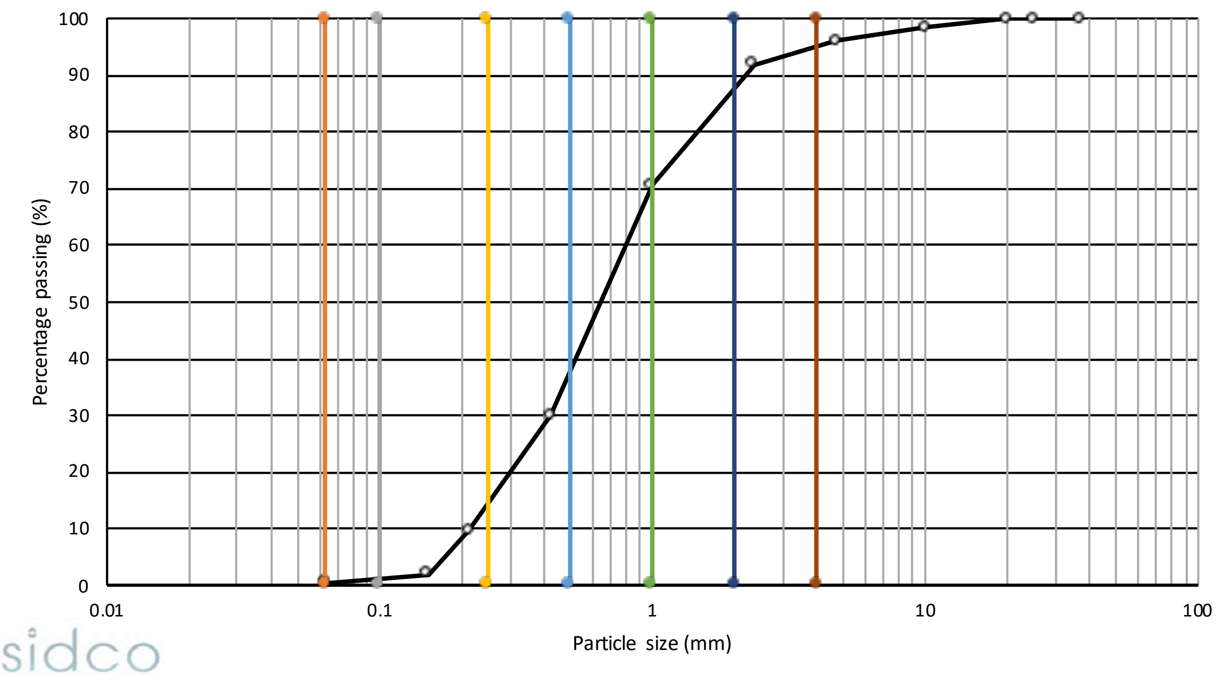
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	290.24	100.0
2	**25**	0	0	0.0	290.24	100.0
3	**20**	0	0	0.0	290.24	100.0
4	**10**	4.65	4.65	1.6	285.59	98.4
5	**4.75**	6.88	12	4.0	278.71	96.0
8	**2.36**	12.12	23.65	8.1	266.59	91.9
16	**1**	61.91	85.56	29.5	204.68	70.5
30	**0.425**	118.00	203.56	70.1	86.68	29.9
50	**0.212**	58.60	262.16	90.3	28.08	9.7
100	**0.15**	22.36	284.52	98.0	5.72	2.0
200	**0.063**	4.54	289.06	99.6	1.18	0.4
Total weight sieved through #200				1.18		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				290	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.4%	0.7%	12.2%	21.9%	35.4%	15.7%	13.8%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

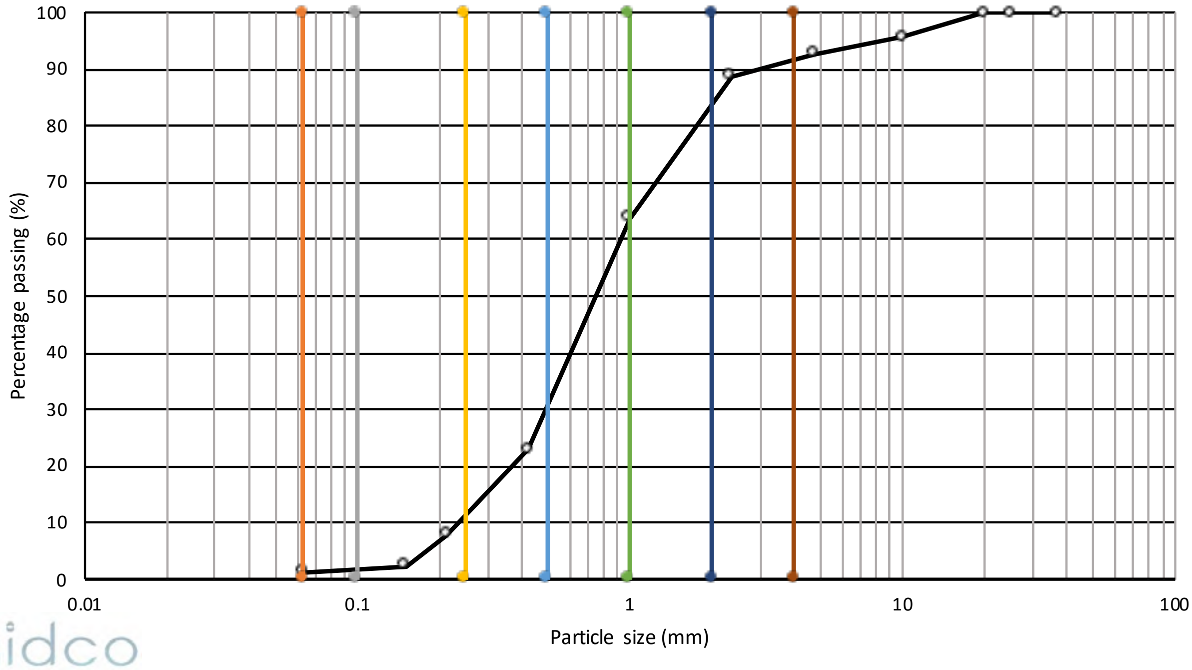
Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	2m	**Test #**	**TP 1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	274.17	100.0
2	**25**	0	0	0.0	274.17	100.0
3	**20**	0	0	0.0	274.17	100.0
4	**10**	12.29	12.29	4.5	261.88	95.5
5	**4.75**	7.77	20	7.3	254.11	92.7
8	**2.36**	10.78	30.84	11.2	243.33	88.8
16	**1**	68.62	99.46	36.3	174.71	63.7
30	**0.425**	112.03	211.49	77.1	62.68	22.9
50	**0.212**	41.35	252.84	92.2	21.33	7.8
100	**0.15**	14.92	267.76	97.7	6.41	2.3
200	**0.063**	3.01	270.77	98.8	3.4	1.2
Total weight sieved through #200				3.40		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				274	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.2%	0.5%	8.8%	17.7%	35.5%	18.4%	17.9%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

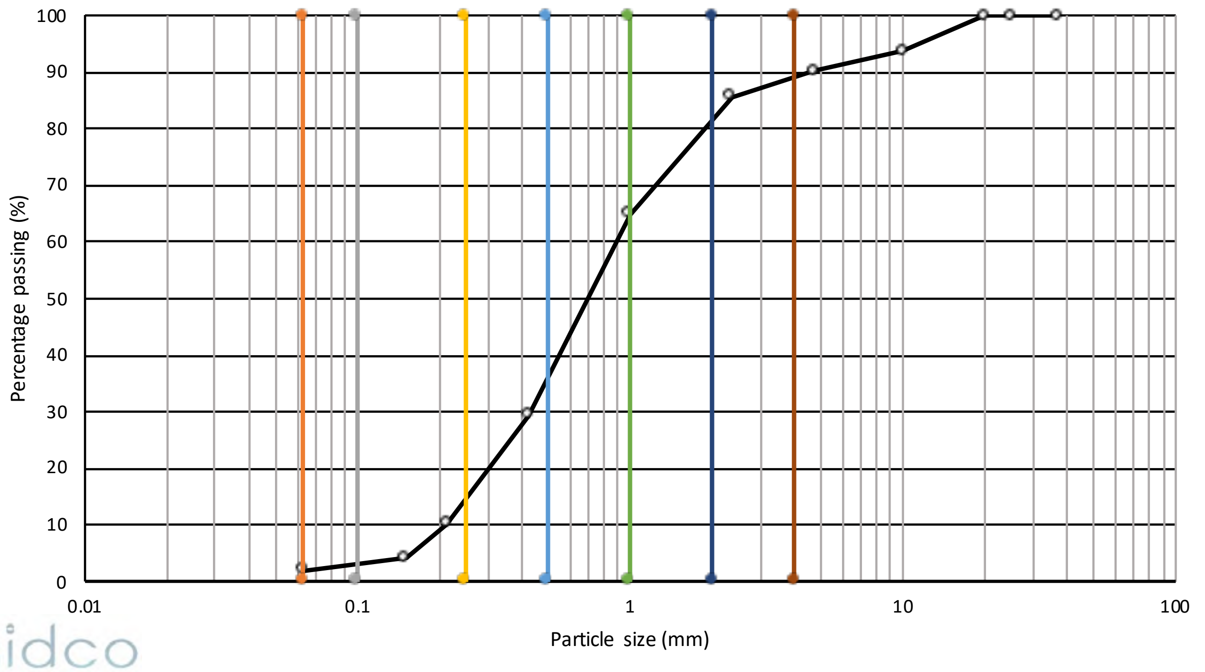
Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	2.5 m	**Test #**	**TP 1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	272.89	100.0
2	**25**	0	0	0.0	272.89	100.0
3	**20**	0	0	0.0	272.89	100.0
4	**10**	17.56	17.56	6.4	255.33	93.6
5	**4.75**	9.23	27	9.8	246.1	90.2
8	**2.36**	12.54	39.33	14.4	233.56	85.6
16	**1**	56.32	95.65	35.1	177.24	64.9
30	**0.425**	96.87	192.52	70.5	80.37	29.5
50	**0.212**	52.34	244.86	89.7	28.03	10.3
100	**0.15**	16.87	261.73	95.9	11.16	4.1
200	**0.063**	5.95	267.68	98.1	5.21	1.9
Total weight sieved through #200				5.21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				273	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.9%	0.9%	10.9%	20.4%	30.9%	15.2%	19.9%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

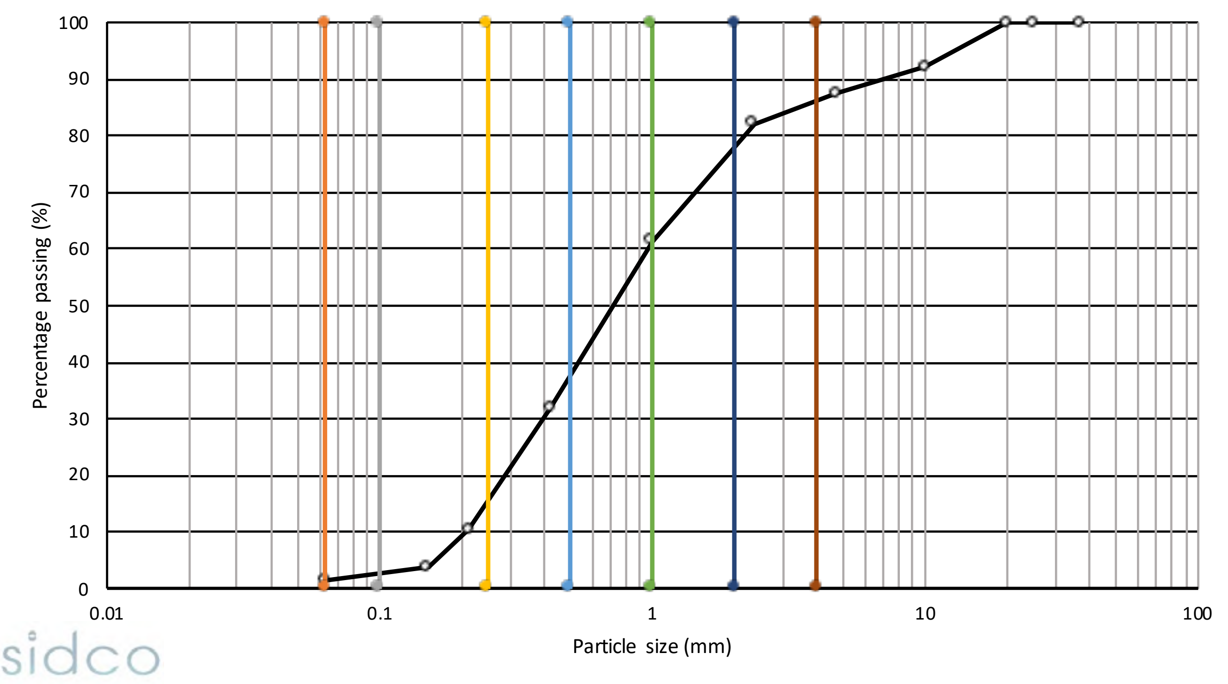
Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023		**Tested by:**	Hewage	
	Depth (m)	3.0 m		**Test #**	**TP 1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	294.11	100.0
2	**25**	0	0	0.0	294.11	100.0
3	**20**	0	0	0.0	294.11	100.0
4	**10**	23.41	23.41	8.0	270.7	92.0
5	**4.75**	13.43	37	12.5	257.27	87.5
8	**2.36**	15.61	52.45	17.8	241.66	82.2
16	**1**	61.23	113.68	38.7	180.43	61.3
30	**0.425**	86.34	200.02	68.0	94.09	32.0
50	**0.212**	63.56	263.58	89.6	30.53	10.4
100	**0.15**	19.34	282.92	96.2	11.19	3.8
200	**0.063**	6.87	289.79	98.5	4.32	1.5
Total weight sieved through #200				4.32		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				294	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.5%	1.0%	11.8%	21.6%	25.5%	15.3%	23.3%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

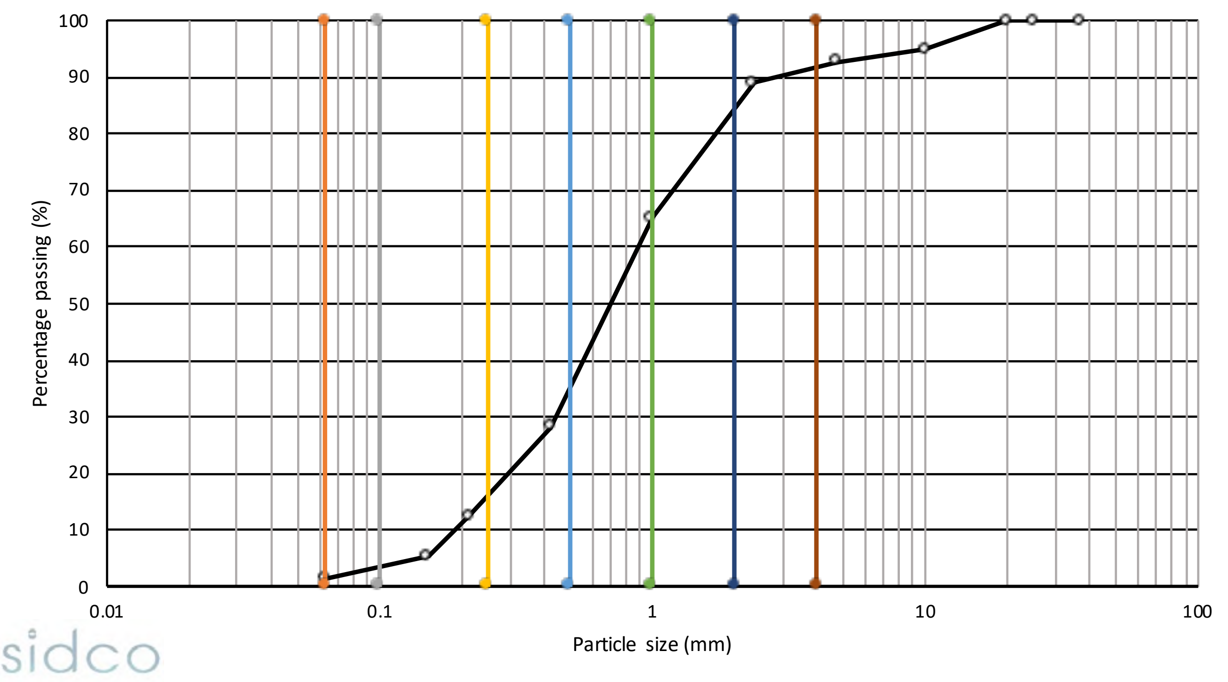
Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	0.0 m	**Test #**	**TP 2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	271.76	100.0
2	**25**	0	0	0.0	271.76	100.0
3	**20**	0	0	0.0	271.76	100.0
4	**10**	13.96	13.96	5.1	257.8	94.9
5	**4.75**	6.08	20	7.4	251.72	92.6
8	**2.36**	10.06	30.1	11.1	241.66	88.9
16	**1**	64.72	94.82	34.9	176.94	65.1
30	**0.425**	100.50	195.32	71.9	76.44	28.1
50	**0.212**	42.94	238.26	87.7	33.5	12.3
100	**0.15**	19.12	257.38	94.7	14.38	5.3
200	**0.063**	10.56	267.94	98.6	3.82	1.4
Total weight sieved through #200				3.82		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				272	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.4%	1.7%	12.1%	17.8%	32.2%	17.5%	17.4%

Maldives Engineering Research Laboratories

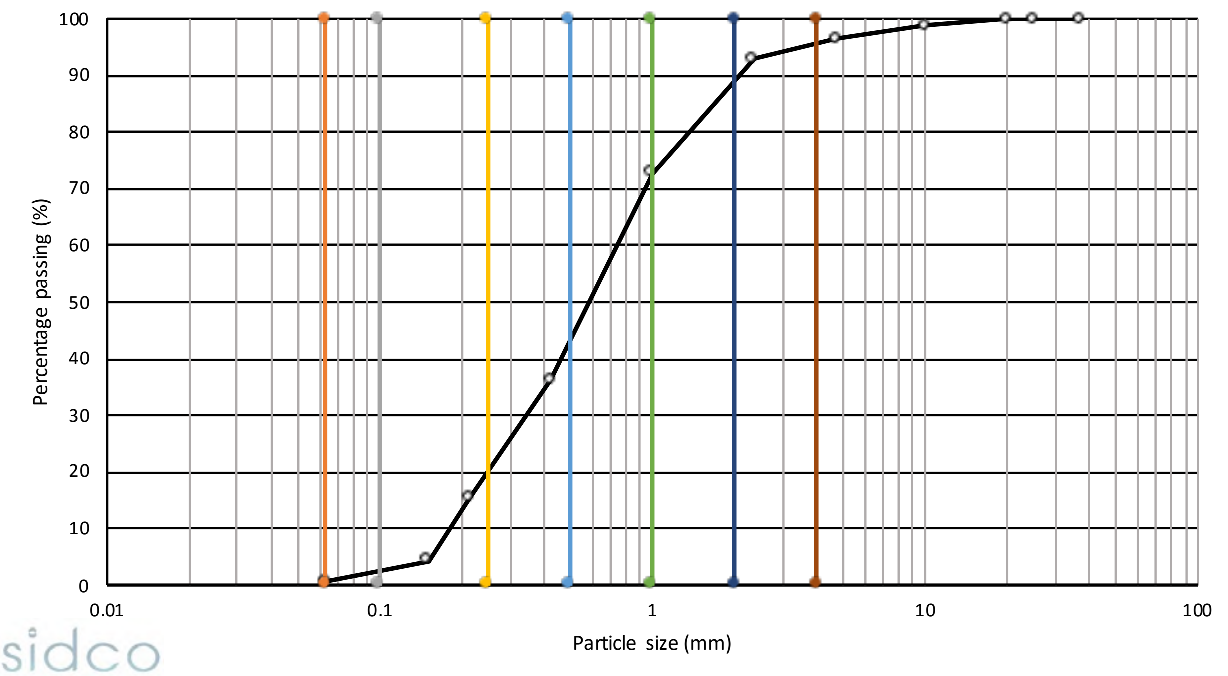
H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023		**Tested by:**	Hewage	
	Depth (m)	0.5m		**Test #**	**TP 2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	442.58	100.0
2	**25**	0	0	0.0	442.58	100.0
3	**20**	0	0	0.0	442.58	100.0
4	**10**	5.94	5.94	1.3	436.64	98.7
5	**4.75**	9.84	16	3.6	426.8	96.4
8	**2.36**	15.57	31.35	7.1	411.23	92.9
16	**1**	88.88	120.23	27.2	322.35	72.8
30	**0.425**	162.03	282.26	63.8	160.32	36.2
50	**0.212**	92.91	375.17	84.8	67.41	15.2
100	**0.15**	48.00	423.17	95.6	19.41	4.4
200	**0.063**	16.33	439.5	99.3	3.08	0.7
Total weight sieved through #200				3.08		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				443	Error (%)	
Remarks						
C_u= 4.3375 C_c=0.7292						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.7%	1.6%	16.7%	22.0%	31.8%	14.8%	12.4%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	1m	**Test #**	**TP 2**

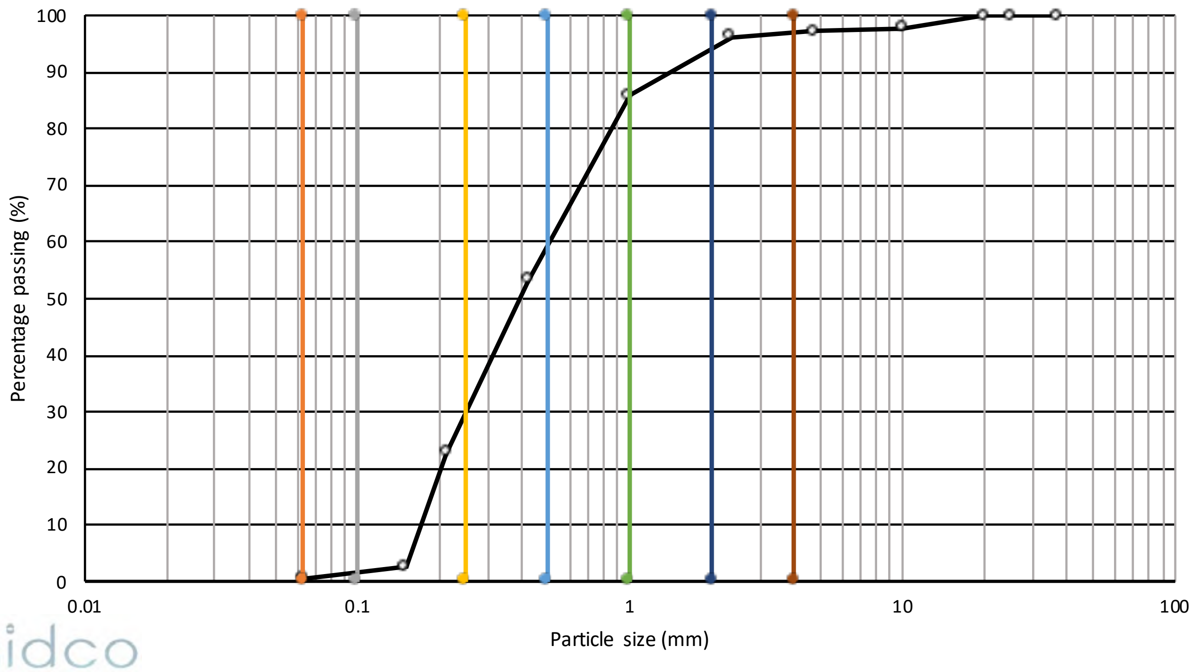
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	253.34	100.0
2	**25**	0	0	0.0	253.34	100.0
3	**20**	0	0	0.0	253.34	100.0
4	**10**	5.55	5.55	2.2	247.79	97.8
5	**4.75**	1.65	7	2.8	246.14	97.2
8	**2.36**	2.43	9.63	3.8	243.71	96.2
16	**1**	26.08	35.71	14.1	217.63	85.9
30	**0.425**	82.68	118.39	46.7	134.95	53.3
50	**0.212**	77.56	195.95	77.3	57.39	22.7
100	**0.15**	50.77	246.72	97.4	6.62	2.6
200	**0.063**	5.31	252.03	99.5	1.31	0.5
Total weight sieved through #200				1.31		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				253	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.5%	0.9%	26.7%	29.4%	28.4%	7.6%	6.5%

Maldives Engineering Research Laboratories

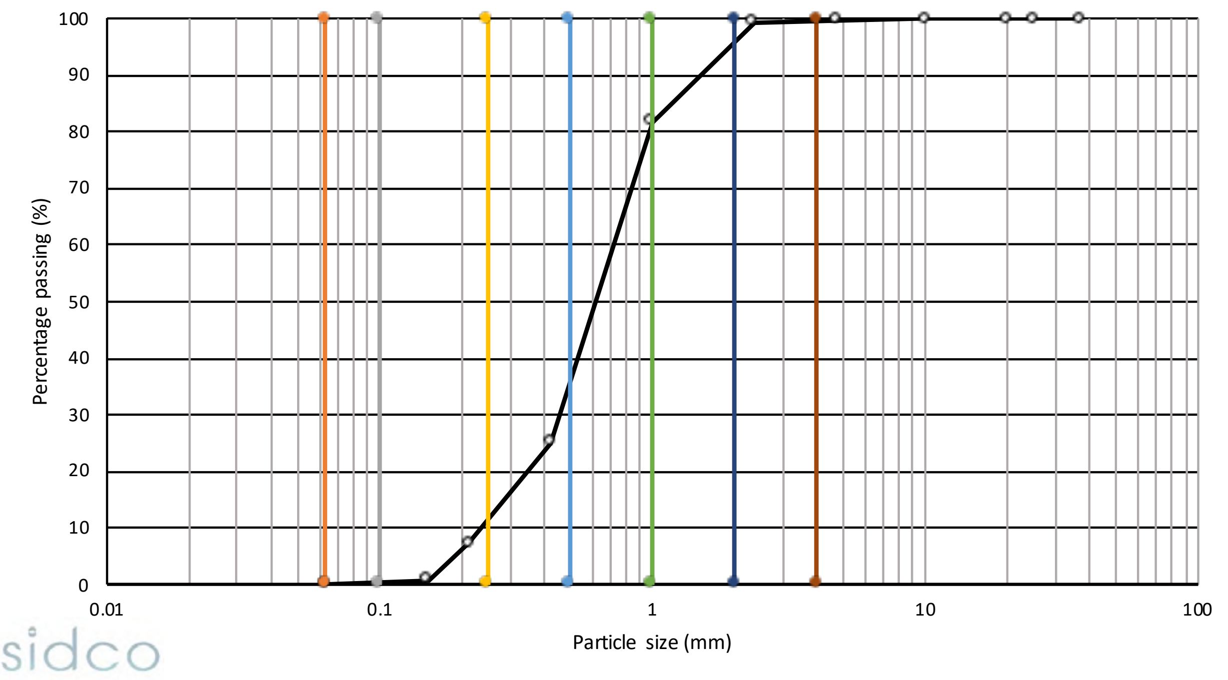
H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi		**File #:**	
Date:	Monday, 20 March 2023	**Tested by:**	Hewage	
	Depth (m)	1.5m	**Test #**	**TP 2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	242.32	100.0
2	**25**	0	0	0.0	242.32	100.0
3	**20**	0	0	0.0	242.32	100.0
4	**10**	0.00	0	0.0	242.32	100.0
5	**4.75**	0.47	0	0.2	241.85	99.8
8	**2.36**	1.17	1.64	0.7	240.68	99.3
16	**1**	42.83	44.47	18.4	197.85	81.6
30	**0.425**	137.34	181.81	75.0	60.51	25.0
50	**0.212**	42.95	224.76	92.8	17.56	7.2
100	**0.15**	15.43	240.19	99.1	2.13	0.9
200	**0.063**	1.95	242.14	99.9	0.18	0.1
Total weight sieved through #200				0.18		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				242	Error (%)	
Remarks						
C_u= 4.3375 C_c=0.7292						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.1%	0.3%	10.0%	22.0%	49.3%	13.0%	5.4%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

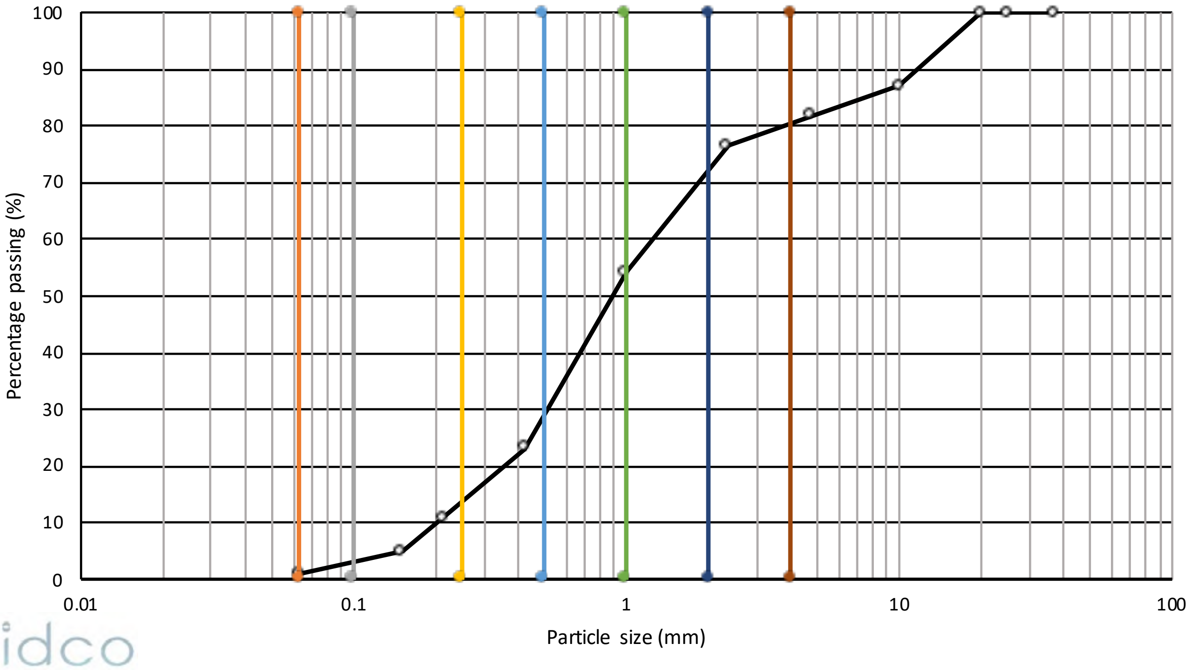
Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023		**Tested by:**	Hewage	
	Depth (m)	2.0 m		**Test #**	**TP 2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	329.57	100.0
2	**25**	0	0	0.0	329.57	100.0
3	**20**	0	0	0.0	329.57	100.0
4	**10**	42.86	42.86	13.0	286.71	87.0
5	**4.75**	17.66	61	18.4	269.05	81.6
8	**2.36**	17.10	77.62	23.6	251.95	76.4
16	**1**	73.41	151.03	45.8	178.54	54.2
30	**0.425**	102.33	253.36	76.9	76.21	23.1
50	**0.212**	40.46	293.82	89.2	35.75	10.8
100	**0.15**	19.58	313.4	95.1	16.17	4.9
200	**0.063**	12.83	326.23	99.0	3.34	1.0
Total weight sieved through #200				3.34		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				330	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.0%	1.7%	10.4%	14.1%	27.0%	16.4%	29.4%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	B. Eydhafushi		**File #:**		
Date:	Monday, 20 March 2023	**Tested by:**	Hewage		
	Depth (m)	2.5 m	**Test #**	**TP 2**	

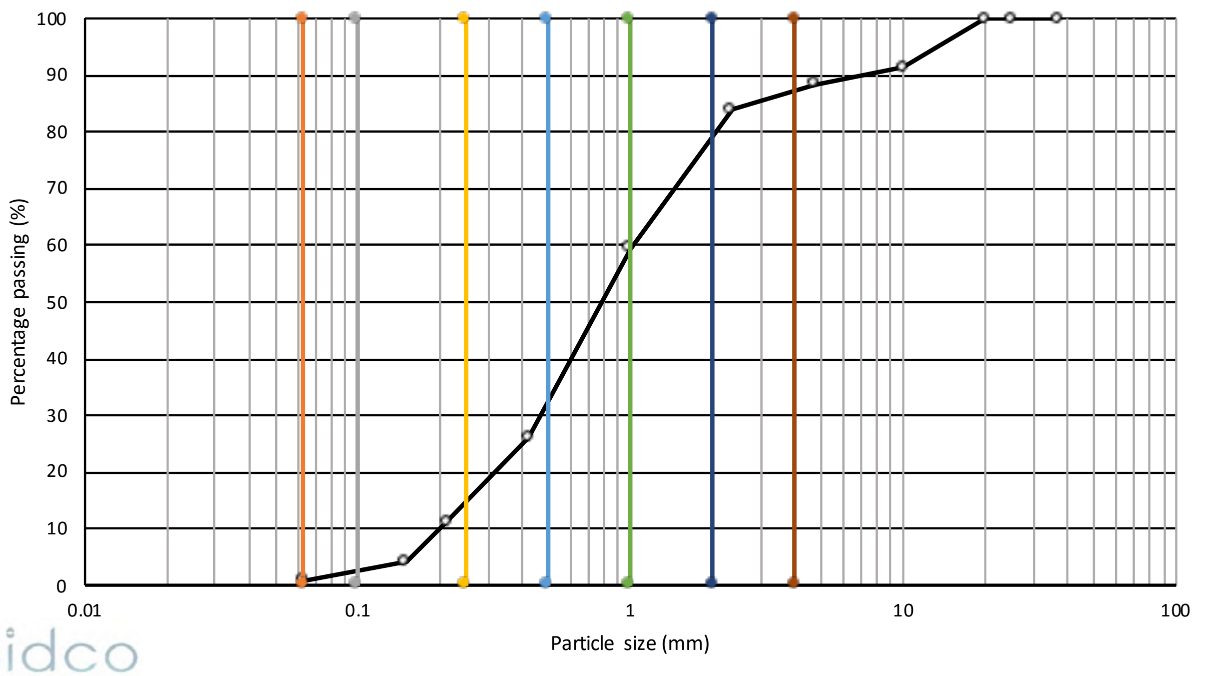
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	419.33	100.0
2	**25**	0	0	0.0	419.33	100.0
3	**20**	0	0	0.0	419.33	100.0
4	**10**	36.21	36.21	8.6	383.12	91.4
5	**4.75**	12.75	49	11.7	370.37	88.3
8	**2.36**	18.62	67.58	16.1	351.75	83.9
16	**1**	102.76	170.34	40.6	248.99	59.4
30	**0.425**	140.02	310.36	74.0	108.97	26.0
50	**0.212**	62.11	372.47	88.8	46.86	11.2
100	**0.15**	29.37	401.84	95.8	17.49	4.2
200	**0.063**	14.03	415.87	99.2	3.46	0.8
Total weight sieved through #200				3.46		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				419	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.8%	1.4%	11.6%	16.5%	29.0%	18.0%	22.6%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

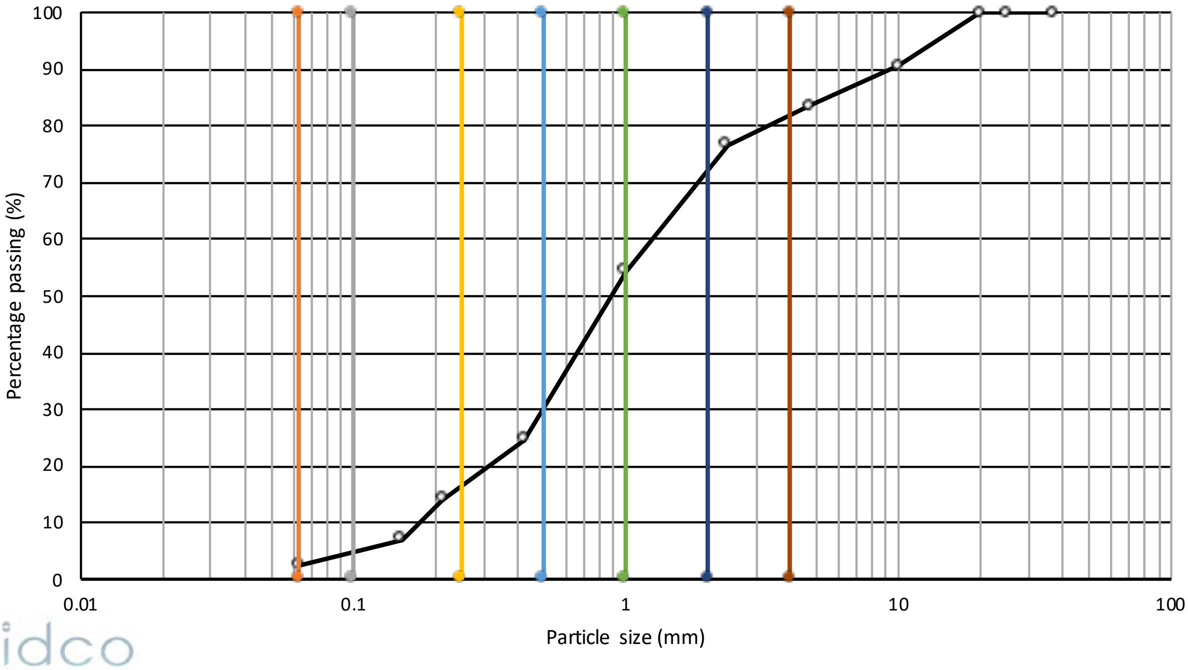
Project:	B. Eydhafushi			**File #:**	
Date:	Monday, 20 March 2023		**Tested by:**	Hewage	
	Depth (m)	3.0 m		**Test #**	**TP 2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	372.66	100.0
2	**25**	0	0	0.0	372.66	100.0
3	**20**	0	0	0.0	372.66	100.0
4	**10**	34.97	34.97	9.4	337.69	90.6
5	**4.75**	26.54	62	16.5	311.15	83.5
8	**2.36**	25.43	86.94	23.3	285.72	76.7
16	**1**	82.87	169.81	45.6	202.85	54.4
30	**0.425**	110.65	280.46	75.3	92.2	24.7
50	**0.212**	39.34	319.8	85.8	52.86	14.2
100	**0.15**	26.73	346.53	93.0	26.13	7.0
200	**0.063**	16.90	363.43	97.5	9.23	2.5
Total weight sieved through #200				9.23		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				373	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.5%	1.9%	11.7%	12.5%	25.8%	16.4%	29.2%

APPENDIX 6: PROCTOR TEST RESULT

SIDCO PVT LTD

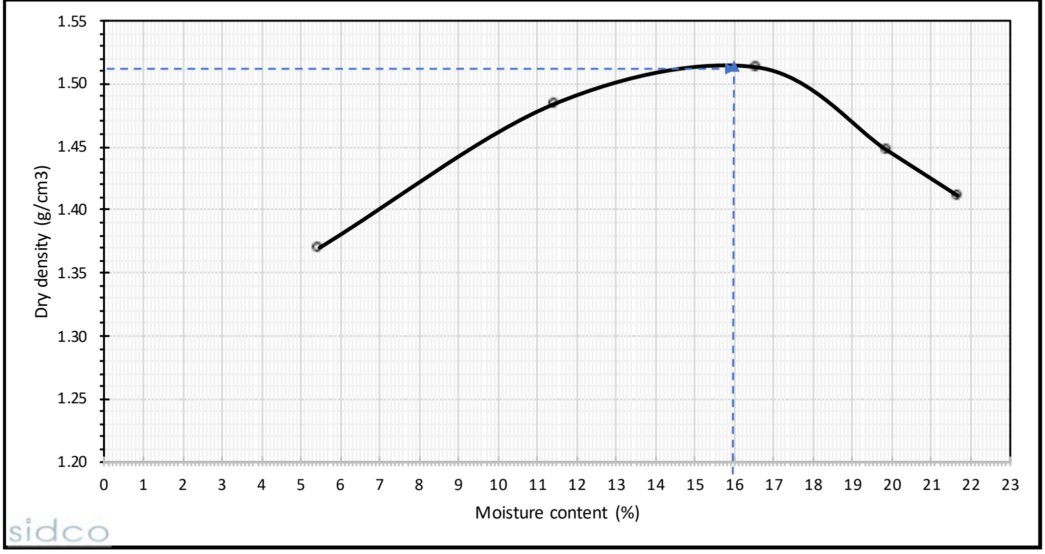
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**B. Eydhafushi**	**Date:**	**11/03/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.6	
Water dennsity, 𝛾w	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4894	5103	5213	5184	5166
weight of compacted soil, w2-w1 (g)	1445.00	1654.00	1764.00	1735.00	1717.00
Wet density, 𝛾b = ((w2-w1)/v), g/cm3	1.45	1.65	1.76	1.74	1.72
Dry density, 𝛾d = (𝛾b/(1+(w/100))), g/cm3	**1.37**	**1.48**	**1.51**	**1.45**	**1.41**
Void Ratio e = ((Gs𝛾w)/𝛾d-1	1.90	1.75	1.72	1.80	1.84
Moisture content					
Weight of container, g	29.96	29.99	30.12	30.05	29.97
Weight of container + wet soil, g	72.3	64.6	59.3	70.5	66.3
Wet container + dry soil, g	70.14	61.01	55.13	63.83	59.83
Weight of moisture, ww (g)	2.20	3.55	4.15	6.71	6.47
Weight of dry soil, ws (g)	40.18	31.02	25.01	33.78	29.86
Water content, w= ((ww/ws)x100), %	**5.48**	**11.44**	**16.59**	**19.86**	**21.67**



APPENDIX 7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

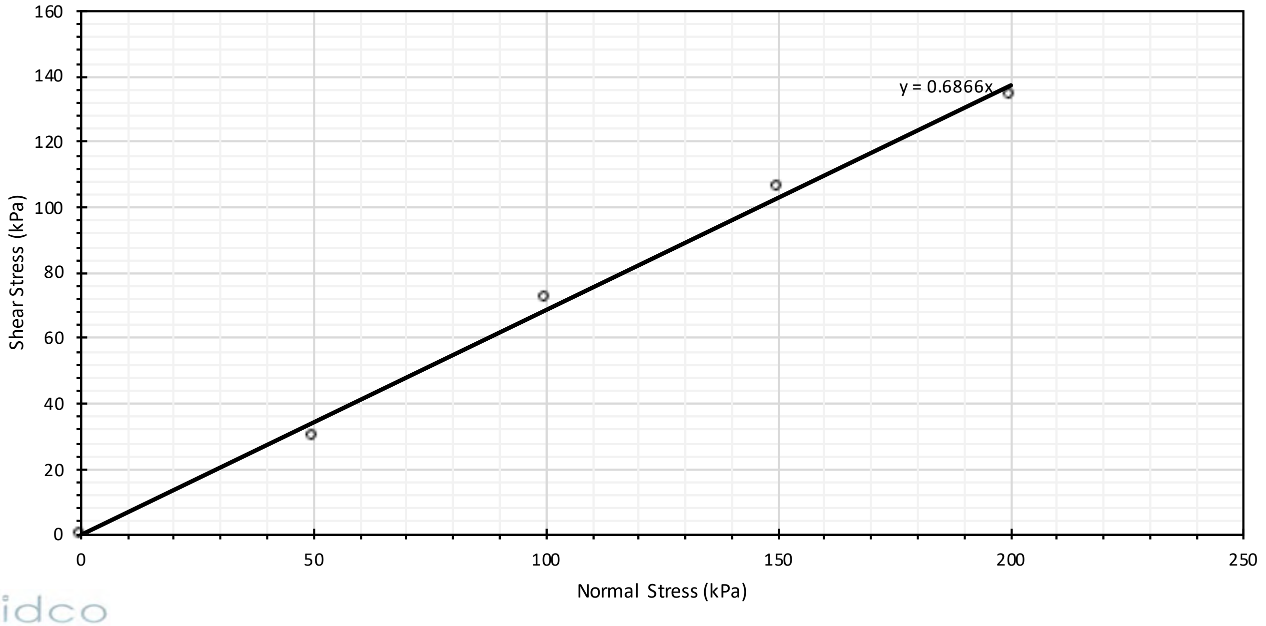
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**B. Eydhafushi**	**Date:**	**12/03/2023**	**Direct Shear**	**1**

Moisture content (%)	10.24%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	34	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	30.21
100.00	72.34
150.00	106.09
200.00	134.20



sidco

APPENDIX 8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**B. Eydhafushi**	**Date:**	**21/02/2022**
TEST 1			
Mass of dnesity bottle	W1	31.32	g
Mass of bottle + dry sand	W2	84.21	g
Mass of bottle + dry sand + water	W3	163.59	g
Mass of bottle + water	W4	130.92	g
Specific Gravity	Gs	2.62	

TEST 2

Mass of dnesity bottle	W1	35.02	g
Mass of bottle + dry sand	W2	91.51	g
Mass of bottle + dry sand + water	W3	181.51	g
Mass of bottle + water	W4	146.68	g
Specific Gravity	Gs	2.61	

Avarege Gs		2.61	

APPENDIX 9: SOIL RESITIVITY SURVEY RESULT

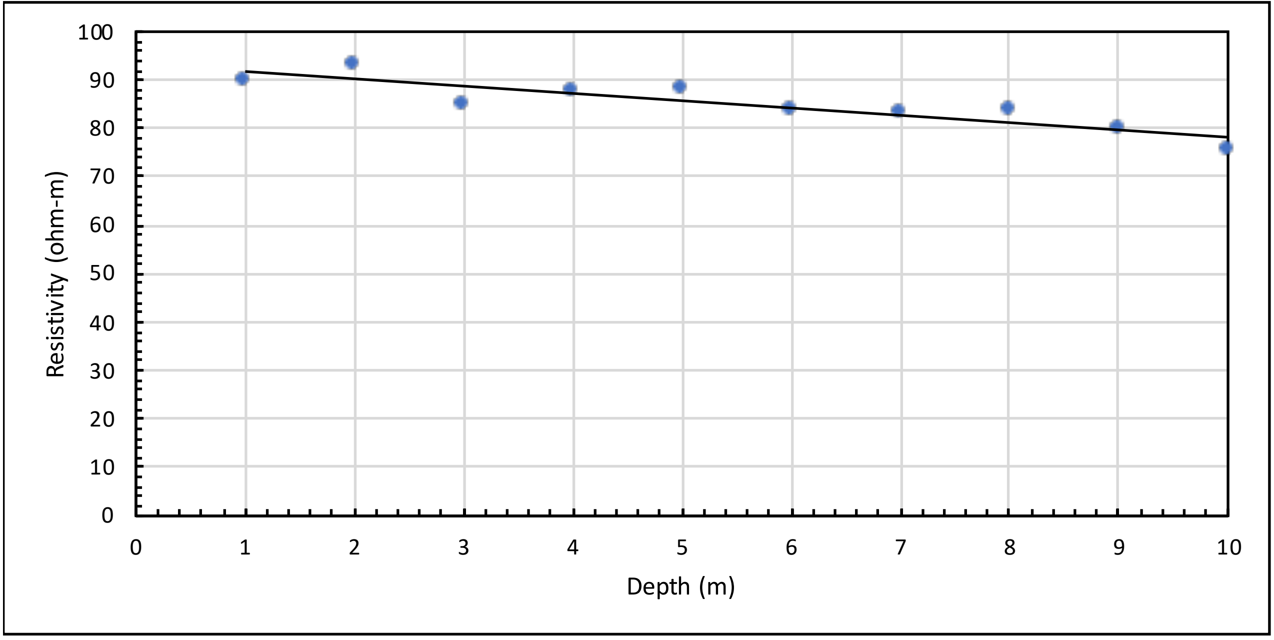
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	14.32	90
2	2	7.43	93
3	3	4.51	85
4	4	3.48	87
5	5	2.81	88
6	6	2.23	84
7	7	1.89	83
8	8	1.67	84
9	9	1.41	80
10	10	1.20	75



SIDCO SOILS LAB

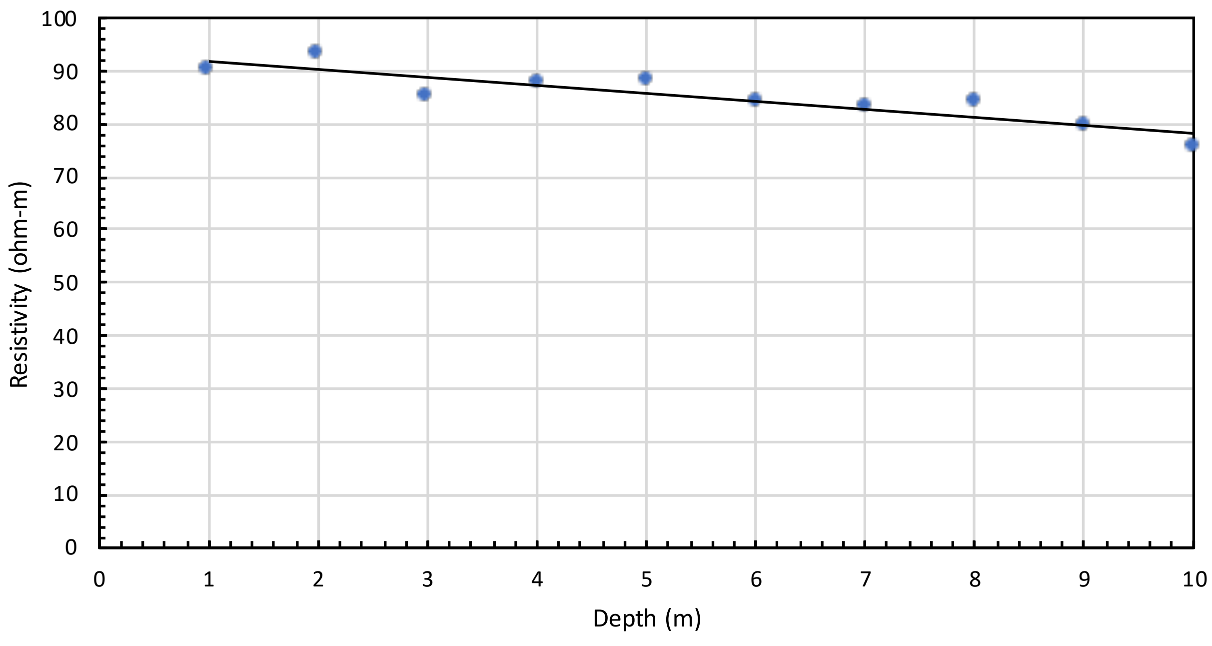
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 2

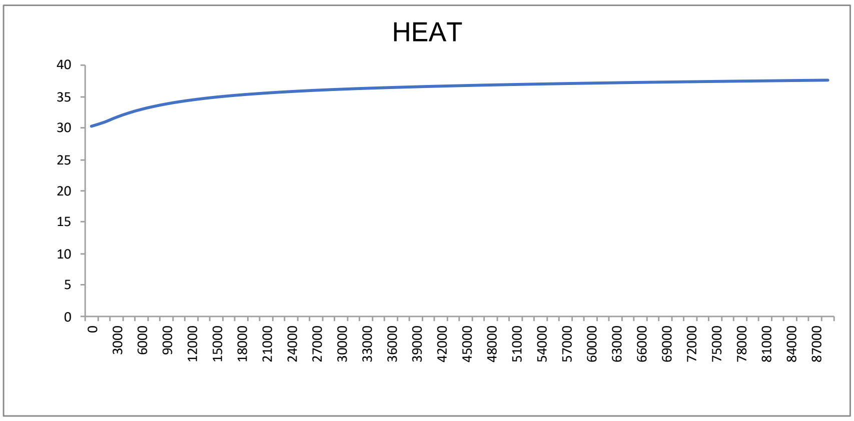
Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	16.31	102
2	2	8.64	109
3	3	4.65	88
4	4	3.57	90
5	5	2.96	93
6	6	2.26	85
7	7	1.93	85
8	8	1.60	80
9	9	1.37	77
10	10	1.12	70

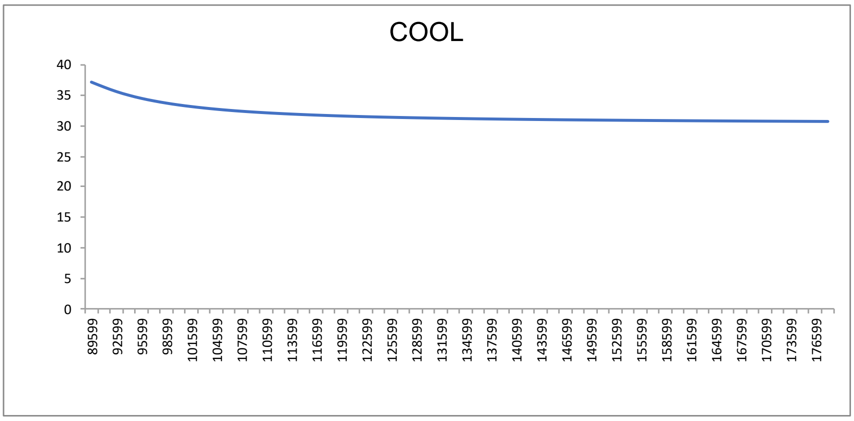


APPENDIX 10: THERMAL CONDUCTIVITY TEST RESULTS

TEST 1

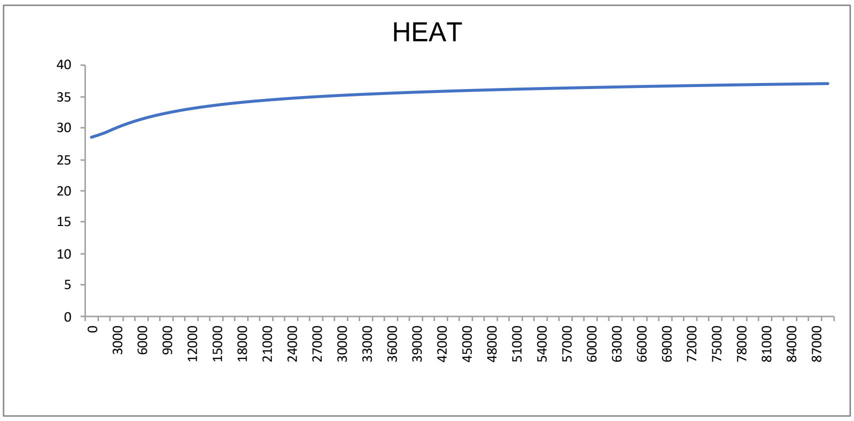
HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	30.272276		89599	37.183998
1500	30.895424		91099	36.373917
3000	31.702		92599	35.635517
4500	32.393284		94099	35.030209
6000	32.963512		95599	34.521385
7500	33.430313		97099	34.102657
9000	33.826431		98599	33.742813
10500	34.161716		100099	33.43364
12000	34.445427		101599	33.17231
13500	34.695953		103099	32.942966
15000	34.915028		104599	32.741497
16500	35.106182		106099	32.563026
18000	35.274891		107599	32.40847
19500	35.424557		109099	32.272659
21000	35.561172		110599	32.151447
22500	35.68692		112099	32.041767
24000	35.80093		113599	31.943378
25500	35.904121		115099	31.853916
27000	36.000084		116599	31.772507
28500	36.087513		118099	31.699036
30000	36.167633		119599	31.631386
31500	36.24332		121099	31.569229
33000	36.31311		122599	31.512527
34500	36.378605		124099	31.461214
36000	36.439552		125599	31.414272
37500	36.498035		127099	31.370878
39000	36.555153		128599	31.330717
40500	36.609257		130099	31.292925
42000	36.660393		131599	31.25738
43500	36.709385		133099	31.224428
45000	36.756683		134599	31.193876
46500	36.801655		136099	31.164263
48000	36.845108		137599	31.137297
49500	36.884731		139099	31.111206
51000	36.923157		140599	31.08696
52500	36.961956		142099	31.064112
54000	36.998936		143599	31.041998
55500	37.034107		145099	31.020727
57000	37.068787		146599	31.000889
58500	37.102413		148099	30.982347
60000	37.13446		149599	30.964745
61500	37.166004		151099	30.947132
63000	37.196281		152599	30.930298
64500	37.225689		154099	30.914642
66000	37.254208		155599	30.90015
67500	37.282269		157099	30.88537
69000	37.309196		158599	30.871351
70500	37.335159		160099	30.857807
72000	37.360859		161599	30.845228
73500	37.385448		163099	30.832899
75000	37.4105		164599	30.821127
76500	37.433231		166099	30.809507
78000	37.456554		167599	30.79833
79500	37.479298		169099	30.787918
81000	37.501934		170599	30.777143
82500	37.524395		172099	30.767567
84000	37.54636		173599	30.758232
85500	37.567871		175099	30.748703
87000	37.589046		176599	30.739227
88500	37.609749		178099	30.730793

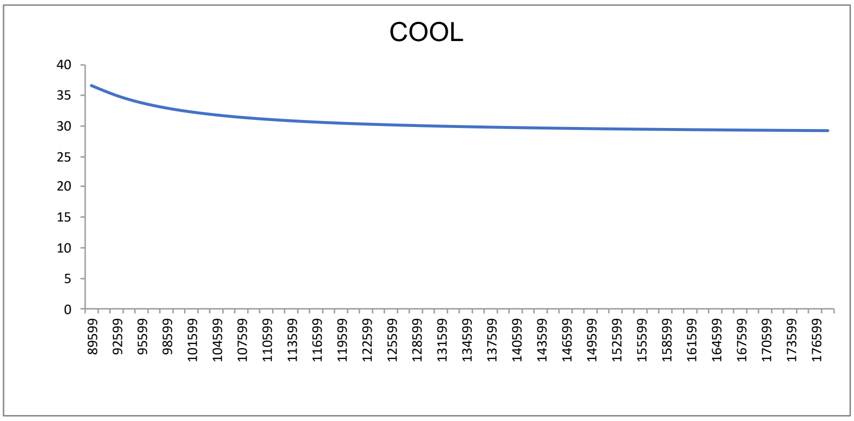




TEST 2

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	28.518848		89599	36.615906
1500	29.178272		91099	35.773842
3000	30.025642		92599	34.993496
4500	30.77224		94099	34.341507
6000	31.394218		95599	33.798176
7500	31.92128		97099	33.333439
9000	32.364143		98599	32.93787
10500	32.749191		100099	32.590111
12000	33.083393		101599	32.291637
13500	33.373173		103099	32.029587
15000	33.632046		104599	31.796482
16500	33.86525		106099	31.587063
18000	34.071575		107599	31.403387
19500	34.257339		109099	31.240416
21000	34.423565		110599	31.09351
22500	34.577614		112099	30.959604
24000	34.721172		113599	30.837597
25500	34.852867		115099	30.725952
27000	34.973602		116599	30.623402
28500	35.084976		118099	30.529875
30000	35.189308		119599	30.444885
31500	35.285896		121099	30.367933
33000	35.37616		122599	30.296057
34500	35.46106		124099	30.230003
36000	35.542442		125599	30.168297
37500	35.620651		127099	30.110197
39000	35.694618		128599	30.056147
40500	35.765079		130099	30.005398
42000	35.831093		131599	29.957556
43500	35.894943		133099	29.912951
45000	35.95546		134599	29.870089
46500	36.013283		136099	29.830387
48000	36.068073		137599	29.792305
49500	36.121334		139099	29.756643
51000	36.172966		140599	29.722631
52500	36.222263		142099	29.690262
54000	36.269283		143599	29.65962
55500	36.315136		145099	29.629772
57000	36.359131		146599	29.601631
58500	36.401463		148099	29.575052
60000	36.442959		149599	29.549202
61500	36.48341		151099	29.524401
63000	36.522491		152599	29.501091
64500	36.561817		154099	29.479511
66000	36.600048		155599	29.458326
67500	36.636551		157099	29.438393
69000	36.673027		158599	29.419123
70500	36.708069		160099	29.400307
72000	36.74229		161599	29.382421
73500	36.775719		163099	29.36553
75000	36.808701		164599	29.348843
76500	36.840191		166099	29.332848
78000	36.870956		167599	29.317234
79500	36.901428		169099	29.302145
81000	36.931587		170599	29.287565
82500	36.959213		172099	29.273859
84000	36.986534		173599	29.259752
85500	37.012444		175099	29.246332
87000	37.039776		176599	29.233831
88500	37.066044		178099	29.221451





APPENDIX 11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500195058

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Male K

Report date: **21/02/2023**
Test Requisition Form No: **900196882**
Sample(s) Recieved Date: **20/02/2023**
Date of Analysis: **20/02/2023 - 20/02/2023**

Sample Description ~	B.Eydhafushi 1	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83236579		
Sampled Date ~	10/02/2023 04:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Opaque and cloudy with particles		
Conductivity *	2580	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	8.1	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	1289	Electrometry	mg/L
Chloride	672	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	1.3	HACH Method 8171	mg/L
Sulphate *	130	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Senior Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************** END OF REPORT **************************

sidco

MARCH 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
Fuahmulah Airport Area

CLIENT

HDEC

中国电建
POWERCHINA

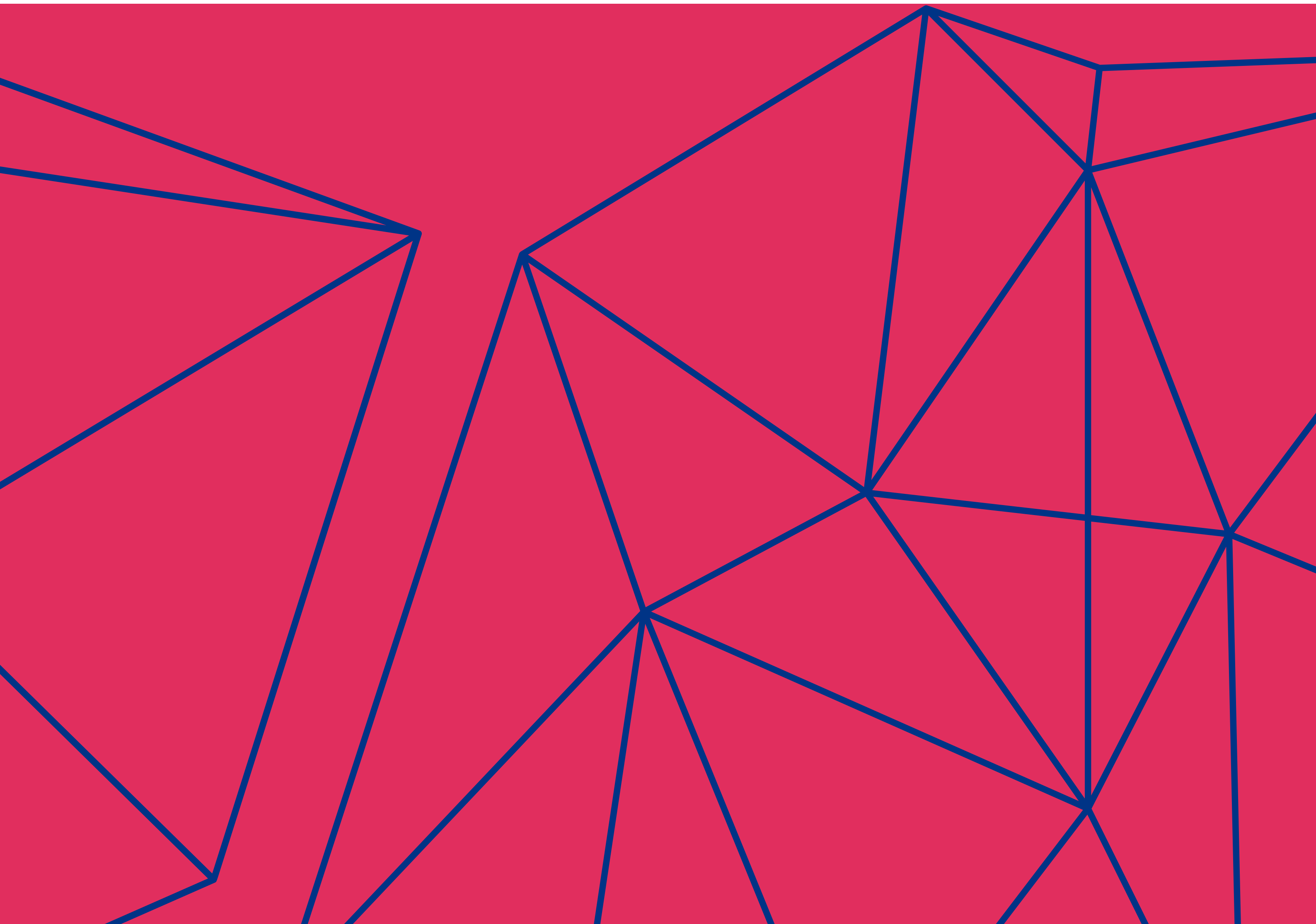


Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out between 10th January and 16th February 2023 and 20th February 2023 in Fuahmulah for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Borehole / Standard Penetration Test (SPT)
2. Dynamic Cone Penetration (DCP) tests
3. Mackintosh Probe
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. BS 5930:2015+A1:2020 Code of practice for ground investigation
2. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
3. BS EN ISO 17892-4:2016 Determination of particle size distribution
4. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
5. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

Solar PV is to be installed in 2 locations in Fuahmulah Airport area.

Figure 1: Map of Fuahmulah (Google Earth)

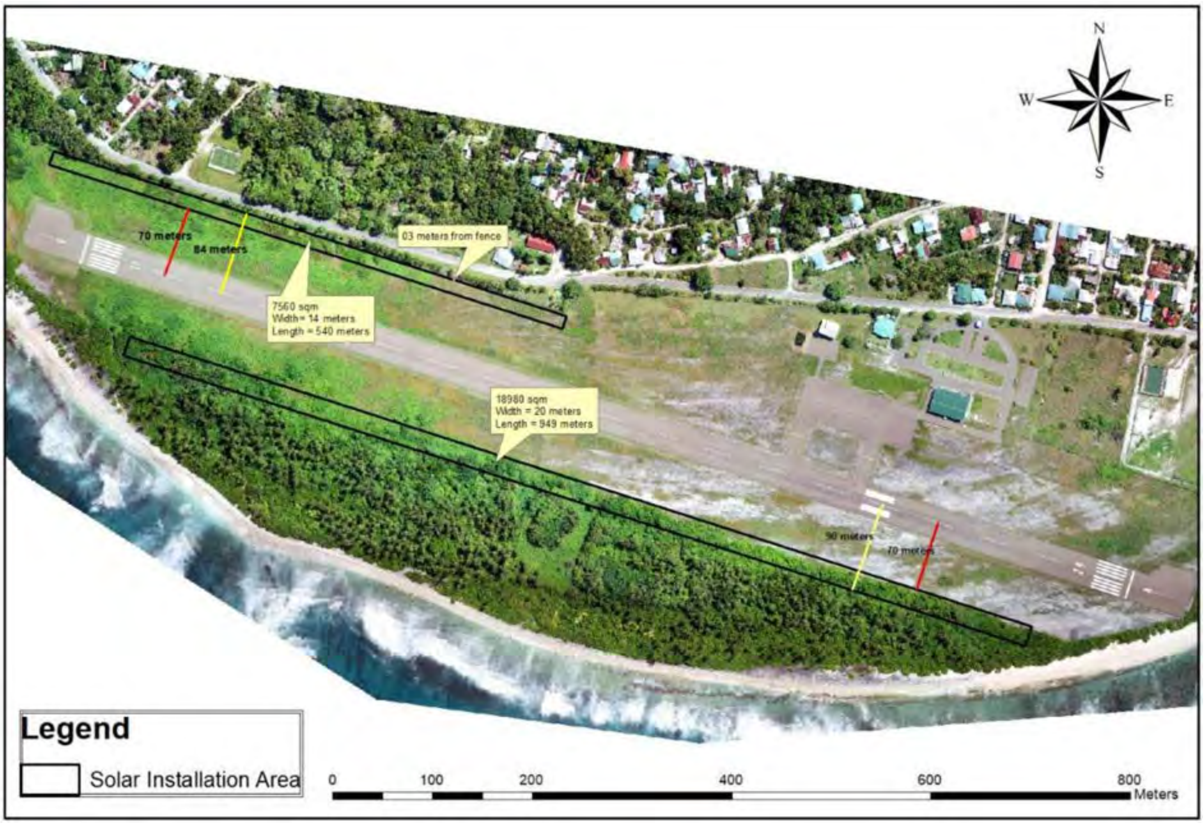


Figure 2: Map showing Fuahmulah Airport site

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed roads for development have a flat terrain and the ground elevation is between 1 and 1.5 meters.

Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands that was dredged from deep sea to reclaim the land. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP 2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.

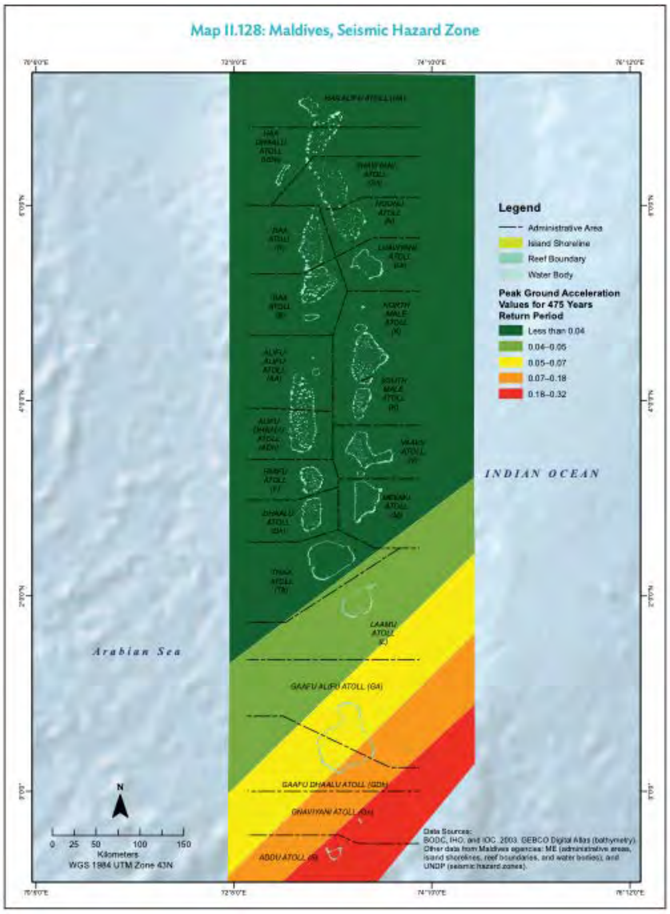


Figure 3: Seismic Hazard Zone (ADB 2020)

Fuahmulah is located in south of Maldives where peak ground acceleration value for 475 years return period is less than 0.18-0.32. This is highest risk zone in Maldives for seismic activities.

2.4 CLIMATE

This section contains general information about the project area. Data if from Department of Meteorology which has recorded that data from the weather station at S. Gan, the island which is about 50 km away from Fuahmulah.

The local climate is warm and humid tropical climate with average temperatures ranging between 27°C to 31°C and average relative humidity ranging from 72.2 per cent to 88.1 per cent. The mean annual rainfall in S. Gan is 2295.3 mm ranges between 1548.8 mm and 3185.7 mm between 1978 and 2006 (Zahid 2011).

The climate in Maldives is dependent upon the Indian Ocean Monsoons. Monsoon wind reversal plays a significant role in weather patterns.

The two monsoon seasons observed in the Maldives are the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The northeast monsoon is the dry season that occurs from December to February whereas the southwest monsoon is the rainy season, which lasts from May to September. The transition period of northeast monsoon occurs from October to November while that of southwest monsoon occurs between March and April.

2.5 GROUND WATER

The ground water is typically encountered at a depth of 1.2 m below the existing ground level depending on the tide.

2.6 RAINFALL

Rainfall data and other meteorological data are not available for Fuahmulah. The closest weather centre is located at S. Gan Airport (located at 00º41’36” S and 73º09’20” E), which is about 50 km south of Fuahmulah. Therefore, data from Gan weather centre is used for the project.

The rainfall pattern in Maldives is influenced by the monsoons, where heavy rainfall in south-west monsoon (*Hulhan’gu*) from May to November followed by a transition period from

December to January and dry period in north-east monsoon (*Iruvai*) from January to April with scattered rainfall.

Gan rainfall data shows a periodic pattern and annual precipitation varies from year to year with a mean rainfall of 2243.9 mm and ranging between 1548.8 mm and 3056.5 mm (Zahid 2011).

On average the maximum number of rainy days for the Addu region is 164 rainy days per calendar year. According to Zahid (2011), there is a strong correlation between the number of rainy days and the annual rainfall in Gan (CC=0.59).

In addition, the trend observed is that the number of rainy days has been decreasing without decreasing annual rainfall. This indicates that more rainfall is received over a shorter period increasing the chances of flooding due to heavy rain.

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Borehole Investigation / SPT

3.2.1.1 Rotatory Drilling

Boreholes shall be drilled using Rotary drilling machine. Borehole with the nominal diameter of 76 mm were be drilled using rotary drill rig. Drilling was carried out using rotary boring machine Figure 4. A metal drill bit as a cutting tool would be attached at the lower end of the drilling rods and circulated mud water pumped through the hollow rods into the bottom of borehole to stabilize the borehole and wash out the cuttings to ground surface.

Drilling was done using clear water/ bentonite water as drilling fluid. The return water from the borehole carried out the sludge and become muddy. This muddy water was kept in the surface pit and later pumped into the hole through drill rods as drilling fluid. Water would be changed when the muddy water turned too thick. As the whole circulating process was running in a closed system, no spillage and contamination of muddy water occurred throughout the drilling time.

Figure 4: Rotatory drilling machine used for boring and SPT

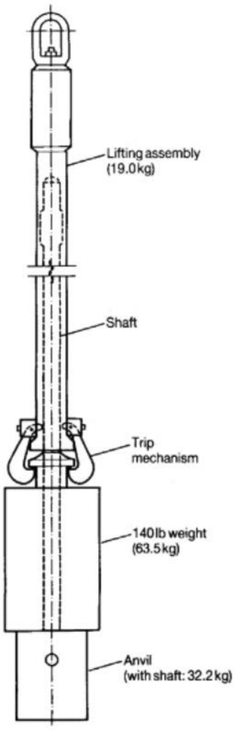


Figure 5: SPT Trip Hammer schematic diagram

3.2.1.2 Standard Penetration Test (SPT)

The 'Standard Penetration Test, commonly known as the 'SPT', was carried out in a borehole, by driving a standard 50mm O.D x 60mm long thick wall 'split spoon' sampler using repeated blows of a 63.5 kg hammer free falling through 750mm. Automatic Trip Hammer was used to do SPT test. It is designed to hammer Split Spoon Sampler with standard 63.5 kg weight with exact height of 760 mm fall. It eliminates the human error of measurement and lifting the weight and then dropping on split tube sampler. The split spoon is lowered to the bottom of the hole, and is then driven 450 mm taking SPT number for every 150 mm. At the end of driving, the split spoon is pulled from the base of the hole, and the sample is preserved in an airtight container.

The penetration resistance (N) is the number of blows required to drive the split spoon for the last 300mm of penetration. The penetration resistance during the first 150 mm of penetration is ignored, because the soil is considered to have been disturbed by the action of boring the hole.

Upon completion of test, the sampler was removed and dissembled to provide a disturbed but representative sample. These SPT samples and other disturbed samples from all soil strata were kept properly sealed, labelled, and packed in plastic bag for verification in preparing this report. The "N" values are indicated in the logs of boring. Corrected N values $(N_1)_{60}$ are also included in the logs.

The SPT tests were conducted at 1 m interval up to 3 m and then every 1.5 m intervals up to refusal.

Field log sheets will contain the soil description based on field observation, depth, and type of samples

3.2.2 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

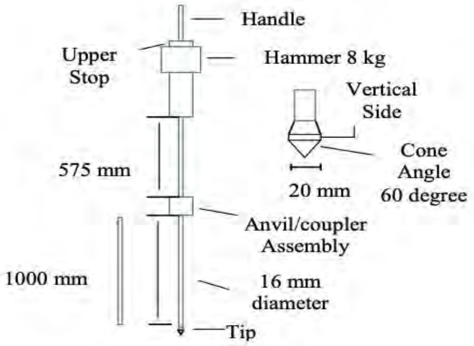


Figure 6: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.3 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.
6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.
7. The data is then plotted number of blows against depth.

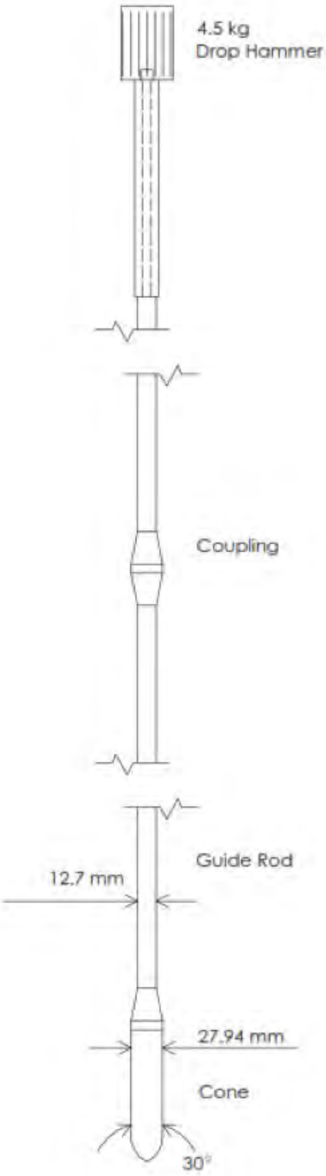


Figure 7: Schematic diagram of Mackintosh Probe

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

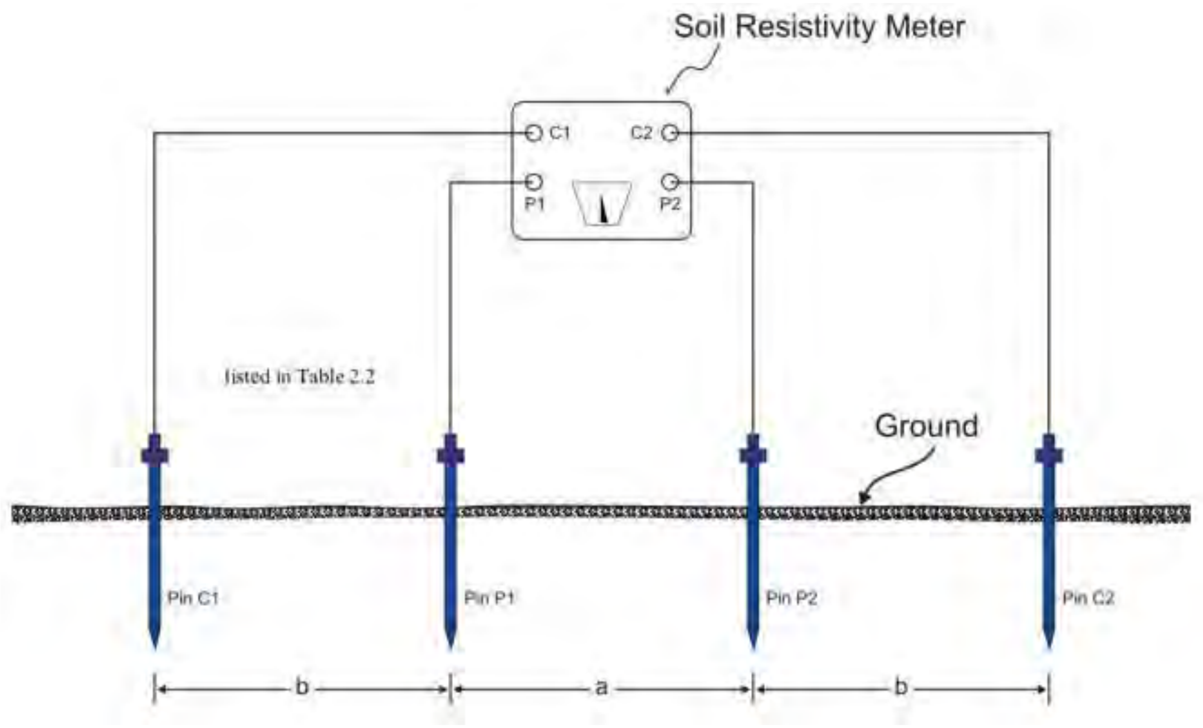


Figure 8: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 9: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W m^{-1}°C^{-1}). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 10: TLS-100 Portable Thermal Conductivity Meter

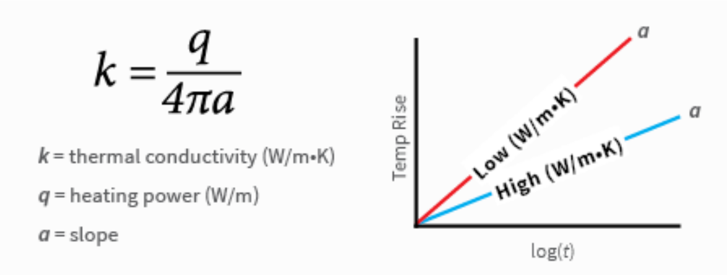


Figure 11: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\gamma_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 12.

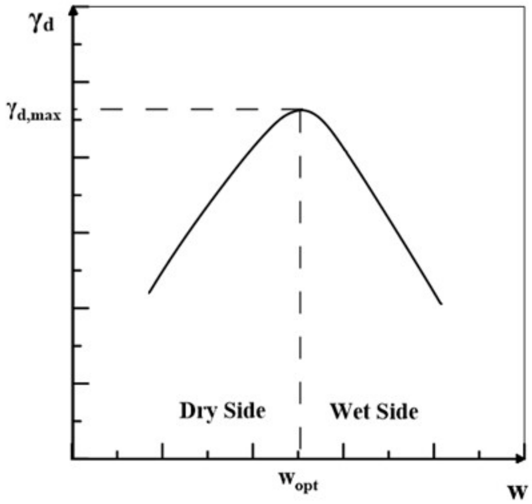


Figure 12: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 13, highest strength of a soil is achieved dry of optimum moisture content of a soil.

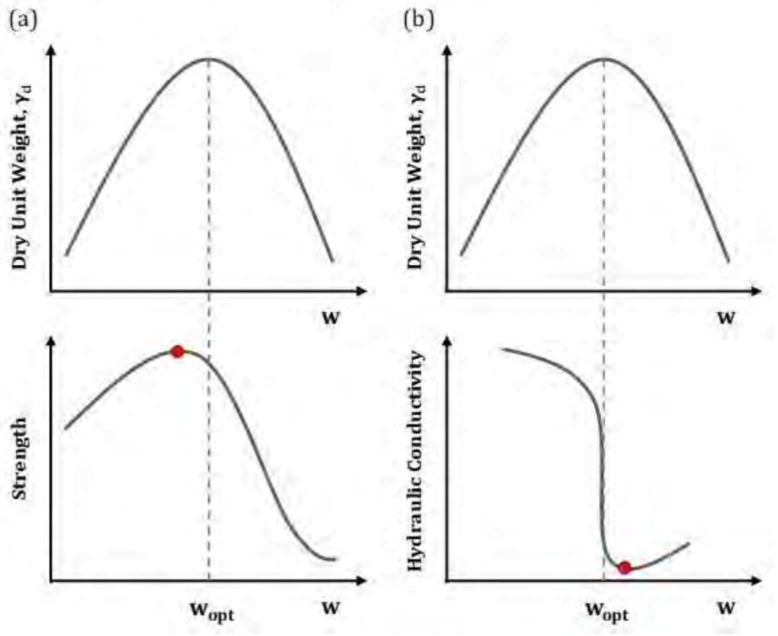


Figure 13: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Data Analysis Methods

4.1 Standard Penetration Test (SPT)

4.1.1 SPT N Corrections

According to Skempton (1986) that the penetration resistance would be significantly affected by the energy transmitted by SPT hammer and rod system and argued that SPT N values should be corrected to a common reference energy rating. Skempton (1986) proposed the use of 60% of the free fall energy as the reference energy rating. N_{60} is given as:

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.60}$$

E_m= Hammer efficiency

C_B= Borehole diameter correction

C_S= Sample barrel correction

C_R= Rod length correction

N= N measured

N_{60}= SPT N-value corrected for field procedures and apparatus

Liao and Whitman (1986) proposed overburden correction to Skempton's N60 to consider increasing confinement with depth. This correction was termed as $(N_1)_{60}$ and is given as:

$$(N_1)_{60} = N_{60} \times C_N$$

Where C_N is given as:

$$C_N = 9.78\sqrt{\frac{1}{\sigma'_v}}$$

$\boldsymbol{\sigma}'_v$ is given in kN/m^2

Robertson and Wride (1997) have modified the Skempton's correction factors chart to add the factors proposed by Liao and Whitman (1986).

Table 1: Recommended corrections for SPT N values Robertson and Wride (1997)

Factor	Equipment Variable	Term	Correction
Overburden Pressure		C_N	$(Pa / \sigma'_{vo})^{0.5}$ but $C_N \leq 2$
Energy ratio	Donut Hammer Safety Hammer Automatic Hammer	C_E	0.5 to 1.0 0.7 to 1.2 0.8 to 1.5
Borehole diameter	65 mm to 115 mm 150 mm 200 mm	C_B	1.0 1.05 1.15
Rod length	3 m to 4 m 4 m to 6 m 6 m to 10 m 10m to 30 m >30 m	C_R	0.75 0.85 0.95 1.0 <1.0
Sampling method	Standard sampler Sampler without liners	Cs	1.0 1.1 to 1.3

Below given are the tables with standardised SPT N-values for 2 boreholes.

4.1.2 Safe Bearing Capacity (SBC) for Pad Foundation

In a geotechnical investigation, calculating safe bearing capacity is utmost important. In general data from shearing of undisturbed samples, especially triaxial shearing results are considered as an accurate method. However, in non-cohesive soils, like that was found in the project sites, both corrected SPT N values are used to estimate the safe bearing capacity of soil.

4.1.2.1 SBC using $(N_1)_{60}$ values for pad foundation

One of the earliest published relationship between was proposed by Terzaghi and Peck (1967). With the accumulation field data over the time has shown the bearing capacity curves to be overly conservative. To address this Meyerhof (1976) proposed new set of equations for a 25 mm settlement. The equations are given below.

For foundation footing width ≤ 4 ft

$$q_a = \left(\frac{N}{4}\right) K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{6}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

However, the equations proposed by Meyerhof (1976) were also found to be conservative which produce similar safe bearing capacity values as equations proposed by Terzaghi and Peck (1967). Hence, Bowles (1996) adjusted the Meyerhof's equations and proposed the following equations.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{4}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

Since Bowles (1996) showed that Meyerhof (1976) under-estimates the SBC, we have to check settlement of each bearing capacity to determine an allowable bearing capacity.

Since the soil is granular, the settlement in sand is generally the immediate settlement, unless the soil contains very high content of silt. This is because it is unlikely for porewater pressure to build up in granular soil.

Generally shallow foundation is designed for a maximum of 25 mm settlement. The bearing capacities of both Meyerhof's and Bowles' methods are calculated for a settlement limit of 25 mm. The average settlement of normally consolidated sand is calculated using Burland and Burbidge (1985) approach where average settlement is expressed as;

$$S_i = \frac{q_n B^{0.7}}{3}\left(\frac{1.71}{N^{1.4}}\right)$$

Where q_n is the net foundation pressure, B is foundation breadth and N is e $(N)_{60}$.

4.2 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

4.3 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550\ (R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

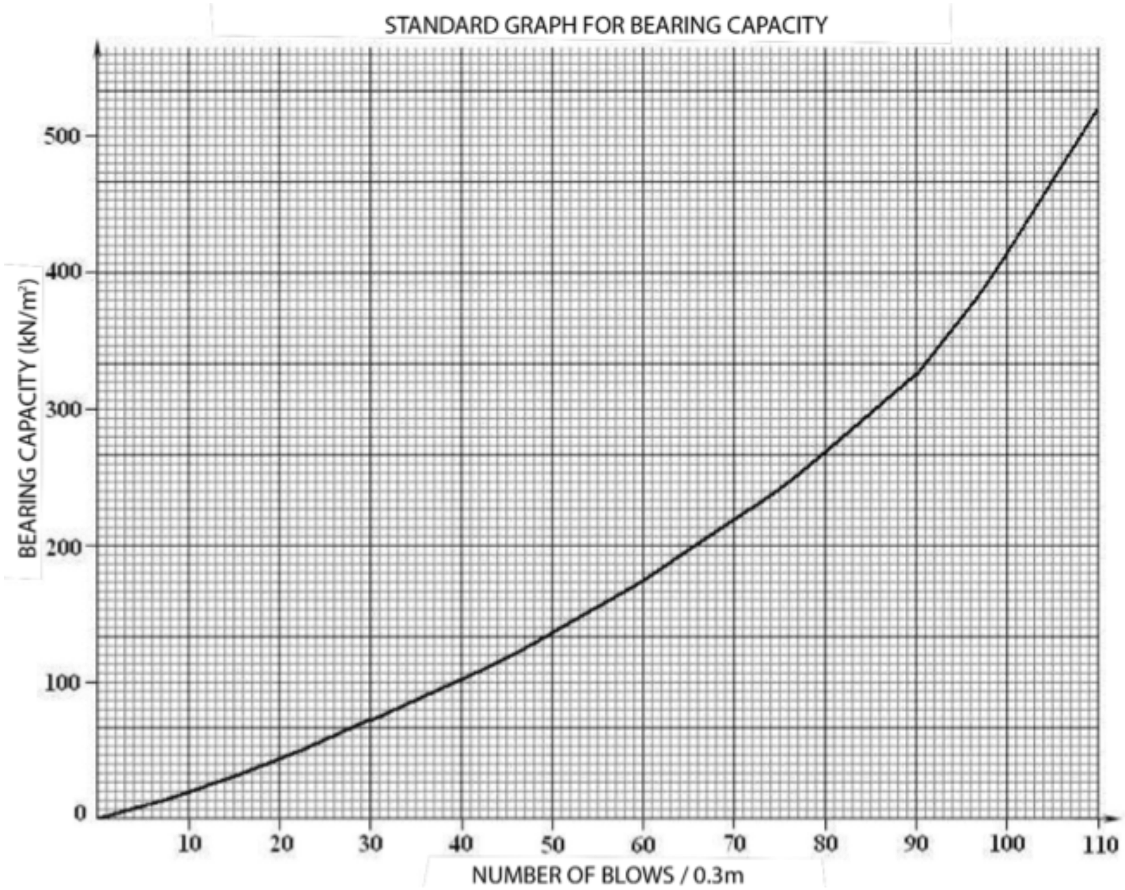


Figure 14: Standard bearing capacity graph for Mackintosh Probe

5 Results and Discussions

5.1 Borehole/SPT

5.1.1 SPT N Corrections

The tables below give the corrected N value and friction angle. The area reclaimed during harbour construction. While loose layer was encountered at a depth of 1-2 m, a hard rock layer was encountered at a depth of 7.0 m.

Table 2: Borehole 1 SPT N-values corrected

BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	22	0.7	1	1	0.75	19	17	2.00	39	33
2.00	21	0.7	1	1	0.75	18	24	2.00	37	32
3.00	26	0.7	1	1	0.75	23	31	2.00	46	34
4.50	26	0.7	1	1	0.75	23	42	1.51	34	34
6.00	24	0.7	1	1	0.85	24	53	1.35	32	34

Table 3: Borehole 2 SPT N-values corrected

BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	24	0.7	1	1	0.75	21	17	2.00	42	33
2.00	23	0.7	1	1	0.75	20	24	2.00	40	33
3.00	20	0.7	1	1	0.75	18	31	2.00	35	32
4.50	18	0.7	1	1	0.75	16	42	1.51	24	32
6.00	20	0.7	1	1	0.85	20	53	1.35	27	33

5.1.2 Safe Bearing Capacity

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 6 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 185 kPa as safe bearing capacity for foundation design.

Table 4:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.

BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	398	480
	1.0	2.00	303	454
BH2	1.0	1.00	429	517
	1.0	2.00	327	491

5.2 Dynamic Cone Penetrometer (DCP)

Table 5: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

	Safe Bearing Capacity (kPa)					
Depth (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	Average
0.3	167	69	82	63	82	**93**
0.6	212	111	56	82	111	**114**
0.9	190	167	111	132	142	**148**
1.2	137	181	116	121	121	**135**
1.5	142	127	167	137	127	**140**
1.8	152	121	121	105	132	**126**
2.0	132	142	116	132	94	**123**

Table 5 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

5.3 Mackintosh Probe (MP)

Table 6 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 6: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	91	110	**101**
0.6	85	122	**104**
0.9	91	120	**106**
1.2	103	130	**117**
1.5	91	138	**115**
1.8	110	152	**131**
2.1	151	173	**162**
2.4	-	189	**189**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

5.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at Fuahmulah Airport area are provided in the Table 7 and Table 8. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 7: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
1.0	50.9	5.4	8.6	10.6	18.5	5.0	1.0
2.0	45.6	4.8	5.3	3.9	25.3	12.8	2.3
3.0	44.5	7.8	8.2	5.2	22.2	10.3	1.8
4.5	56.1	6.4	11.6	6.4	13.6	5.2	0.8

Table 8: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
1.0	35.9	8.7	14.9	12.2	21.8	5.8	0.7
2.0	51.7	8.2	10.7	7.2	15.2	5.3	1.7
3.0	49.9	3.4	7.0	6.7	21.4	8.3	3.3
4.5	42.6	9.2	14.7	10.4	14.6	5.5	3.0

5.5 Direct Shear

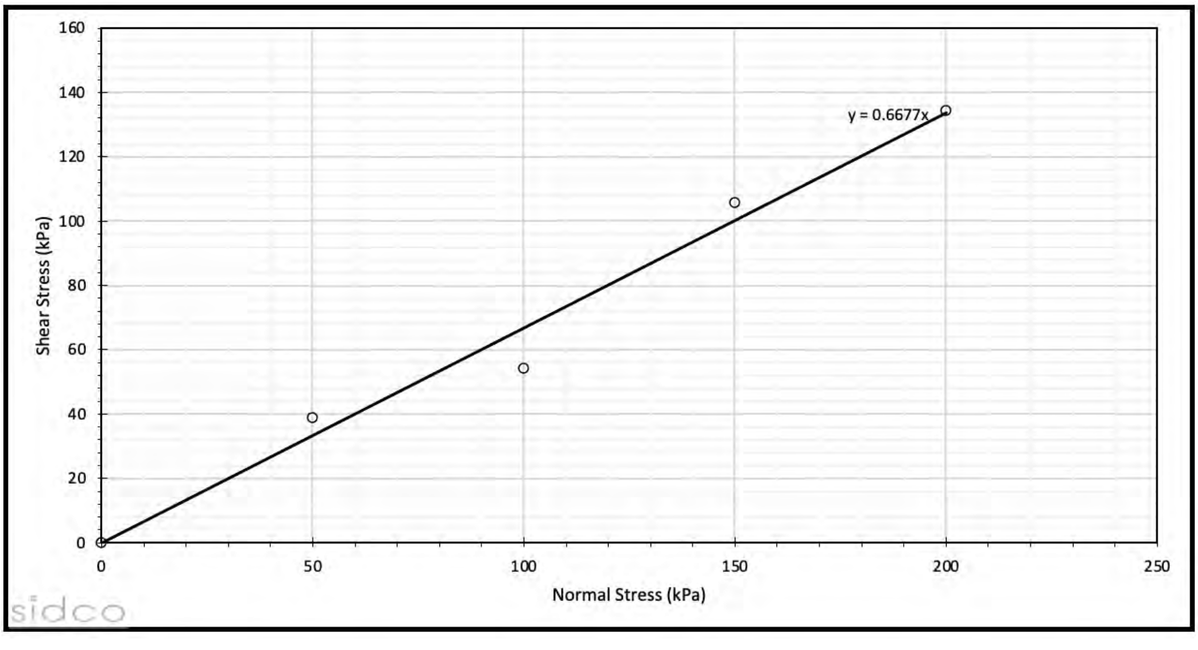


Figure 15: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 36 degrees, which is typical for carbonated sand found in Maldives.

5.6 Proctor Compaction Test

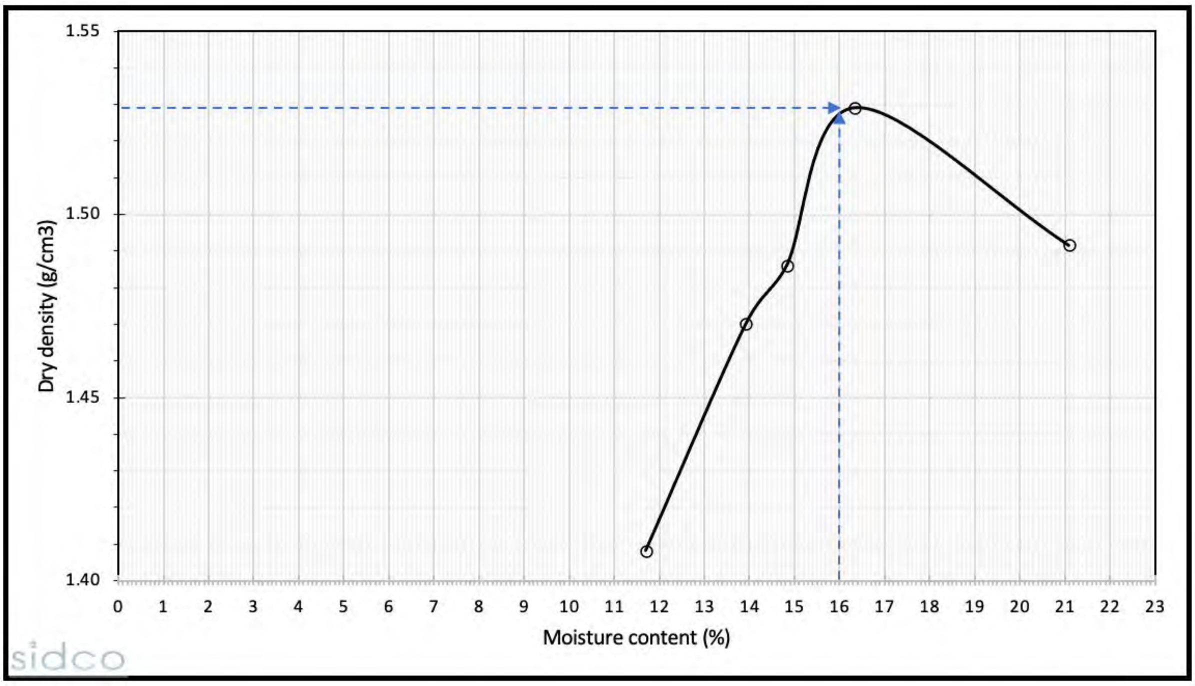
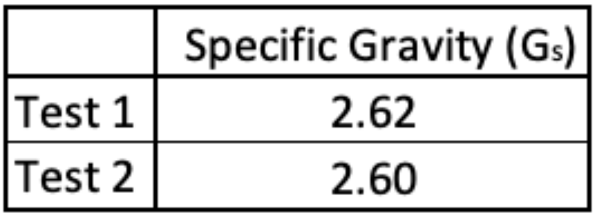


Figure 16: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.53 g/cm^3 and an optimum moisture content of 16%.

5.7 Specific Gravity Test

Table 9: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.62
Test 2	2.60

Table 9 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

5.8 Electrical Resistivity Test

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system.

There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content. The tables and graphs below show ER test results.

Table 10: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	5.20	33
2	2	3.40	43
3	3	2.20	41
4	4	2.20	55
5	5	1.60	50
6	6	1.23	46
7	7	1.09	48
8	8	0.95	48
9	9	0.74	42
10	10	0.69	43

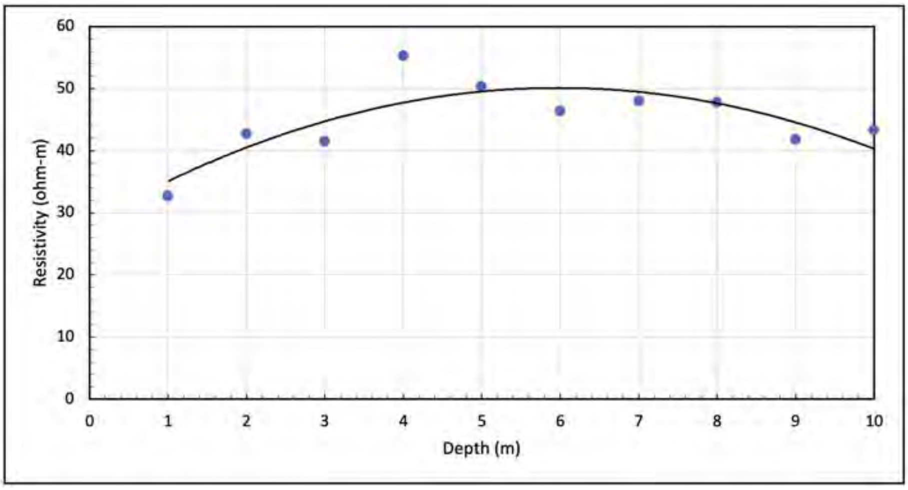


Figure 17: Resistivity graph for Test 1

Table 11: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	8.43	53
2	2	4.26	54
3	3	2.77	52
4	4	1.72	43
5	5	1.21	38
6	6	1.01	38
7	7	0.88	39
8	8	0.59	30
9	9	0.48	27
10	10	0.40	25

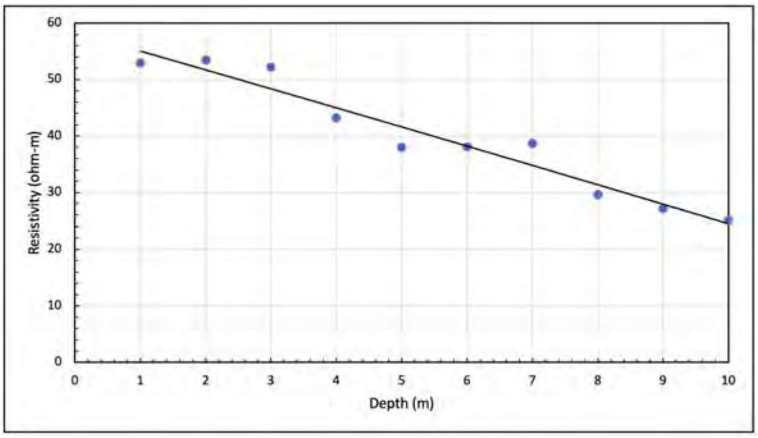


Figure 18: Resistivity graph for Test 2

Overall resistivity remains constant, highest being 56 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

5.9 Thermal Conductivity Test

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 12: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (°C)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	33.80	0.343	2.92	200
2	TLS100	30.40	0.596	1.68	200
Average		32.10	0.470	2.30	

The average thermal conductivity is 0.470 W/mK.

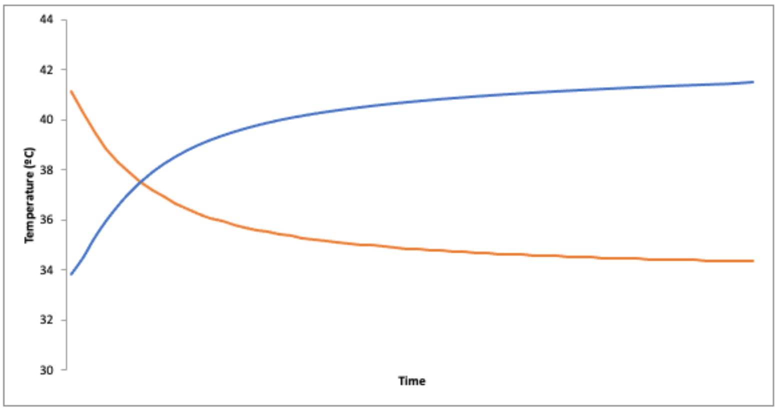


Figure 19: Heat and Colling Curve to TC Test 1

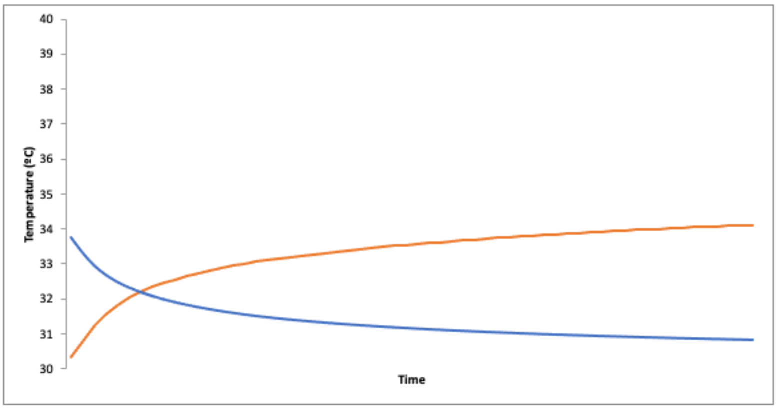
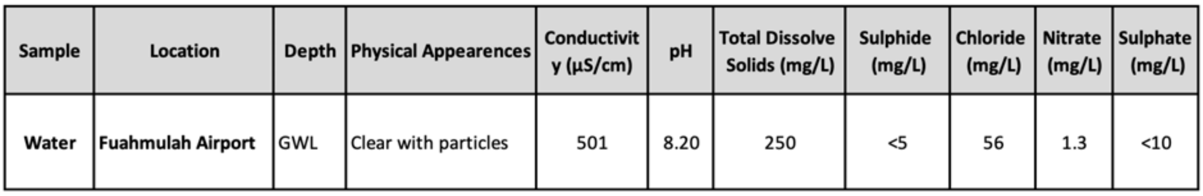


Figure 20: Heat and Colling Curve to TC Test 2

5.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 501 µS/cm with a Sulphate content of <10 mg/L, Nitrate content of 1.3 mg/L, Chloride content of 56 mg/L and Sulphide content of <5 mg/L. The project location is part of the natural island; hence the water quality is very good. However, since the islands in Maldives has very thin freshwater layer which can easily deplete. Hence, sub-structural concrete will have to be designed to have high quality concrete with low permeability and should be treated with surface sealant like bitumen.

Table 13: Chemical test results of water sample from Fuahmulah Airport site



Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	**Fuahmulah Airport**	GWL	Clear with particles	501	8.20	250	<5	56	1.3	<10

6 Conclusion

6.1 GEOTECHNICAL CONSIDERATIONS

6.1.1 Safe Bearing Capacity

The soil is gravelly sand with less than 10% silt content. Hard rock layer was encountered at 7 m depth. The result of SPT is most accurate out of SPT, DCP and MP conducted at the site. DCP and MP was used to see if the ground has significant variations and SPT data are representation of whole site. Hence, we recommend using safe bearing capacity 150 kPa as the foundations are assumed to be isolated pad footings.

6.1.2 Electrical Resistivity

Error! Reference source not found. gives the ER values of each site. It is recommended to use 56 ohm-m, the ER value at 1.0 m for designing for grounding.

6.1.3 Thermal Conductivity

The recommended thermal conductivity value is 0.470 W/mK.

6.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Fuahmulah is located north of Maldives where peak ground acceleration value is between 0.12 and 0.32.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.32 for Fuahmulah, S_s is 0.729 and S_1 is 0.250.

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

Bowles, L. E. (1996). Foundation analysis and design, McGraw-hill.

Burland, J. B. and M. C. Burbidge (1985). "Settlement of foundations on sand and gravel." Proceedings of the institution of Civil Engineers 78(6): 1325-1381.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User's Manual for K-100 Models of KSE DCP. USA.

Liao, S. and R. Whitman (1986). "Overburden Correction Factors for SPT in Sand." Journal of Geotechnical Engineering 112: 373-377.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

Meyerhof, G. (1976). "Bearing capacity and settlement of pile foundations (11th Terzaghi Lecture)." Journal of the Geotechnical Engineering Division ASCE 102: 195-228.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

Robertson, P. and C. E. Wride (1997). "Cyclic liquefaction and its evaluation based on SPT and CPT. Proc. NCEER Work-shop on Evaluation of Liquefaction Resistance of Soils." Report NCEER-97-0022, National Center for Earthquake Engineering Research, SUNY Buffalo, NY.

Skempton, A. W. (1986). "Standard penetration test procedures and the effects in sands of overburden pressure, relative density, particle size, ageing and overconsolidation." Geotechnique 36(3): 425-447.

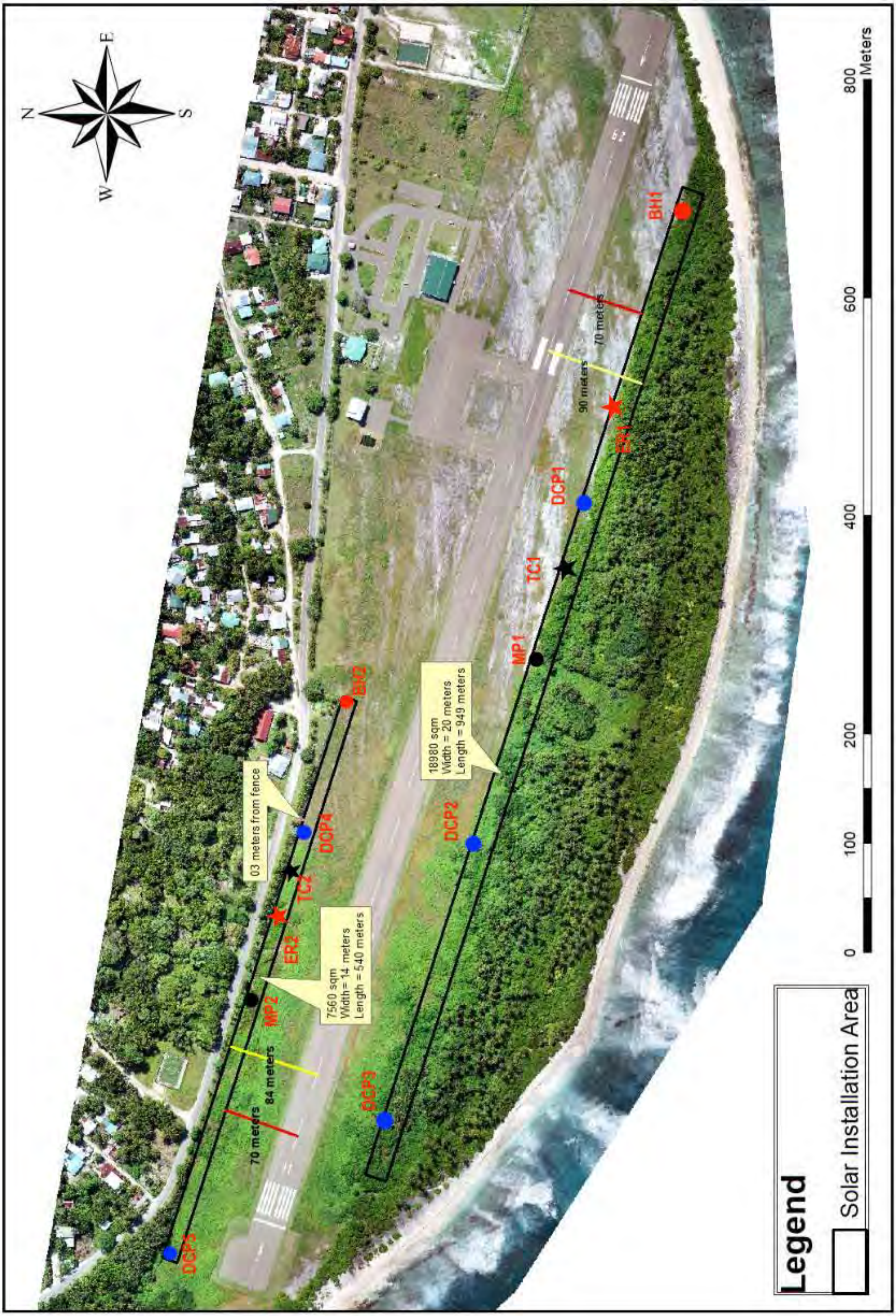
Terzaghi, K. and R. B. Peck (1967). Soil mechanics in engineering practice. New York, John Wiley & Sons, Inc.

UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES

APPENDIX 1: TEST LOCATIONS


N
E
S
W
BH1
70 meters
90 meters
ER1
DCP1
TC1
MP1
18980 sqm
Width = 20 meters
Length = 949 meters
BH2
03 meters from fence
DCP4
TC2
ER2
7560 sqm
Width = 14 meters
Length = 540 meters
MP2
DCP2
84 meters
70 meters
DCP3
DCP5
Legend
Solar Installation Area
0
100
200
400
600
800
Meters

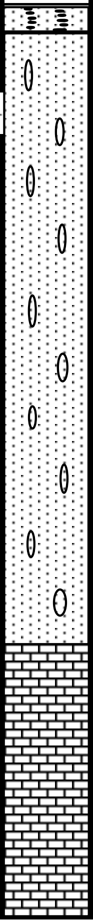
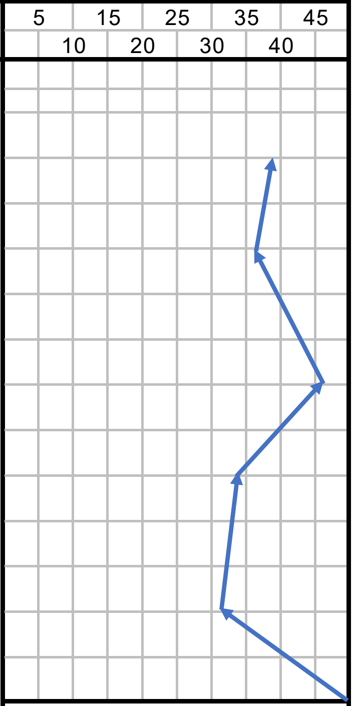
APPENDIX 2: BOREHOLE LOGS

sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - Fuahmulah Airport						
Project Number:	2023/HDEC/01			Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.2	Date	Started: 15/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	6		Completed 16/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Hulhumeedhoo STP		Backfilled: 16/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	 15 cm	 15 cm	 N	Corrected N (N1)$_{60}$	Graphical representation of corrected SPT N values
					Top soil						
1	SS	D1			Medium dense, off white fine sand with some gravel	9	10	12	22	39	
		D2	▼								
2	SS	D3				12	10	11	21	37	
3	CS	D4				13	13	13	26	46	
4	CS	D5									
						13	13	13	26	34	
5	CS	D5									
6						13	12	12	24	32	
7											
8					Weathered limestone rock						RQD=0%, CR=56%
9											RQD=25%, CR=79%
10											RQD=41%, CR=91%

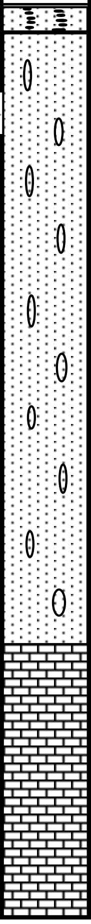
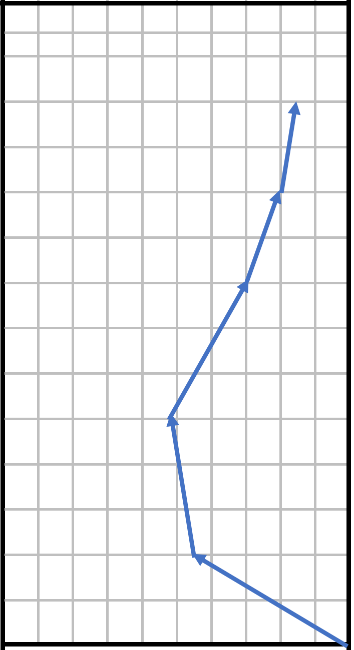
Notes

SPT	Standard Penetration Test	▼	Ground water level
N	SPT value		
N60	Corrected N value		
SS	SPT Spoon sample		
CS	Core sample		

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - Fuahmulah Airport						
Project Number:	2023/HDEC/01		Client:	HDEC		BH No.	2
Drill Rig type	Rotatary Drill		Drilling Contractor	SIDCO Pvt Ltd			
Drilling method	Rotatory						
Ground water depth (m)	1.2	Date Started:	17/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	6	Date Completed	17/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Hulhumeedhoo STP	Date Backfilled:	18/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)$_{60}$	Graphical representation of corrected SPT N values 5 15 25 35 45 10 20 30 40
					Top soil						
1	SS	D1			Medium dense, off white fine sand with some gravel	11	11	13	24	42	
		D2	▼								
2	SS					10	11	12	23	40	
		D3									
3	CS	D4				9	12	8	20	35	
4	CS	D5									
						9	9	9	18	24	
5	CS	D5									
6						11	9	11	20	27	
7											
8					Weathered limestone rock						No sample
9											RQD=0%, CR=41%
10											RQD=15%, CR=74%

Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample

▼ Ground water level

APPENDIX 3: DCP TEST RESULTS

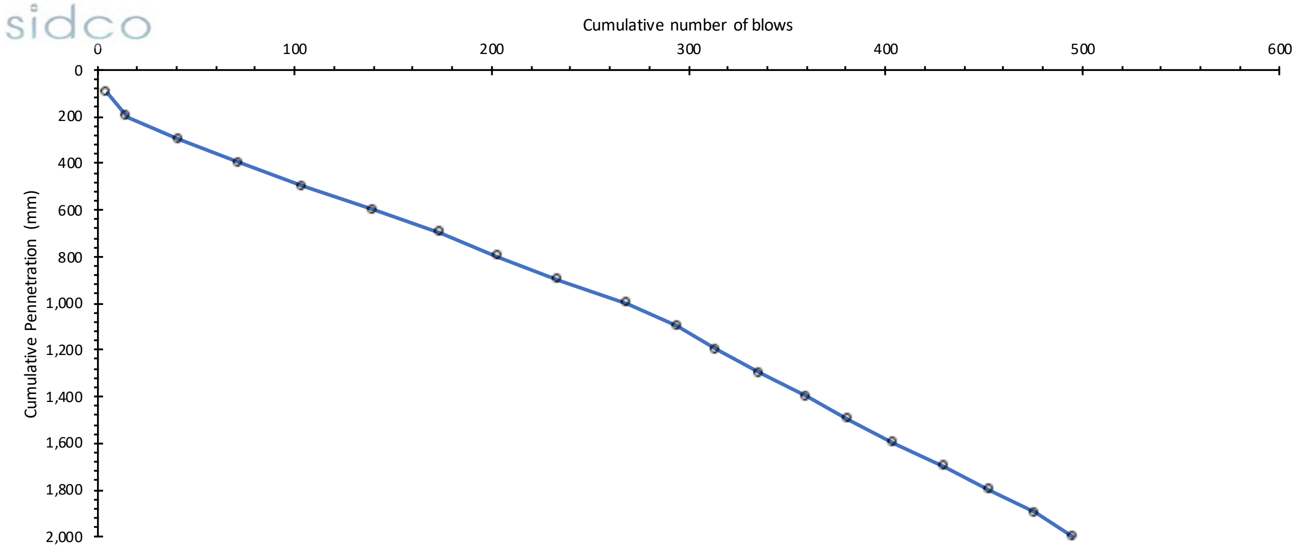
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Fuahmulah Airport**		**17/01/2023**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	10	15	10.0	22	205	82
200-300	26	41	3.8	65	416	167
300-400	31	72	3.2	79	475	190
400-500	32	104	3.1	81	486	194
500-600	36	140	2.8	93	530	212
600-700	34	174	2.9	87	508	203
700-800	29	203	3.4	73	452	181
800-900	31	234	3.2	79	475	190
900-1000	35	269	2.9	90	519	208
1000-1100	25	294	4.0	62	404	162
1100-1200	20	314	5.0	48	343	137
1200-1300	22	336	4.5	54	368	147
1300-1400	24	360	4.2	59	392	157
1400-1500	21	381	4.8	51	355	142
1500-1600	23	404	4.3	56	380	152
1600-1700	26	430	3.8	65	416	167
1700-1800	23	453	4.3	56	380	152
1800-1900	23	476	4.3	56	380	152
1900-2000	19	495	5.3	45	330	132



SIDCO SOILS LAB

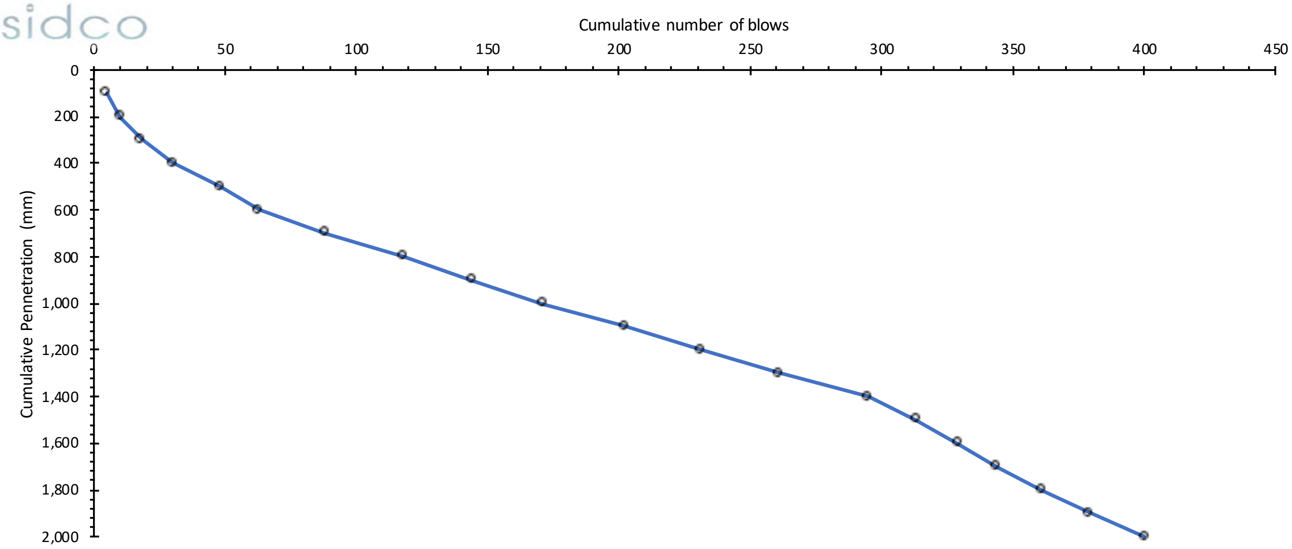
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Fuahmulah Airport**		**17/01/2023**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	5	10	20.0	10	122	49
200-300	8	18	12.5	17	173	69
300-400	12	30	8.3	27	234	94
400-500	18	48	5.6	43	317	127
500-600	15	63	6.7	35	277	111
600-700	25	88	4.0	62	404	162
700-800	30	118	3.3	76	463	185
800-900	26	144	3.8	65	416	167
900-1000	27	171	3.7	67	428	171
1000-1100	31	202	3.2	79	475	190
1100-1200	29	231	3.4	73	452	181
1200-1300	30	261	3.3	76	463	185
1300-1400	34	295	2.9	87	508	203
1400-1500	18	313	5.6	43	317	127
1500-1600	16	329	6.3	37	290	116
1600-1700	15	344	6.7	35	277	111
1700-1800	17	361	5.9	40	304	121
1800-1900	18	379	5.6	43	317	127
1900-2000	21	400	4.8	51	355	142

sidco



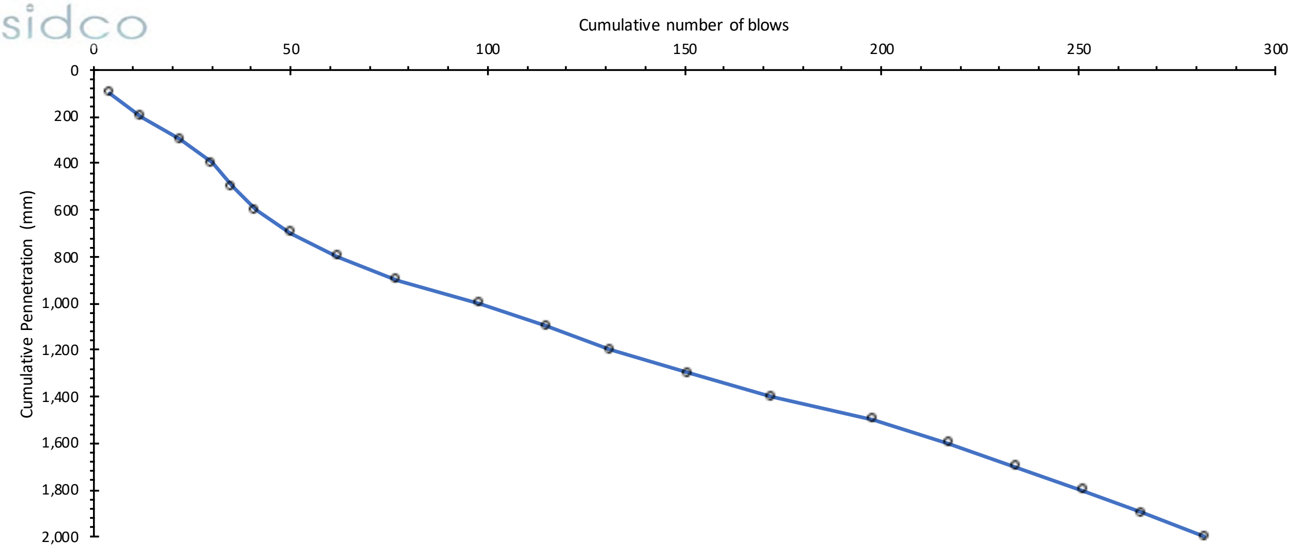
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Fuahmulah Airport**		**17/01/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	8	12	12.5	17	173	69
200-300	10	22	10.0	22	205	82
300-400	8	30	12.5	17	173	69
400-500	5	35	20.0	10	122	49
500-600	6	41	16.7	13	140	56
600-700	9	50	11.1	20	189	76
700-800	12	62	8.3	27	234	94
800-900	15	77	6.7	35	277	111
900-1000	21	98	4.8	51	355	142
1000-1100	17	115	5.9	40	304	121
1100-1200	16	131	6.3	37	290	116
1200-1300	20	151	5.0	48	343	137
1300-1400	21	172	4.8	51	355	142
1400-1500	26	198	3.8	65	416	167
1500-1600	19	217	5.3	45	330	132
1600-1700	17	234	5.9	40	304	121
1700-1800	17	251	5.9	40	304	121
1800-1900	15	266	6.7	35	277	111
1900-2000	16	282	6.3	37	290	116

sidco



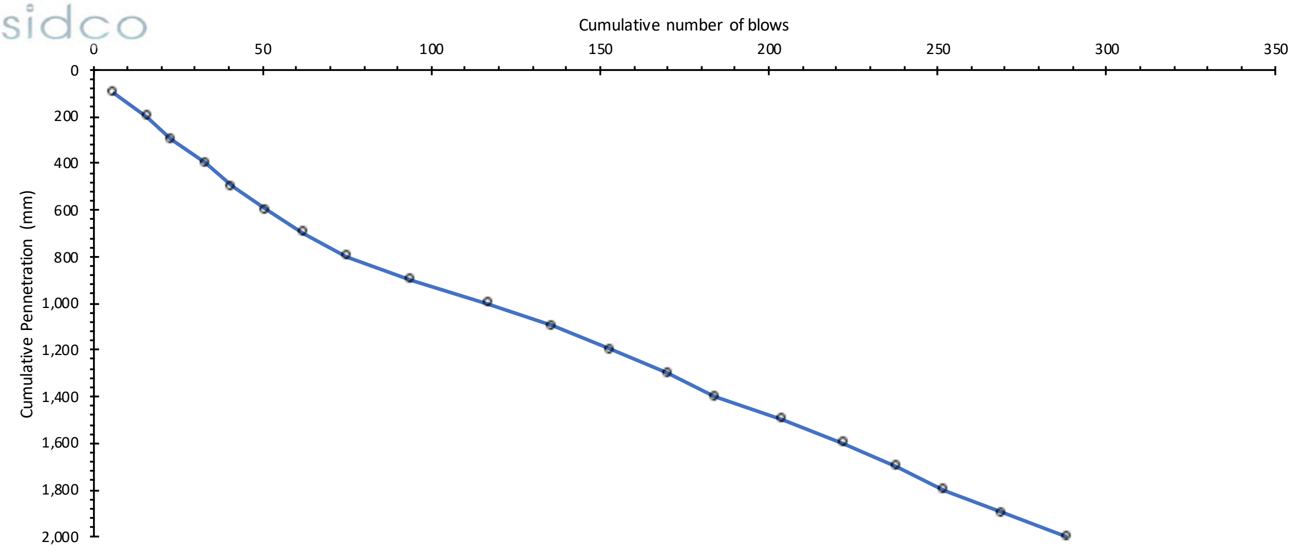
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Fuahmulah Airport**		**17/01/2023**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	10	16	10.0	22	205	82
200-300	7	23	14.3	15	157	63
300-400	10	33	10.0	22	205	82
400-500	8	41	12.5	17	173	69
500-600	10	51	10.0	22	205	82
600-700	11	62	9.1	25	220	88
700-800	13	75	7.7	30	249	99
800-900	19	94	5.3	45	330	132
900-1000	23	117	4.3	56	380	152
1000-1100	19	136	5.3	45	330	132
1100-1200	17	153	5.9	40	304	121
1200-1300	17	170	5.9	40	304	121
1300-1400	14	184	7.1	32	263	105
1400-1500	20	204	5.0	48	343	137
1500-1600	18	222	5.6	43	317	127
1600-1700	16	238	6.3	37	290	116
1700-1800	14	252	7.1	32	263	105
1800-1900	17	269	5.9	40	304	121
1900-2000	19	288	5.3	45	330	132



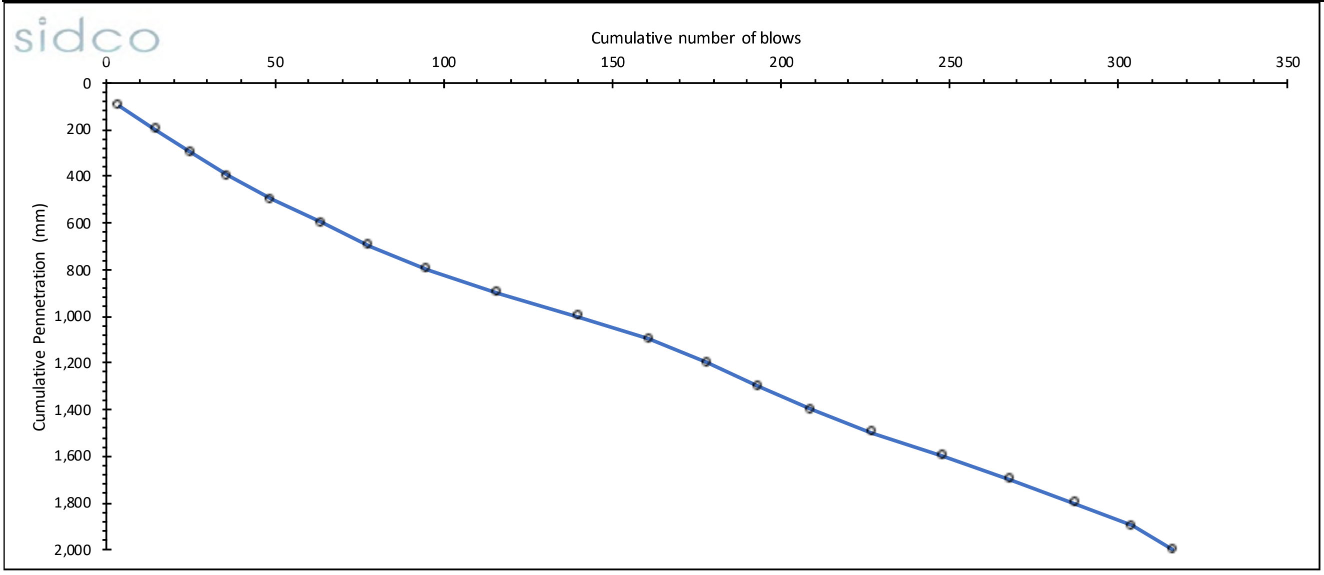
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Fuahmulah Airport**		**17/01/2023**		**DCP#**	**5**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	11	15	9.1	25	220	88
200-300	10	25	10.0	22	205	82
300-400	11	36	9.1	25	220	88
400-500	13	49	7.7	30	249	99
500-600	15	64	6.7	35	277	111
600-700	14	78	7.1	32	263	105
700-800	17	95	5.9	40	304	121
800-900	21	116	4.8	51	355	142
900-1000	24	140	4.2	59	392	157
1000-1100	21	161	4.8	51	355	142
1100-1200	17	178	5.9	40	304	121
1200-1300	15	193	6.7	35	277	111
1300-1400	16	209	6.3	37	290	116
1400-1500	18	227	5.6	43	317	127
1500-1600	21	248	4.8	51	355	142
1600-1700	20	268	5.0	48	343	137
1700-1800	19	287	5.3	45	330	132
1800-1900	17	304	5.9	40	304	121
1900-2000	12	316	8.3	27	234	94



APPENDIX 4: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

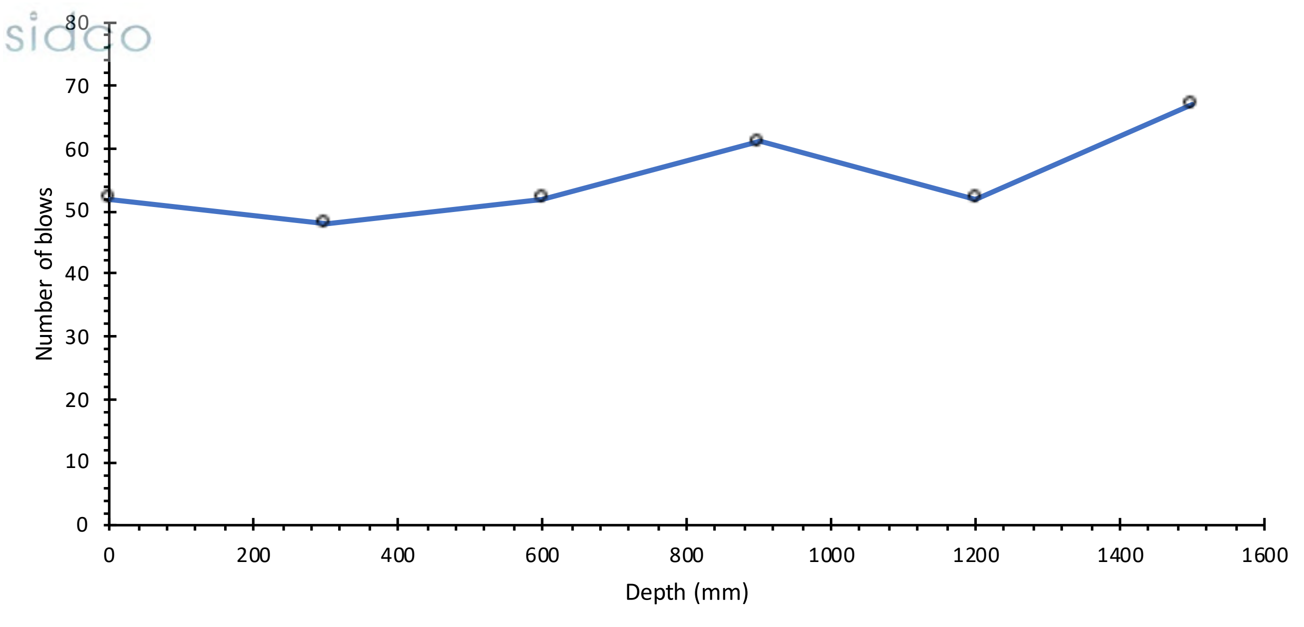
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Fuahmulah**	**Date:**	**17/01/2023**	**MP#**	**1**

Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Safe Bearing Capacity kPa**
0-300	52	52	228	91
300-600	48	100	211	85
600-900	52	152	228	91
900-1200	61	213	258	103
1200-1500	52	265	228	91
1500-1800	67	332	274	110
1800-2100	123	455	377	151
2100-2400	>400 blows. Hitting hard strata at 2.1 m			
2400-2700				
2700-3000				
3000-3300				
3300-3600				
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



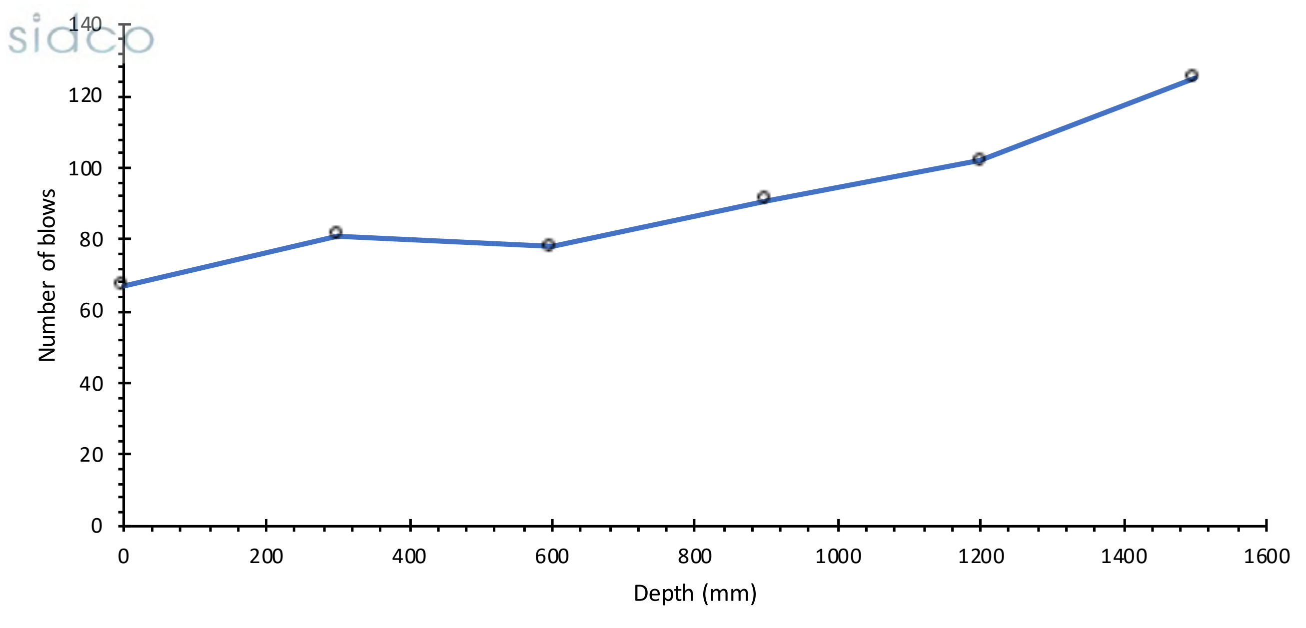
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Fuahmulah**	**Date:**	**17/01/2023**	**MP#**	**2**
Depth (mm)		**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Safe Bearing Capacity kPa**
0-300		67	67	274	110
300-600		81	148	306	122
600-900		78	226	299	120
900-1200		91	317	325	130
1200-1500		102	419	344	138
1500-1800		125	544	380	152
1800-2100		165	709	431	173
2100-2400		202	911	472	189
2400-2700		>400 blows. Hitting hard strata at 2.4 m			
2700-3000					
3000-3300					
3300-3600					
3600-3900					
3900-4200					
4200-4500					
4500-4800					
4800-5100					
5100-5400					
5400-5700					
5700-6000					



APPENDIX 5: RESULTS OF PARTICLE SIZE DISTRIBUTION

Maldives Engineering Research Laboratories

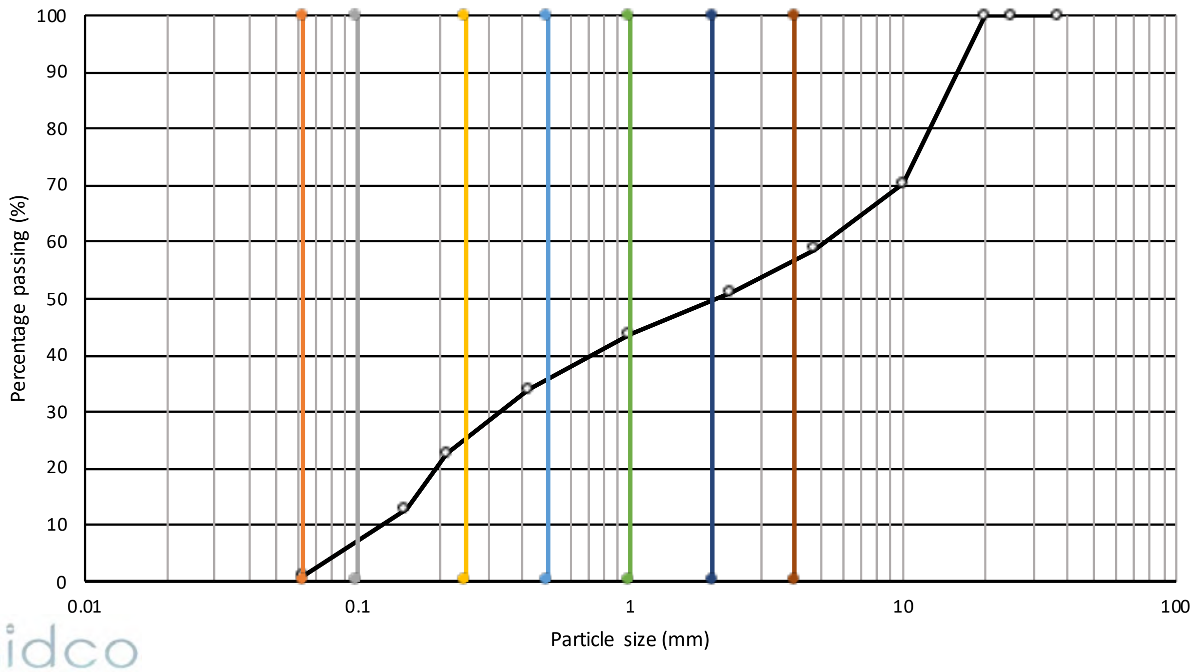
H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Fuvahmulah			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	1m		**Test #**	**BH-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	234.6	100.0
2	**25**	0.0	0.0	0.0	234.6	100.0
3	**20**	0.0	0.0	0.0	234.6	100.0
4	**10**	70.0	70.0	29.9	164.5	70.1
5	**4.75**	26.8	96.9	41.3	137.7	58.7
8	**2.36**	18.0	114.8	49.0	119.7	51.0
16	**1**	17.2	132.0	56.3	102.6	43.7
30	**0.425**	23.2	155.2	66.2	79.3	33.8
50	**0.212**	26.7	181.9	77.5	52.7	22.5
100	**0.15**	22.8	204.7	87.2	29.9	12.8
200	**0.063**	27.6	232.3	99.0	2.3	1.0
Total weight sieved through #200				2.30		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				235	Error (%)	
Remarks						
C_u= 4.3375 C_c=0.7292						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.0%	5.0%	18.5%	10.6%	8.6%	5.4%	50.9%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

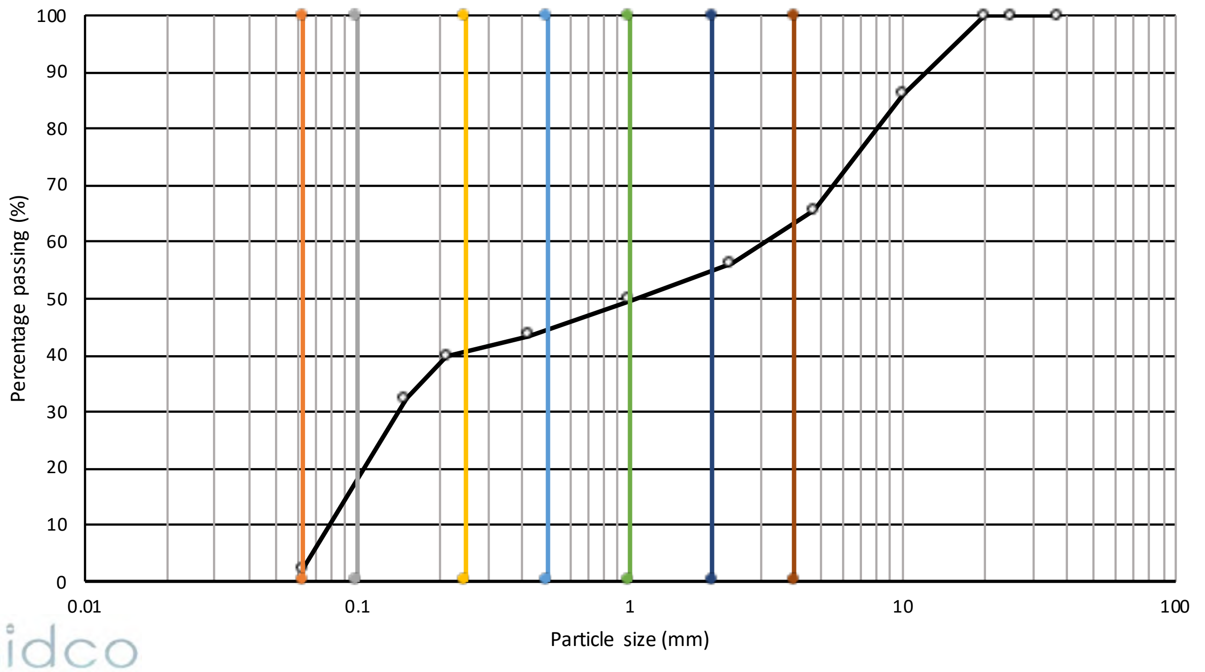
Project:	Fuvahmulah		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	2m	**Test #**	**BH-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	318.5	100.0
2	**25**	0.0	0.0	0.0	318.5	100.0
3	**20**	0.0	0.0	0.0	318.5	100.0
4	**10**	44.7	44.7	14.0	273.8	86.0
5	**4.75**	65.1	109.9	34.5	208.7	65.5
8	**2.36**	29.8	139.7	43.9	178.9	56.1
16	**1**	20.9	160.6	50.4	158.0	49.6
30	**0.425**	19.6	180.1	56.5	138.4	43.5
50	**0.212**	12.1	192.2	60.3	126.3	39.7
100	**0.15**	23.5	215.8	67.7	102.8	32.3
200	**0.063**	95.6	311.4	97.7	7.2	2.3
Total weight sieved through #200				7.19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				319	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.3%	12.8%	25.3%	3.9%	5.3%	4.8%	45.6%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Fuvahmulah		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	3 m	**Test #**	**BH-1**

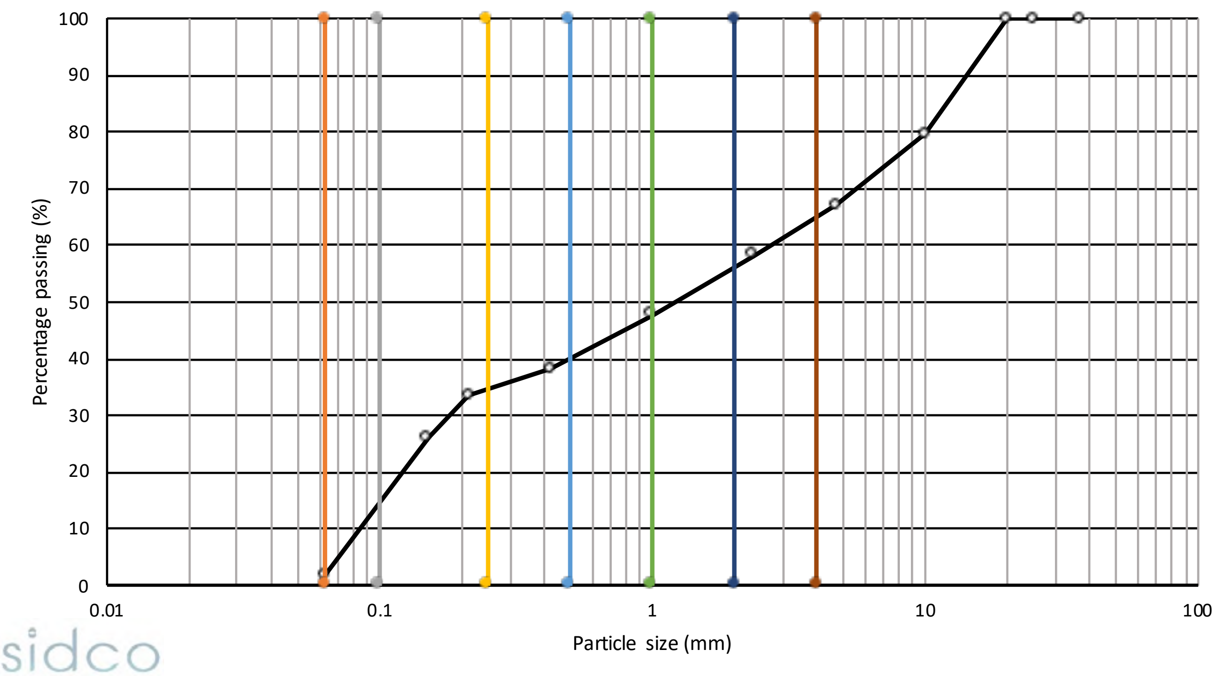
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	266.2	100.0
2	**25**	0.0	0.0	0.0	266.2	100.0
3	**20**	0.0	0.0	0.0	266.2	100.0
4	**10**	54.1	54.1	20.3	212.1	79.7
5	**4.75**	33.6	87.7	32.9	178.5	67.1
8	**2.36**	23.2	110.9	41.7	155.3	58.3
16	**1**	28.2	139.1	52.3	127.1	47.7
30	**0.425**	25.3	164.4	61.8	101.8	38.2
50	**0.212**	12.7	177.1	66.5	89.1	33.5
100	**0.15**	20.0	197.1	74.0	69.1	26.0
200	**0.063**	64.2	261.3	98.2	4.9	1.8
Total weight sieved through #200				4.90		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				266	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.8%	10.3%	22.2%	5.2%	8.2%	7.8%	44.5%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Fuvahmulah			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	4.5 m		**Test #**	**BH-1**

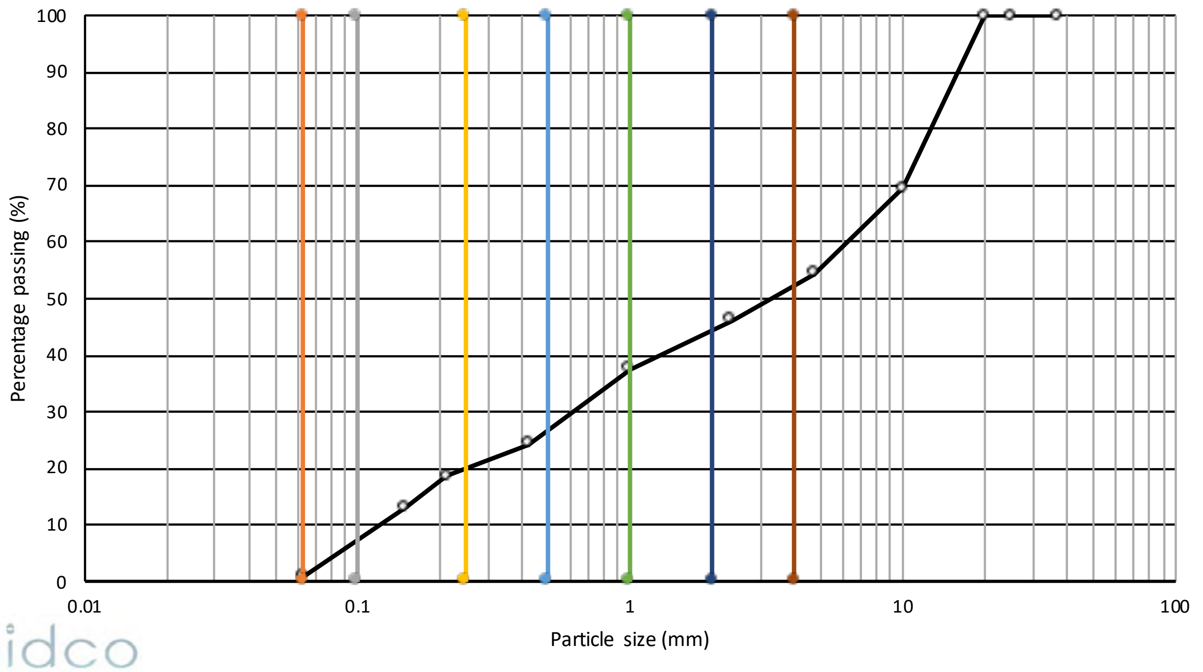
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	274.1	100.0
2	**25**	0.0	0.0	0.0	274.1	100.0
3	**20**	0.0	0.0	0.0	274.1	100.0
4	**10**	83.8	83.8	30.6	190.3	69.4
5	**4.75**	41.2	125.0	45.6	149.0	54.4
8	**2.36**	22.3	147.3	53.8	126.7	46.2
16	**1**	23.8	171.1	62.4	103.0	37.6
30	**0.425**	36.5	207.6	75.7	66.5	24.3
50	**0.212**	15.5	223.0	81.4	51.0	18.6
100	**0.15**	15.0	238.1	86.9	36.0	13.1
200	**0.063**	33.7	271.8	99.2	2.3	0.8
Total weight sieved through #200				2.27		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				274	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.8%	5.2%	13.6%	6.4%	11.6%	6.4%	56.1%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

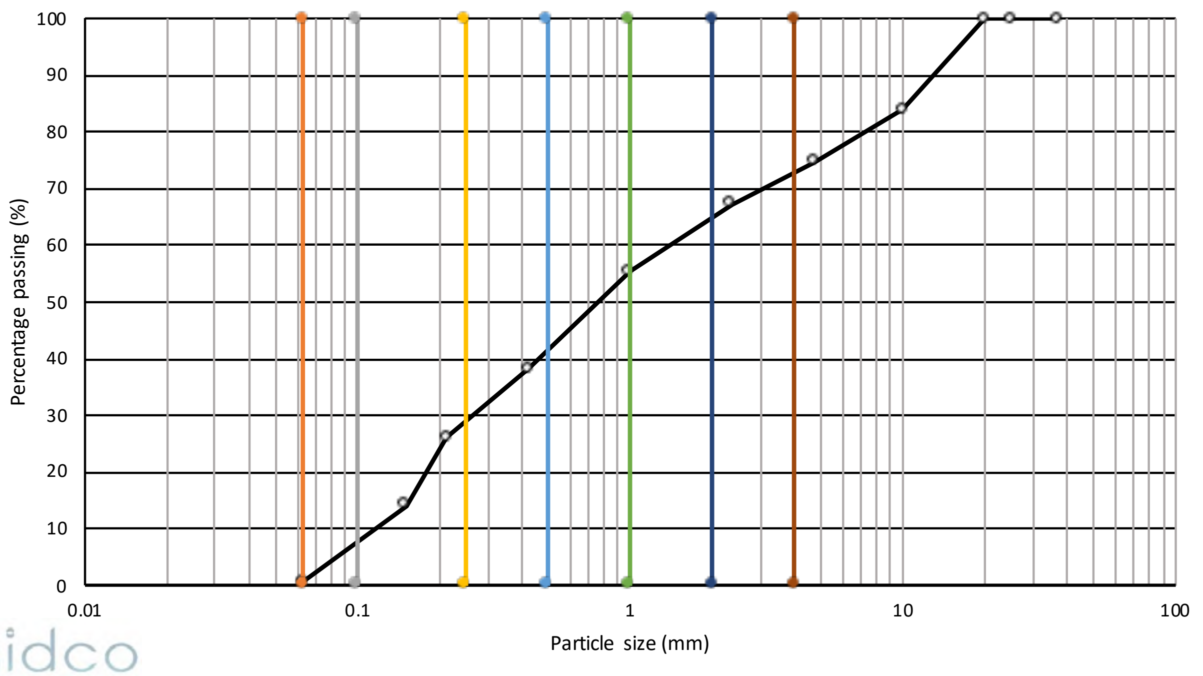
Project:	Fuvahmulah		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	1m	**Test #**	**BH-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	175.2	100.0
2	**25**	0.0	0.0	0.0	175.2	100.0
3	**20**	0.0	0.0	0.0	175.2	100.0
4	**10**	28.2	28.2	16.1	146.9	83.9
5	**4.75**	16.0	44.2	25.2	130.9	74.8
8	**2.36**	13.2	57.4	32.8	117.8	67.2
16	**1**	20.8	78.2	44.7	96.9	55.3
30	**0.425**	30.1	108.3	61.8	66.8	38.2
50	**0.212**	21.2	129.5	73.9	45.7	26.1
100	**0.15**	20.8	150.3	85.8	24.9	14.2
200	**0.063**	23.7	174.0	99.3	1.2	0.7
Total weight sieved through #200				1.20		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				175	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.7%	5.8%	21.8%	12.2%	14.9%	8.7%	35.9%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

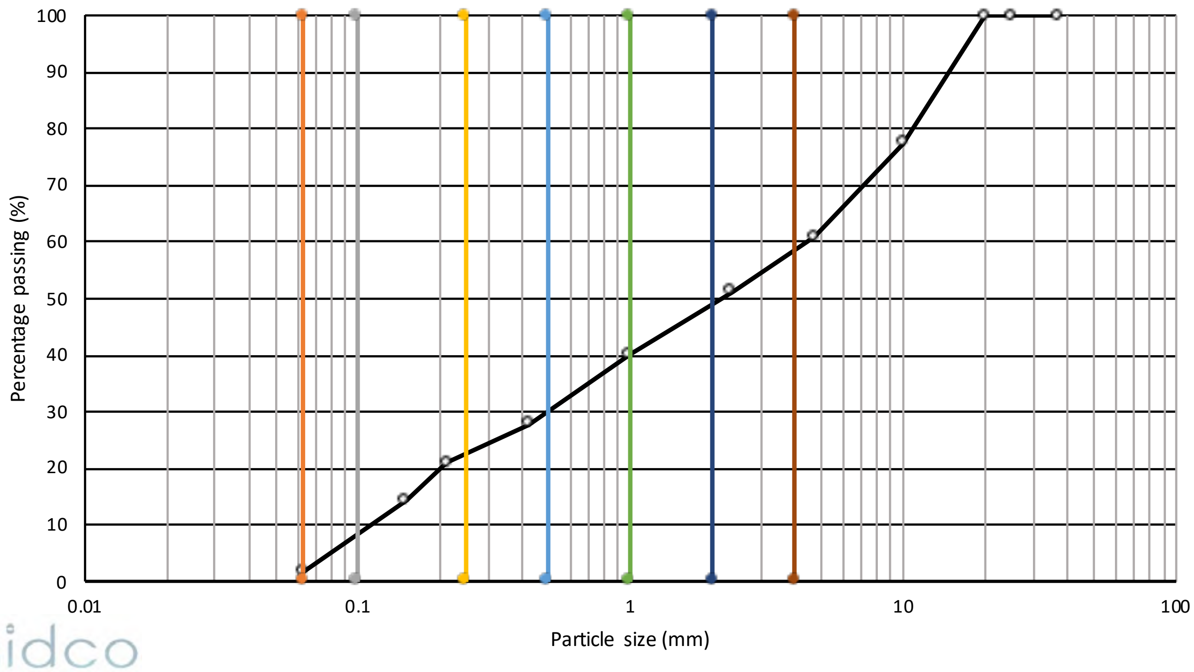
Project:	Fuvahmulah		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	2m	**Test #**	**BH-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	325.9	100.0
2	**25**	0.0	0.0	0.0	325.9	100.0
3	**20**	0.0	0.0	0.0	325.9	100.0
4	**10**	73.3	73.3	22.5	252.6	77.5
5	**4.75**	54.3	127.6	39.1	198.3	60.9
8	**2.36**	31.3	158.9	48.8	167.0	51.2
16	**1**	36.1	195.0	59.8	130.9	40.2
30	**0.425**	40.2	235.2	72.2	90.7	27.8
50	**0.212**	22.2	257.5	79.0	68.4	21.0
100	**0.15**	22.1	279.6	85.8	46.3	14.2
200	**0.063**	40.8	320.3	98.3	5.6	1.7
Total weight sieved through #200				5.56		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				326	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.7%	5.3%	15.2%	7.2%	10.7%	8.2%	51.7%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Fuvahmulah		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	3 m	**Test #**	**BH-2**

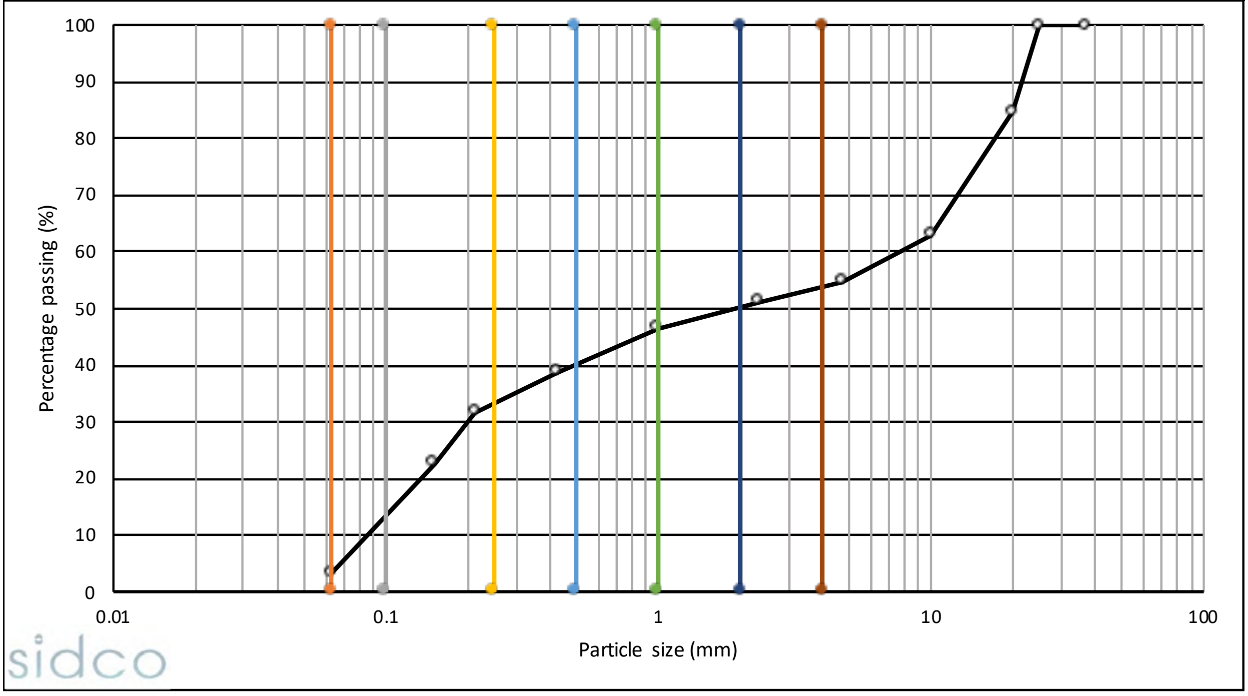
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0.0	0.0	0.0	243.3	100.0
2	**25**	0.0	0.0	0.0	243.3	100.0
3	**20**	37.6	37.6	15.4	205.8	84.6
4	**10**	52.6	90.1	37.0	153.2	63.0
5	**4.75**	19.7	109.9	45.2	133.4	54.8
8	**2.36**	8.6	118.4	48.7	124.9	51.3
16	**1**	11.4	129.8	53.3	113.5	46.7
30	**0.425**	19.5	149.3	61.3	94.0	38.7
50	**0.212**	16.8	166.0	68.2	77.3	31.8
100	**0.15**	22.0	188.0	77.3	55.3	22.7
200	**0.063**	47.3	235.3	96.7	8.0	3.3
Total weight sieved through #200				8.00		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				243	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.3%	8.3%	21.4%	6.7%	7.0%	3.4%	49.9%

APPENDIX 6: PROCTOR TEST RESULT

Maldives Engineering Research Laboratories

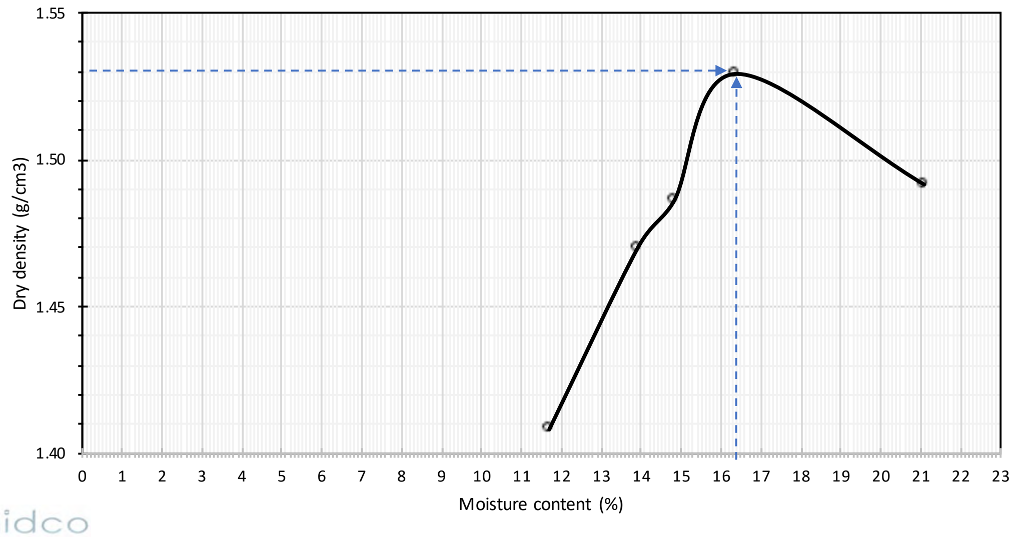
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Proctor Test Data Sheet

Location:	**Fuahmulah**	**Date:**	**14.03.2023**	**Proctor Test No:**	**1**

Soil sample	=	2.5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3448.4	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.67	
Water dennsity, γw	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	5021.40	5123.00	5154.80	5227.50	5254.50
weight of compacted soil, w2-w1 (g)	1573.00	1674.60	1706.40	1779.10	1806.10
Wet density, γb = ((w2-w1)/v), g/cm3	1.57	1.67	1.71	1.78	1.81
Dry density, γd = (γb/(1+(w/100))), g/cm3	**1.41**	**1.47**	**1.49**	**1.53**	**1.49**
Void Ratio e = ((Gsγw)/γd-1	1.90	1.82	1.80	1.75	1.79
Moisture content					
Weight of container, g	2.885	2.885	2.885	2.885	2.885
Weight of container + wet soil, g	25.515	27.485	32.275	28.190	36.2
Wet container + dry soil, g	23.145	24.480	28.480	24.635	30.37
Weight of moisture, ww (g)	2.370	3.005	3.795	3.555	5.79
Weight of dry soil, ws (g)	20.260	21.595	25.595	21.750	27.48
Water content, w= ((ww/ws)x100), %	**11.70**	**13.92**	**14.83**	**16.34**	**21.09**



APPENDIX 7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

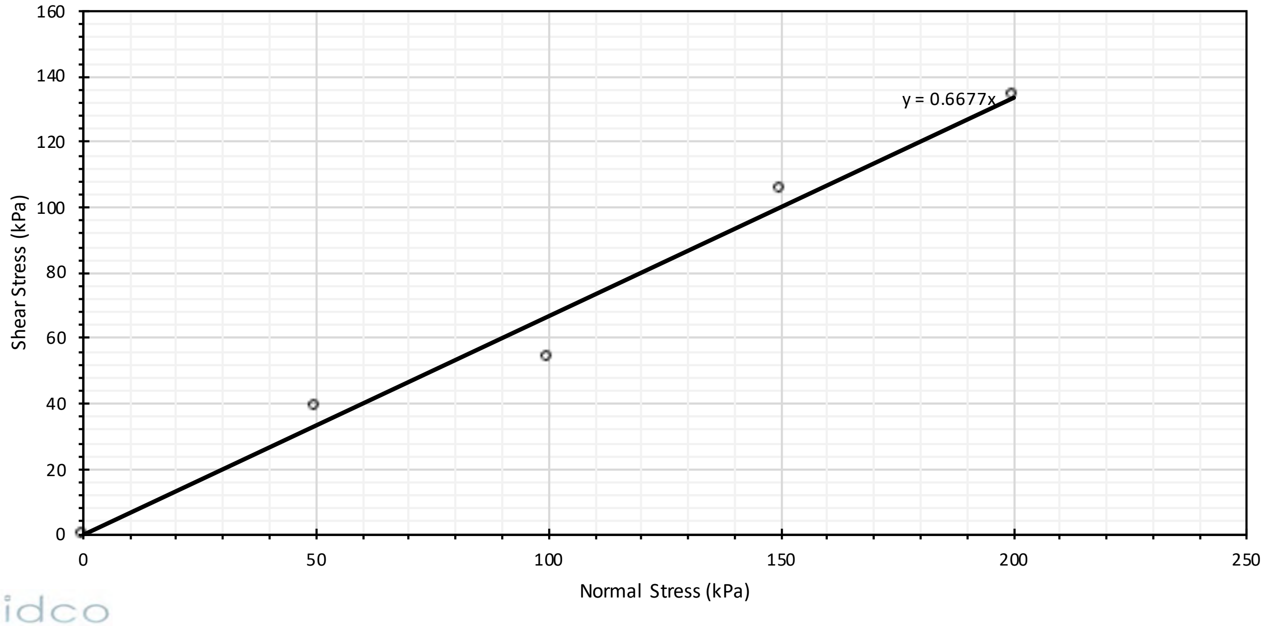
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**S. Hulhumeedhoo**	**Date:**	**24/02/2023**	**Direct Shear**	**1**

Moisture content (%)	10.10%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	33	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	38.90
100.00	54.20
150.00	105.70
200.00	134.30



APPENDIX 8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**Fuahmulah**	**Date:**	**04/03/2022**
TEST 1			
Mass of dnesity bottle	W1	35.02	g
Mass of bottle + dry sand	W2	87.21	g
Mass of bottle + dry sand + water	W3	163.23	g
Mass of bottle + water	W4	130.93	g
Specific Gravity	Gs	2.62	

TEST 2

Mass of dnesity bottle	W1	31.02	g
Mass of bottle + dry sand	W2	58.09	g
Mass of bottle + dry sand + water	W3	163.23	g
Mass of bottle + water	W4	146.64	g
Specific Gravity	Gs	2.58	

Avarege Gs		2.60	

APPENDIX 9: SOIL RESITIVITY SURVEY RESULT

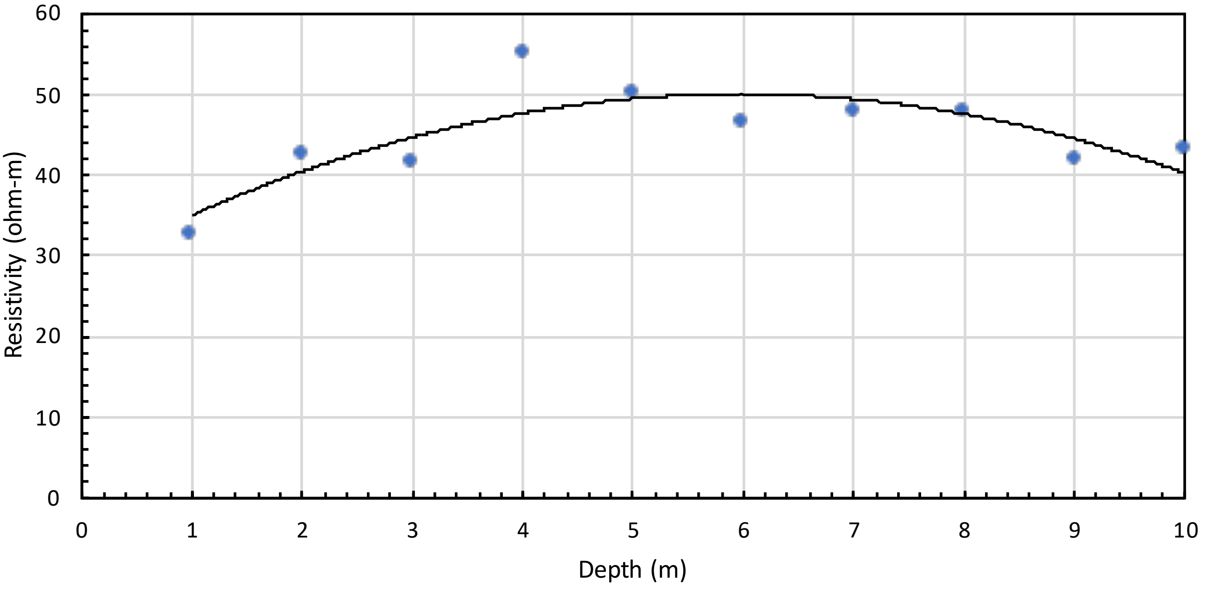
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	5.20	33
2	2	3.40	43
3	3	2.20	41
4	4	2.20	55
5	5	1.60	50
6	6	1.23	46
7	7	1.09	48
8	8	0.95	48
9	9	0.74	42
10	10	0.69	43

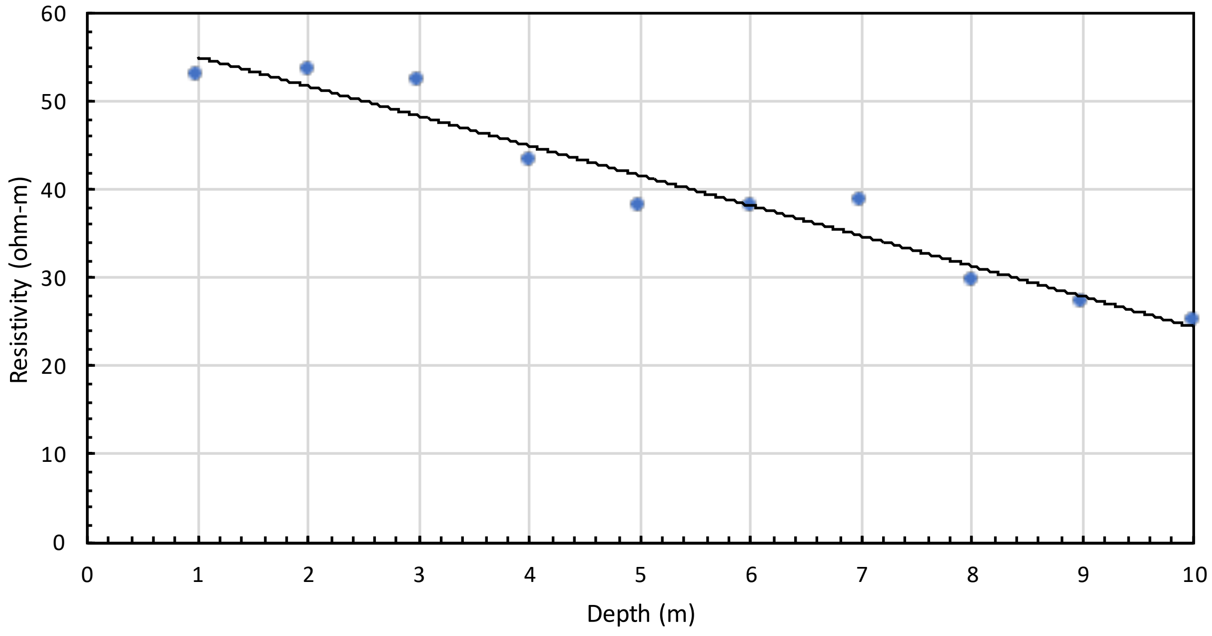


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

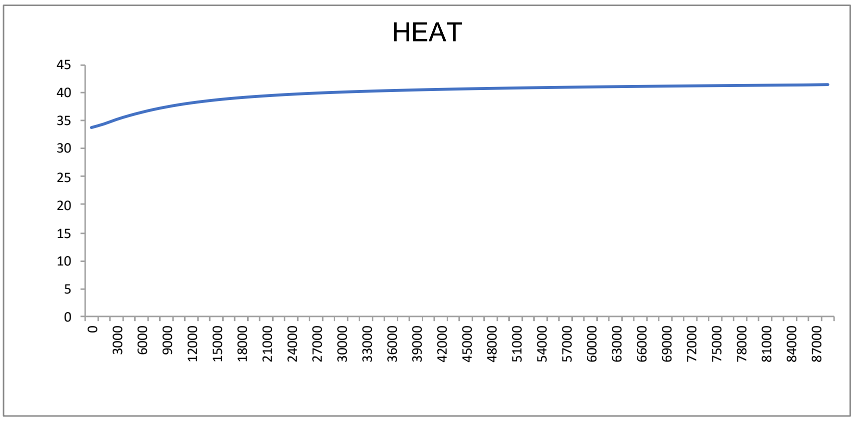
TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	8.43	53
2	2	4.26	54
3	3	2.77	52
4	4	1.72	43
5	5	1.21	38
6	6	1.01	38
7	7	0.88	39
8	8	0.59	30
9	9	0.48	27
10	10	0.40	25

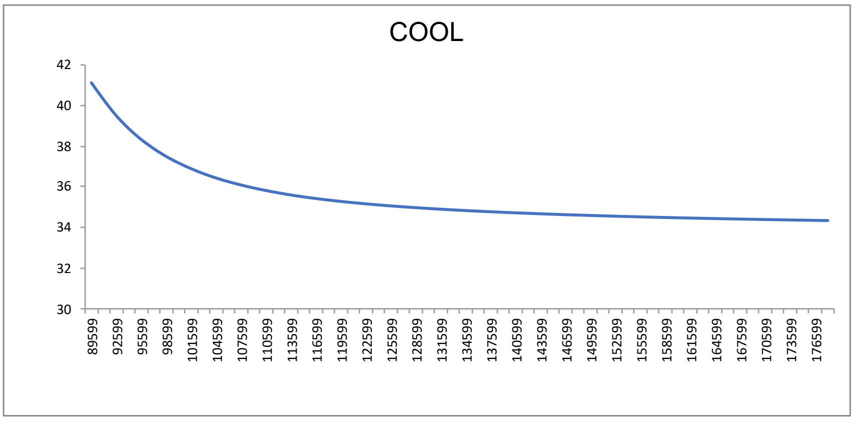


APPENDIX 10: THERMAL CONDUCTIVITY TEST RESULTS

TEST 1

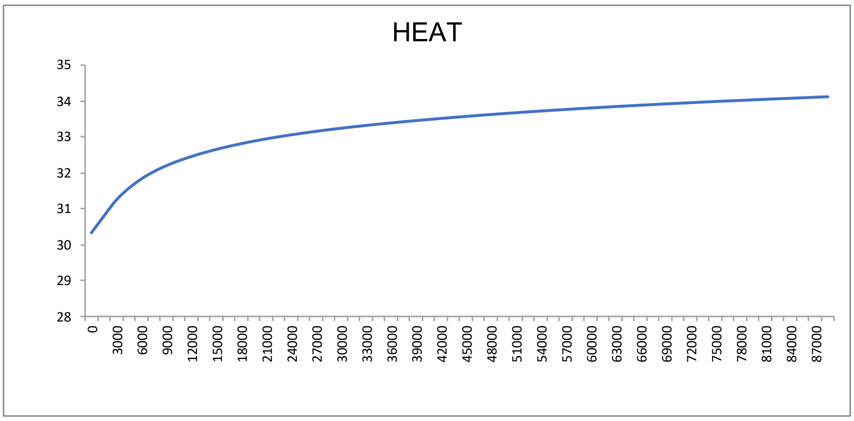
HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	33.824333		89599	41.12112
1500	34.465382		91099	40.271645
3000	35.264202		92599	39.49683
4500	35.947998		94099	38.861649
6000	36.539928		95599	38.326183
7500	37.067486		97099	37.878586
9000	37.512848		98599	37.493282
10500	37.905952		100099	37.171741
12000	38.239334		101599	36.891037
13500	38.525112		103099	36.64621
15000	38.779942		104599	36.433739
16500	39.000519		106099	36.250908
18000	39.193161		107599	36.089462
19500	39.362953		109099	35.945694
21000	39.514103		110599	35.817303
22500	39.653091		112099	35.702648
24000	39.777996		113599	35.598492
25500	39.891354		115099	35.505871
27000	39.99379		116599	35.424057
28500	40.087421		118099	35.349712
30000	40.171638		119599	35.282162
31500	40.249943		121099	35.220367
33000	40.32198		122599	35.163055
34500	40.388618		124099	35.110874
36000	40.45076		125599	35.062115
37500	40.508717		127099	35.017731
39000	40.564922		128599	34.975548
40500	40.61734		130099	34.93626
42000	40.666328		131599	34.899609
43500	40.713478		133099	34.865051
45000	40.757278		134599	34.833202
46500	40.798584		136099	34.802658
48000	40.838516		137599	34.774117
49500	40.875751		139099	34.747063
51000	40.911469		140599	34.720966
52500	40.945957		142099	34.697289
54000	40.97839		143599	34.673748
55500	41.010162		145099	34.651741
57000	41.040749		146599	34.630276
58500	41.06945		148099	34.61071
60000	41.097206		149599	34.591206
61500	41.12471		151099	34.572929
63000	41.150211		152599	34.555325
64500	41.175236		154099	34.5383
66000	41.199322		155599	34.522018
67500	41.22237		157099	34.50576
69000	41.245274		158599	34.491688
70500	41.266109		160099	34.477829
72000	41.288322		161599	34.464249
73500	41.308887		163099	34.451077
75000	41.32851		164599	34.438694
76500	41.348862		166099	34.426491
78000	41.367805		167599	34.414776
79500	41.385494		169099	34.40316
81000	41.403633		170599	34.391445
82500	41.421028		172099	34.381256
84000	41.437504		173599	34.37056
85500	41.453926		175099	34.360641
87000	41.485275		176599	34.350887
88500	41.522568		178099	34.3409

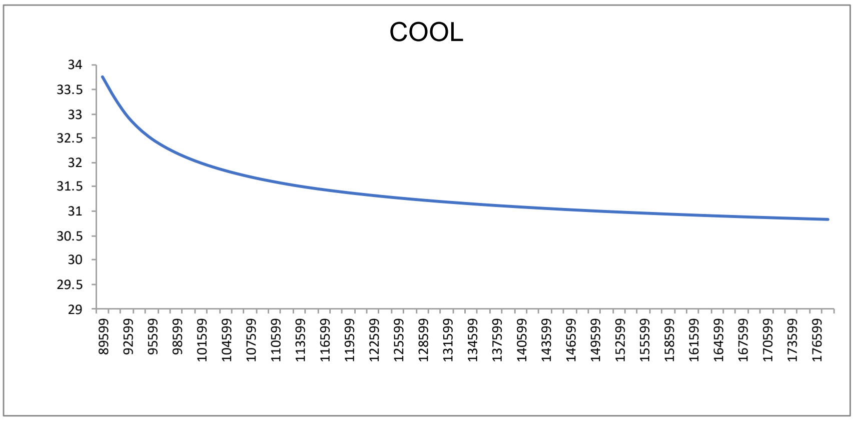




TEST 2

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	30.329575		89599	33.756737
1500	30.794252		91099	33.319901
3000	31.243679		92599	32.956402
4500	31.571518		94099	32.690647
6000	31.830254		95599	32.486359
7500	32.033745		97099	32.327892
9000	32.198372		98599	32.196655
10500	32.336246		100099	32.08569
12000	32.453903		101599	31.989929
13500	32.55864		103099	31.906399
15000	32.65237		104599	31.832325
16500	32.736382		106099	31.765923
18000	32.812435		107599	31.705784
19500	32.881981		109099	31.65123
21000	32.945663		110599	31.602421
22500	33.004128		112099	31.556202
24000	33.058552		113599	31.51442
25500	33.108898		115099	31.476538
27000	33.156425		116599	31.441776
28500	33.200813		118099	31.409567
30000	33.242897		119599	31.378912
31500	33.282776		121099	31.350657
33000	33.319962		122599	31.323416
34500	33.356358		124099	31.297653
36000	33.390614		125599	31.273394
37500	33.423565		127099	31.250599
39000	33.454823		128599	31.228981
40500	33.48505		130099	31.20808
42000	33.514885		131599	31.188345
43500	33.543694		133099	31.170052
45000	33.571747		134599	31.151615
46500	33.599308		136099	31.134125
48000	33.625347		137599	31.117592
49500	33.64999		139099	31.101995
51000	33.674435		140599	31.086824
52500	33.698887		142099	31.072176
54000	33.721497		143599	31.058035
55500	33.744183		145099	31.044531
57000	33.765427		146599	31.030964
58500	33.786976		148099	31.018679
60000	33.80687		149599	31.006109
61500	33.826958		151099	30.994265
63000	33.846535		152599	30.983356
64500	33.865913		154099	30.971954
66000	33.884598		155599	30.961603
67500	33.902306		157099	30.951342
69000	33.920391		158599	30.941034
70500	33.937191		160099	30.931311
72000	33.954155		161599	30.921709
73500	33.97097		163099	30.91246
75000	33.987255		164599	30.903561
76500	34.003193		166099	30.894766
78000	34.018089		167599	30.886194
79500	34.033867		169099	30.877892
81000	34.048717		170599	30.870434
82500	34.063721		172099	30.862091
84000	34.077351		173599	30.854788
85500	34.091515		175099	30.847002
87000	34.106133		176599	30.839596
88500	34.119469		178099	30.832424





APPENDIX 11: WATER QUALITY TEST REPORT

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT
Report No: 500195059

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Male K

Report date: **21/02/2023**
Test Requisition Form No: **900196881**
Sample(s) Recieved Date: **20/02/2023**
Date of Analysis: **20/02/2023 - 20/02/2023**

Sample Description ~	Gn.Fuvahmulah 1	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83236578		
Sampled Date ~	01/01/2023 04:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	501	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	8.2	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	250	Electrometry	mg/L
Chloride	56	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	1.3	HACH Method 8171	mg/L
Sulphate *	<10 (LoQ 10 mg/L)	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: **µS/cm** : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by
Aminath Sofa
Senior Laboratory Executive

Approved by
Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

sidco

MARCH 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
Lh. Hinnavaru

CLIENT

HDEC

中国电建
POWERCHINA

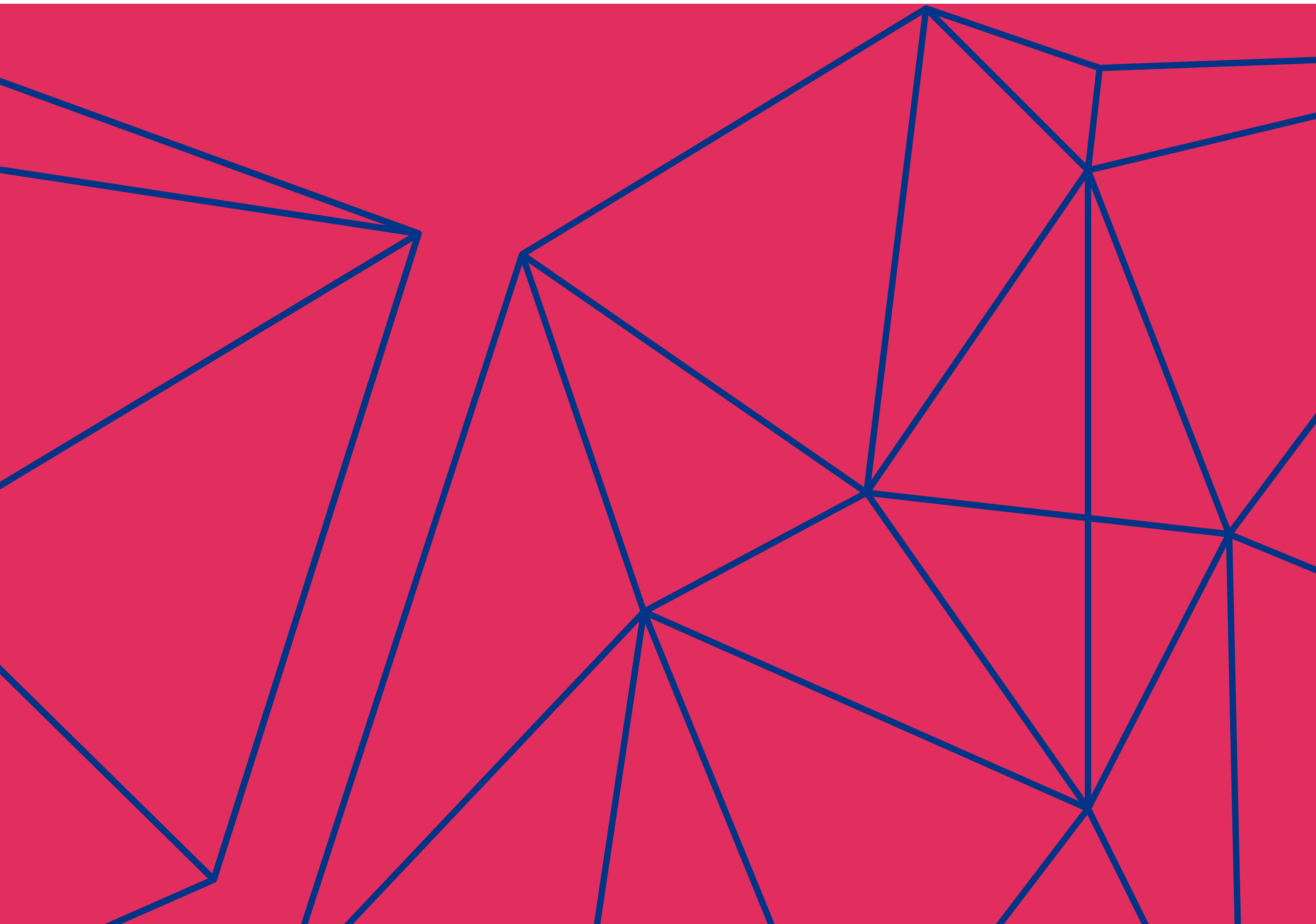


Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out on 21st and 22nd January 2023 in Lh. Hinnavaru for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Dynamic Cone Penetration (DCP) tests
2. Mackintosh Probe
3. Trial Pits
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
2. BS EN ISO 17892-4:2016 Determination of particle size distribution
3. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
4. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

Lh. Hinnavaru is located 146 km north of Male' at approximately 73° 24' 46"E and 05° 29' 35" N. The geographic land area of the island is 55 hectares. The length of the island measures length 1.162 km and about 0.584 km wide. The population of the Island is 4873.[1]

Figure 1: Location of Lh, Hinnavaru (www.isles.gov.mv)

The island was originally only 22 ha, but 33 ha land was added to the west side of the island through reclamation.

The proposed solar PV installation is to be carried out on reclaimed area.

---

[1] https://www.isles.gov.mv/Island/DetailsEn/971

Figure 2: Satellite image of Hinnavaru in 2023 (google maps)

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed roads for development have a flat terrain and the ground elevation is between 1 and 1.5 meters.

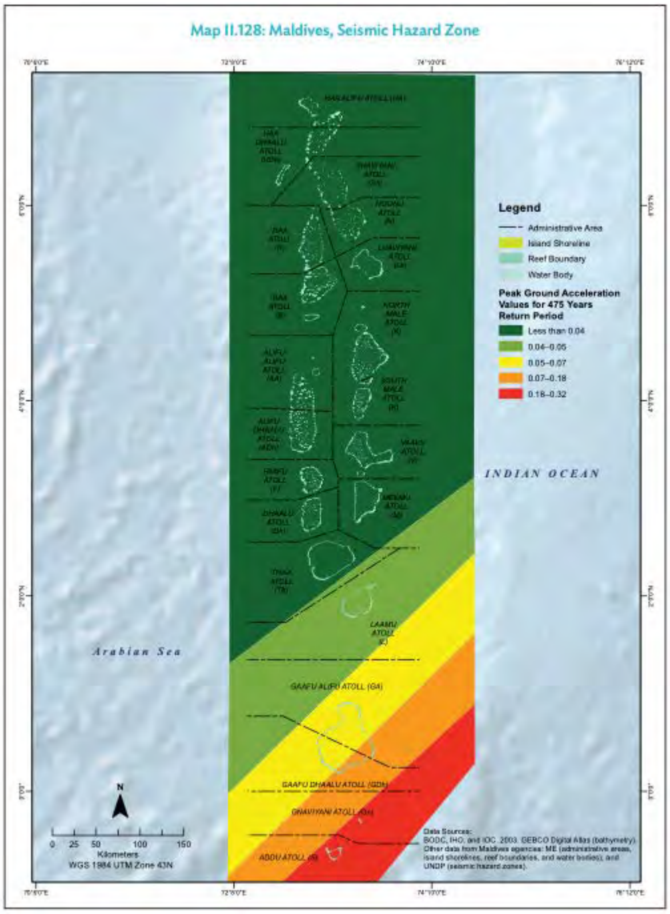
Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

In Hinnnavaru, the eastern side of the island has been modified by construction of a local harbour, and western side by reclamation of 33 ha of land.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP 2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.



Data Sources:
BODC, IHO, and IOC. 2003. GEBCO Digital Atlas (bathymetry).
Other data from Maldives agencies: ME (administrative areas, island shorelines, reef boundaries, and water bodies); and UNDP (seismic hazard zones).

Figure 3: Seismic Hazard Zone (ADB 2020)

Hinnavaru is located north of Maldives where peak ground acceleration value for 475 years return period is less than 0.04.

2.4 RAINFALL

Rainfall data and other meteorological data are not available for Hinnavaru. The closest weather centre is located at Hulhule' (located at 4.1875º N and 73.5292º E) and are available and is representative of the weather conditions of northern part of Maldives.

Hulhulé rainfall data shows a periodic pattern and annual precipitation varies from year to year with an average rainfall of 2003.3 mm and ranging between 1407.0 mm and 2711.2 mm (Zahid 2011).

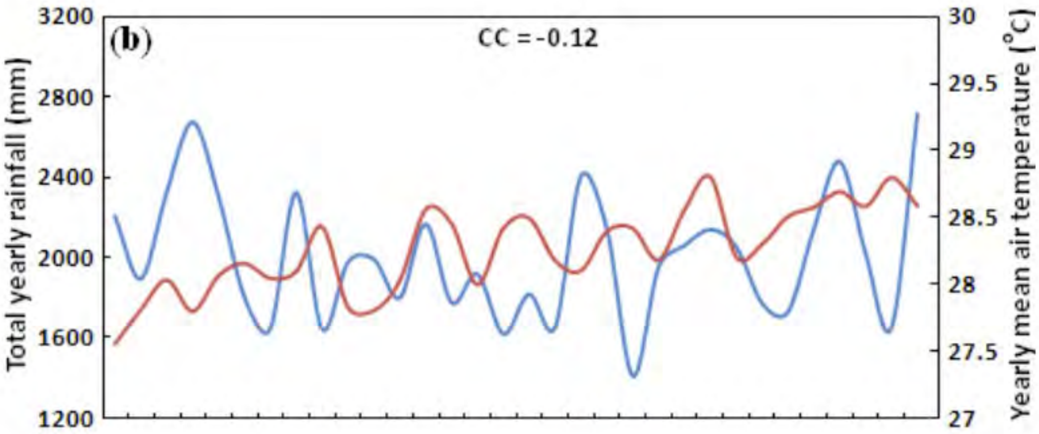


Figure 4: Annual total rainfall and mean air temperature for Hulhule, (Zahid 2011)

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

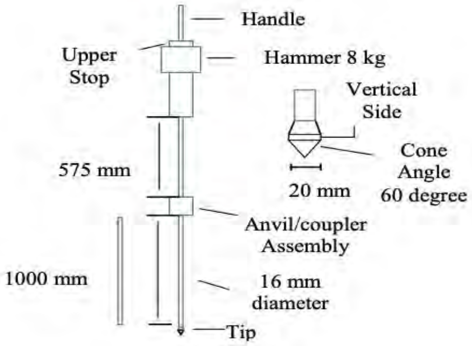


Figure 5: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.2 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.

6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.
7. The data is then plotted number of blows against depth.

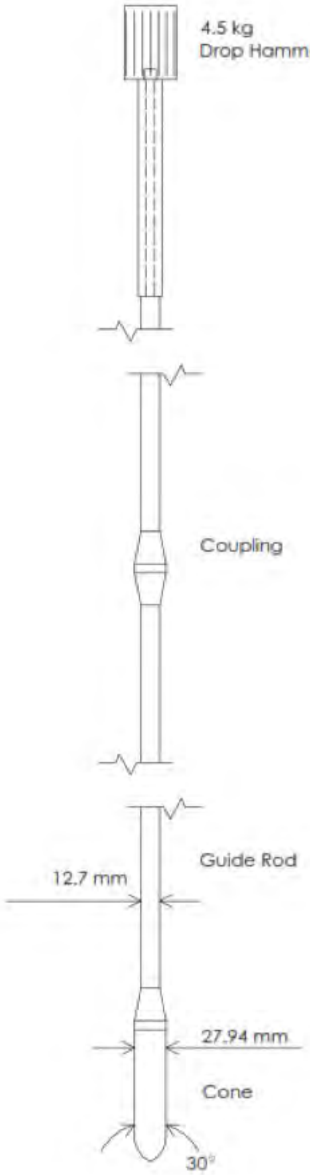


Figure 6: Schematic diagram of Mackintosh Probe

3.2.3 Trial Pits

Two trial pits were made using an excavator. A soil sample was taken at the top, 0.5 m, 1.0 m, 2.0 m and 3.0 m for laboratory investigation of sieve analysis. Photographs and were taken and observation noted to determine soil profile up to 3.0 m.

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

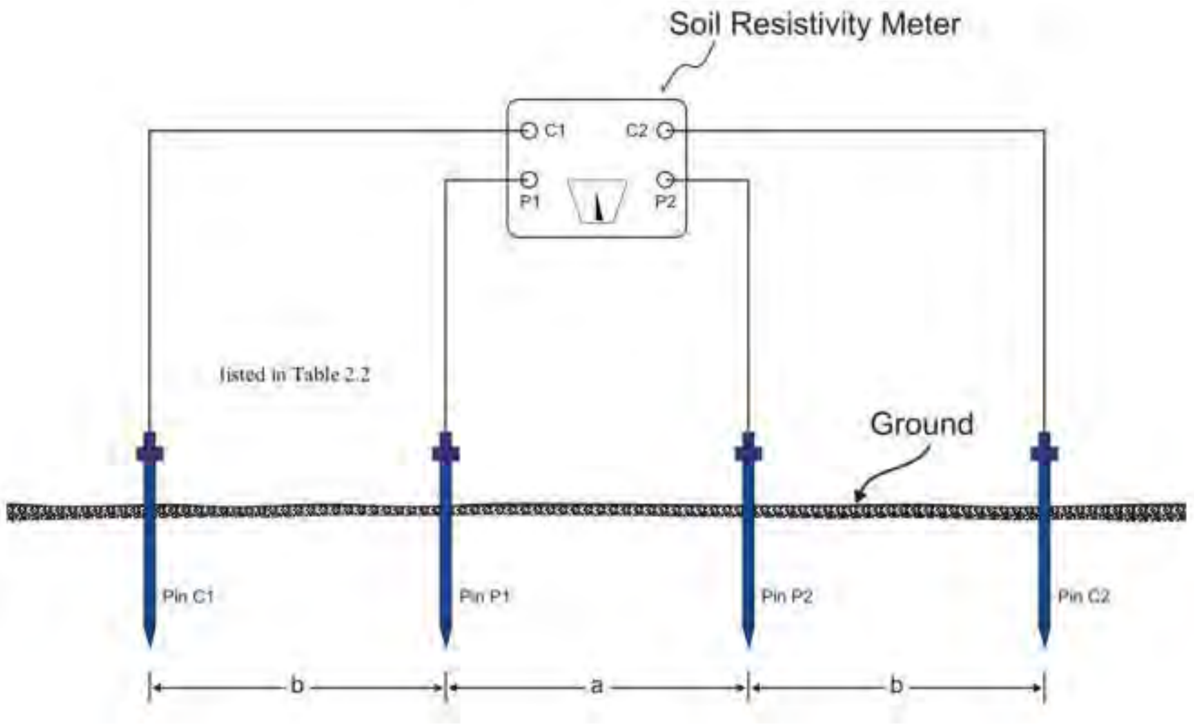


Figure 7: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 8: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W $m^{-1o}C^{-1}$). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 9: TLS-100 Portable Thermal Conductivity Meter

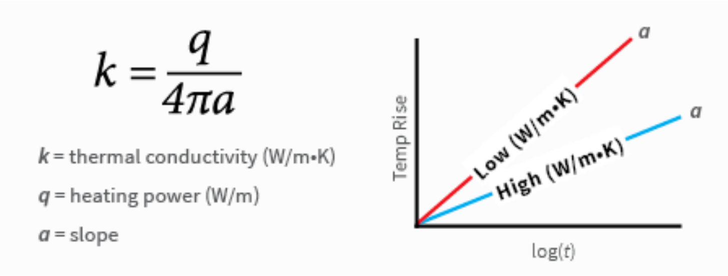


Figure 10: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\boldsymbol{\gamma}_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 11.

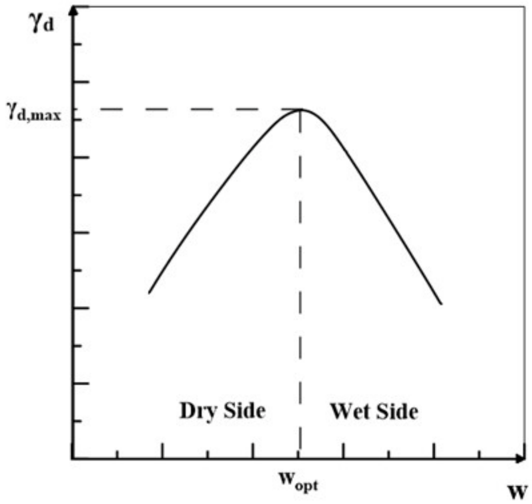


Figure 11: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 12, highest strength of a soil is achieved dry of optimum moisture content of a soil.

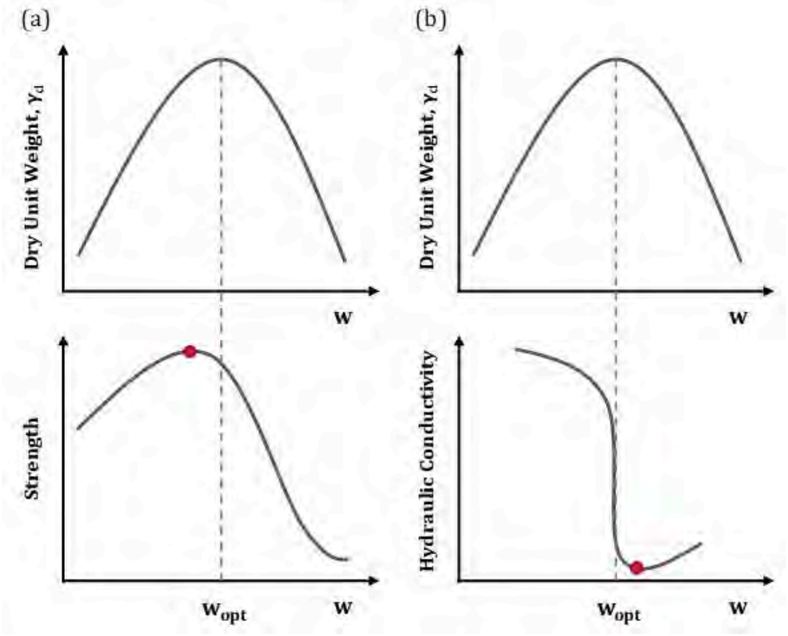


Figure 12: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Results and discussions

4.1.1 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

Table 1: Safe Bearing Capacities calculated from DCP readings

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	82	99	88	105	88	**92**
0.6	111	127	121	147	121	**125**
0.9	152	190	132	121	157	**150**
1.2	162	157	132	137	167	**151**
1.5	171	147	99	152	181	**150**
1.8	147	137	94	132	147	**131**
2.0	137	111	99	132	152	**126**

Table 1 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

4.1.2 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550\ (R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

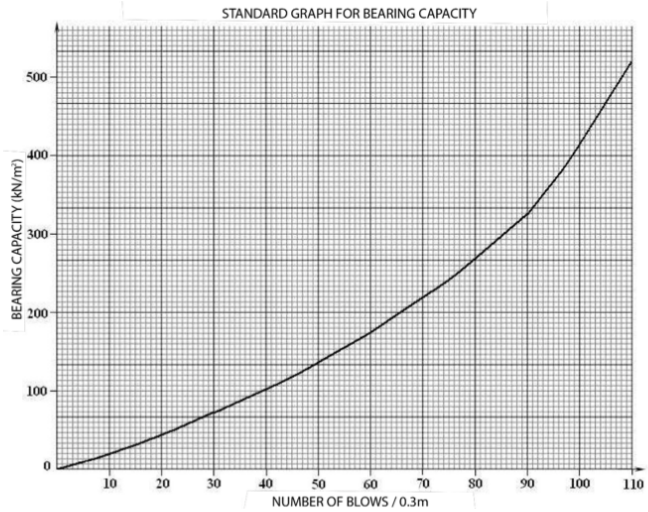


Figure 13: Standard bearing capacity graph for Mackintosh Probe

Table 2 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 2: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	140	134	**137**
0.6	155	161	**158**
0.9	161	151	**156**
1.2	168	154	**161**
1.5	165	157	**161**
1.8	162	155	**158**
2.1	157	163	**160**
2.4	164	166	**165**
2.7	161	168	**164**
3.0	-	154	**154**
3.3	-	152	**152**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum possible depth. Since the soil is medium dense gravelly sand, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used. In few cases, excavation had to be used to remove rods.

4.1.3 Trial Pits

Trial pits were conducted to get soil samples for testing, measuring water table and to check the soil profile.

The two trial pits excavated at two ends of the Hinnavaru site; soil strata are gravelly sand up throughout the depth of 3.0 m with the content of gravels and pebbles increases after 1.5 m. The water table was at 1.2 m depth.

The samples collected at 0, 0.5, 1.0, 2.0 and 3.0 were tested in the laboratory for particle size distribution. The results are given in 4.1.4.

As seen in the photo below the soil doesn't change with the depth and is gravelly sand. Since the soil is granular with the significant quantity of gravel, pebbles and stones, it was difficult excavate smoothly because the side of the pit keeps collapsing.

Figure 14: Excavating trial pit 1

Figure 15: Excavating trial pit 2

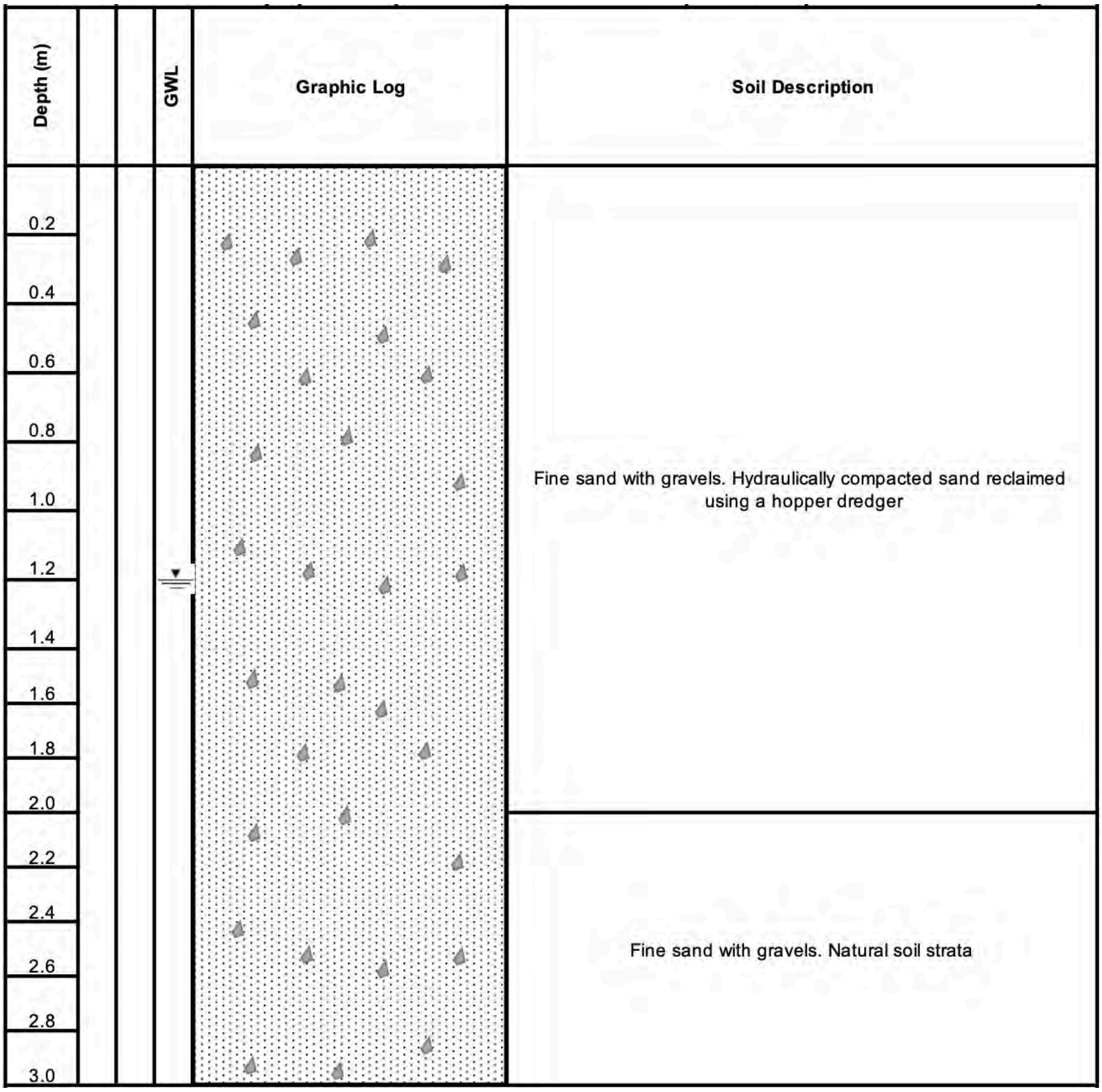


Figure 16: Log for Trial Pit 1

4.1.4 Particle size distribution

Particle size distribution of samples collected from trial pits at Lh. Hinnavaru site. The result shows the sand is gravelly with silt content less than 2.3 %, but gravel and larger sizes consist about 1/3 of the soil. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The particle size distribution graphs are included in the appendix.

Table 3: Results of Particle size distribution of samples from Trial Pit 1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	5.1	4.6	21.4	28.1	35.6	3.7	1.5
0.5	24.1	12.6	19.8	13.3	22.8	6.7	0.8
1.0	25.5	11.5	25.4	15.5	17.1	3.6	1.4
1.5	31.4	10.4	21.3	14.7	16.5	3.5	2.3
2.0	48.6	10.5	18.8	10.3	9.3	1.5	1.0
2.5	37.3	7.4	15.5	12.7	21.7	3.8	1.6
3.0	46.4	5.4	13.2	10.4	18.0	4.6	1.9

Table 4: Results of Particle size distribution of samples from Trial Pit 2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	8.3	5.9	31.9	28.5	22.7	1.8	0.9
0.5	23.0	11.9	24.9	16.0	18.3	3.9	2.0
1.0	42.5	9.1	14.8	10.1	16.7	4.9	2.0
1.5	37.7	11.3	20.0	12.4	14.1	3.2	1.2
2.0	54.7	9.3	16.4	9.1	8.1	1.3	1.2
2.5	39.3	7.5	15.8	13.1	19.8	3.1	1.4
3.0	42.6	7.2	15.4	11.9	17.6	3.3	2.1

4.1.5 Direct Shear

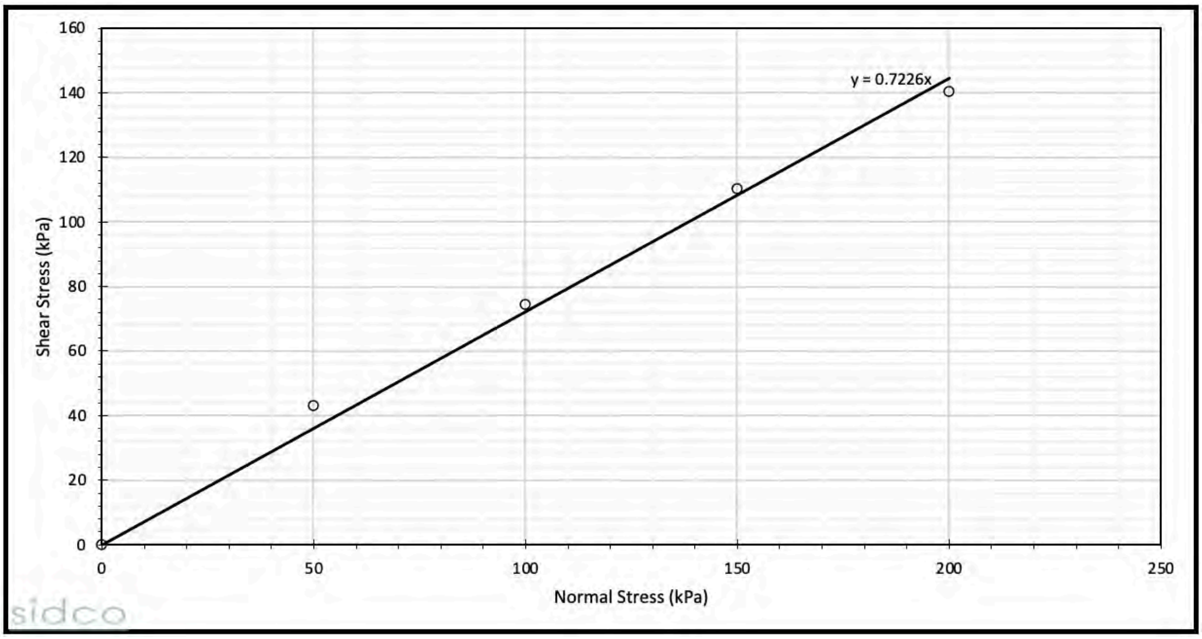


Figure 17: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 36 degrees, which is typical for carbonated sand found in Maldives.

4.1.6 Proctor Compaction Test

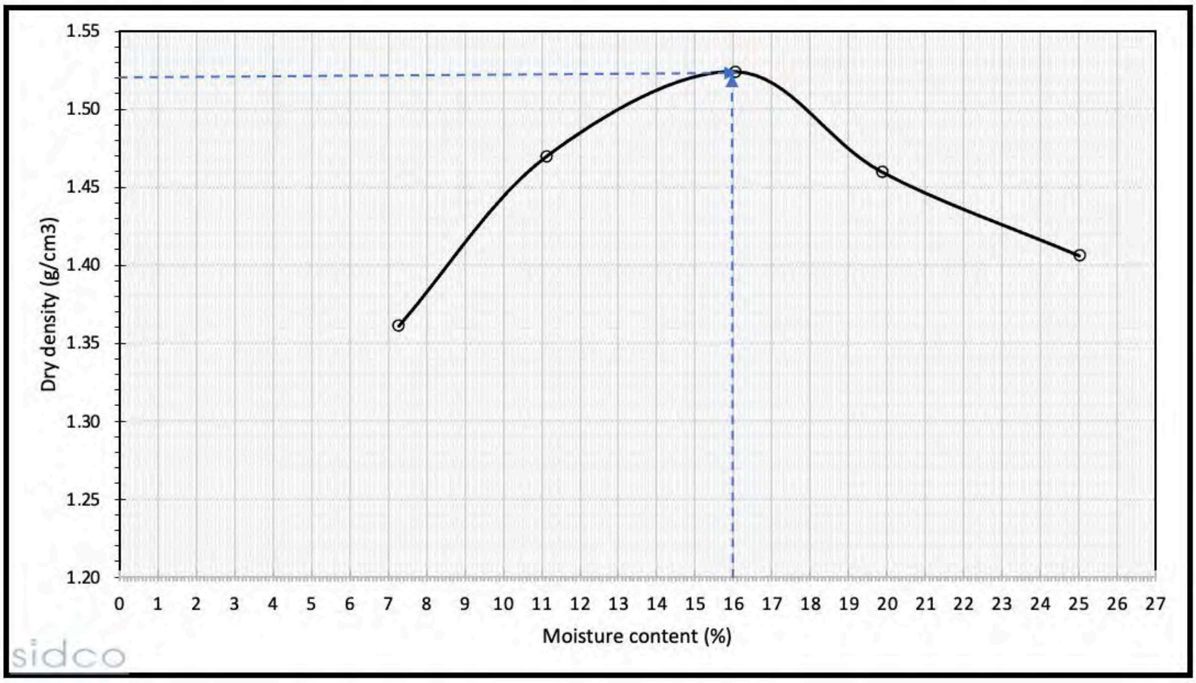
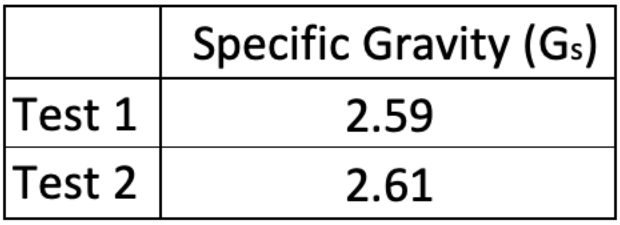


Figure 18: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.52 g/cm^3 and an optimum moisture content of 16%.

4.1.7 Specific gravity test

Table 5: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.59
Test 2	2.61

Table 5 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

4.1.8 Electrical Resistivity (ER)

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content.

1. Hinnavaru project site is a reclaimed area is covered with weeds and grass and moisture content appears to be low. High moisture content reduces the resistivity.
2. The temperature is approximately 34 degrees Celsius. Higher temperature decreases the resistivity.
3. The site was previously sea, which was reclaimed. Hence, contains salt. This also reduces the resistivity.

The tables and graphs below show ER test results.

Table 6: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	20.23	127
2	2	10.41	131
3	3	6.72	127
4	4	3.72	93
5	5	2.65	83
6	6	2.10	79
7	7	1.78	78
8	8	1.48	74
9	9	1.19	67
10	10	1.01	63

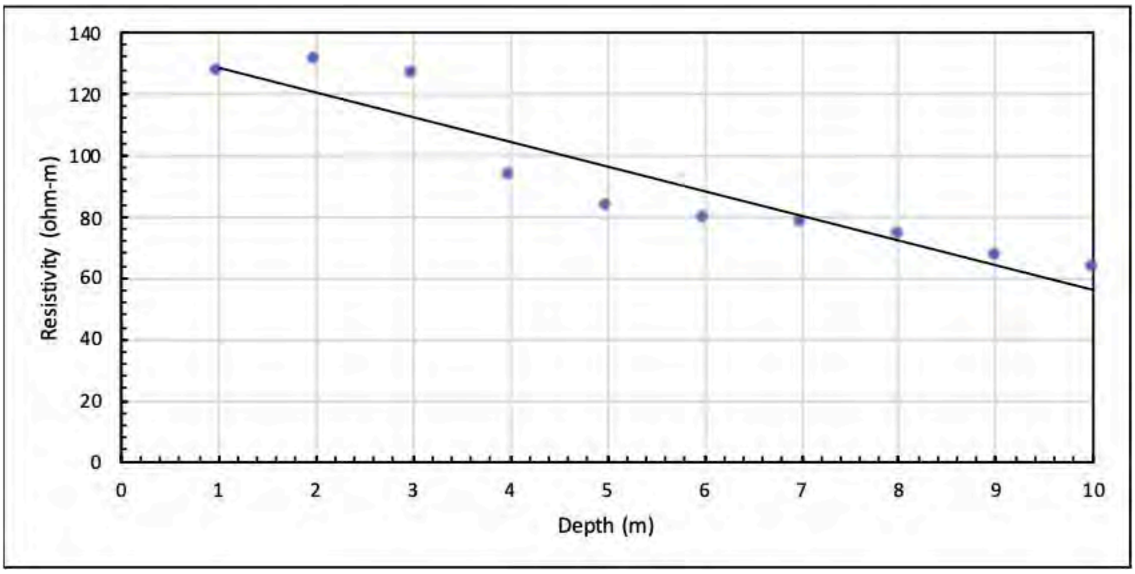


Figure 19: Resistivity graph for Test 1

Table 7: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	18.32	115
2	2	10.21	128
3	3	6.63	125
4	4	4.08	102
5	5	3.37	106
6	6	2.86	108
7	7	2.43	107
8	8	2.19	110
9	9	1.89	107
10	10	1.67	105

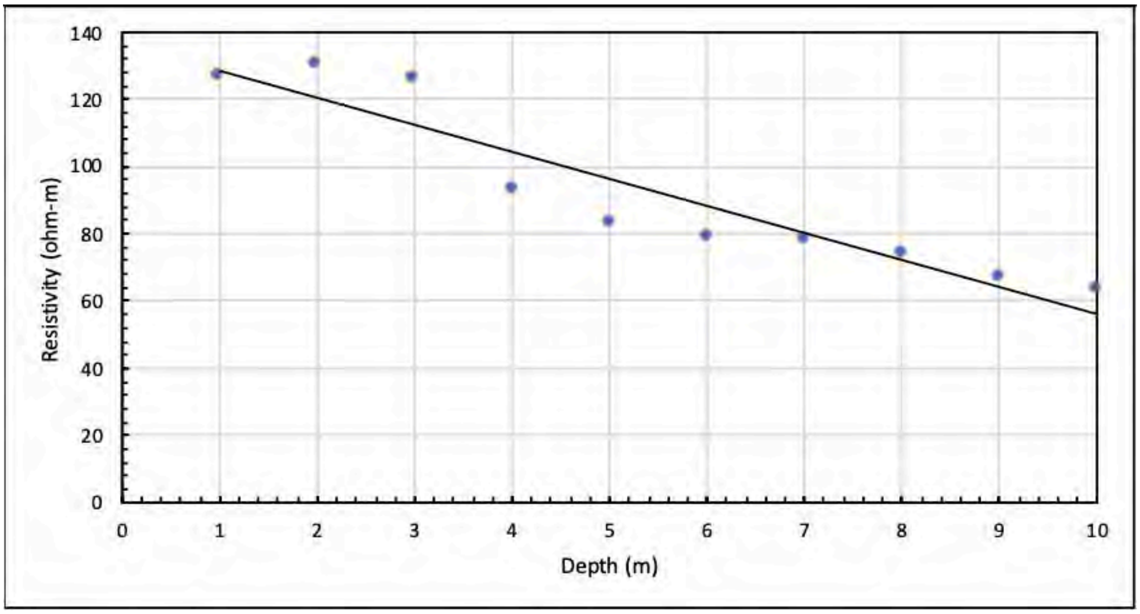


Figure 20: Resistivity graph for Test 2

Resistivity of soil remains between 135 and 100 ohm-m. Overall, the 135 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

4.1.9 Thermal Conductivity

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 8: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (^oC)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	35.70	0.300	3.33	200
2	TLS100	34.60	0.350	2.86	200
Average		35.15	0.325	3.10	

The average thermal conductivity is 0.325 W/mK.

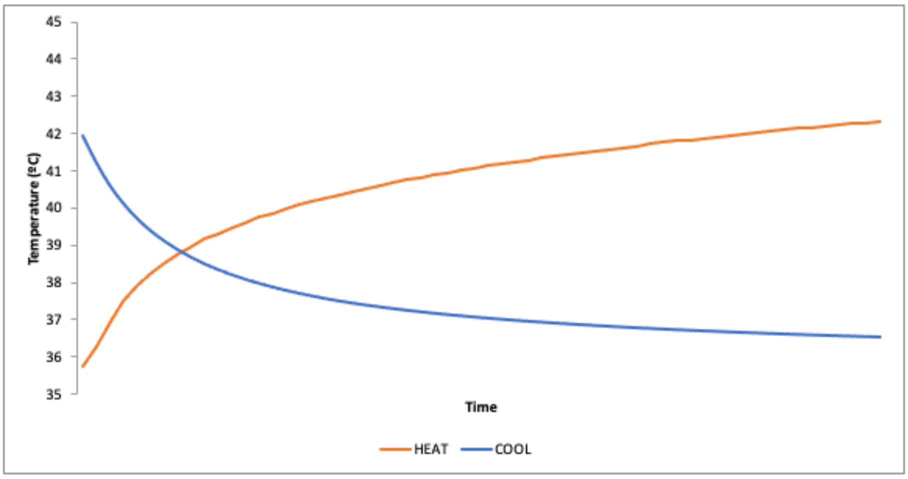


Figure 21: Heat and Colling Curve to TC Test 1

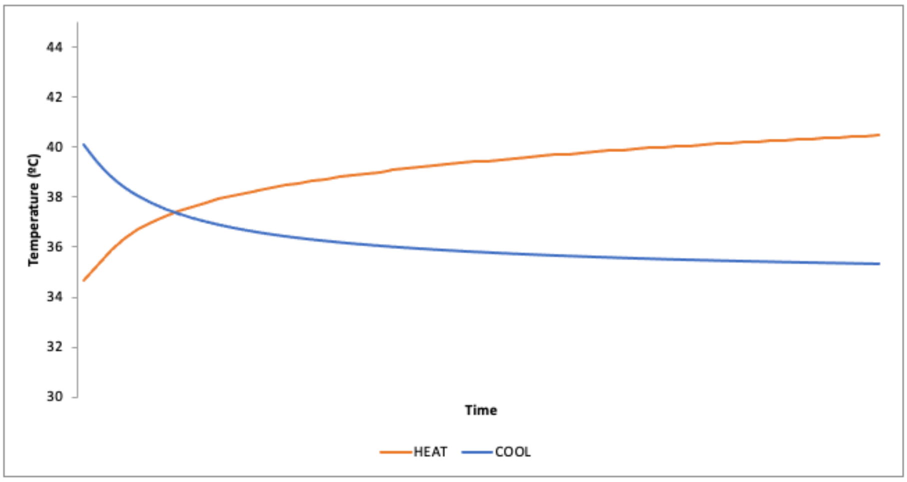


Figure 22: Heat and Colling Curve to TC Test 2

4.1.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 10830 µS/cm with a Sulphate content of 425 mg/L, Nitrate content of 2.4 mg/L, Chloride content of 3200 mg/L and Sulphide content of <5 mg/L. The project location is part of reclaimed land in 2010. The ground water at the site is salty and not portable. Hence, sub-structural concrete will have to be designed to have high quality concrete with low permeability and should be treated with surface sealant like bitumen.

Table 9: Chemical test results of water sample from Lh. Hinnavaru project site

Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	**Lh. Hinnavaru site**	GWL	Clear with particles	10830	7.50	5420	<5	3200	2.4	425

5 Conclusion

5.1 GEOTECHNICAL CONSIDERATIONS

5.1.1 Safe Bearing Capacity

Since the soil is gravelly sand, the result of DCP should more accurate and reliable than MP. Hence it is recommended to use the safe bearing capacity in the table below.

Table 10: Safe bearing capacity for shallow foundation at different depths

	Safe Bearing Capacity (kPa)					
Depth (m)	**DCP 1**	**DCP 2**	**DCP 3**	**DCP 4**	**DCP 5**	**Average**
0.3	82	99	88	105	88	**92**
0.6	111	127	121	147	121	**125**
0.9	152	190	132	121	157	**150**
1.2	162	157	132	137	167	**151**
1.5	171	147	99	152	181	**150**
1.8	147	137	94	132	147	**131**
2.0	137	111	99	132	152	**126**

5.1.2 Electrical Resistivity

For grounding design use electrical resistivity of 130 Ohm-m. And consider soil as moderately corrosive for sub-structure design.

5.1.3 Thermal Conductivity

For underground cable design use 0.325 W/mK as thermal conductivity and 3.10 mK/W as thermal resistance.

5.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Hinnavaru is located north of Maldives where peak ground acceleration value is less than 0.04.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.04, S_s is 0.09 and S_1 is 0.025.

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User’s Manual for K-100 Models of KSE DCP. USA.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES

APPENDIX 1: TEST LOCATIONS

Hinnavaru (ASPIRE Site)

APPENDIX 2: DCP TEST RESULTS

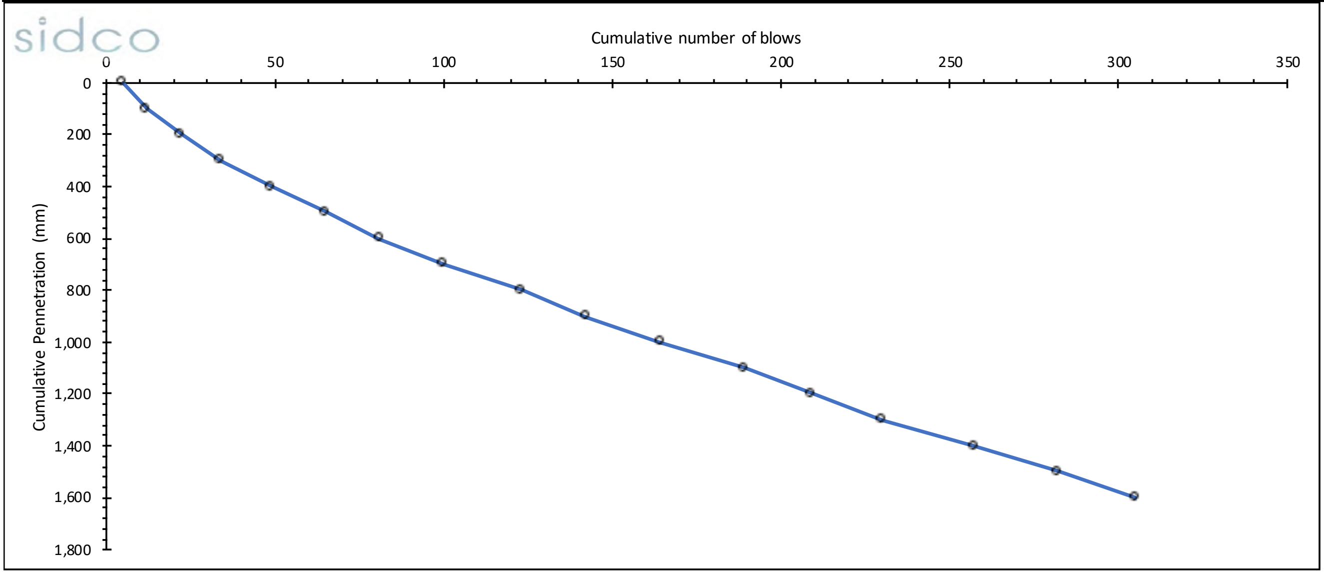
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Lh. Hinnavaru**		**20/01/2022**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	7	12	14.3	15	157	63
200-300	10	22	10.0	22	205	82
300-400	12	34	8.3	27	234	94
400-500	15	49	6.7	35	277	111
500-600	16	65	6.3	37	290	116
600-700	16	81	6.3	37	290	116
700-800	19	100	5.3	45	330	132
800-900	23	123	4.3	56	380	152
900-1000	19	142	5.3	45	330	132
1000-1100	22	164	4.5	54	368	147
1100-1200	25	189	4.0	62	404	162
1200-1300	20	209	5.0	48	343	137
1300-1400	21	230	4.8	51	355	142
1400-1500	27	257	3.7	67	428	171
1500-1600	25	282	4.0	62	404	162
1600-1700	23	305	4.3	56	380	152
1700-1800	22	327	4.5	54	368	147
1800-1900	21	348	4.8	51	355	142
1900-2000	20	368	5.0	48	343	137

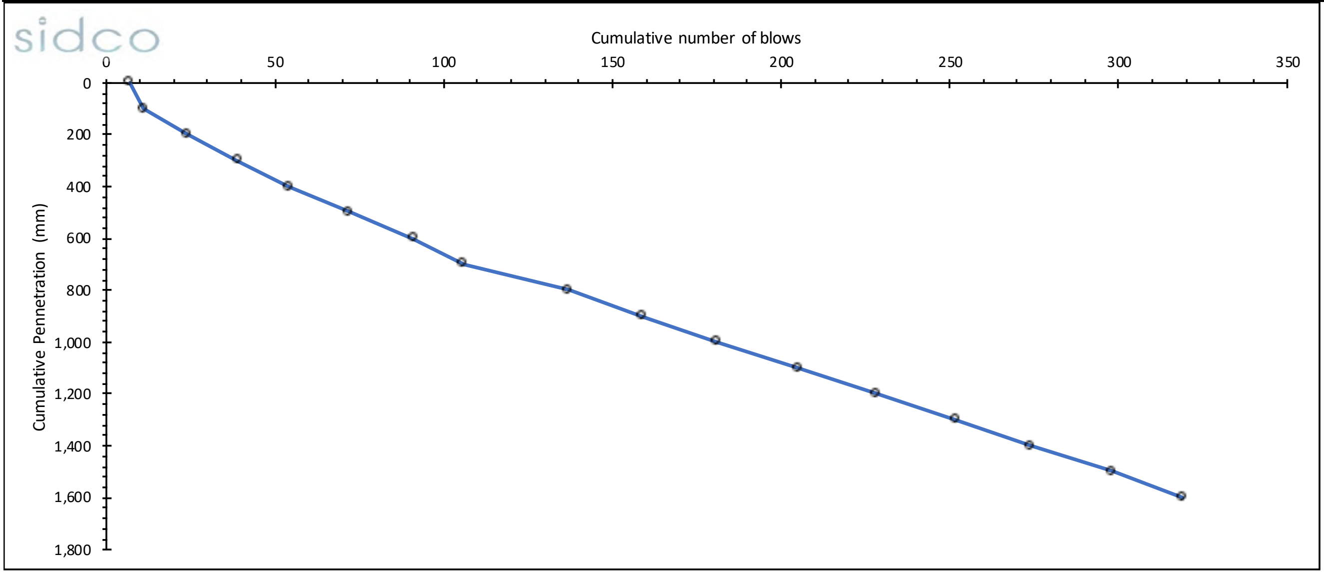


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	Lh. Hinnavaru		20/01/2022		DCP#	2
Depth (mm)	Number of Blows	Cumulative Number of Blows	DCP Index (mm/blow)	CBR (%)	Ultimate Bearing Capacity, q (kPa)	Safe Bearing Capacity, q (kPa)
0-100	7	7	14.3	15	157	63
100-200	4	11	25.0	8	104	41
200-300	13	24	7.7	30	249	99
300-400	15	39	6.7	35	277	111
400-500	15	54	6.7	35	277	111
500-600	18	72	5.6	43	317	127
600-700	19	91	5.3	45	330	132
700-800	15	106	6.7	35	277	111
800-900	31	137	3.2	79	475	190
900-1000	22	159	4.5	54	368	147
1000-1100	22	181	4.5	54	368	147
1100-1200	24	205	4.2	59	392	157
1200-1300	23	228	4.3	56	380	152
1300-1400	24	252	4.2	59	392	157
1400-1500	22	274	4.5	54	368	147
1500-1600	24	298	4.2	59	392	157
1600-1700	21	319	4.8	51	355	142
1700-1800	20	339	5.0	48	343	137
1800-1900	18	357	5.6	43	317	127
1900-2000	15	372	6.7	35	277	111



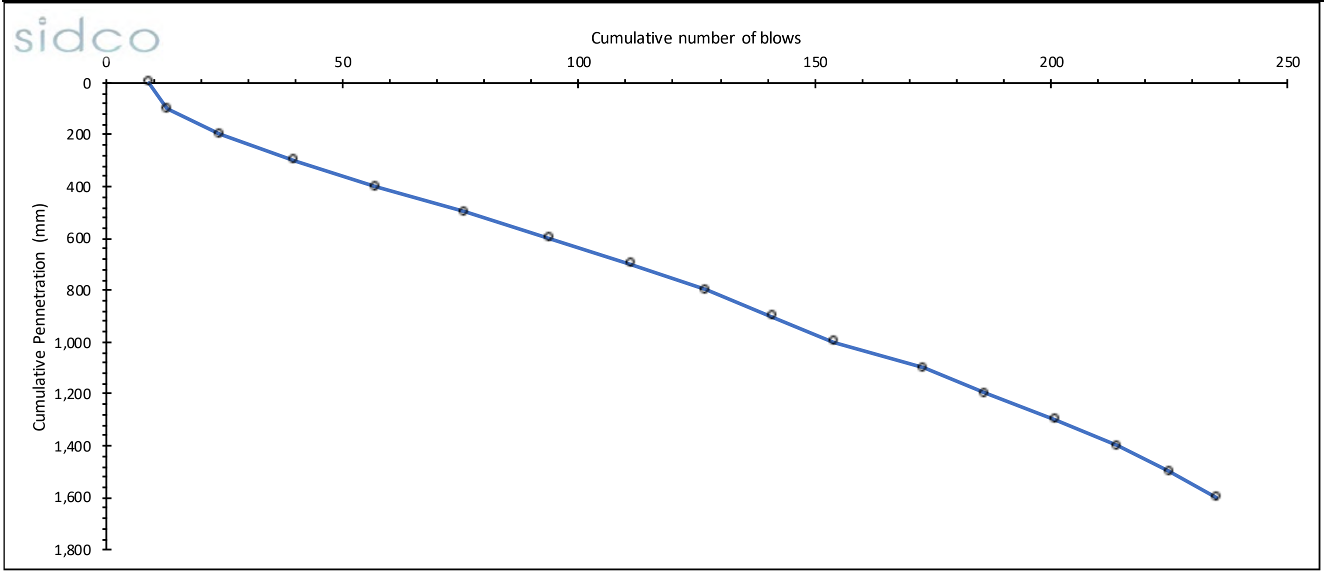
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Lh. Hinnavaru**		**20/01/2022**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	9	9	11.1	20	189	76
100-200	4	13	25.0	8	104	41
200-300	11	24	9.1	25	220	88
300-400	16	40	6.3	37	290	116
400-500	17	57	5.9	40	304	121
500-600	19	76	5.3	45	330	132
600-700	18	94	5.6	43	317	127
700-800	17	111	5.9	40	304	121
800-900	16	127	6.3	37	290	116
900-1000	14	141	7.1	32	263	105
1000-1100	13	154	7.7	30	249	99
1100-1200	19	173	5.3	45	330	132
1200-1300	13	186	7.7	30	249	99
1300-1400	15	201	6.7	35	277	111
1400-1500	13	214	7.7	30	249	99
1500-1600	11	225	9.1	25	220	88
1600-1700	10	235	10.0	22	205	82
1700-1800	12	247	8.3	27	234	94
1800-1900	10	257	10.0	22	205	82
1900-2000	13	270	7.7	30	249	99

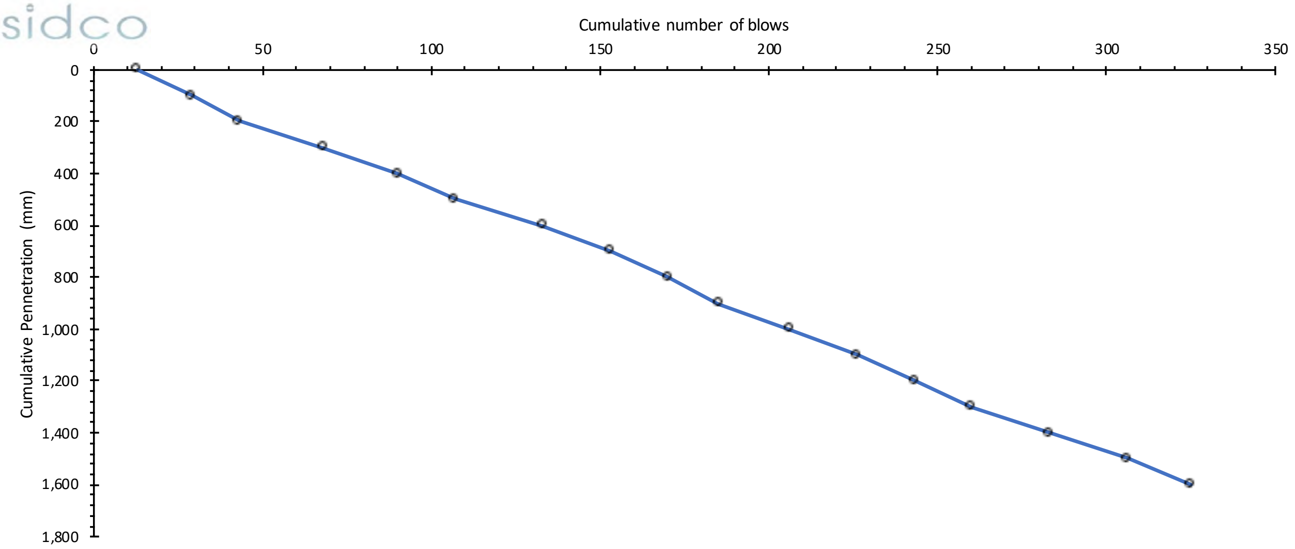


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Lh. Hinnavaru**		**20/01/2022**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	13	13	7.7	30	249	99
100-200	16	29	6.3	37	290	116
200-300	14	43	7.1	32	263	105
300-400	25	68	4.0	62	404	162
400-500	22	90	4.5	54	368	147
500-600	17	107	5.9	40	304	121
600-700	26	133	3.8	65	416	167
700-800	20	153	5.0	48	343	137
800-900	17	170	5.9	40	304	121
900-1000	15	185	6.7	35	277	111
1000-1100	21	206	4.8	51	355	142
1100-1200	20	226	5.0	48	343	137
1200-1300	17	243	5.9	40	304	121
1300-1400	17	260	5.9	40	304	121
1400-1500	23	283	4.3	56	380	152
1500-1600	23	306	4.3	56	380	152
1600-1700	19	325	5.3	45	330	132
1700-1800	19	344	5.3	45	330	132
1800-1900	17	361	5.9	40	304	121
1900-2000	19	380	5.3	45	330	132

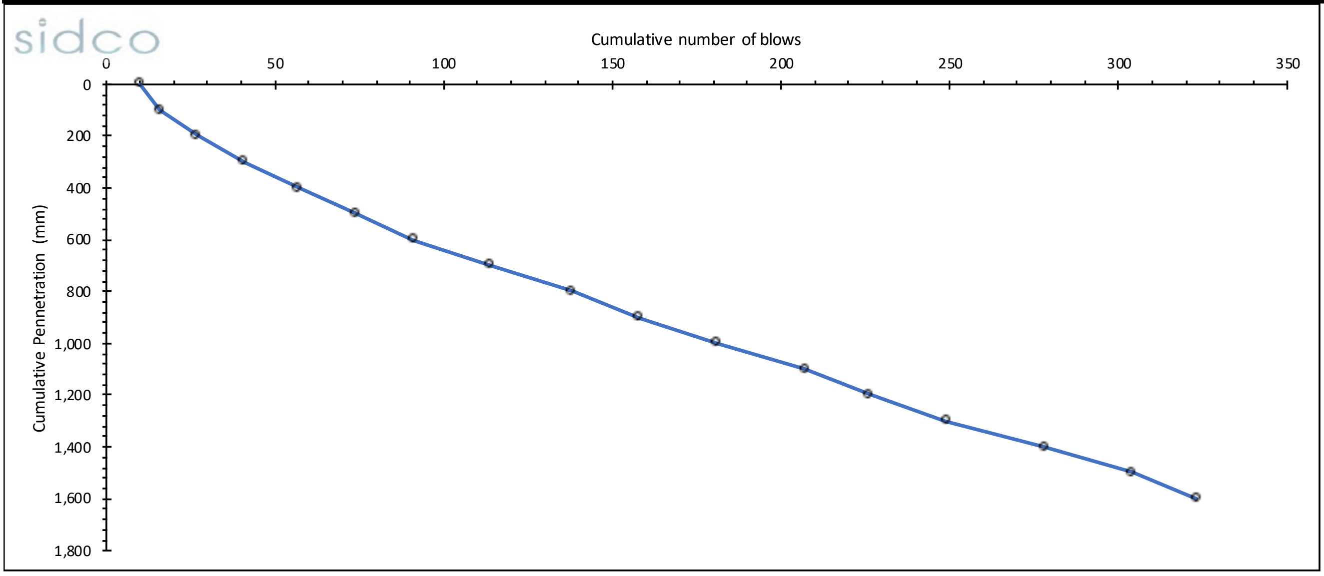


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**Lh. Hinnavaru**		**20/01/2022**		**DCP#**	**5**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	10	10	10.0	22	205	82
100-200	6	16	16.7	13	140	56
200-300	11	27	9.1	25	220	88
300-400	14	41	7.1	32	263	105
400-500	16	57	6.3	37	290	116
500-600	17	74	5.9	40	304	121
600-700	17	91	5.9	40	304	121
700-800	23	114	4.3	56	380	152
800-900	24	138	4.2	59	392	157
900-1000	20	158	5.0	48	343	137
1000-1100	23	181	4.3	56	380	152
1100-1200	26	207	3.8	65	416	167
1200-1300	19	226	5.3	45	330	132
1300-1400	23	249	4.3	56	380	152
1400-1500	29	278	3.4	73	452	181
1500-1600	26	304	3.8	65	416	167
1600-1700	19	323	5.3	45	330	132
1700-1800	22	345	4.5	54	368	147
1800-1900	20	365	5.0	48	343	137
1900-2000	23	388	4.3	56	380	152



APPENDIX 3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

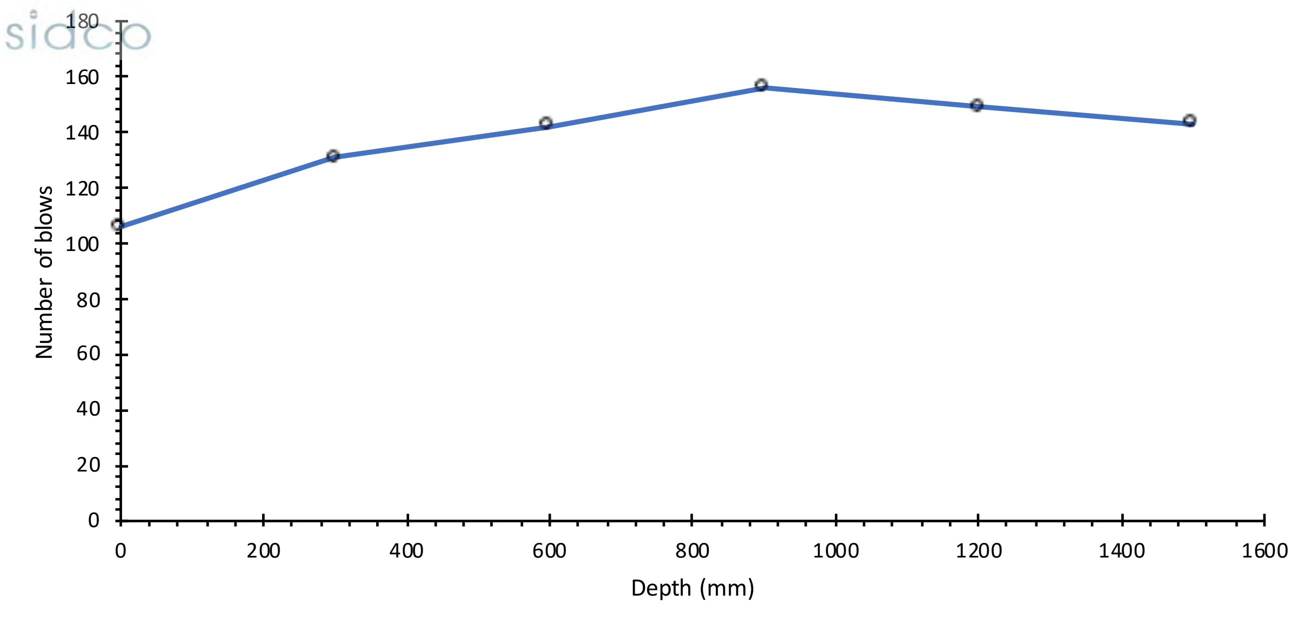
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Lh. Hinnavaru**	**Date:**	**20/01/2022**	**MP#**	**1**

Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity kPa**
0-300	106	106	351	140
300-600	131	237	388	155
600-900	142	379	403	161
900-1200	156	535	421	168
1200-1500	149	684	412	165
1500-1800	143	827	404	162
1800-2100	135	962	394	157
2100-2400	147	1109	409	164
2400-2700	142	1251	403	161
2700-3000	>400 blows per 0.3 m as MP got rebound on a hard rock			
3000-3300				
3300-3600				
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



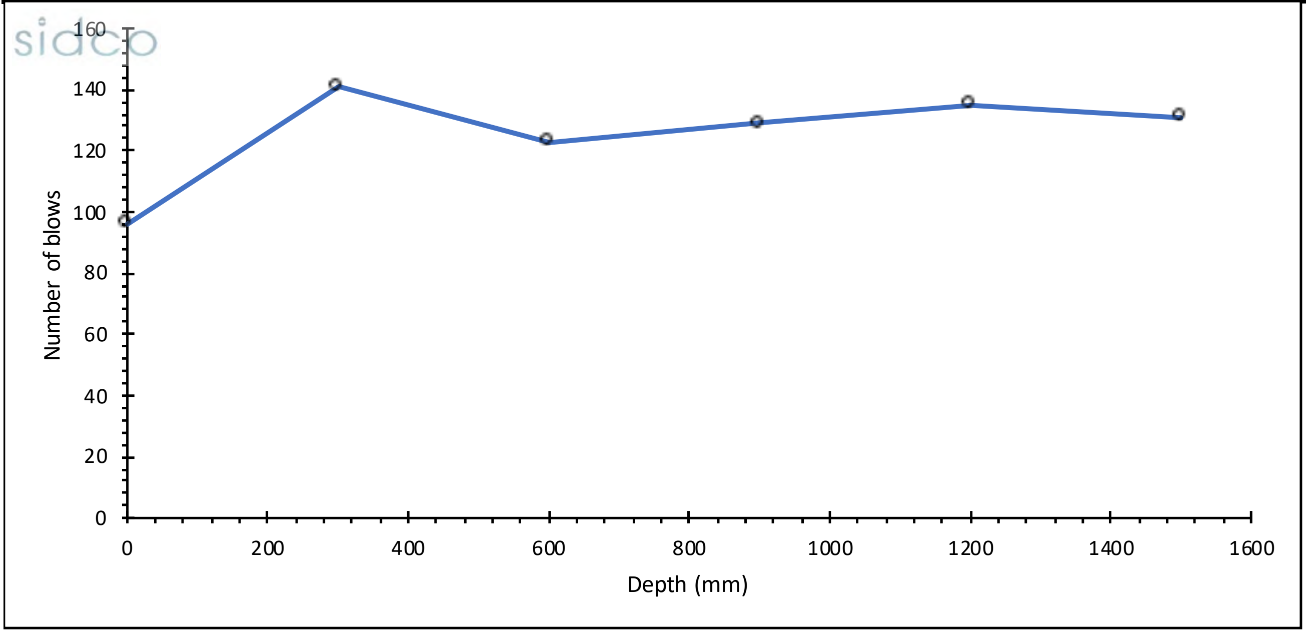
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location: **Lh. Hinnavaru**	**Date:**	**20/01/2022**	**MP# 1**	**2**
Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity kPa**
0-300	96	96	334	134
300-600	141	237	402	161
600-900	123	360	377	151
900-1200	129	489	385	154
1200-1500	135	624	394	157
1500-1800	131	755	388	155
1800-2100	145	900	407	163
2100-2400	152	1052	416	166
2400-2700	155	1207	419	168
2700-3000	129	1336	385	154
3000-3300	126	1462	381	152
3300-3600	>400 blows per 0.3 m as MP got rebound on hard rock			
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				

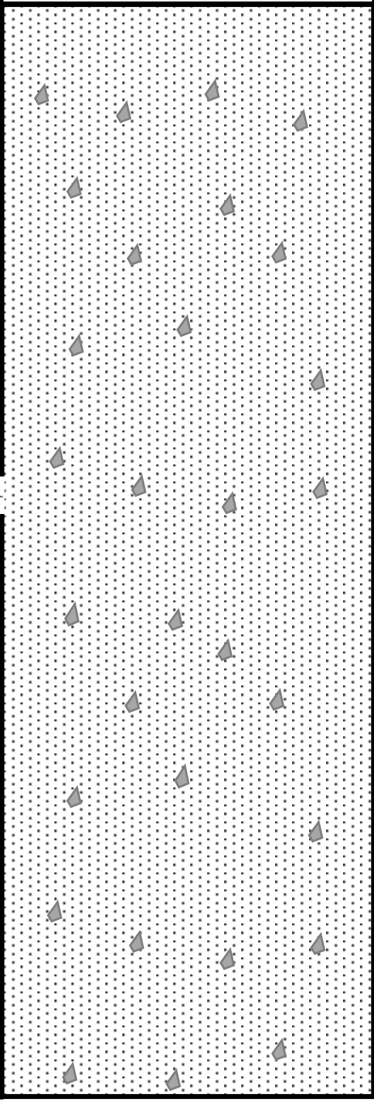


APPENDIX 4: BOREHOLE LOGS

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire Project - Solar PV Installation - Lh. Hinnavaru							
Project Number:	HDEC/2023/1				Client:	HDEC		
Equipment	Excavator				Contractor	SIDCO Pvt Ltd		
Ground water depth (m)	1.2	Date	Started:	20/01/2023			Trial Pit	1
Total depth (m)	3.0		Completed	20/01/2023				
Location	Hinnavaru West Side		Backfilled:	10/01/2023				

Depth (m)			GWL	Graphic Log	Soil Description
0.2					Fine sand with gravels. Hydraulically compacted sand reclaimed using a hopper dredger
0.4					
0.6					
0.8					
1.0					
1.2			▼		
1.4					
1.6					
1.8					
2.0					
2.2					Fine sand with gravels. Natural soil strata
2.4					
2.6					
2.8					
3.0					

Notes

▼ Ground water level

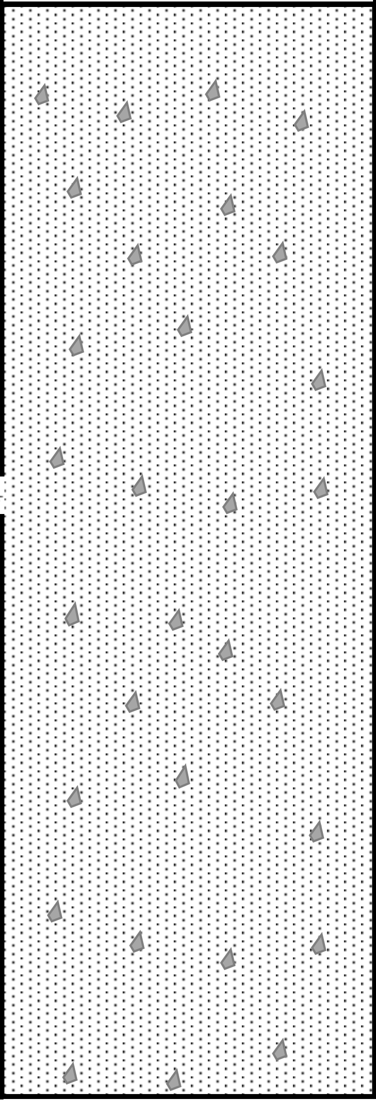
sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire Project - Solar PV Installation - Lh. Hinnavaru						
Project Number:	HDEC/2023/1			Client:	HDEC		
Equipment	Excavator			Contractor	SIDCO Pvt Ltd		
Ground water depth (m)	1.2	Date	Started:	20/01/2023		Trial Pit	2
Total depth (m)	3.0		Completed	20/01/2023			
Location	Hinnavaru West Side		Backfilled:	10/01/2023			

Depth (m)			GWL	Graphic Log	Soil Description
0.2					Fine sand with gravels. Hydraulically compacted sand reclaimed using a hopper dredger
0.4					
0.6					
0.8					
1.0					
1.2			▽		
1.4					
1.6					
1.8					
2.0					
2.2					Fine sand with gravels. Natural soil strata
2.4					
2.6					
2.8					
3.0					



Notes

▽ Ground water level

APPENDIX 5: RESULTS OF PARTICLE SIZE DISTRIBUTION

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	0.0 m		**Test #**	**TP-1**

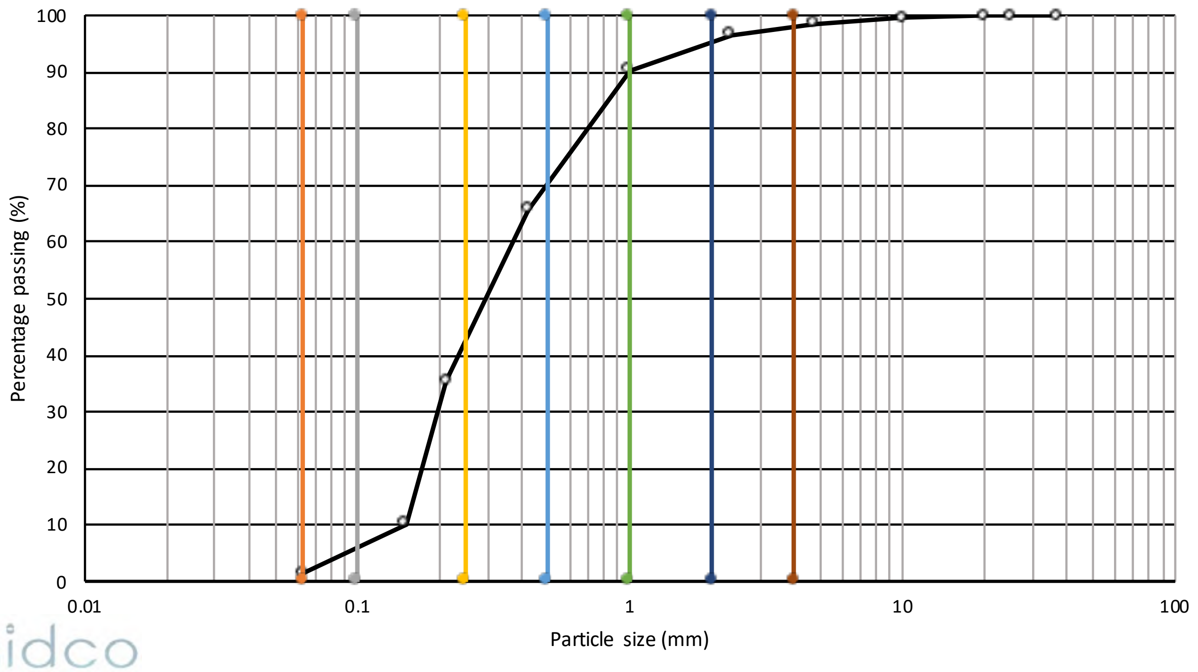
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	306.81	100.0
2	**25**	0	0	0.0	306.81	100.0
3	**20**	0	0	0.0	306.81	100.0
4	**10**	1.42	1.42	0.5	305.39	99.5
5	**4.75**	3.34	5	1.6	302.05	98.4
8	**2.36**	5.75	10.51	3.4	296.3	96.6
16	**1**	19.27	29.78	9.7	277.03	90.3
30	**0.425**	75.41	105.19	34.3	201.62	65.7
50	**0.212**	93.03	198.22	64.6	108.59	35.4
100	**0.15**	77.16	275.38	89.8	31.43	10.2
200	**0.063**	26.86	302.24	98.5	4.57	1.5
Total weight sieved through #200				4.57		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				307	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.5%	3.7%	35.6%	28.1%	21.4%	4.6%	5.1%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

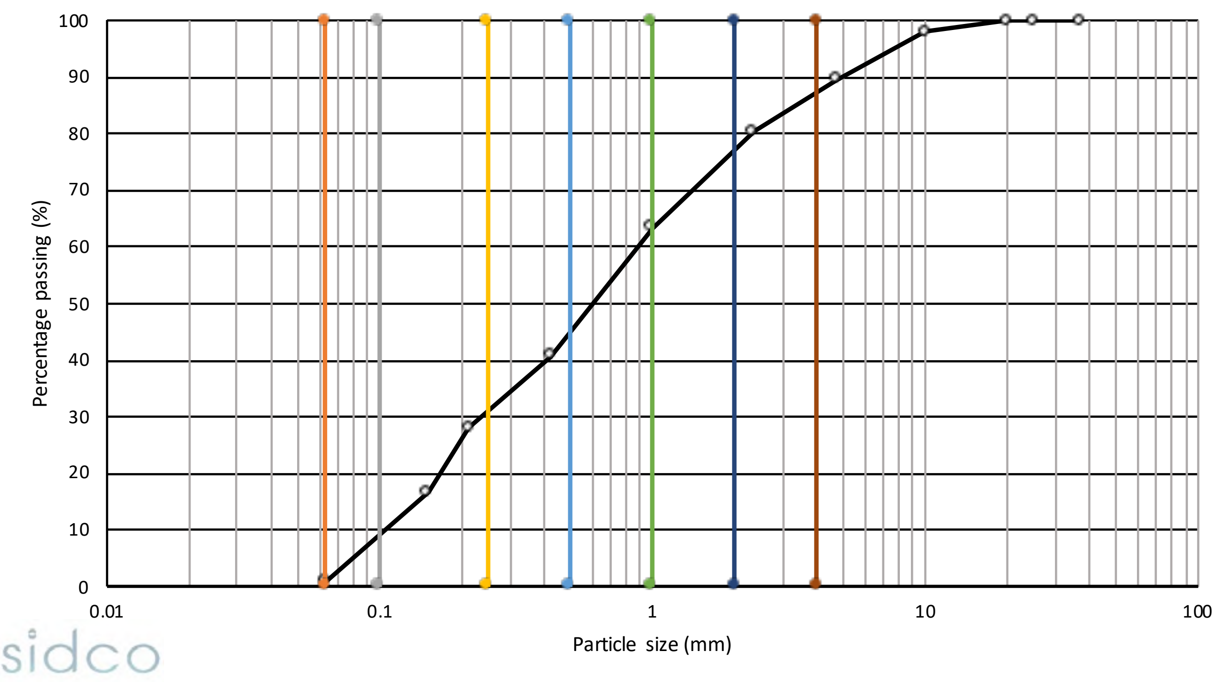
Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	0.5m	**Test #**	**TP-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	244.11	100.0
2	**25**	0	0	0.0	244.11	100.0
3	**20**	0	0	0.0	244.11	100.0
4	**10**	4.81	4.81	2.0	239.3	98.0
5	**4.75**	20.91	26	10.5	218.39	89.5
8	**2.36**	22.10	47.82	19.6	196.29	80.4
16	**1**	41.69	89.51	36.7	154.6	63.3
30	**0.425**	55.48	144.99	59.4	99.12	40.6
50	**0.212**	30.68	175.67	72.0	68.44	28.0
100	**0.15**	27.98	203.65	83.4	40.46	16.6
200	**0.063**	38.61	242.26	99.2	1.85	0.8
Total weight sieved through #200				1.85		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				244	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.8%	6.7%	22.8%	13.3%	19.8%	12.6%	24.1%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

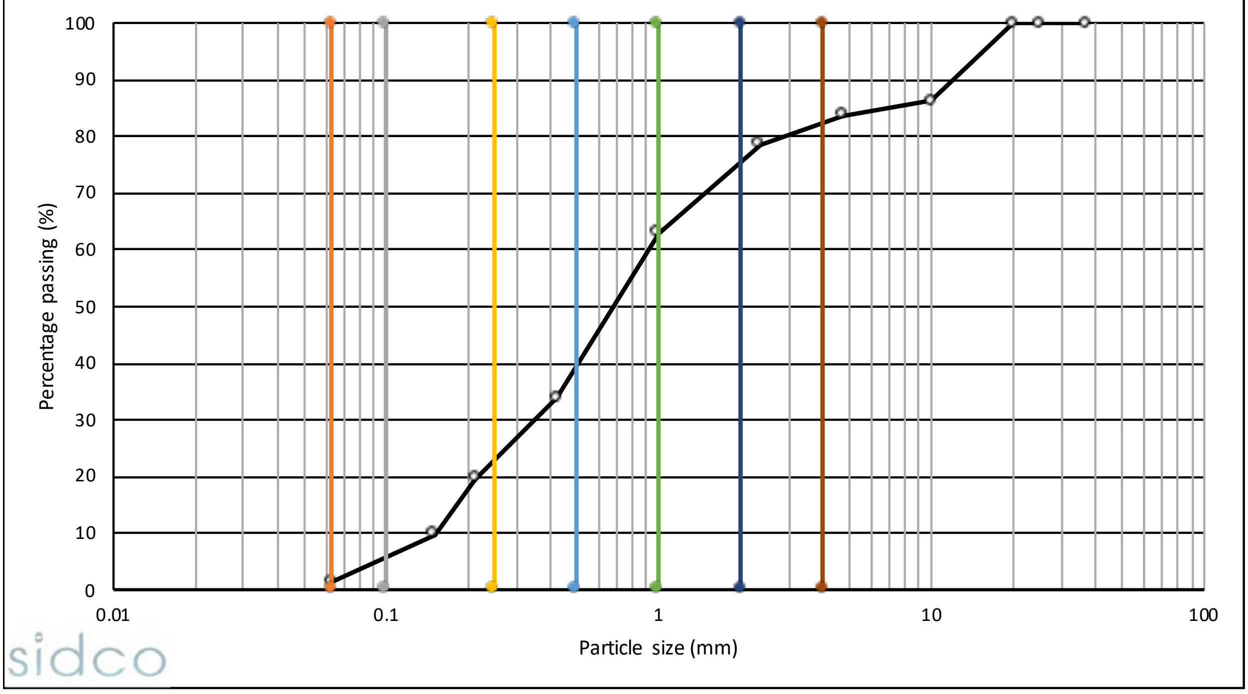
Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**		Hewage	
	Depth (m)	1m		**Test #**	**TP-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	276.37	100.0
2	**25**	0	0	0.0	276.37	100.0
3	**20**	0	0	0.0	276.37	100.0
4	**10**	38.03	38.03	13.8	238.34	86.2
5	**4.75**	7.05	45	16.3	231.29	83.7
8	**2.36**	13.95	59.03	21.4	217.34	78.6
16	**1**	43.37	102.4	37.1	173.97	62.9
30	**0.425**	80.59	182.99	66.2	93.38	33.8
50	**0.212**	39.46	222.45	80.5	53.92	19.5
100	**0.15**	26.85	249.3	90.2	27.07	9.8
200	**0.063**	23.16	272.46	98.6	3.91	1.4
Total weight sieved through #200				3.91		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				276	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.4%	3.6%	17.1%	15.5%	25.4%	11.5%	25.5%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	1.5m		**Test #**	**TP-1**

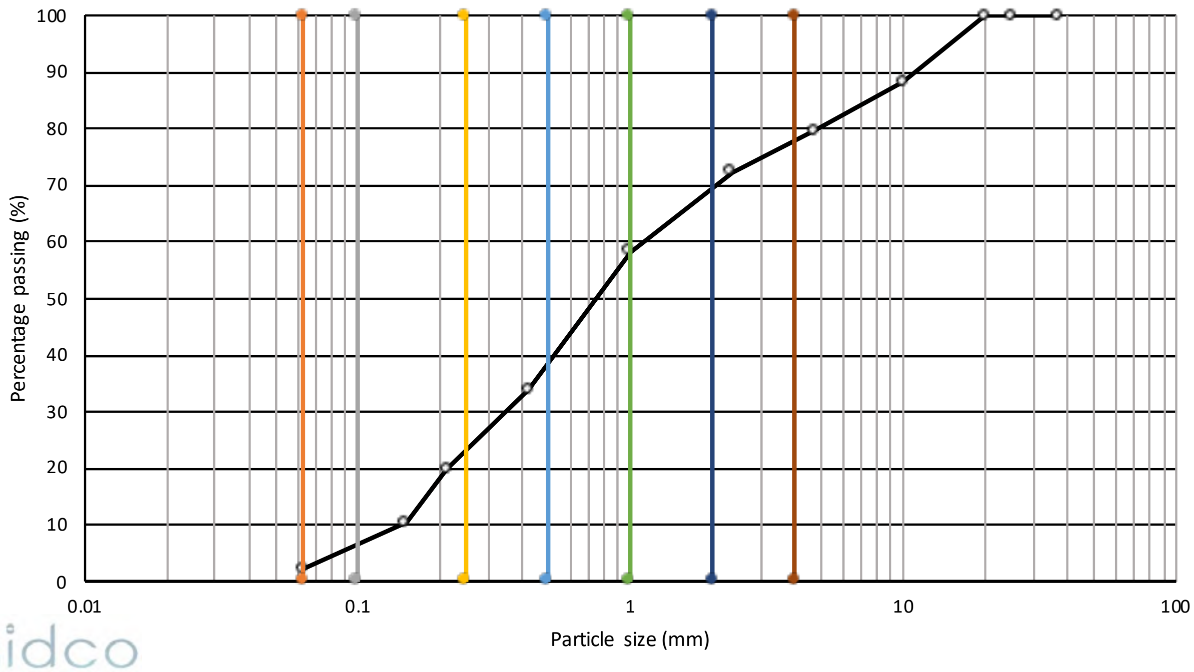
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	217.91	100.0
2	**25**	0	0	0.0	217.91	100.0
3	**20**	0	0	0.0	217.91	100.0
4	**10**	25.60	25.6	11.7	192.31	88.3
5	**4.75**	18.85	44	20.4	173.46	79.6
8	**2.36**	15.78	60.23	27.6	157.68	72.4
16	**1**	30.85	91.08	41.8	126.83	58.2
30	**0.425**	53.26	144.34	66.2	73.57	33.8
50	**0.212**	30.52	174.86	80.2	43.05	19.8
100	**0.15**	20.19	195.05	89.5	22.86	10.5
200	**0.063**	17.93	212.98	97.7	4.93	2.3
Total weight sieved through #200				4.93		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				218	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.3%	3.5%	16.5%	14.7%	21.3%	10.4%	31.4%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

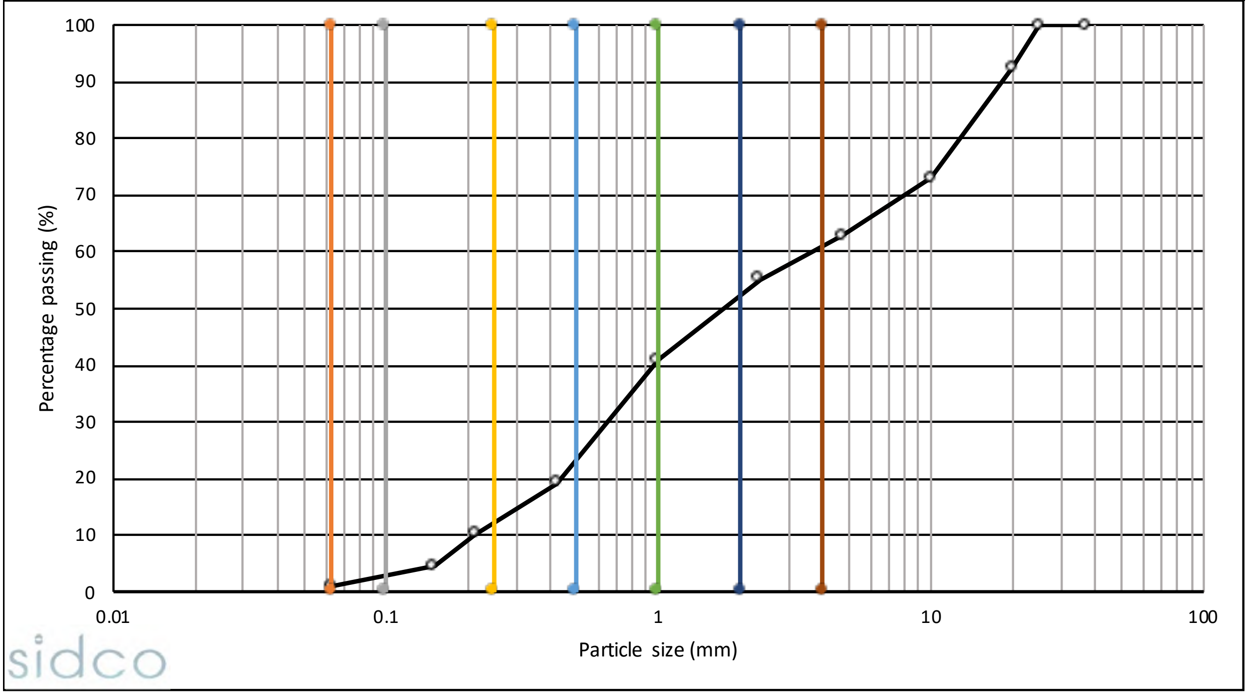
Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	2m		**Test #**	**TP-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	296.75	100.0
2	**25**	0	0	0.0	296.75	100.0
3	**20**	22.29	22.29	7.5	274.46	92.5
4	**10**	57.78	80.07	27.0	216.68	73.0
5	**4.75**	30.44	111	37.2	186.24	62.8
8	**2.36**	22.47	132.98	44.8	163.77	55.2
16	**1**	42.30	175.28	59.1	121.47	40.9
30	**0.425**	64.23	239.51	80.7	57.24	19.3
50	**0.212**	27.09	266.6	89.8	30.15	10.2
100	**0.15**	16.77	283.37	95.5	13.38	4.5
200	**0.063**	10.32	293.69	99.0	3.06	1.0
Total weight sieved through #200				3.06		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				297	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.0%	1.5%	9.3%	10.3%	18.8%	10.5%	48.6%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

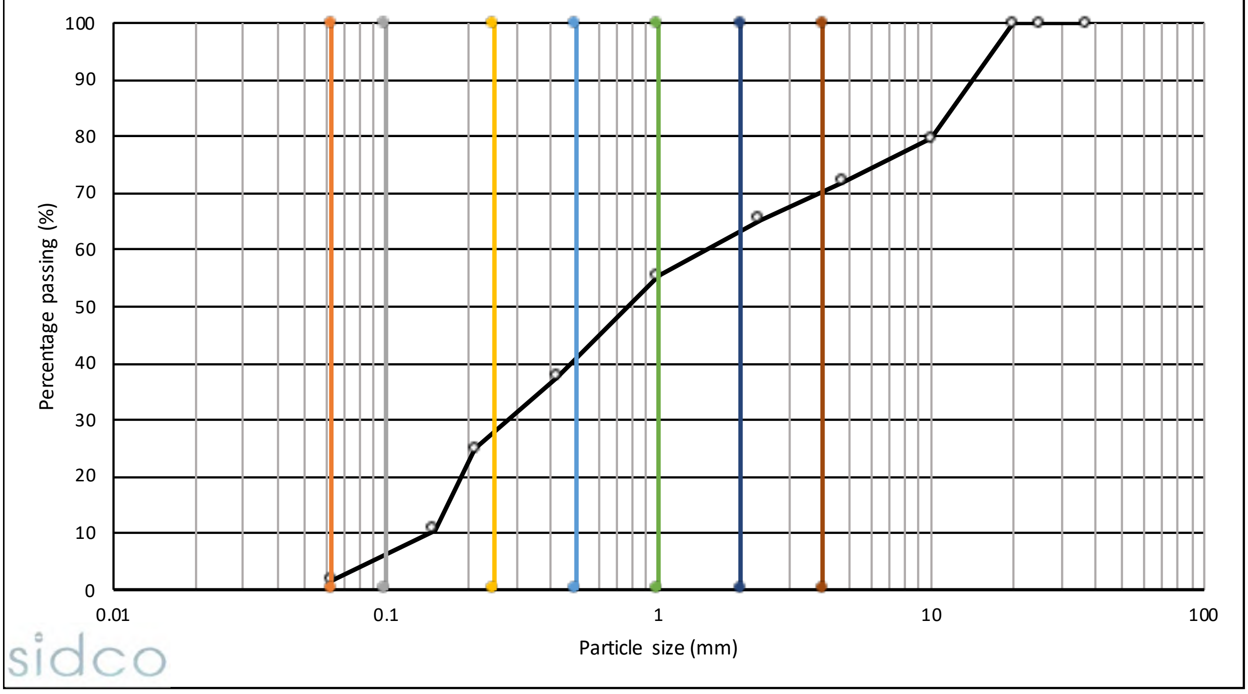
Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	2.5m		**Test #**	**TP-1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	326.23	100.0
2	**25**	0	0	0.0	326.23	100.0
3	**20**	0	0	0.0	326.23	100.0
4	**10**	66.40	66.4	20.4	259.83	79.6
5	**4.75**	25.34	92	28.1	234.49	71.9
8	**2.36**	21.35	113.09	34.7	213.14	65.3
16	**1**	32.63	145.72	44.7	180.51	55.3
30	**0.425**	58.26	203.98	62.5	122.25	37.5
50	**0.212**	41.20	245.18	75.2	81.05	24.8
100	**0.15**	46.62	291.8	89.4	34.43	10.6
200	**0.063**	29.07	320.87	98.4	5.36	1.6
Total weight sieved through #200				5.36		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				326	Error (%)	

Remarks

C_u= 7.955
C_c= 0.537

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.6%	3.8%	21.7%	12.7%	15.5%	7.4%	37.3%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023		**Tested by:**	Hewage	
	Depth (m)	3m		**Test #**	**TP-1**

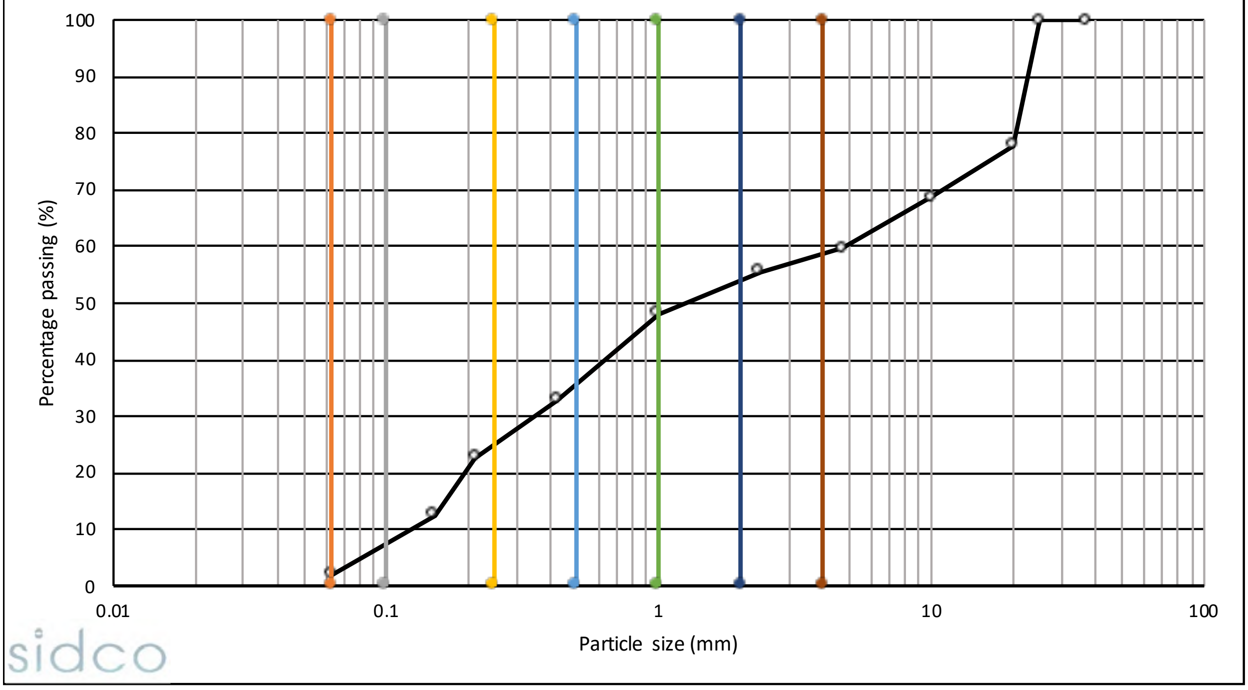
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	333.61	100.0
2	**25**	0	0	0.0	333.61	100.0
3	**20**	74.21	74.21	22.2	259.4	77.8
4	**10**	30.25	104.46	31.3	229.15	68.7
5	**4.75**	29.83	134	40.3	199.32	59.7
8	**2.36**	14.16	148.45	44.5	185.16	55.5
16	**1**	24.57	173.02	51.9	160.59	48.1
30	**0.425**	50.83	223.85	67.1	109.76	32.9
50	**0.212**	34.11	257.96	77.3	75.65	22.7
100	**0.15**	33.44	291.4	87.3	42.21	12.7
200	**0.063**	35.72	327.12	98.1	6.49	1.9
Total weight sieved through #200				6.49		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				334	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.9%	4.6%	18.0%	10.4%	13.2%	5.4%	46.4%

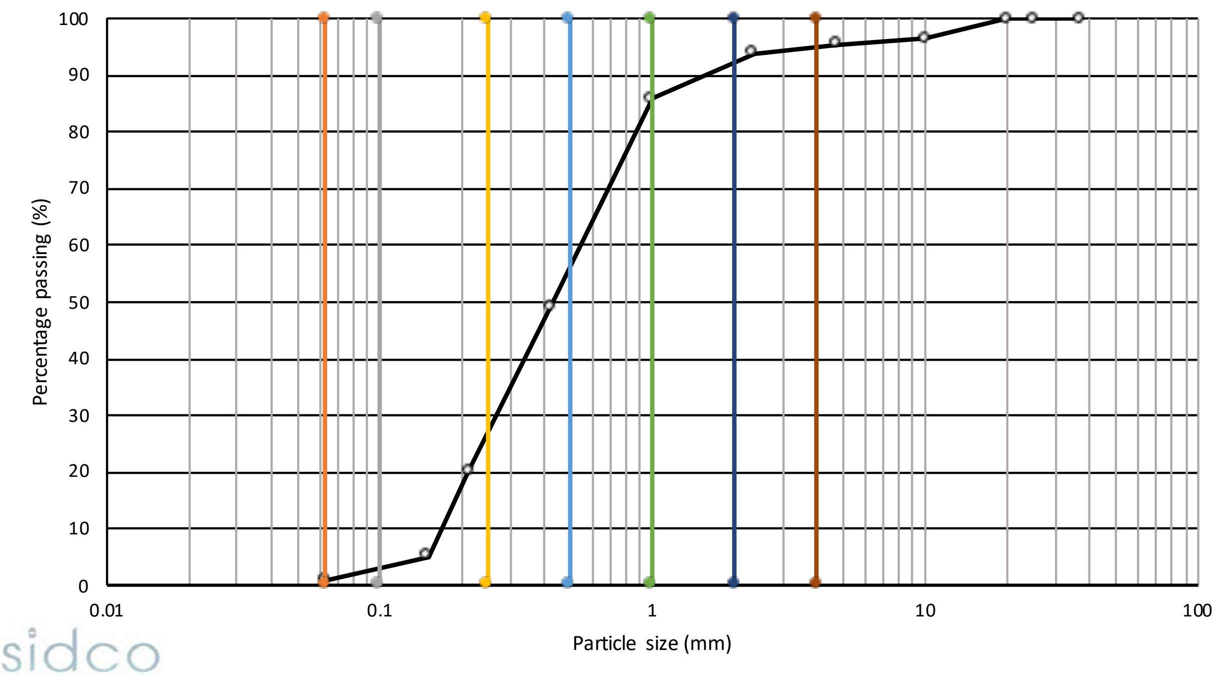
Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**		Hewage	
	Depth (m)	0.0 m		**Test #**	**TP-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	231.78	100.0
2	**25**	0	0	0.0	231.78	100.0
3	**20**	0	0	0.0	231.78	100.0
4	**10**	8.45	8.45	3.6	223.33	96.4
5	**4.75**	2.25	11	4.6	221.08	95.4
8	**2.36**	3.64	14.34	6.2	217.44	93.8
16	**1**	18.59	32.93	14.2	198.85	85.8
30	**0.425**	84.92	117.85	50.8	113.93	49.2
50	**0.212**	66.97	184.82	79.7	46.96	20.3
100	**0.15**	34.95	219.77	94.8	12.01	5.2
200	**0.063**	9.96	229.73	99.1	2.05	0.9
Total weight sieved through #200				2.05		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				232	Error (%)	
Remarks						
C_u= 4.3375 C_c=0.7292						
Technician		Computed by		Checked by		



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
0.9%	1.8%	22.7%	28.5%	31.9%	5.9%	8.3%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	0.5 m	**Test #**	**TP-2**

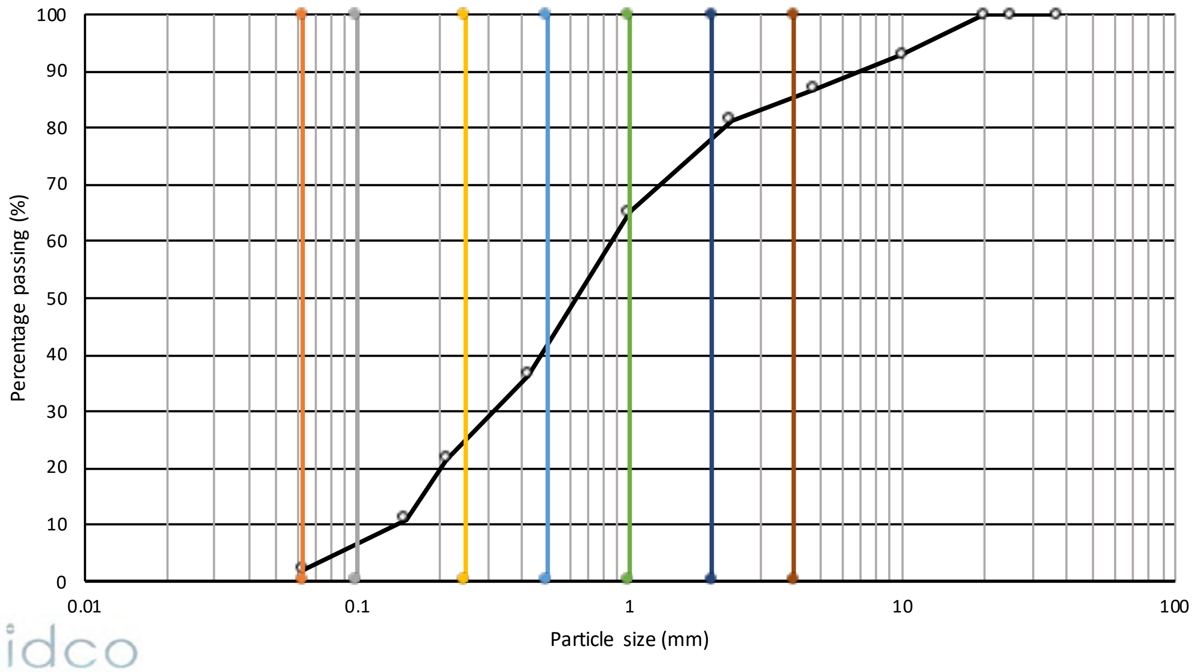
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	269.29	100.0
2	**25**	0	0	0.0	269.29	100.0
3	**20**	0	0	0.0	269.29	100.0
4	**10**	19.33	19.33	7.2	249.96	92.8
5	**4.75**	16.12	35	13.2	233.84	86.8
8	**2.36**	14.90	50.35	18.7	218.94	81.3
16	**1**	43.47	93.82	34.8	175.47	65.2
30	**0.425**	77.21	171.03	63.5	98.26	36.5
50	**0.212**	40.28	211.31	78.5	57.98	21.5
100	**0.15**	28.14	239.45	88.9	29.84	11.1
200	**0.063**	24.43	263.88	98.0	5.41	2.0
Total weight sieved through #200				5.41		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				269	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.0%	3.9%	18.3%	16.0%	24.9%	11.9%	23.0%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

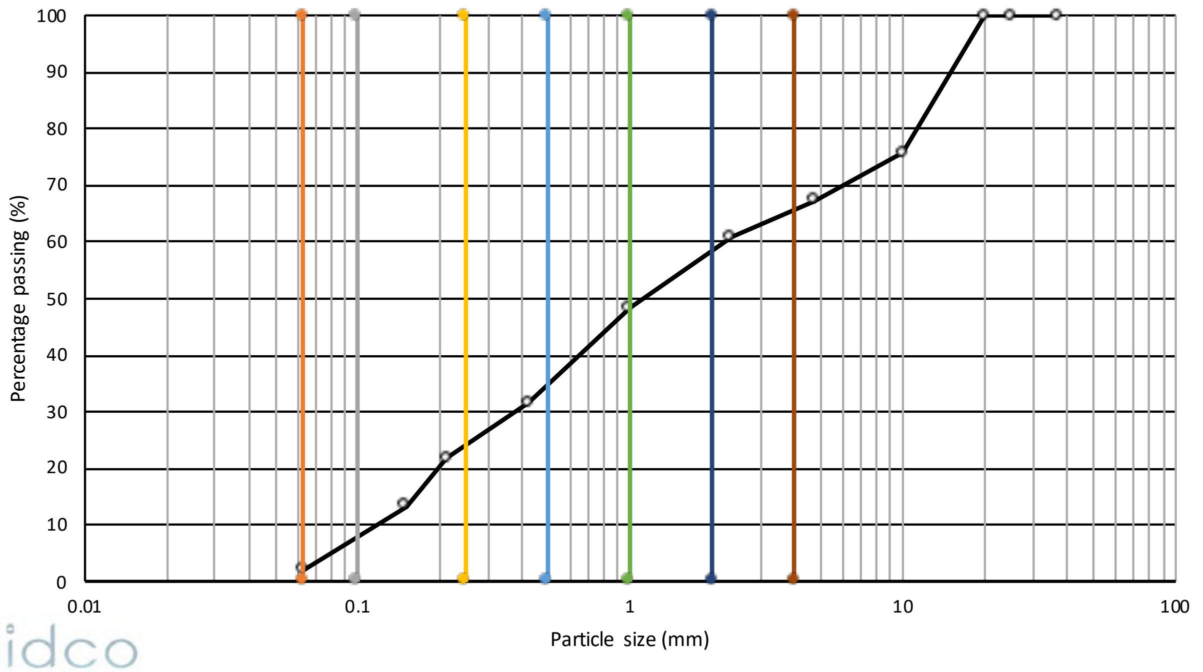
Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	1.0 m	**Test #**	**TP-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	324.11	100.0
2	**25**	0	0	0.0	324.11	100.0
3	**20**	0	0	0.0	324.11	100.0
4	**10**	78.67	78.67	24.3	245.44	75.7
5	**4.75**	27.31	106	32.7	218.13	67.3
8	**2.36**	21.28	127.26	39.3	196.85	60.7
16	**1**	40.00	167.26	51.6	156.85	48.4
30	**0.425**	55.02	222.28	68.6	101.83	31.4
50	**0.212**	31.21	253.49	78.2	70.62	21.8
100	**0.15**	27.16	280.65	86.6	43.46	13.4
200	**0.063**	37.03	317.68	98.0	6.43	2.0
Total weight sieved through #200				6.43		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				324	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.0%	4.9%	16.7%	10.1%	14.8%	9.1%	42.5%

Maldives Engineering Research Laboratories

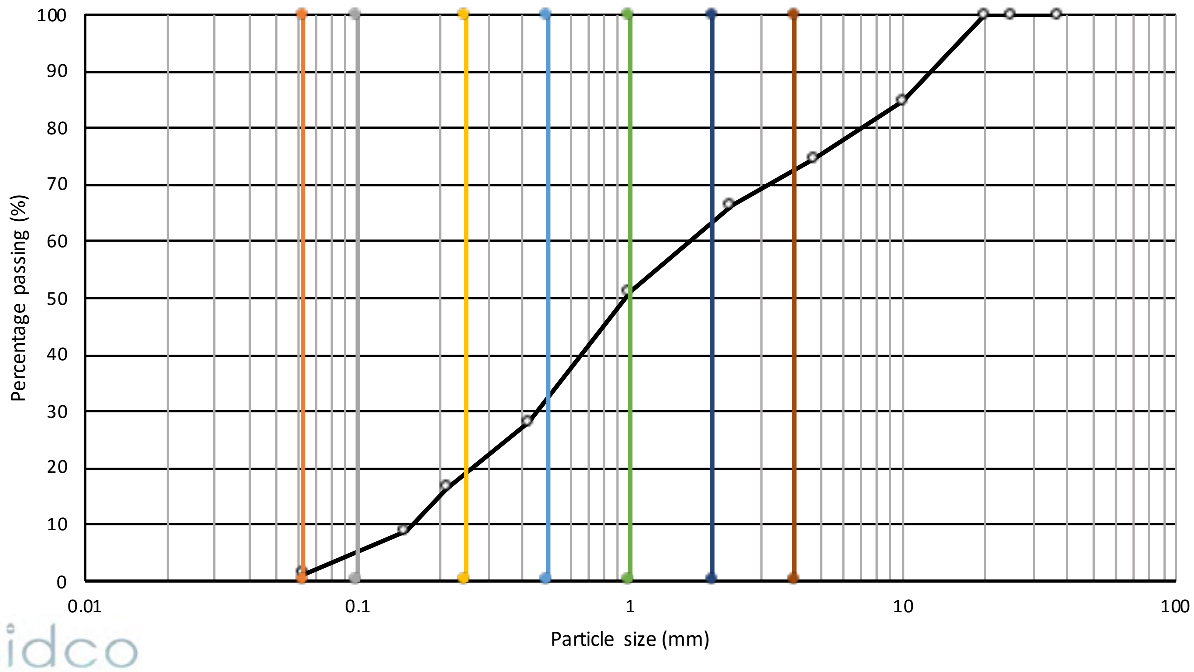
H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	1.5 m	**Test #**	**TP-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	295.65	100.0
2	**25**	0	0	0.0	295.65	100.0
3	**20**	0	0	0.0	295.65	100.0
4	**10**	45.56	45.56	15.4	250.09	84.6
5	**4.75**	29.71	75	25.5	220.38	74.5
8	**2.36**	24.16	99.43	33.6	196.22	66.4
16	**1**	45.54	144.97	49.0	150.68	51.0
30	**0.425**	67.94	212.91	72.0	82.74	28.0
50	**0.212**	33.99	246.9	83.5	48.75	16.5
100	**0.15**	22.71	269.61	91.2	26.04	8.8
200	**0.063**	22.57	292.18	98.8	3.47	1.2
Total weight sieved through #200				3.47		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				296	Error (%)	
Remarks						
C_u= 4.3375 C_c=0.7292						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.2%	3.2%	14.1%	12.4%	20.0%	11.3%	37.7%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Project:	Lh. Hinnavaru			**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage		
	Depth (m)	2.0 m		**Test #**	**TP-2**

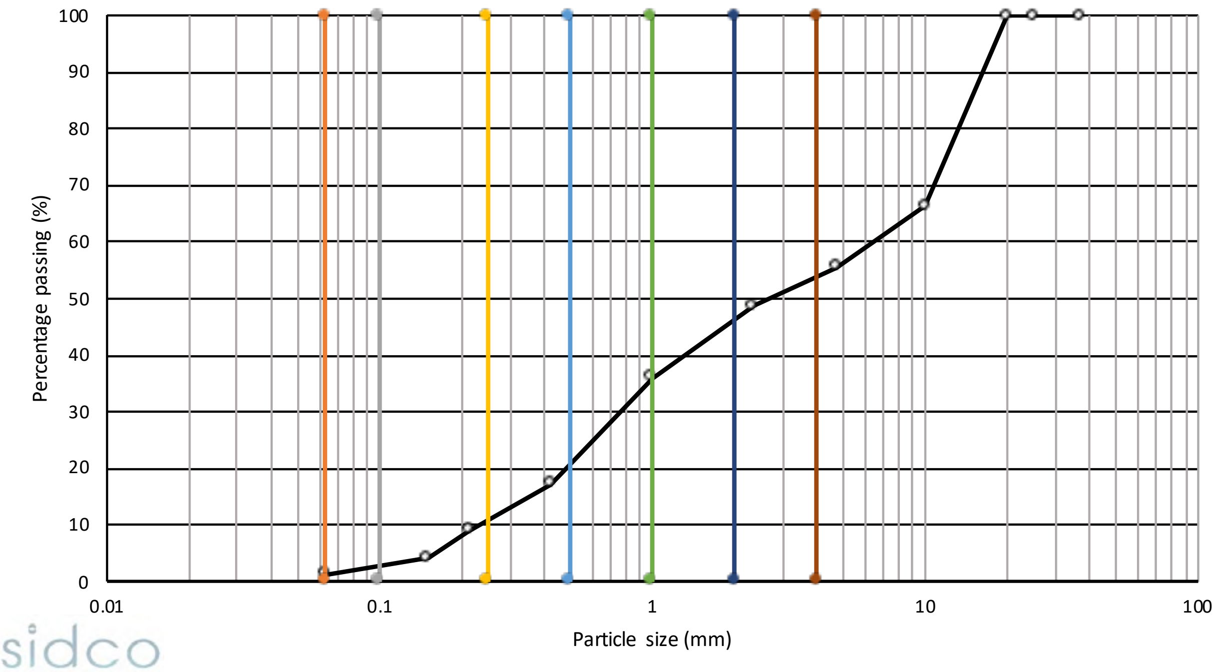
Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	366.07	100.0
2	**25**	0	0	0.0	366.07	100.0
3	**20**	0	0	0.0	366.07	100.0
4	**10**	123.05	123.05	33.6	243.02	66.4
5	**4.75**	39.54	163	44.4	203.48	55.6
8	**2.36**	25.42	188.01	51.4	178.06	48.6
16	**1**	46.14	234.15	64.0	131.92	36.0
30	**0.425**	68.96	303.11	82.8	62.96	17.2
50	**0.212**	29.58	332.69	90.9	33.38	9.1
100	**0.15**	18.12	350.81	95.8	15.26	4.2
200	**0.063**	10.85	361.66	98.8	4.41	1.2
Total weight sieved through #200				4.41		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				366	Error (%)	

Remarks

C_u= 4.3375

C_c=0.7292

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.2%	1.3%	8.1%	9.1%	16.4%	9.3%	54.7%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

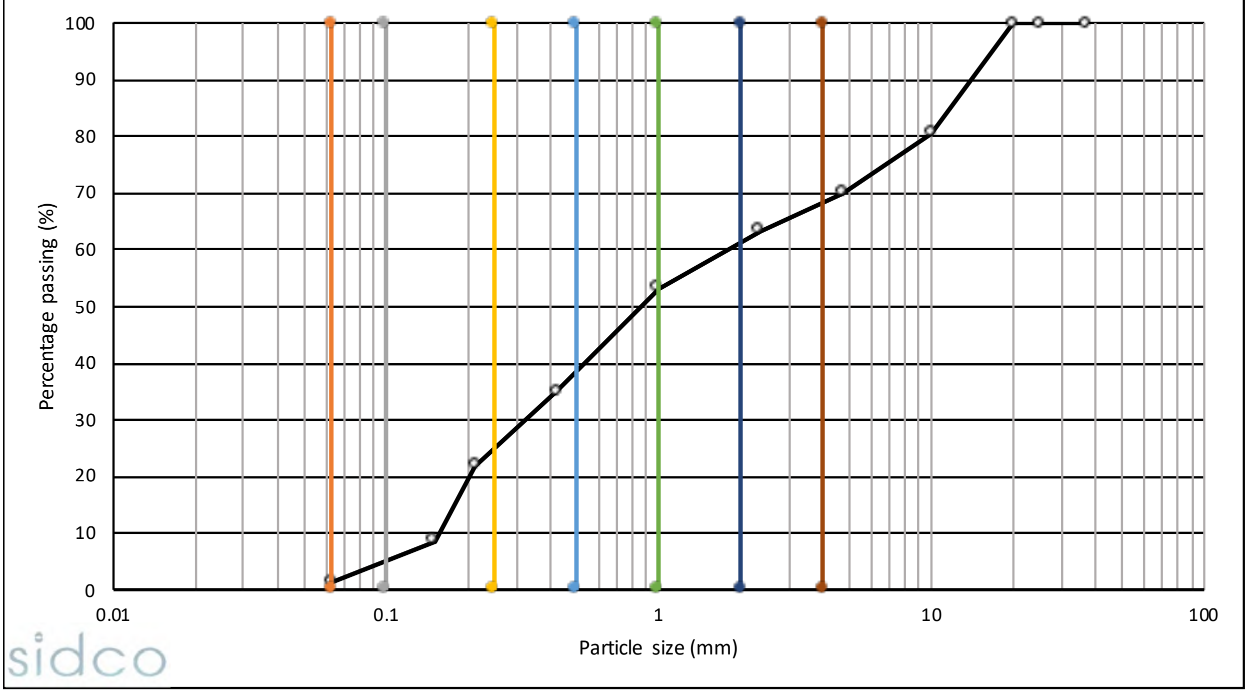
Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	2.5m	**Test #**	**TP-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	299.82	100.0
2	**25**	0	0	0.0	299.82	100.0
3	**20**	0	0	0.0	299.82	100.0
4	**10**	58.43	58.43	19.5	241.39	80.5
5	**4.75**	31.76	90	30.1	209.63	69.9
8	**2.36**	19.49	109.68	36.6	190.14	63.4
16	**1**	30.77	140.45	46.8	159.37	53.2
30	**0.425**	54.48	194.93	65.0	104.89	35.0
50	**0.212**	39.26	234.19	78.1	65.63	21.9
100	**0.15**	39.87	274.06	91.4	25.76	8.6
200	**0.063**	21.68	295.74	98.6	4.08	1.4
Total weight sieved through #200				4.08		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				300	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
1.4%	3.1%	19.8%	13.1%	15.8%	7.5%	39.3%

Maldives Engineering Research Laboratories

H. Andhunge, Raivilla Magu, 20049
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

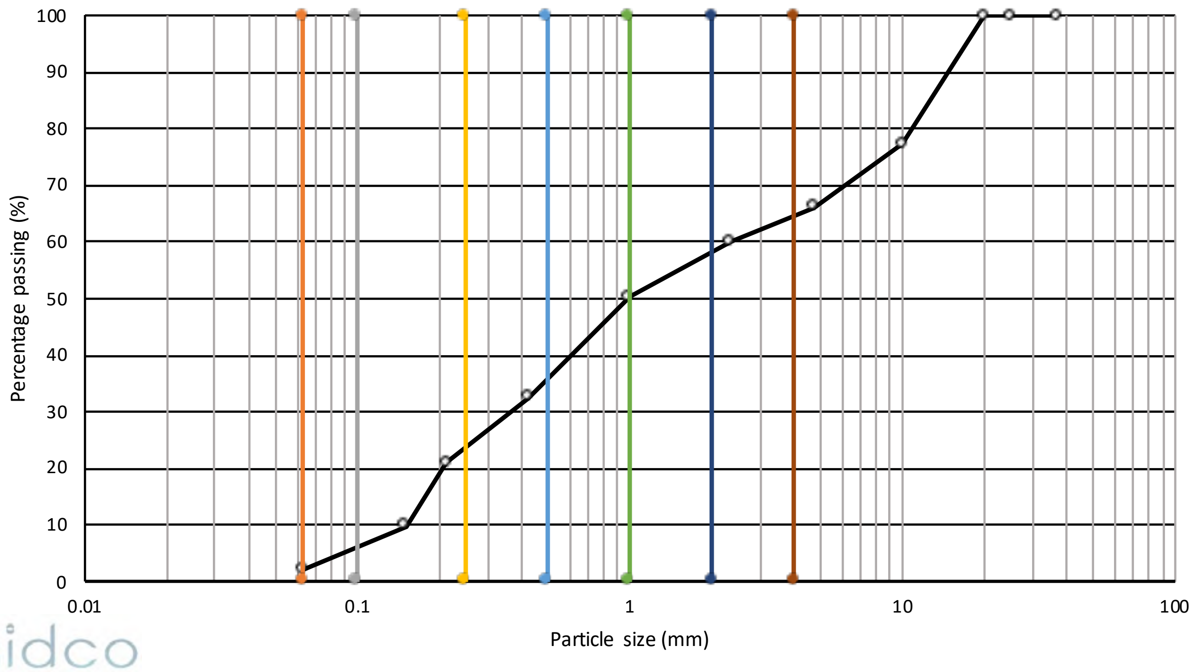
Project:	Lh. Hinnavaru		**File #:**	
Date:	Sunday, 12 March 2023	**Tested by:**	Hewage	
	Depth (m)	3m	**Test #**	**TP-2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	341.58	100.0
2	**25**	0	0	0.0	341.58	100.0
3	**20**	0	0	0.0	341.58	100.0
4	**10**	77.77	77.77	22.8	263.81	77.2
5	**4.75**	37.75	116	33.8	226.06	66.2
8	**2.36**	21.19	136.71	40.0	204.87	60.0
16	**1**	33.29	170	49.8	171.58	50.2
30	**0.425**	60.44	230.44	67.5	111.14	32.5
50	**0.212**	39.76	270.2	79.1	71.38	20.9
100	**0.15**	37.90	308.1	90.2	33.48	9.8
200	**0.063**	26.26	334.36	97.9	7.22	2.1
Total weight sieved through #200				7.22		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				342	Error (%)	

Remarks

C_u= 4.3375
C_c=0.7292

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.1%	3.3%	17.6%	11.9%	15.4%	7.2%	42.6%

APPENDIX 6: PROCTOR TEST RESULT

SIDCO PVT LTD

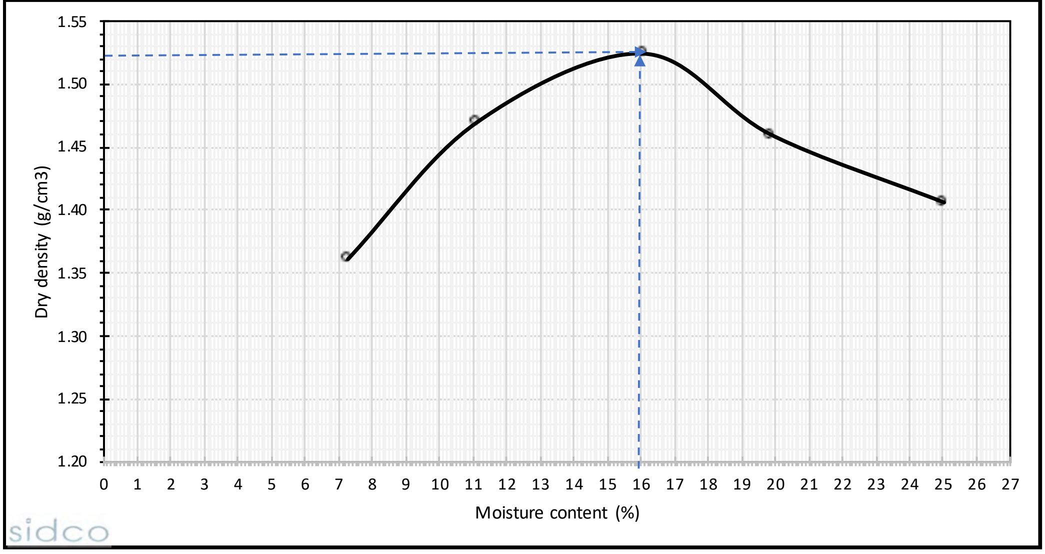
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**Lh. Hinnavaru**	**Date:**	**10/03/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.6	
Water dennsity, γw	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4909.00	5082.00	5218.00	5199.00	5207.00
weight of compacted soil, w2-w1 (g)	1460.00	1633.00	1769.00	1750.00	1758.00
Wet density, γb = ((w2-w1)/v), g/cm3	1.46	1.63	1.77	1.75	1.76
Dry density, γd = (γb/(1+(w/100))), g/cm3	**1.36**	**1.47**	**1.52**	**1.46**	**1.41**
Void Ratio e = ((Gsγw)/γd-1	1.91	1.77	1.71	1.78	1.85
Moisture content					
Weight of container, g	30.05	30.12	29.98	30.10	29.95
Weight of container + wet soil, g	68.7	70.2	60.0	63.5	72.3
Wet container + dry soil, g	66.09	66.20	55.82	57.92	63.83
Weight of moisture, ww (g)	2.62	4.01	4.15	5.53	8.48
Weight of dry soil, ws (g)	36.04	36.08	25.84	27.82	33.88
Water content, w= ((ww/ws)x100), %	**7.27**	**11.11**	**16.06**	**19.88**	**25.03**



APPENDIX 7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

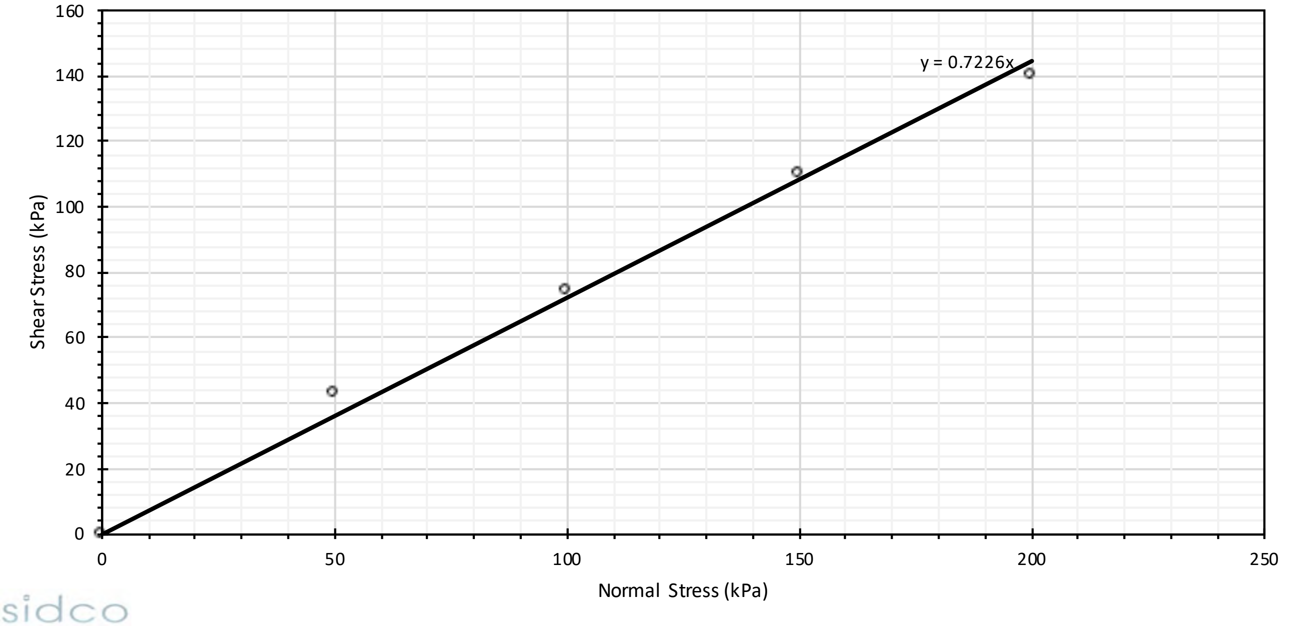
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**Lh. Hinnavaru**	**Date:**	**11/03/2023**	**Direct Shear**	**1**

Moisture content (%)	8.75%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	36	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	43.10
100.00	74.32
150.00	110.21
200.00	140.40



APPENDIX 8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**Gdh. Thinadhoo**	**Date:**	**26/01/2022**
TEST 1			
Mass of dnesity bottle	W1	31.32	g
Mass of bottle + dry sand	W2	73.45	g
Mass of bottle + dry sand + water	W3	156.78	g
Mass of bottle + water	W4	130.92	g
Specific Gravity	Gs	2.59	

TEST 2

Mass of dnesity bottle	W1	35.02	g
Mass of bottle + dry sand	W2	62.51	g
Mass of bottle + dry sand + water	W3	163.74	g
Mass of bottle + water	W4	146.68	g
Specific Gravity	Gs	2.64	

Avarege Gs		2.61	

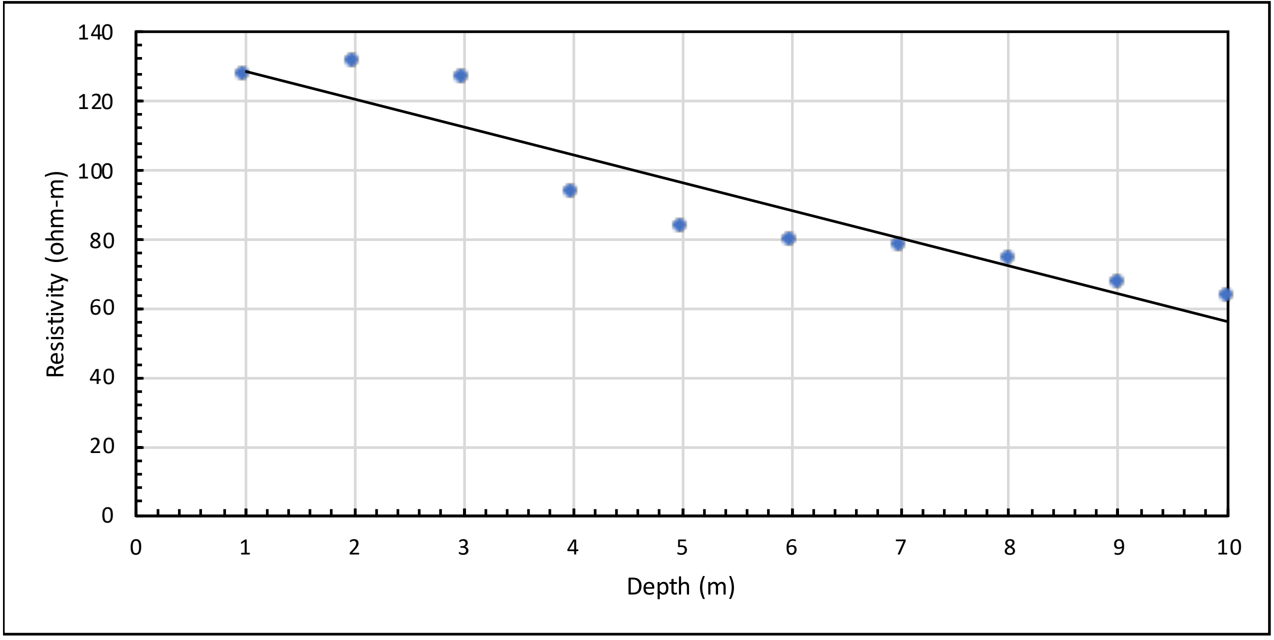
APPENDIX 9: SOIL RESITIVITY SURVEY RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

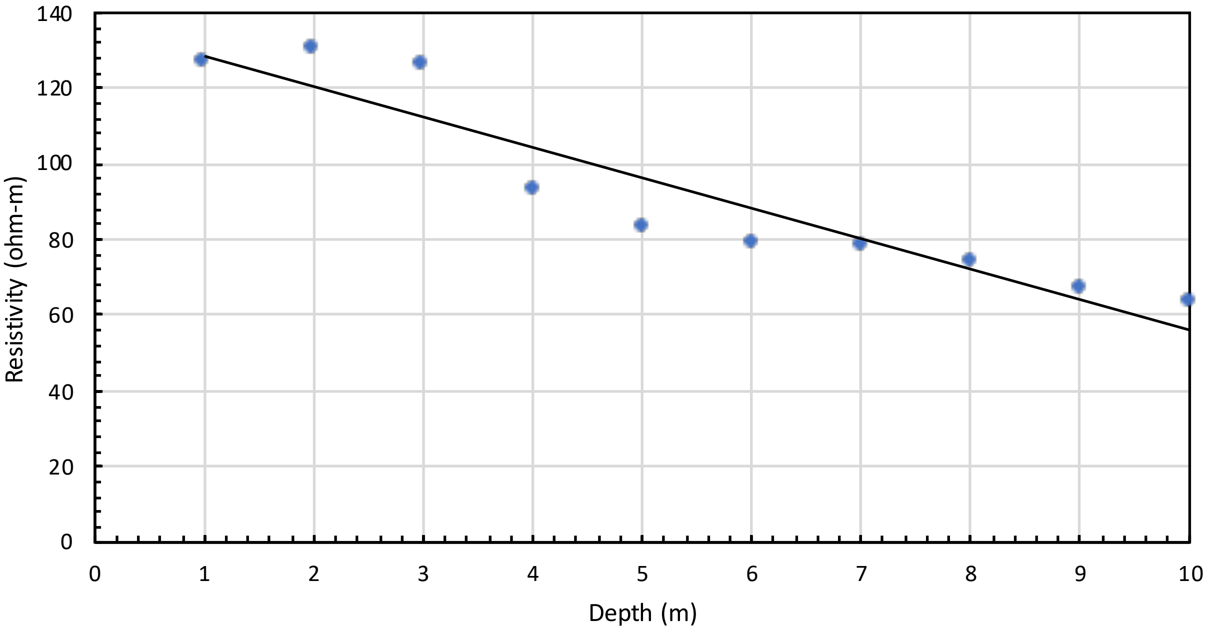
TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	20.23	127
2	2	10.41	131
3	3	6.72	127
4	4	3.72	93
5	5	2.65	83
6	6	2.10	79
7	7	1.78	78
8	8	1.48	74
9	9	1.19	67
10	10	1.01	63



Soil Resistivity Survey - Wenner Method

TEST 2

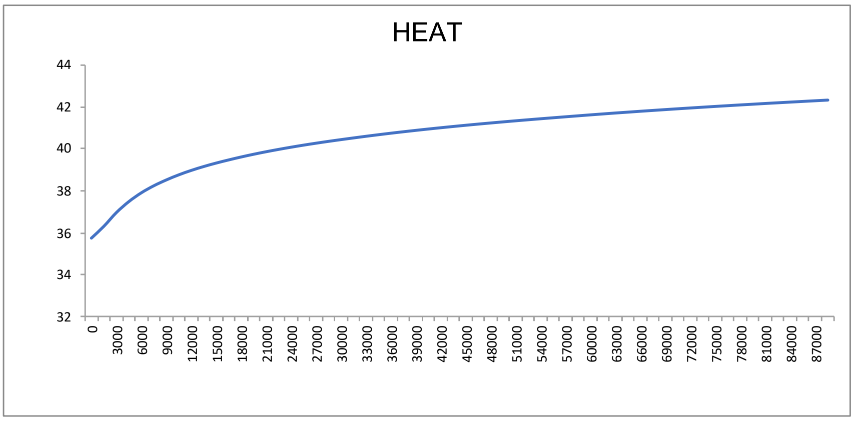
Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	18.32	115
2	2	10.21	128
3	3	6.63	125
4	4	4.08	102
5	5	3.37	106
6	6	2.86	108
7	7	2.43	107
8	8	2.19	110
9	9	1.89	107
10	10	1.67	105

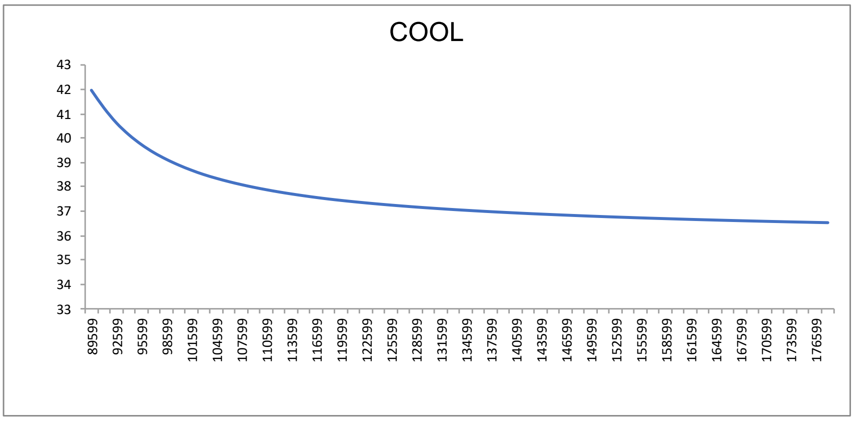


APPENDIX 10: THERMAL CONDUCTIVITY TEST RESULTS

TEST 1

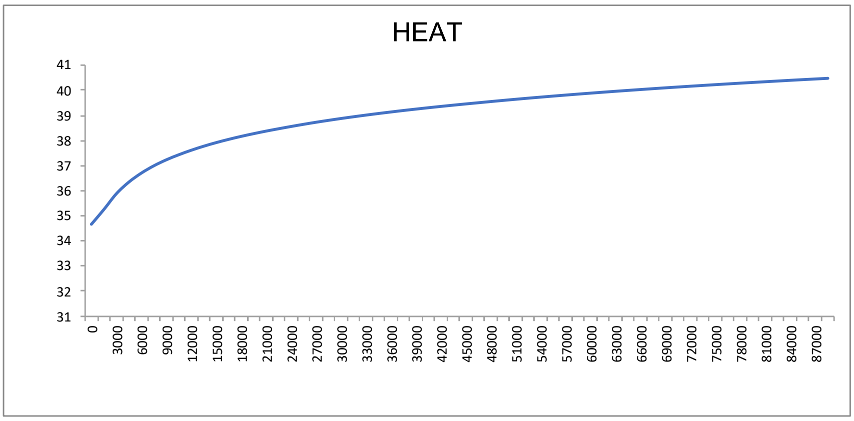
HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	35.738308		89599	41.962563
1500	36.305244		91099	41.24139
3000	36.958447		92599	40.625084
4500	37.483086		94099	40.137287
6000	37.9034		95599	39.737198
7500	38.239441		97099	39.405457
9000	38.51749		98599	39.129993
10500	38.761772		100099	38.89286
12000	38.973125		101599	38.686871
13500	39.158676		103099	38.505581
15000	39.324638		104599	38.352459
16500	39.474155		106099	38.215591
18000	39.614834		107599	38.093338
19500	39.744923		109099	37.983257
21000	39.865307		110599	37.884216
22500	39.977055		112099	37.793304
24000	40.081825		113599	37.711315
25500	40.180611		115099	37.635777
27000	40.273075		116599	37.565594
28500	40.361099		118099	37.501587
30000	40.444164		119599	37.444088
31500	40.524456		121099	37.391319
33000	40.603008		122599	37.341835
34500	40.678066		124099	37.295292
36000	40.750835		125599	37.25153
37500	40.819851		127099	37.211029
39000	40.886269		128599	37.172268
40500	40.950577		130099	37.136257
42000	41.012127		131599	37.102154
43500	41.071911		133099	37.06929
45000	41.129814		134599	37.039051
46500	41.185799		136099	37.009792
48000	41.239483		137599	36.981865
49500	41.292103		139099	36.95557
51000	41.343349		140599	36.930466
52500	41.392757		142099	36.905941
54000	41.441132		143599	36.883064
55500	41.487984		145099	36.861202
57000	41.534962		146599	36.839886
58500	41.581139		148099	36.819359
60000	41.627186		149599	36.7994
61500	41.671539		151099	36.780441
63000	41.715542		152599	36.762184
64500	41.756565		154099	36.745193
66000	41.798855		155599	36.727787
67500	41.838909		157099	36.711708
69000	41.878605		158599	36.69622
70500	41.917595		160099	36.68084
72000	41.955536		161599	36.665932
73500	41.992996		163099	36.651749
75000	42.030094		164599	36.638
76500	42.065735		166099	36.624596
78000	42.101402		167599	36.611774
79500	42.135181		169099	36.599361
81000	42.170643		170599	36.586868
82500	42.203426		172099	36.575191
84000	42.236324		173599	36.5634
85500	42.268459		175099	36.55291
87000	42.300568		176599	36.541668
88500	42.331657		178099	36.531368

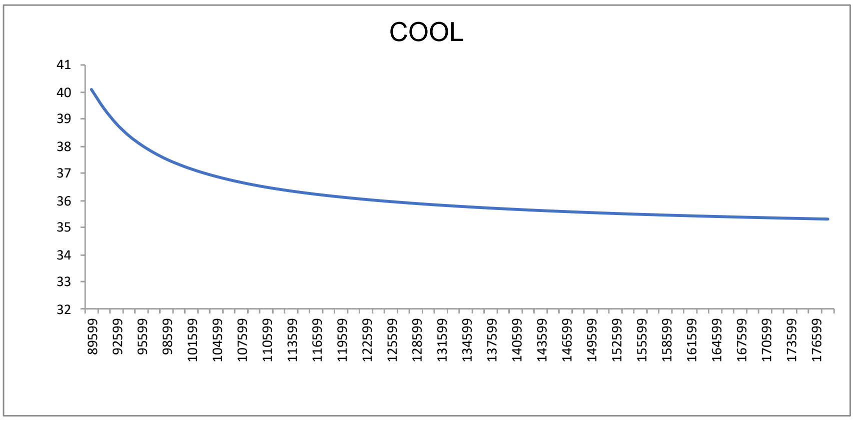




TEST 2

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	34.667244		89599	40.095104
1500	35.255363		91099	39.397137
3000	35.882328		92599	38.830383
4500	36.345619		94099	38.389172
6000	36.703606		95599	38.045219
7500	36.993618		97099	37.762032
9000	37.232204		98599	37.523899
10500	37.433758		100099	37.328403
12000	37.613537		101599	37.15942
13500	37.774055		103099	37.012455
15000	37.917606		104599	36.883064
16500	38.04707		106099	36.767765
18000	38.165417		107599	36.664993
19500	38.273865		109099	36.571644
21000	38.375553		110599	36.487812
22500	38.469086		112099	36.413986
24000	38.559467		113599	36.345921
25500	38.645592		115099	36.283566
27000	38.727512		116599	36.226013
28500	38.803761		118099	36.172928
30000	38.877048		119599	36.123909
31500	38.946064		121099	36.07761
33000	39.012642		122599	36.034069
34500	39.075912		124099	35.993244
36000	39.1367		125599	35.955662
37500	39.19585		127099	35.919682
39000	39.251366		128599	35.885227
40500	39.305664		130099	35.853138
42000	39.357807		131599	35.822903
43500	39.408146		133099	35.794334
45000	39.456974		134599	35.766422
46500	39.504173		136099	35.740131
48000	39.551712		137599	35.714905
49500	39.597691		139099	35.691593
51000	39.642429		140599	35.668598
52500	39.686176		142099	35.6465
54000	39.727882		143599	35.625465
55500	39.769291		145099	35.605938
57000	39.809299		146599	35.58654
58500	39.848473		148099	35.56797
60000	39.886517		149599	35.549992
61500	39.923832		151099	35.532959
63000	39.960251		152599	35.515976
64500	39.995571		154099	35.500134
66000	40.030075		155599	35.4851
67500	40.0644		157099	35.471031
69000	40.09811		158599	35.457119
70500	40.130199		160099	35.44389
72000	40.16235		161599	35.431011
73500	40.19334		163099	35.41851
75000	40.224106		164599	35.406475
76500	40.254082		166099	35.394619
78000	40.28397		167599	35.38269
79500	40.312263		169099	35.371964
81000	40.340988		170599	35.360764
82500	40.368732		172099	35.349941
84000	40.397148		173599	35.339993
85500	40.423836		175099	35.330669
87000	40.44994		176599	35.320248
88500	40.476048		178099	35.311142





APPENDIX 11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500195060

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **21/02/2023**
Test Requisition Form No: **900196880**
Sample(s) Recieved Date: **20/02/2023**
Date of Analysis: **20/02/2023 - 20/02/2023**

Male K

Sample Description ~	Lh.Hinnavaru 1	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83236577		
Sampled Date ~	12/02/2023 10:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	10830	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	5420	Electrometry	mg/L
Chloride	3200	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	2.4	HACH Method 8171	mg/L
Sulphate *	425	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Senior Laboratory Executive

Approved by

Nihaz A. Zahir
Assistant Quality Manager

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

sidco

MARCH 2023

Soil Investigation Report

ASPIRE PROJECT
Solar PV Installation Project
Addu Atoll

Feydhoo Harbour, Maradhoo Feydhoo Harbour, Hithadhoo Stadium & Hulhumeedhoo STP

CLIENT

HDEC

中国电建
POWERCHINA

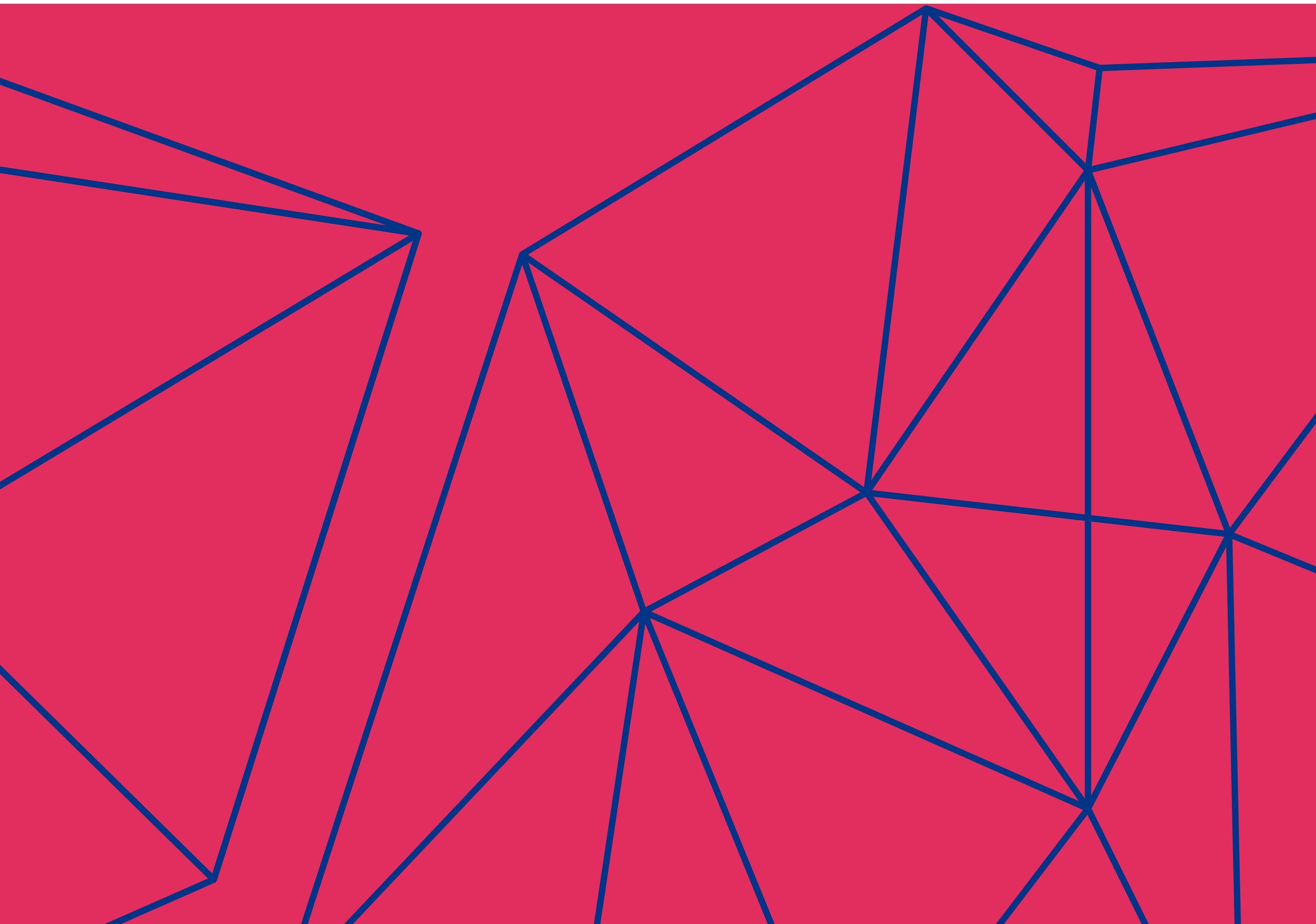


Table of Contents

1 INTRODUCTION

This report presents the results of the geotechnical investigation carried out between 10th January and 15th February 2023 in 4 sites in Addu for PowerChina HuaDong Engineering Corporation Limited. The investigation is done for the Aspire Solar PV installation Project.

1.1 OBJECTIVES AND SCOPE OF WORK

The main objective of the investigation is to determine the geotechnical properties of the project location. The scope of investigation works include:

1. Borehole / Standard Penetration Test (SPT)
2. Dynamic Cone Penetration (DCP) tests
3. Mackintosh Probe
4. Electrical Resistivity Test
5. Thermal Conductivity Test
6. Chemical analysis of ground water
7. Reporting

1.2 CODES AND STANDARDS

The investigations were conducted as per the following standards:

1. BS 5930:2015+A1:2020 Code of practice for ground investigation
2. ASTM D6951 / D6951M – 18 Standard Test Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications
3. BS EN ISO 17892-4:2016 Determination of particle size distribution
4. ASTM D5334-14 – Thermal Conductivity of Soil and Soft Rock by Thermal Needle Probe
5. ASTM G57-20 – Standard Test Method for Measurement of Soil Resistivity Using the Wenner Four-Electrode Method

2 LITERATURE REVIEW

2.1 SITE HISTORY

Solar PV is to be installed in 4 separate sites in Addu City. The sites are:

1. Feydhoo Harbour
2. Maradhoo – Feydhoo Harbour
3. Hithadhoo Football Stadium
4. Hulhumeedhoo STP

Figure 1: Map of Addu City (Google Earth)

Figure 2: Map showing Feydhoo Harbour site

Figure 3: Map showing Hithadhoo Stadium site

Figure 4: Map showing Maradhoo-Feydhoo Harbour site

Figure 5: Map showing Hulhumeedhoo STP site

2.2 GEOLOGICAL CONDITIONS

In all islands of Maldives, the coral reef formation is predominated. The top layer consists of fine calcareous sand. The strata below the reclaimed sand layer consist of un-weathered coral parent material, coral rock and coral sand. Generally, the soils found in the top layer have weakly developed structure. But some places have hard-pan layer of about 30 cm cemented with calcium carbonate. The water retention capacity of the calcareous soil is very poor due to high porosity and very high infiltration (MEE 2015).

The proposed roads for development have a flat terrain and the ground elevation is between 1 and 1.5 meters.

Typically for the islands of Maldives, the top layer (~0-3 meters) of the islands are mainly the fine coral sands that was dredged from deep sea to reclaim the land. Medium sand and coarse sand layer (~3-9 meters), coral gravel layer (~9-12 meters) and reef limestone layer (~12 meters and below) are the main constituents of the soil below the reclaimed layer.

2.3 GEOPHYSICAL CONDITIONS

Even though Maldives has faced several natural disasters in the past, it is very rare for Maldives to experience cyclones, earthquakes, and Tsunamis. According to UNDP (2006), Maldives has experienced 11 cyclones in the past 12 decades. In these events, many islands experience strong wind, heavy rain and storm surges.

Maldives is geologically located on the Indian tectonic plate where Indian Ocean ring is the main area of concern for Maldives. Large magnitude earthquakes in the subduction zones (plate boundaries near Sumatra, Indonesia and Makran coast) tend to create Tsunamis (MMS 2020). In the past 25 years, Maldives has experienced three earthquakes with the magnitude of 7.0 and the decay of peak ground acceleration for a 475 year return period is estimated (UNDP 2006). Maldives is tectonically very stable and seismic activities low. The seismic hazard Zone in Maldives was shown below.

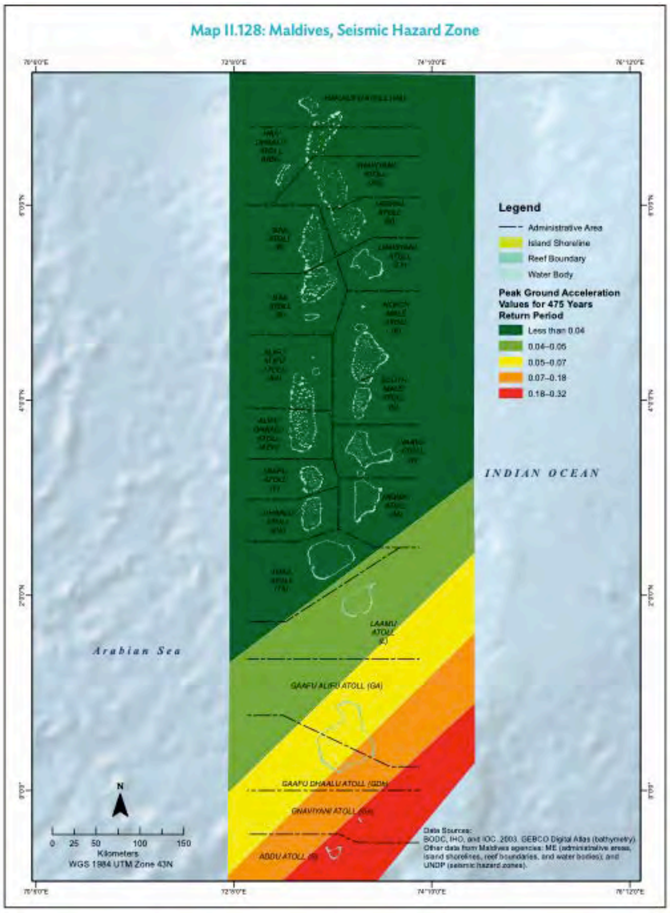


Figure 6: Seismic Hazard Zone (ADB 2020)

Addu is located in south of Maldives where peak ground acceleration value for 475 years return period is less than 0.18-0.32. This is highest risk zone in Maldives for seismic activities.

2.4 CLIMATE

This section contains general information about the project area. Data if from Department of Meteorology which has recorded that data from the weather station at S. Gan, the island which is about 12 km away from Hulhumeedhoo and is in same atoll.

The local climate is warm and humid tropical climate with average temperatures ranging between 27°C to 31°C and average relative humidity ranging from 72.2 per cent to 88.1 per cent. The mean annual rainfall in S. Gan is 2295.3 mm ranges between 1548.8 mm and 3185.7 mm between 1978 and 2006 (Zahid 2011).

The climate in Maldives is dependent upon the Indian Ocean Monsoons. Monsoon wind reversal plays a significant role in weather patterns.

The two monsoon seasons observed in the Maldives are the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The northeast monsoon is the dry season that occurs from December to February whereas the southwest monsoon is the rainy season, which lasts from May to September. The transition period of northeast monsoon occurs from October to November while that of southwest monsoon occurs between March and April.

2.5 GROUND WATER

The ground water is typically encountered at a depth of 1.0 – 1.6 m below the existing ground level depending on the tide. Since harbour is constructed on reclaimed land in lagoon, the ground water is salty and unsuitable to drink or use for construction. This makes it extremely important to take great care and adopt a corrosion resistant foundation design.

2.6 RAINFALL

Rainfall data and other meteorological data are not available for Hulhumeedhoo. The closest weather centre is located at S. Gan Airport (located at 00º41’36” S and 73º09’20” E), which is about 12 km south of Hulhumeedhoo. Therefore, data from Gan weather centre is used for the project.

The rainfall pattern in Maldives is influenced by the monsoons, where heavy rainfall in south-west monsoon (*Hulhan’gu*) from May to November followed by a transition period from December to January and dry period in north-east monsoon (*Iruvai*) from January to April with scattered rainfall.

Gan rainfall data shows a periodic pattern and annual precipitation varies from year to year with a mean rainfall of 2243.9 mm and ranging between 1548.8 mm and 3056.5 mm (Zahid 2011).

On average the maximum number of rainy days for the Addu region is 164 rainy days per calendar year. According to Zahid (2011), there is a strong correlation between the number of rainy days and the annual rainfall in Gan (CC=0.59).

In addition, the trend observed is that the number of rainy days has been decreasing without decreasing annual rainfall. This indicates that more rainfall is received over a shorter period increasing the chances of flooding due to heavy rain.

3 GEOTECHNICAL FIELD INVESTIGATION AND LABORATORY TESTING

3.1 Methods of investigation and testing

Following a review and evaluation of existing information regarding soil and material conditions for the project a field investigation and laboratory testing program has been developed and implemented.

Field investigation, sampling and laboratory testing has been designed to provide information as given below.

3.2 Field Investigation

3.2.1 Borehole Investigation / SPT

3.2.1.1 Rotatory Drilling

Boreholes shall be drilled using Rotary drilling machine. Borehole with the nominal diameter of 76 mm were be drilled using rotary drill rig. Drilling was carried out using rotary boring machine Figure 7. A metal drill bit as a cutting tool would be attached at the lower end of the drilling rods and circulated mud water pumped through the hollow rods into the bottom of borehole to stabilize the borehole and wash out the cuttings to ground surface.

Drilling was done using clear water/ bentonite water as drilling fluid. The return water from the borehole carried out the sludge and become muddy. This muddy water was kept in the surface pit and later pumped into the hole through drill rods as drilling fluid. Water would be changed when the muddy water turned too thick. As the whole circulating process was running in a closed system, no spillage and contamination of muddy water occurred throughout the drilling time.

Figure 7: Rotatory drilling machine used for boring and SPT

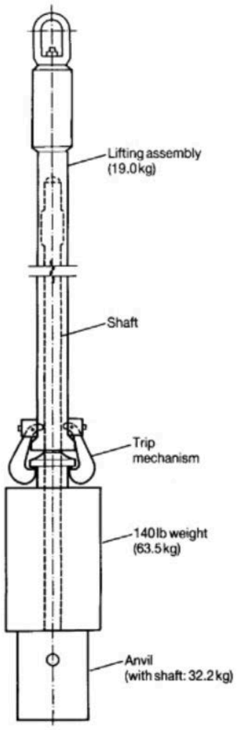


Figure 8: SPT Trip Hammer schematic diagram

3.2.1.2 Standard Penetration Test (SPT)

The 'Standard Penetration Test, commonly known as the 'SPT', was carried out in a borehole, by driving a standard 50mm O.D x 60mm long thick wall 'split spoon' sampler using repeated blows of a 63.5 kg hammer free falling through 750mm. Automatic Trip Hammer was used to do SPT test. It is designed to hammer Split Spoon Sampler with standard 63.5 kg weight with exact height of 760 mm fall. It eliminates the human error of measurement and lifting the weight and then dropping on split tube sampler. The split spoon is lowered to the bottom of the hole, and is then driven 450 mm taking SPT number for every 150 mm. At the end of driving, the split spoon is pulled from the base of the hole, and the sample is preserved in an airtight container.

The penetration resistance (N) is the number of blows required to drive the split spoon for the last 300mm of penetration. The penetration resistance during the first 150 mm of penetration is ignored, because the soil is considered to have been disturbed by the action of boring the hole.

Upon completion of test, the sampler was removed and dissembled to provide a disturbed but representative sample. These SPT samples and other disturbed samples from all soil strata were kept properly sealed, labelled, and packed in plastic bag for verification in preparing this report. The "N" values are indicated in the logs of boring. Corrected N values $(N_1)_{60}$ are also included in the logs.

The SPT tests were conducted at 1 m interval up to 3 m and then every 1.5 m intervals up to refusal.

Field log sheets will contain the soil description based on field observation, depth, and type of samples

3.2.2 Dynamic Cone Penetration Test (DCP)

DCP is to record length/blow to determine soil bearing capacity by correlation. DCP was conducted up to 2.0 m.

Drop hammer of DCP was dropped while the DCP rod was in vertical position and reading taken carefully after each blow or a suitable number of blows depending on the site condition.

Dynamic Cone Penetrometer (DCP) tests were conducted to provide an estimate of bearing capacity up to 2000 mm depth. DCP tests was conducted at 5 locations at project site. For the acquisition of relevant field data to estimate bearing capacity, DCP testing was carried out, using a Cone Penetrometer with the following characteristics that comply with ASTM D6951 / D6951M – 18:

Weight of hammer	8 kg
Height of drop of hammer	575 mm
Cone diameter	20 mm
Cone angle	60 degrees

DCP tests were performed by taking readings of cone penetration after several blows depending on the consistency of the soil layer being penetrated. At some test points, where it is suspected that the test was conducted on a stone, the tests were repeated at a new point nearby.

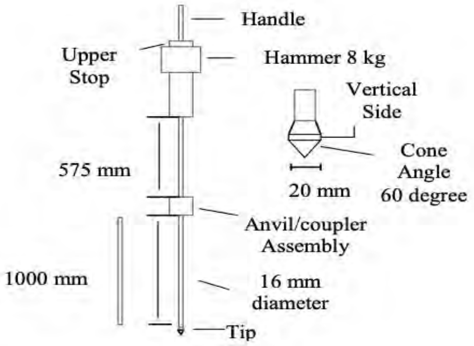


Figure 9: Schematic diagram of Dynamic Cone Penetrometer (DCP)

3.2.3 Mackintosh Probe (MP)

The mackintosh Probe (MP) is a portable and light weight penetrometer. It is generally used to investigate loose or soft soil because it is faster, cheaper and can investigate soils in difficult terrain where borehole machine is difficult and expensive to transport.

Mackintosh Probe has a 30º cone with a diameter of 27.94 mm, 12.7 mm diameter driving rods and a 4.5 kg dead weight with a standard drop height of 300 mm.

While MP is portable and inexpensive, it can only be used to investigate loose or soft soil such as peat and due to low impact energy of the weight, very high drop counts are recorded for each 0.3 m, and this may lead to wrong counting, non-consistent drop height, and equipment not being vertical. The following procedure was followed for MP testing.

1. Check cone, rods, and other equipment parts to see if everything is in good condition.
2. Assemble the equipment and distance of 0.3 m is measured and marked on the rod start from the tip of the cone. Make a mark on every 0.3 m on the driving rod.
3. The equipment is set up vertically on the ground.
4. Hammer is pulled up until it reaches the maximum and then drop freely to drive the cone into the soil.
5. The number of blows to drive rod 0.3 m into the ground is then recorded. Repeat until last 0.3 m of the rod. Then remove the hammer, connect next rod, and then place the hammer.
6. Continue hammering and recording number of blows for each 0.3 m until the blow count is more than 400 for 0.3 m penetration or the depth is reached 13.0 m.
7. The data is then plotted number of blows against depth.

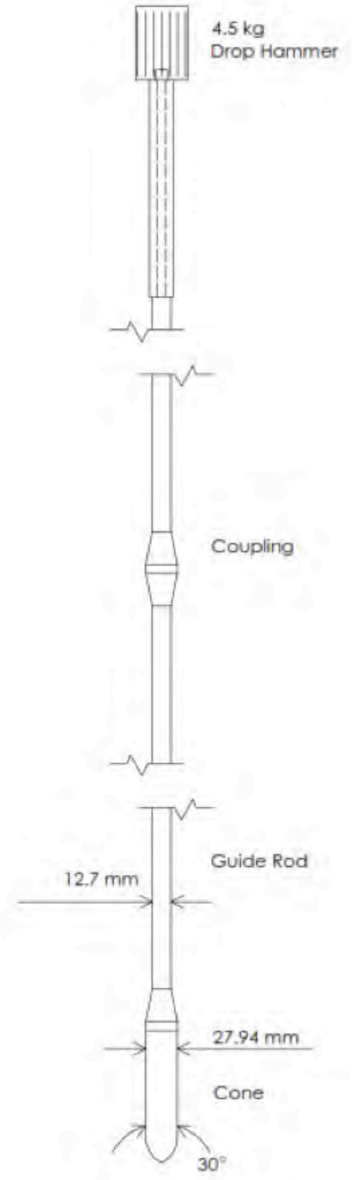


Figure 10: Schematic diagram of Mackintosh Probe

3.2.4 Electrical Resistivity (Wenner Method)

The Wenner alpha four-pin method is the most commonly used method for soil resistivity test. The test is conducted by placing four pins in-line and at equal distance and supplying a known current on the outermost electrodes and taking voltage between the interior electrodes, which is then used to calculate resistance. The depth is equal to the spacing between two pins.

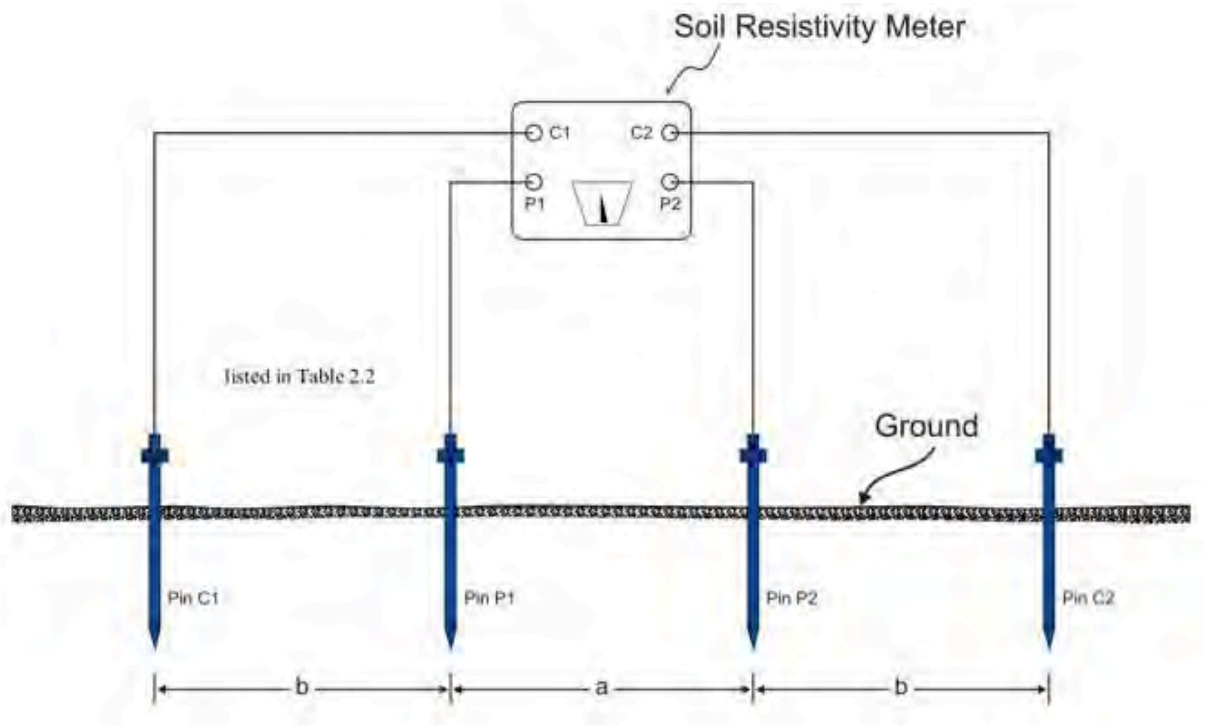


Figure 11: Wenner four pin soil resistivity test set-up

Resistivity of the soil is then computed from the instrument reading, according to the following formula:

$\rho = 2\pi AR$

ρ is the soil resistivity (ohm-m)

A is the distance between probes (m)

R is the soil resistance (ohms), instrument reading

π equals 3.1416

The tests were conducted at 1 m, 2 m, 3 m, 4 m, 5 m, 6 m, 7 m, 8 m, 9 m, and 10 m spacing between two pins to get resistivity up to 10 m depth.

Figure 12: TP4300B Soil Resistivity Meter

3.2.5 Thermal Conductivity

The soil thermal conductivity (λ) is the ratio of the magnitude of the conductive heat flux through the soil to the magnitude of the temperature gradient (W m^{-1}°C^{-1}). It is a measure of the ability of the soil to conduct heat. There are several factors which can affect the soil thermal conductivity: air-filled porosity, water content, bult density, texture, mineralogy, organic matter content, soil structure and soil temperature.

A transient line source instrument, the TLS-100 portable meter by Thermtest was used to measure soil thermal conductivity. The TLS meter follows ASTM D5334 and IEE 442-2017. The sensor needle consists of a thin heating wire and 100 mm sensor sealed in steel tube was used. The sensor was completely inserted into the soil and heat is supplied to the soil using a constant current source (q) and temperature rise is recorded over a defined period. The meter uses the slope (a) from the plot of temperature versus logarithm of time to calculate thermal conductivity (k). The higher the thermal conductivity of soil, the lower the slope.

Figure 13: TLS-100 Portable Thermal Conductivity Meter

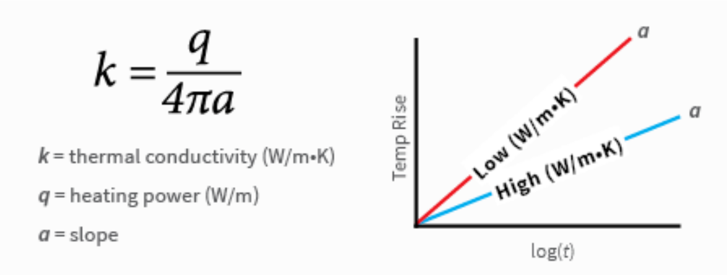


Figure 14: Thermal conductivity calculation

3.3 LABORATORY TESTING

3.3.1 Particle Size Distribution

The purpose of the particle size distribution is to determine the percentage of soil passing different sieves for classification of soils and for overall engineering characteristics indication. Dry sieve method was used in this investigation as the materials from the project site are non-cohesive granular soils. Samples were dried in an oven at 104 degrees for 24 hours and then sieved mechanically. The gradation was conducted according to BS EN ISO 17892-4.

3.3.2 Direct Shear

Since the soil is granular and difficult to get undisturbed samples, disturbed soil sample from 0.5 m depth is tested in direct shear apparatus.

Moisture content was measured since moisture content affects cohesion. Test was conducted at in-situ moisture content in drained condition.

Normal stress of 50, 100, 150 and 200 kPa was applied and shear stress value measured. The graph is then plotted to calculate the angle of shear.

3.3.3 Proctor Compaction Test

The proctor compaction test is conducted to determine the compressibility of soil. The test was a laboratory test where 0.95 litre volume cylindrical mould in which the soil mass was place and compacted in 3 layers. Each layer was compacted by dropping 25 times a 2.5 kg weight falling from. An elevation of 30 cm.

The degree of compaction depends on the properties of soil, the type and energy provided by the compaction process and the water content of the soil. For each soil, maximum compression is achieved at its optimum amount of moisture content. That is, for a given compaction, a soil is reaching its maximum dry unit weight ($\gamma_{d,\ max}$), at an optimum water content (w_{opt}). A relatively dry soil increases its compressibility as water is added to it. A typical correlation between dry unit weight and moisture content is given in Figure 15.

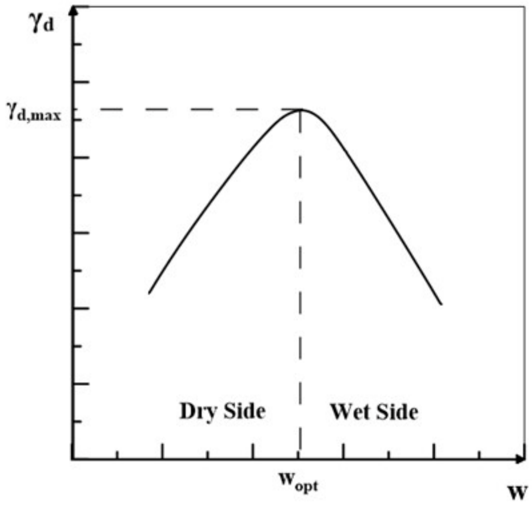


Figure 15: Effect of moisture content on the dry unit weight during compaction of a soil

As given in Figure 16, highest strength of a soil is achieved dry of optimum moisture content of a soil.

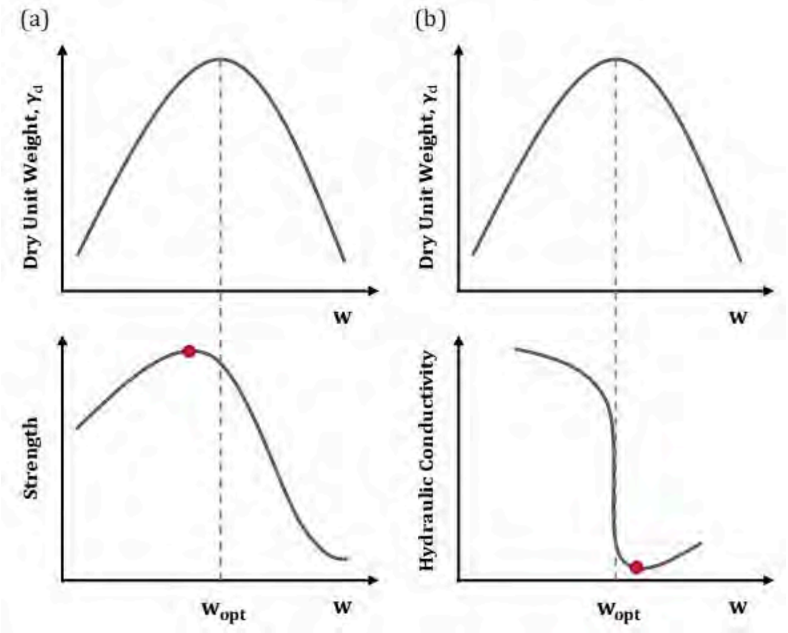


Figure 16: Effect of moisture content on soil (a) strength, and (b) hydraulic conductivity

3.3.4 Specific Gravity Test

Specific gravity (G_s) soil or relative density of soil is a measure of density of soil in comparison to the density of water. G_s is important for foundation design as it is used to determine load bearing capacity of soil. The specific gravity of soil generally ranges from 2.60 to 2.90.

Pycnometer method is used in the laboratory to measure the specific gravity of soil. The following steps were followed.

1. Weigh the pycnometer bottle and record the mass (M1)
2. Add a portion of oven dried sand into the pycnometer bottle and measure the weight (M2)
3. Add water to the pycnometer bottle (about half full) and remove all air in the sample by heating.
4. Water is added to fill pycnometer bottle completely and measure the weight (M3).
5. Empty the pycnometer of all its contents and clean it. Fill the pycnometer with water only and measure the weight (M4)

Specific Gravity is calculated using the formular below.

$$G_s = \frac{(M2 - M1)}{[(M2 - M1) - (M3 - M4)]}$$

4 Data Analysis Methods

4.1 Standard Penetration Test (SPT)

4.1.1 SPT N Corrections

According to Skempton (1986) that the penetration resistance would be significantly affected by the energy transmitted by SPT hammer and rod system and argued that SPT N values should be corrected to a common reference energy rating. Skempton (1986) proposed the use of 60% of the free fall energy as the reference energy rating. N_{60} is given as:

$$N_{60} = \frac{E_m C_B C_S C_R N}{0.60}$$

E_m= Hammer efficiency

C_B= Borehole diameter correction

C_S= Sample barrel correction

C_R= Rod length correction

N= N measured

N_{60}= SPT N-value corrected for field procedures and apparatus

Liao and Whitman (1986) proposed overburden correction to Skempton's N60 to consider increasing confinement with depth. This correction was termed as $(N_1)_{60}$ and is given as:

$$(N_1)_{60} = N_{60} \times C_N$$

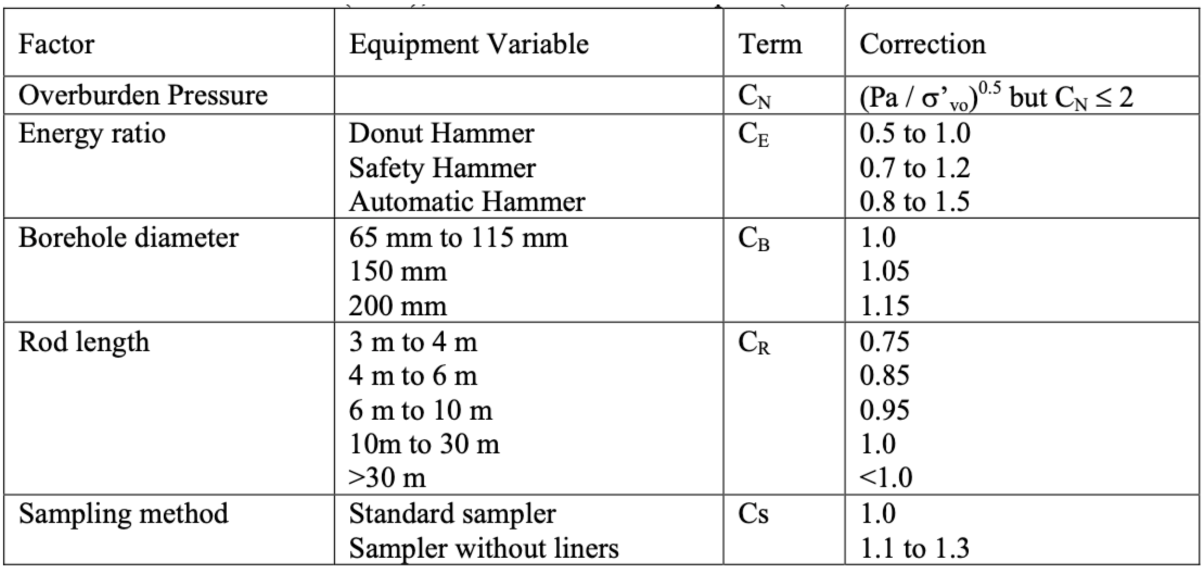
Where C_N is given as:

$$C_N = 9.78\sqrt{\frac{1}{\sigma_v'}}$$

$\boldsymbol{\sigma}'_v$ is given in kN/m^2

Robertson and Wride (1997) have modified the Skempton's correction factors chart to add the factors proposed by Liao and Whitman (1986).

Table 1: Recommended corrections for SPT N values Robertson and Wride (1997)



Factor	Equipment Variable	Term	Correction
Overburden Pressure		C_N	$(Pa / \sigma'_{vo})^{0.5}$ but $C_N \leq 2$
Energy ratio	Donut Hammer Safety Hammer Automatic Hammer	C_E	0.5 to 1.0 0.7 to 1.2 0.8 to 1.5
Borehole diameter	65 mm to 115 mm 150 mm 200 mm	C_B	1.0 1.05 1.15
Rod length	3 m to 4 m 4 m to 6 m 6 m to 10 m 10m to 30 m >30 m	C_R	0.75 0.85 0.95 1.0 <1.0
Sampling method	Standard sampler Sampler without liners	Cs	1.0 1.1 to 1.3

Below given are the tables with standardised SPT N-values for 2 boreholes.

4.1.2 Safe Bearing Capacity (SBC) for Pad Foundation

In a geotechnical investigation, calculating safe bearing capacity is utmost important. In general data from shearing of undisturbed samples, especially triaxial shearing results are considered as an accurate method. However, in non-cohesive soils, like that was found in the project sites, both corrected SPT N values are used to estimate the safe bearing capacity of soil.

4.1.2.1 SBC using $(N_1)_{60}$ values for pad foundation

One of the earliest published relationship between was proposed by Terzaghi and Peck (1967). With the accumulation field data over the time has shown the bearing capacity curves to be overly conservative. To address this Meyerhof (1976) proposed new set of equations for a 25 mm settlement. The equations are given below.

For foundation footing width ≤ 4 ft

$$q_a = \left(\frac{N}{4}\right) K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{6}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

However, the equations proposed by Meyerhof (1976) were also found to be conservative which produce similar safe bearing capacity values as equations proposed by Terzaghi and Peck (1967). Hence, Bowles (1996) adjusted the Meyerhof's equations and proposed the following equations.

For foundation footing width ≥ 4 ft

$$q_a = \left(\frac{N}{4}\right)\left[\frac{(B+1)}{B}\right]^2 K_d$$

where q_a (kip/ft^2) is the allowable bearing pressure, N is SPT number at the foundation depth and,

$$K_d = 1 + 0.33\left(\frac{D}{B}\right) \leq 1.33$$

Where D is the foundation depth and B is the foundation width.

Since Bowles (1996) showed that Meyerhof (1976) under-estimates the SBC, we have to check settlement of each bearing capacity to determine an allowable bearing capacity.

Since the soil is granular, the settlement in sand is generally the immediate settlement, unless the soil contains very high content of silt. This is because it is unlikely for porewater pressure to build up in granular soil.

Generally shallow foundation is designed for a maximum of 25 mm settlement. The bearing capacities of both Meyerhof's and Bowles' methods are calculated for a settlement limit of 25 mm. The average settlement of normally consolidated sand is calculated using Burland and Burbidge (1985) approach where average settlement is expressed as;

$$S_i = \frac{q_n B^{0.7}}{3}\left(\frac{1.71}{N^{1.4}}\right)$$

Where q_n is the net foundation pressure, B is foundation breadth and N is e $(N)_{60}$.

4.2 Dynamic Cone Penetrometer Test (DCP)

Results from DCP tests are analysed to determine CBR and then correlate to get ultimate and safe bearing capacities.

For correlation to get the CBR of soil, following equations are recommended by the US Army Corps of Engineers, where PR is the DCP penetration rate in mm per blow (Kessler Soils Engineering Products 2014).

$$CBR = \frac{292}{PR^{1.12}}$$

For analysis of shallow foundations, estimate of bearing capacity can be made from the following equation adapted from the Portland Cement Association (PCA) showing the relationship between bearing capacity and CBR (Kessler Soils Engineering Products 2014).

$$q = 3.794 \times CBR^{0.664}$$

q is the ultimate bearing capacity in psi.

Factor of safety of 2.5 is used to determine safe bearing capacity from ultimate bearing capacity.

4.3 Mackintosh Probe (MP)

The relationship between Mackintosh Probe and Safe Bearing Capacity is given below.

SBC = $(2860+550\ (R-40)^{1/2} \times 0.04788$ kN/m^2 for blow counter over 40

Refer to the chart below for blow counter below 40.

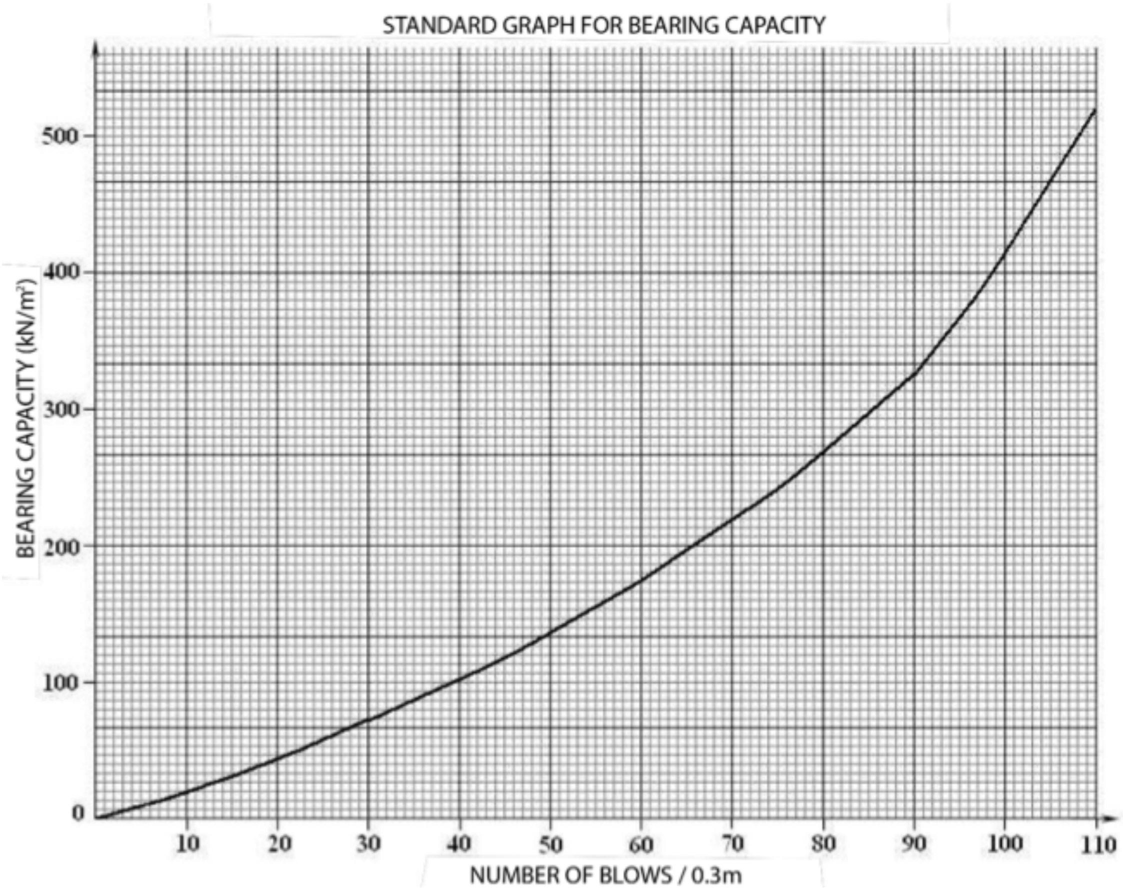


Figure 17: Standard bearing capacity graph for Mackintosh Probe

5 Results and Discussions

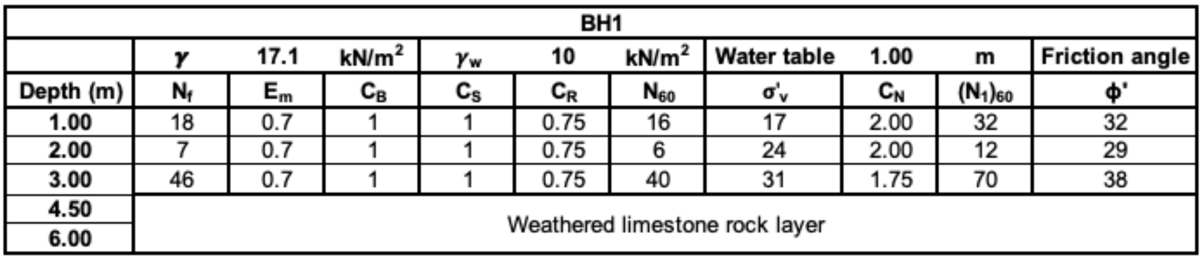
5.1 Feydhoo Harbour

5.1.1 Borehole/SPT

5.1.1.1 SPT N Corrections

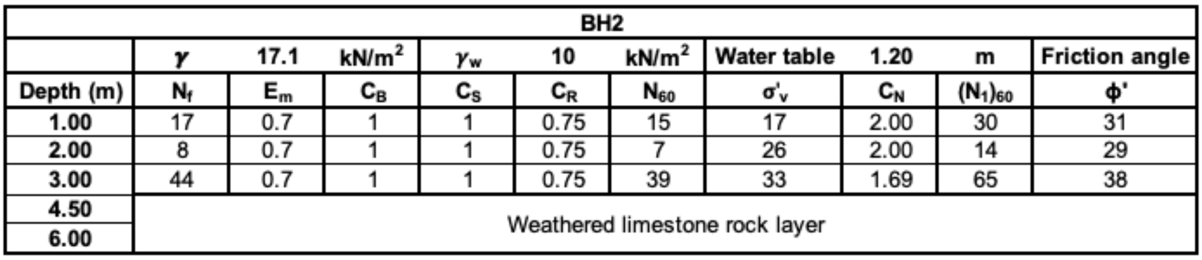
The tables below give the corrected N value and friction angle. The area reclaimed during harbour construction. While loose layer was encountered at a depth of 1-2 m, a hard rock layer was encountered at a depth of 4.0 m.

Table 2: Borehole 1 SPT N-values corrected



BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	18	0.7	1	1	0.75	16	17	2.00	32	32
2.00	7	0.7	1	1	0.75	6	24	2.00	12	29
3.00	46	0.7	1	1	0.75	40	31	1.75	70	38
4.50	Weathered limestone rock layer									
6.00										

Table 3: Borehole 2 SPT N-values corrected



BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.20	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	17	0.7	1	1	0.75	15	17	2.00	30	31
2.00	8	0.7	1	1	0.75	7	26	2.00	14	29
3.00	44	0.7	1	1	0.75	39	33	1.69	65	38
4.50	Weathered limestone rock layer									
6.00										

5.1.1.2 Safe Bearing Capacity

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 3 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 185 kPa as safe bearing capacity for foundation design.

Table 4:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.

BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	184	221
	1.0	2.00	98	147
BH2	1.0	1.00	153	185
	1.0	2.00	57	86

5.1.2 Dynamic Cone Penetrometer (DCP)

Table 5: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

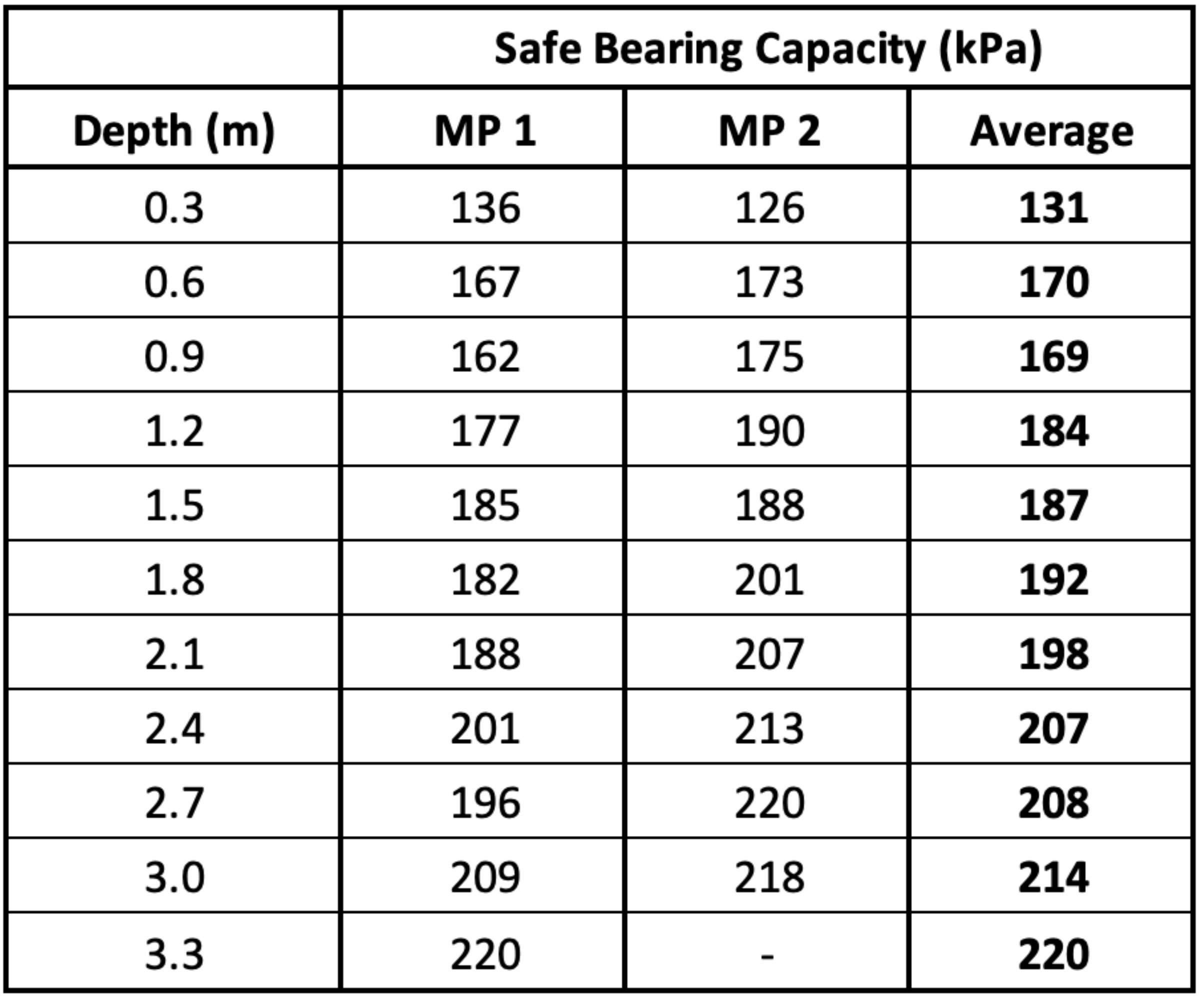
	Safe Bearing Capacity (kPa)					
Depth (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	Average
0.3	121	121	99	127	137	**121**
0.6	121	127	127	167	181	**145**
0.9	116	137	157	167	181	**152**
1.2	127	157	157	142	162	**149**
1.5	132	132	142	121	176	**141**
1.8	121	167	167	132	152	**148**
2.0	116	142	132	127	132	**130**

Table 5 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

5.1.3 Mackintosh Probe (MP)

Table 6 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 6: Safe Bearing Capacity calculated from MP results



	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	136	126	**131**
0.6	167	173	**170**
0.9	162	175	**169**
1.2	177	190	**184**
1.5	185	188	**187**
1.8	182	201	**192**
2.1	188	207	**198**
2.4	201	213	**207**
2.7	196	220	**208**
3.0	209	218	**214**
3.3	220	-	**220**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

5.1.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at S. Feydhoo Harbour area are provided in the Table 7 and Table 8. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 7: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	42.0	11.0	14.0	11.0	10.0	5.7	6.3
1.0	35.0	15.0	16.0	9.0	12.0	4.9	8.1
2.0	37.0	13.0	17.0	11.0	11.0	4.2	6.8
3.0	44.0	11.0	15.0	9.0	10.0	5.2	5.8

Table 8: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	40.0	11.0	17.0	10.0	10.0	5.6	6.4
1.0	40.0	18.0	6.0	7.0	13.0	6.5	9.5
2.0	37.0	13.0	16.0	12.0	11.0	4.2	6.8
3.0	41.0	10.0	12.0	16.0	10.0	3.9	7.1

5.1.5 Direct Shear

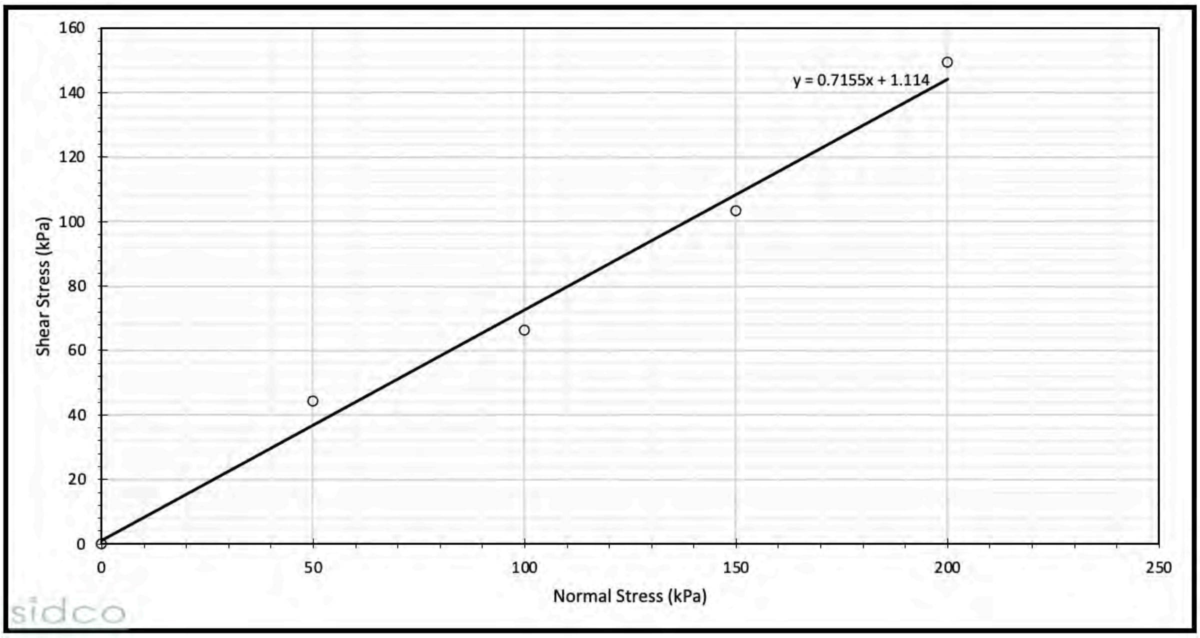


Figure 18: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 36 degrees, which is typical for carbonated sand found in Maldives.

5.1.6 Proctor Compaction Test

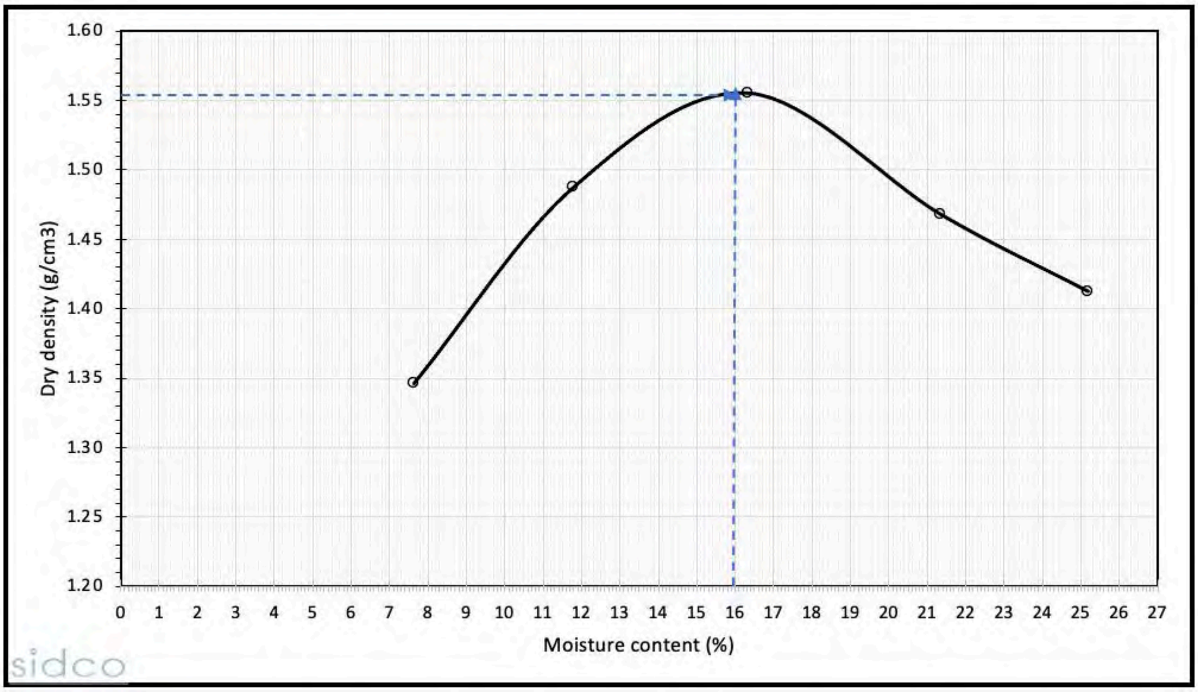
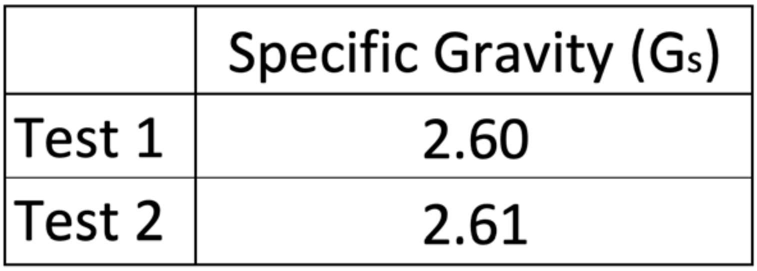


Figure 19: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.55 g/cm^3 and an optimum moisture content of 16%.

5.1.7 Specific Gravity Test

Table 9: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.60
Test 2	2.61

Table 9 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

5.1.8 Electrical Resistivity Test

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content. The tables and graphs below show ER test results.

Table 10: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	14.10	89
2	2	7.23	91
3	3	4.81	91
4	4	3.65	92
5	5	2.67	84
6	6	1.76	66
7	7	1.49	66
8	8	1.23	62
9	9	1.03	58
10	10	0.99	62

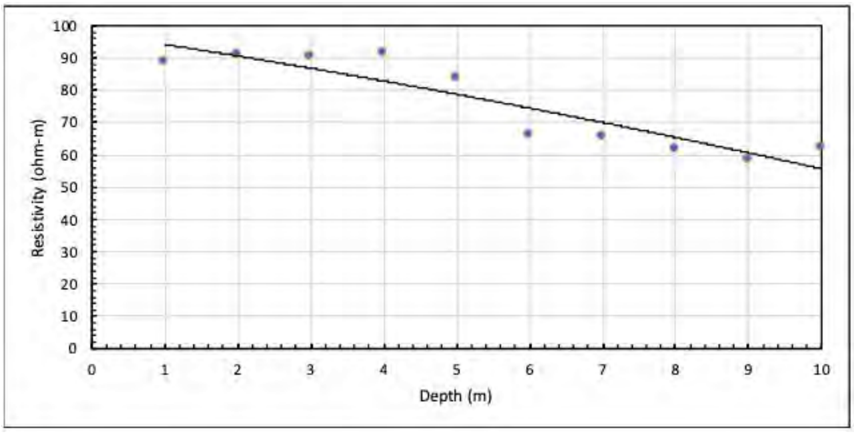


Figure 20: Resistivity graph for Test 1

Table 11: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	12.31	77
2	2	6.15	77
3	3	4.15	78
4	4	3.12	78
5	5	2.62	82
6	6	2.10	79
7	7	1.84	81
8	8	1.65	83
9	9	1.38	78
10	10	1.05	66

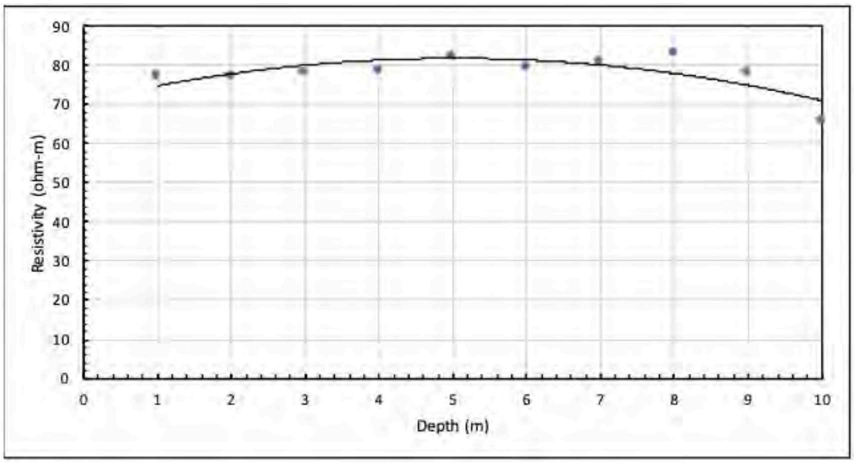


Figure 21: Resistivity graph for Test 2

Resistivity of soil remain constant up to 10 m. This could be because the area was previously shallow lagoon area which was reclaimed during harbour construction. But overall, the 76 Ohm-m resistivity provides very low resistivity and therefore:

1. Good for grounding
2. Moderately corrosive

5.1.9 Thermal Conductivity Test

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 12: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (°C)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	30.70	0.407	2.46	200
2	TLS100	33.30	0.417	2.40	200
Average		32.00	0.412	2.43	

The average thermal conductivity is 0.412 W/mK.

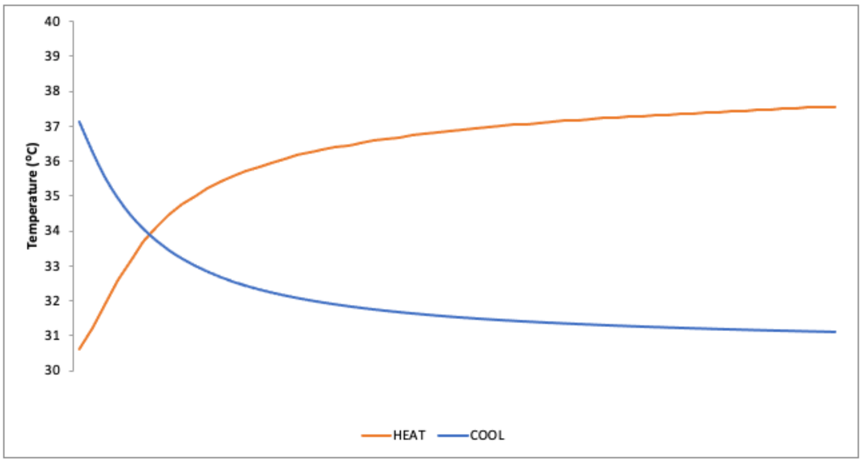


Figure 22: Heat and Colling Curve to TC Test 1

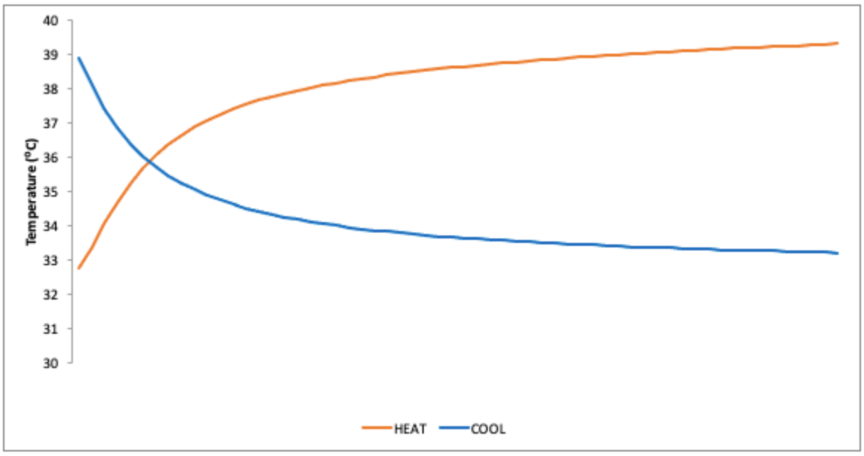
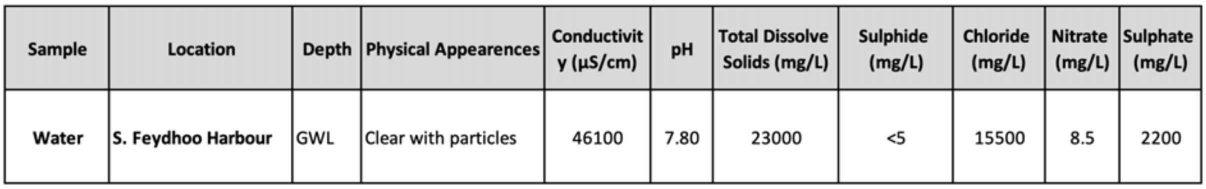


Figure 23: Heat and Colling Curve to TC Test 2

5.1.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 46100 µS/cm with a Sulphate content of 2200 mg/L, Nitrate content of 8.5 mg/L, Chloride content of 15500 mg/L and Sulphide content of <5 mg/L. This is because the project location is next to the harbour and was reclaimed during the construction of the harbour.

Table 13: Chemical test results of water sample from S. Feydhoo Harbour site



Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	S. Feydhoo Harbour	GWL	Clear with particles	46100	7.80	23000	<5	15500	8.5	2200

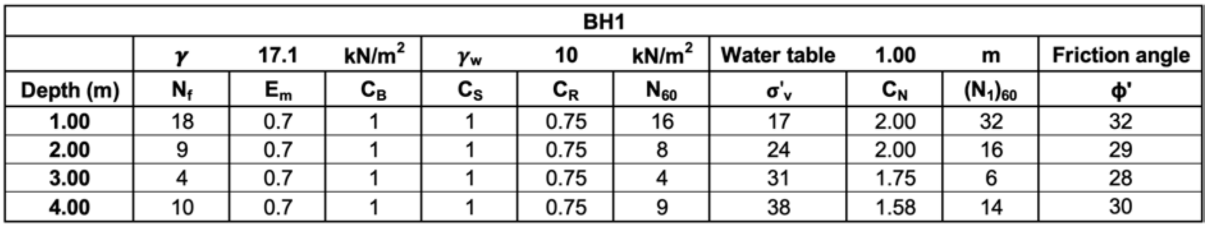
5.2 Maradhoo-Feydhoo Harbour

5.2.1 Borehole/SPT

5.2.1.1 SPT N Corrections

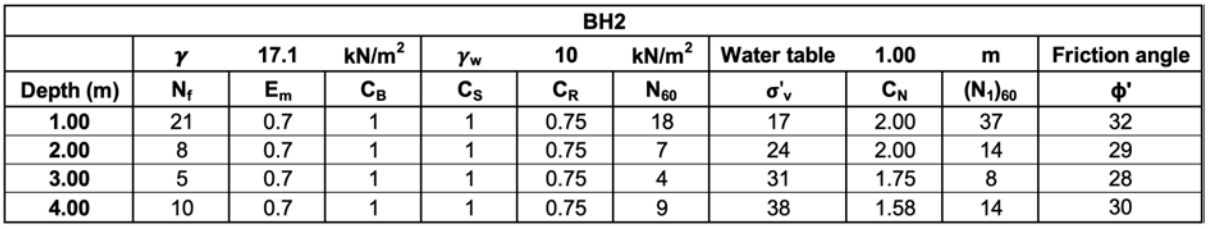
The tables below give the corrected N value and friction angle. The area reclaimed during harbour construction. While loose layer was encountered at a from the depth of 2.0 m.

Table 14: Borehole 1 SPT N-values corrected



BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	18	0.7	1	1	0.75	16	17	2.00	32	32
2.00	9	0.7	1	1	0.75	8	24	2.00	16	29
3.00	4	0.7	1	1	0.75	4	31	1.75	6	28
4.00	10	0.7	1	1	0.75	9	38	1.58	14	30

Table 15: Borehole 2 SPT N-values corrected



BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	21	0.7	1	1	0.75	18	17	2.00	37	32
2.00	8	0.7	1	1	0.75	7	24	2.00	14	29
3.00	5	0.7	1	1	0.75	4	31	1.75	8	28
4.00	10	0.7	1	1	0.75	9	38	1.58	14	30

5.2.1.2 Safe Bearing Capacity

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 3 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 197 kPa as safe bearing capacity for foundation design.

Table 16:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.

BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	163	197
	1.0	2.00	65	98
BH2	1.0	1.00	184	221
	1.0	2.00	57	86

5.2.2 Dynamic Cone Penetrometer (DCP)

Table 17: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

	Safe Bearing Capacity (kPa)					
Depth (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	Average
0.3	137	99	94	82	69	**96**
0.6	142	116	121	111	127	**123**
0.9	147	132	157	147	137	**144**
1.2	162	181	152	137	147	**156**
1.5	167	190	181	167	185	**178**
1.8	190	181	185	176	185	**183**
2.0	132	157	167	176	176	**162**

Table 5 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

5.2.3 Mackintosh Probe (MP)

Table 6 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 18: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	149	150	**150**
0.6	173	176	**175**
0.9	188	188	**188**
1.2	198	196	**197**
1.5	205	198	**202**
1.8	136	168	**152**
2.1	125	139	**132**
2.4	140	129	**135**
2.7	144	149	**147**
3.0	150	148	**149**
3.3	147	156	**152**
3.6	156	152	**154**
3.9	151	147	**149**
4.2	149	143	**146**
4.5	177	-	**177**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

5.2.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at S. Maradhoo-Feydhoo Harbour area are provided in the Table 7 and Table 8. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 19: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	47.0	12.0	5.0	13.0	11.0	4.9	7.1
1.0	38.0	6.0	25.0	9.0	9.0	5.9	7.1
2.0	47.0	13.0	10.0	9.0	10.0	4.0	7.0
3.0	48.0	12.0	9.0	9.0	10.0	5.2	6.8
4.0	49.0	10.0	9.0	7.0	10.0	8.5	6.5

Table 20: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	37.0	4.0	23.0	14.0	14.0	6.1	1.9
1.0	33.0	7.0	20.0	14.0	17.0	6.7	2.3
2.0	31.0	19.0	21.0	14.0	8.0	4.8	2.2
3.0	34.0	16.0	21.0	13.0	8.0	4.9	3.1
4.0	27.0	3.0	20.0	17.0	23.0	7.9	2.1

5.2.5 Direct Shear

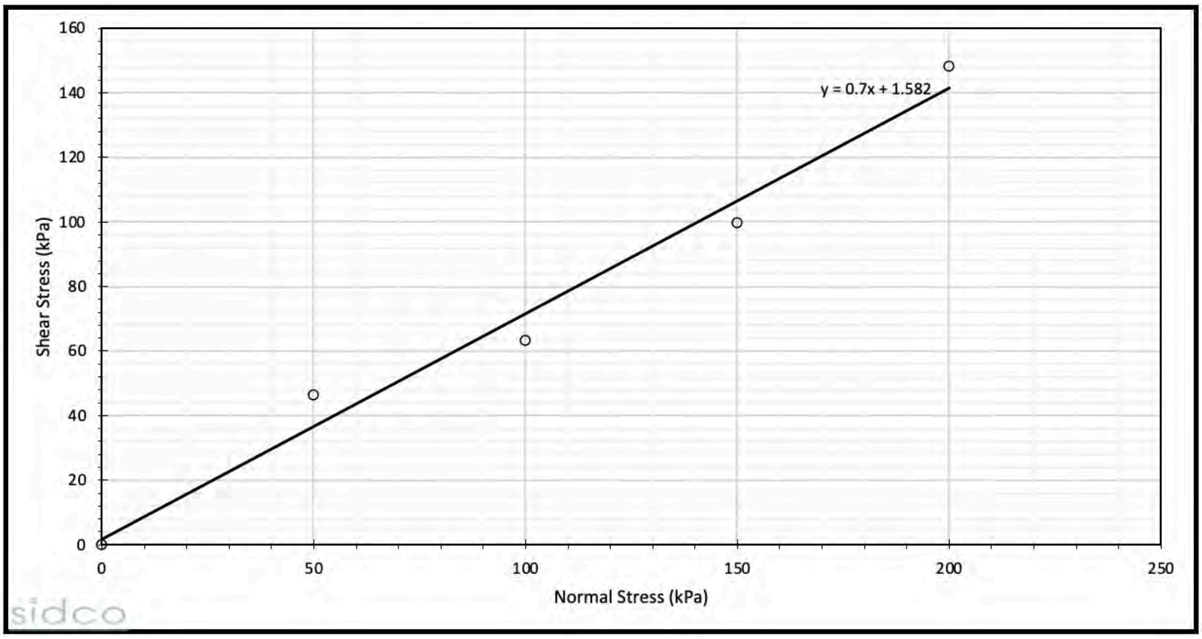


Figure 24: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 36 degrees, which is typical for carbonated sand found in Maldives.

5.2.6 Proctor Compaction Test

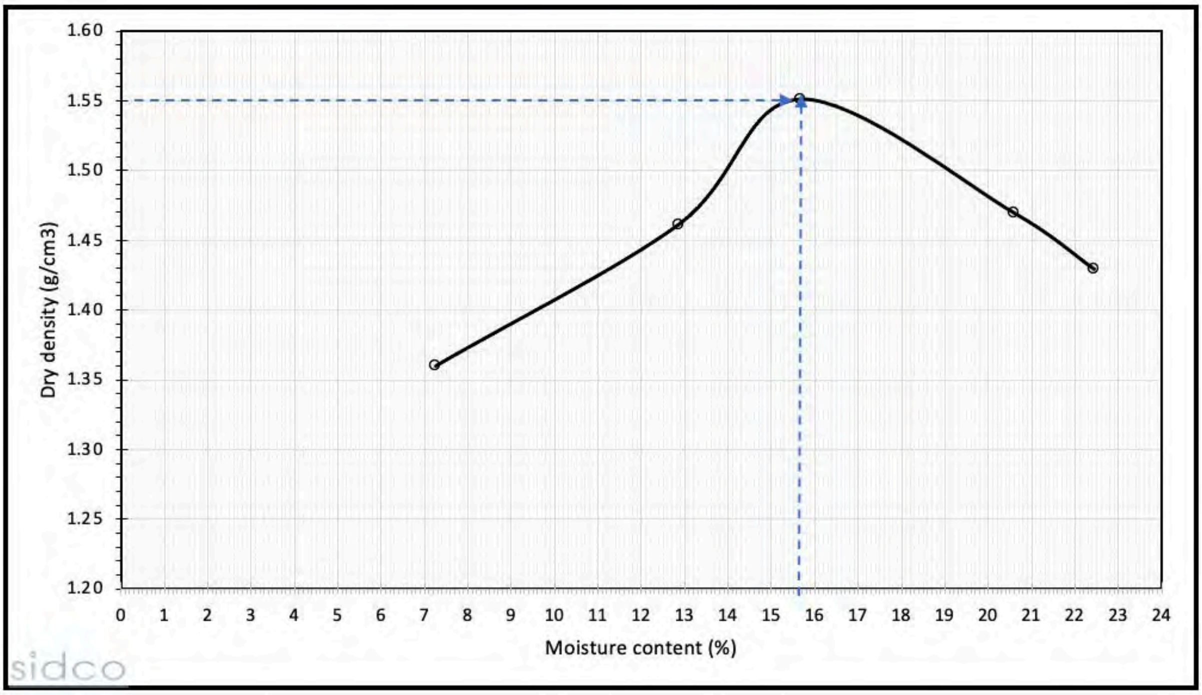
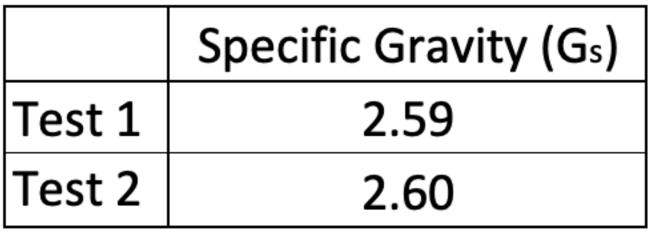


Figure 25: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.55 g/cm^3 and an optimum moisture content of 15.5%.

5.2.7 Specific Gravity Test

Table 21: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.59
Test 2	2.60

Table 9 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

5.2.8 Electrical Resistivity Test

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system.

There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content. The tables and graphs below show ER test results.

Table 22: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	28.90	181
2	2	10.80	136
3	3	7.30	138
4	4	5.65	142
5	5	4.19	132
6	6	3.76	142
7	7	3.01	132
8	8	2.65	133
9	9	1.99	112
10	10	1.46	92

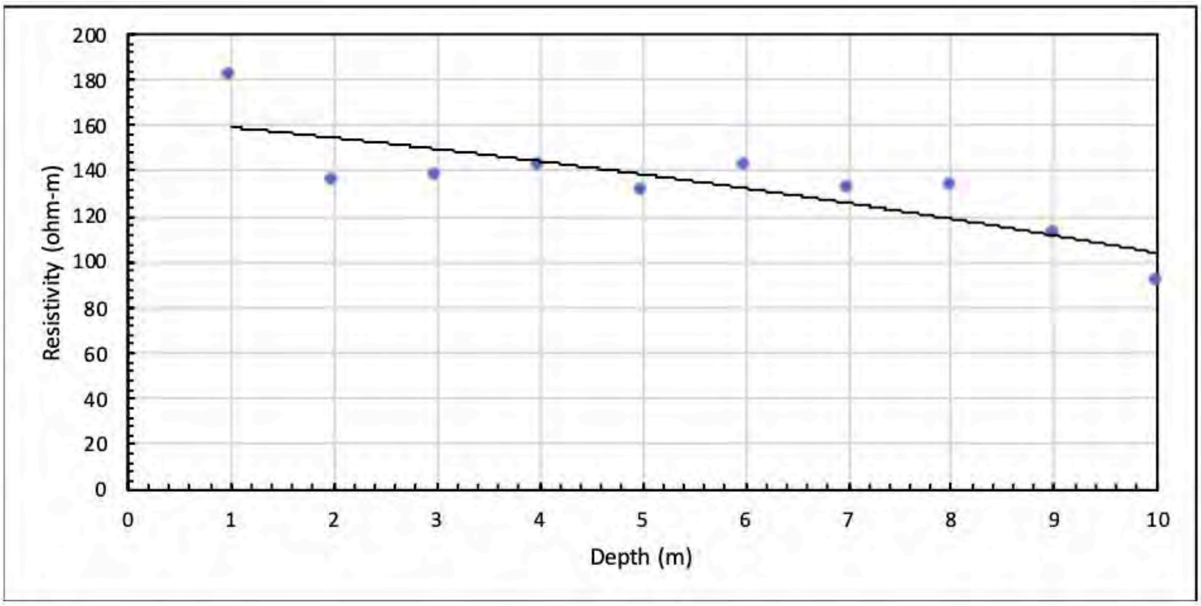


Figure 26: Resistivity graph for Test 1

Table 23: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	24.95	157
2	2	11.34	142
3	3	8.07	152
4	4	6.32	159
5	5	5.19	163
6	6	4.01	151
7	7	3.58	157
8	8	3.01	151
9	9	2.45	138
10	10	1.99	125

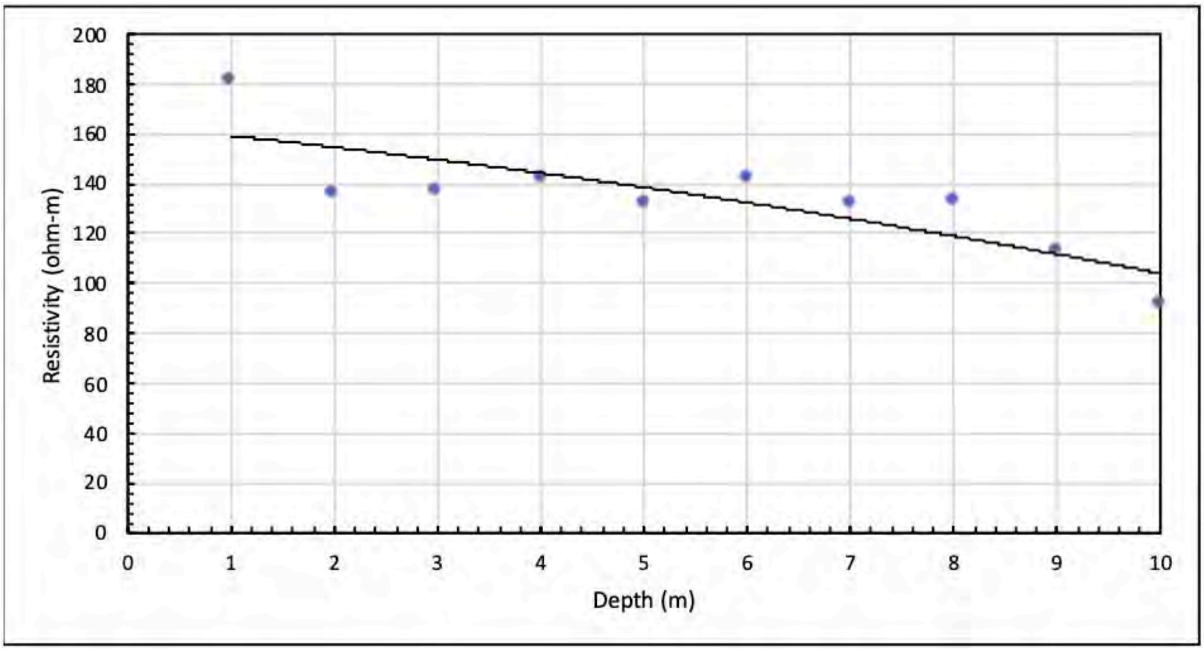


Figure 27: Resistivity graph for Test 2

Resistivity of soil decreases with depth from 180 ohm-m to 100 ohm-m. This could be because the area was previously shoreline which was reclaimed as part of harbour construction. But overall, the 100-180 Ohm-m resistivity provides low resistivity and therefore:

3. Good for grounding
4. Moderately corrosive

5.2.9 Thermal Conductivity Test

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 24: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (°C)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	32.50	0.206	4.85	200
2	TLS100	32.30	0.210	4.76	200
Average		32.40	0.208	4.81	

The average thermal conductivity is 0.481 W/mK.

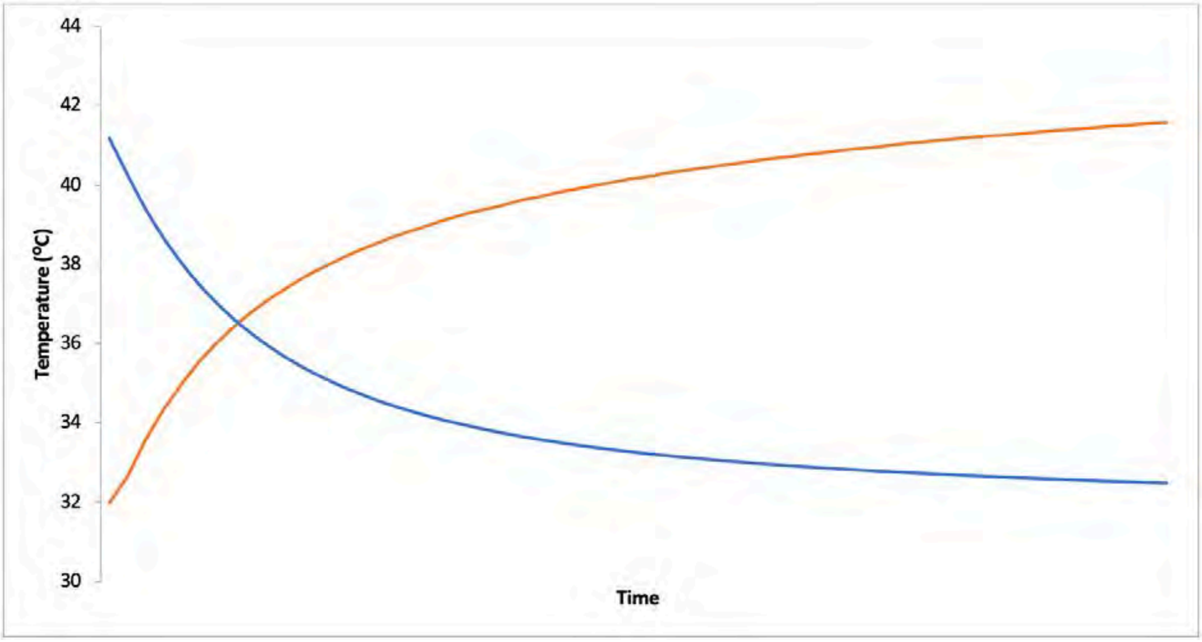


Figure 28: Heat and Colling Curve to TC Test 1

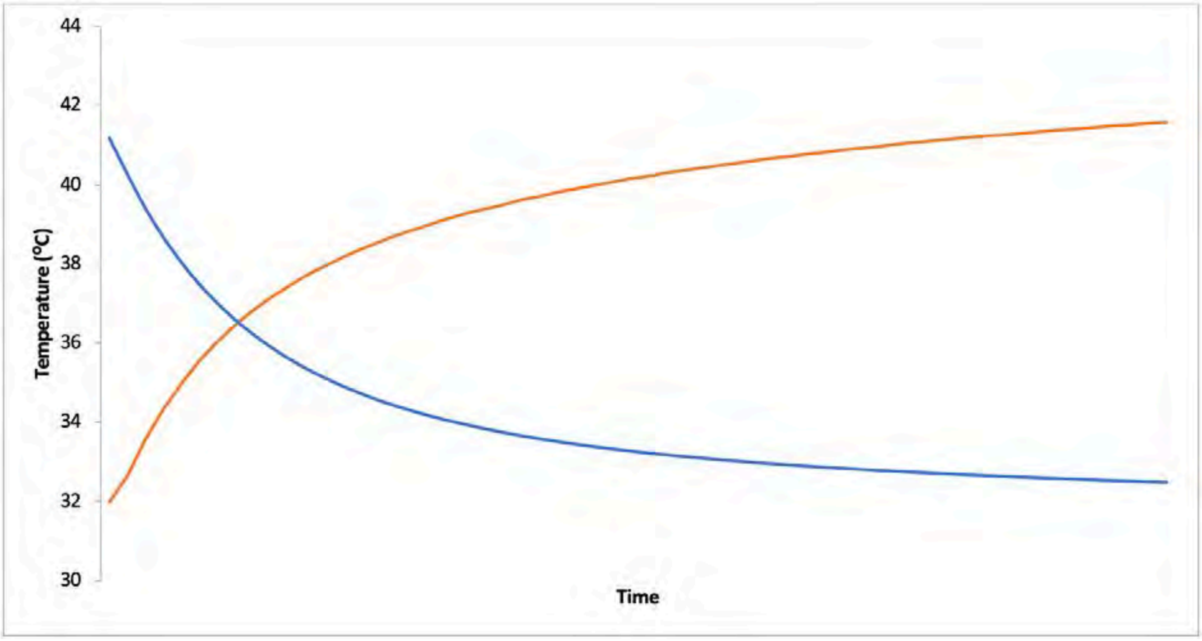


Figure 29: Heat and Colling Curve to TC Test 2

5.2.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 53800 µS/cm with a Sulphate content of 2800 mg/L, Nitrate content of 5.8 mg/L, Chloride content of 18550 mg/L and Sulphide content of <5 mg/L. This is because the project location is next to the harbour and was reclaimed during the construction of the harbour.

Table 25: Chemical test results of water sample from S. Maradhoo Feydhoo Harbour site

Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	**S. Maradhoo Feydhoo Harbour**	GWL	Clear with particles	53800	7.60	26900	<5	18550	5.8	2800

5.3 Hithadhoo Stadium

5.3.1 Borehole/SPT

5.3.1.1 SPT N Corrections

The tables below give the corrected N value and friction angle. The area reclaimed during harbour construction. While loose layer was encountered at a from the depth of 2.0 m.

Table 26: Borehole 1 SPT N-values corrected

BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	9	0.7	1	1	0.75	8	17	2.00	16	29
2.00	7	0.7	1	1	0.75	6	24	2.00	12	29
3.00	20	0.7	1	1	0.75	18	31	1.75	31	32
4.00	14	0.7	1	1	0.75	12	38	1.58	19	31

Table 27: Borehole 2 SPT N-values corrected

BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	14	0.7	1	1	0.75	12	17	2.00	25	31
2.00	7	0.7	1	1	0.75	6	24	2.00	12	29
3.00	18	0.7	1	1	0.75	16	31	1.75	28	32
4.00	14	0.7	1	1	0.75	12	38	1.58	19	31

5.3.1.2 Safe Bearing Capacity

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 3 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 197 kPa as safe bearing capacity for foundation design.

Table 28:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.

BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	163	197
	1.0	2.00	98	147
BH2	1.0	1.00	255	308
	1.0	2.00	98	147

5.3.2 Dynamic Cone Penetrometer (DCP)

Table 29: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

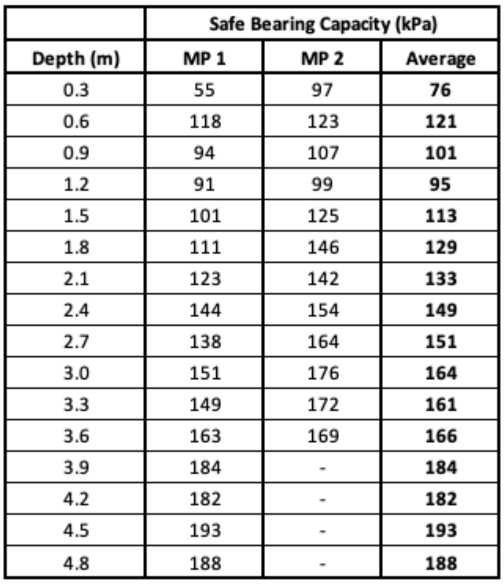
	Safe Bearing Capacity (kPa)					
Depth (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	Average
0.3	63	69	56	56	49	**59**
0.6	63	69	56	41	56	**57**
0.9	56	82	56	69	56	**64**
1.2	69	49	99	105	162	**97**
1.5	121	99	121	142	176	**132**
1.8	121	116	111	132	152	**126**
2.0	121	116	116	121	132	**121**

Table 5 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

5.3.3 Mackintosh Probe (MP)

Table 6 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 30: Safe Bearing Capacity calculated from MP results



	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	55	97	**76**
0.6	118	123	**121**
0.9	94	107	**101**
1.2	91	99	**95**
1.5	101	125	**113**
1.8	111	146	**129**
2.1	123	142	**133**
2.4	144	154	**149**
2.7	138	164	**151**
3.0	151	176	**164**
3.3	149	172	**161**
3.6	163	169	**166**
3.9	184	-	**184**
4.2	182	-	**182**
4.5	193	-	**193**
4.8	188	-	**188**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

5.3.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at S. Hithadhoo Stadium area are provided in the Table 7 and Table 8. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 31: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	20.0	18.0	31.0	11.0	10.0	7.1	2.9
1.0	18.0	12.0	31.0	18.0	11.0	6.9	3.1
2.0	38.0	9.0	17.0	12.0	11.0	6.2	6.8
3.0	55.0	5.0	10.0	10.0	9.0	3.7	7.3
4.0	59.0	4.0	11.0	7.0	9.0	3.6	6.4

Table 32: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	22.0	18.0	30.0	12.0	9.0	4.9	4.1
1.0	19.0	11.0	30.0	14.0	15.0	5.5	5.5
2.0	32.0	12.0	21.0	13.0	12.0	3.3	6.7
3.0	50.0	9.0	10.0	10.0	9.0	5.5	6.5
4.0	47.0	5.0	16.0	8.0	9.0	6.6	8.4

5.3.5 Direct Shear

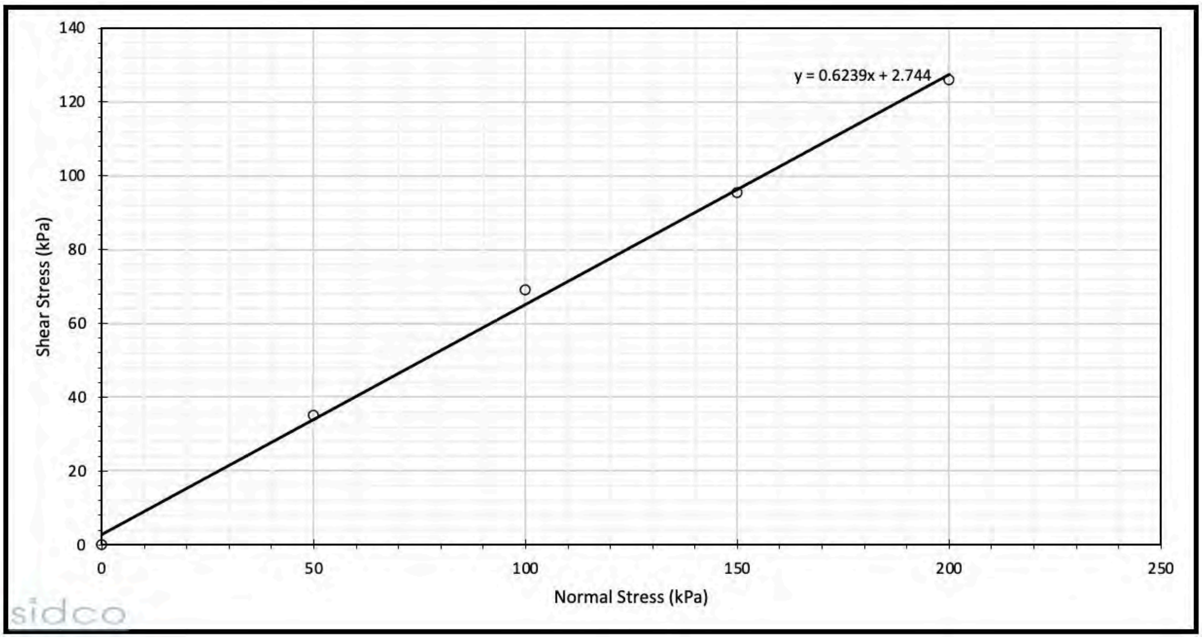


Figure 30: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 32 degrees, which is typical for carbonated sand found in Maldives.

5.3.6 Proctor Compaction Test

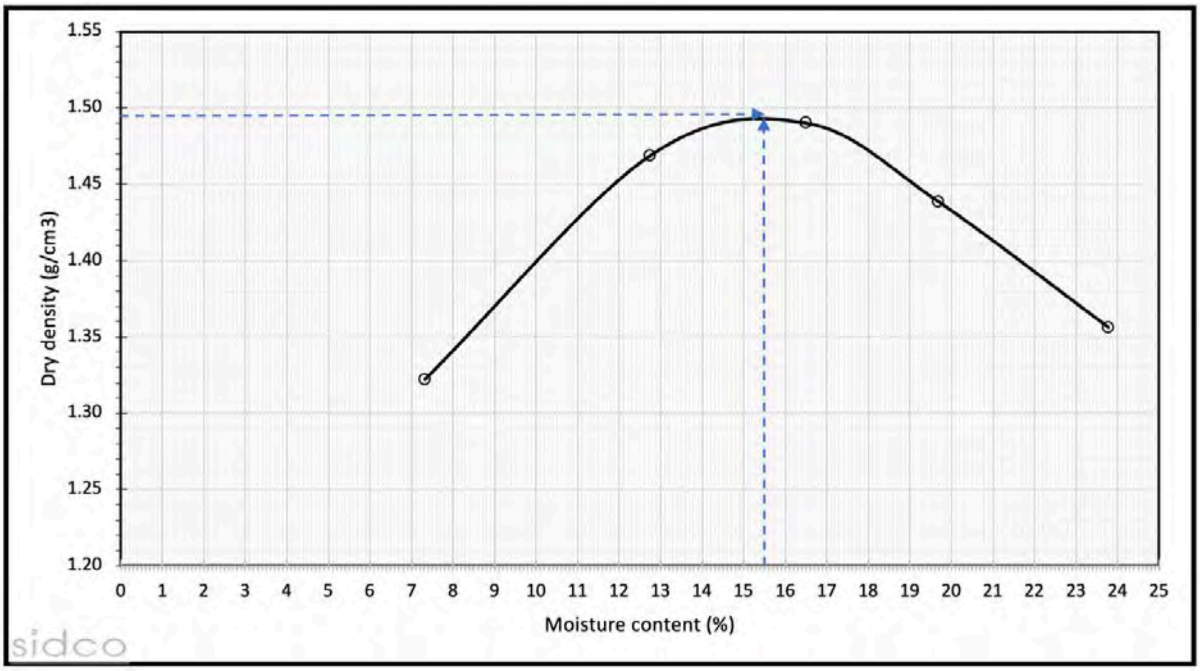


Figure 31: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.49 g/cm^3 and an optimum moisture content of 15.5%.

5.3.7 Specific Gravity Test

Table 33: Results of 2 specific gravity tests

	Specific Gravity (G_s)
Test 1	2.60
Test 2	2.60

Table 9 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

5.3.8 Electrical Resistivity Test

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content. The tables and graphs below show ER test results.

Table 34: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	54.60	343
2	2	28.60	359
3	3	16.54	312
4	4	12.48	313
5	5	9.75	306
6	6	6.81	257
7	7	5.34	235
8	8	4.76	239
9	9	3.29	186
10	10	2.07	130

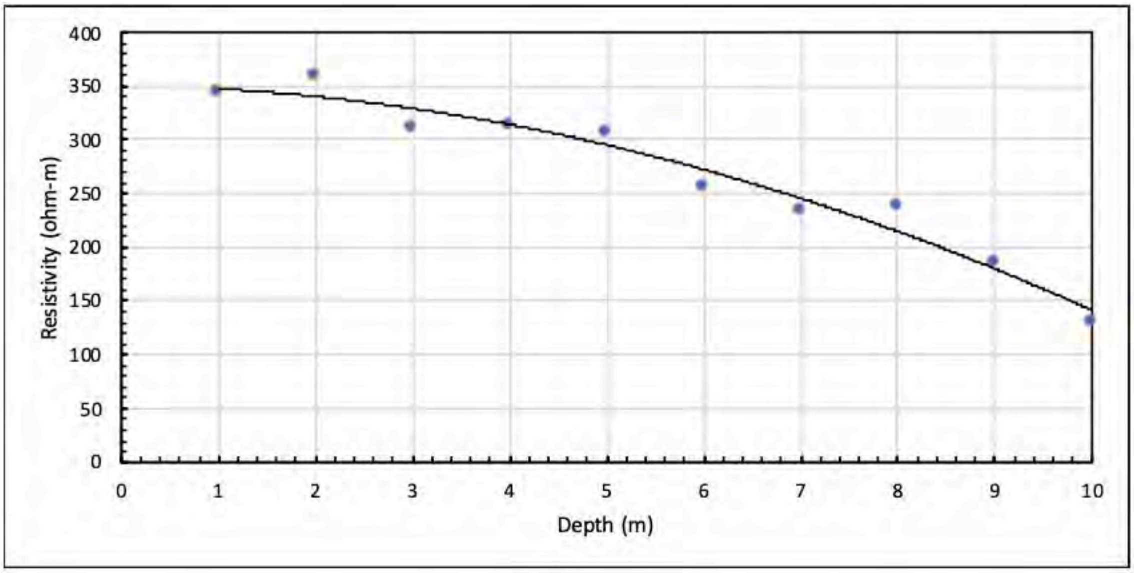


Figure 32: Resistivity graph for Test 1

Table 35: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	60.21	378
2	2	31.86	400
3	3	20.94	395
4	4	15.50	389
5	5	12.09	380
6	6	9.73	367
7	7	8.25	363
8	8	7.01	352
9	9	5.99	339
10	10	4.33	272

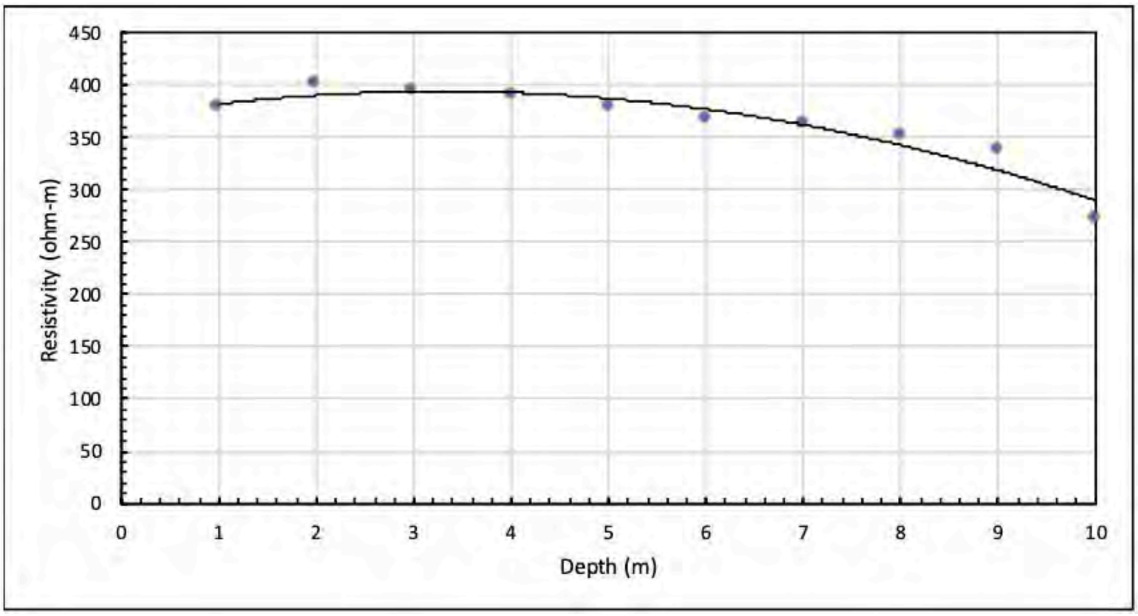


Figure 33: Resistivity graph for Test 2

Resistivity of soil remains overall constant up to 10.0 m. This could be because the area is natural island where ground water remains relatively fresh. But overall, the 60 Ohm-m resistivity provides very low resistivity and therefore:

5. Good for grounding
6. Moderately corrosive

5.3.9 Thermal Conductivity Test

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 36: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (^oC)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	32.00	0.445	2.25	200
2	TLS100	31.20	0.422	2.37	200
Average		31.60	0.434	2.31	

The average thermal conductivity is 0.434 W/mK.

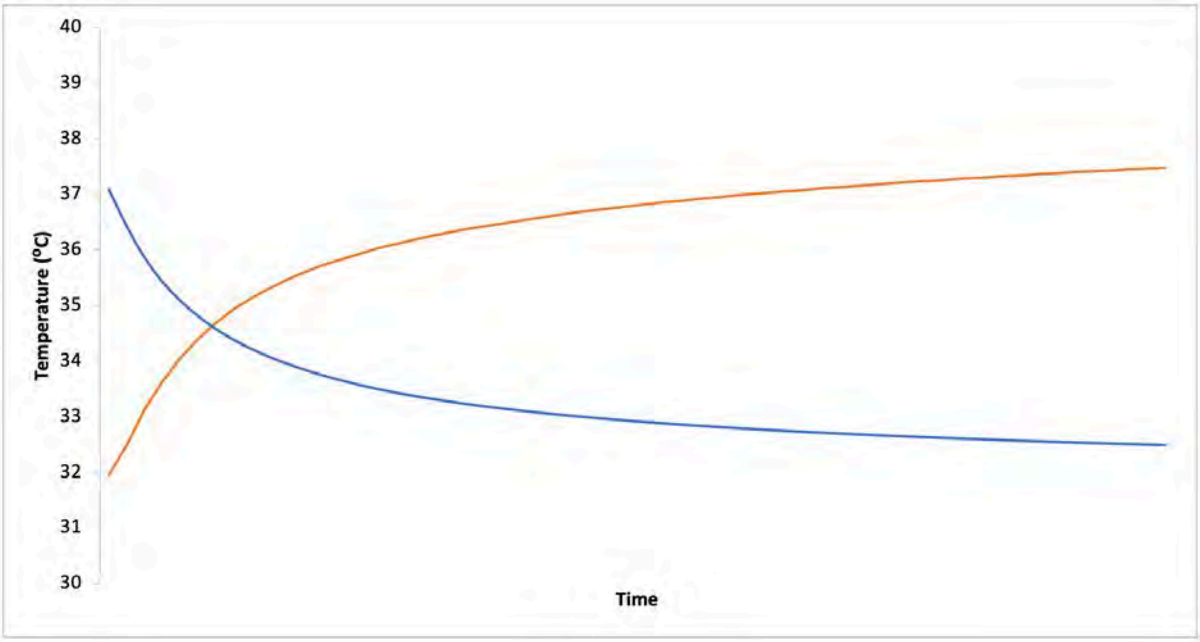


Figure 34: Heat and Colling Curve to TC Test 1

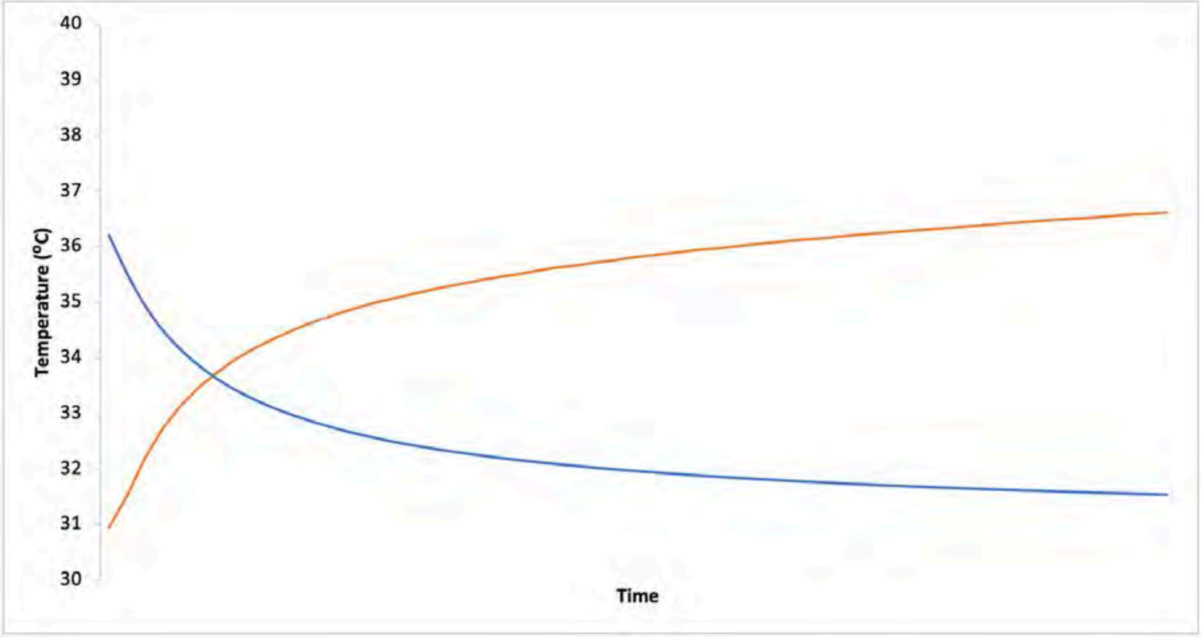
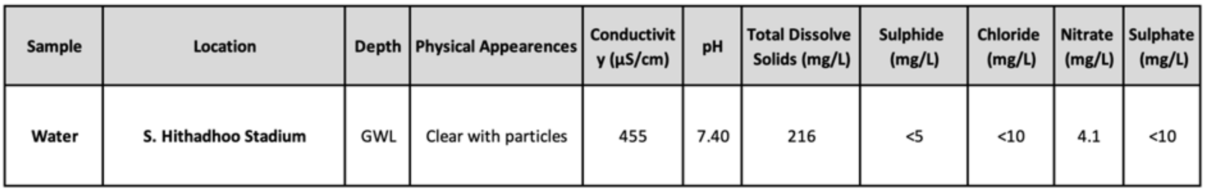


Figure 35: Heat and Colling Curve to TC Test 2

5.3.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 455 µS/cm with a Sulphate content of <10 mg/L, Nitrate content of 4.1 mg/L, Chloride content of <10 mg/L and Sulphide content of <5 mg/L. This is because the project location is next to the harbour and was reclaimed during the construction of the harbour.

Table 37: Chemical test results of water sample from S. Hithadhoo Stadium site



Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	**S. Hithadhoo Stadium**	GWL	Clear with particles	455	7.40	216	<5	<10	4.1	<10

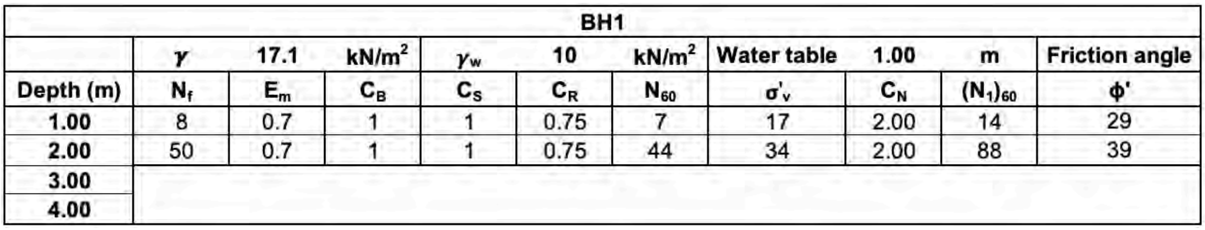
5.4 Hulhumeedhoo STP

5.4.1 Borehole/SPT

5.4.1.1 SPT N Corrections

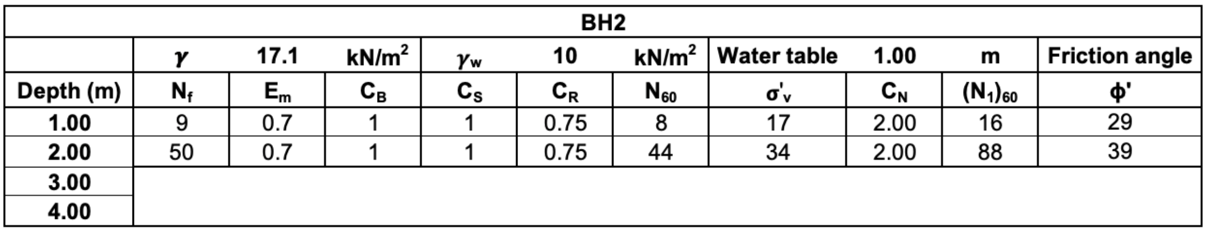
The tables below give the corrected N value and friction angle. The area reclaimed during harbour construction. While loose layer was encountered at a from the depth of 2.0 m.

Table 38: Borehole 1 SPT N-values corrected



BH1										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	8	0.7	1	1	0.75	7	17	2.00	14	29
2.00	50	0.7	1	1	0.75	44	34	2.00	88	39
3.00										
4.00										

Table 39: Borehole 2 SPT N-values corrected



BH2										
	γ	17.1	kN/m^2	γ_w	10	kN/m^2	Water table	1.00	m	Friction angle
Depth (m)	N_f	E_m	C_B	C_S	C_R	N_{60}	σ'_v	C_N	$(N_1)_{60}$	ϕ'
1.00	9	0.7	1	1	0.75	8	17	2.00	16	29
2.00	50	0.7	1	1	0.75	44	34	2.00	88	39
3.00										
4.00										

5.4.1.2 Safe Bearing Capacity

This report contains safe bearing capacity values calculated using the two sets of equations and the values are discussed and recommendation made for two boreholes. BH1 and BH2 have varying $(N_1)_{60}$ value at the depth of 1.5 - 3 m. However, since it was only two boreholes investigated, it is safer to use lower of the two as safe bearing capacity. Hence, I recommend using 197 kPa as safe bearing capacity for foundation design.

Table 40:SBC values against breadth (B) of raft foundation for Borehole BH-1 and borehole BH-2 at 1.0 m and 1.5 m depth.

BH No	Foundation width (B), m	Foundation Depth (D), m	SBC (kPa)	
			Meyerhof (1976)	Bowles (1996)
BH1	1.0	1.00	143	172
	1.0	2.00	409	614
BH2	1.0	1.00	163	197
	1.0	2.00	409	614

5.4.2 Dynamic Cone Penetrometer (DCP)

Table 41: Safe Bearing Capacities calculated from DCP readings from South side of Airport runway

	Safe Bearing Capacity (kPa)					
Depth (m)	DCP 1	DCP 2	DCP 3	DCP 4	DCP 5	Average
0.3	82	56	49	63	63	**63**
0.6	69	63	69	63	69	**67**
0.9	76	49	88	63	63	**68**
1.2	116	56	127	56	105	**92**
1.5	121	88	152	111	121	**119**
1.8	142	132	127	137	127	**133**
2.0	137	137	132	137	132	**135**

Table 5 shows safe bearing capacities calculated for each DCP test at different depths. The safe bearing capacity varies. It is recommended to use average safe bearing capacity at foundation depth.

5.4.3 Mackintosh Probe (MP)

Table 6 give bearing capacity correlated from MP results. The results are comparable to the bearing capacities derived from DCP.

Table 42: Safe Bearing Capacity calculated from MP results

	Safe Bearing Capacity (kPa)		
Depth (m)	**MP 1**	**MP 2**	**Average**
0.3	81	91	**86**
0.6	125	116	**121**
0.9	118	120	**119**
1.2	116	118	**117**
1.5	121	123	**122**
1.8	125	132	**129**

Carrying out Mackintosh Probe was extremely challenging for reasons given the soil type and conditions. Several attempts were made to reach maximum depth possible. Since the soil is medium dense gravelly sand after couple of meters, when the cone hits a large stone, penetration stops. This has occurred at different depths in same site. Removing rod from ground was another challenge, where rods get bent when a rod puller is used.

5.4.4 Particle size distribution

Particle size distribution of samples collected from 2 boreholes at S. Hithadhoo Stadium area are provided in the Table 7 and Table 8. The result shows the sand is gravelly with silt content less than 10%. Since silt content are less, it is not likely to have any long-term settlement due to pore water pressure in the soil. The strength of the soil layers is mainly due to compaction, rather than presence of silt/clay or organic matter. The particle size distribution graphs are included in the appendix.

Table 43: Results of Particle size distribution of samples from borehole BH1

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	50.0	18.0	7.0	9.0	8.0	3.5	4.5
1.0	39.0	12.0	18.0	11.0	10.0	7.1	2.9
2.0	38.0	12.0	18.0	11.0	11.0	5.5	4.5

Table 44: Results of Particle size distribution of samples from borehole, BH2

Depth m	Gravel & larger (%)	Very coarse sand (%)	Coarse sand (%)	Medium sand (%)	Fine sand (%)	Very fine sand (%)	Silt (%)
0.0	50.0	16.0	6.0	10.0	9.0	4.0	5.0
1.0	39.0	11.0	19.0	10.0	11.0	6.6	3.4
2.0	34.0	14.0	16.0	14.0	12.0	4.4	5.6

5.4.5 Direct Shear

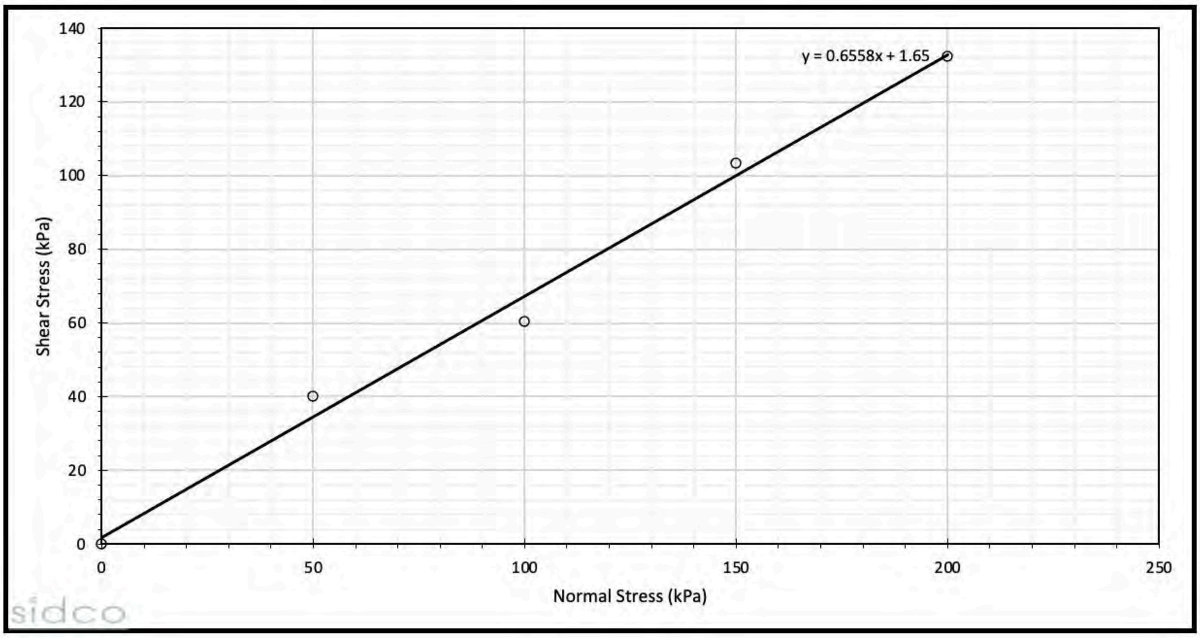


Figure 36: Direct Shear Test Result graph

Since the soil is granular sand (SP classification), it does not have any cohesion. The reason for drained test is because in undrained condition, excess pore water pressure can cause a cohesion on the graph.

The shear angle is calculated to be 34 degrees, which is typical for carbonated sand found in Maldives.

5.4.6 Proctor Compaction Test

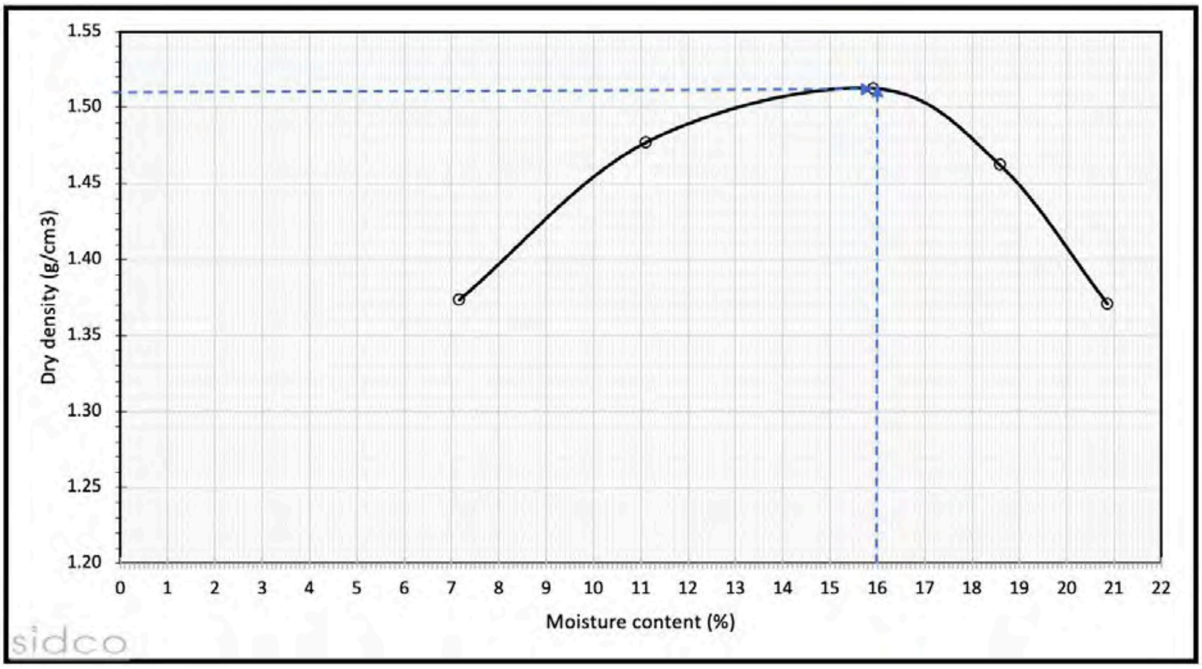
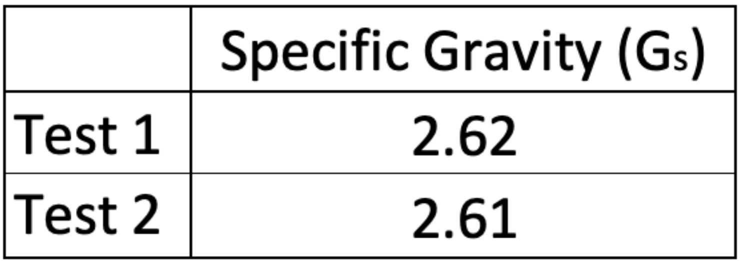


Figure 37: Standard Proctor Test Result

Standard proctor test result shows maximum dry density (MDD) of 1.51 g/cm^3 and an optimum moisture content of 16%.

5.4.7 Specific Gravity Test

Table 45: Results of 2 specific gravity tests



	Specific Gravity (G_s)
Test 1	2.62
Test 2	2.61

Table 9 shows the results of 2 specific gravity tests conducted in the laboratory using a pycnometer.

5.4.8 Electrical Resistivity Test

Soil resistivity measurement is generally done for two purposes; to determine the degree of corrosion in underground pipelines and structural elements and to design the grounding system. There are several factors which affect the soil resistivity: moisture content of soil, temperature, salt content. The tables and graphs below show ER test results.

Table 46: Results of ER Test 1

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	15.21	96
2	2	9.34	117
3	3	6.56	124
4	4	4.71	118
5	5	3.94	124
6	6	2.64	99
7	7	2.08	91
8	8	1.89	95
9	9	1.67	94
10	10	1.54	97

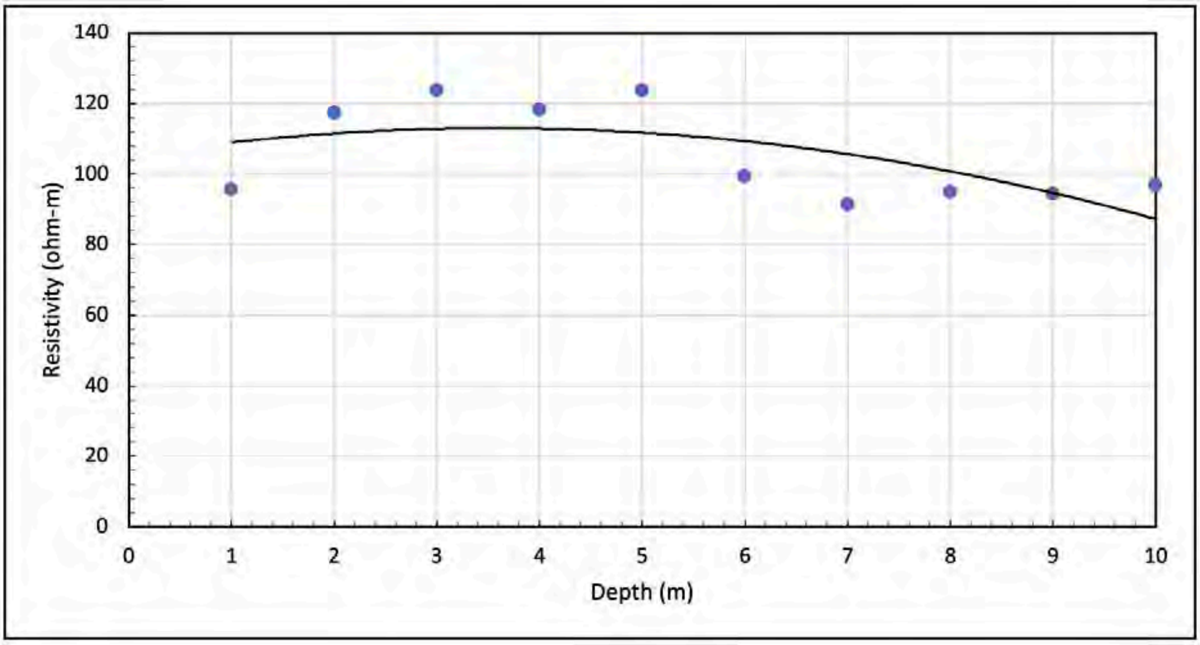


Figure 38: Resistivity graph for Test 1

Table 47: Results of ER Test 2

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	17.45	110
2	2	8.94	112
3	3	6.04	114
4	4	4.87	122
5	5	3.75	118
6	6	2.87	108
7	7	2.22	98
8	8	2.01	101
9	9	1.77	100
10	10	1.44	90

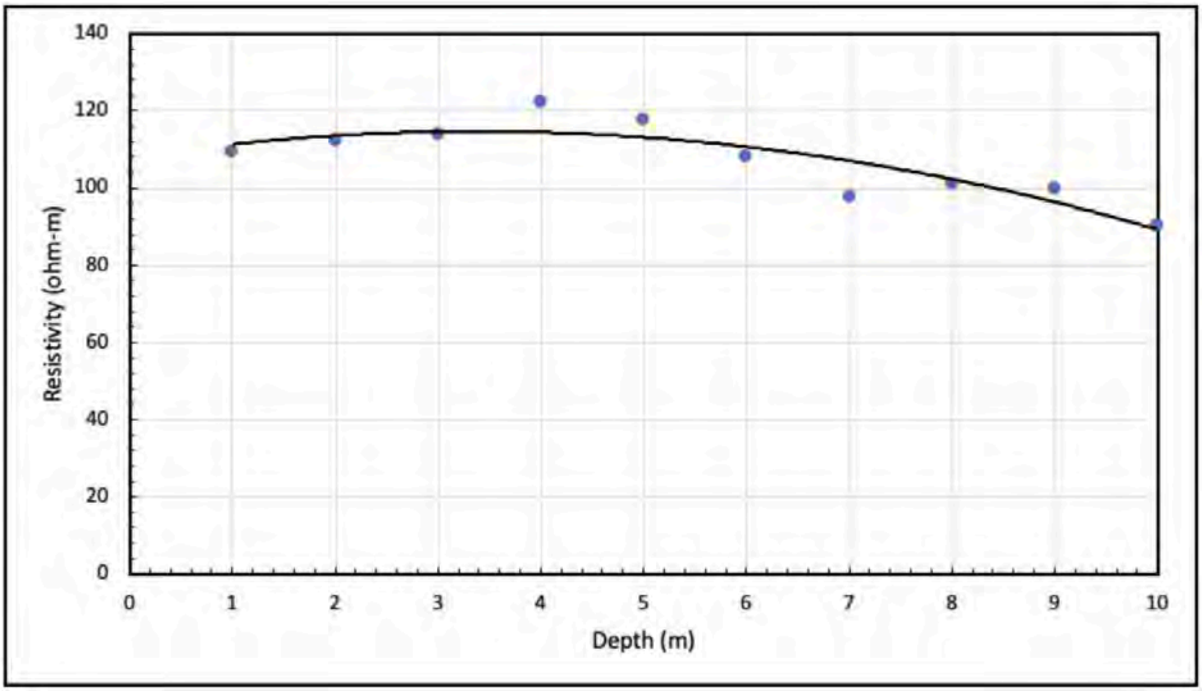


Figure 39: Resistivity graph for Test 2

Resistivity of soil remains overall constant up to 10.0 m. This could be because the area is natural island where ground water remains relatively fresh. But overall, the 60 Ohm-m resistivity provides very low resistivity and therefore:

7. Good for grounding
8. Moderately corrosive

5.4.9 Thermal Conductivity Test

Thermal conductivity of soil is very important when designing the underground electricity network.

Table 48: Thermal Conductivity Test Results

Test #	Sensor Type	Ambinet Temperature (ºC)	Conductivity λ (W/mK)	Resistance R (mK/W)	Current (mA)
1	TLS100	31.10	0.764	1.31	200
2	TLS100	32.70	0.431	2.32	200
Average		31.90	0.598	1.81	

The average thermal conductivity is 0.598 W/mK.

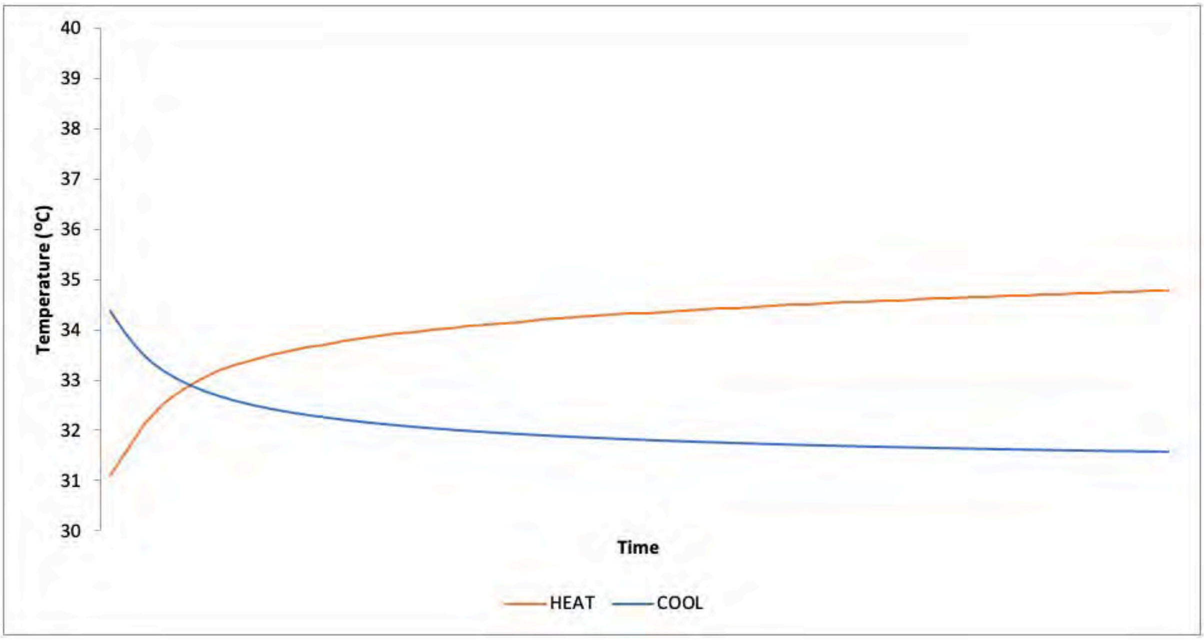


Figure 40: Heat and Colling Curve to TC Test 1

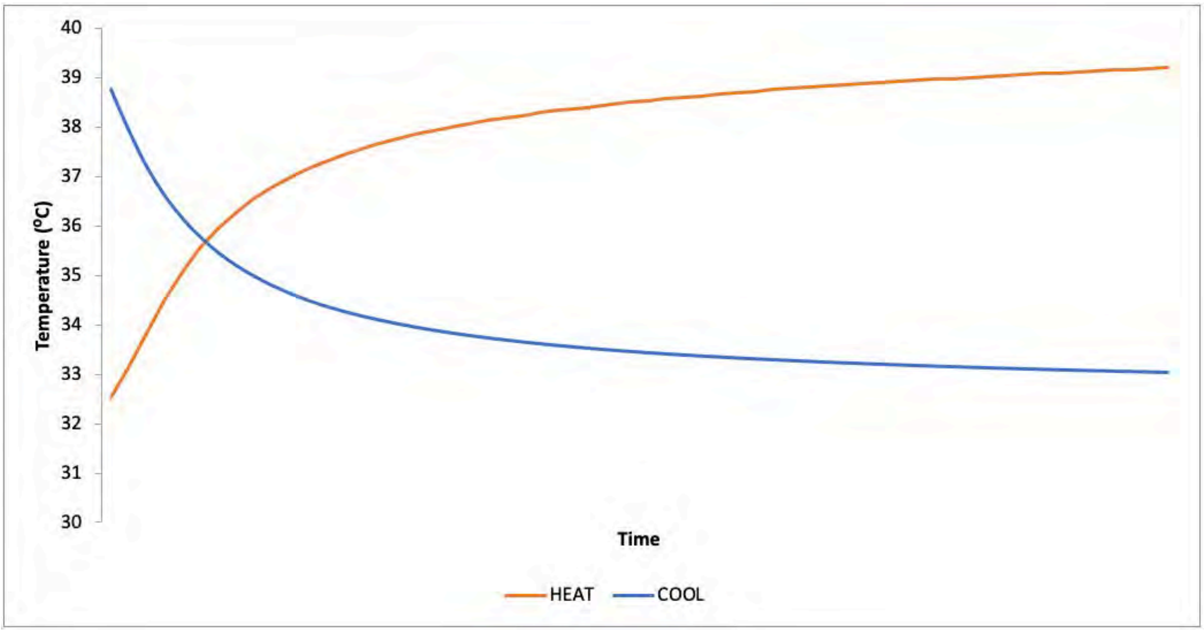


Figure 41: Heat and Colling Curve to TC Test 2

5.4.10 Chemical Analysis of Ground Water

Water samples were collected from one of the boreholes. The result shows a conductivity of about 712 µS/cm with a Sulphate content of 20 mg/L, Nitrate content of 11.3 mg/L, Chloride content of 79 mg/L and Sulphide content of <5 mg/L. This is because the project location is next to the harbour and was reclaimed during the construction of the harbour.

Table 49: Chemical test results of water sample from S. Hulhumeedho STP site

Sample	Location	Depth	Physical Appearences	Conductivity (µS/cm)	pH	Total Dissolve Solids (mg/L)	Sulphide (mg/L)	Chloride (mg/L)	Nitrate (mg/L)	Sulphate (mg/L)
Water	S. Hulhumeedhoo STP	GWL	Clear with particles	712	7.50	356	<5	79	11.3	20

6 Conclusion

6.1 GEOTECHNICAL CONSIDERATIONS

6.1.1 Safe Bearing Capacity

Since the soil is gravelly sand with less than 10% silt content from 0-15 m. The result of SPT is most accurate out of SPT, DCP and MP conducted at the site. DCP and MP was used to see if the ground has significant variations and SPT data are representation of whole site. Hence, we recommend to use safe bearing capacity given in Table 50 for foundation design.

Table 50: Safe bearing capacity for shallow foundation at different depths for 4 sites in Addu

Location	Safe Bearing Capacity (kPa)	
	D_f=1.0 m	D_f=2.0 m
S. Feydhoo Harbour	150	150
S. Maradhoo Feydhoo Harbour	150	150
S. Hithadhoo Stadium	150	150
S. Hulhumeedhoo STP	150	150

6.1.2 Electrical Resistivity

Table 51 gives the ER values of each site. It is recommended to use the ER value at 1.0 m for designing for grounding.

Table 51: ER measured at each site at 1.0 m and at 10.0 m

Location	Electrical Resistivity (Ohm-m)	
	ER @ 1.0 m	ER @ 10.0 m
S. Feydhoo Harbour	89	62
S. Maradhoo Feydhoo Harbour	181	92
S. Hithadhoo Stadium	343	130
S. Hulhumeedhoo STP	96	97

6.1.3 Thermal Conductivity

Table 52 gives Thermal Conductivity for underground cable design for each site.

Table 52: Thermal Conductivity values for each site

Location	Thermal Conductivity (W/mK)
S. Feydhoo Harbour	0.412
S. Maradhoo Feydhoo Harbour	0.208
S. Hithadhoo Stadium	0.434
S. Hulhumeedhoo STP	0.598

6.1.4 Seismic Zone and Ground Type

Based on the soil being medium-dense sand, the ground type is D as per the table 3.1 of Eurocode 8 – Part 1 (CEN 2004).

As explained in 2.3, Addu is located north of Maldives where peak ground acceleration value is between 0.12 and 0.32.

Lubkowski and Aluisi (2012) provided formula to derive S_s and S_1 parameters from PGA maps.

$$S_s = PGA(0.3386PGA + 2.1696)$$

$$S_1 = PGA(0.5776PGA + 0.5967)$$

Based on the above formula and using PGA value as 0.32 for Addu Atoll, S_s is 0.729 and S_1 is 0.250.

Table 53: S_s and S_1 value for Addu Project sites

Location	S_s	S_1
S. Feydhoo Harbour	0.729	0.250
S. Maradhoo Feydhoo Harbour	0.729	0.250
S. Hithadhoo Stadium	0.729	0.250
S. Hulhumeedhoo STP	0.729	0.250

REFERENCES

ADB (2020). Climate and Geophysical hazards—Volume II. MULTIHAZARD RISK ATLAS OF MALDIVES. Manila, Asian Development Bank. II: 155.

Bowles, L. E. (1996). Foundation analysis and design, McGraw-hill.

Burland, J. B. and M. C. Burbidge (1985). "Settlement of foundations on sand and gravel." Proceedings of the institution of Civil Engineers 78(6): 1325-1381.

CEN (2004). Eurocode 8: Design of structures for earthquake resistance — Part 1: General rules, seismic actions and rules for buildings. Brussels.

Kessler Soils Engineering Products, I. (2014). User's Manual for K-100 Models of KSE DCP. USA.

Liao, S. and R. Whitman (1986). "Overburden Correction Factors for SPT in Sand." Journal of Geotechnical Engineering 112: 373-377.

Lubkowski, Z. and B. Aluisi (2012). Deriving Ss and S1 Parameters from PGA Maps.

MEE (2015). Fifth National Report to the United Nations Convention on Biological Diversity, Ministry of Environment and Energy.

Meyerhof, G. (1976). "Bearing capacity and settlement of pile foundations (11th Terzaghi Lecture)." Journal of the Geotechnical Engineering Division ASCE 102: 195-228.

MMS (2020). "Earthquake and Tsunami Watch in MMS." Retrieved 28 March 2021, 2021.

Robertson, P. and C. E. Wride (1997). "Cyclic liquefaction and its evaluation based on SPT and CPT. Proc. NCEER Work-shop on Evaluation of Liquefaction Resistance of Soils." Report NCEER-97-0022, National Center for Earthquake Engineering Research, SUNY Buffalo, NY.

Skempton, A. W. (1986). "Standard penetration test procedures and the effects in sands of overburden pressure, relative density, particle size, ageing and overconsolidation." Geotechnique 36(3): 425-447.

Terzaghi, K. and R. B. Peck (1967). Soil mechanics in engineering practice. New York, John Wiley & Sons, Inc.

UNDP (2006). Developing a Disaster Risk Profile for Maldives, United Nations Development Programme.

Zahid (2011). The influence of Asian monsoon variability on precipitation patterns over the Maldives. Department of Geography. Christchurch, University of Canterbury. PhD.

APPENDICES (A)
S. Feydhoo Harbour

APPENDIX A1: TEST LOCATIONS


N
W
E
S
DCP5
BH2
DCP4
MP2
ER2
TC2
DCP3
MP1
DCP2
14725
ER1
TC1
DCP1
BH1
Legend
Solar Panel Site
0
45
90
180
270
360
Meters

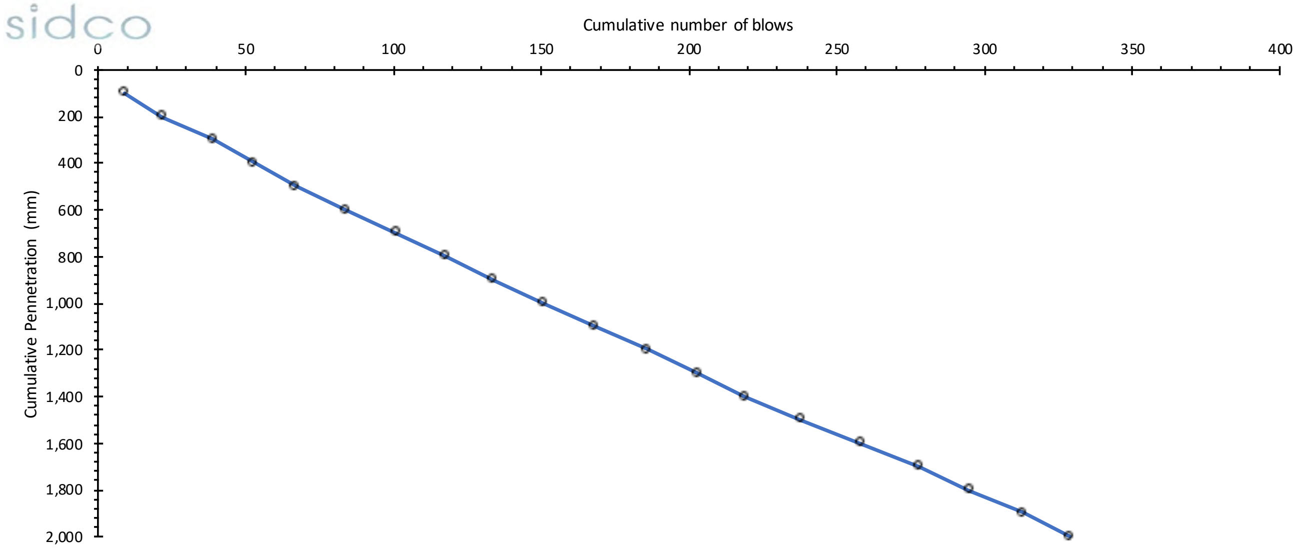
APPENDIX A2: DCP TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Feydhoo**		**12/01/2023**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	9	9	11.1	20	189	76
100-200	13	22	7.7	30	249	99
200-300	17	39	5.9	40	304	121
300-400	14	53	7.1	32	263	105
400-500	14	67	7.1	32	263	105
500-600	17	84	5.9	40	304	121
600-700	17	101	5.9	40	304	121
700-800	17	118	5.9	40	304	121
800-900	16	134	6.3	37	290	116
900-1000	17	151	5.9	40	304	121
1000-1100	17	168	5.9	40	304	121
1100-1200	18	186	5.6	43	317	127
1200-1300	17	203	5.9	40	304	121
1300-1400	16	219	6.3	37	290	116
1400-1500	19	238	5.3	45	330	132
1500-1600	20	258	5.0	48	343	137
1600-1700	20	278	5.0	48	343	137
1700-1800	17	295	5.9	40	304	121
1800-1900	18	313	5.6	43	317	127
1900-2000	16	329	6.3	37	290	116



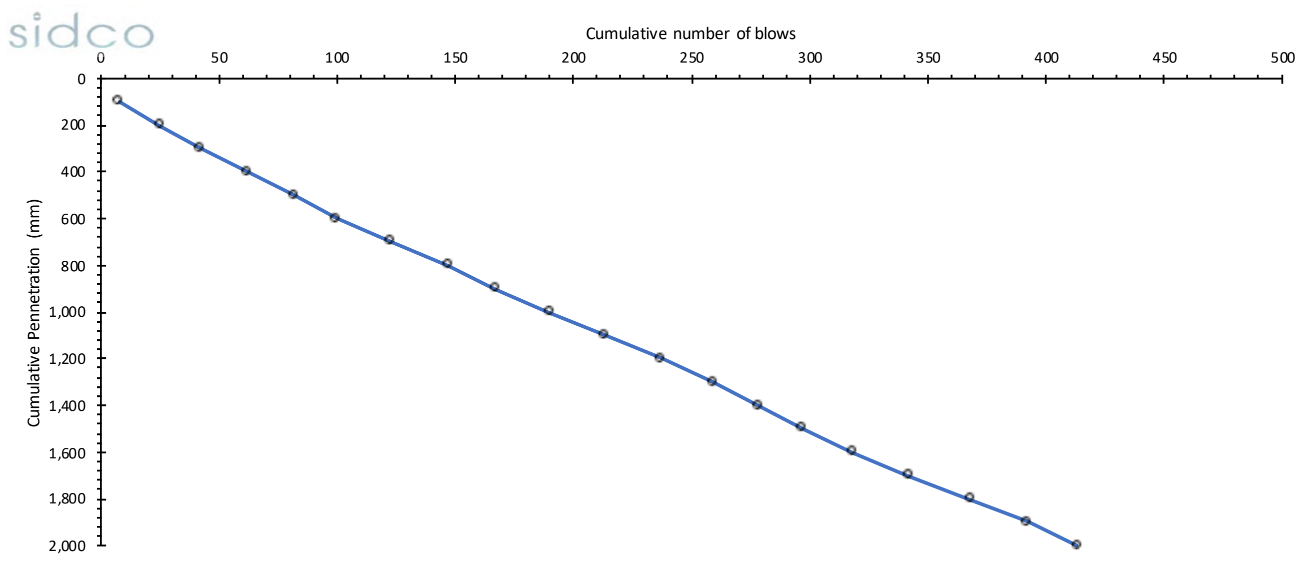
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Feydhoo**		**12/01/2023**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	8	8	12.5	17	173	69
100-200	17	25	5.9	40	304	121
200-300	17	42	5.9	40	304	121
300-400	20	62	5.0	48	343	137
400-500	20	82	5.0	48	343	137
500-600	18	100	5.6	43	317	127
600-700	23	123	4.3	56	380	152
700-800	24	147	4.2	59	392	157
800-900	20	167	5.0	48	343	137
900-1000	23	190	4.3	56	380	152
1000-1100	23	213	4.3	56	380	152
1100-1200	24	237	4.2	59	392	157
1200-1300	22	259	4.5	54	368	147
1300-1400	19	278	5.3	45	330	132
1400-1500	19	297	5.3	45	330	132
1500-1600	21	318	4.8	51	355	142
1600-1700	24	342	4.2	59	392	157
1700-1800	26	368	3.8	65	416	167
1800-1900	24	392	4.2	59	392	157
1900-2000	21	413	4.8	51	355	142

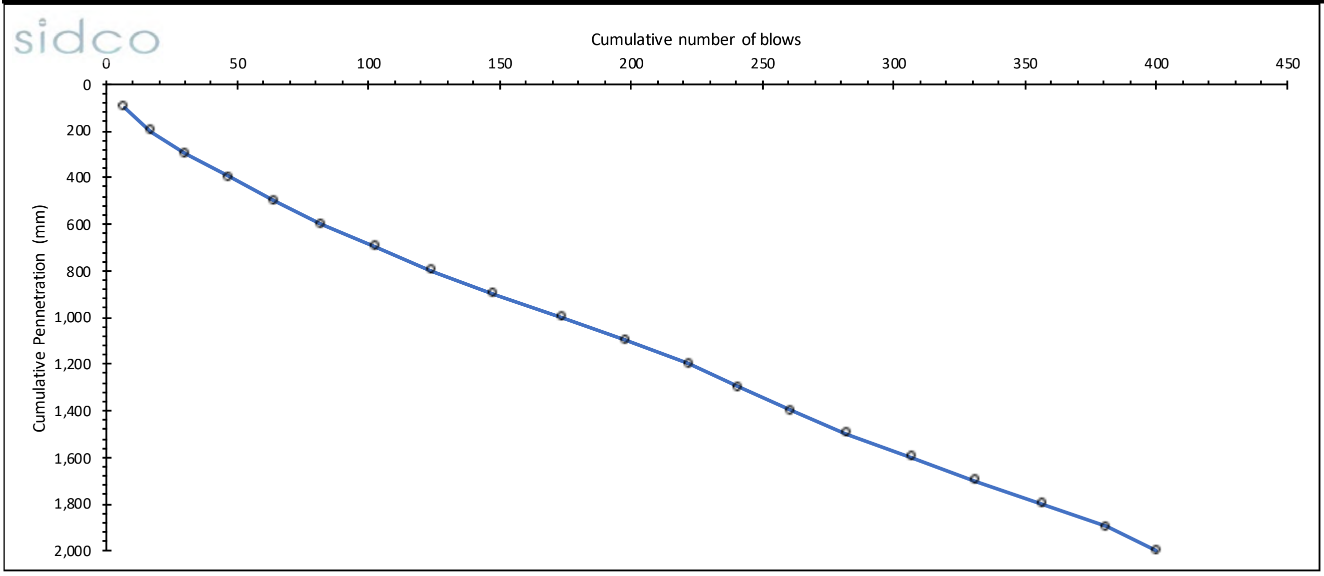


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Feydhoo**		**12/01/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	7	7	14.3	15	157	63
100-200	10	17	10.0	22	205	82
200-300	13	30	7.7	30	249	99
300-400	17	47	5.9	40	304	121
400-500	17	64	5.9	40	304	121
500-600	18	82	5.6	43	317	127
600-700	21	103	4.8	51	355	142
700-800	21	124	4.8	51	355	142
800-900	24	148	4.2	59	392	157
900-1000	26	174	3.8	65	416	167
1000-1100	24	198	4.2	59	392	157
1100-1200	24	222	4.2	59	392	157
1200-1300	19	241	5.3	45	330	132
1300-1400	20	261	5.0	48	343	137
1400-1500	21	282	4.8	51	355	142
1500-1600	25	307	4.0	62	404	162
1600-1700	24	331	4.2	59	392	157
1700-1800	26	357	3.8	65	416	167
1800-1900	24	381	4.2	59	392	157
1900-2000	19	400	5.3	45	330	132



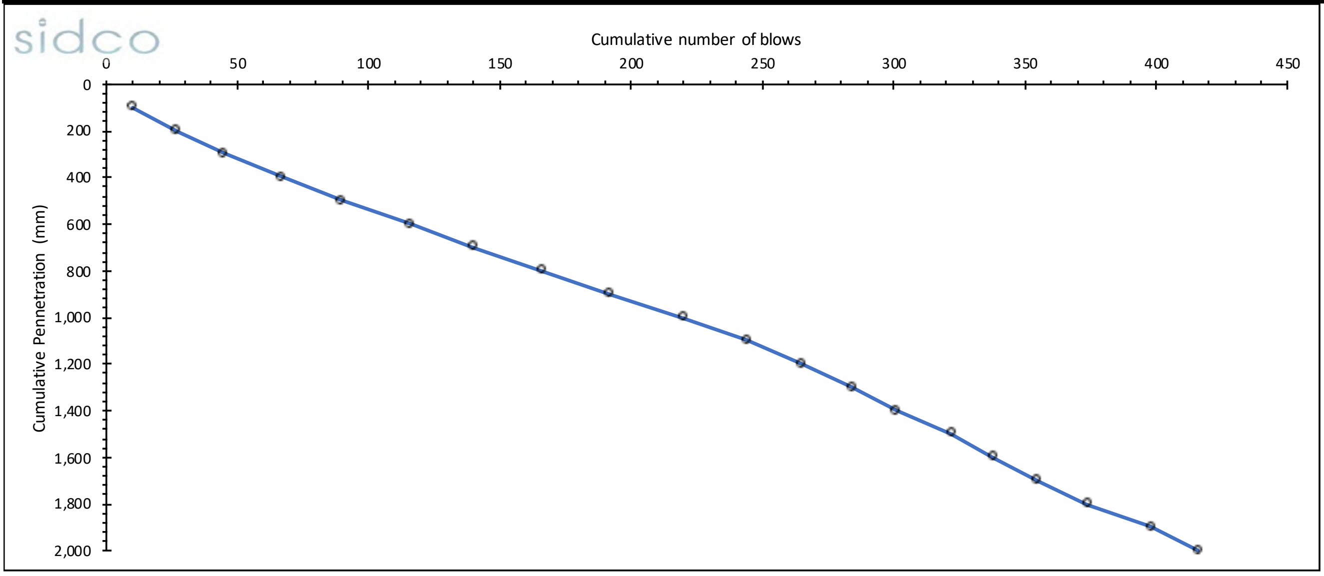
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Feydhoo**		**12/01/2023**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	10	10	10.0	22	205	82
100-200	17	27	5.9	40	304	121
200-300	18	45	5.6	43	317	127
300-400	22	67	4.5	54	368	147
400-500	23	90	4.3	56	380	152
500-600	26	116	3.8	65	416	167
600-700	24	140	4.2	59	392	157
700-800	26	166	3.8	65	416	167
800-900	26	192	3.8	65	416	167
900-1000	28	220	3.6	70	440	176
1000-1100	24	244	4.2	59	392	157
1100-1200	21	265	4.8	51	355	142
1200-1300	19	284	5.3	45	330	132
1300-1400	17	301	5.9	40	304	121
1400-1500	21	322	4.8	51	355	142
1500-1600	16	338	6.3	37	290	116
1600-1700	17	355	5.9	40	304	121
1700-1800	19	374	5.3	45	330	132
1800-1900	24	398	4.2	59	392	157
1900-2000	18	416	5.6	43	317	127



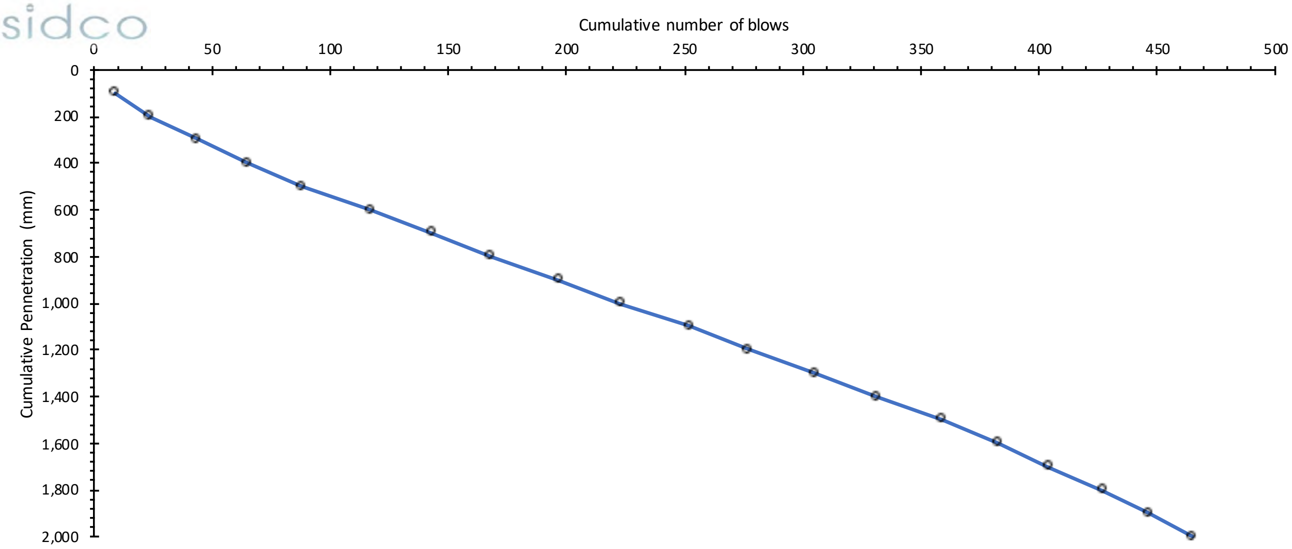
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Feydhoo**		**12/01/2023**		**DCP#**	**5**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	9	9	11.1	20	189	76
100-200	15	24	6.7	35	277	111
200-300	20	44	5.0	48	343	137
300-400	21	65	4.8	51	355	142
400-500	23	88	4.3	56	380	152
500-600	29	117	3.4	73	452	181
600-700	26	143	3.8	65	416	167
700-800	25	168	4.0	62	404	162
800-900	29	197	3.4	73	452	181
900-1000	26	223	3.8	65	416	167
1000-1100	29	252	3.4	73	452	181
1100-1200	25	277	4.0	62	404	162
1200-1300	28	305	3.6	70	440	176
1300-1400	26	331	3.8	65	416	167
1400-1500	28	359	3.6	70	440	176
1500-1600	24	383	4.2	59	392	157
1600-1700	21	404	4.8	51	355	142
1700-1800	23	427	4.3	56	380	152
1800-1900	19	446	5.3	45	330	132
1900-2000	19	465	5.3	45	330	132



APPENDIX A3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

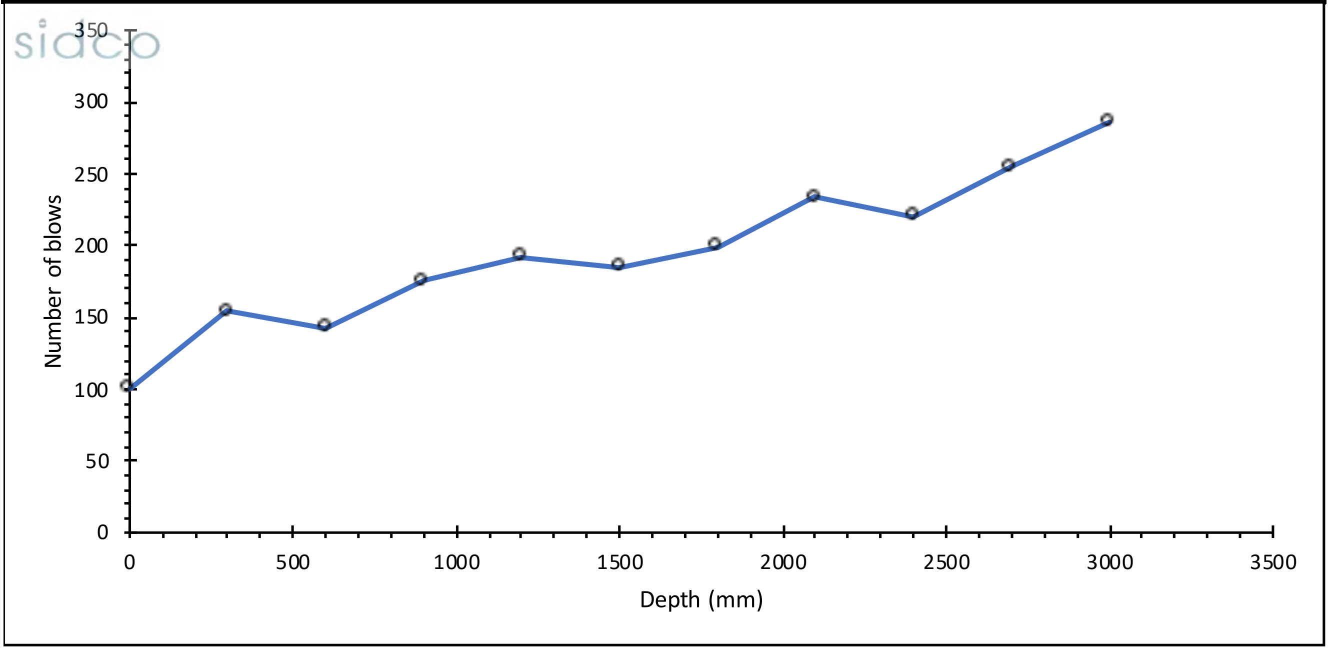
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	Feydhoo	Date:	12/01/2023	MP#	1

Depth (mm)	Number of Blows, N_{MP}	Cumulative Number of Blows	Bearing Capacity kPa	Bearing Capacity
0-300	100	100	341	136
300-600	154	254	418	167
600-900	143	397	404	162
900-1200	175	572	443	177
1200-1500	192	764	462	185
1500-1800	185	949	454	182
1800-2100	199	1148	469	188
2100-2400	234	1382	504	201
2400-2700	220	1602	490	196
2700-3000	255	1857	523	209
3000-3300	286	2143	550	220
3300-3600	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



SIDCO SOILS LAB

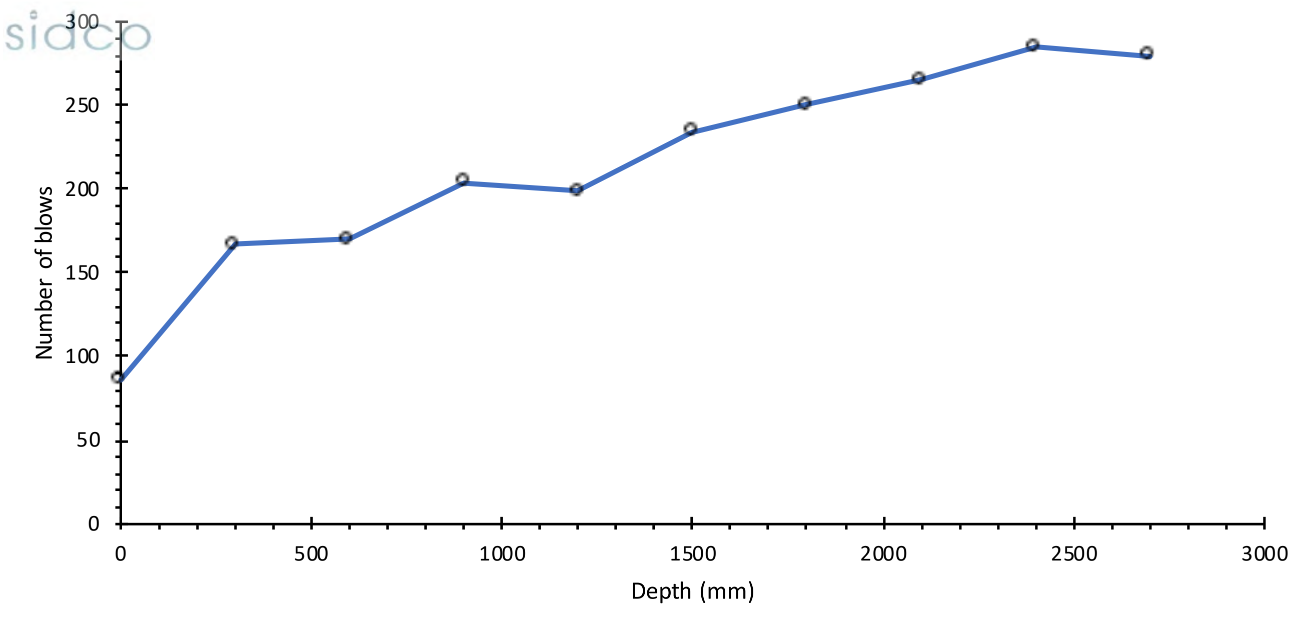
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Maradhoo-Feydhc**	**Date:**	**12/01/2023**	**MP#**	**2**

Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity kPa**
0-300	86	86	316	126
300-600	167	253	434	173
600-900	170	423	437	175
900-1200	204	627	474	190
1200-1500	199	826	469	188
1500-1800	234	1060	504	201
1800-2100	250	1310	519	207
2100-2400	265	1575	532	213
2400-2700	285	1860	549	220
2700-3000	280	2140	545	218
3000-3300	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
3300-3600				
3600-3900				
3900-4200				
4200-4500				
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



APPENDIX A4: BOREHOLE LOGS

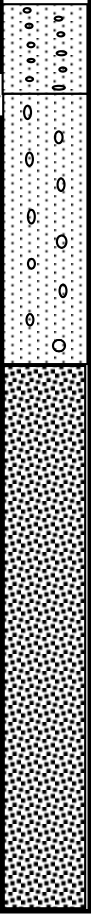
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

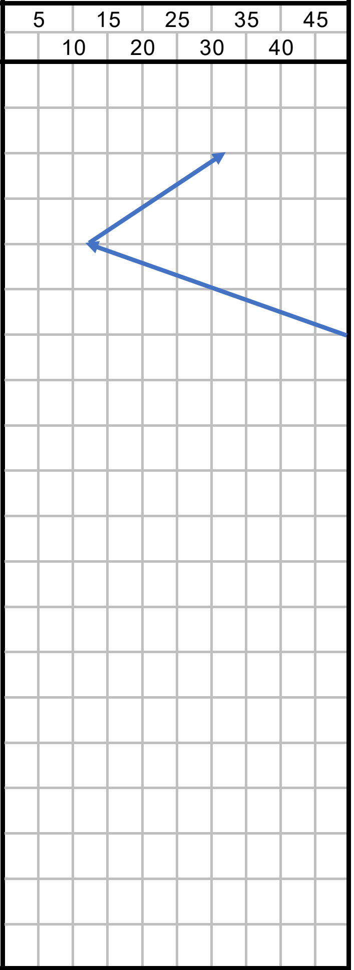
Project:	Aspire - Solar PV Installation Project - S. Feydhoo Harbour						
Project Number:	2023/HDEC/01			Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date	Started: 06/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	6		Completed 06/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Feydhoo Harbour		Backfilled: 07/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60
1	SS	D1	▼	Medium dense, off white coral sand with some rock pieces (backfilled material)	8	10	8	18	32
	SS	D2		loose , off white fine sand with some gravel					
2					3	3	4	7	12
	SS	D3							
3	SS	D4		Highly weathered rock pieces mixed with fine sand	22	22	24	46	70
4									
	SS	D5		Weathered limestone rock					
5									
6	SS	D6							
7									
	SS	D7							
8									
9									
	SS	D8							
10									

Graphic Log



Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

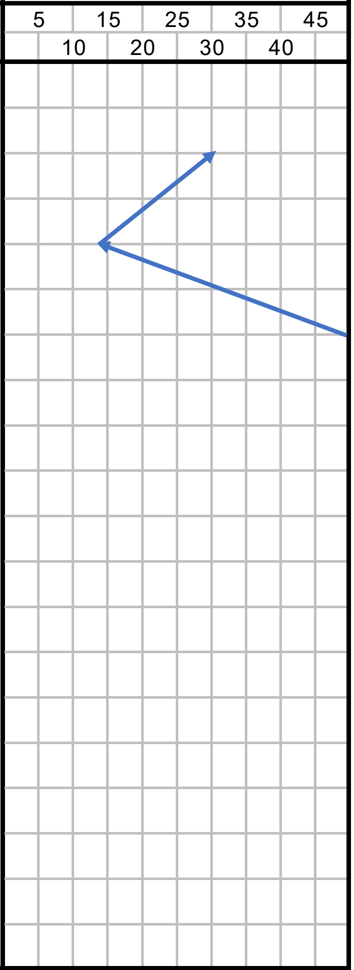
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Feydhoo Harbour						
Project Number:	2023/HDEC/01			Client:	HDEC	BH No.	2
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date	Started: 06/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	6		Completed 06/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Feydhoo Harbour		Backfilled: 07/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)$_{60}$
1	SS	D1	▼		Medium dense, off white coral sand with some rock pieces (backfilled material)	10	10	7	17	30
	SS	D2			loose , off white fine sand with some gravel					
2						5	4	4	8	14
	SS	D3								
3	SS	D4			Highly weathered rock pieces mixed with fine sand	20	22	22	44	67
4					Weathered limestone rock					
	SS	D5								
5										
	SS	D6								
6										
7										
	SS	D7								
8										
9	SS	D8								
10										

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

APPENDIX A5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

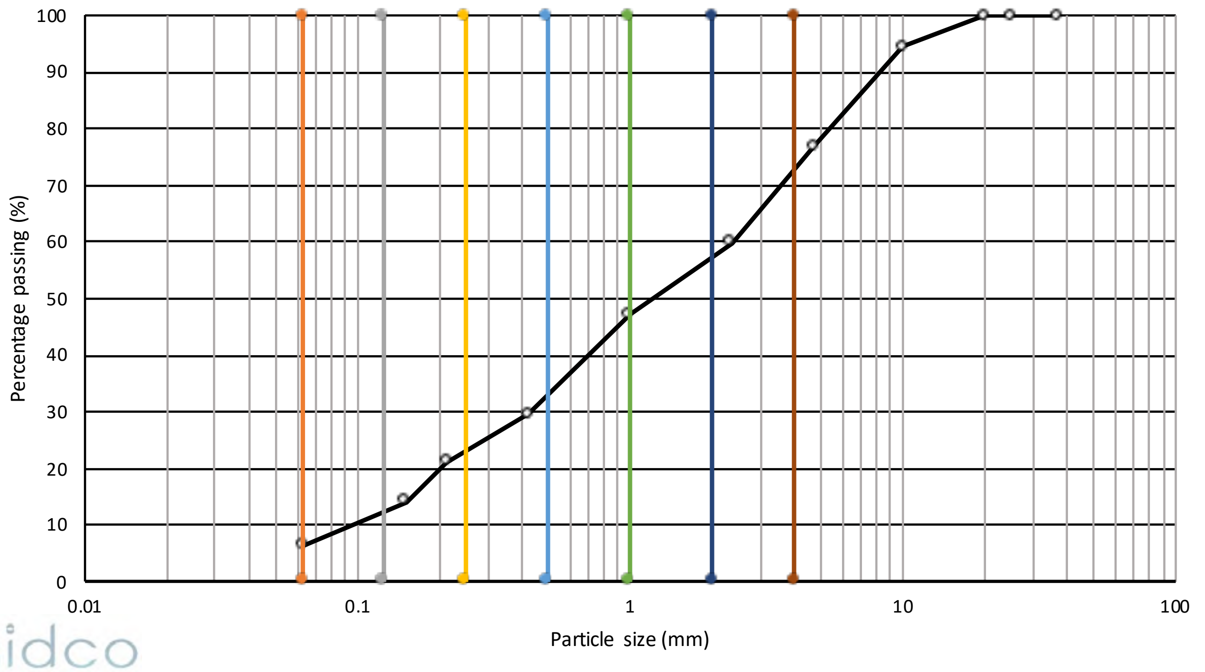
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	0.0	**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	284	100.0
2	**25**	0	0	0.0	284	100.0
3	**20**	0	0	0.0	284	100.0
4	**10**	16	16	5.6	268	94.4
5	**4.75**	50	66	23.2	218	76.8
8	**2.36**	48	114	40.1	170	59.9
16	**1**	36	150	52.8	134	47.2
30	**0.425**	50	200	70.4	84	29.6
50	**0.212**	24	224	78.9	60	21.1
100	**0.15**	20	244	85.9	40	14.1
200	**0.063**	22	266	93.7	18	6.3
Total weight sieved through 200 (g)				18		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				284	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.3%	5.7%	10.0%	11.0%	14.0%	11.0%	42.0%

SIDCO PVT LTD

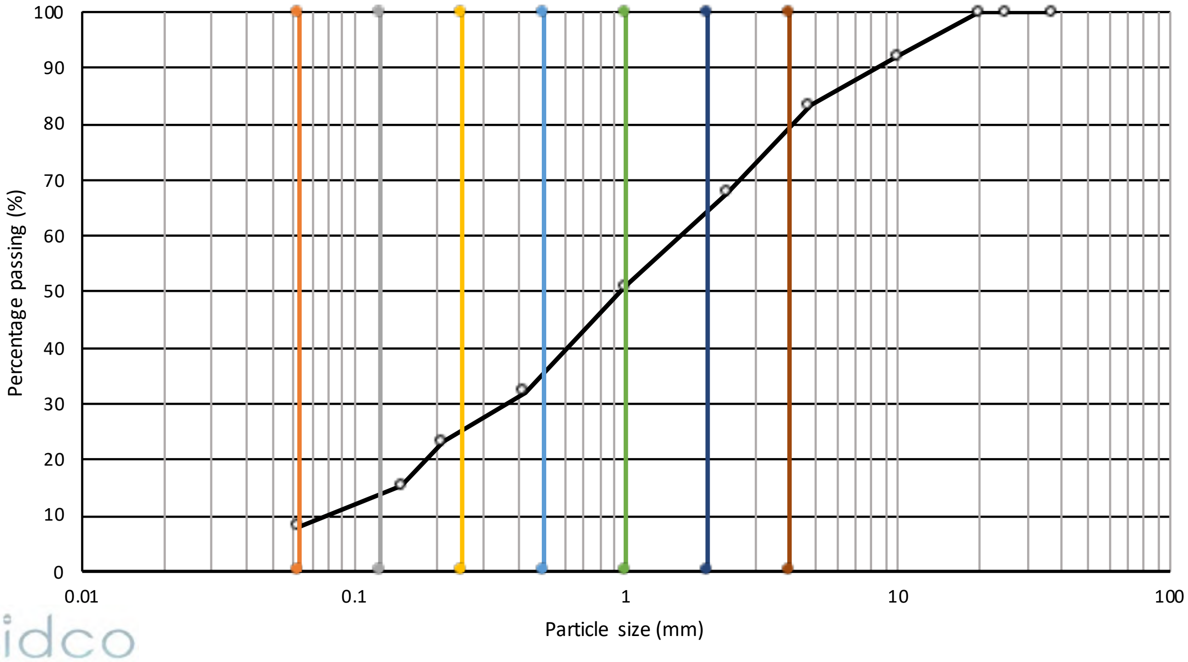
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour			**File #:**	HDEC/2023/1
Date:	16/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	1.0		**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	397	100.0
2	**25**	0	0	0.0	397	100.0
3	**20**	0	0	0.0	397	100.0
4	**10**	32	32	8.1	365	91.9
5	**4.75**	34	66	16.6	331	83.4
8	**2.36**	62	128	32.2	269	67.8
16	**1**	67	195	49.1	202	50.9
30	**0.425**	75	270	68.0	127	32.0
50	**0.212**	35	305	76.8	92	23.2
100	**0.15**	31	336	84.6	61	15.4
200	**0.063**	29	365	91.9	32	8.1
Total weight sieved through 200 (g)				32		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				397	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.1%	4.9%	12.0%	9.0%	16.0%	15.0%	35.0%

SIDCO PVT LTD

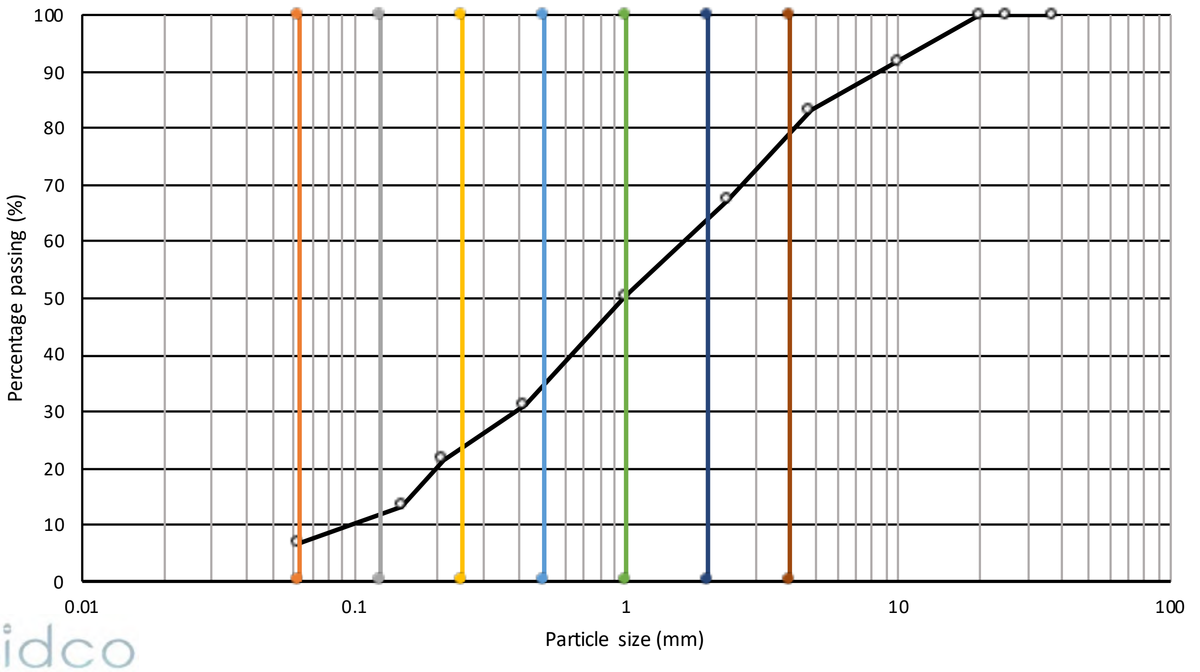
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	2.0	**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	366	100.0
2	**25**	0	0	0.0	366	100.0
3	**20**	0	0	0.0	366	100.0
4	**10**	30	30	8.2	336	91.8
5	**4.75**	32	62	16.9	304	83.1
8	**2.36**	58	120	32.8	246	67.2
16	**1**	62	182	49.7	184	50.3
30	**0.425**	70	252	68.9	114	31.1
50	**0.212**	35	287	78.4	79	21.6
100	**0.15**	30	317	86.6	49	13.4
200	**0.063**	24	341	93.2	25	6.8
Total weight sieved through 200 (g)				25		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				366	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	**Very Fine sand**	**Fine Sand**	**Medium Sand**	**Coarse Sand**	**Very Coarse sand**	**Gravel & larger**
6.8%	4.2%	11.0%	11.0%	17.0%	13.0%	37.0%

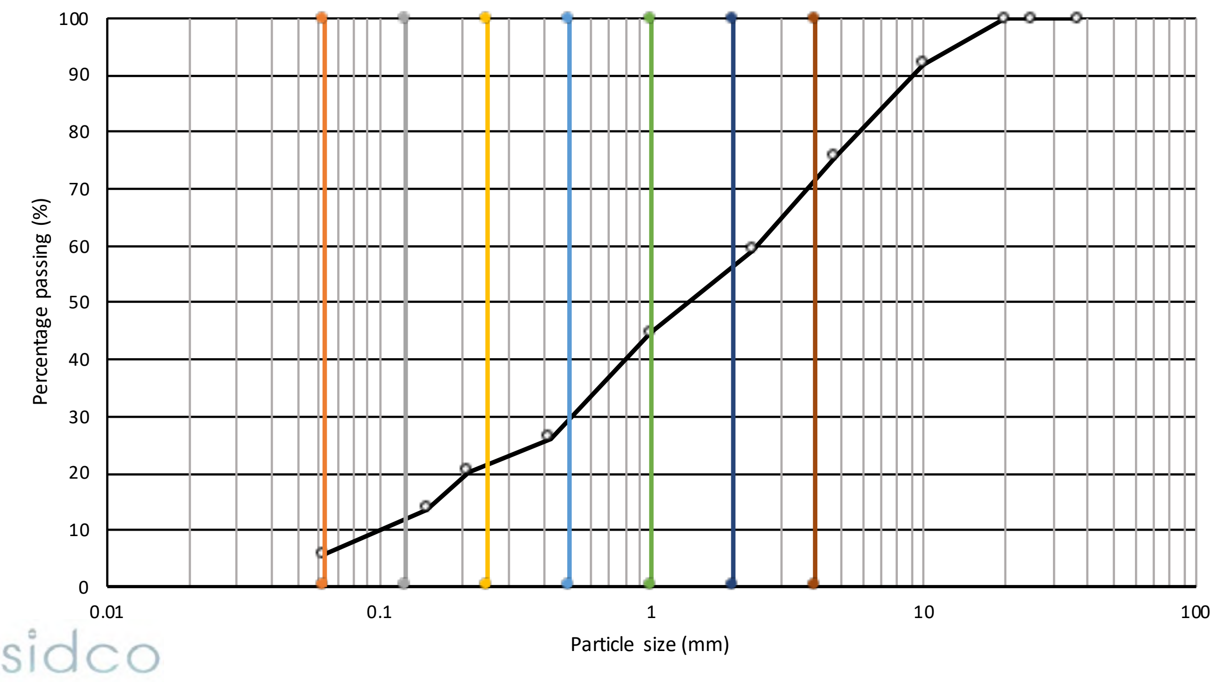
Sieve Analysis

Location:	S. Feydhoo Harbour			**File #:**	HDEC/2023/1
Date:	16/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	3.0		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	363	100.0
2	**25**	0	0	0.0	363	100.0
3	**20**	0	0	0.0	363	100.0
4	**10**	29	29	8.0	334	92.0
5	**4.75**	59	88	24.2	275	75.8
8	**2.36**	60	148	40.8	215	59.2
16	**1**	53	201	55.4	162	44.6
30	**0.425**	67	268	73.8	95	26.2
50	**0.212**	21	289	79.6	74	20.4
100	**0.15**	24	313	86.2	50	13.8
200	**0.063**	29	342	94.2	21	5.8
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				363	Error (%)	

Remarks

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.8%	5.2%	10.0%	9.0%	15.0%	11.0%	44.0%

SIDCO PVT LTD

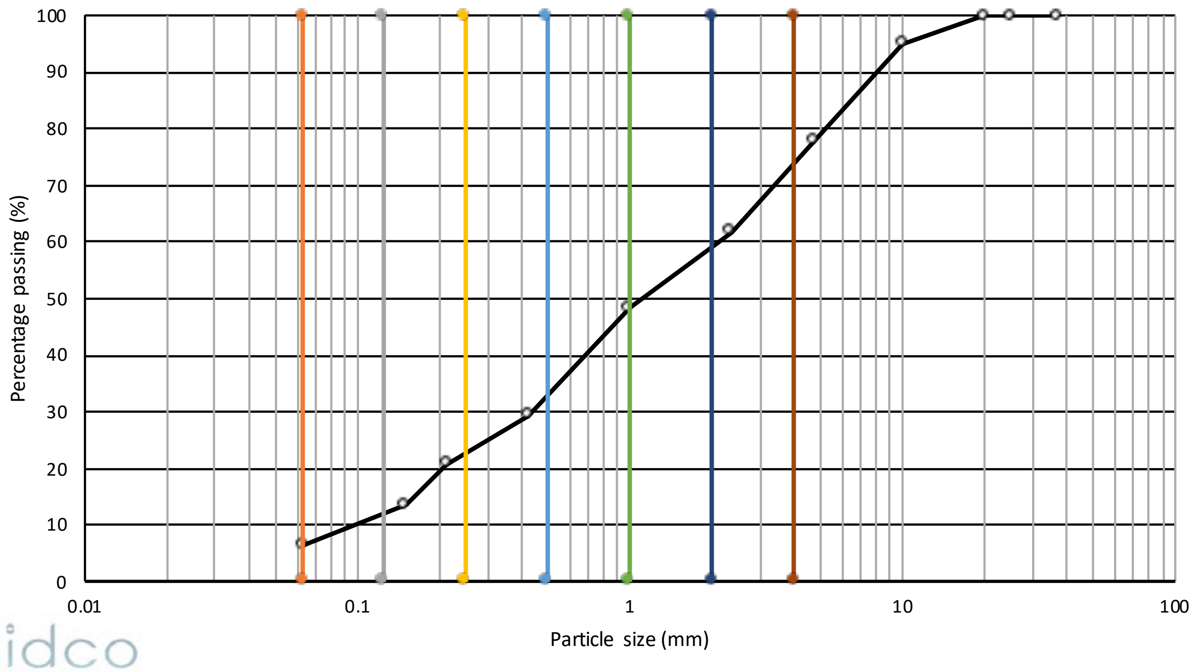
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	0.0	**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	265	100.0
2	**25**	0	0	0.0	265	100.0
3	**20**	0	0	0.0	265	100.0
4	**10**	13	13	4.9	252	95.1
5	**4.75**	46	59	22.3	206	77.7
8	**2.36**	42	101	38.1	164	61.9
16	**1**	36	137	51.7	128	48.3
30	**0.425**	50	187	70.6	78	29.4
50	**0.212**	23	210	79.2	55	20.8
100	**0.15**	19	229	86.4	36	13.6
200	**0.063**	19	248	93.6	17	6.4
22				17		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				265	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.4%	5.6%	10.0%	10.0%	17.0%	11.0%	40.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

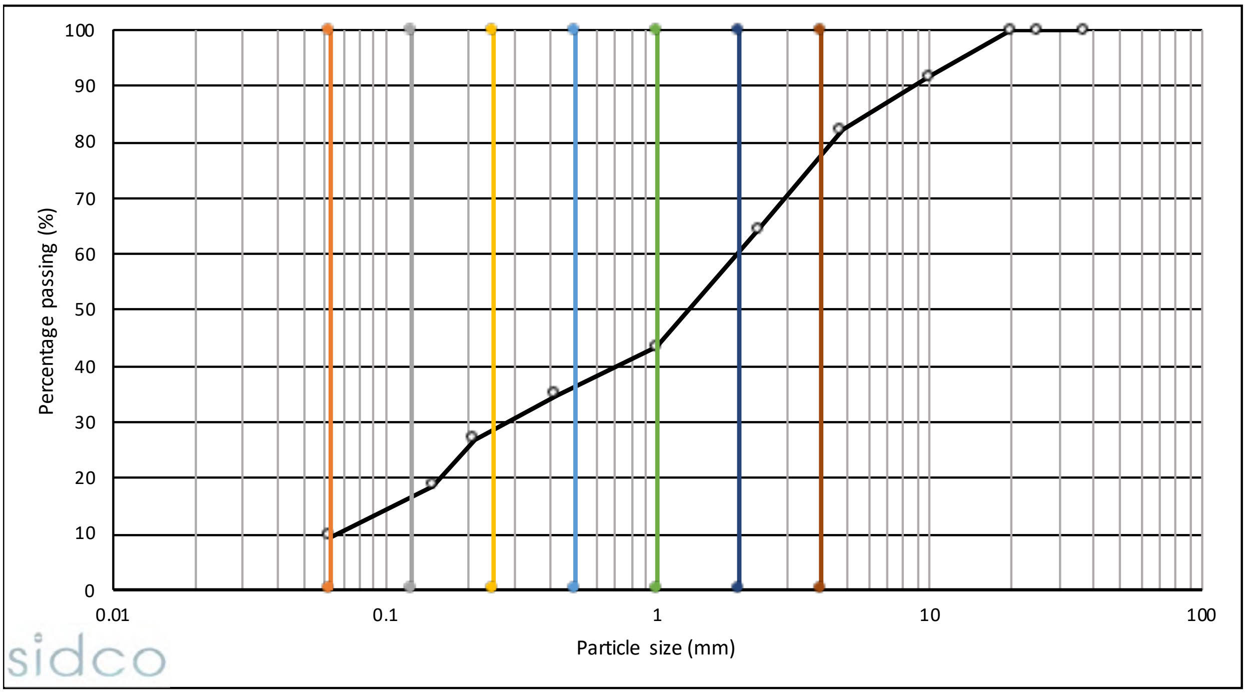
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	1.0	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	275	100.0
2	**25**	0	0	0.0	275	100.0
3	**20**	0	0	0.0	275	100.0
4	**10**	23	23	8.4	252	91.6
5	**4.75**	26	49	17.8	226	82.2
8	**2.36**	49	98	35.6	177	64.4
16	**1**	58	156	56.7	119	43.3
30	**0.425**	23	179	65.1	96	34.9
50	**0.212**	22	201	73.1	74	26.9
100	**0.15**	23	224	81.5	51	18.5
200	**0.063**	25	249	90.5	26	9.5
Total weight sieved through 200 (g)				26		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				275	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
9.5%	6.5%	13.0%	7.0%	6.0%	18.0%	40.0%

SIDCO PVT LTD

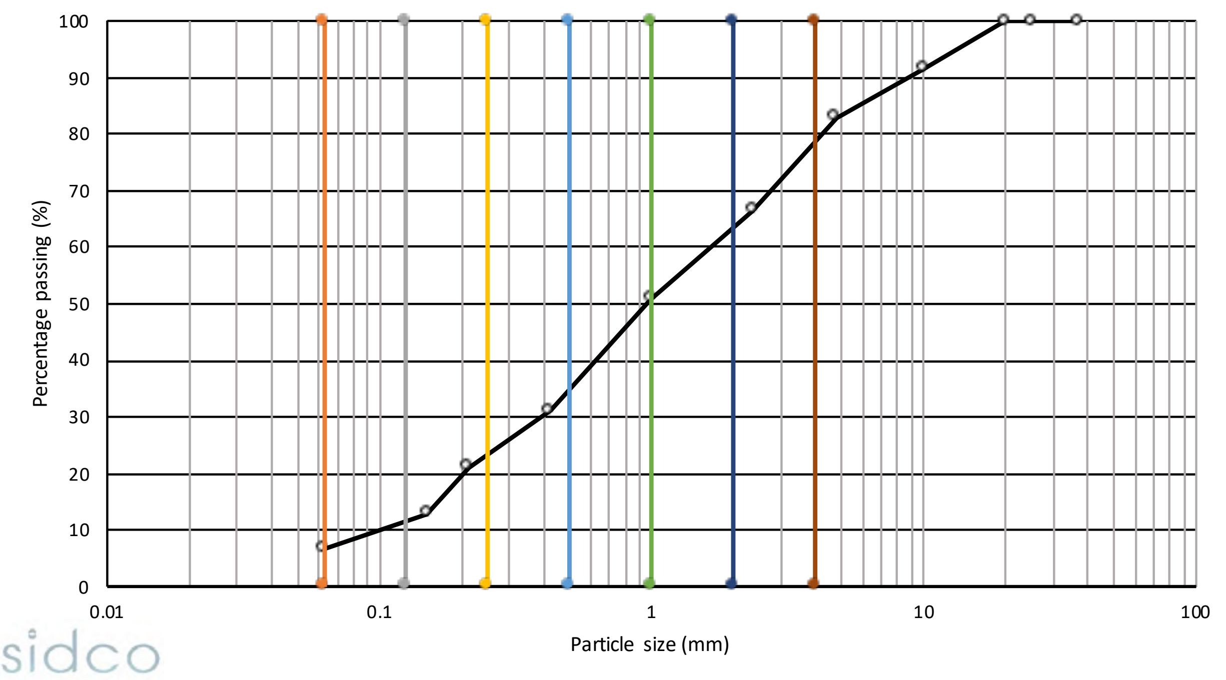
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1	
Date:	16/02/2023	**Tested by:**	SM		
BH2	**Depth (m)**	2.0	**Test #**	**3**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	311	100.0
2	**25**	0	0	0.0	311	100.0
3	**20**	0	0	0.0	311	100.0
4	**10**	26	26	8.4	285	91.6
5	**4.75**	27	53	17.0	258	83.0
8	**2.36**	51	104	33.4	207	66.6
16	**1**	49	153	49.2	158	50.8
30	**0.425**	61	214	68.8	97	31.2
50	**0.212**	31	245	78.8	66	21.2
100	**0.15**	26	271	87.1	40	12.9
200	**0.063**	19	290	93.2	21	6.8
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				311	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.8%	4.2%	11.0%	12.0%	16.0%	13.0%	37.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

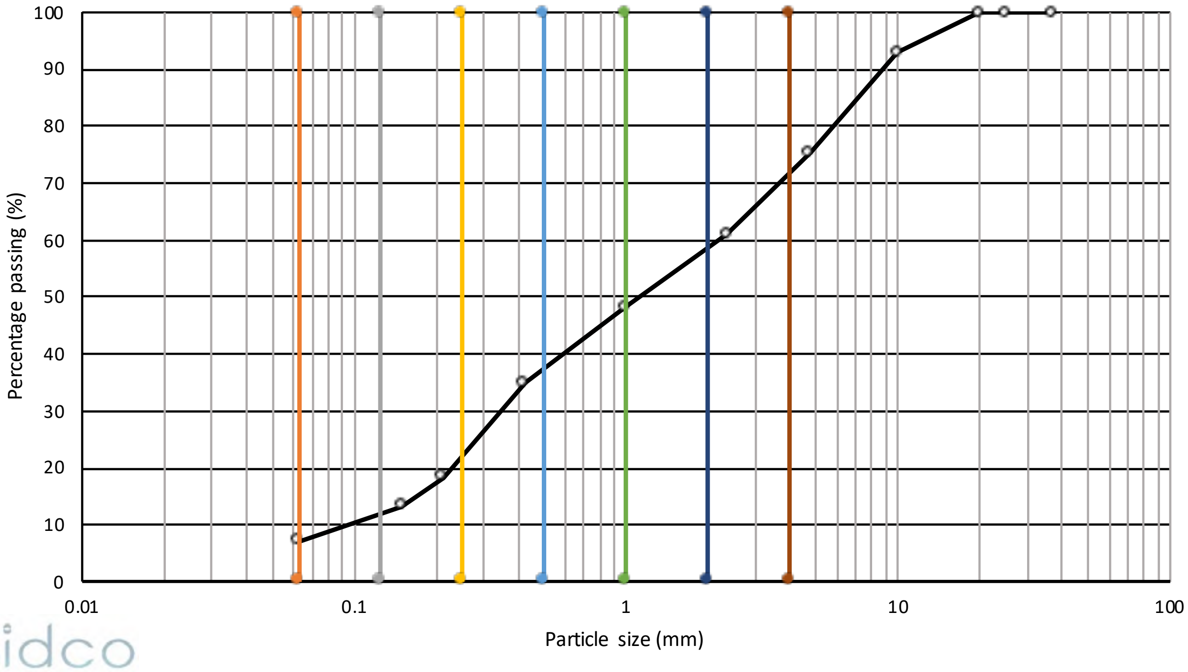
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	3.0	**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	338	100.0
2	**25**	0	0	0.0	338	100.0
3	**20**	0	0	0.0	338	100.0
4	**10**	24	24	7.1	314	92.9
5	**4.75**	59	83	24.6	255	75.4
8	**2.36**	49	132	39.1	206	60.9
16	**1**	43	175	51.8	163	48.2
30	**0.425**	45	220	65.1	118	34.9
50	**0.212**	56	276	81.7	62	18.3
100	**0.15**	17	293	86.7	45	13.3
200	**0.063**	21	314	92.9	24	7.1
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				338	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.1%	3.9%	10.0%	16.0%	12.0%	10.0%	41.0%

APPENDIX A6: PROCTOR TEST RESULT

SIDCO PVT LTD

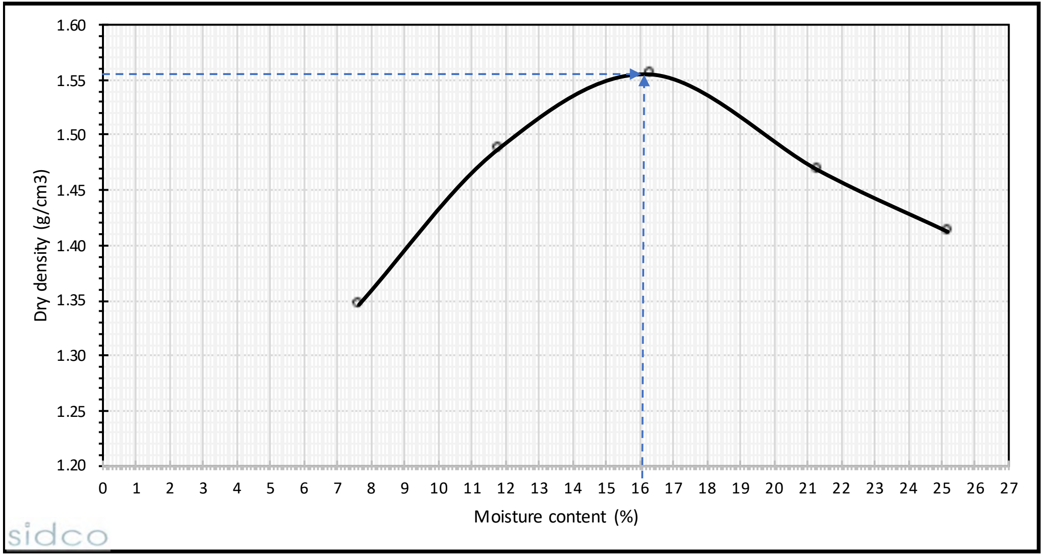
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**S. Feydhoo**	**Date:**	**21/02/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.61	
Water dennsity, 𝜸w	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4898.00	5112.00	5258.00	5230.00	5217.00
weight of compacted soil, w2-w1 (g)	1449.00	1663.00	1809.00	1781.00	1768.00
Wet density, 𝜸b = ((w2-w1)/v), g/cm3	1.45	1.66	1.81	1.78	1.77
Dry density, 𝜸d = (𝜸b/(1+(w/100))), g/cm3	**1.35**	**1.49**	**1.55**	**1.47**	**1.41**
Void Ratio e = ((Gs𝜸w)/𝜸d-1	1.94	1.75	1.68	1.78	1.85
Moisture content					
Weight of container, g	30.04	30.15	30.09	29.99	30.06
Weight of container + wet soil, g	72.3	65.1	68.3	74.1	70.4
Wet container + dry soil, g	69.34	61.43	62.95	66.36	62.31
Weight of moisture, ww (g)	3.00	3.69	5.37	7.76	8.12
Weight of dry soil, ws (g)	39.30	31.28	32.86	36.37	32.25
Water content, w= ((ww/ws)x100), %	**7.63**	**11.80**	**16.34**	**21.34**	**25.18**



APPENDIX A7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

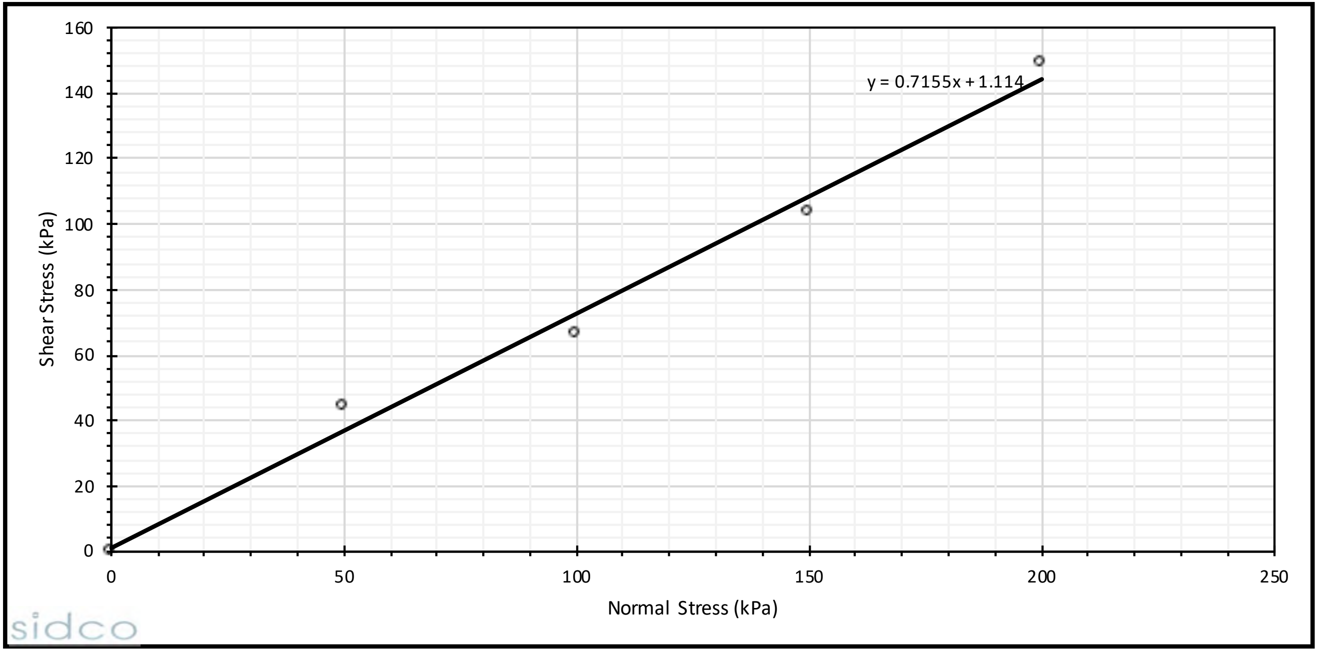
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**S. Feydhoo**	**Date:**	**17/02/2023**	**Direct Shear**	**1**

Moisture content (%)	9.25%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	35.79	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	44.35
100.00	66.21
150.00	103.41
200.00	149.34



APPENDIX A8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**S. Feydhoo**	**Date:**	**22/02/2022**
TEST 1			
Mass of dnesity bottle	W1	31.32	g
Mass of bottle + dry sand	W2	60.23	g
Mass of bottle + dry sand + water	W3	148.73	g
Mass of bottle + water	W4	130.93	g
Specific Gravity	Gs	2.60	

TEST 2

Mass of dnesity bottle	W1	35.01	g
Mass of bottle + dry sand	W2	73.21	g
Mass of bottle + dry sand + water	W3	170.21	g
Mass of bottle + water	W4	146.64	g
Specific Gravity	Gs	2.61	

Avarege Gs		2.61	

APPENDIX A9: SOIL RESITIVITY SURVEY RESULT

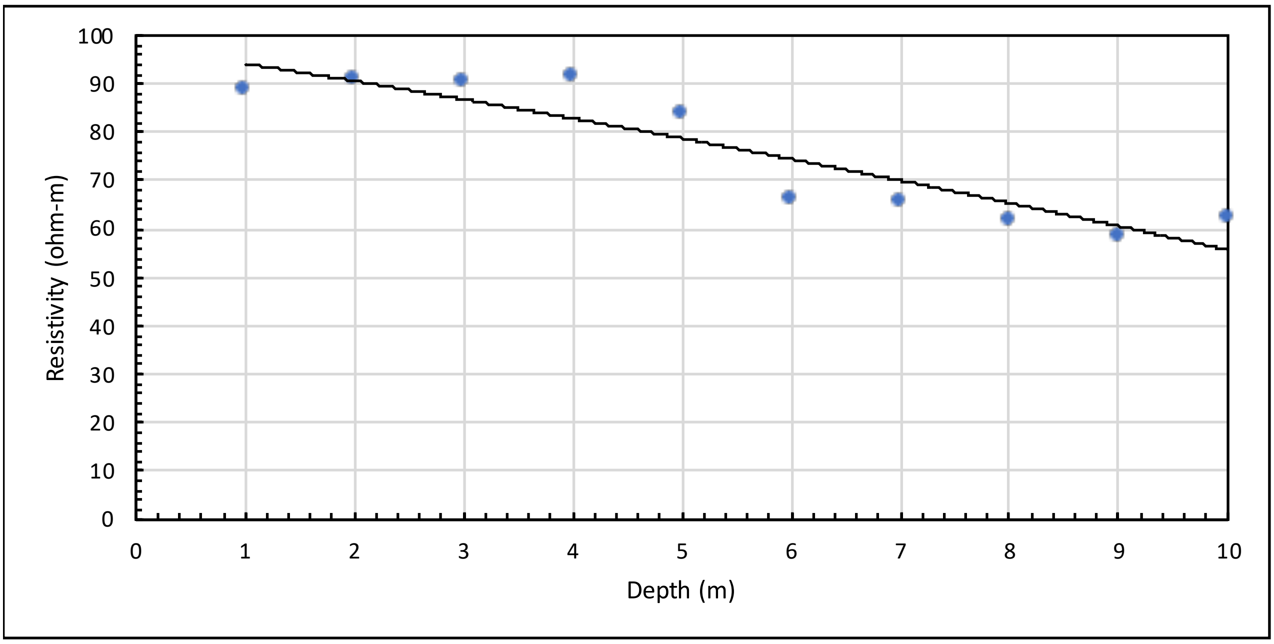
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	14.10	89
2	2	7.23	91
3	3	4.81	91
4	4	3.65	92
5	5	2.67	84
6	6	1.76	66
7	7	1.49	66
8	8	1.23	62
9	9	1.03	58
10	10	0.99	62

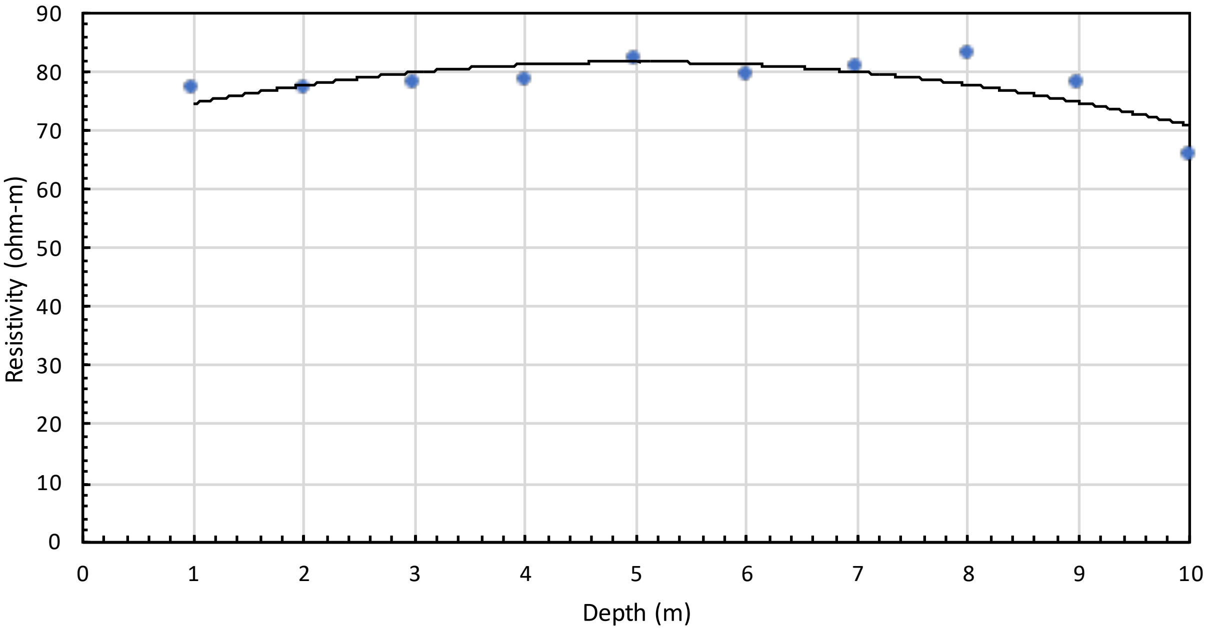


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

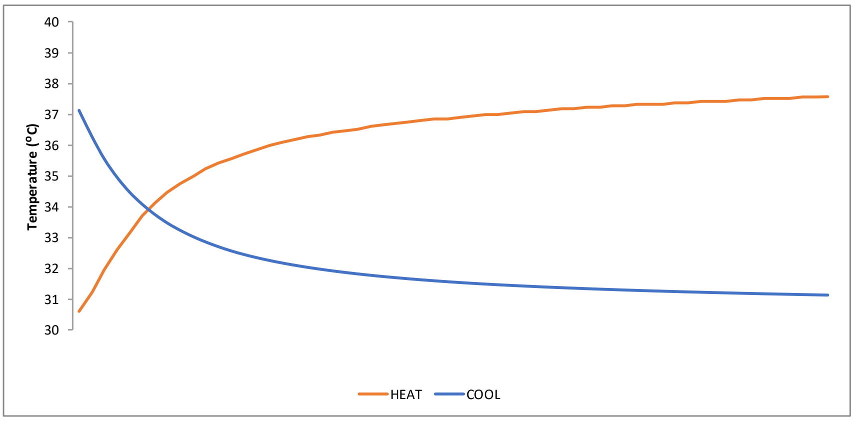
Soil Resistivity Survey - Wenner Method

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	12.31	77
2	2	6.15	77
3	3	4.15	78
4	4	3.12	78
5	5	2.62	82
6	6	2.10	79
7	7	1.84	81
8	8	1.65	83
9	9	1.38	78
10	10	1.05	66

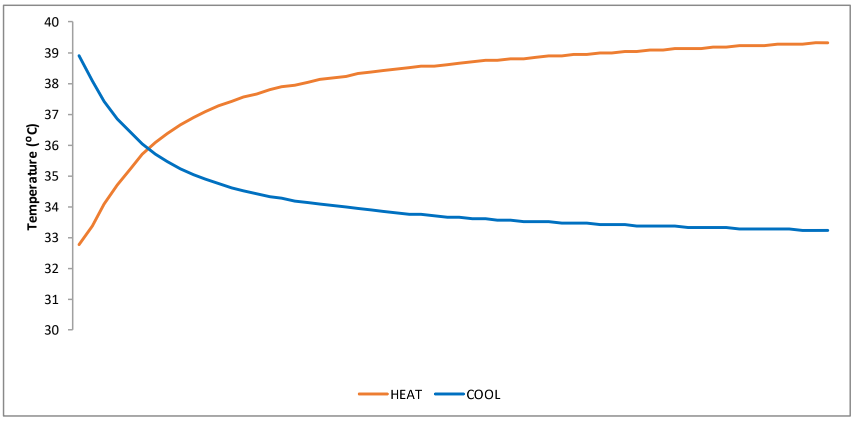


APPENDIX A10: THERMAL CONDUCTIVITY TEST RESULTS

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	30.596928		89599	37.118725
1500	31.230659		91099	36.283516
3000	31.950489		92599	35.537529
4500	32.589798		94099	34.945511
6000	33.183743		95599	34.458321
7500	33.689228		97099	34.065125
9000	34.109692		98599	33.733425
10500	34.455883		100099	33.453087
12000	34.753601		101599	33.220543
13500	35.006447		103099	33.019924
15000	35.22192		104599	32.845932
16500	35.407627		106099	32.693615
18000	35.571518		107599	32.558235
19500	35.719833		109099	32.44249
21000	35.84967		110599	32.340694
22500	35.964375		112099	32.249676
24000	36.068832		113599	32.167923
25500	36.162655		115099	32.094109
27000	36.247425		116599	32.026901
28500	36.324543		118099	31.966164
30000	36.395485		119599	31.910103
31500	36.461147		121099	31.858822
33000	36.522438		122599	31.811165
34500	36.580208		124099	31.767265
36000	36.634983		125599	31.726471
37500	36.686314		127099	31.68935
39000	36.733822		128599	31.653675
40500	36.778976		130099	31.620464
42000	36.821918		131599	31.589672
43500	36.862446		133099	31.560333
45000	36.900028		134599	31.533356
46500	36.936325		136099	31.507618
48000	36.97147		137599	31.483625
49500	37.004646		139099	31.461552
51000	37.036308		140599	31.440559
52500	37.066418		142099	31.420702
54000	37.09586		143599	31.401255
55500	37.123787		145099	31.383278
57000	37.150581		146599	31.366159
58500	37.176704		148099	31.350029
60000	37.201927		149599	31.334126
61500	37.2257		151099	31.318613
63000	37.249237		152599	31.304399
64500	37.272167		154099	31.290123
66000	37.293892		155599	31.277157
67500	37.315449		157099	31.264257
69000	37.336124		158599	31.251991
70500	37.35603		160099	31.239941
72000	37.375763		161599	31.228703
73500	37.394432		163099	31.217804
75000	37.413746		164599	31.207113
76500	37.431263		166099	31.197266
78000	37.448879		167599	31.186728
79500	37.466106		169099	31.17728
81000	37.483074		170599	31.167589
82500	37.499245		172099	31.159277
84000	37.515457		173599	31.150616
85500	37.531933		175099	31.142096
87000	37.548325		176599	31.134031
88500	37.563423		178099	31.125893



HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	32.76265		89599	38.892651
1500	33.361317		91099	38.101105
3000	34.076332		92599	37.400742
4500	34.688732		94099	36.846508
6000	35.229095		95599	36.393497
7500	35.682739		97099	36.026703
9000	36.063641		98599	35.718502
10500	36.379593		100099	35.457291
12000	36.650719		101599	35.240891
13500	36.885044		103099	35.053516
15000	37.084793		104599	34.891926
16500	37.257336		106099	34.749435
18000	37.407494		107599	34.623917
19500	37.540962		109099	34.513115
21000	37.662052		110599	34.417625
22500	37.769798		112099	34.332172
24000	37.867786		113599	34.25531
25500	37.955524		115099	34.186111
27000	38.035404		116599	34.122246
28500	38.108307		118099	34.064842
30000	38.175591		119599	34.011967
31500	38.237328		121099	33.962299
33000	38.295856		122599	33.917461
34500	38.348942		124099	33.875706
36000	38.399303		125599	33.836269
37500	38.44627		127099	33.799774
39000	38.490532		128599	33.765182
40500	38.533478		130099	33.733093
42000	38.575123		131599	33.703045
43500	38.613895		133099	33.674717
45000	38.651157		134599	33.647469
46500	38.686798		136099	33.621582
48000	38.720379		137599	33.597862
49500	38.753151		139099	33.574375
51000	38.784363		140599	33.552219
52500	38.814369		142099	33.531765
54000	38.843105		143599	33.511955
55500	38.87096		145099	33.492943
57000	38.897423		146599	33.475983
58500	38.923473		148099	33.458942
60000	38.948364		149599	33.442787
61500	38.972355		151099	33.427166
63000	38.996147		152599	33.412354
64500	39.019337		154099	33.397945
66000	39.041008		155599	33.384815
67500	39.062466		157099	33.370865
69000	39.083145		158599	33.358582
70500	39.103458		160099	33.346035
72000	39.123234		161599	33.333694
73500	39.142662		163099	33.322323
75000	39.161434		164599	33.310833
76500	39.179951		166099	33.300358
78000	39.197319		167599	33.289772
79500	39.214878		169099	33.280304
81000	39.232407		170599	33.270092
82500	39.248947		172099	33.260509
84000	39.264832		173599	33.251015
85500	39.281048		175099	33.242409
87000	39.296627		176599	33.23373
88500	39.311642		178099	33.22427



APPENDIX A11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT
Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Maradhoo-Feydhoo Harbour	Hithadhoo Stadium E	Hulhumeedhoo SPT	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83235949	83235950	83235951		
Sampled Date ~	24/01/2023 02:00	24/01/2023 02:00	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
Conductivity *	53800	433	712	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.6	7.4	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	26900	216	356	Electrometry	mg/L
Chloride	18550	<10 (LoQ 10 mg/L)	79	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	5.8	4.1	11.3	HACH Method 8171	mg/L
Sulphate *	2800	<10 (LoQ 10 mg/L)	20	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT
Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Feydhoo Harbour	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235952		
Sampled Date ~	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	46100	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.8	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	23000	Electrometry	mg/L
Chloride	15500	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	8.5	HACH Method 8171	mg/L
Sulphate *	2200	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

APPENDICES (B)

S. Maradhoo Feydhoo Harbour

APPENDIX B1: TEST LOCATIONS


N
W
E
S
BH2
15 m x 100 m
1500 sqm
DCP5
MP2
ER2
TC2
DCP4
DCP3
15 m x 50 m
750 sqm
DCP2
15 m x 50 m
750 sqm
BH1
15 m x 100 m
1500 sqm
DCP1
TC1
MP1
ER1
0
75
150
300
450
600
Meters
Legend
Solar Installation Area

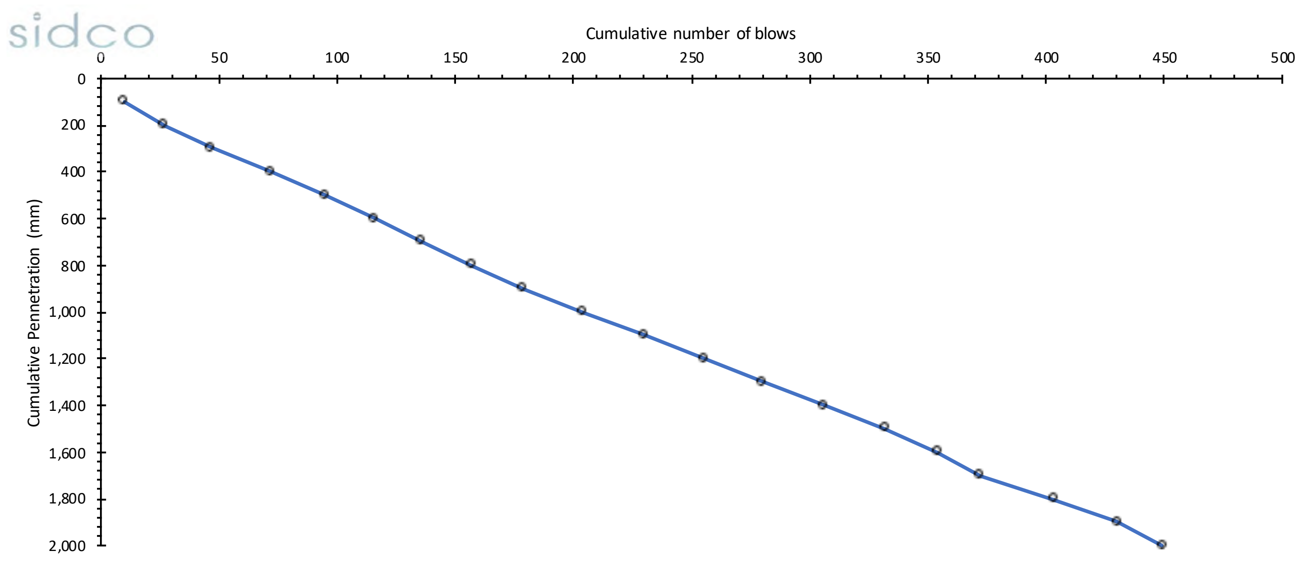
APPENDIX B2: DCP TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Maradhoo - Fetdhoo**		**12/01/2023**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	10	10	10.0	22	205	82
100-200	17	27	5.9	40	304	121
200-300	20	47	5.0	48	343	137
300-400	25	72	4.0	62	404	162
400-500	23	95	4.3	56	380	152
500-600	21	116	4.8	51	355	142
600-700	20	136	5.0	48	343	137
700-800	21	157	4.8	51	355	142
800-900	22	179	4.5	54	368	147
900-1000	25	204	4.0	62	404	162
1000-1100	26	230	3.8	65	416	167
1100-1200	25	255	4.0	62	404	162
1200-1300	25	280	4.0	62	404	162
1300-1400	26	306	3.8	65	416	167
1400-1500	26	332	3.8	65	416	167
1500-1600	22	354	4.5	54	368	147
1600-1700	18	372	5.6	43	317	127
1700-1800	31	403	3.2	79	475	190
1800-1900	27	430	3.7	67	428	171
1900-2000	19	449	5.3	45	330	132



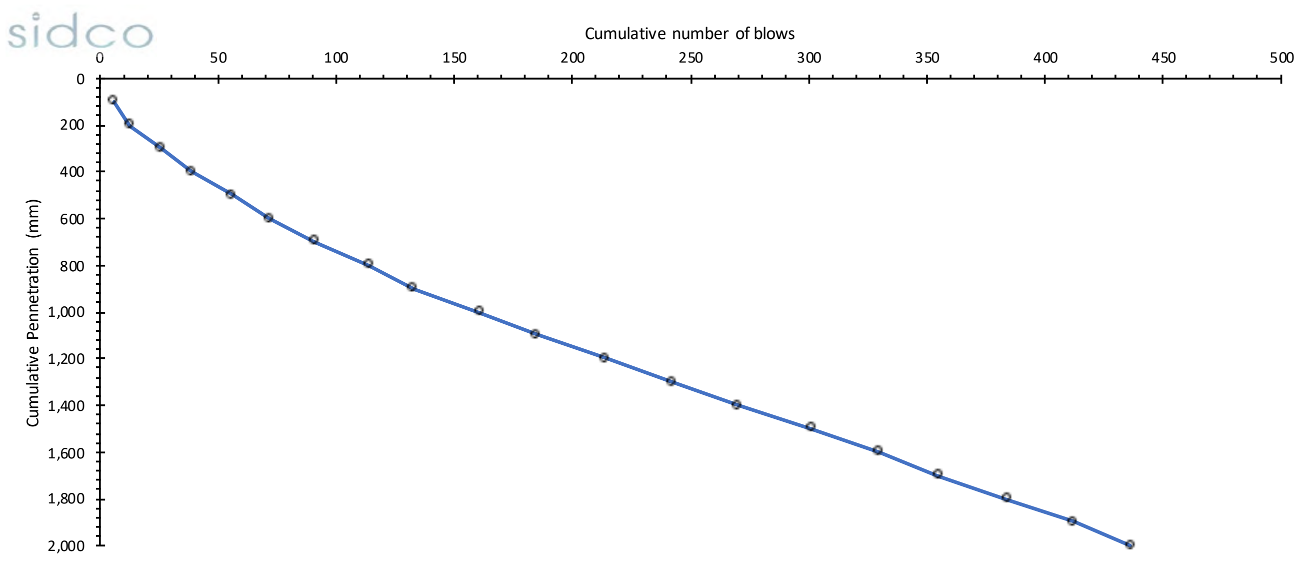
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	S. Maradhoo - Fetdhoo		12/01/2023		DCP#	2
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	7	13	14.3	15	157	63
200-300	13	26	7.7	30	249	99
300-400	13	39	7.7	30	249	99
400-500	17	56	5.9	40	304	121
500-600	16	72	6.3	37	290	116
600-700	19	91	5.3	45	330	132
700-800	23	114	4.3	56	380	152
800-900	19	133	5.3	45	330	132
900-1000	28	161	3.6	70	440	176
1000-1100	24	185	4.2	59	392	157
1100-1200	29	214	3.4	73	452	181
1200-1300	28	242	3.6	70	440	176
1300-1400	28	270	3.6	70	440	176
1400-1500	31	301	3.2	79	475	190
1500-1600	29	330	3.4	73	452	181
1600-1700	25	355	4.0	62	404	162
1700-1800	29	384	3.4	73	452	181
1800-1900	28	412	3.6	70	440	176
1900-2000	24	436	4.2	59	392	157



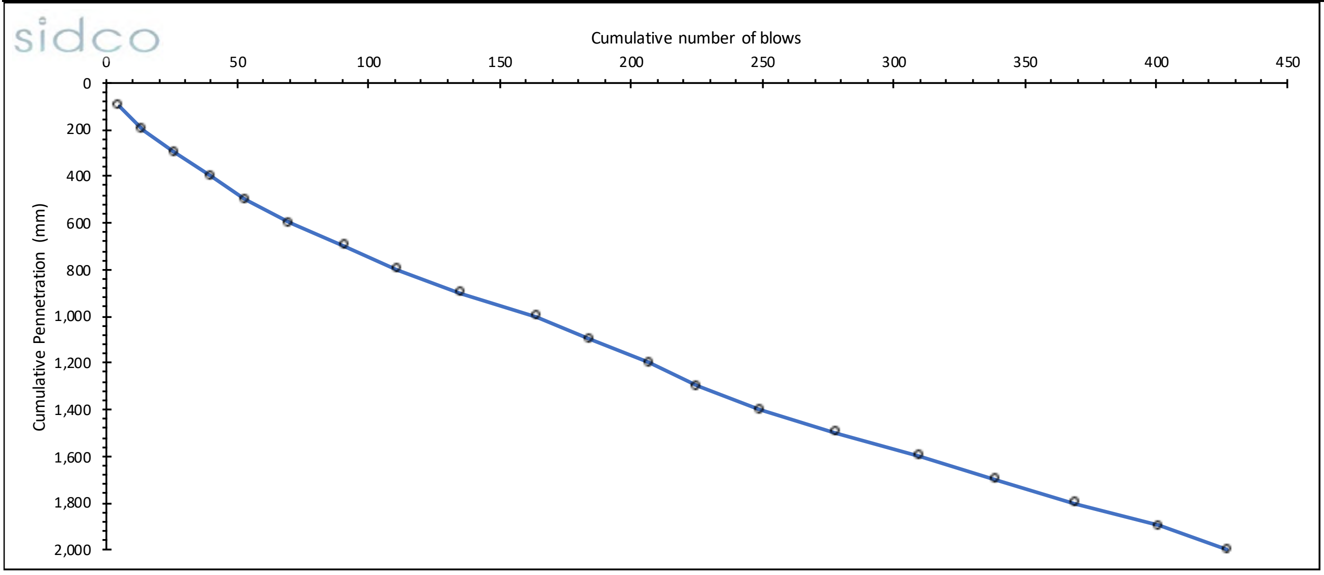
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Maradhoo - Fetdhoo**		**12/01/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	5	5	20.0	10	122	49
100-200	9	14	11.1	20	189	76
200-300	12	26	8.3	27	234	94
300-400	14	40	7.1	32	263	105
400-500	13	53	7.7	30	249	99
500-600	17	70	5.9	40	304	121
600-700	21	91	4.8	51	355	142
700-800	20	111	5.0	48	343	137
800-900	24	135	4.2	59	392	157
900-1000	29	164	3.4	73	452	181
1000-1100	20	184	5.0	48	343	137
1100-1200	23	207	4.3	56	380	152
1200-1300	18	225	5.6	43	317	127
1300-1400	24	249	4.2	59	392	157
1400-1500	29	278	3.4	73	452	181
1500-1600	32	310	3.1	81	486	194
1600-1700	29	339	3.4	73	452	181
1700-1800	30	369	3.3	76	463	185
1800-1900	32	401	3.1	81	486	194
1900-2000	26	427	3.8	65	416	167



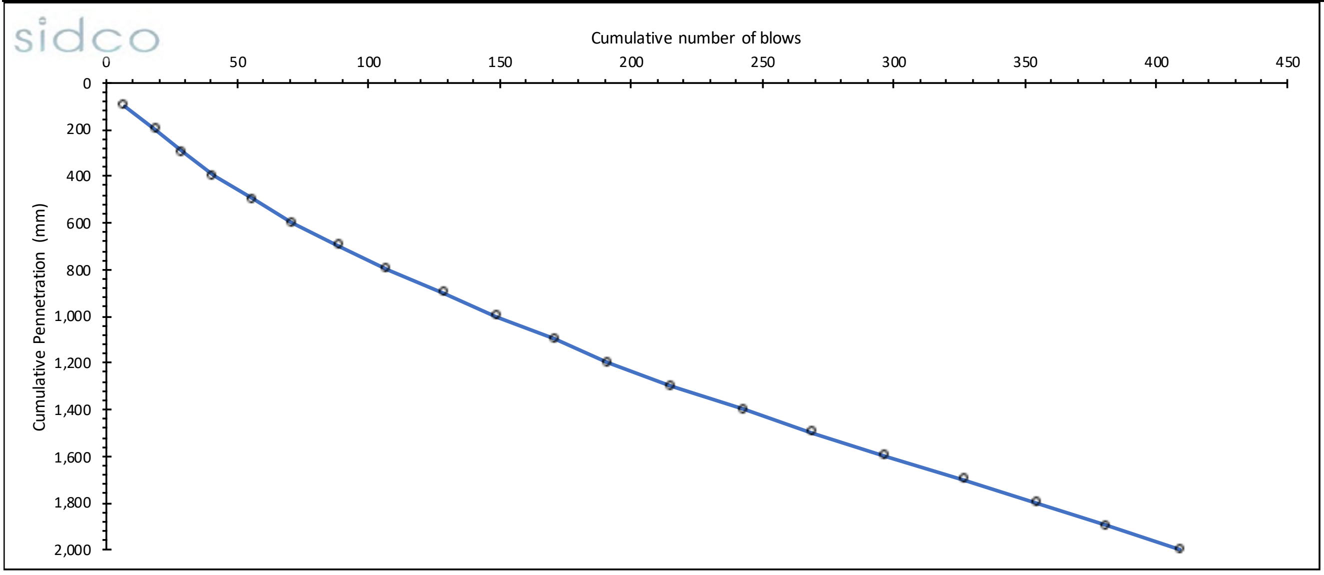
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	S. Maradhoo - Fetdhoo		12/01/2023		DCP#	4
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	7	7	14.3	15	157	63
100-200	12	19	8.3	27	234	94
200-300	10	29	10.0	22	205	82
300-400	12	41	8.3	27	234	94
400-500	15	56	6.7	35	277	111
500-600	15	71	6.7	35	277	111
600-700	18	89	5.6	43	317	127
700-800	18	107	5.6	43	317	127
800-900	22	129	4.5	54	368	147
900-1000	20	149	5.0	48	343	137
1000-1100	22	171	4.5	54	368	147
1100-1200	20	191	5.0	48	343	137
1200-1300	24	215	4.2	59	392	157
1300-1400	28	243	3.6	70	440	176
1400-1500	26	269	3.8	65	416	167
1500-1600	28	297	3.6	70	440	176
1600-1700	30	327	3.3	76	463	185
1700-1800	28	355	3.6	70	440	176
1800-1900	26	381	3.8	65	416	167
1900-2000	28	409	3.6	70	440	176



SIDCO SOILS LAB

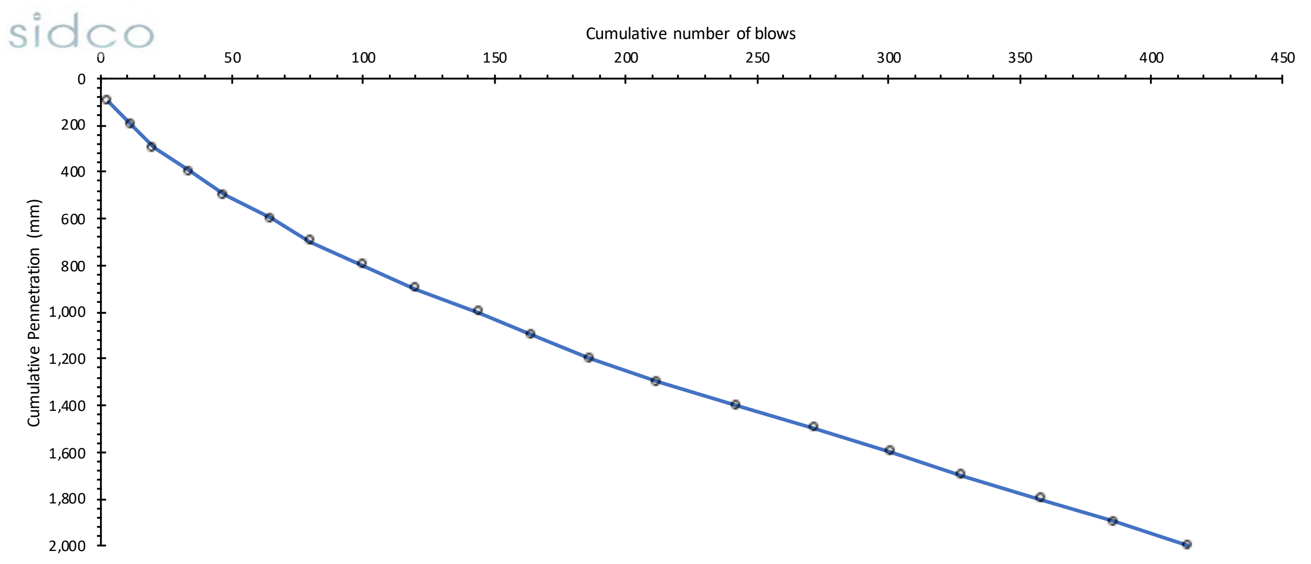
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Maradhoo - Fetdhoo**	**12/01/2023**	**DCP#**	**5**

Depth (mm)	Number of Blows	Cumulative Number of Blows	DCP Index (mm/blow)	CBR (%)	Ultimate Bearing Capacity, q (kPa)	Safe Bearing Capacity, q (kPa)
0-100	3	3	33.3	6	84	33
100-200	9	12	11.1	20	189	76
200-300	8	20	12.5	17	173	69
300-400	14	34	7.1	32	263	105
400-500	13	47	7.7	30	249	99
500-600	18	65	5.6	43	317	127
600-700	15	80	6.7	35	277	111
700-800	20	100	5.0	48	343	137
800-900	20	120	5.0	48	343	137
900-1000	24	144	4.2	59	392	157
1000-1100	20	164	5.0	48	343	137
1100-1200	22	186	4.5	54	368	147
1200-1300	26	212	3.8	65	416	167
1300-1400	30	242	3.3	76	463	185
1400-1500	30	272	3.3	76	463	185
1500-1600	29	301	3.4	73	452	181
1600-1700	27	328	3.7	67	428	171
1700-1800	30	358	3.3	76	463	185
1800-1900	28	386	3.6	70	440	176
1900-2000	28	414	3.6	70	440	176



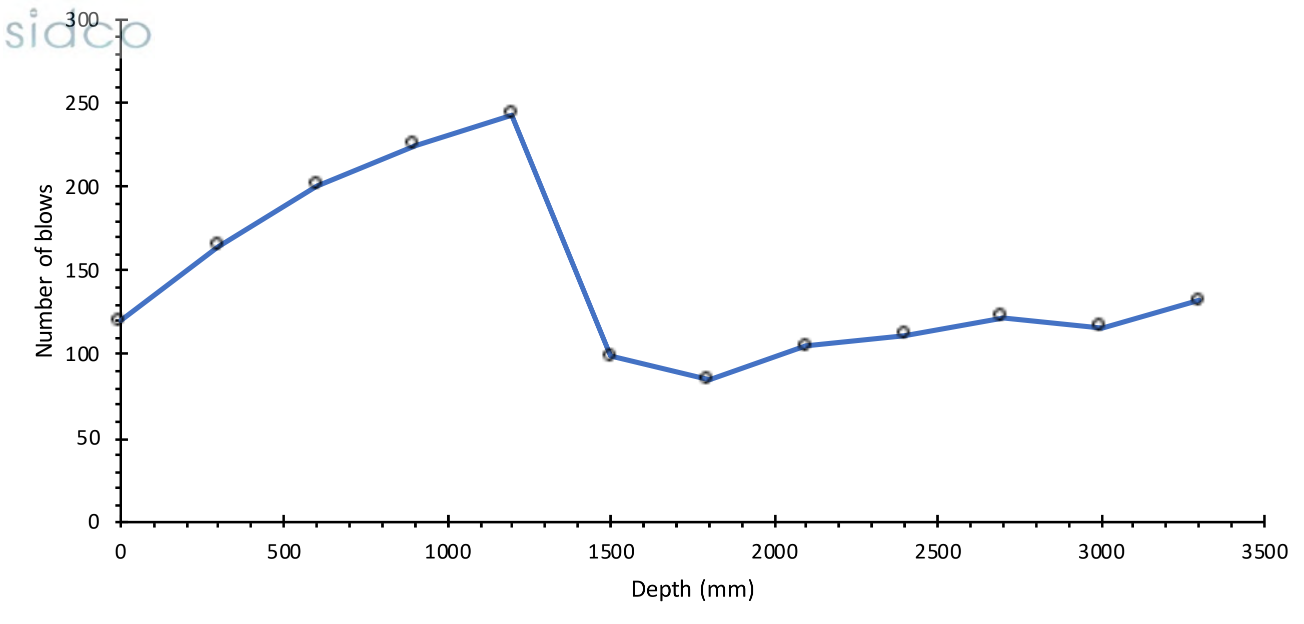
APPENDIX B3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	S. Maradhoo - Feydhoo		MP#	1
Depth (mm)	Number of Blows, N_{MP}	Cumulative Number of Blows	Bearing Capacity kPa	Bearing Capacity
0-300	120	120	372	149
300-600	165	285	431	173
600-900	201	486	471	188
900-1200	225	711	495	198
1200-1500	243	954	512	205
1500-1800	99	1053	339	136
1800-2100	85	1138	314	125
2100-2400	105	1243	349	140
2400-2700	112	1355	360	144
2700-3000	122	1477	375	150
3000-3300	116	1593	367	147
3300-3600	132	1725	390	156
3600-3900	124	1849	378	151
3900-4200	120	1969	372	149
4200-4500	175	2144	443	177
4500-4800	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
4800-5100				
5100-5400				
5400-5700				
5700-6000				



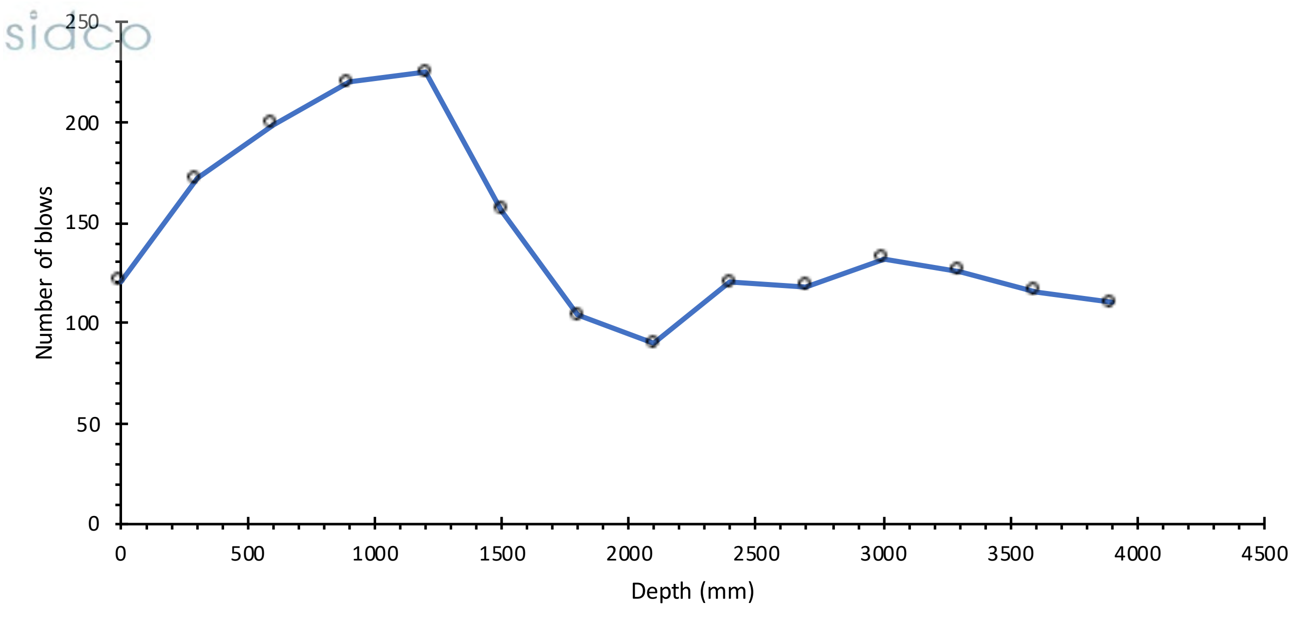
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**S. Maradhoo - Feydhoo**		**MP#**	**2**
Depth (mm)	**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Bearing Capacity**
0-300	121	121	374	150
300-600	172	293	439	176
600-900	199	492	469	188
900-1200	220	712	490	196
1200-1500	225	937	495	198
1500-1800	156	1093	421	168
1800-2100	104	1197	348	139
2100-2400	90	1287	323	129
2400-2700	120	1407	372	149
2700-3000	118	1525	370	148
3000-3300	132	1657	390	156
3300-3600	126	1783	381	152
3600-3900	116	1899	367	147
3900-4200	110	2009	357	143
4200-4500	>400 blows per 0.3 m as MP got rebound on hard strata/rock			
4500-4800				
4800-5100				
5100-5400				
5400-5700				
5700-6000				



APPENDIX B4: BOREHOLE LOGS

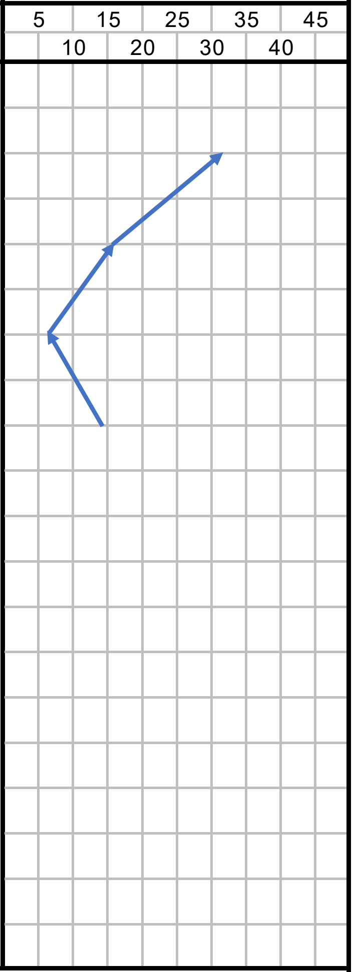
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Maradhoo-Feydhoo Harbour				
Project Number:	2023/HDEC/01	Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill	Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory				
Ground water depth (m)	1.0	Date Started:	09/02/2023	Bit Type	PDC
				Diameter (mm)	76
Total depth of boring (m)	4	Date Completed	09/02/2023	Hammer Type	Auto tripped hammer
BH Location	Maradhoo-Feydhoo Harbour	Date Backfilled:	10/02/2023	Hammer Weight (kg)	63.5
				Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60
1	SS	D1	▼		Medium dense, off white coral sand with some rock pieces (backfilled material)	10	10	8	18	32
	SS	D2			loose , off white fine sand with some gravel					
2						4	4	5	9	16
	SS	D3								
3	SS	D4				3	2	2	4	6
4						5	5	5	10	14
	SS	D5								
5										
	SS	D6								
6										
7										
	SS	D7								
8										
	SS	D8								
9										
10										

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

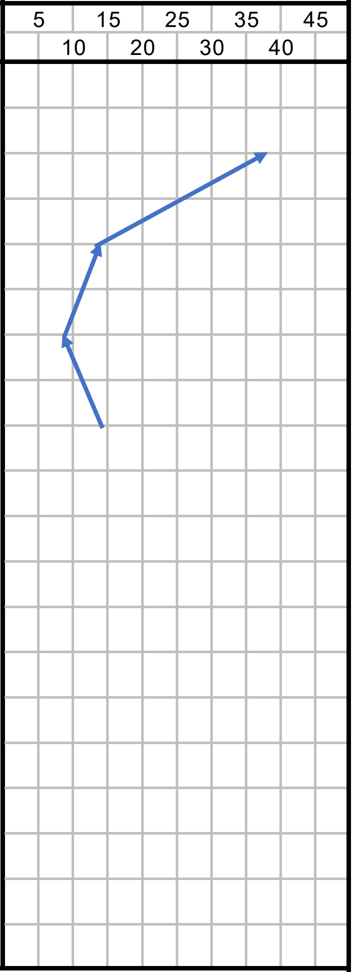
sidco
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Maradhoo-Feydhoo Harbour							
Project Number:	2023/HDEC/01			Client:	HDEC		BH No.	2
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd			
Drilling method	Rotatory							
Ground water depth (m)	1.0	Date	Started: 09/02/2023	Bit Type	PDC	Diameter (mm)	76	
Total depth of boring (m)	4		Completed 09/02/2023	Hammer Type	Auto tripped hammer			
BH Location	Maradhoo-Feydhoo Harbour		Backfilled: 10/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760	

Depth (m)	Sample Type	Sample Number	GWL	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)$_{60}$
1	SS	D1	▼	Medium dense, off white coral sand with some rock pieces (backfilled material)	13	11	10	21	37
	SS	D2		loose , off white fine sand with some gravel					
2	SS	D3			5	4	4	8	14
3	SS	D4			4	2	3	5	8
4					4	5	5	10	14
5	SS	D5							
6	SS	D6							
7									
8	SS	D7							
9	SS	D8							
10									

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

APPENDIX B5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

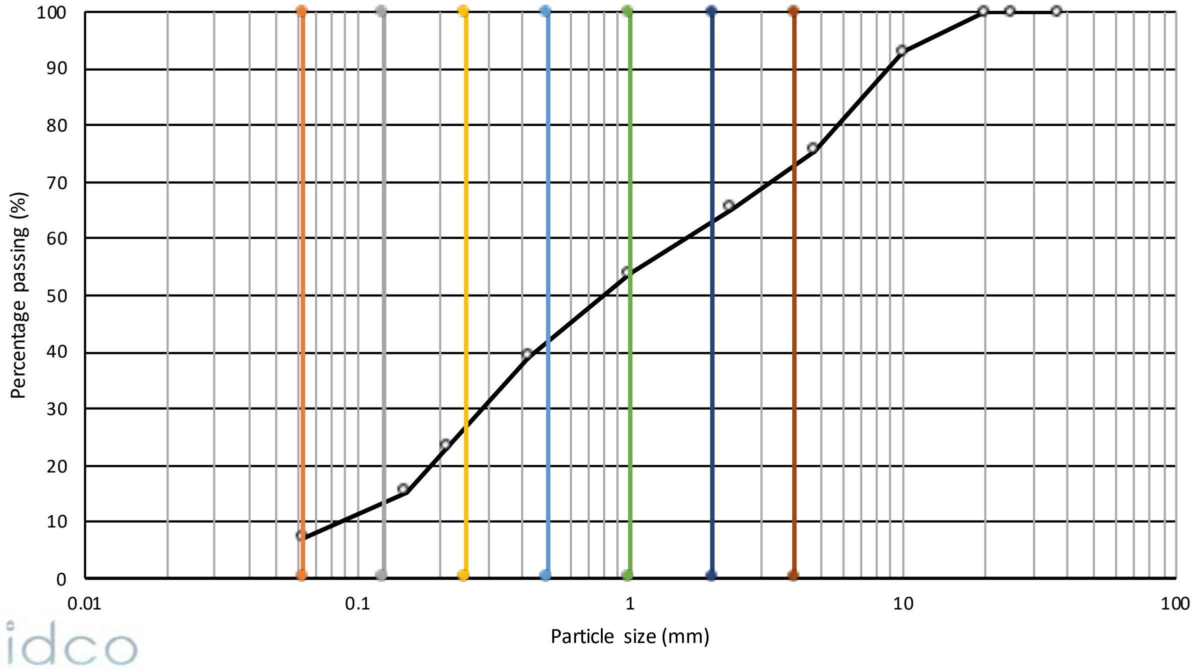
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Maradhoo Feydhoo Harbour		**File #:**	HDEC/2023/1	
Date:	16/02/2023	**Tested by:**	SM		
BH1	**Depth (m)**	0.0	**Test #**	**1**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	338	100.0
2	**25**	0	0	0.0	338	100.0
3	**20**	0	0	0.0	338	100.0
4	**10**	24	24	7.1	314	92.9
5	**4.75**	59	83	24.6	255	75.4
8	**2.36**	34	117	34.6	221	65.4
16	**1**	39	156	46.2	182	53.8
30	**0.425**	50	206	60.9	132	39.1
50	**0.212**	54	260	76.9	78	23.1
100	**0.15**	26	286	84.6	52	15.4
200	**0.063**	28	314	92.9	24	7.1
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				338	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.1%	4.9%	11.0%	13.0%	5.0%	12.0%	47.0%

SIDCO PVT LTD

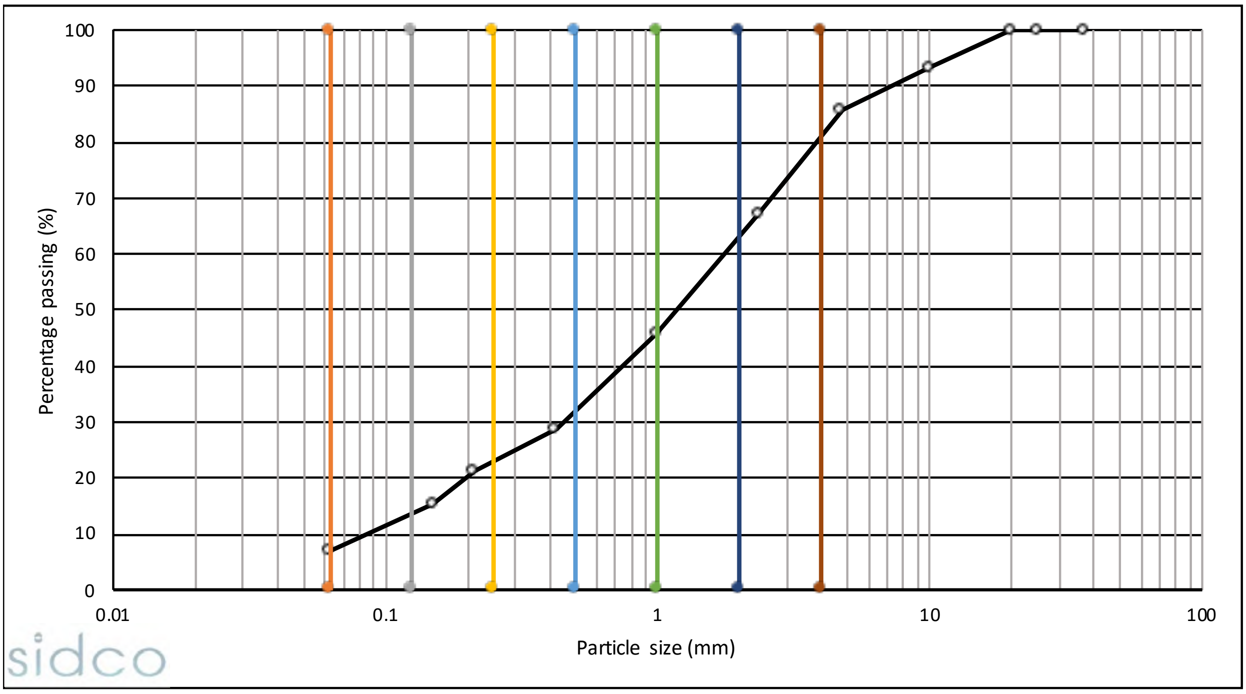
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Maradhoo Feydhoo Harbour		**File #:**	HDEC/2023/1
Date:	16/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	1.0	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	382	100.0
2	**25**	0	0	0.0	382	100.0
3	**20**	0	0	0.0	382	100.0
4	**10**	26	26	6.8	356	93.2
5	**4.75**	29	55	14.4	327	85.6
8	**2.36**	71	126	33.0	256	67.0
16	**1**	81	207	54.2	175	45.8
30	**0.425**	65	272	71.2	110	28.8
50	**0.212**	29	301	78.8	81	21.2
100	**0.15**	23	324	84.8	58	15.2
200	**0.063**	31	355	92.9	27	7.1
Total weight sieved through 200 (g)				27		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				382	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.1%	5.9%	9.0%	9.0%	25.0%	6.0%	38.0%

SIDCO PVT LTD

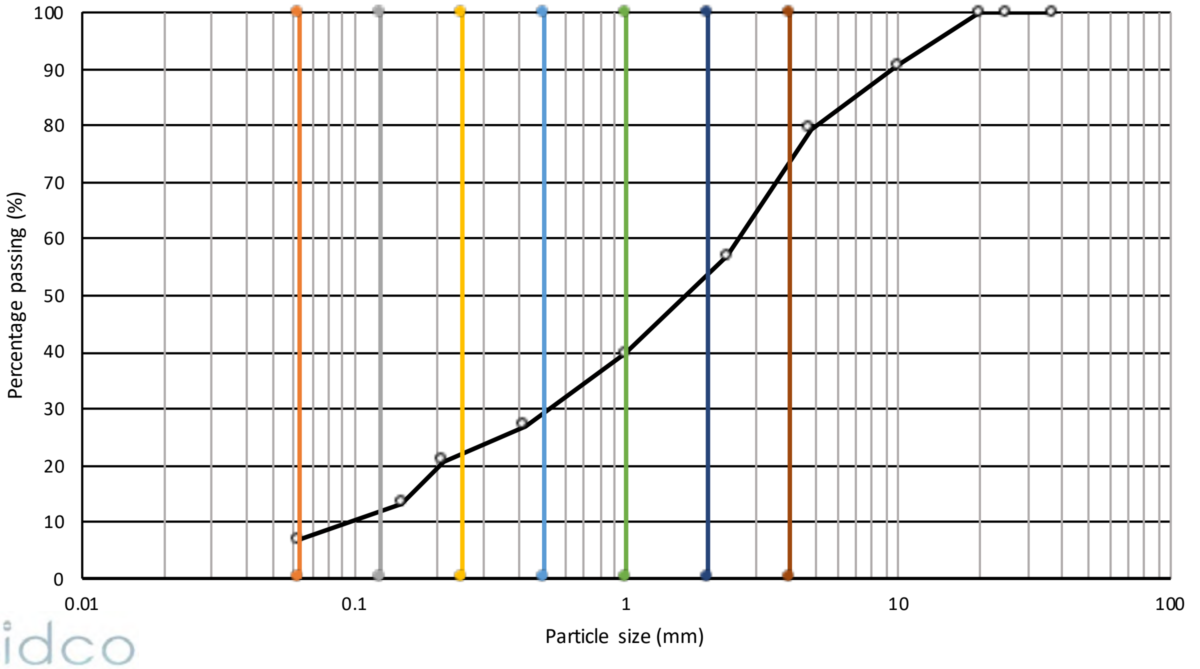
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Maradhoo Feydhoo Harbour		**File #:**	HDEC/2023/1	
Date:	16/02/2023	**Tested by:**	SM		
BH1	**Depth (m)**	2.0	**Test #**	**3**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	459	100.0
2	**25**	0	0	0.0	459	100.0
3	**20**	0	0	0.0	459	100.0
4	**10**	43	43	9.4	416	90.6
5	**4.75**	51	94	20.5	365	79.5
8	**2.36**	104	198	43.1	261	56.9
16	**1**	79	277	60.3	182	39.7
30	**0.425**	58	335	73.0	124	27.0
50	**0.212**	29	364	79.3	95	20.7
100	**0.15**	34	398	86.7	61	13.3
200	**0.063**	29	427	93.0	32	7.0
Total weight sieved through 200 (g)				32		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				459	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.0%	4.0%	10.0%	9.0%	10.0%	13.0%	47.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

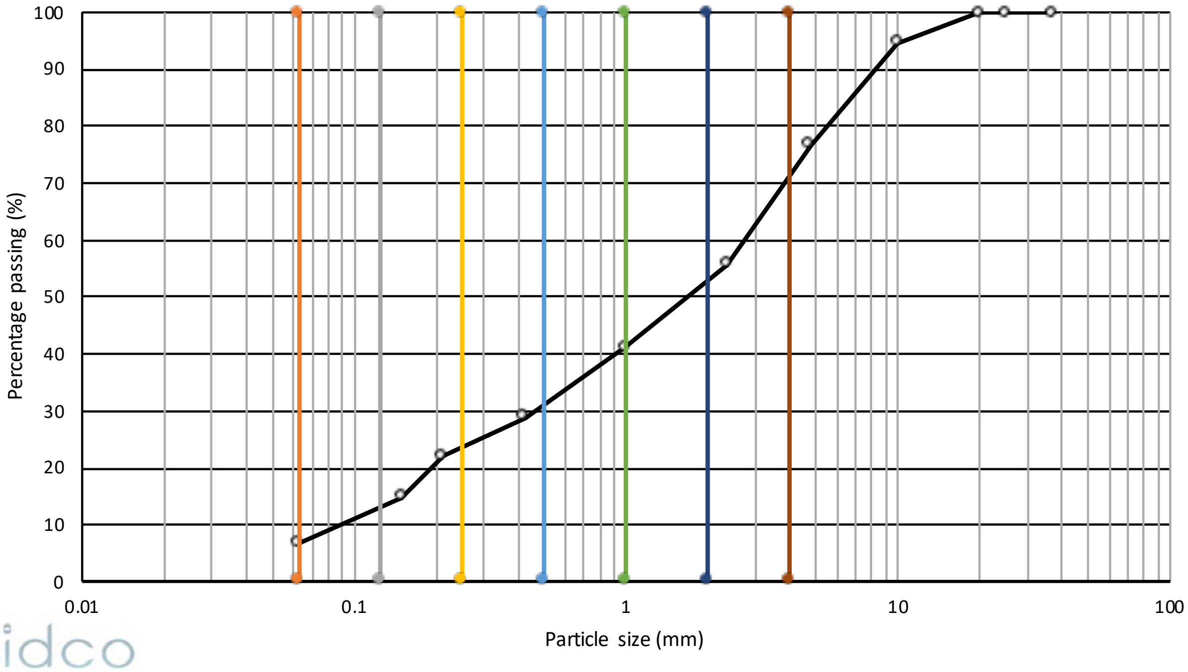
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Maradhoo Feydhoo Harbour			**File #:**	HDEC/2023/1
Date:	16/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	3.0		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	425	100.0
2	**25**	0	0	0.0	425	100.0
3	**20**	0	0	0.0	425	100.0
4	**10**	23	23	5.4	402	94.6
5	**4.75**	76	99	23.3	326	76.7
8	**2.36**	89	188	44.2	237	55.8
16	**1**	62	250	58.8	175	41.2
30	**0.425**	52	302	71.1	123	28.9
50	**0.212**	29	331	77.9	94	22.1
100	**0.15**	31	362	85.2	63	14.8
200	**0.063**	34	396	93.2	29	6.8
Total weight sieved through 200 (g)				29		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				425	Error (%)	
Remarks						

Technician	Computed by	Checked by



sidco

Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.8%	5.2%	10.0%	9.0%	9.0%	12.0%	48.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

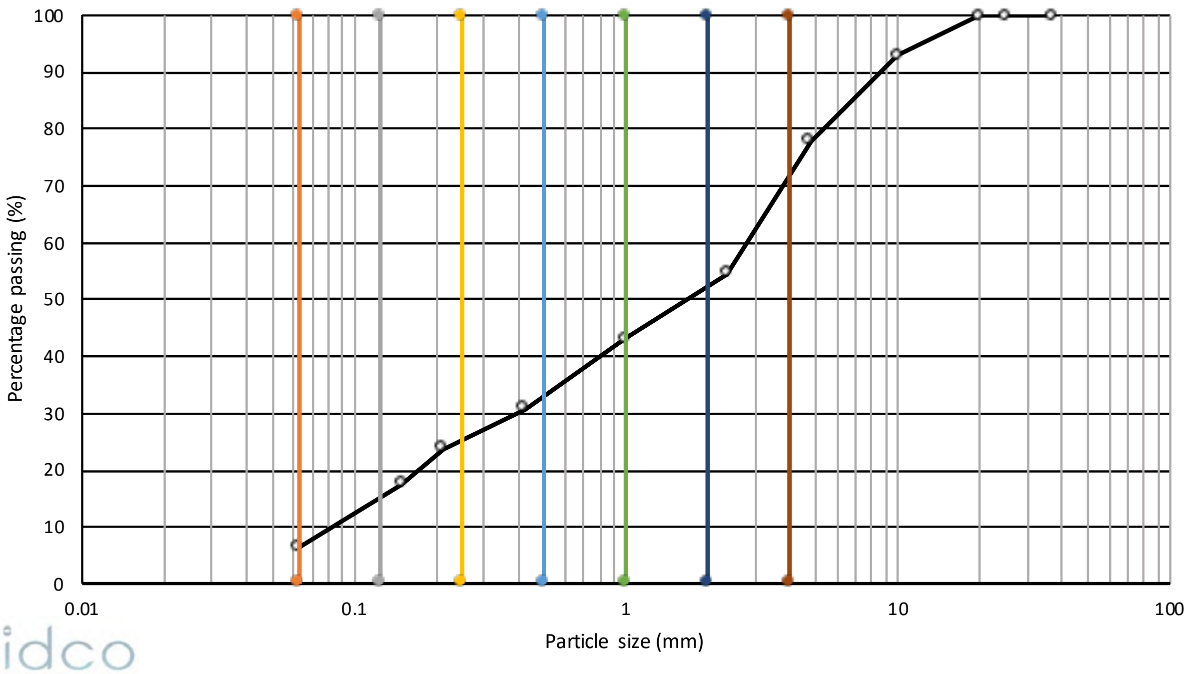
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Maradhoo Feydhoo Harbour		**File #:**	HDEC/2023/1	
Date:	16/02/2023	**Tested by:**	SM		
BH1	**Depth (m)**	4.0	**Test #**	**5**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	370	100.0
2	**25**	0	0	0.0	370	100.0
3	**20**	0	0	0.0	370	100.0
4	**10**	26	26	7.0	344	93.0
5	**4.75**	56	82	22.2	288	77.8
8	**2.36**	86	168	45.4	202	54.6
16	**1**	43	211	57.0	159	43.0
30	**0.425**	45	256	69.2	114	30.8
50	**0.212**	26	282	76.2	88	23.8
100	**0.15**	23	305	82.4	65	17.6
200	**0.063**	41	346	93.5	24	6.5
Total weight sieved through 200 (g)				24		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				370	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.5%	8.5%	10.0%	7.0%	9.0%	10.0%	49.0%

APPENDIX B6: PROCTOR TEST RESULT

SIDCO PVT LTD

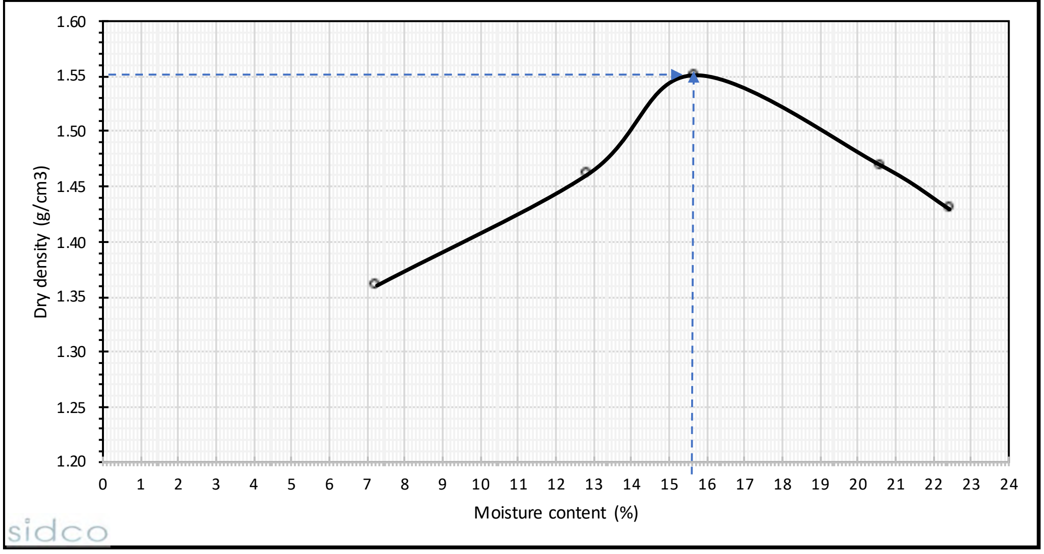
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**S. Maradhoo-Feydhoo**	**Date:**	**22/02/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.61	
Water dennsity, γw	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4908.00	5098.00	5243.00	5221.00	5199.00
weight of compacted soil, w2-w1 (g)	1459.00	1649.00	1794.00	1772.00	1750.00
Wet density, γb = ((w2-w1)/v), g/cm3	1.46	1.65	1.79	1.77	1.75
Dry density, γd = (γb/(1+(w/100))), g/cm3	**1.36**	**1.46**	**1.55**	**1.47**	**1.43**
Void Ratio e = ((Gsγw)/γd-1	1.92	1.79	1.68	1.78	1.83
Moisture content					
Weight of container, g	29.98	30.05	30.12	30.06	30.09
Weight of container + wet soil, g	65.41	58.23	55.36	61.03	67.97
Wet container + dry soil, g	63.01	55.02	51.94	55.74	61.03
Weight of moisture, ww (g)	2.40	3.21	3.42	5.29	6.94
Weight of dry soil, ws (g)	33.03	24.97	21.82	25.68	30.94
Water content, w= ((ww/ws)x100), %	**7.27**	**12.86**	**15.67**	**20.60**	**22.43**



APPENDIX B7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

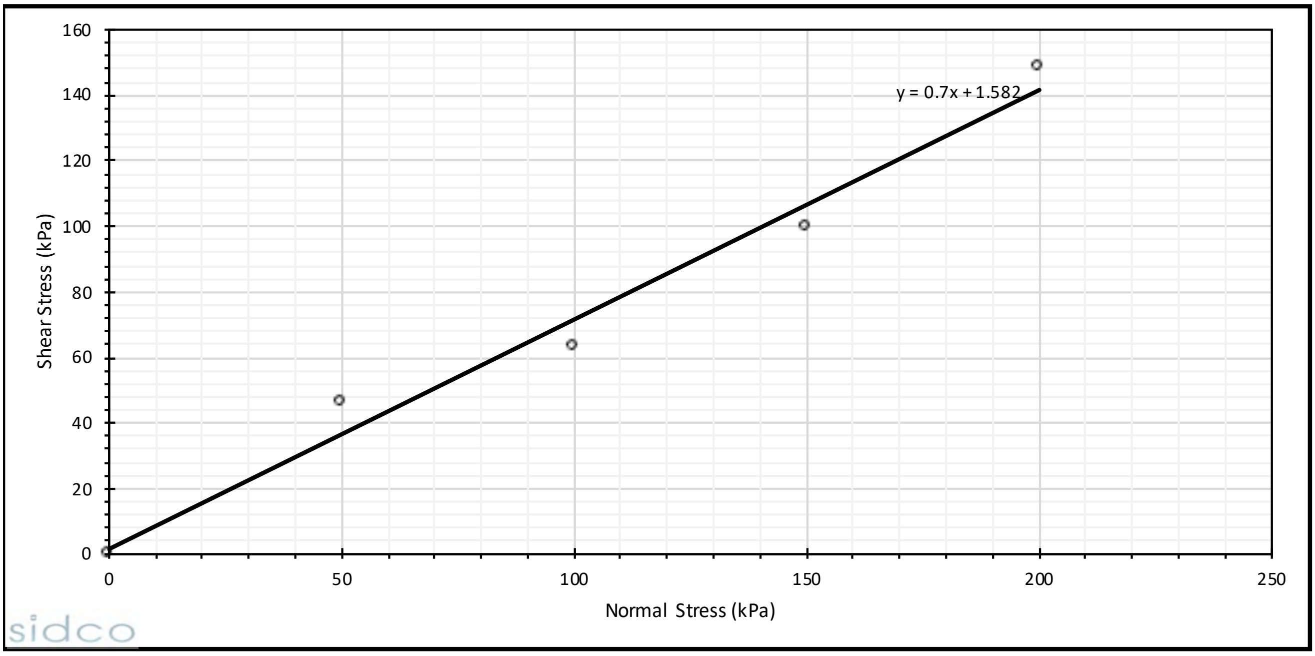
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**S. Maradhoo-Feydhoo**	**Date:**	**15/02/2023**	**Direct Shear**	**1**

Moisture content (%)	10.10%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	35.295	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	46.51
100.00	63.21
150.00	99.89
200.00	148.32



APPENDIX B8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**Maradhoo-Feydhoo**	**Date:**	**16/02/2022**
TEST 1			
Mass of dnesity bottle	W1	30.10	g
Mass of bottle + dry sand	W2	85.21	g
Mass of bottle + dry sand + water	W3	164.83	g
Mass of bottle + water	W4	130.96	g
Specific Gravity	Gs	2.59	

TEST 2

Mass of dnesity bottle	W1	35.00	g
Mass of bottle + dry sand	W2	79.34	g
Mass of bottle + dry sand + water	W3	174.00	g
Mass of bottle + water	W4	146.63	g
Specific Gravity	Gs	2.61	

Avarege Gs		2.60	

APPENDIX B9: SOIL RESITIVITY SURVEY RESULT

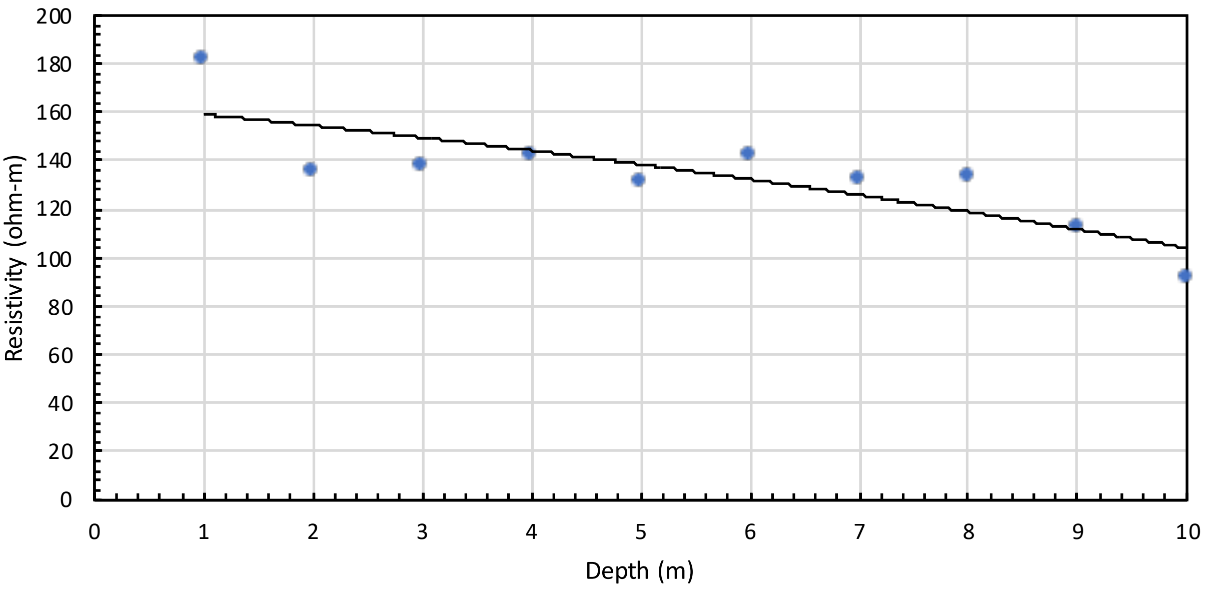
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	28.90	181
2	2	10.80	136
3	3	7.30	138
4	4	5.65	142
5	5	4.19	132
6	6	3.76	142
7	7	3.01	132
8	8	2.65	133
9	9	1.99	112
10	10	1.46	92



SIDCO SOILS LAB

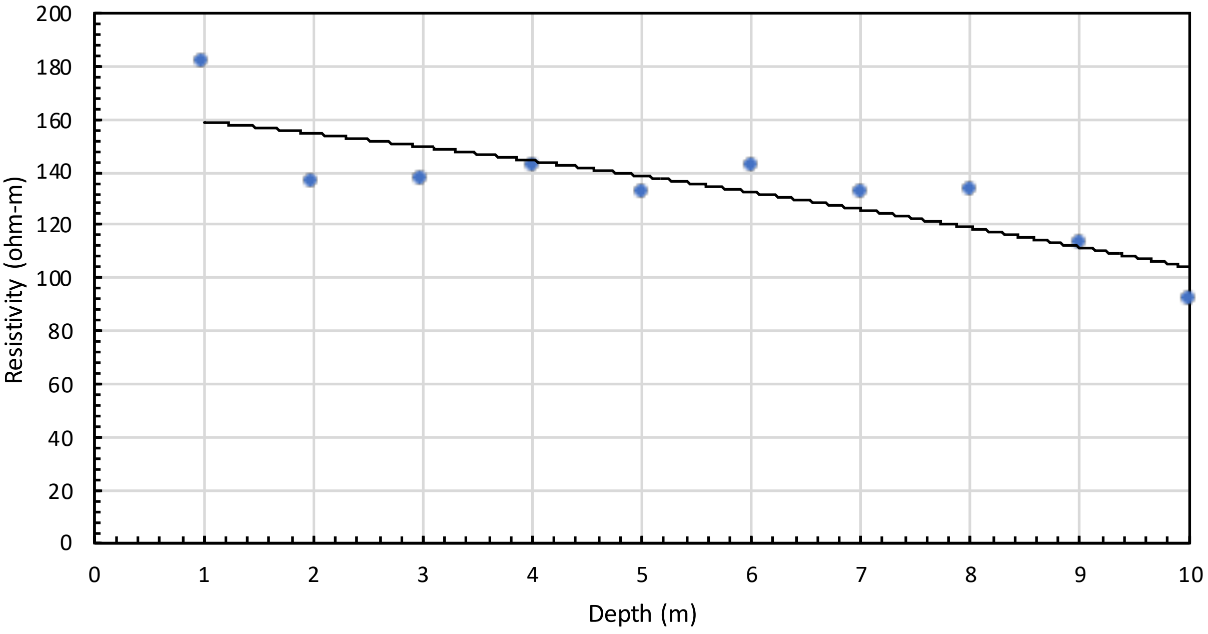
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

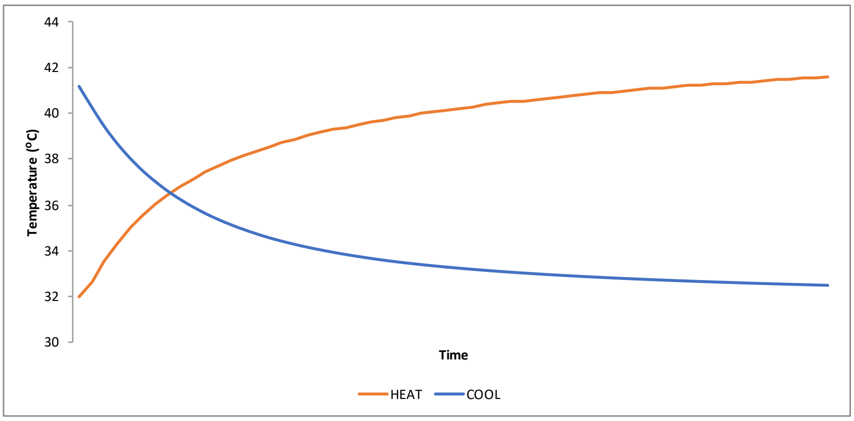
TEST 2

Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	24.95	157
2	2	11.34	142
3	3	8.07	152
4	4	6.32	159
5	5	5.19	163
6	6	4.01	151
7	7	3.58	157
8	8	3.01	151
9	9	2.45	138
10	10	1.99	125



APPENDIX B10: THERMAL CONDUCTIVITY TEST RESULTS

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	31.982143		89599	41.173515
1500	32.6577		91099	40.269623
3000	33.550224		92599	39.414524
4500	34.326107		94099	38.680447
6000	34.984604		95599	38.048611
7500	35.54076		97099	37.493889
9000	36.02874		98599	37.019833
10500	36.446644		100099	36.595615
12000	36.821983		101599	36.228394
13500	37.151608		103099	35.902653
15000	37.442028		104599	35.609825
16500	37.709091		106099	35.352715
18000	37.9491		107599	35.124229
19500	38.166283		109099	34.917385
21000	38.362522		110599	34.73056
22500	38.54311		112099	34.560127
24000	38.713573		113599	34.409283
25500	38.870731		115099	34.273159
27000	39.016678		116599	34.148426
28500	39.151413		118099	34.034706
30000	39.277214		119599	33.929913
31500	39.394608		121099	33.833164
33000	39.50523		122599	33.743492
34500	39.613083		124099	33.660702
36000	39.714275		125599	33.583767
37500	39.809967		127099	33.512489
39000	39.900242		128599	33.447525
40500	39.986359		130099	33.387436
42000	40.067673		131599	33.33157
43500	40.146156		133099	33.279217
45000	40.220234		134599	33.230125
46500	40.290813		136099	33.183464
48000	40.358253		137599	33.139519
49500	40.423508		139099	33.098385
51000	40.485439		140599	33.059212
52500	40.547344		142099	33.022141
54000	40.607891		143599	32.986828
55500	40.664982		145099	32.953423
57000	40.720863		146599	32.921909
58500	40.774643		148099	32.891586
60000	40.826744		149599	32.862572
61500	40.877239		151099	32.835018
63000	40.926071		152599	32.808548
64500	40.973186		154099	32.783123
66000	41.019466		155599	32.758842
67500	41.064278		157099	32.735855
69000	41.107552		158599	32.713982
70500	41.149109		160099	32.692394
72000	41.190697		161599	32.671661
73500	41.229973		163099	32.651276
75000	41.268787		164599	32.632141
76500	41.30703		166099	32.614227
78000	41.343552		167599	32.595562
79500	41.379593		169099	32.578465
81000	41.41571		170599	32.562481
82500	41.450424		172099	32.545845
84000	41.483662		173599	32.529842
85500	41.517086		175099	32.515381
87000	41.550774		176599	32.500164
88500	41.584167		178099	32.486324



APPENDIX B11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT
Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Maradhoo-Feydhoo Harbour	Hithadhoo Stadium E	Hulhumeedhoo SPT	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83235949	83235950	83235951		
Sampled Date ~	24/01/2023 02:00	24/01/2023 02:00	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
Conductivity *	53800	433	712	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.6	7.4	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	26900	216	356	Electrometry	mg/L
Chloride	18550	<10 (LoQ 10 mg/L)	79	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	5.8	4.1	11.3	HACH Method 8171	mg/L
Sulphate *	2800	<10 (LoQ 10 mg/L)	20	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Feydhoo Harbour	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235952		
Sampled Date ~	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	46100	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.8	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	23000	Electrometry	mg/L
Chloride	15500	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	8.5	HACH Method 8171	mg/L
Sulphate *	2200	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

APPENDICES (C)
S. Hithadhoo Stadium

APPENDIX C1: TEST LOCATIONS

Hithadhoo Stadium (ASPIRE Site)

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

APPENDIX C2: DCP TEST RESULTS

SIDCO SOILS LAB

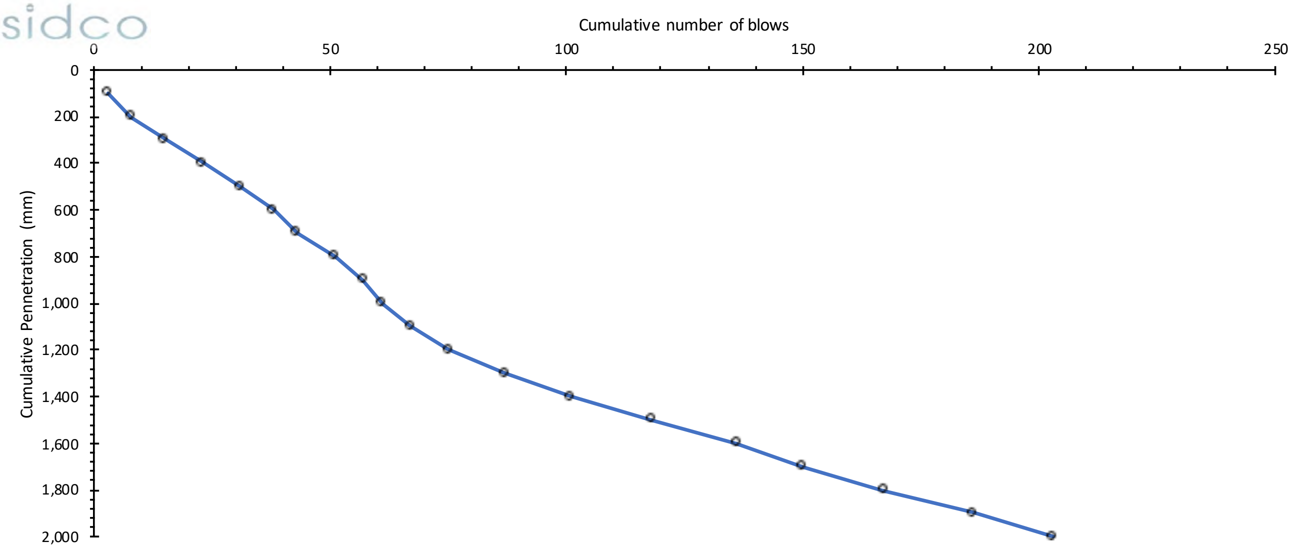
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hithadhoo Stadium**		**13/01/2023**		**DCP#**	**1**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	3	3	33.3	6	84	33
100-200	5	8	20.0	10	122	49
200-300	7	15	14.3	15	157	63
300-400	8	23	12.5	17	173	69
400-500	8	31	12.5	17	173	69
500-600	7	38	14.3	15	157	63
600-700	5	43	20.0	10	122	49
700-800	8	51	12.5	17	173	69
800-900	6	57	16.7	13	140	56
900-1000	4	61	25.0	8	104	41
1000-1100	6	67	16.7	13	140	56
1100-1200	8	75	12.5	17	173	69
1200-1300	12	87	8.3	27	234	94
1300-1400	14	101	7.1	32	263	105
1400-1500	17	118	5.9	40	304	121
1500-1600	18	136	5.6	43	317	127
1600-1700	14	150	7.1	32	263	105
1700-1800	17	167	5.9	40	304	121
1800-1900	19	186	5.3	45	330	132
1900-2000	17	203	5.9	40	304	121

sidco

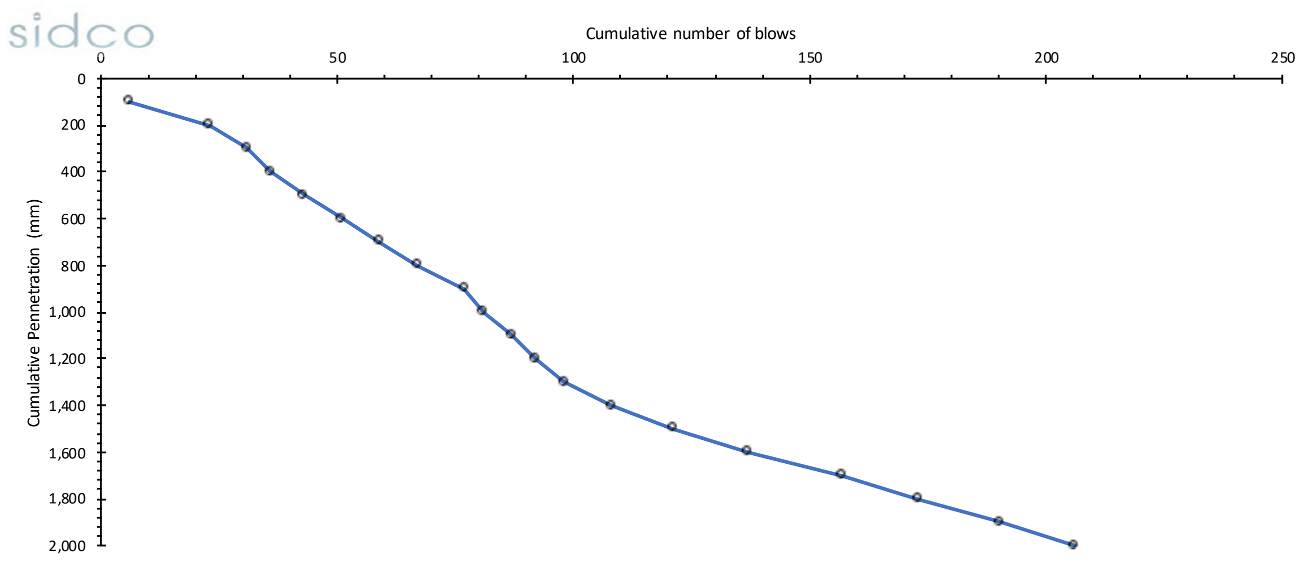


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hithadhoo Stadium**		**13/01/2023**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	17	23	5.9	40	304	121
200-300	8	31	12.5	17	173	69
300-400	5	36	20.0	10	122	49
400-500	7	43	14.3	15	157	63
500-600	8	51	12.5	17	173	69
600-700	8	59	12.5	17	173	69
700-800	8	67	12.5	17	173	69
800-900	10	77	10.0	22	205	82
900-1000	4	81	25.0	8	104	41
1000-1100	6	87	16.7	13	140	56
1100-1200	5	92	20.0	10	122	49
1200-1300	6	98	16.7	13	140	56
1300-1400	10	108	10.0	22	205	82
1400-1500	13	121	7.7	30	249	99
1500-1600	16	137	6.3	37	290	116
1600-1700	20	157	5.0	48	343	137
1700-1800	16	173	6.3	37	290	116
1800-1900	17	190	5.9	40	304	121
1900-2000	16	206	6.3	37	290	116

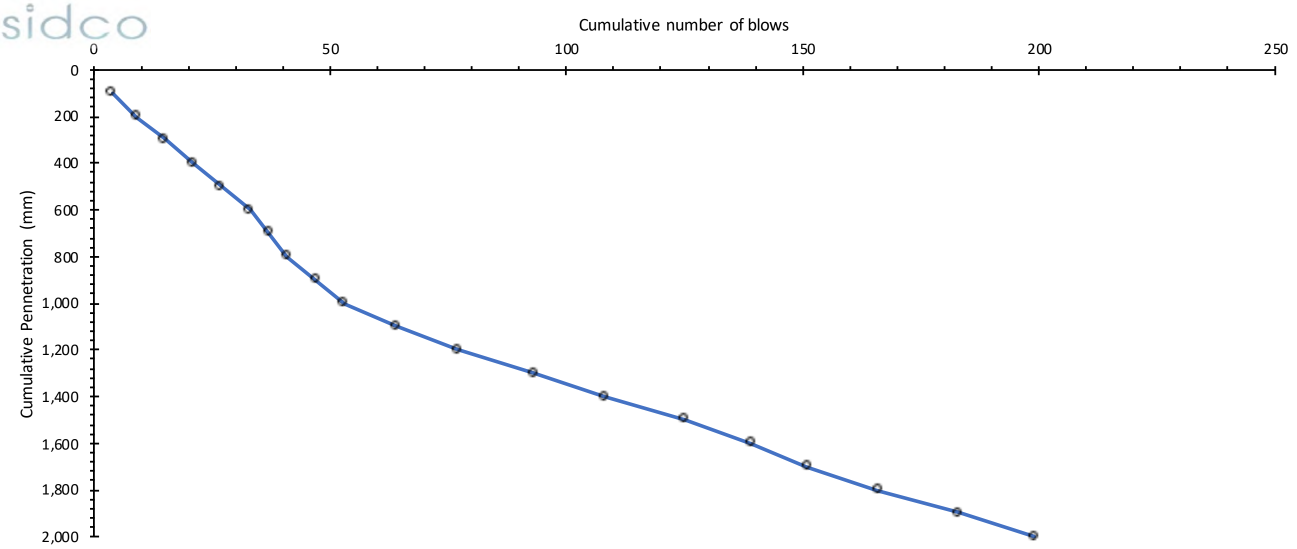


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hithadhoo Stadium**		**13/01/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	5	9	20.0	10	122	49
200-300	6	15	16.7	13	140	56
300-400	6	21	16.7	13	140	56
400-500	6	27	16.7	13	140	56
500-600	6	33	16.7	13	140	56
600-700	4	37	25.0	8	104	41
700-800	4	41	25.0	8	104	41
800-900	6	47	16.7	13	140	56
900-1000	6	53	16.7	13	140	56
1000-1100	11	64	9.1	25	220	88
1100-1200	13	77	7.7	30	249	99
1200-1300	16	93	6.3	37	290	116
1300-1400	15	108	6.7	35	277	111
1400-1500	17	125	5.9	40	304	121
1500-1600	14	139	7.1	32	263	105
1600-1700	12	151	8.3	27	234	94
1700-1800	15	166	6.7	35	277	111
1800-1900	17	183	5.9	40	304	121
1900-2000	16	199	6.3	37	290	116



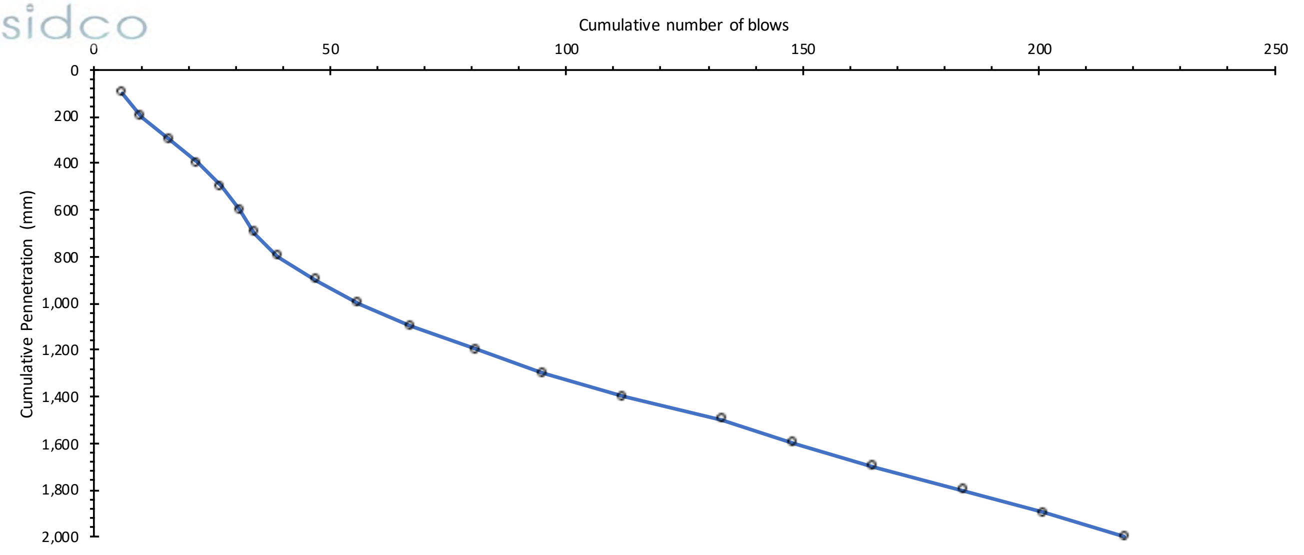
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hithadhoo Stadium**		**13/01/2023**		**DCP#**	**4**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	6	6	16.7	13	140	56
100-200	4	10	25.0	8	104	41
200-300	6	16	16.7	13	140	56
300-400	6	22	16.7	13	140	56
400-500	5	27	20.0	10	122	49
500-600	4	31	25.0	8	104	41
600-700	3	34	33.3	6	84	33
700-800	5	39	20.0	10	122	49
800-900	8	47	12.5	17	173	69
900-1000	9	56	11.1	20	189	76
1000-1100	11	67	9.1	25	220	88
1100-1200	14	81	7.1	32	263	105
1200-1300	14	95	7.1	32	263	105
1300-1400	17	112	5.9	40	304	121
1400-1500	21	133	4.8	51	355	142
1500-1600	15	148	6.7	35	277	111
1600-1700	17	165	5.9	40	304	121
1700-1800	19	184	5.3	45	330	132
1800-1900	17	201	5.9	40	304	121
1900-2000	17	218	5.9	40	304	121



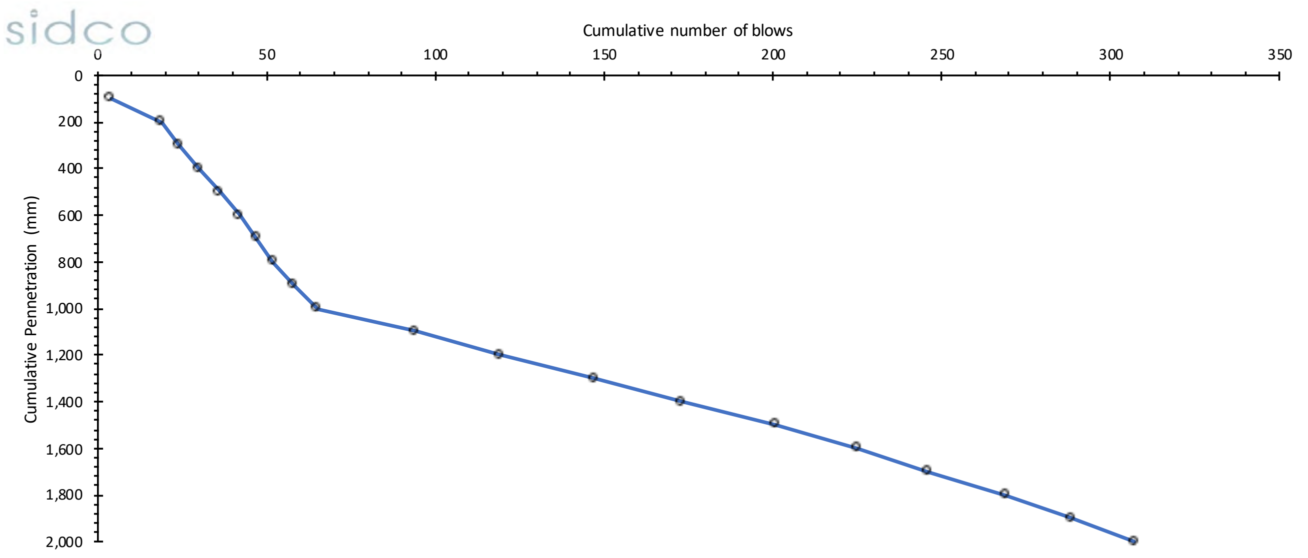
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hithadhoo Stadium**		**13/01/2023**		**DCP#**	**5**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	15	19	6.7	35	277	111
200-300	5	24	20.0	10	122	49
300-400	6	30	16.7	13	140	56
400-500	6	36	16.7	13	140	56
500-600	6	42	16.7	13	140	56
600-700	5	47	20.0	10	122	49
700-800	5	52	20.0	10	122	49
800-900	6	58	16.7	13	140	56
900-1000	7	65	14.3	15	157	63
1000-1100	29	94	3.4	73	452	181
1100-1200	25	119	4.0	62	404	162
1200-1300	28	147	3.6	70	440	176
1300-1400	26	173	3.8	65	416	167
1400-1500	28	201	3.6	70	440	176
1500-1600	24	225	4.2	59	392	157
1600-1700	21	246	4.8	51	355	142
1700-1800	23	269	4.3	56	380	152
1800-1900	19	288	5.3	45	330	132
1900-2000	19	307	5.3	45	330	132



APPENDIX C3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

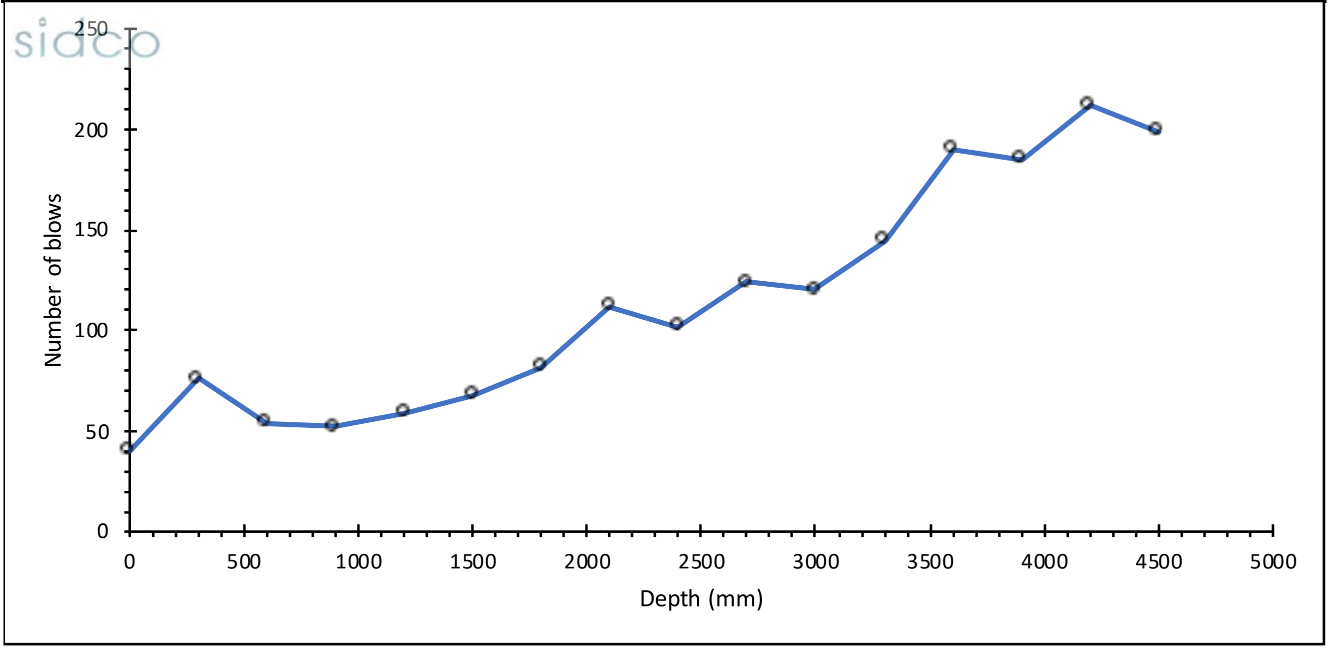
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Hithadhoo**	**Date:**	**13/01/2023**	**MP#**	**1**

Depth (mm)	Number of Blows, N_{MP}	Cumulative Number of Blows	Bearing Capacity kPa	Safe Bearing Capacity kPa
0-300	40	40	137	55
300-600	76	116	295	118
600-900	54	170	235	94
900-1200	52	222	228	91
1200-1500	59	281	252	101
1500-1800	68	349	276	111
1800-2100	82	431	308	123
2100-2400	112	543	360	144
2400-2700	102	645	344	138
2700-3000	124	769	378	151
3000-3300	120	889	372	149
3300-3600	145	1034	407	163
3600-3900	190	1224	459	184
3900-4200	185	1409	454	182
4200-4500	212	1621	482	193
4500-4800	199	1820	469	188
4800-5100	>400 blows. Hitting a large rock/stone			
5100-5400				
5400-5700				
5700-6000				

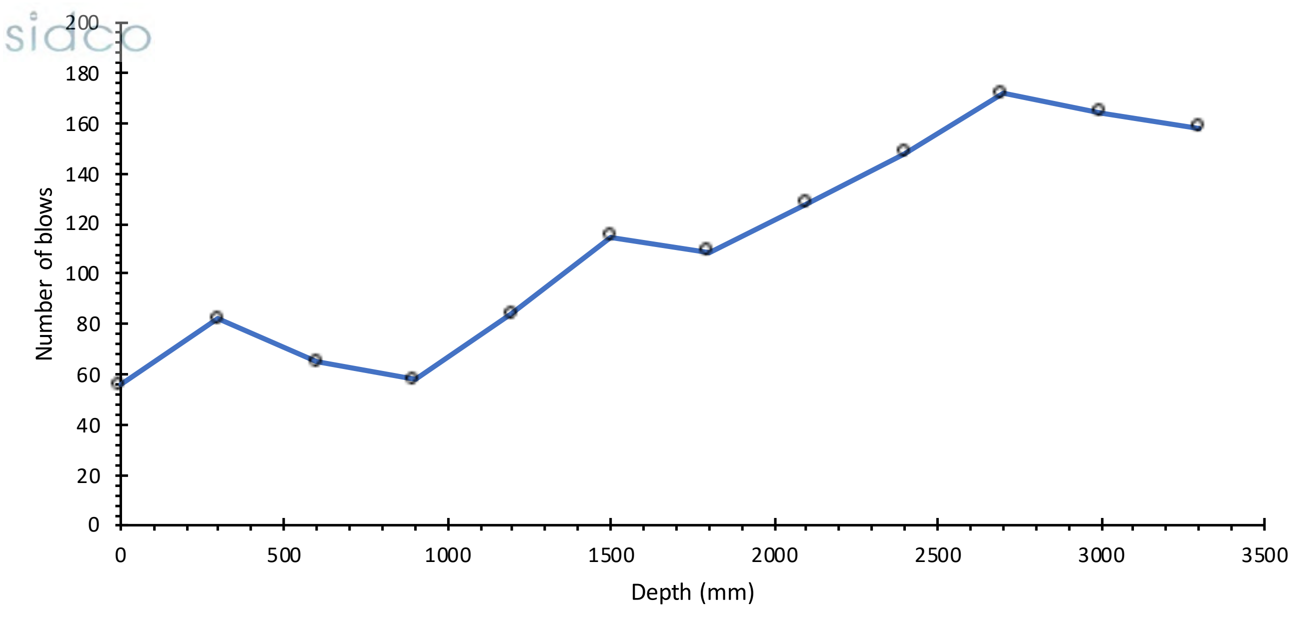


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

<table>
<tr><td>Location:</td><td>Hithadhoo</td><td>Date:</td><td>13/01/2023</td><td>MP#</td><td>2</td></tr>
<tr><td colspan="2">Depth (mm)</td><td>Number of Blows, N_{MP}</td><td>Cumulative Number of Blows</td><td>Bearing Capacity kPa</td><td>Safe Bearing Capacity kPa</td></tr>
<tr><td colspan="2">0-300</td><td>56</td><td>56</td><td>242</td><td>97</td></tr>
<tr><td colspan="2">300-600</td><td>82</td><td>138</td><td>308</td><td>123</td></tr>
<tr><td colspan="2">600-900</td><td>65</td><td>203</td><td>269</td><td>107</td></tr>
<tr><td colspan="2">900-1200</td><td>58</td><td>261</td><td>249</td><td>99</td></tr>
<tr><td colspan="2">1200-1500</td><td>84</td><td>345</td><td>312</td><td>125</td></tr>
<tr><td colspan="2">1500-1800</td><td>115</td><td>460</td><td>365</td><td>146</td></tr>
<tr><td colspan="2">1800-2100</td><td>109</td><td>569</td><td>356</td><td>142</td></tr>
<tr><td colspan="2">2100-2400</td><td>128</td><td>697</td><td>384</td><td>154</td></tr>
<tr><td colspan="2">2400-2700</td><td>148</td><td>845</td><td>411</td><td>164</td></tr>
<tr><td colspan="2">2700-3000</td><td>172</td><td>1017</td><td>439</td><td>176</td></tr>
<tr><td colspan="2">3000-3300</td><td>164</td><td>1181</td><td>430</td><td>172</td></tr>
<tr><td colspan="2">3300-3600</td><td>158</td><td>1339</td><td>423</td><td>169</td></tr>
<tr><td colspan="2">3600-3900</td><td colspan="4">>400 blows. Hitting a large rock/stone</td></tr>
<tr><td colspan="2">3900-4200</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">4200-4500</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">4500-4800</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">4800-5100</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">5100-5400</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">5400-5700</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">5700-6000</td><td></td><td></td><td></td><td></td></tr>
</table>

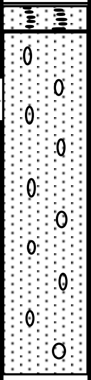
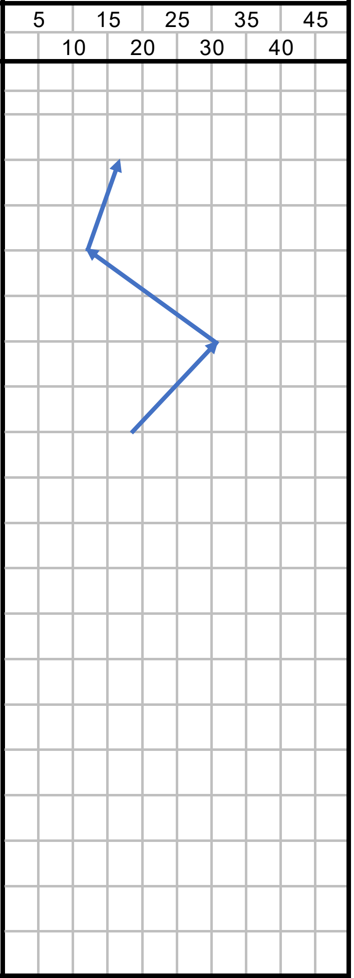


APPENDIX C4: BOREHOLE LOGS

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Hithadhoo Stadium						
Project Number:	2023/HDEC/01			Client:	HDEC	BH No.	1
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date	Started: 09/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	4		Completed 09/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Hithadhoo Stadium		Backfilled: 10/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60	Graphical representation of corrected SPT N values
					Top soil						
1	SS	D1	▼		Loose, off white fine sand with some gravel	5	5	4	9	16	
2	SS	D2				2	3	4	7	12	
	SS	D3									
3	SS	D4			Medium dense, off white fine sand with some gravel	9	10	10	20	31	
4	SS	D5				4	6	8	14	19	
5											
6											
7											
8											
9											
10											

Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

sidco

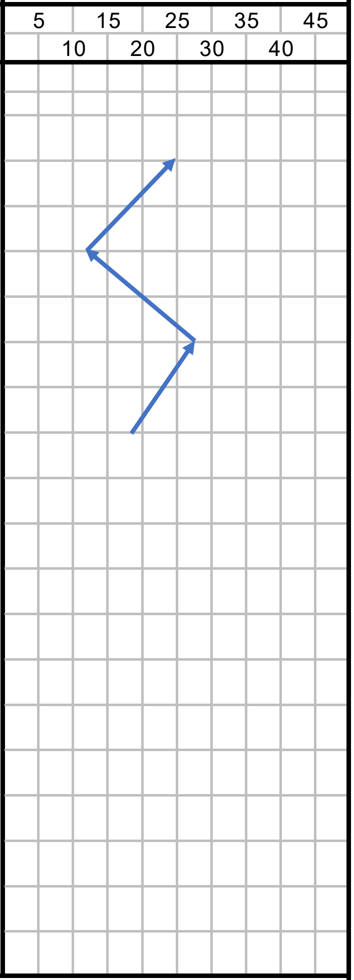
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Hithadhoo Stadium						
Project Number:	2023/HDEC/01			Client:	HDEC	BH No.	2
Drill Rig type	Rotatary Drill			Drilling Contractor	SIDCO Pvt Ltd		
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date	Started: 09/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	4		Completed 09/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Hithadhoo Stadium		Backfilled: 10/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	**Sample Type**	**Sample Number**	**GWL**	**Graphic Log**	**Soil Description**	**Field Data** **SPT values** **15 cm**	**15 cm**	**15 cm**	**N**	**Corrected N** $(N_1)_{60}$
					Top soil					
1	SS	D1	▼			6	7	7	14	25
	SS	D2			Loose, off white fine sand with some gravel					
2						2	3	4	7	12
	SS	D3								
3	SS	D4			Medium dense, off white fine sand with some gravel	8	9	9	18	28
4	SS	D5				6	7	7	14	19
5										
6										
7										
8										
9										
10										

Graphical representation of corrected SPT N values



Notes

SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample

▼ Ground water level

APPENDIX C5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

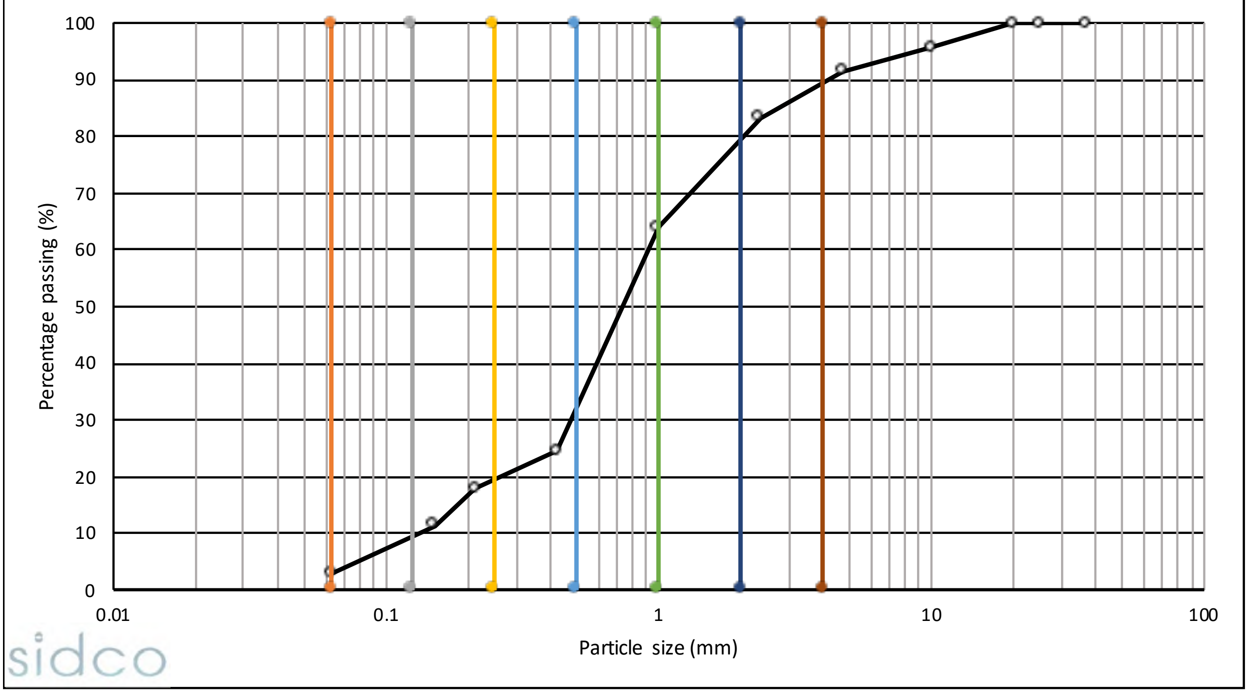
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	0.0	**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	206.5	100.0
2	**25**	0	0.0	0.0	206.5	100.0
3	**20**	0	0.0	0.0	206.5	100.0
4	**10**	9	9.0	4.4	197.5	95.6
5	**4.75**	8	17.4	8.4	189.2	91.6
8	**2.36**	17	34.6	16.7	172.0	83.3
16	**1**	40	74.6	36.1	131.9	63.9
30	**0.425**	81	155.8	75.5	50.7	24.5
50	**0.212**	14	169.7	82.2	36.8	17.8
100	**0.15**	13	182.8	88.5	23.7	11.5
200	**0.063**	18	200.5	97.1	6.0	2.9
Total weight sieved through 200 (g)				6		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				207	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.9%	7.1%	10.0%	11.0%	31.0%	18.0%	20.0%

SIDCO PVT LTD

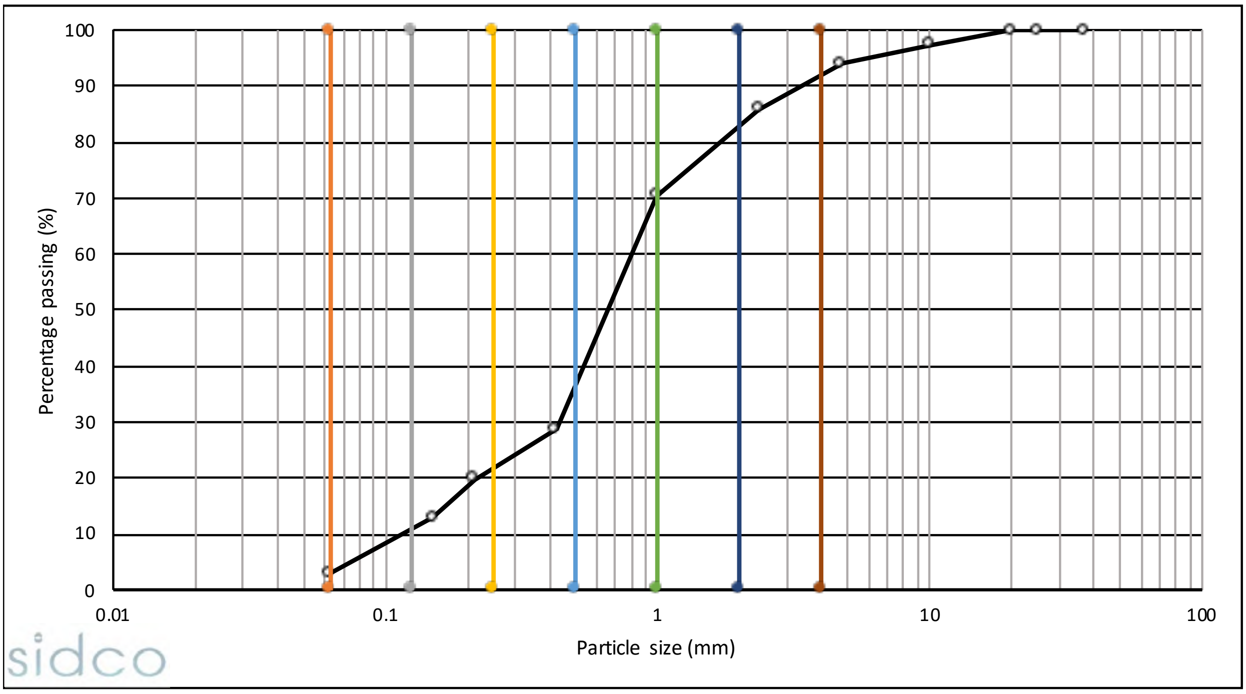
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium	**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM
BH1	**Depth (m)** 1.0	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	227.4	100.0
2	**25**	0	0.0	0.0	227.4	100.0
3	**20**	0	0.0	0.0	227.4	100.0
4	**10**	6	6.0	2.6	221.4	97.4
5	**4.75**	8	13.7	6.0	213.7	94.0
8	**2.36**	19	32.4	14.2	195.0	85.8
16	**1**	35	67.0	29.5	160.3	70.5
30	**0.425**	95	162.2	71.3	65.2	28.7
50	**0.212**	20	182.3	80.2	45.1	19.8
100	**0.15**	16	197.9	87.0	29.5	13.0
200	**0.063**	22	220.4	96.9	7.0	3.1
Total weight sieved through 200 (g)				7		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				227	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.1%	6.9%	11.0%	18.0%	31.0%	12.0%	18.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

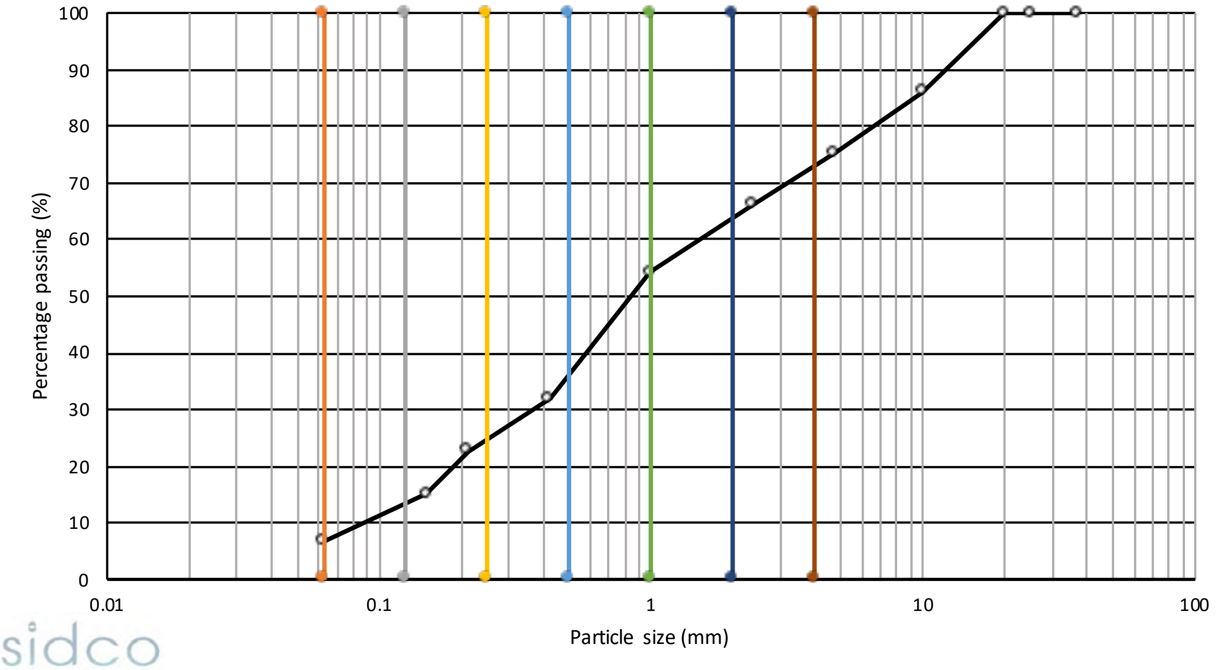
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	2.0	**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	307.9	100.0
2	**25**	0	0.0	0.0	307.9	100.0
3	**20**	0	0.0	0.0	307.9	100.0
4	**10**	43	43.1	14.0	264.8	86.0
5	**4.75**	33	75.7	24.6	232.2	75.4
8	**2.36**	29	104.3	33.9	203.6	66.1
16	**1**	37	141.0	45.8	166.9	54.2
30	**0.425**	69	209.8	68.1	98.1	31.9
50	**0.212**	28	238.0	77.3	69.9	22.7
100	**0.15**	23	261.2	84.8	46.7	15.2
200	**0.063**	26	286.9	93.2	21.0	6.8
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				308	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.8%	6.2%	11.0%	12.0%	17.0%	9.0%	38.0%

SIDCO PVT LTD

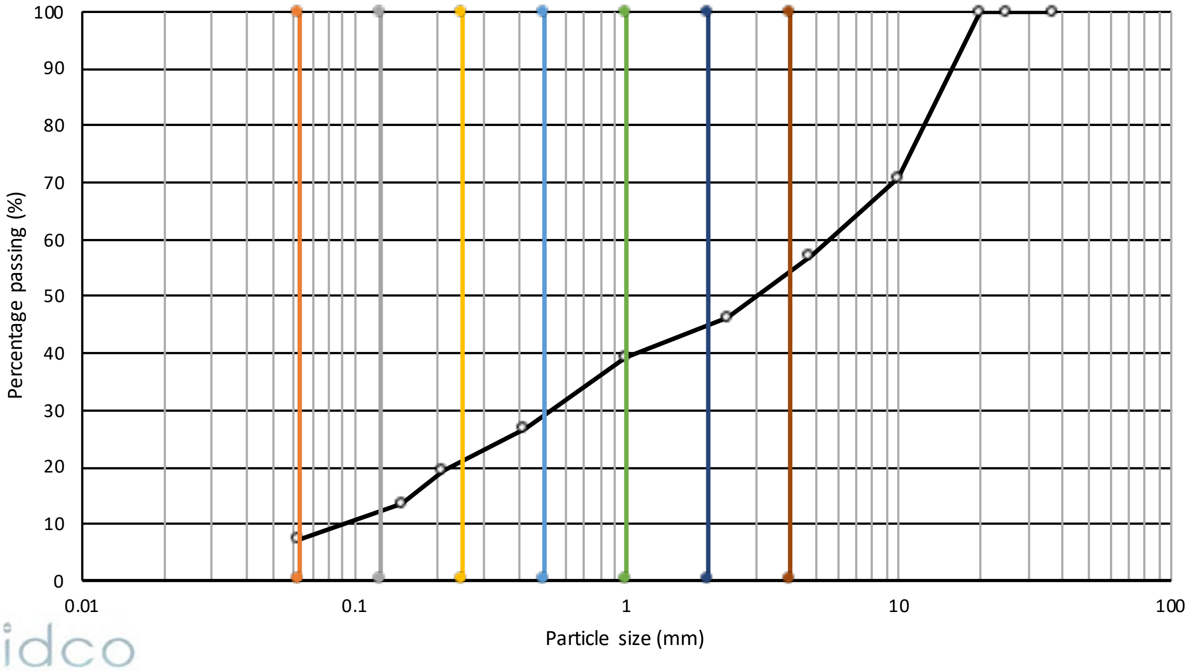
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	3.0		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	260.0	100.0
2	**25**	0	0	0.0	260.0	100.0
3	**20**	0	0	0.0	260.0	100.0
4	**10**	76	76.0	29.2	184.0	70.8
5	**4.75**	35	111.5	42.9	148.5	57.1
8	**2.36**	28	139.9	53.8	120.1	46.2
16	**1**	18	158.2	60.8	101.8	39.2
30	**0.425**	32	190.6	73.3	69.4	26.7
50	**0.212**	19	209.6	80.6	50.3	19.4
100	**0.15**	15	225.0	86.6	34.9	13.4
200	**0.063**	16	241.0	92.7	19.0	7.3
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				260	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
7.3%	3.7%	9.0%	10.0%	10.0%	5.0%	55.0%

SIDCO PVT LTD

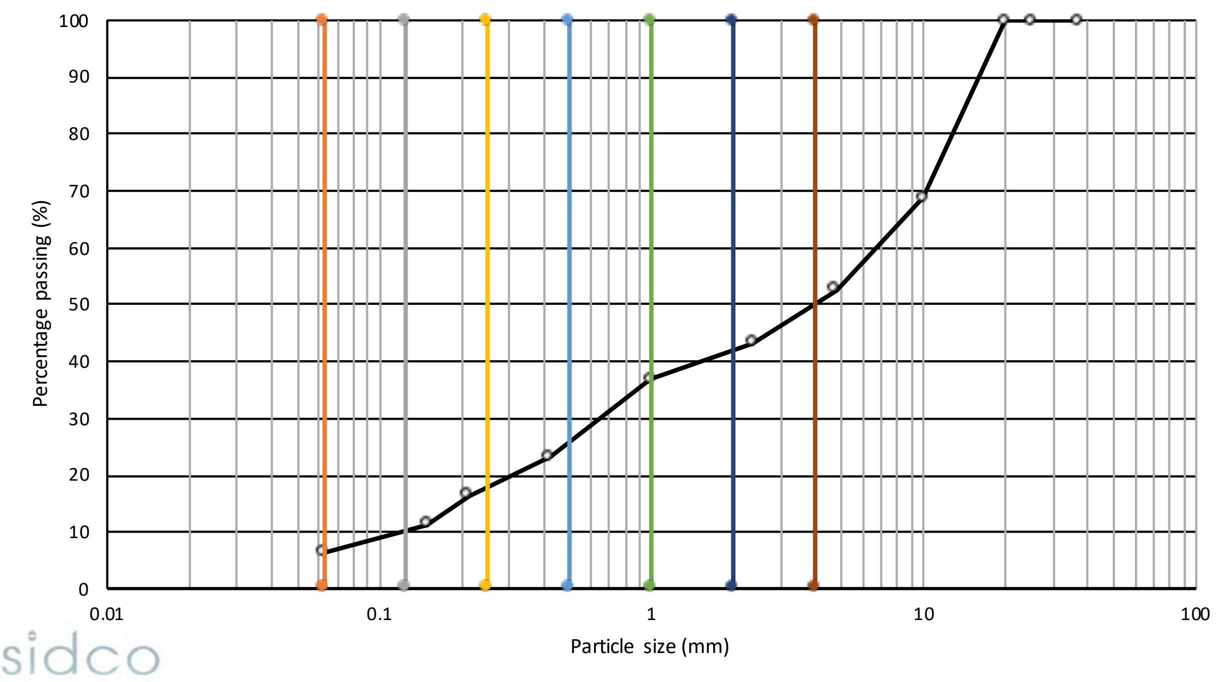
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	4.0		**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	249.2	100.0
2	**25**	0	0.0	0.0	249.2	100.0
3	**20**	0	0.0	0.0	249.2	100.0
4	**10**	78	77.9	31.2	171.3	68.8
5	**4.75**	40	118.0	47.4	131.2	52.6
8	**2.36**	23	141.3	56.7	107.9	43.3
16	**1**	16	157.4	63.2	91.8	36.8
30	**0.425**	34	191.1	76.7	58.1	23.3
50	**0.212**	17	208.4	83.6	40.8	16.4
100	**0.15**	12	220.9	88.6	28.3	11.4
200	**0.063**	12	233.2	93.6	16.0	6.4
Total weight sieved through 200 (g)				16		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				249	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.4%	3.6%	9.0%	7.0%	11.0%	4.0%	59.0%

SIDCO PVT LTD

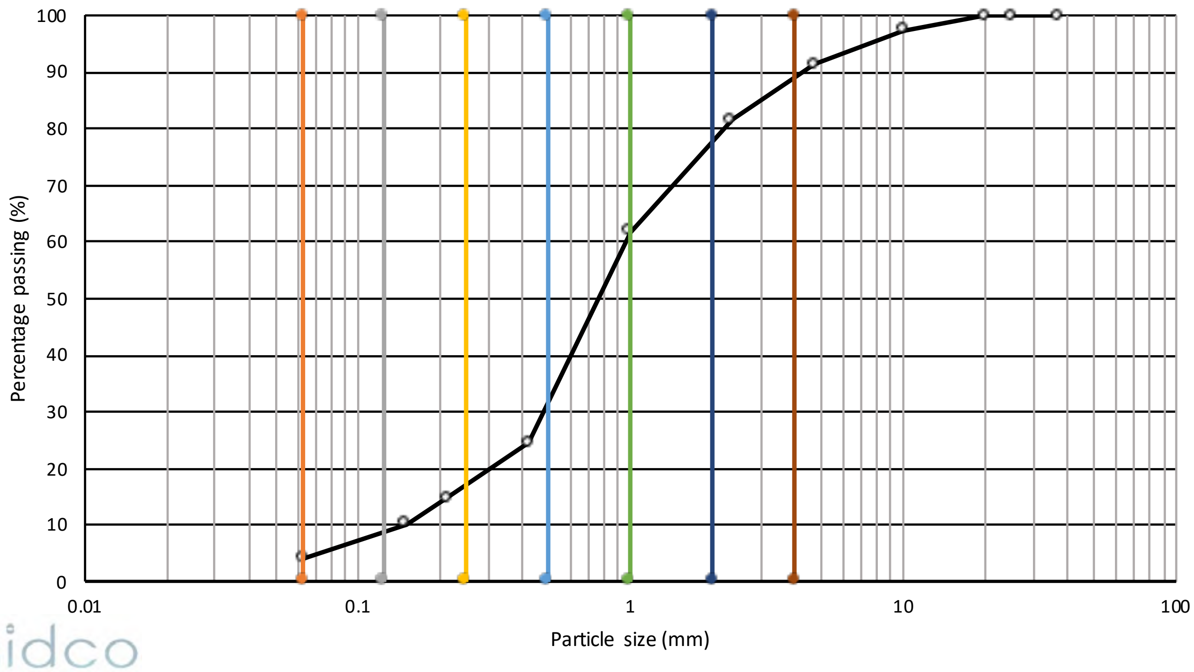
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	0.0	**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	196.0	100.0
2	**25**	0	0.0	0.0	196.0	100.0
3	**20**	0	0.0	0.0	196.0	100.0
4	**10**	5	5.0	2.6	191.0	97.4
5	**4.75**	12	17.0	8.7	179.0	91.3
8	**2.36**	19	36.0	18.4	160.0	81.6
16	**1**	39	75.0	38.3	121.0	61.7
30	**0.425**	73	148.0	75.5	48.0	24.5
50	**0.212**	19	167.0	85.2	29.0	14.8
100	**0.15**	9	176.0	89.8	20.0	10.2
200	**0.063**	12	188.0	95.9	8.0	4.1
Total weight sieved through 200 (g)				8		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				196	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
4.1%	4.9%	9.0%	12.0%	30.0%	18.0%	22.0%

SIDCO PVT LTD

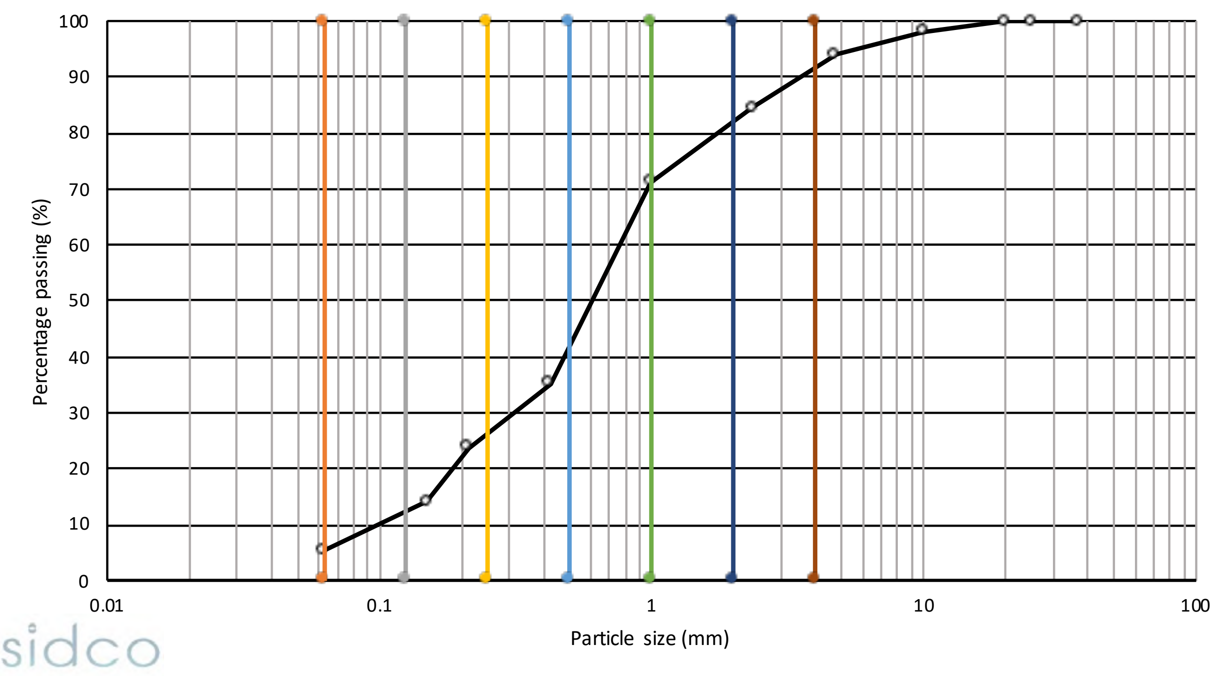
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023		**Tested by:**	SM	
BH2	**Depth (m)**	1.0		**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	219.0	100.0
2	**25**	0	0.0	0.0	219.0	100.0
3	**20**	0	0.0	0.0	219.0	100.0
4	**10**	4	4.0	1.8	215.0	98.2
5	**4.75**	9	13.0	5.9	206.0	94.1
8	**2.36**	21	34.0	15.5	185.0	84.5
16	**1**	29	63.0	28.8	156.0	71.2
30	**0.425**	79	142.0	64.8	77.0	35.2
50	**0.212**	25	167.0	76.3	52.0	23.7
100	**0.15**	21	188.0	85.8	31.0	14.2
200	**0.063**	19	207.0	94.5	12.0	5.5
Total weight sieved through 200 (g)				12		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				219	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.5%	5.5%	15.0%	14.0%	30.0%	11.0%	19.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

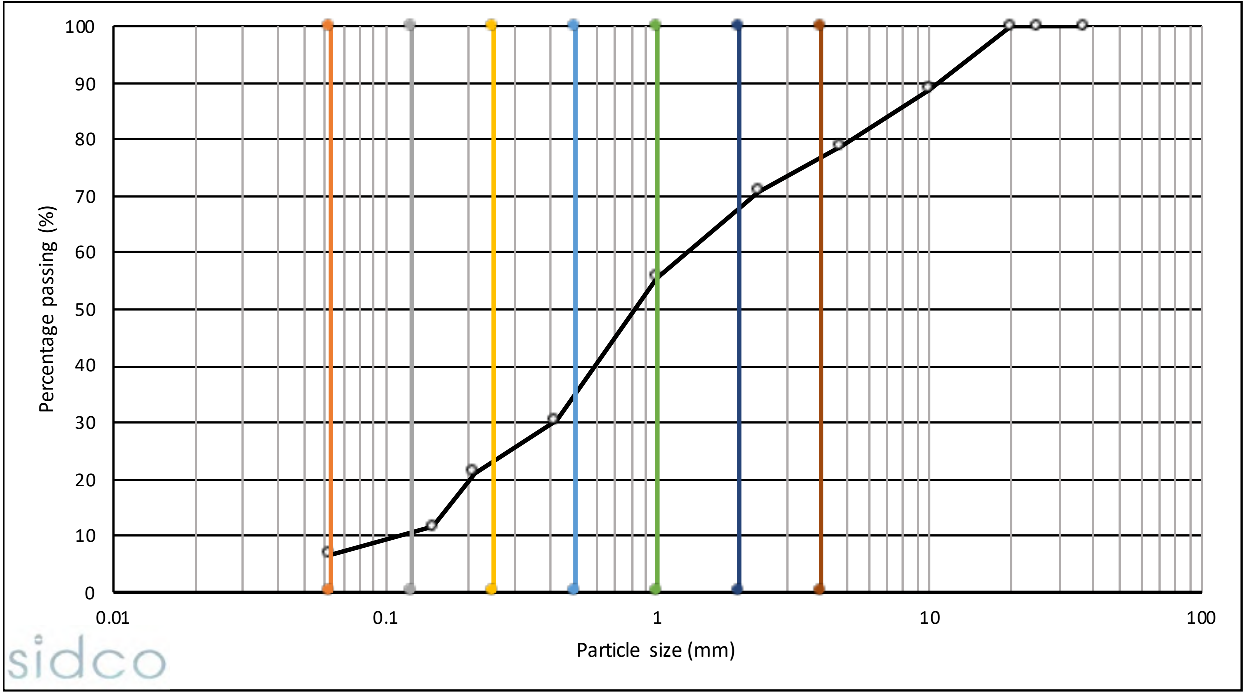
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1	
Date:	17/02/2023	**Tested by:**	SM		
BH2	**Depth (m)**	2.0	**Test #**	**3**	

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	284.0	100.0
2	**25**	0	0.0	0.0	284.0	100.0
3	**20**	0	0.0	0.0	284.0	100.0
4	**10**	32	32.0	11.3	252.0	88.7
5	**4.75**	28	60.0	21.1	224.0	78.9
8	**2.36**	23	83.0	29.2	201.0	70.8
16	**1**	43	126.0	44.4	158.0	55.6
30	**0.425**	72	198.0	69.7	86.0	30.3
50	**0.212**	26	224.0	78.9	60.0	21.1
100	**0.15**	27	251.0	88.4	33.0	11.6
200	**0.063**	14	265.0	93.3	19.0	6.7
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				284	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.7%	3.3%	12.0%	13.0%	21.0%	12.0%	32.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

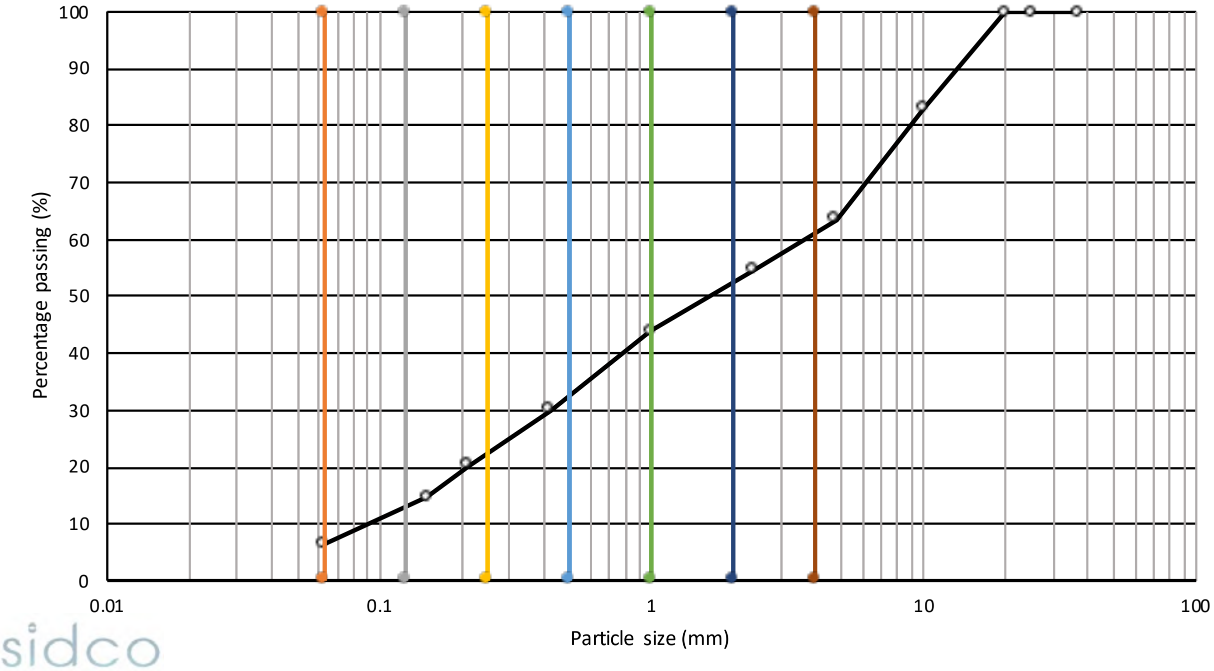
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**		SM	
BH2	**Depth (m)**	3.0		**Test #**	**4**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0	0.0	246.0	100.0
2	**25**	0	0	0.0	246.0	100.0
3	**20**	0	0	0.0	246.0	100.0
4	**10**	42	42.0	17.1	204.0	82.9
5	**4.75**	48	90.0	36.6	156.0	63.4
8	**2.36**	22	112.0	45.5	134.0	54.5
16	**1**	26	138.0	56.1	108.0	43.9
30	**0.425**	34	172.0	69.9	74.0	30.1
50	**0.212**	24	196.0	79.7	50.0	20.3
100	**0.15**	14	210.0	85.4	36.0	14.6
200	**0.063**	20	230.0	93.5	16.0	6.5
Total weight sieved through 200 (g)				16		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				246	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
6.5%	5.5%	9.0%	10.0%	10.0%	9.0%	50.0%

SIDCO PVT LTD

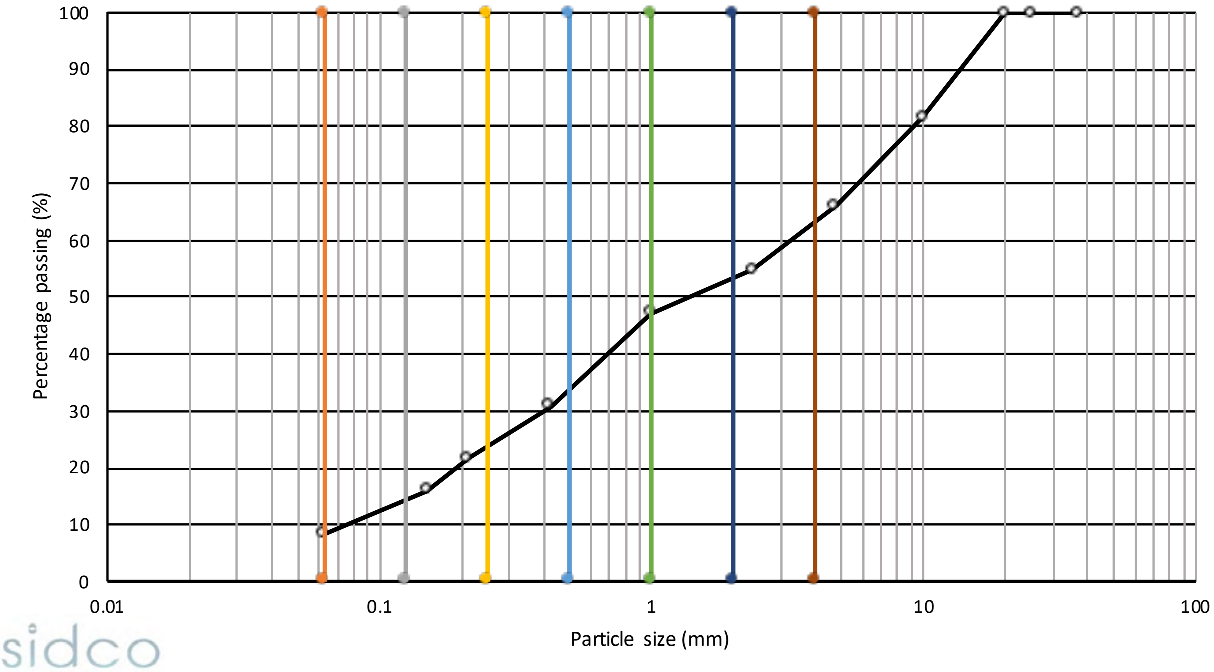
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	4.0	**Test #**	**5**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	250.0	100.0
2	**25**	0	0.0	0.0	250.0	100.0
3	**20**	0	0.0	0.0	250.0	100.0
4	**10**	46	46.0	18.4	204.0	81.6
5	**4.75**	39	85.0	34.0	165.0	66.0
8	**2.36**	28	113.0	45.2	137.0	54.8
16	**1**	19	132.0	52.8	118.0	47.2
30	**0.425**	41	173.0	69.2	77.0	30.8
50	**0.212**	23	196.0	78.4	54.0	21.6
100	**0.15**	14	210.0	84.0	40.0	16.0
200	**0.063**	19	229.0	91.6	21.0	8.4
Total weight sieved through 200 (g)				21		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				250	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
8.4%	6.6%	9.0%	8.0%	16.0%	5.0%	47.0%

APPENDIX C6: PROCTOR TEST RESULT

SIDCO PVT LTD

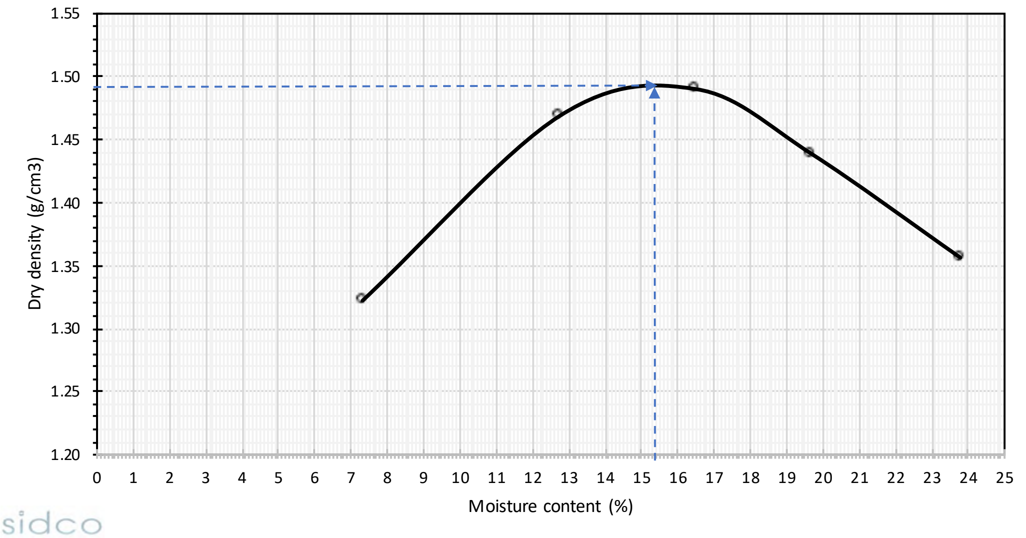
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**S. Hithadhoo**	**Date:**	**24/02/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.61	
Water dennsity, γw	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4868.00	5105.00	5185.00	5171.00	5128.00
weight of compacted soil, w2-w1 (g)	1419.00	1656.00	1736.00	1722.00	1679.00
Wet density, γb = ((w2-w1)/v), g/cm3	1.42	1.66	1.74	1.72	1.68
Dry density, γd = (γb/(1+(w/100))), g/cm3	**1.32**	**1.47**	**1.49**	**1.44**	**1.36**
Void Ratio e = ((Gsγw)/γd-1	1.97	1.78	1.75	1.81	1.92
Moisture content					
Weight of container, g	30.05	30.10	29.98	30.03	29.97
Weight of container + wet soil, g	60.56	62.39	66.34	58.86	61.98
Wet container + dry soil, g	58.48	58.74	61.19	54.12	55.83
Weight of moisture, ww (g)	2.08	3.65	5.15	4.74	6.15
Weight of dry soil, ws (g)	28.43	28.64	31.21	24.09	25.86
Water content, w= ((ww/ws)x100), %	**7.32**	**12.74**	**16.50**	**19.68**	**23.78**



APPENDIX C7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

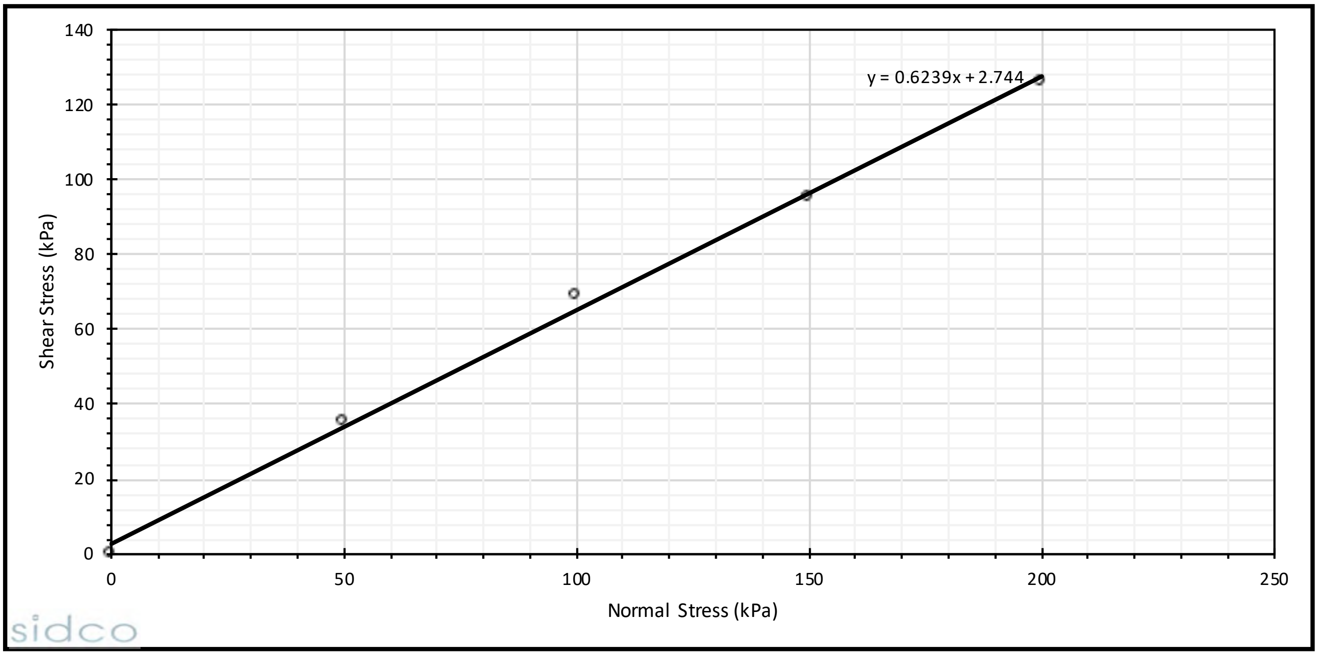
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**S. Hithadhoo**	**Date:**	**16/02/2023**	**Direct Shear**	**1**

Moisture content (%)	10.10%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	32	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	35.21
100.00	69.21
150.00	95.34
200.00	125.91



APPENDIX C8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**S. Hithadhoo**	**Date:**	**24/02/2022**
TEST 1			
Mass of dnesity bottle	W1	31.34	g
Mass of bottle + dry sand	W2	75.31	g
Mass of bottle + dry sand + water	W3	158.01	g
Mass of bottle + water	W4	130.93	g
Specific Gravity	Gs	2.60	

TEST 2

Mass of dnesity bottle	W1	35	g
Mass of bottle + dry sand	W2	79.43	g
Mass of bottle + dry sand + water	W3	173.92	g
Mass of bottle + water	W4	146.64	g
Specific Gravity	Gs	2.59	

Avarege Gs		2.60	

APPENDIX C9: SOIL RESITIVITY SURVEY RESULT

SIDCO SOILS LAB

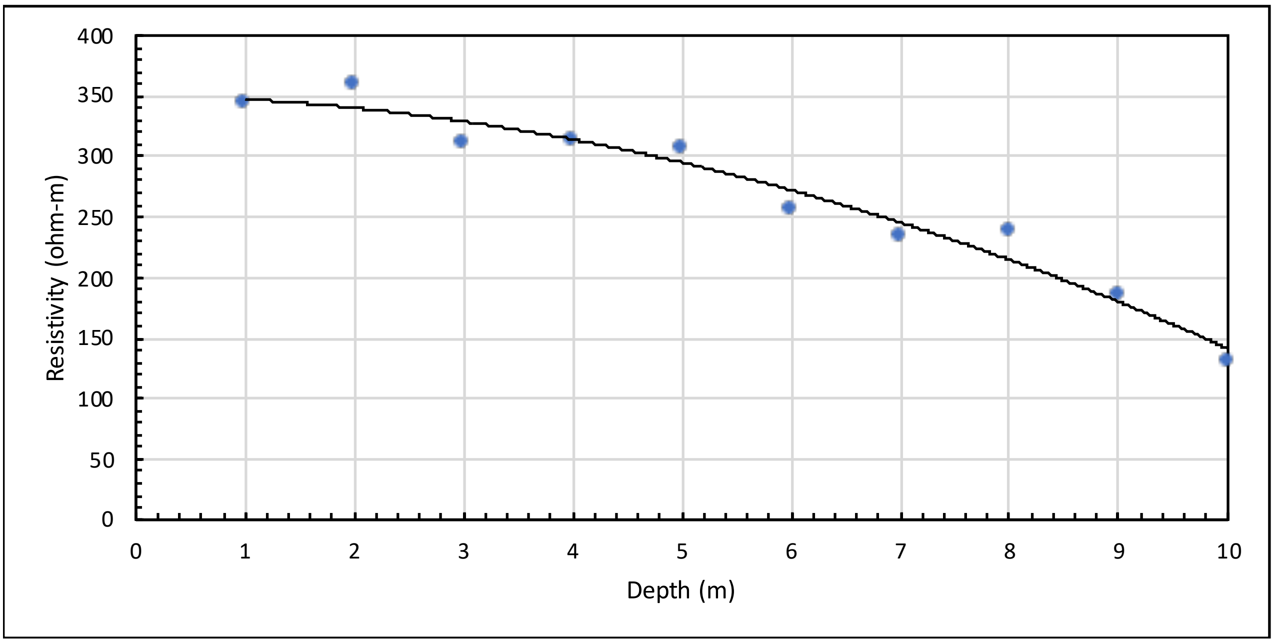
M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1

Probe Spacing "a" meters	Depth "h" meters	Resistance "R" ohm	Layer Resistivity (Ohm-m)
1	1	54.60	343
2	2	28.60	359
3	3	16.54	312
4	4	12.48	313
5	5	9.75	306
6	6	6.81	257
7	7	5.34	235
8	8	4.76	239
9	9	3.29	186
10	10	2.07	130

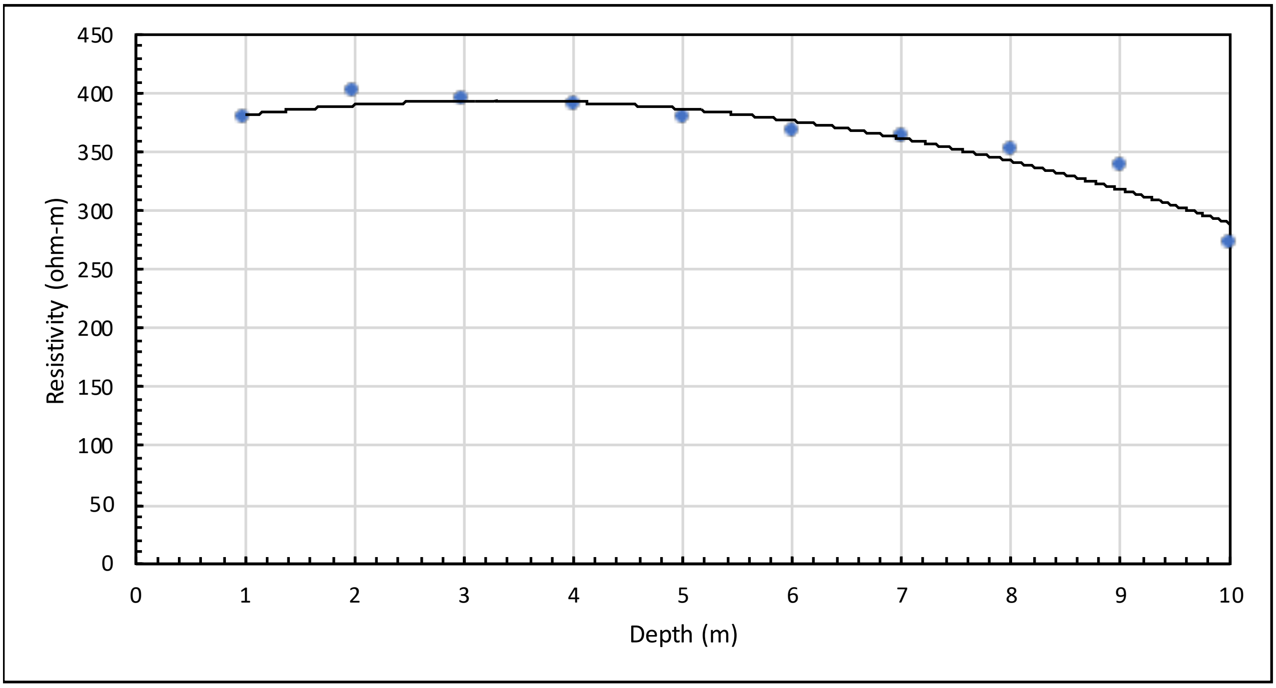


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

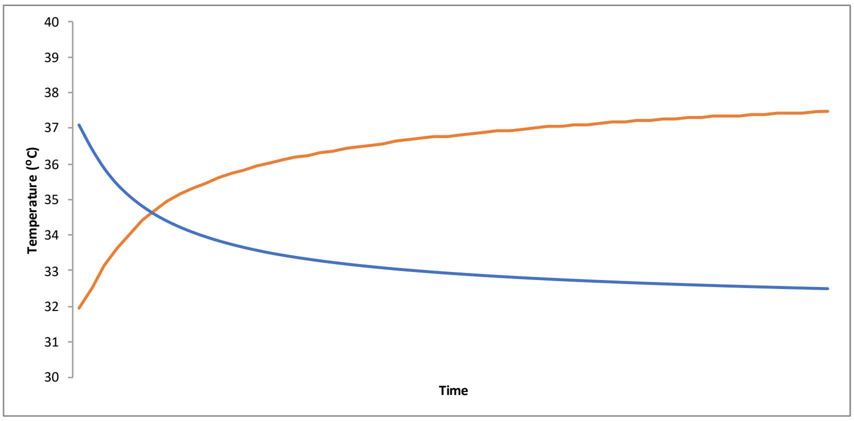
Soil Resistivity Survey - Wenner Method

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	60.21	378
2	2	31.86	400
3	3	20.94	395
4	4	15.50	389
5	5	12.09	380
6	6	9.73	367
7	7	8.25	363
8	8	7.01	352
9	9	5.99	339
10	10	4.33	272

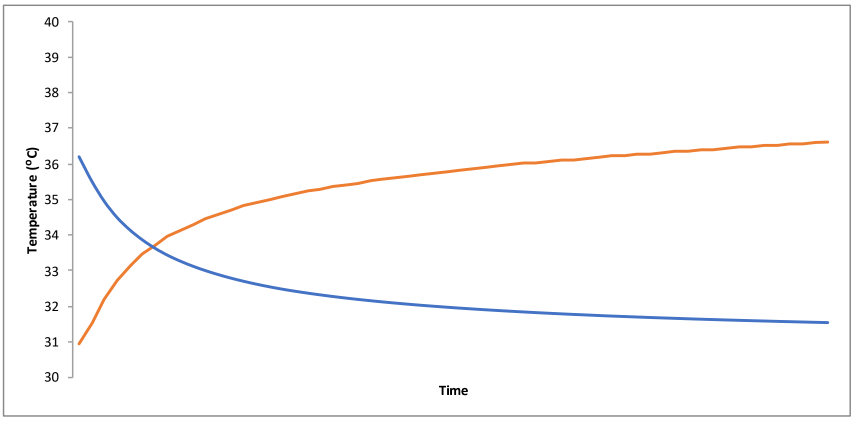


APPENDIX C10: THERMAL CONDUCTIVITY TEST RESULTS

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	31.94978		89599	37.095558
1500	32.509613		91099	36.430794
3000	33.14806		92599	35.869564
4500	33.649338		94099	35.430954
6000	34.065624		95599	35.090023
7500	34.410332		97099	34.811001
9000	34.699856		98599	34.57703
10500	34.941792		100099	34.383484
12000	35.144901		101599	34.219398
13500	35.320087		103099	34.077061
15000	35.470543		104599	33.952442
16500	35.607468		106099	33.841846
18000	35.729294		107599	33.743378
19500	35.838535		109099	33.65559
21000	35.936779		110599	33.575924
22500	36.026005		112099	33.503532
24000	36.107346		113599	33.440079
25500	36.182018		115099	33.381947
27000	36.250919		116599	33.328827
28500	36.314934		118099	33.279396
30000	36.374161		119599	33.233952
31500	36.429398		121099	33.19141
33000	36.481827		122599	33.151958
34500	36.532066		124099	33.114876
36000	36.579693		125599	33.08036
37500	36.625744		127099	33.047623
39000	36.669361		128599	33.017105
40500	36.710705		130099	32.988071
42000	36.749741		131599	32.960552
43500	36.787128		133099	32.934559
45000	36.822594		134599	32.909885
46500	36.857384		136099	32.88636
48000	36.890514		137599	32.863667
49500	36.922157		139099	32.842319
51000	36.952801		140599	32.822075
52500	36.982063		142099	32.802235
54000	37.010296		143599	32.783451
55500	37.03764		145099	32.765907
57000	37.064289		146599	32.748039
58500	37.089634		148099	32.731884
60000	37.115189		149599	32.716419
61500	37.138668		151099	32.701202
63000	37.162613		152599	32.686527
64500	37.185253		154099	32.671661
66000	37.207348		155599	32.658295
67500	37.22871		157099	32.644657
69000	37.249947		158599	32.632061
70500	37.269974		160099	32.619858
72000	37.289696		161599	32.607803
73500	37.309341		163099	32.596626
75000	37.327995		164599	32.584961
76500	37.346214		166099	32.573673
78000	37.364525		167599	32.563343
79500	37.381317		169099	32.55257
81000	37.399273		170599	32.543034
82500	37.415741		172099	32.533463
84000	37.432507		173599	32.523308
85500	37.449036		175099	32.514641
87000	37.464813		176599	32.505337
88500	37.479893		178099	32.496666



HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	30.947769		89599	36.202736
1500	31.530239		91099	35.520573
3000	32.213776		92599	34.944748
4500	32.737244		94099	34.49506
6000	33.144669		95599	34.148743
7500	33.466198		97099	33.865696
9000	33.736317		98599	33.629433
10500	33.96159		100099	33.432129
12000	34.153114		101599	33.267551
13500	34.31723		103099	33.125031
15000	34.461773		104599	33.00013
16500	34.593102		106099	32.889576
18000	34.709999		107599	32.790649
19500	34.817287		109099	32.702404
21000	34.913982		110599	32.622356
22500	35.002068		112099	32.55022
24000	35.08337		113599	32.484425
25500	35.158413		115099	32.426476
27000	35.228268		116599	32.372864
28500	35.293011		118099	32.32341
30000	35.354927		119599	32.277695
31500	35.411678		121099	32.234539
33000	35.465702		122599	32.194908
34500	35.517925		124099	32.157986
36000	35.56868		125599	32.122349
37500	35.617386		127099	32.089909
39000	35.663097		128599	32.058994
40500	35.707638		130099	32.029629
42000	35.750046		131599	32.002357
43500	35.791039		133099	31.9762
45000	35.830029		134599	31.951046
46500	35.867813		136099	31.927856
48000	35.904476		137599	31.905365
49500	35.940216		139099	31.883999
51000	35.973873		140599	31.863541
52500	36.007809		142099	31.844109
54000	36.039238		143599	31.824718
55500	36.070797		145099	31.807072
57000	36.101456		146599	31.790188
58500	36.130821		148099	31.7733
60000	36.159428		149599	31.758297
61500	36.187782		151099	31.742107
63000	36.215401		152599	31.72776
64500	36.242222		154099	31.714355
66000	36.268993		155599	31.700745
67500	36.294479		157099	31.687458
69000	36.320229		158599	31.675095
70500	36.345074		160099	31.663269
72000	36.369083		161599	31.651188
73500	36.393139		163099	31.639755
75000	36.416836		164599	31.629047
76500	36.439365		166099	31.61805
78000	36.462006		167599	31.6082
79500	36.484962		169099	31.598217
81000	36.50663		170599	31.588696
82500	36.52903		172099	31.578842
84000	36.550999		173599	31.569962
85500	36.572384		175099	31.561089
87000	36.594322		176599	31.552376
88500	36.615639		178099	31.54414



APPENDIX C11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Maradhoo-Feydhoo Harbour	Hithadhoo Stadium E	Hulhumeedhoo SPT	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83235949	83235950	83235951		
Sampled Date ~	24/01/2023 02:00	24/01/2023 02:00	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
Conductivity *	53800	433	712	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.6	7.4	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	26900	216	356	Electrometry	mg/L
Chloride	18550	<10 (LoQ 10 mg/L)	79	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	5.8	4.1	11.3	HACH Method 8171	mg/L
Sulphate *	2800	<10 (LoQ 10 mg/L)	20	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

MWSC

WATER QUALITY TEST REPORT

Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Feydhoo Harbour	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235952		
Sampled Date ~	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	46100	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.8	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	23000	Electrometry	mg/L
Chloride	15500	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	8.5	HACH Method 8171	mg/L
Sulphate *	2200	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

APPENDICES (D)
S. Hulhumeedhoo STP

APPENDIX D1: TEST LOCATIONS

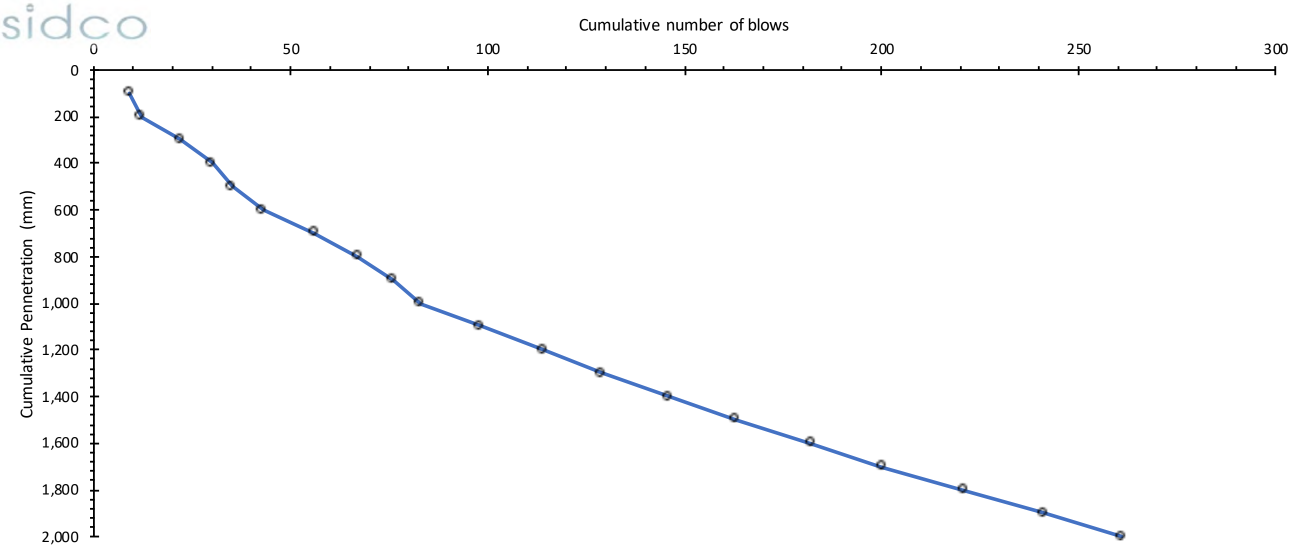
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

APPENDIX D2: DCP TEST RESULTS

SIDCO SOILS LAB
M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	S. Hulhumeedhoo STP		12/02/2023		DCP#	1
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	9	9	11.1	20	189	76
100-200	3	12	33.3	6	84	33
200-300	10	22	10.0	22	205	82
300-400	8	30	12.5	17	173	69
400-500	5	35	20.0	10	122	49
500-600	8	43	12.5	17	173	69
600-700	13	56	7.7	30	249	99
700-800	11	67	9.1	25	220	88
800-900	9	76	11.1	20	189	76
900-1000	7	83	14.3	15	157	63
1000-1100	15	98	6.7	35	277	111
1100-1200	16	114	6.3	37	290	116
1200-1300	15	129	6.7	35	277	111
1300-1400	17	146	5.9	40	304	121
1400-1500	17	163	5.9	40	304	121
1500-1600	19	182	5.3	45	330	132
1600-1700	18	200	5.6	43	317	127
1700-1800	21	221	4.8	51	355	142
1800-1900	20	241	5.0	48	343	137
1900-2000	20	261	5.0	48	343	137



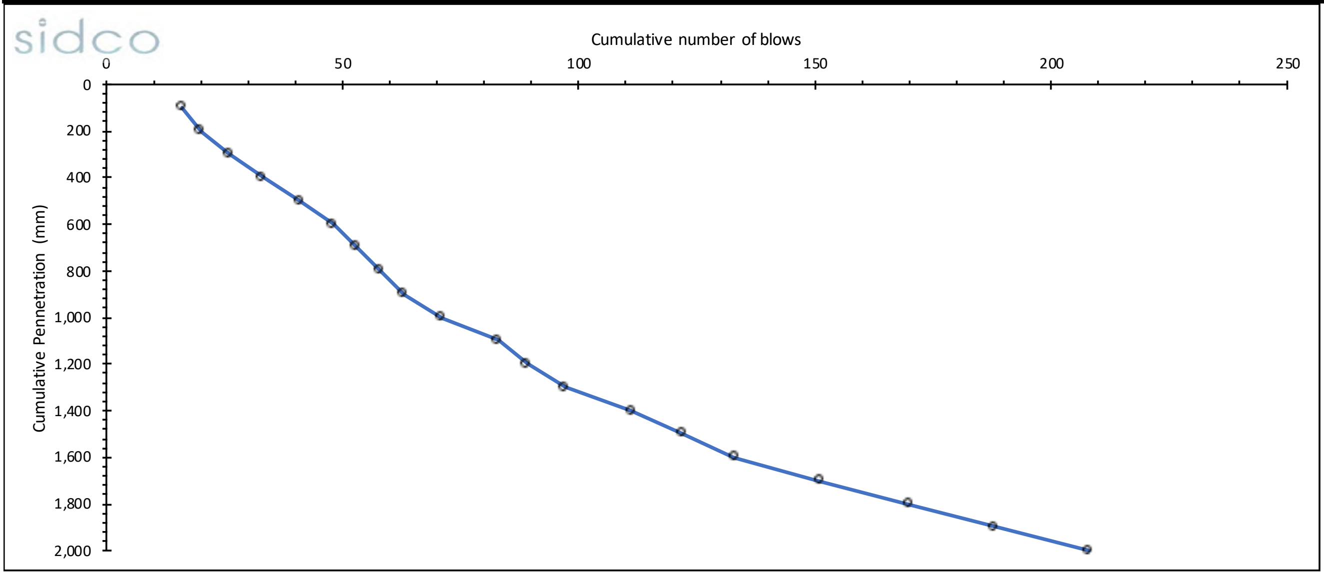
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hulhumeedhoo STP**		**12/02/2023**		**DCP#**	**2**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	16	16	6.3	37	290	116
100-200	4	20	25.0	8	104	41
200-300	6	26	16.7	13	140	56
300-400	7	33	14.3	15	157	63
400-500	8	41	12.5	17	173	69
500-600	7	48	14.3	15	157	63
600-700	5	53	20.0	10	122	49
700-800	5	58	20.0	10	122	49
800-900	5	63	20.0	10	122	49
900-1000	8	71	12.5	17	173	69
1000-1100	12	83	8.3	27	234	94
1100-1200	6	89	16.7	13	140	56
1200-1300	8	97	12.5	17	173	69
1300-1400	14	111	7.1	32	263	105
1400-1500	11	122	9.1	25	220	88
1500-1600	11	133	9.1	25	220	88
1600-1700	18	151	5.6	43	317	127
1700-1800	19	170	5.3	45	330	132
1800-1900	18	188	5.6	43	317	127
1900-2000	20	208	5.0	48	343	137

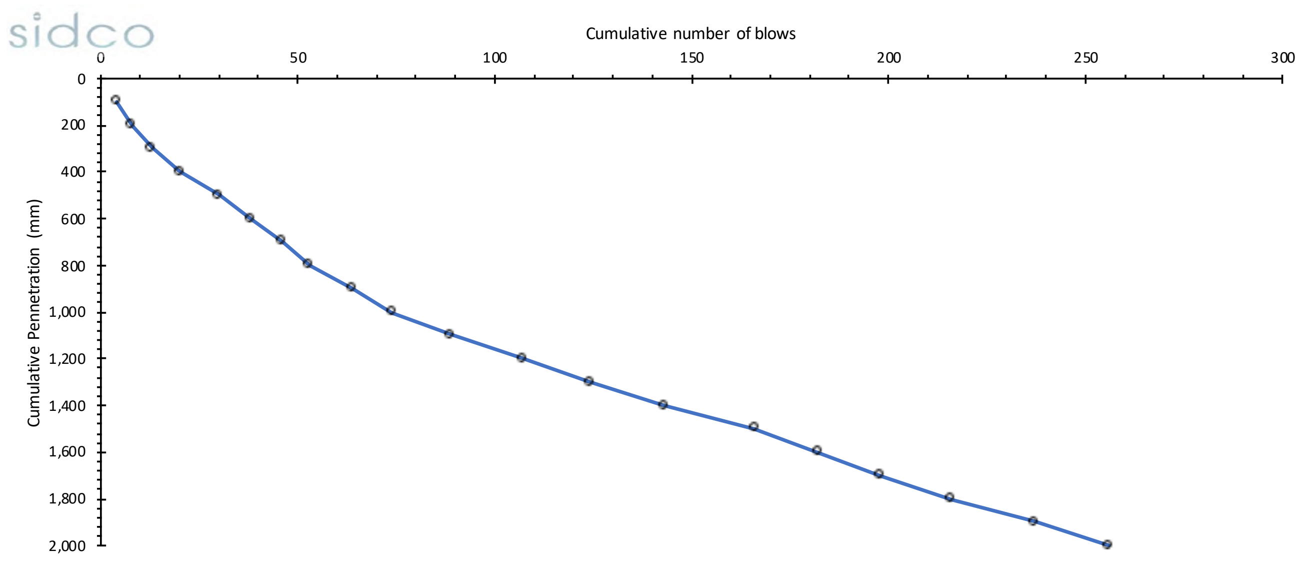


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hulhumeedhoo STP**		**12/02/2023**		**DCP#**	**3**
Depth (mm)	**Number of Blows**	**Cumulative Number of Blows**	**DCP Index (mm/blow)**	**CBR (%)**	**Ultimate Bearing Capacity, q (kPa)**	**Safe Bearing Capacity, q (kPa)**
0-100	4	4	25.0	8	104	41
100-200	4	8	25.0	8	104	41
200-300	5	13	20.0	10	122	49
300-400	7	20	14.3	15	157	63
400-500	10	30	10.0	22	205	82
500-600	8	38	12.5	17	173	69
600-700	8	46	12.5	17	173	69
700-800	7	53	14.3	15	157	63
800-900	11	64	9.1	25	220	88
900-1000	10	74	10.0	22	205	82
1000-1100	15	89	6.7	35	277	111
1100-1200	18	107	5.6	43	317	127
1200-1300	17	124	5.9	40	304	121
1300-1400	19	143	5.3	45	330	132
1400-1500	23	166	4.3	56	380	152
1500-1600	16	182	6.3	37	290	116
1600-1700	16	198	6.3	37	290	116
1700-1800	18	216	5.6	43	317	127
1800-1900	21	237	4.8	51	355	142
1900-2000	19	256	5.3	45	330	132



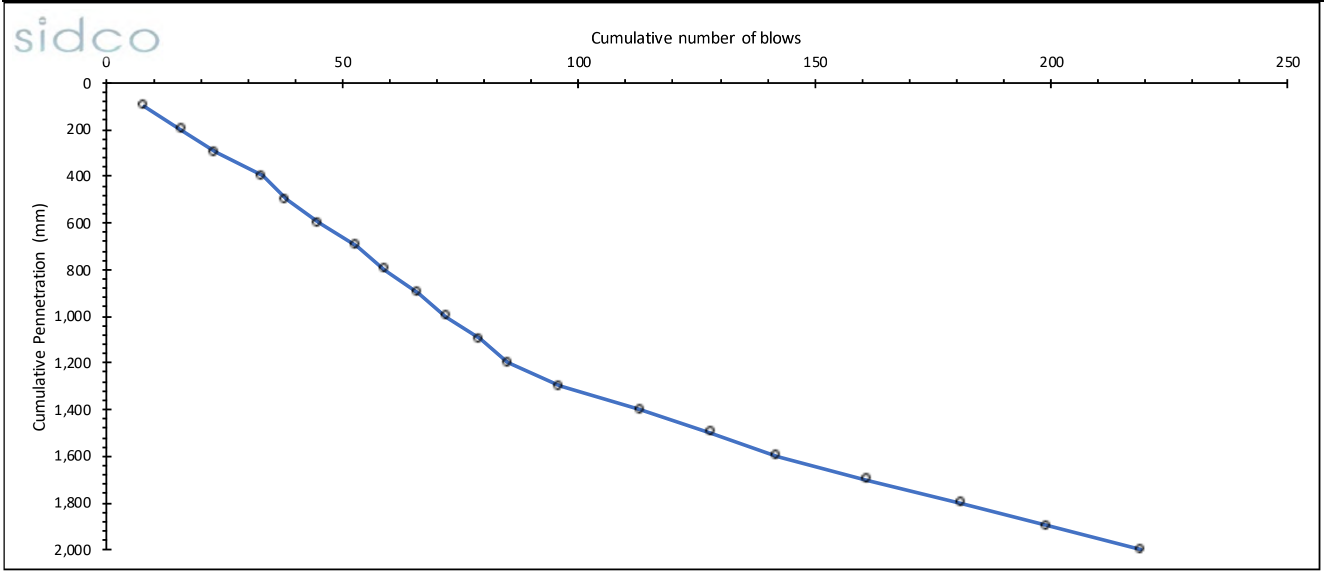
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	S. Hulhumeedhoo STP		12/02/2023		DCP#	4
Depth (mm)	Number of Blows	Cumulative Number of Blows	DCP Index (mm/blow)	CBR (%)	Ultimate Bearing Capacity, q (kPa)	Safe Bearing Capacity, q (kPa)
0-100	8	8	12.5	17	173	69
100-200	8	16	12.5	17	173	69
200-300	7	23	14.3	15	157	63
300-400	10	33	10.0	22	205	82
400-500	5	38	20.0	10	122	49
500-600	7	45	14.3	15	157	63
600-700	8	53	12.5	17	173	69
700-800	6	59	16.7	13	140	56
800-900	7	66	14.3	15	157	63
900-1000	6	72	16.7	13	140	56
1000-1100	7	79	14.3	15	157	63
1100-1200	6	85	16.7	13	140	56
1200-1300	11	96	9.1	25	220	88
1300-1400	17	113	5.9	40	304	121
1400-1500	15	128	6.7	35	277	111
1500-1600	14	142	7.1	32	263	105
1600-1700	19	161	5.3	45	330	132
1700-1800	20	181	5.0	48	343	137
1800-1900	18	199	5.6	43	317	127
1900-2000	20	219	5.0	48	343	137



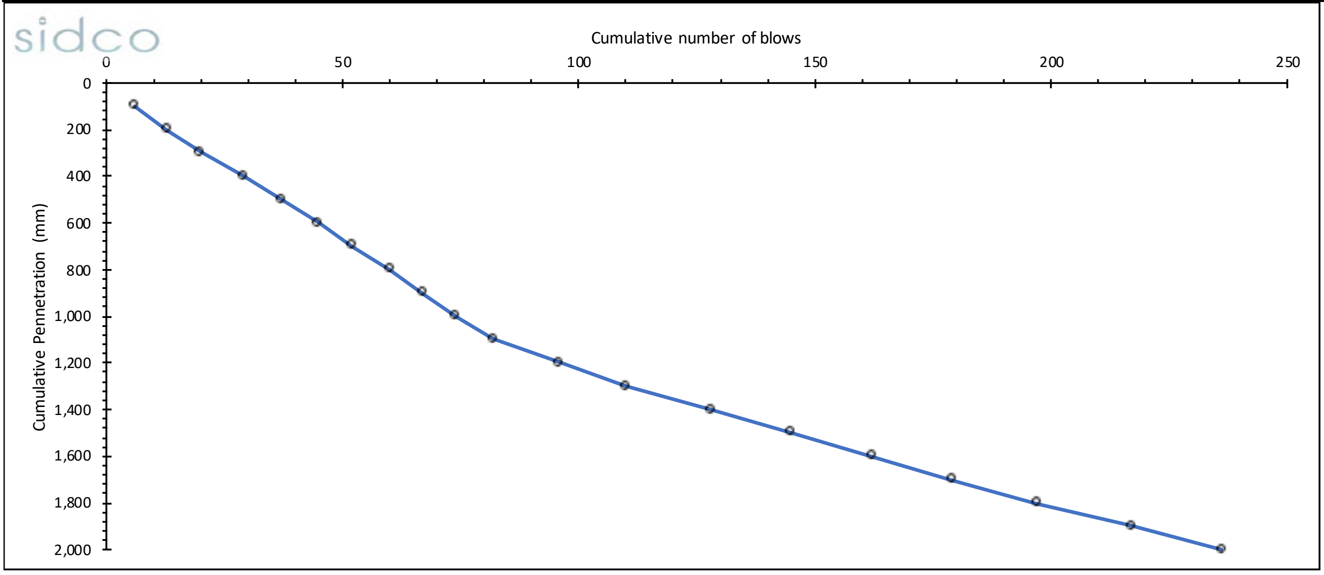
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

DCP Data Sheet

Location:	**S. Hulhumeedhoo STP**	**12/02/2023**	**DCP#**	**5**

Depth (mm)	Number of Blows	Cumulative Number of Blows	DCP Index (mm/blow)	CBR (%)	Ultimate Bearing Capacity, q (kPa)	Safe Bearing Capacity, q (kPa)
0-100	6	6	16.7	13	140	56
100-200	7	13	14.3	15	157	63
200-300	7	20	14.3	15	157	63
300-400	9	29	11.1	20	189	76
400-500	8	37	12.5	17	173	69
500-600	8	45	12.5	17	173	69
600-700	7	52	14.3	15	157	63
700-800	8	60	12.5	17	173	69
800-900	7	67	14.3	15	157	63
900-1000	7	74	14.3	15	157	63
1000-1100	8	82	12.5	17	173	69
1100-1200	14	96	7.1	32	263	105
1200-1300	14	110	7.1	32	263	105
1300-1400	18	128	5.6	43	317	127
1400-1500	17	145	5.9	40	304	121
1500-1600	17	162	5.9	40	304	121
1600-1700	17	179	5.9	40	304	121
1700-1800	18	197	5.6	43	317	127
1800-1900	20	217	5.0	48	343	137
1900-2000	19	236	5.3	45	330	132



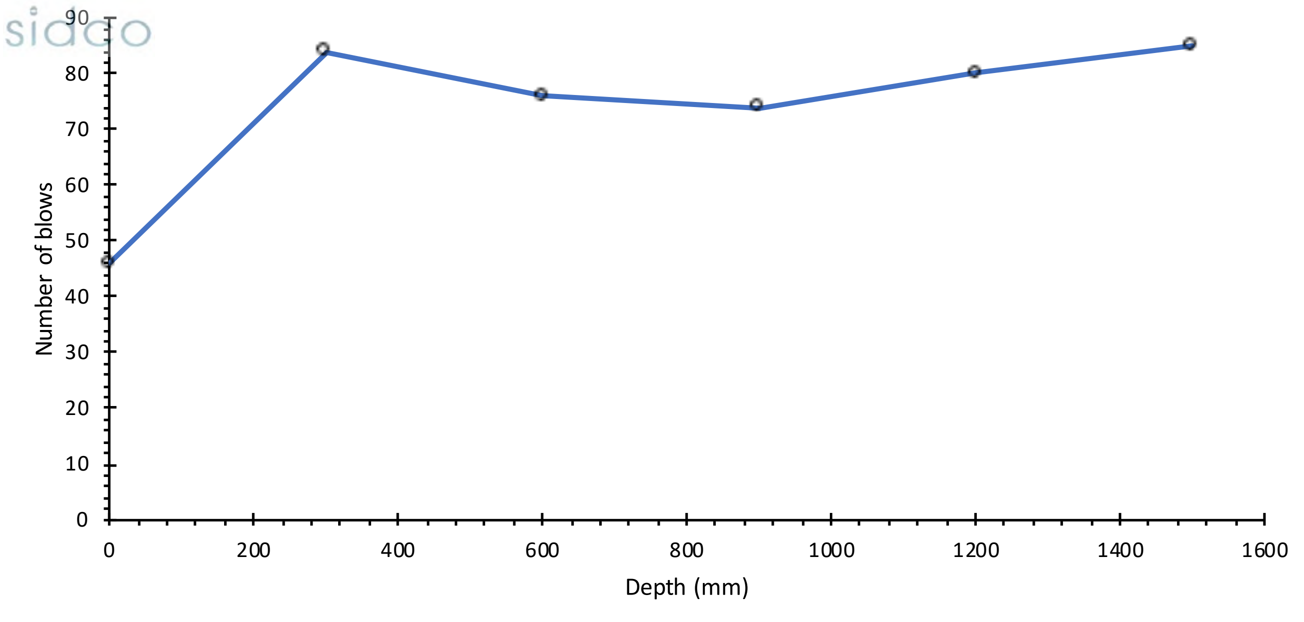
APPENDIX D3: MACKINTOSH PROBE TEST RESULTS

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Hulhumeedhoo**	**Date:**	**13/01/2023**	**MP#**	**1**
Depth (mm)		**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Safe Bearing Capacity kPa**
0-300		46	46	201	81
300-600		84	130	312	125
600-900		76	206	295	118
900-1200		74	280	290	116
1200-1500		80	360	303	121
1500-1800		85	445	314	125
1800-2100		>400 blows. Hitting hard strata at 2.0 m			
2100-2400					
2400-2700					
2700-3000					
3000-3300					
3300-3600					
3600-3900					
3900-4200					
4200-4500					
4500-4800					
4800-5100					
5100-5400					
5400-5700					
5700-6000					

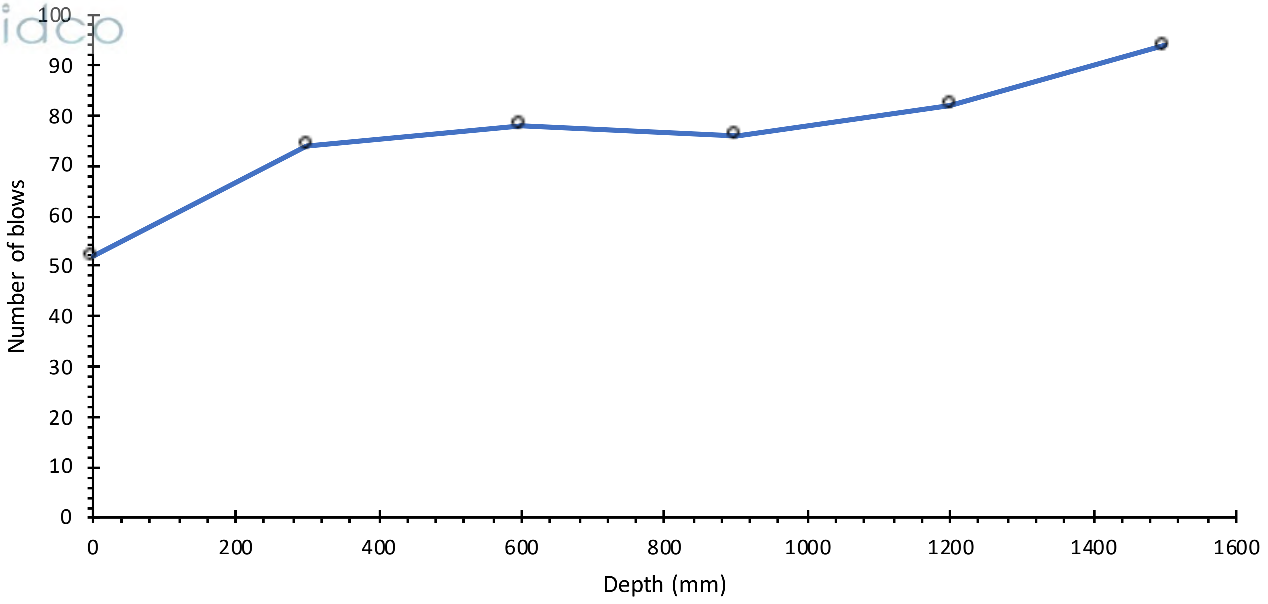


SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

MP Data Sheet

Location:	**Hulhumeedhoo**	**Date:**	**13/01/2023**	**MP#**	**2**
Depth (mm)		**Number of Blows, N_{MP}**	**Cumulative Number of Blows**	**Bearing Capacity kPa**	**Safe Bearing Capacity kPa**
0-300		52	52	228	91
300-600		74	126	290	116
600-900		78	204	299	120
900-1200		76	280	295	118
1200-1500		82	362	308	123
1500-1800		94	456	330	132
1800-2100		>400 blows. Hitting hard strata at 2.0 m			
2100-2400					
2400-2700					
2700-3000					
3000-3300					
3300-3600					
3600-3900					
3900-4200					
4200-4500					
4500-4800					
4800-5100					
5100-5400					
5400-5700					
5700-6000					



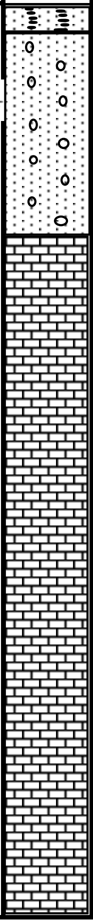
APPENDIX D4: BOREHOLE LOGS

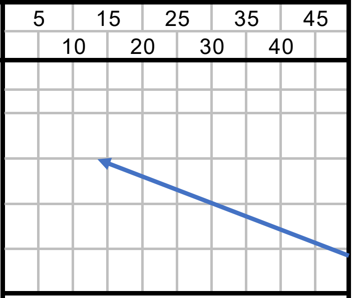
SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Hulhumeedhoo STP						
Project Number:	2023/HDEC/01		Client:	HDEC		BH No.	1
Drill Rig type	Rotatary Drill		Drilling Contractor	SIDCO Pvt Ltd			
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date Started:	11/02/2023	Bit Type	PDC	Diameter (mm)	76
Total depth of boring (m)	6	Date Completed	11/02/2023	Hammer Type	Auto tripped hammer		
BH Location	Hulhumeedhoo STP	Date Backfilled:	12/02/2023	Hammer Weight (kg)	63.5	Hammer Drop (mm)	760

Depth (m)	Sample Type	Sample Number	GWL	Graphic Log	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)$_{60}$	Graphical representation of corrected SPT N values
					Top soil						
1	SS	D1	▼		Loose, off white fine sand with some gravel	4	4	4	8	14	
		D2									
2	SS	D3				20	HB	HB	>50	>50	
3	CS	D4			Weathered limestone rock						RQD=24%, CR=79%
4	CS	D5									RQD=40%, CR=86%
5	CS	D5									RQD=32%, CR=88%
6											
7											
8											
9											
10											





Notes

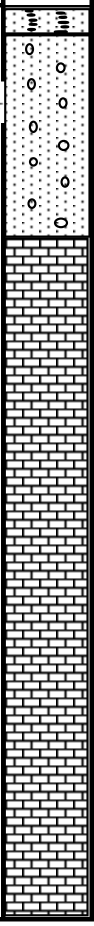
SPT	Standard Penetration Test
N	SPT value
N60	Corrected N value
SS	SPT Spoon sample
CS	Core sample
▼	Ground water level

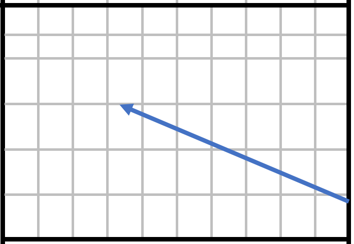
sidco

SIDCO PVT LTD, Reg No: C-0514/2017
Coralville C5-1D, Hulhumalé, 23000, Maldives
Mob: +960-7962004, E-mail: sidco.mv@gmail.com

Geotechnical Investigation

Project:	Aspire - Solar PV Installation Project - S. Hulhumeedhoo STP						
Project Number:	2023/HDEC/01		Client:	HDEC		BH No.	2
Drill Rig type	Rotatary Drill		Drilling Contractor	SIDCO Pvt Ltd			
Drilling method	Rotatory						
Ground water depth (m)	1.0	Date Started: 12/02/2023	Bit Type	PDC		Diameter (mm)	76
Total depth of boring (m)	6	Date Completed: 12/02/2023	Hammer Type	Auto tripped hammer			
BH Location	Hulhumeedhoo STP	Date Backfilled: 13/02/2023	Hammer Weight (kg)	63.5		Hammer Drop (mm)	760





Depth (m)	Sample Type	Sample Number	GWL	Soil Description	Field Data SPT values 15 cm	15 cm	15 cm	N	Corrected N (N1)60	Graphical representation of corrected SPT N values 5 10 15 20 25 30 35 40 45
				Top soil						
1	SS	D1	▼	Loose, off white fine sand with some gravel	4	4	5	9	16	
		D2								
2	SS				21	HB	HB	>50	>50	
		D3								
3	CS	D4		Weathered limestone rock						RQD=45%, CR=91%
4	CS	D5								RQD=18%, CR=76%
5	CS	D5								RQD=30%, CR=84%
6										
7										
8										
9										
10										

Notes

SPT	Standard Penetration Test	▼ Ground water level
N	SPT value	
N60	Corrected N value	
SS	SPT Spoon sample	
CS	Core sample	

APPENDIX D5: RESULTS OF PARTICLE SIZE DISTRIBUTION

SIDCO PVT LTD

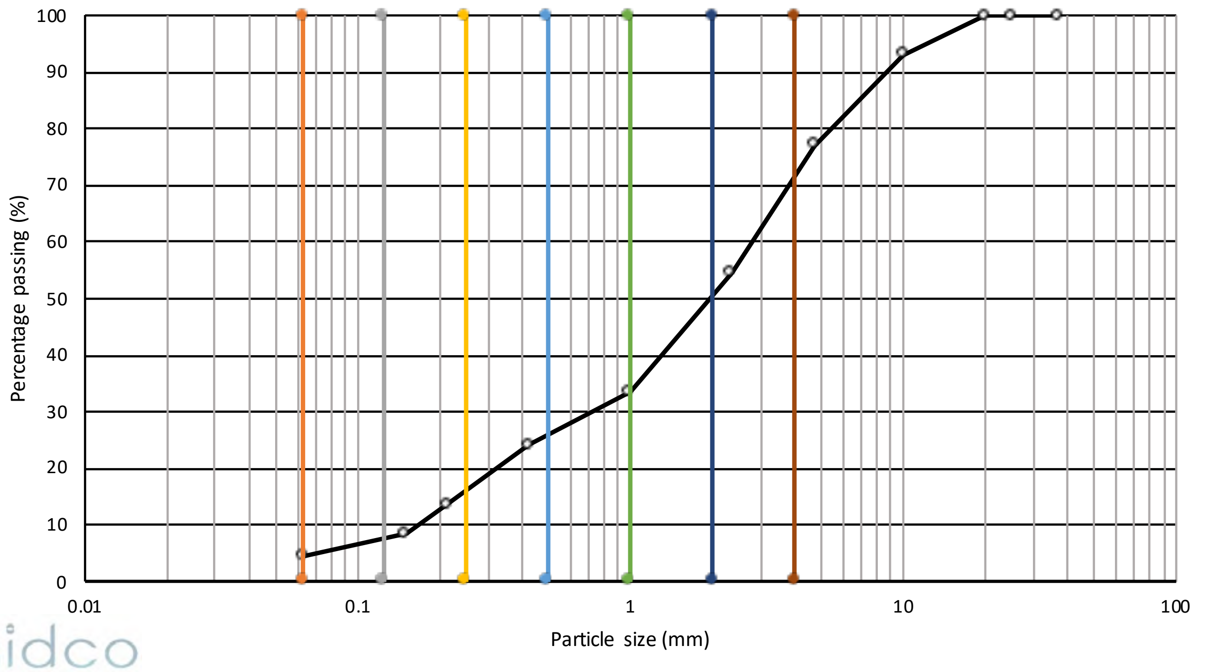
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hulhumeedhoo STP		**File #:**	HDEC/2023/1
Date:	20/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	0.0	**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	200.0	100.0
2	**25**	0	0.0	0.0	200.0	100.0
3	**20**	0	0.0	0.0	200.0	100.0
4	**10**	14	14.0	7.0	186.0	93.0
5	**4.75**	32	46.0	23.0	154.0	77.0
8	**2.36**	45	91.0	45.5	109.0	54.5
16	**1**	42	133.0	66.5	67.0	33.5
30	**0.425**	19	152.0	76.0	48.0	24.0
50	**0.212**	21	173.0	86.5	27.0	13.5
100	**0.15**	10	183.0	91.5	17.0	8.5
200	**0.063**	8	191.0	95.5	9.0	4.5
Total weight sieved through 200 (g)				9		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				200	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	**Very Fine sand**	**Fine Sand**	**Medium Sand**	**Coarse Sand**	**Very Coarse sand**	**Gravel & larger**
4.5%	3.5%	8.0%	9.0%	7.0%	18.0%	50.0%

SIDCO PVT LTD

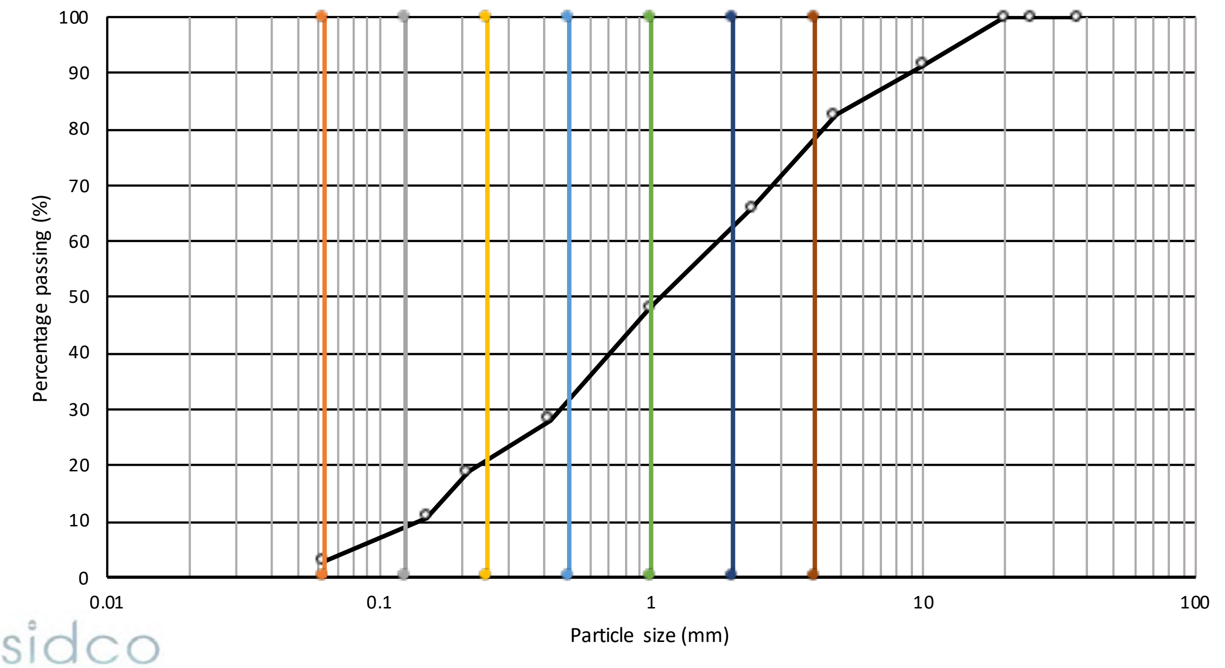
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hulhumeedhoo STP		**File #:**	HDEC/2023/1
Date:	20/02/2023	**Tested by:**	SM	
BH1	**Depth (m)**	1.0	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	376.0	100.0
2	**25**	0	0.0	0.0	376.0	100.0
3	**20**	0	0.0	0.0	376.0	100.0
4	**10**	32	32.0	8.5	344.0	91.5
5	**4.75**	34	66.0	17.6	310.0	82.4
8	**2.36**	62	128.0	34.0	248.0	66.0
16	**1**	67	195.0	51.9	181.0	48.1
30	**0.425**	75	270.0	71.8	106.0	28.2
50	**0.212**	35	305.0	81.1	71.0	18.9
100	**0.15**	31	336.0	89.4	40.0	10.6
200	**0.063**	29	365.0	97.1	11.0	2.9
Total weight sieved through 200 (g)				11		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				376	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
2.9%	7.1%	10.0%	11.0%	18.0%	12.0%	39.0%

SIDCO PVT LTD

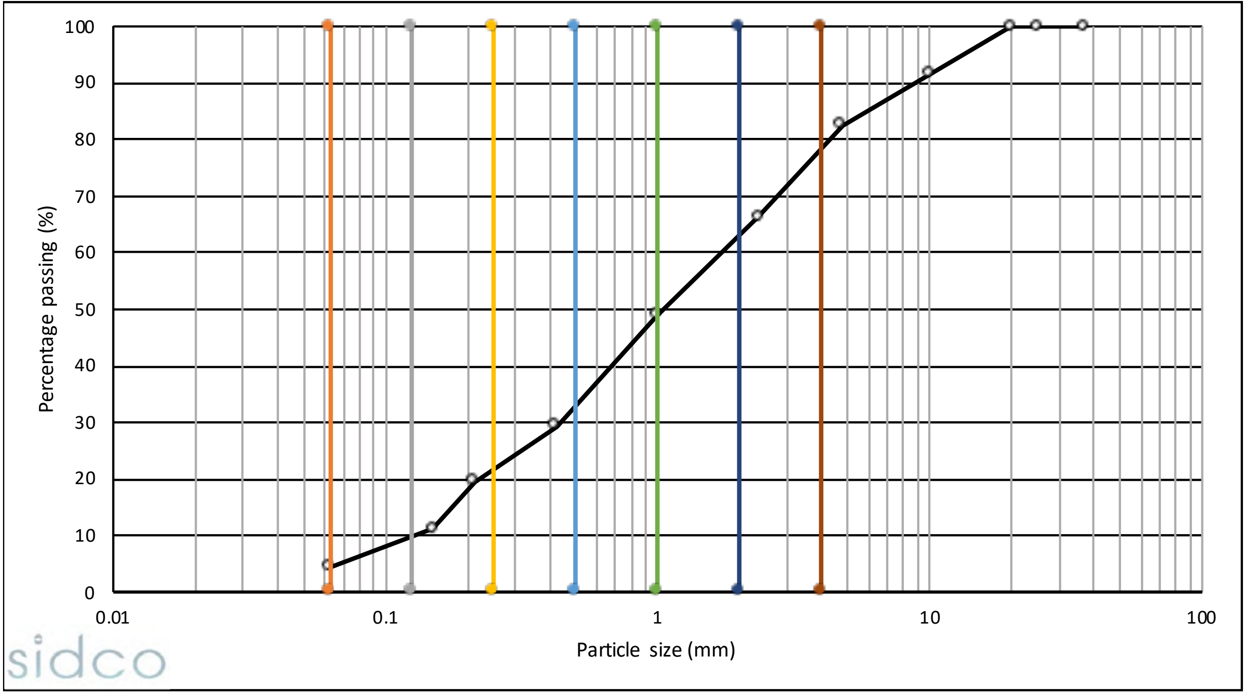
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hulhumeedhoo STP			**File #:**	HDEC/2023/1
Date:	20/02/2023		**Tested by:**	SM	
BH1	**Depth (m)**	2.0		**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	357.0	100.0
2	**25**	0	0.0	0.0	357.0	100.0
3	**20**	0	0.0	0.0	357.0	100.0
4	**10**	30	30.0	8.4	327.0	91.6
5	**4.75**	32	62.0	17.4	295.0	82.6
8	**2.36**	58	120.0	33.6	237.0	66.4
16	**1**	62	182.0	51.0	175.0	49.0
30	**0.425**	70	252.0	70.6	105.0	29.4
50	**0.212**	35	287.0	80.4	70.0	19.6
100	**0.15**	30	317.0	88.8	40.0	11.2
200	**0.063**	24	341.0	95.5	16.0	4.5
Total weight sieved through 200 (g)				16		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				357	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
4.5%	5.5%	11.0%	11.0%	18.0%	12.0%	38.0%

SIDCO PVT LTD

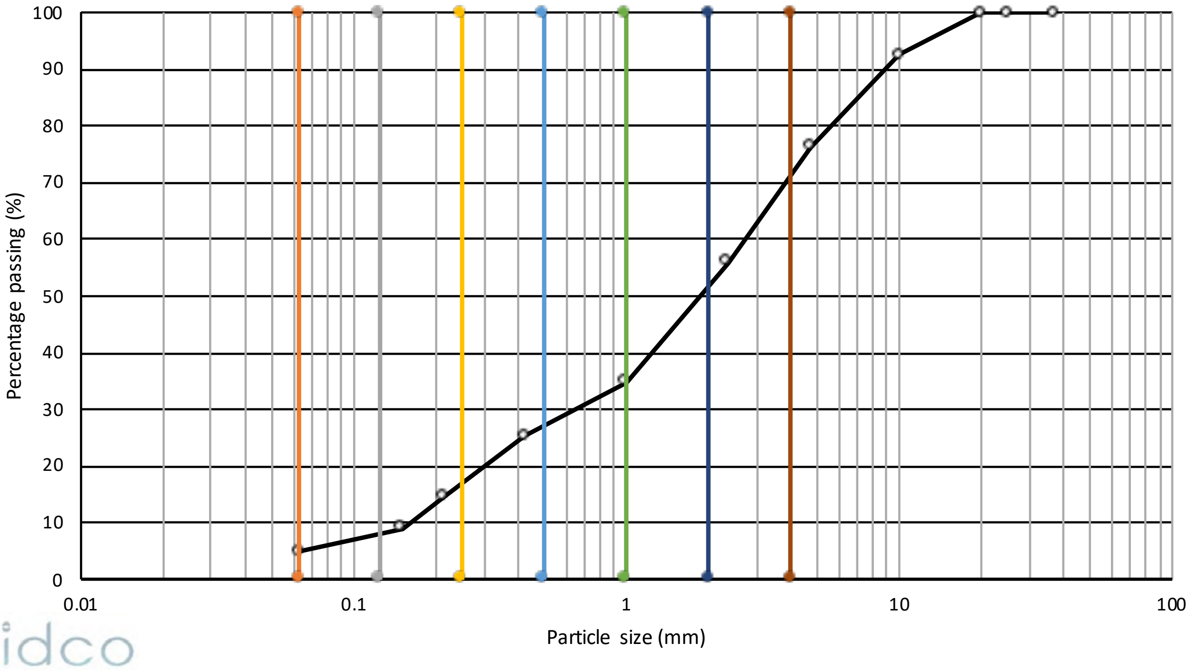
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023		**Tested by:**	SM	
BH2	**Depth (m)**	0.0		**Test #**	**1**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	241.0	100.0
2	**25**	0	0.0	0.0	241.0	100.0
3	**20**	0	0.0	0.0	241.0	100.0
4	**10**	18	18.0	7.5	223.0	92.5
5	**4.75**	39	57.0	23.7	184.0	76.3
8	**2.36**	49	106.0	44.0	135.0	56.0
16	**1**	51	157.0	65.1	84.0	34.9
30	**0.425**	23	180.0	74.7	61.0	25.3
50	**0.212**	26	206.0	85.5	35.0	14.5
100	**0.15**	13	219.0	90.9	22.0	9.1
200	**0.063**	10	229.0	95.0	12.0	5.0
Total weight sieved through 200 (g)				12		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				241	Error (%)	
Remarks						
Technician		Computed by		Checked by		



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.0%	4.0%	9.0%	10.0%	6.0%	16.0%	50.0%

SIDCO PVT LTD

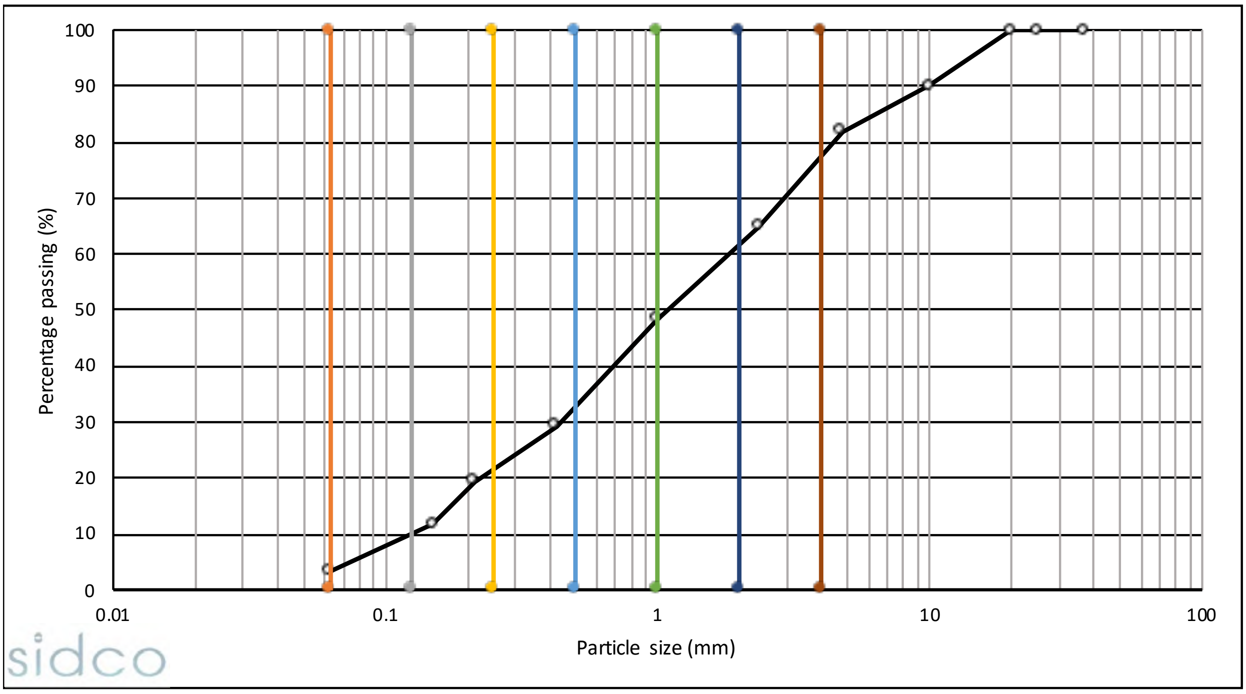
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium		**File #:**	HDEC/2023/1
Date:	17/02/2023	**Tested by:**	SM	
BH2	**Depth (m)**	1.0	**Test #**	**2**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	381.0	100.0
2	**25**	0	0.0	0.0	381.0	100.0
3	**20**	0	0.0	0.0	381.0	100.0
4	**10**	38	38.0	10.0	343.0	90.0
5	**4.75**	31	69.0	18.1	312.0	81.9
8	**2.36**	65	134.0	35.2	247.0	64.8
16	**1**	63	197.0	51.7	184.0	48.3
30	**0.425**	72	269.0	70.6	112.0	29.4
50	**0.212**	38	307.0	80.6	74.0	19.4
100	**0.15**	29	336.0	88.2	45.0	11.8
200	**0.063**	32	368.0	96.6	13.0	3.4
Total weight sieved through 200 (g)				13		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				381	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
3.4%	6.6%	11.0%	10.0%	19.0%	11.0%	39.0%

SIDCO PVT LTD

M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives

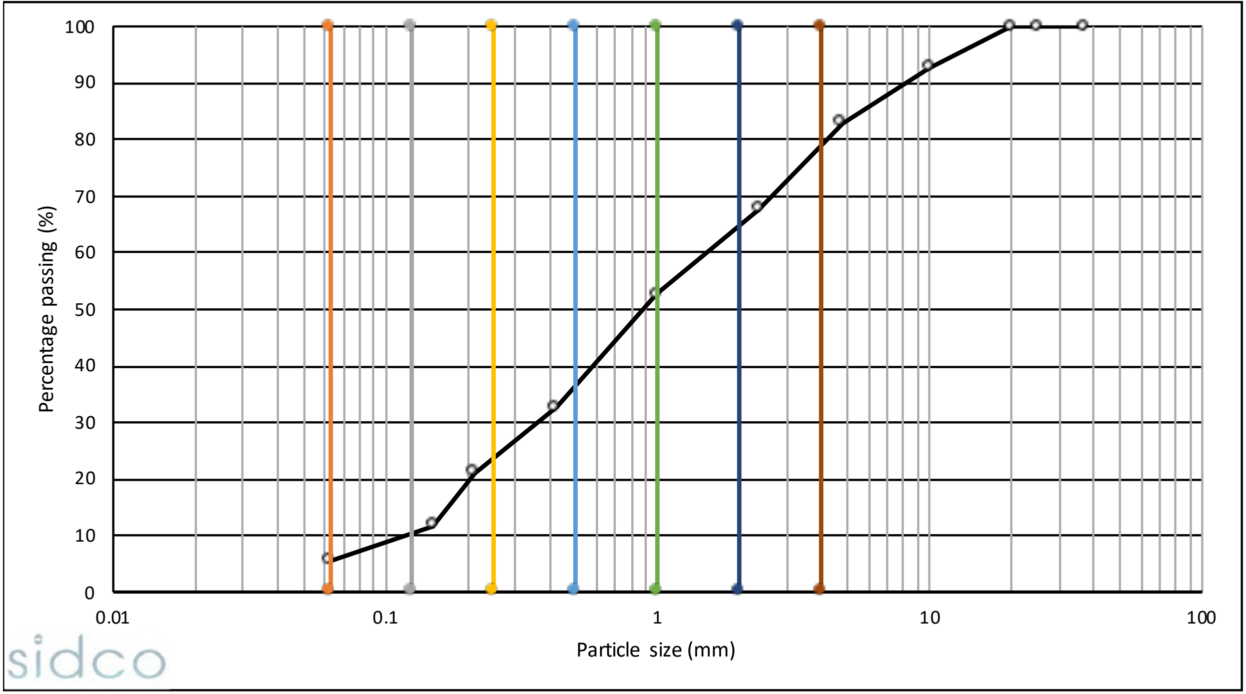
Mobile: +960-7962004, Email: mer.lab.mv@gmail.com

Sieve Analysis

Location:	S. Hithadhoo Stadium			**File #:**	HDEC/2023/1
Date:	17/02/2023		**Tested by:**	SM	
BH2	**Depth (m)**	2.0		**Test #**	**3**

Sieve #	Sieve size	Mass retained (g)	Cumulative mass retained (g)	Cumulative mass retained (%)	Passing	
					mass (g)	percent (%)
1	**37.5**	0	0.0	0.0	340.0	100.0
2	**25**	0	0.0	0.0	340.0	100.0
3	**20**	0	0.0	0.0	340.0	100.0
4	**10**	25	25.0	7.4	315.0	92.6
5	**4.75**	33	58.0	17.1	282.0	82.9
8	**2.36**	52	110.0	32.4	230.0	67.6
16	**1**	51	161.0	47.4	179.0	52.6
30	**0.425**	68	229.0	67.4	111.0	32.6
50	**0.212**	39	268.0	78.8	72.0	21.2
100	**0.15**	32	300.0	88.2	40.0	11.8
200	**0.063**	21	321.0	94.4	19.0	5.6
Total weight sieved through 200 (g)				19		
Washing loss (g)				0		
Total weight passing sieve no. 200 (g)				0	Error (g)	
Total weight of fractions (g)				340	Error (%)	
Remarks						

Technician	Computed by	Checked by



Silt/Clay	Very Fine sand	Fine Sand	Medium Sand	Coarse Sand	Very Coarse sand	Gravel & larger
5.6%	4.4%	12.0%	14.0%	16.0%	14.0%	34.0%

APPENDIX D6: PROCTOR TEST RESULT

SIDCO PVT LTD

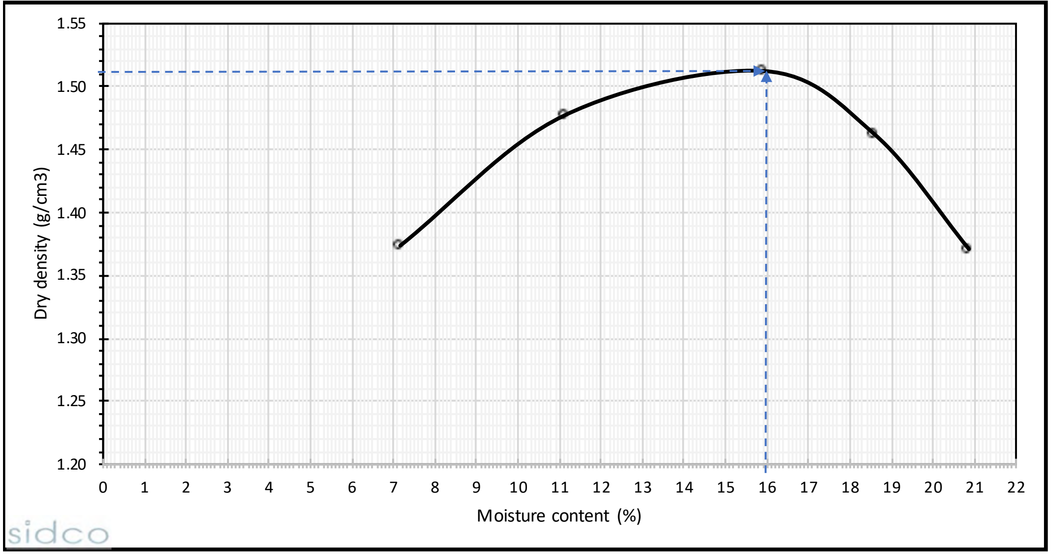
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Proctor Test Data Sheet

Location:	**S. Hulhumeedhoo**	**Date:**	**03/03/2023**	**Proctor Test No:**	**1**

Soil sample	=	5	kg
Diamter of mould	=	105	mm
Height of mould	=	115.5	mm
Weight of mould + base plate (w1)	=	3449	g
Volume of mould, v	=	1000	cm3
Height of fall	=	300	mm
Weight of rammer	=	2.5	kg
Number of blows	=	25	
Number of layers	=	3	
Specific gravity of soil, Gs	=	2.62	
Water dennsity, γw	=	1	

Description	Trials				
	1	2	3	4	5
weight of mould + base + compacted soil, w2 (g)	4921.00	5090.00	5202.00	5183.00	5106.00
weight of compacted soil, w2-w1 (g)	1472.00	1641.00	1753.00	1734.00	1657.00
Wet density, γb = ((w2-w1)/v), g/cm3	1.47	1.64	1.75	1.73	1.66
Dry density, γd = (γb/(1+(w/100))), g/cm3	**1.37**	**1.48**	**1.51**	**1.46**	**1.37**
Void Ratio e = ((Gsγw)/γd-1	1.91	1.77	1.73	1.79	1.91
Moisture content					
Weight of container, g	29.96	29.99	30.05	30.10	29.95
Weight of container + wet soil, g	72.31	68.40	70.71	63.21	73.74
Wet container + dry soil, g	69.48	64.56	65.13	58.02	66.18
Weight of moisture, ww (g)	2.83	3.84	5.58	5.19	7.56
Weight of dry soil, ws (g)	39.52	34.57	35.08	27.92	36.23
Water content, w= ((ww/ws)x100), %	**7.16**	**11.11**	**15.91**	**18.59**	**20.87**



APPENDIX D7: DIRECT SHEAR TEST RESULT

SIDCO PVT LTD

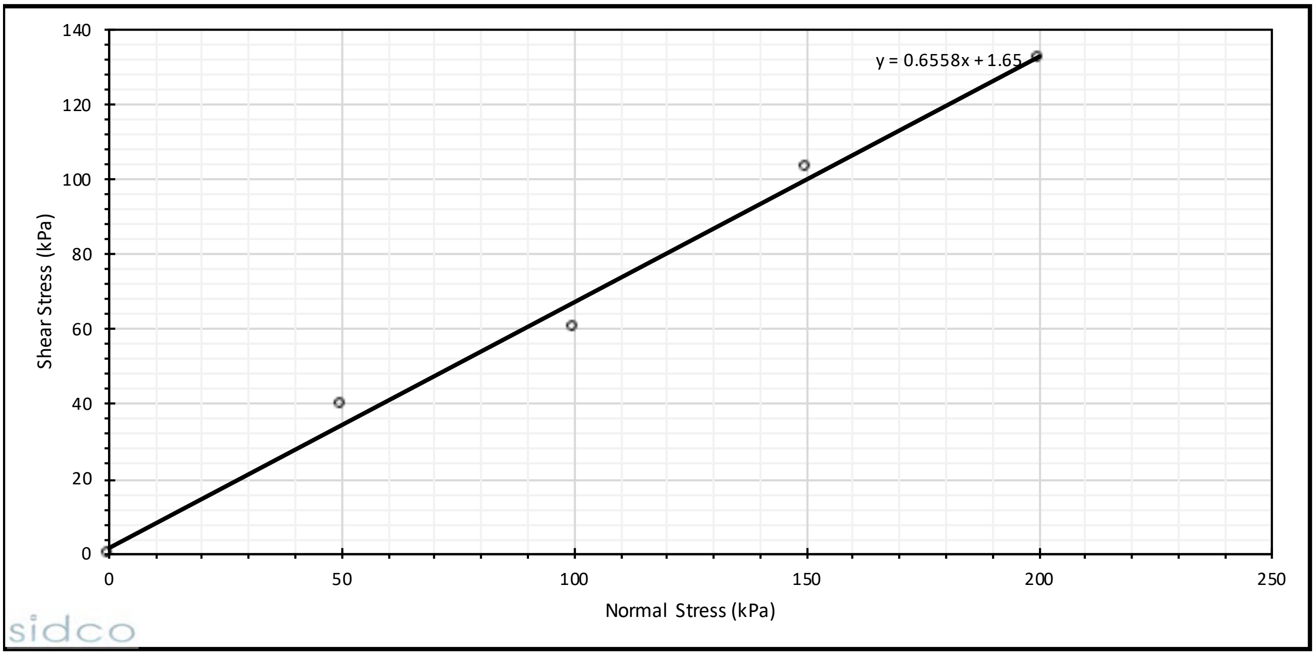
M. Asrafeege, 3rd Floor, Orchid Magu, Malé, Maldives
Mobile: +960-7962004, Email: info@sidco.mv

Direct Shear Test Data Sheet

Location:	**S. Hulhumeedhoo**	**Date:**	**24/02/2023**	**Direct Shear**	**1**

Moisture content (%)	10.10%				
Soil Type:	Whitish fine sand with gravels (poorly graded)				
Depth	0.5 m				
Cohesion	0	kPa	Shear angle	34	degrees

Normal Stress, kPa	Shear Stress, kPa
0.00	0.00
50.00	40.12
100.00	60.32
150.00	103.41
200.00	132.31



APPENDIX D8: SPECIFIC GRAVITY TEST RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Specific Gravity Test

Location:	**S. Hulhumeedhoo**	**Date:**	**24/02/2022**
TEST 1			
Mass of dnesity bottle	W1	31.02	g
Mass of bottle + dry sand	W2	83.21	g
Mass of bottle + dry sand + water	W3	163.23	g
Mass of bottle + water	W4	130.93	g
Specific Gravity	Gs	2.62	

TEST 2

Mass of dnesity bottle	W1	35.02	g
Mass of bottle + dry sand	W2	90.24	g
Mass of bottle + dry sand + water	W3	180.71	g
Mass of bottle + water	W4	146.64	g
Specific Gravity	Gs	2.61	

Avarege Gs		2.62	

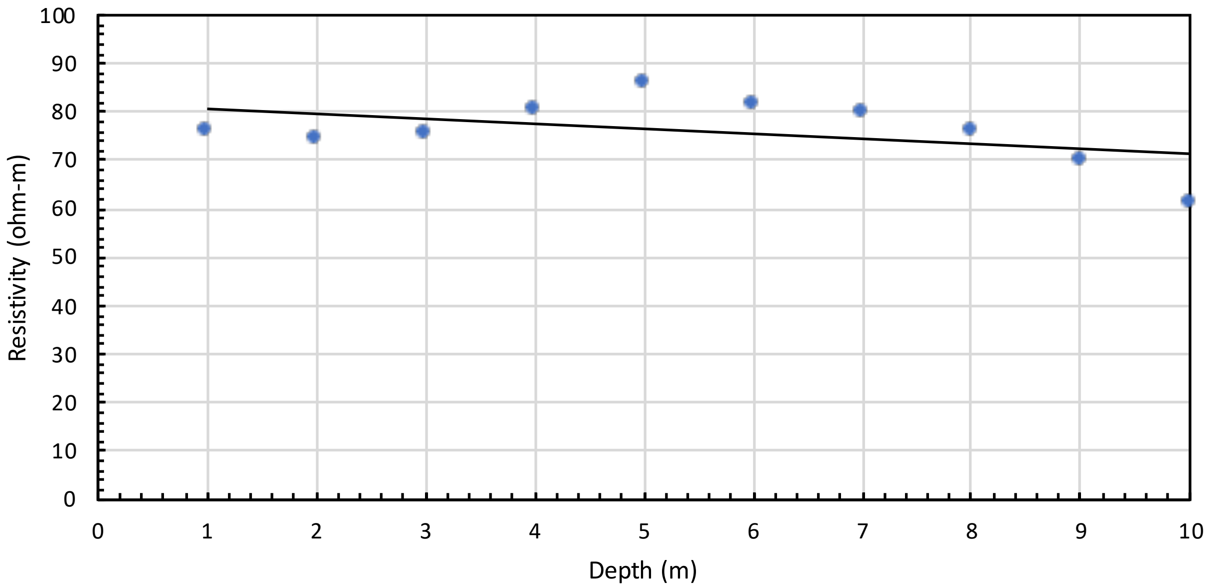
APPENDIX D9: SOIL RESITIVITY SURVEY RESULT

SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu
Mobile: +960-7962004, Email: info@sidco.mv

Soil Resistivity Survey - Wenner Method

TEST 1			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	12.11	76
2	2	5.91	74
3	3	4.01	76
4	4	3.21	81
5	5	2.73	86
6	6	2.16	81
7	7	1.82	80
8	8	1.51	76
9	9	1.24	70
10	10	0.97	61



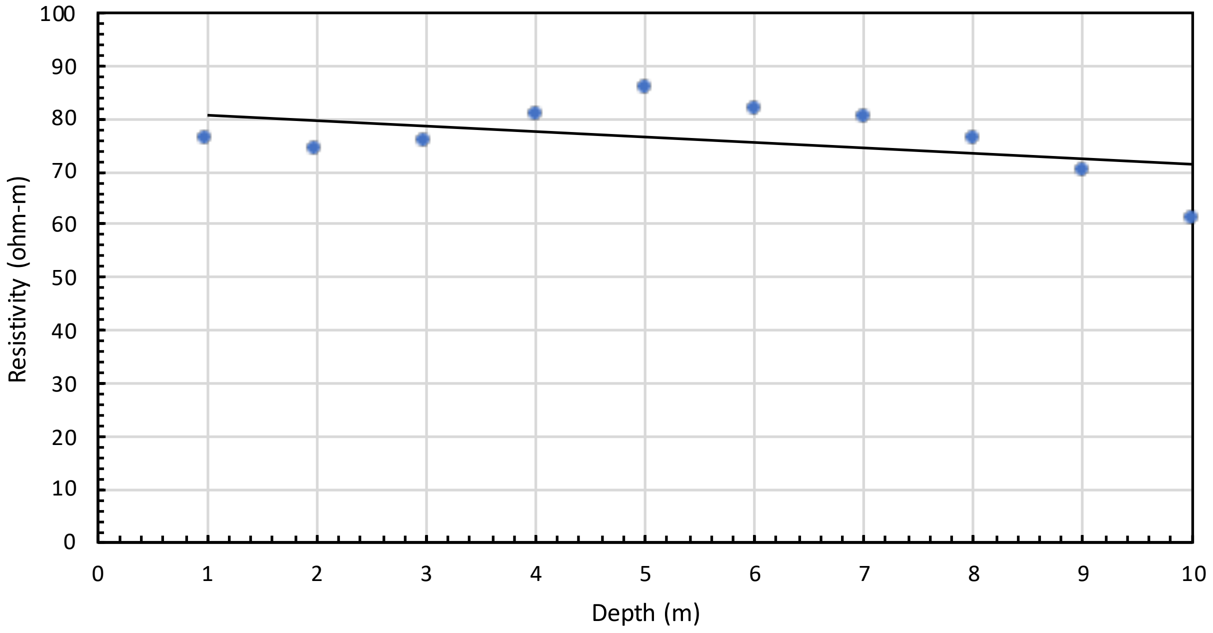
SIDCO SOILS LAB

M. Asrafeege, 3rd Floor, Orchid Magu

Mobile: +960-7962004, Email: info@sidco.mv

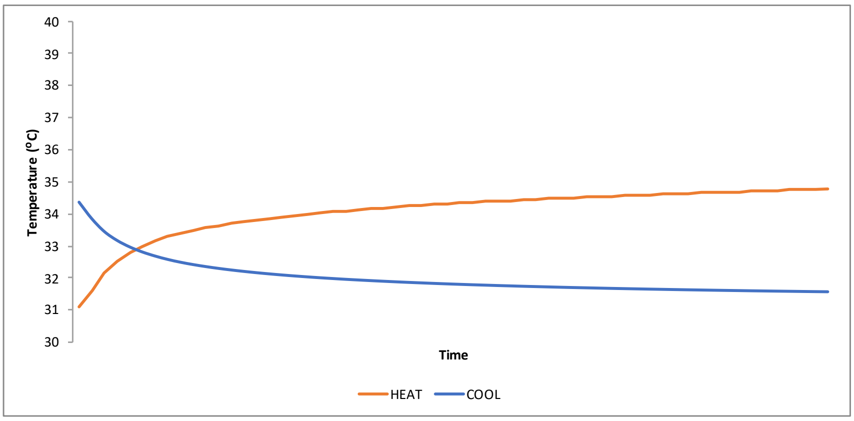
Soil Resistivity Survey - Wenner Method

TEST 2			
Probe Spacing "a" meters	**Depth "h" meters**	**Resistance "R" ohm**	**Layer Resistivity (Ohm-m)**
1	1	11.94	75
2	2	5.60	70
3	3	4.11	77
4	4	3.02	76
5	5	2.41	76
6	6	2.03	76
7	7	1.54	68
8	8	1.25	63
9	9	1.01	57
10	10	0.97	61

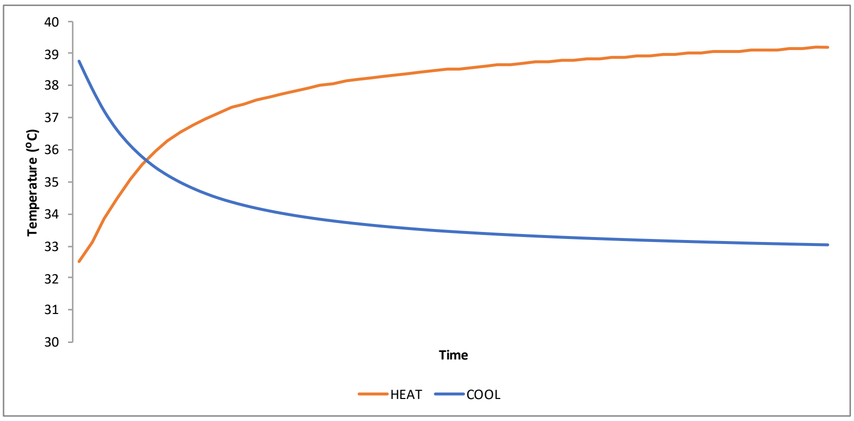


APPENDIX D10: THERMAL CONDUCTIVITY TEST RESULTS

HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	31.10376		89599	34.369064
1500	31.624657		91099	33.855904
3000	32.146484		92599	33.450211
4500	32.523853		94099	33.175377
6000	32.80106		95599	32.971493
7500	33.005741		97099	32.813835
9000	33.164597		98599	32.687794
10500	33.292461		100099	32.58242
12000	33.399246		101599	32.495342
13500	33.490517		103099	32.422234
15000	33.572533		104599	32.359192
16500	33.645496		106099	32.303165
18000	33.709518		107599	32.253838
19500	33.768715		109099	32.209469
21000	33.822575		110599	32.168793
22500	33.872181		112099	32.132057
24000	33.917343		113599	32.098225
25500	33.95916		115099	32.06728
27000	33.998329		116599	32.038589
28500	34.035057		118099	32.011597
30000	34.070629		119599	31.987232
31500	34.102985		121099	31.963585
33000	34.134216		122599	31.942238
34500	34.164364		124099	31.921906
36000	34.192528		125599	31.902584
37500	34.219467		127099	31.884247
39000	34.244835		128599	31.866837
40500	34.27021		130099	31.851089
42000	34.293648		131599	31.835335
43500	34.316528		133099	31.820648
45000	34.338497		134599	31.806759
46500	34.359547		136099	31.793377
48000	34.379776		137599	31.781303
49500	34.399948		139099	31.76878
51000	34.418766		140599	31.757835
52500	34.437973		142099	31.746128
54000	34.45594		143599	31.735893
55500	34.473557		145099	31.725708
57000	34.490814		146599	31.715355
58500	34.507618		148099	31.705986
60000	34.524593		149599	31.697426
61500	34.541008		151099	31.688663
63000	34.556808		152599	31.679867
64500	34.573101		154099	31.672153
66000	34.587826		155599	31.664474
67500	34.602829		157099	31.656868
69000	34.61763		158599	31.649811
70500	34.631931		160099	31.642742
72000	34.645668		161599	31.635868
73500	34.659008		163099	31.629456
75000	34.672409		164599	31.622944
76500	34.68557		166099	31.616825
78000	34.698227		167599	31.61124
79500	34.710934		169099	31.605125
81000	34.72403		170599	31.599735
82500	34.735374		172099	31.594345
84000	34.747696		173599	31.589283
85500	34.759369		175099	31.584183
87000	34.770954		176599	31.579174
88500	34.781635		178099	31.574955



HEAT			COOL	
Time (ms)	T (C)		Time (ms)	T (C)
0	32.516689		89599	38.765404
1500	33.123241		91099	37.933022
3000	33.834354		92599	37.199409
4500	34.481934		94099	36.616116
6000	35.065662		95599	36.152428
7500	35.546329		97099	35.772564
9000	35.946709		98599	35.457424
10500	36.273067		100099	35.200642
12000	36.545513		101599	34.98238
13500	36.782619		103099	34.795494
15000	36.98333		104599	34.633793
16500	37.156441		106099	34.493263
18000	37.306438		107599	34.374966
19500	37.438522		109099	34.270115
21000	37.557167		110599	34.177628
22500	37.664677		112099	34.094616
24000	37.761604		113599	34.020134
25500	37.849194		115099	33.952255
27000	37.928631		116599	33.891243
28500	38.001781		118099	33.834743
30000	38.069027		119599	33.783932
31500	38.129719		121099	33.736385
33000	38.187836		122599	33.69318
34500	38.240509		124099	33.651939
36000	38.290623		125599	33.614067
37500	38.337524		127099	33.578911
39000	38.380989		128599	33.545803
40500	38.422821		130099	33.514805
42000	38.461208		131599	33.485477
43500	38.499371		133099	33.459255
45000	38.53569		134599	33.434925
46500	38.571289		136099	33.411396
48000	38.604416		137599	33.388664
49500	38.636829		139099	33.367428
51000	38.668007		140599	33.347557
52500	38.698051		142099	33.328232
54000	38.726273		143599	33.309635
55500	38.754005		145099	33.29208
57000	38.780945		146599	33.275391
58500	38.806808		148099	33.259098
60000	38.831642		149599	33.243504
61500	38.855515		151099	33.229118
63000	38.879395		152599	33.214764
64500	38.9016		154099	33.20113
66000	38.923702		155599	33.187679
67500	38.945332		157099	33.175289
69000	38.966034		158599	33.163319
70500	38.986408		160099	33.15163
72000	39.006294		161599	33.140236
73500	39.02607		163099	33.12878
75000	39.044899		164599	33.118492
76500	39.063515		166099	33.10891
78000	39.081543		167599	33.098183
79500	39.098827		169099	33.088524
81000	39.116558		170599	33.079487
82500	39.133343		172099	33.070641
84000	39.149738		173599	33.061707
85500	39.166336		175099	33.053623
87000	39.182354		176599	33.04525
88500	39.19762		178099	33.037334



APPENDIX D11: WATER TEST RESULTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Maradhoo-Feydhoo Harbour	Hithadhoo Stadium E	Hulhumeedhoo SPT	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water	Ground Water	Ground Water		
Sample No	83235949	83235950	83235951		
Sampled Date ~	24/01/2023 02:00	24/01/2023 02:00	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**				
Physical Appearance	Clear with particles	Clear with particles	Clear with particles		
Conductivity *	53800	433	712	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.6	7.4	7.5	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	26900	216	356	Electrometry	mg/L
Chloride	18550	<10 (LoQ 10 mg/L)	79	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	5.8	4.1	11.3	HACH Method 8171	mg/L
Sulphate *	2800	<10 (LoQ 10 mg/L)	20	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
Quality Assurance Building, 1st Floor, Male' Hingun, Vilimale', Male' City, Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

LB-TEST-090

WATER QUALITY TEST REPORT

Report No: 500194725

Customer Information:
SIDCO Pvt Ltd (C-0514/2017)

Report date: **01/02/2023**
Test Requisition Form No: **900196650**
Sample(s) Recieved Date: **25/01/2023**
Date of Analysis: **25/01/2023 - 25/01/2023**

Male K

Sample Description ~	Feydhoo Harbour	**TEST METHOD**	**UNIT**
Sample Type ~	Ground Water		
Sample No	83235952		
Sampled Date ~	24/01/2023 02:00		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity *	46100	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	µS/cm
pH *	7.8	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 23rd edition)	-
Total Dissolved Solids	23000	Electrometry	mg/L
Chloride	15500	In-house Test method (Adapted from M926 Chloride analyzer Operation Manual)	mg/L
Nitrate *	8.5	HACH Method 8171	mg/L
Sulphate *	2200	HACH Method 8051	mg/L
Sulphide	<5 (LoQ 5 µg/L)	HACH Method 8131	µg/L

Keys: µS/cm : Micro Seimen per Centimeter, **mg/L** : Milligram Per Liter, **µg/L** : Microgram Per Liter

Checked by

Aminath Sofa
Laboratory Executive

Approved by

Mohamed Eyman
Assistant General Manager, Quality

Notes:
Sampling Authority: Sampling was not done by MWSC Laboratory.
This report shall not be reproduced except in full, without written approval of MWSC.
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer. This information may affect the validity of the test results.
*Parameters accredited by EIAC under ISO/IEC 17025:2017

************************* END OF REPORT *************************

APPENDIX J – General Comments by Utility Regulation Authority of the Maldives

GENERAL COMMENTS

1) Comply with all laws, regulations, guidelines, & precedents related to the provision of electricity services. These include having the involvement of a URA Licensed Engineer during the design, construction, implementation, and approvals. As we would not approve any document without the endorsement of a URA Licensed Engineer, it is important to note this.
Relevant documents to this are:
Provision of Electricity to the Maldive Islands
Generation, Distribution and Supply License
Net Metering Regulation
Guideline on Standby Power Approval
Guideline on Power System Approval
Cable Approvals
Energy Act
Utility Regulatory Authority Act

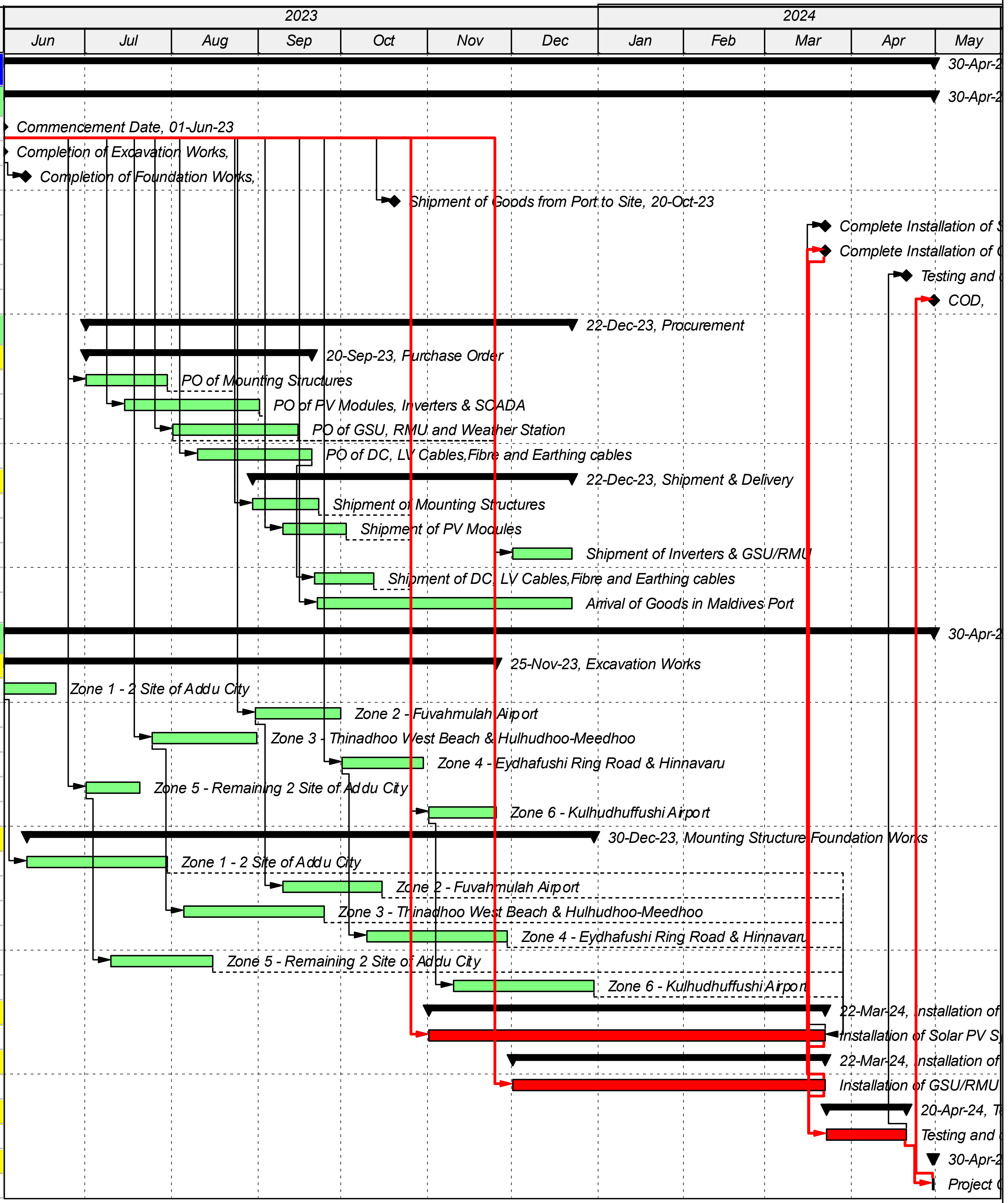
2) Comply with all laws, regulations, guidelines, & precedents related to the provision of Water & Sewerage Services
Relevant documents to this are:
Water and Sanitation Act
Utility Regulatory Authority Act
Design Criteria and Technical Specifications: Design and Construction of Sewerage System URA 2001:2021
General Guideline: Domestic Wastewater Disposal URA 2002:2021
Technical Specifications and Guideline: Design and Build of Vacuum Sewer System URA 2003:2021
Design Criteria and Technical Specifications: Design and Construction of Water Treatment and Supply System URA 4001:2021
Rainwater Harvesting Guidelines URA 4002:2021
Technical Specification and Guidelines: Borehole Drilling URA 4004:2021
Content of Detailed Design Report for Water and Sewerage Systems Detailed Design Report
Supply Water Quality Standard
Dewatering Regulation and its amendments

3) Comply with all laws, regulations, guidelines, & precedents related to the provision of Waste Management Services
Waste Management Act
Utility Regulatory Authority Act
Waste Transportation Standard for vessels
Waste Transportation Standard for Vehicles
Waste Management Standards: General Standards and Operational Requirements for Waste Management Facilities

APPENDIX K – Detail Project Schedule

Maldives Solar Power Project

Activity ID	Activity Name	Start	Finish	Duration
Maldives Solar Power Project		01-Jun-23	30-Apr-24	335d
Milestone		01-Jun-23	30-Apr-24	335d
A-1000	Commencement Date	01-Jun-23		0d
A-1010	Completion of Excavation Works		01-Jun-23	0d
A-1020	Completion of Foundation Works		09-Jun-23	0d
A-1150	Shipment of Goods from Port to Site	20-Oct-23		0d
A-1160	Complete Installation of Solar PV System		22-Mar-24	0d
A-1170	Complete Installation of GSU/RMU		22-Mar-24	0d
A-1180	Testing and commissioning		20-Apr-24	0d
A-1190	COD		30-Apr-24	0d
Procurement		01-Jul-23	22-Dec-23	175d
Purchase Order		01-Jul-23	20-Sep-23	82d
A-1200	PO of Mounting Structures	01-Jul-23	30-Jul-23	30d
A-1210	PO of PV Modules, Inverters & SCADA	15-Jul-23	01-Sep-23	49d
A-1220	PO of GSU, RMU and Weather Station	01-Aug-23	15-Sep-23	46d
A-1230	PO of DC, LV Cables,Fibre and Earthing cables	10-Aug-23	20-Sep-23	42d
Shipment & Delivery		30-Aug-23	22-Dec-23	115d
A-1240	Shipment of Mounting Structures	30-Aug-23	22-Sep-23	24d
A-1250	Shipment of PV Modules	10-Sep-23	02-Oct-23	23d
A-1260	Shipment of Inverters & GSU/RMU	01-Dec-23	22-Dec-23	22d
A-1265	Shipment of DC, LV Cables,Fibre and Earthing cables	21-Sep-23	12-Oct-23	22d
A-1270	Arrival of Goods in Maldives Port	22-Sep-23	22-Dec-23	92d
Construction Work		01-Jun-23	30-Apr-24	335d
Excavation Works		01-Jun-23	25-Nov-23	178d
A-1030	Zone 1 - 2 Site of Addu City	01-Jun-23	20-Jun-23	20d
A-1040	Zone 2 - Fuvahmulah Airport	31-Aug-23	30-Sep-23	31d
A-1050	Zone 3 - Thinadhoo West Beach & Hulhudhoo-Meedhoo	25-Jul-23	31-Aug-23	38d
A-1060	Zone 4 - Eydhafushi Ring Road & Hinnavaru	01-Oct-23	30-Oct-23	30d
A-1070	Zone 5 - Remaining 2 Site of Addu City	01-Jul-23	20-Jul-23	20d
A-1080	Zone 6 - Kulhudhuffushi Airport	01-Nov-23	25-Nov-23	25d
Mounting Structure Foundation Works		10-Jun-23	30-Dec-23	204d
A-1090	Zone 1 - 2 Site of Addu City	10-Jun-23	30-Jul-23	51d
A-1100	Zone 2 - Fuvahmulah Airport	10-Sep-23	15-Oct-23	36d
A-1110	Zone 3 - Thinadhoo West Beach & Hulhudhoo-Meedhoo	05-Aug-23	24-Sep-23	51d
A-1120	Zone 4 - Eydhafushi Ring Road & Hinnavaru	10-Oct-23	29-Nov-23	51d
A-1130	Zone 5 - Remaining 2 Site of Addu City	10-Jul-23	15-Aug-23	37d
A-1140	Zone 6 - Kulhudhuffushi Airport	10-Nov-23	30-Dec-23	51d
Installation of Solar PV System		01-Nov-23	22-Mar-24	143d
A-1280	Installation of Solar PV System	01-Nov-23	22-Mar-24	143d
Installation of GSU/RMU		01-Dec-23	22-Mar-24	113d
A-1290	Installation of GSU/RMU	01-Dec-23	22-Mar-24	113d
Testing and commissioning		23-Mar-24	20-Apr-24	29d
A-1300	Testing and commissioning	23-Mar-24	20-Apr-24	29d
Commerical Operation		30-Apr-24	30-Apr-24	1d
A-1310	Project COD	30-Apr-24	30-Apr-24	1d



▬	Actual Level of Effort
🟦	Actual Work
🟩	Remaining Work
🟥	Critical Remaining Work
◆ ◆	Milestone
▬	summary

OPERATION AND MAINTENANCE PLAN FOR ASPIRE SOLAR, MALDIVES

中国电建
POWERCHINA

华东勘测设计研究院有限公司
HUADONG ENGINEERING CORPORATION LIMITED

Table of Contents

1. Introduction.

This is a typical scope of work derived from the original equipment manufacturer. This scope shall not be treated as exhaustive but is only indicative or illustrative. All the operations and maintenance work shall be performed as per Full Services Agreement, OEM's Operation and Maintenance Manuals and prudent industry practices for following sites.

S/N	Island	Site	Capacity KW
1	Addu - Mainland	Feydhoo Harbour	842
		Hithadhoo Stadium Area	767
		Maradhoo Feydhoo Harbour	475
2	Addu - Hulhumeehdhoo	Hulhudhoomeedhoo - Near STP	1,069
3	Fuvahmulak	Airport North - Control Tower side (CT-1)	2,009
		Airport South Side (PV R01, R02, R03, R04)	
4	Thinadhoo	West Beach Side	2,009
5	Hinnavaru	Public Beach Area	1,102
6	Eydhafushi	Ring Road (Multiple Sections)	1,523
7	Kulhudhuffushi	Airport 1 (PV North)	1,620
		Airport 2 (PV South)	
Total			**11,416**

2. Objective.

- To describe warranty period Operation and Maintenance services provided for the Plant Operation & Maintenance of **ASPIRE SOLAR, MALDIVES.**
- To provide an indicative scope of work derived from the original equipment manufacturer and best industry practice.
- To describe that all O&M procedures will be in compliance with Full Services Agreement, Energy Purchase Agreement, OEM's Operation and Maintenance Manuals and prudent industry practices.

3. Technical Asset Management

3.1. Technical Reporting

The O&M team will be responsible for preparing and providing regular reporting to the Owner and other stakeholders defined in the agreement between the Asset Owner and the Technical Asset Manager.

The frequency of the reporting will be set daily, monthly and annually with defined content for each report.

3.2. Warranty Management

Warranty Management and Coordination will be the responsibility of O&M contactor for agreed years, with support of EPC Team. The operator will also maintain the complex availability of 96% during the both years of operation as per Exhibit-D Availability Guarantee of WP O&M contract or as per the contract.

3.3. Insurance claims

Insurance claims will be the responsibility of the Owner. O&M contactor will only provide technical assistance to the Owner

3.4.Performance Guarantees

O&M team will insure the 96 % availability in the period of contract for plant equipment's under his scope without any major inspection carried out during the reference year. Operator availability guarantees shall be effective on date which on which defect & deficiency item directly affecting system availability and monitoring are rectified. Further, availability above 96 % for any corresponding year will be carried forward to next year.

4. Responsibility Matrix

S/N	DESCRIPTION	Mega First	O&M	REMARKS
1	**ADMINISTRATION**			
1.1	Evaluation & Recruitment of O&M Staff		✓	
1.2	Implementation of SOPs in Plant area		✓	
1.3	Public relations, Amendments of Project Agreements and Dispute Arbitration with, Power Purchaser etc.	✓		
1.4	Managing the Plant site administration		✓	
1.5	Vegetation management, water supply & drainage resources, contractor and labor	✓		
1.6	Electricity for Office and Residential Buildings	✓		
2	**PERSONNEL**			
2.1	O&M Staff Payment, Compensations and Salaries		✓	
2.2	Site and equipment Security	✓		
2.3	Prepare training program for the O&M staff		✓	
2.4	Supply of PPE for O&M Staff		✓	
3	**SUPPLY OF EQUIPMENT**			
3.1	Furnished offices with office Furniture only	✓		
3.2	Maintenance of Offices, Buildings and Furniture	✓		
3.3	General office supplies, Stationaries consumable for O&M team		✓	
3.4	Special tools, hand tools, testing instruments, initial delivery & replacement, Small Consumables		✓	Special tools to be handed over by EPC /Owner.
3.5	Rental Equipment for Plant maintenance		✓	under unplanned maintenance cap
4	**OPERATION/MAINTENANCE / QA / SAFETY**			
4.1	Operation and Maintenance of all equipment and accessories		✓	
4.2	Develop program for preventive Maintenance, QA and safety		✓	
4.3	Perform planned Maintenance		✓	
4.4	Perform unplanned maintenance	✓	✓	Unplanned maintenance cap = 5,000 USD/Year. Operator will bear expenses up to unplanned maintenance cap (after warranty period) Any expenses exceeding this cap shall be borne by the owner.
4.5	Routine monitoring of Plant operation parameters		✓	
4.6	Weather Station Inspection		✓	
4.7	PV Panels Cleaning (4 Cleaning cycle per Year)		✓	Water for the PV Panel cleaning shall be provided by Owner and

				cleaning will be ensured by Operator.
4.8	Water for PV cleaning	✓		Water Quality shall be ensured by the Owner as per OEM recommendation. Availability of the water within the vicinity of the panels shall also be ensured by the Owner.
4.9	Thermography Inspection of PV Panels (Once a Year)		✓	
5	**TEST/DOCUMENTATION/PERFORMANCE**			
5.1	Prepare Annual Operating Plan		✓	
5.2	Prepare Annual Maintenance plan		✓	
5.3	Provide As-Builds Drawings	✓		
5.4	Keep As-Build's documentation up to date		✓	
5.5	Review O&M Manuals and manage its updating as per requirement	✓	✓	
5.6	Reading and record of tariff meters	✓	✓	
5.7	Make recommendations to improve the plant		✓	
5.8	Approve and cover the cost of modification if any	✓		
5.9	Implement and follow up to the modifications	✓	✓	
6	**SPARE PARTS AND CONSUMABLES**			
6.1	Supply of spare parts (Cost born as per actual)	✓		
6.2	Coordination, communication with Vendor and suppliers with logistic support		✓	
6.3	Purchase Order Placement and follow up for deliveries		✓	
6.4	Inspection of supplied spares and tools		✓	
6.5	Procurement planning, inventory management, quotations vetting, preparation of comparative statements for P.O issuance by the Company.		✓	
6.7	Spare Part storage facility such as racks, shelves, bins, etc.	✓		
7	**INSURANCE**			
7.1	Obtain plant and Machinery Insurance	✓		
7.2	Obtain workman's compensation policy (Health & group life Insurance – For O&M staff only)		✓	
8	**PERMITS/LICENSE & CONSENTS**			
8.1	All permits, licenses and consents relating to safe and compliant plant operation	✓		
8.2	Technical support for permits and consents		✓	
8.3	Arrangement of Fuel for EDG Gensets /Supply for Grid Failures	✓		
9	**ADDITIONAL WORKS (OPTIONAL)**			
9.1	Internet services	✓		Owner's scope. Operator can manage with 10% Management Fee while actual expenses to be borne by the Owner.
9.2	Civil Works and Maintenance of overall site, Buildings, structure	✓		Owner's scope. Operator can manage with 10% Management Fee while actual expenses to be borne by the Owner.
9.3	Annual Forecasting as available	✓	✓	
9.4	Performance Optimization		✓	
9.5	Weather Station Inspection		✓	

5. List of Covered Equipment

Following terms explain the scope of work regarding the plant equipment.

- PV Area
    - Solar Modules
    - DCB and DC Cabling
    - Inverter (String/Central)

- GSU/RMU
    - Generator Set up Transformer
    - Ring Main Unit

- Fiber Optic termination and LV Cables
    - LV Cables including GSU
    - Optical fiber termination
    - RMU/GSU Earthing

- MV (11K) Switchgear
    - Circuit breaker compartment
    - Bus-bar compartment
    - PT Compartment
    - Cable connection compartment
    - Low voltage compartment

- Protection, Metering and Communication System (where applicable)
    - LV, MV protection and control system (if applicable)
    - UPS and DC power system
    - Control and communication cables.

6. Services performed by O&M staff

6.1. Plant Operation

The Operator will be responsible for Operation of all the equipment and accessories (PV Modules, Inverters, MV (11KV) & LV Switchgear, DC & UPS Systems, Network and Communication System, Weather Station, RMU, Cables, CCTV) or whichever will be applicable on operator. The Operator will ensure safe and efficient operation of plant as per prudent industry practices and international standards from remote center. The operator will:

- Comply with the Dispatch Instructions under the PPA.
- Maximize the power generation and plant availability.
- Maximize the useful life of the Complex as per the term of the PPA.
- Minimize Complex down time and disruptions.
- Minimize Complex and capacity degradation.
- Minimize the incident, severity and duration of Maintenance Outages and Scheduled
- Outages; and maximize availability and reliability of the Complex.
- Run the Plant as per PPA, Prudent Utility Practices and according to the terms and conditions of this Agreement.

- Perform and record periodic operational checks and tests of equipment in accordance with OEM recommendations.
- Maintain and provide to the Purchaser/Company, upon request, operating logs, records and reports for operation of the Plant in English language in accordance with Energy Purchase Agreement.

6.2.Performance Analysis

The Plant Manager with the leading team within the plant shall review the plant performance on monthly basis.

The primary agenda of review shall be as following

- HSE Review
- Plant Performance
- Interruption Review
- Preventive Maintenance Progress Review
- Preparation on schedule activity etc.
- Forecasting Error

6.3.Quality & Risk Management

Risk Management Plan

Risk Identification will consist of determining the risks that are likely to affect the operation and maintenance. The risk will be documented with its characteristics and mitigation plan will be prepared and communicated to complete team.

Human Resource Risk

The manpower will be planned in such a way that human resources may not be a risk.

Machinery Risk

Adequate amount of machinery will be arranged to minimize risk that may come anytime due series failure.

6.4.Equipment Inspection & Preventive Maintenance

For the Preventive Maintenance, O&M team will follow the daily, weekly, Monthly and Annual equipment inspection plan to avoid the breakdown of any critical equipment. O&M Team will follow the strategy to ensure timely preventive maintenance so that the equipment do not stop unexpectedly. However sometimes it may occur due to unavoidable circumstances like sudden change in the electrical or environmental parameters etc. Sometimes such unscheduled maintenance tasks may have to be carried-out, though break-down has not occurred. This is based on the results and its detailed analysis by field team which helps to predict possible problem in advance and corrective actions are taken-up before actual break-down happens. This is often called Predictive Maintenance.

O&M team will be responsible for implementation and regular update of the Plant's preventive maintenance program for:

- Upkeep of data acquisition and monitoring systems (e.g., electronics, sensors) (frequency: undetermined)

- Up keep of power generation system

Detailed Equipment Inspection Plan is also shown in below table.

DC Section		
Equipment/Parts	**Tasks**	**Frequency**
PV modules	Verify the correct fixture of cables	Semiannual
	Visual inspection of PV modules	Quarterly
	Check if there is presence of growing plants that can create shadows on the modules.	Semiannual
	Verify there is no any damage in the bypass diode box on the back side of the PV module	Quarterly
	Check status of module clamps: properly tightened and without evidence of rust or corrosion.	Quarterly
	Check that string cables has not been bent to an unapproved radius and or are not in contact with metallic/cutting	Quarterly
	PV Module Washing/Cleaning	Quarterly
	Vegetation removal/Management	Client scope
	Thermographic Inspection	Annual
Combiner Box	Voltages checking	Semiannual
	Current checking	Semiannual
	Check of terminals and connectors	Semiannual
	Verify of lighting and surge arrester protection	Semiannual
	Check of switches	Semiannual
	Cleaning (air cleaning)	Semiannual
	General Inspection (no rust or humidity, foreign body or any kind of damage or various anomalies)	Quarterly
	Check the status of each Fuse and SPD device.	Quarterly
	Verify the Communication system for all the signals by SCADA system	Quarterly
	Verify the Equipotential Bonding of the case (enclosure) and the support structure with the earth	Semiannual
	Make cables are properly labeled and identified and that the state of the identification tags is intact.	Annual
	Verify the proper fixing of the Combiner Box, and the tightness of the incoming cables	Annual
	Terminal retightening Annual	Annual
	Functional check, testing for the main load switch.	Annual
Cables	Verify of insulation measure	Annual
	Verify of grounding system	Annual
AC Section		
Equipment/Parts	**Tasks**	**Frequency**

PCS	Check the environmental condition (dust, gas, water dripping, temperature, humidity)	Monthly
	Check the components and parts (vibration, noise, abnormal heating, etc.)	Monthly
	Check the operation status (Output voltage, current and frequency, DC input voltage)	Annual
	Check the LED indicators	Monthly
	Check the air filter	Monthly
	General Inspection (no dirty or rust or humidity, no foreign body or any kind of damage or various anomalies, No any abnormal notice)	Monthly
	Annual Inspection & Maintenance	Annual
Transformer	Check the oil temperature and the winding temperature	Quarterly
	Record the load current and the ambient temperature	Quarterly
	Check the oil level gauge	Quarterly
	Check the oil leaks	Quarterly
	Check if abnormal noise occurring	Quarterly
	Check the silica gel in the breather	Semiannual
	Check the gasket connections	Annual
	Check the oil properties (draw the sample and test at the lab)	Annual
	Check that the transformer does not show excessive cracking or signs of wear	Quarterly
	Check the sealing of all joints	Quarterly
	General Inspection of transformer tank for any anomalies and check LV and MV cabinets and perform basic housekeeping with dry patches.	Quarterly
	Verify the presence of dangerous tags and signals.	Annual
	Make sure they are properly labeled and identified and that the state of the identification tags is intact.	Annual
	Opening and closing of Switches maneuver	Annual
MV SWGR, 0.4kV Switch Board, etc	Check and record the number of operations	Quarterly
	Check absence of heating or vibrations or abnormal noise	Quarterly
	General review of operation of switchgear	Annual
	Opening and closing circuit breaker	Annual
	Check the ground connections of the electrodes	Annual
	Protection relays checking	Annual
	Alarm system checking Annual	Annual
	Auxiliary relays checking Annual	Annual
Battery whichever is applicable	Check the condition of the battery terminal	Quarterly
	Check the cleanliness of the batteries	Quarterly

	Check for any signs of electrolyte on the floor indicating a possible battery leak or overfilling	Semiannual
	Check battery voltage level	Semiannual
General		
Equipment/Parts	**Tasks**	**Frequency**
CCTV (if applicable)	Check the correct performance	Quarterly
	Check of supports, Foundations, anchors	Quarterly
	Check the definition and signal levels from the camera	Quarterly
	Checking of all feeding stabilized power sources (Amplification system, camera voltage, systems)	Quarterly
	Checking of all local function of Commander (UP, DOWN, ZOOM, FOCUS), as well as the bumpers of positioners	Semiannual
	Observation of status indicators for the electronic center	Semiannual
	General testing of electronic center system, adjusting timer, check the memory availability	Semiannual
	Checking of voltage and terminals connected to detectors of electronic center	Semiannual
	Checking status and correct operation of the system Check	Semiannual
	Check the voltage of load of the batteries in the control system	Semiannual
	Check the voltage supply value of all equipment of the security system	Semiannual
Control System	Check the functionality of the system and the correct record of the data from every sensor or indicator	Annual
	Verify all the relative supply system (dc-dc converters)	Quarterly
	General cleaning, Verify ID Label and Dangerous Tags	Semiannual
	Check the cleanliness of the monitoring elements (power supplies, switches, sensors, connectors).	Semiannual
	Verify the Grounding electrode resistance Test & Structure Equipotential Bonding	Semiannual
	General Inspection (no rust or humidity, foreign body or any kind of damage or various anomalies) Clean with dry patches (do not use liquid or chemical products).	Annual
	Checking of external connections	Annual
Meteor Station	Cleaning the pyrometers	Quarterly
	Correct alignment of the irradiation sensors	Semiannual
	Inspect cables and make certain mounting brackets, poles, posts, etc. are stable, vertical and sound and the instrument is securely fastened	Annual

6.5.Planned Maintenance

Planned maintenance refers to any maintenance activity that is planned, documented, and scheduled. The aim of planned maintenance is to reduce downtime and increase the equipment life by having all necessary resources on hand, such as labor and parts, and a strategy to use these resources. The O&M team is responsible for the planned maintenance Once a year for whole PV Power Plant.

The Operator will perform Schedule / Maintenance Outages, routine maintenance services and also provide technical supervision of any maintenance activity carried out by original equipment manufacturer.

6.6. Unplanned Maintenance

Unplanned maintenance is any unexpected maintenance task related to critical equipment. Unplanned maintenance is commonly the result of equipment failure that was not anticipated. Unplanned maintenance activity includes Spare's arrangement, manpower arrangement breakdown time and the replacement activity. The Operator will perform Unplanned Maintenance as per industry practices with defined Cap of USD 5,000/- (Ten Thousand Dollars).

6.7. Corrective Maintenance

Corrective maintenance is basically unscheduled maintenance task which occur due to nonperformance of the equipment and stopped working or broken-down condition. Key parameters are speed of response and repair time whenever an unscheduled maintenance is diagnosed. This kind of maintenance requires to be performed as quickly as possible so that the system is normalized. The Equipment in PV power plant is quite stable and the availability is very high in comparison to conventional power plants, however, the breakdown can happen anytime, and O&M Team will rectify those faults as quickly as possible.

The Operator will implement and regularly update the Plant's corrective maintenance program for:

- On-site monitoring/mitigation
- Critical reactive repair
- Non-critical reactive repair
- Warranty enforcement (as needed)

6.8. Extra Ordinary Maintenance

Extraordinary Maintenance actions are necessary when major unpredictable events take place in the plant that require substantial activities and works to restore the previous plant conditions in case of Force majeure event. "Force Majeure" events affecting PV plants have Included high winds, flooding, hurricanes, tornados, hail and any number of other severe weather events. Extraordinary maintenance associated with severe weather include: Safety Shutdown; Inspection; Electrical Testing (integrity of circuits and grounding); Remove/repair/replace decisions; and after repairs are completed a recommissioning confirming proper operation and documenting changes made in the repair. All these will be not responsibility of O&M team and these activities will be billed separately.

6.9. Maintenance Scheduling

For each maintenance activity, the Operator will also coordinate with the Purchaser/ Company to arrange times for maintenance as required. The Operator will also provide and make Maintenance Management Plan to maintain the plant and keep documents in compliance with OEM's recommendations / O&M Instructions.

The Operator will perform the Services in a manner so that it does not result in a breach of any manufacturer's warranties on any machinery, equipment and other items at the Plant.

The Operator will assess the nature and impact of any equipment failure and review the situation with the Company and mutually agree on the best course of action to repair/ replace the equipment in a timely fashion and if required also provide exception reporting such as major equipment failure (third party or self) such as root cause failure analysis (RCFA).

7. Interface with Employers Staff

7.1.Monthly Review Meeting

The Monthly Review Meeting shall be conducted in line with Weekly Meeting, but it shall consist the Monthly Performance. The Monthly Review meeting should also be joined by Owner Team Coordinator to ensure the plant team is getting proper support from internal O&M Management. The Owner Team senior management may join the meeting. The estimated agenda shall be as following

- Monthly Plant Performance
- Monthly Major Breakdown
- Major Spare Consumption
- Monthly Maintenance activities
- Spares Management

7.2.Yearly Review Meeting

The Yearly Review Meeting shall be conducted in line with Monthly Review Meeting, but it shall consist the Yearly Performance. The Plant General Manager O&M should also join the Monthly Review meeting, as the yearly review shall also consist the financial review as well. The O&M Team senior management may join the meeting. The Owner may request O&M Team to attend their Senior Management if needed. The estimated agenda shall be as following:

- Annual Plant Performance
- Annual Major Breakdown
- Major Spare Consumption
- Forecasted Vs Actual Energy Analysis,
- Maintenance Management
- Spares Management

8. Reporting

8.1. Service Reports

The O&M team shall provide the Service Reports for each service work - not later than 1 week after completion of each month, containing as minimum the affected no. of equipment, description of the failure and its underlying cause, description of the work done, time of shut down, time of start-up, spare parts used, labor hours used, responsible technicians for the repair.

8.2. Monthly Operation Reports

Monthly Operation Reports – not later than 20 days after the end of each calendar months
The O&M team shall provide to the Employer a Monthly Operation Report containing as minimum total PV Plant monthly and year to date figures of generation, availability, operating efficiency, downtime, lost energy, service works performed, spare parts and consumables used, labour hours consumed, testing and calibration reports.

8.3. Support in Insurance Claim Reports

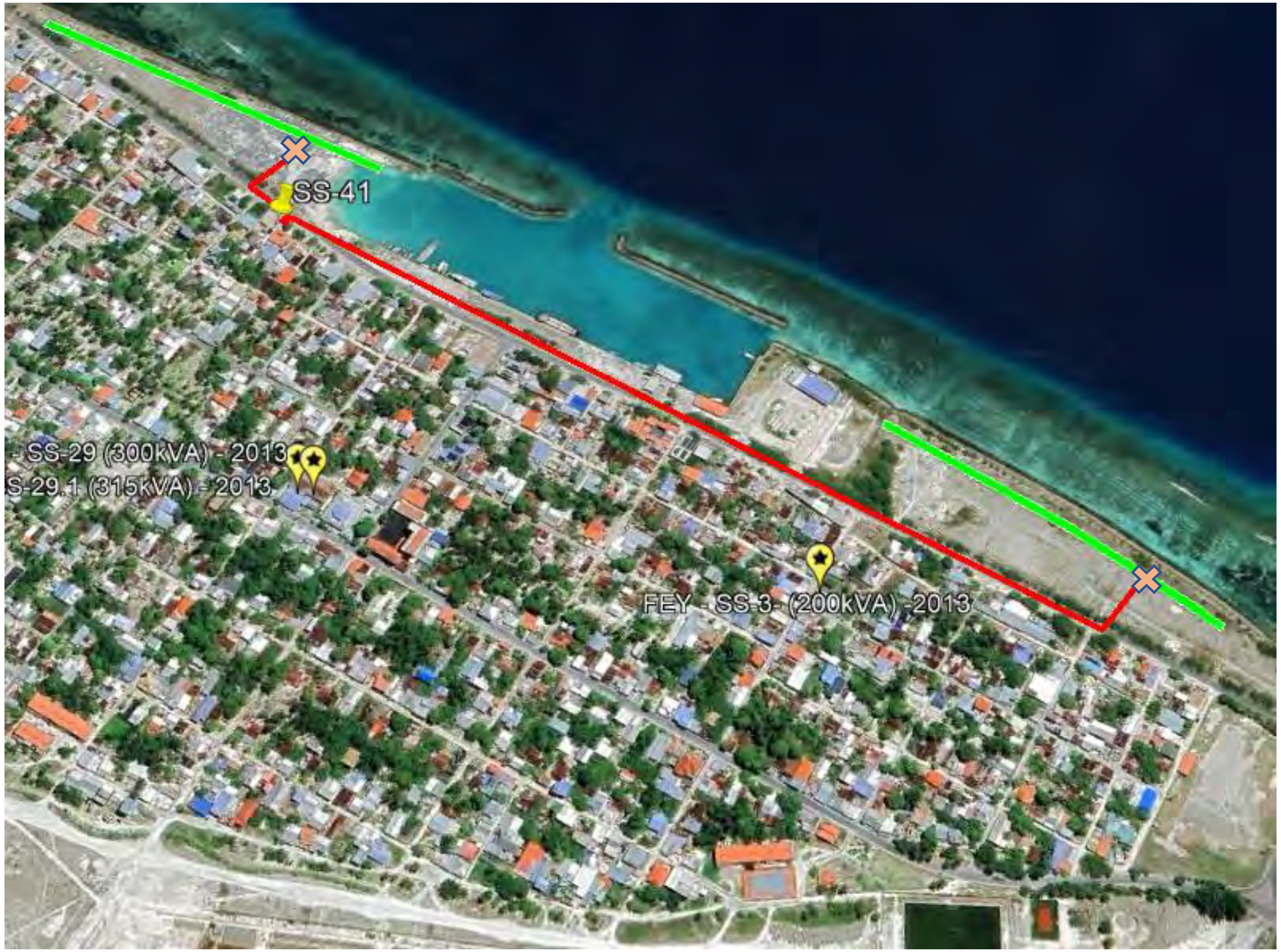
Support in Insurance Claim Reports for each insurance on each failure giving rise to an insurance case The O&M team shall provide to the Employer for further transfer to the Employer’s Insurance Broker, Insurers/Reinsurers, Loss Adjusters an Insurance Claim Report containing as minimum – the affected equipment, description of the failure and its underlying cause, photos of the failed equipment, description of the repair work done, photos of the repair works, time of shut down, time of start-up, spare parts used, statement if the repair is covered under the Tenderer warranties and/or service obligations.

9. Spares & Inventory Management

Operator will keep track of spare parts inventory record. (Initial Spare parts will be provided by Owner with list). By identifying critical spares, we will provide regular recommendations of required spare parts to minimize breakdown losses.

APPENDIX L – Transformer Locations

Addu city



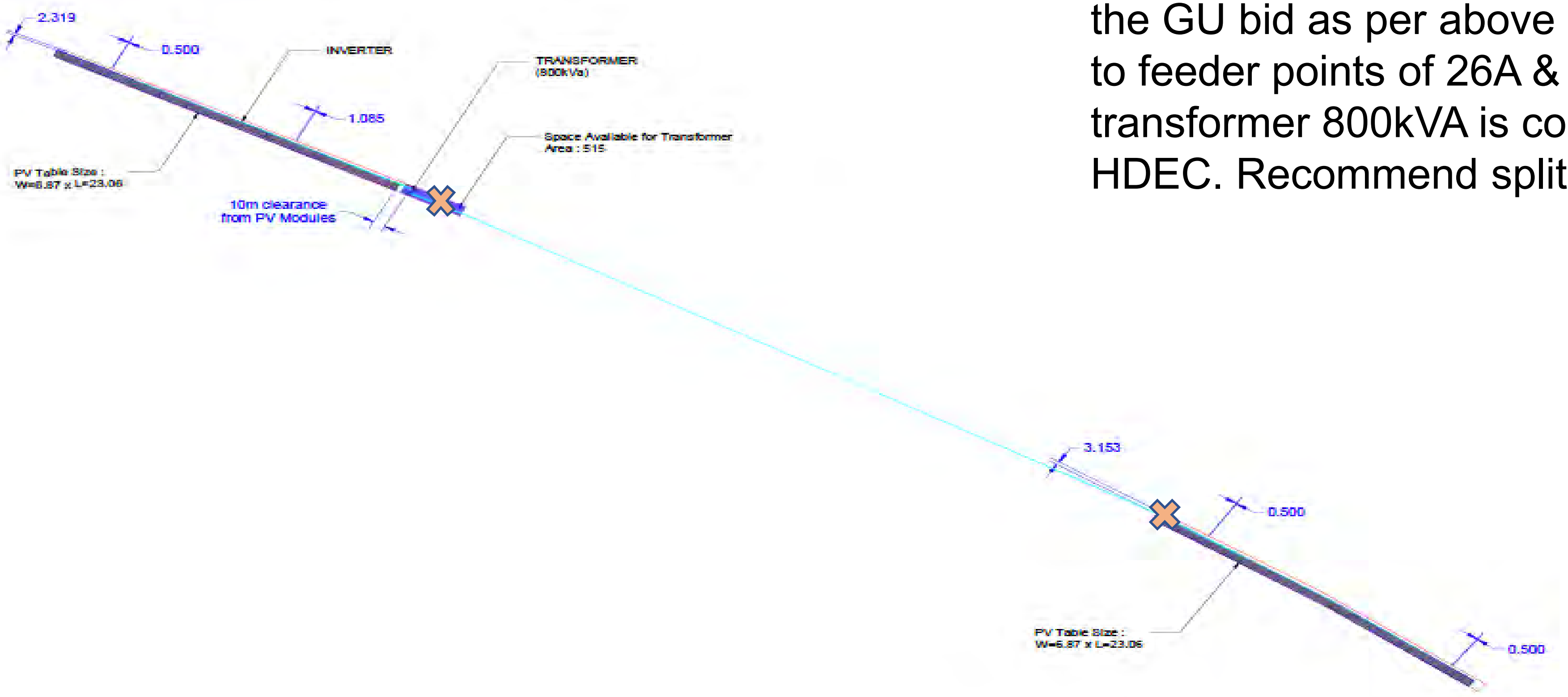
Substation designated for PV = SS41,

Cables & Grid side switchgear for PV interconnection under grid contract below

Distance (m)	Cable Cross Section (mm^2)@11kV
947	70
141	70

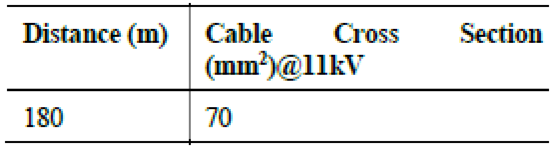
Feeder	RMU connection	Nominal Load Amps @11kV	Nominal Load kVA
Solar PV1	Circuit Breaker	26A	500
Solar PV1	Circuit Breaker	21A	400

2 x Solar RMU's required to be provided by PV developer around "X" marked points in the map

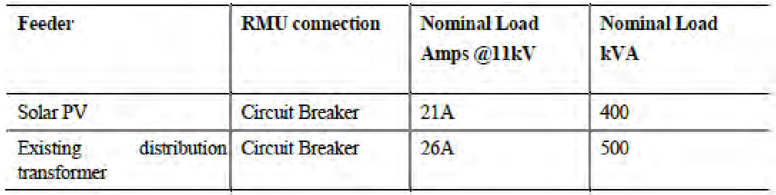


Interconnection transformer is specified in the GU bid as per above slide with PV split to feeder points of 26A & 21A. Here one transformer 800kVA is considered by HDEC. Recommend splitting to two.

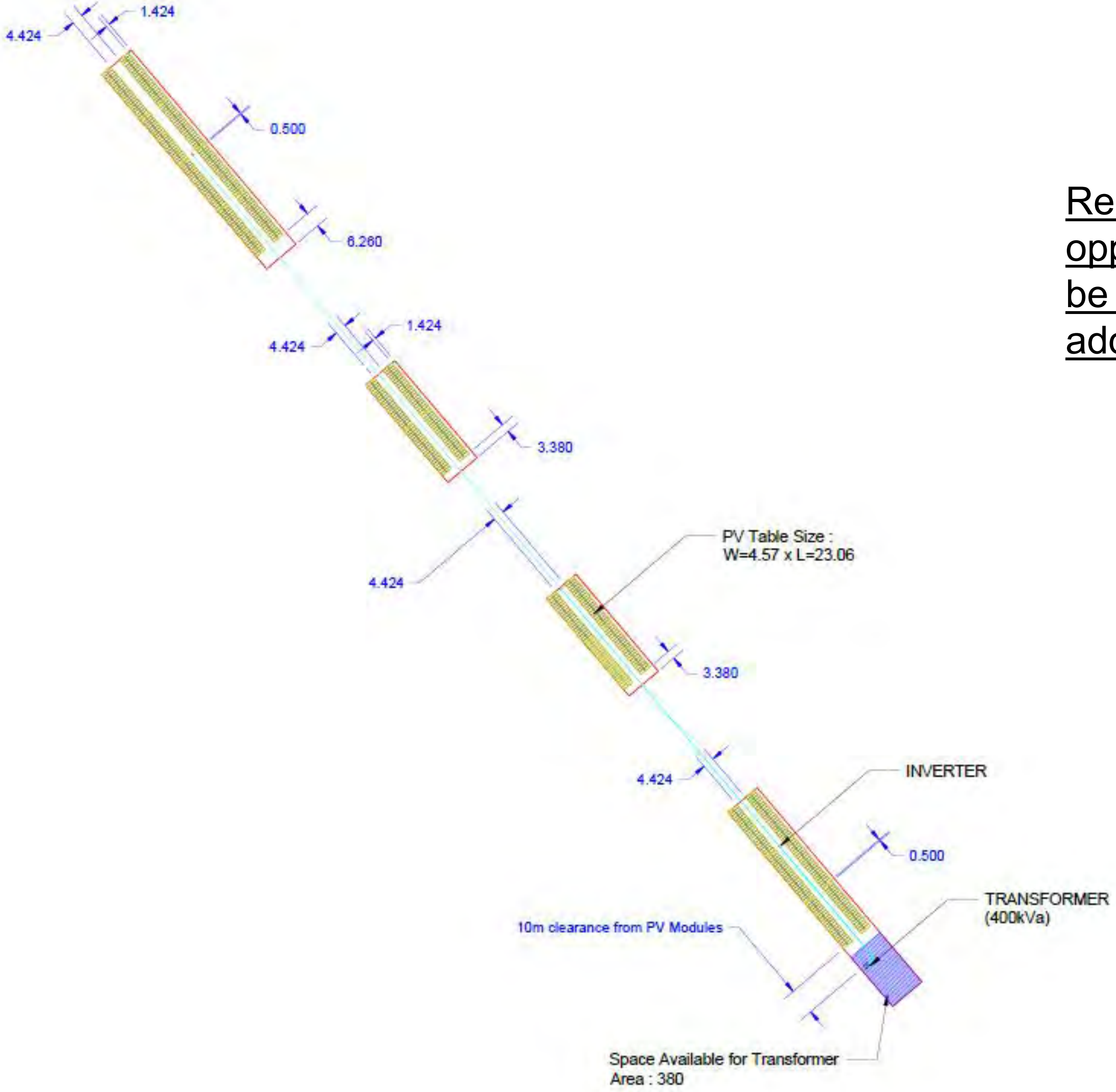
Cables & Grid side switchgear for PV interconnection under grid contract below



Distance (m)	Cable Cross Section (mm^2)@11kV
180	70

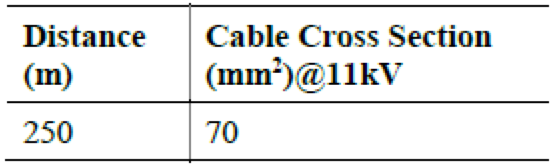


Feeder	RMU connection	Nominal Load Amps @11kV	Nominal Load kVA
Solar PV	Circuit Breaker	21A	400
Existing distribution transformer	Circuit Breaker	26A	500

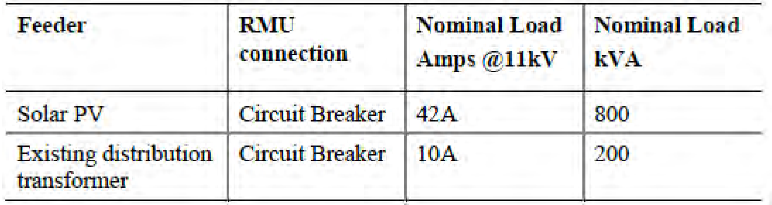


<u>Recommend placing transformer on opposite end to what is shown here. Would be of no extra cost. Also to avoid an additional cable length to Grid contract</u>

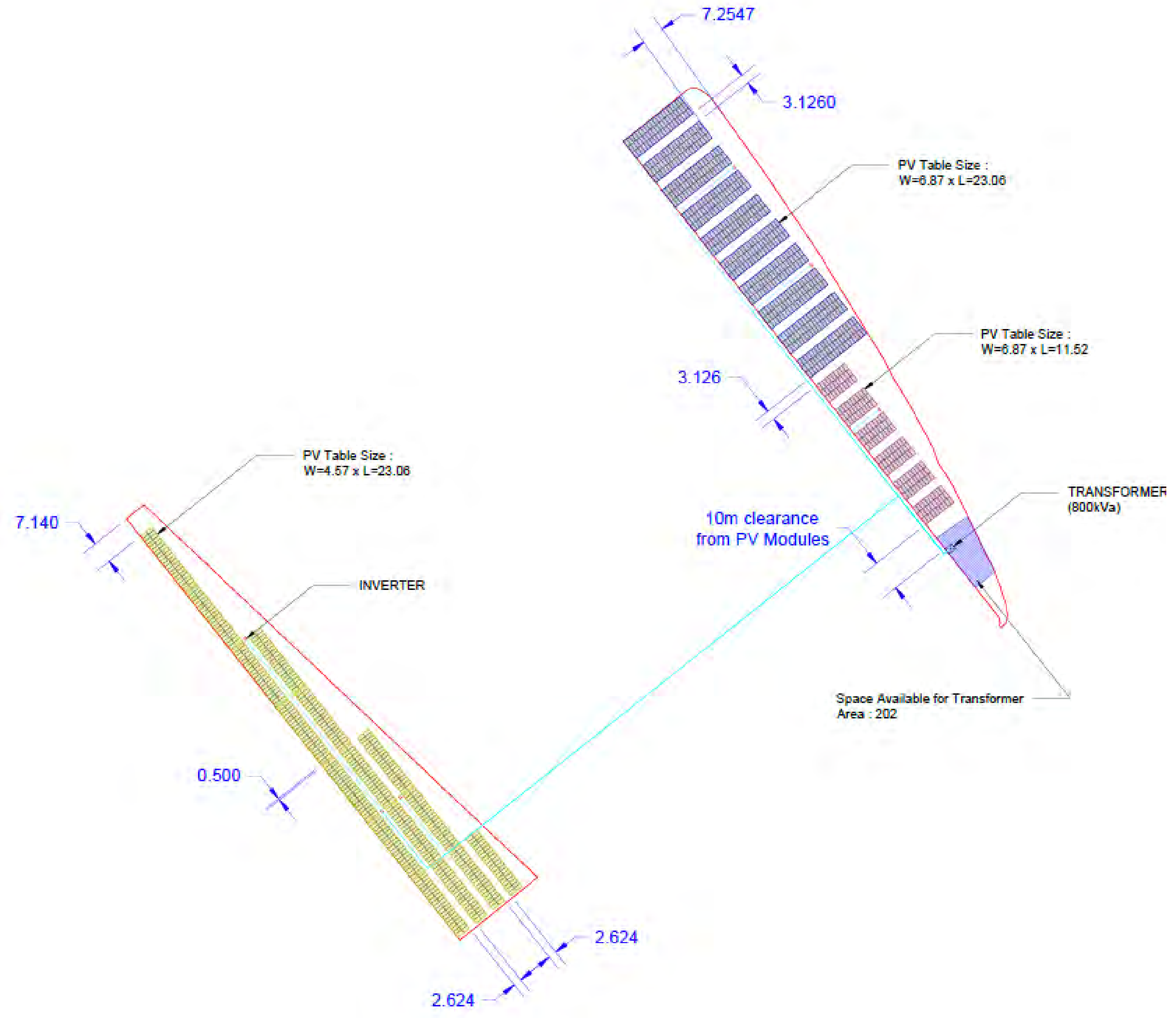
Cables & Grid side switchgear for PV interconnection under grid contract below



Distance (m)	Cable Cross Section (mm^2)@11kV
250	70



Feeder	RMU connection	Nominal Load Amps @11kV	Nominal Load kVA
Solar PV	Circuit Breaker	42A	800
Existing distribution transformer	Circuit Breaker	10A	200

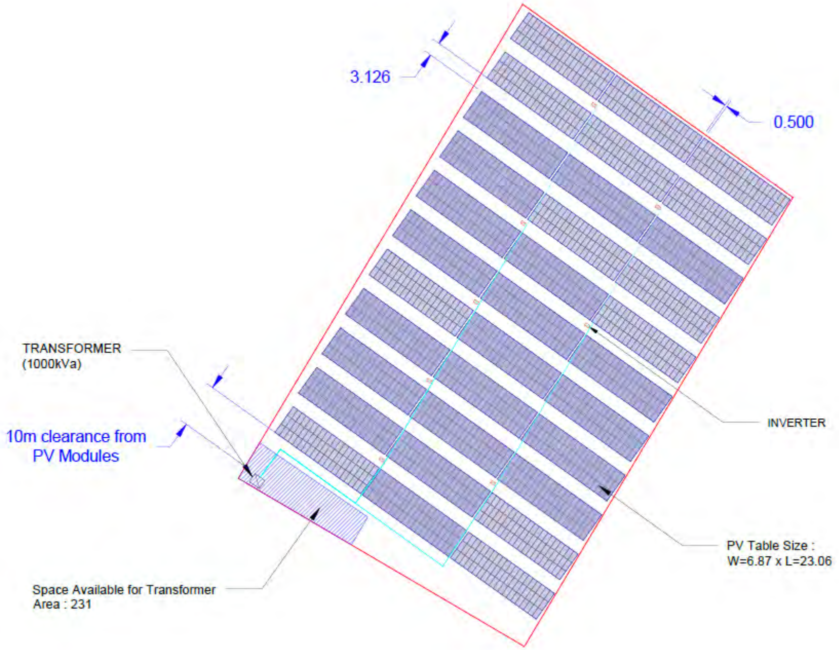


Recommend placing transformer & Switch gear in location marked in previous slide

PV interconnection details specified under grid contract below

5.3.2 1 MW PV - Waste yard

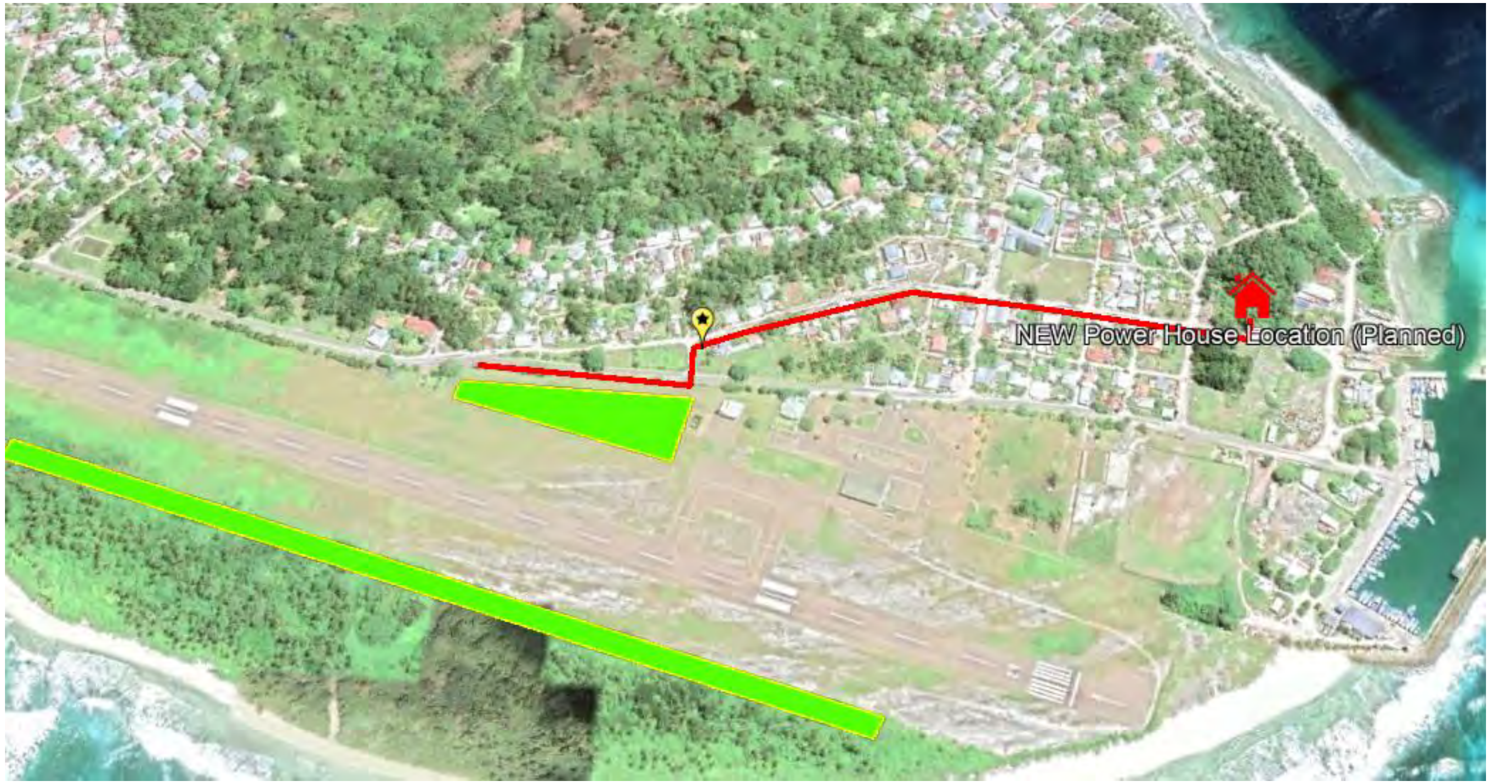
The new Solar PV installation (by others) will include an RMU a new 11kV ground mounted RMU consisting of two (2) 11 kV circuit breakers. The proposed 11 kV network will directly pass this solar PV site. Supply and installation of the new 11 kV network is required of the Contractor under MV Upgrades in 5.3.3. Contractor will be required to connect the solar PV RMU into the 11kV feeder loop as part of this work.



Comment: Place Soalr Tx cl;oser to roadside so it is easier to integrate to main network

Fuvamulah

Cables for PV interconnection under grid contract below



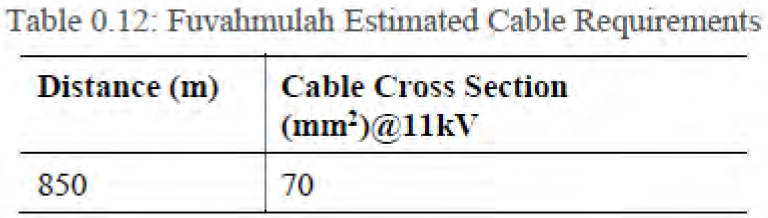
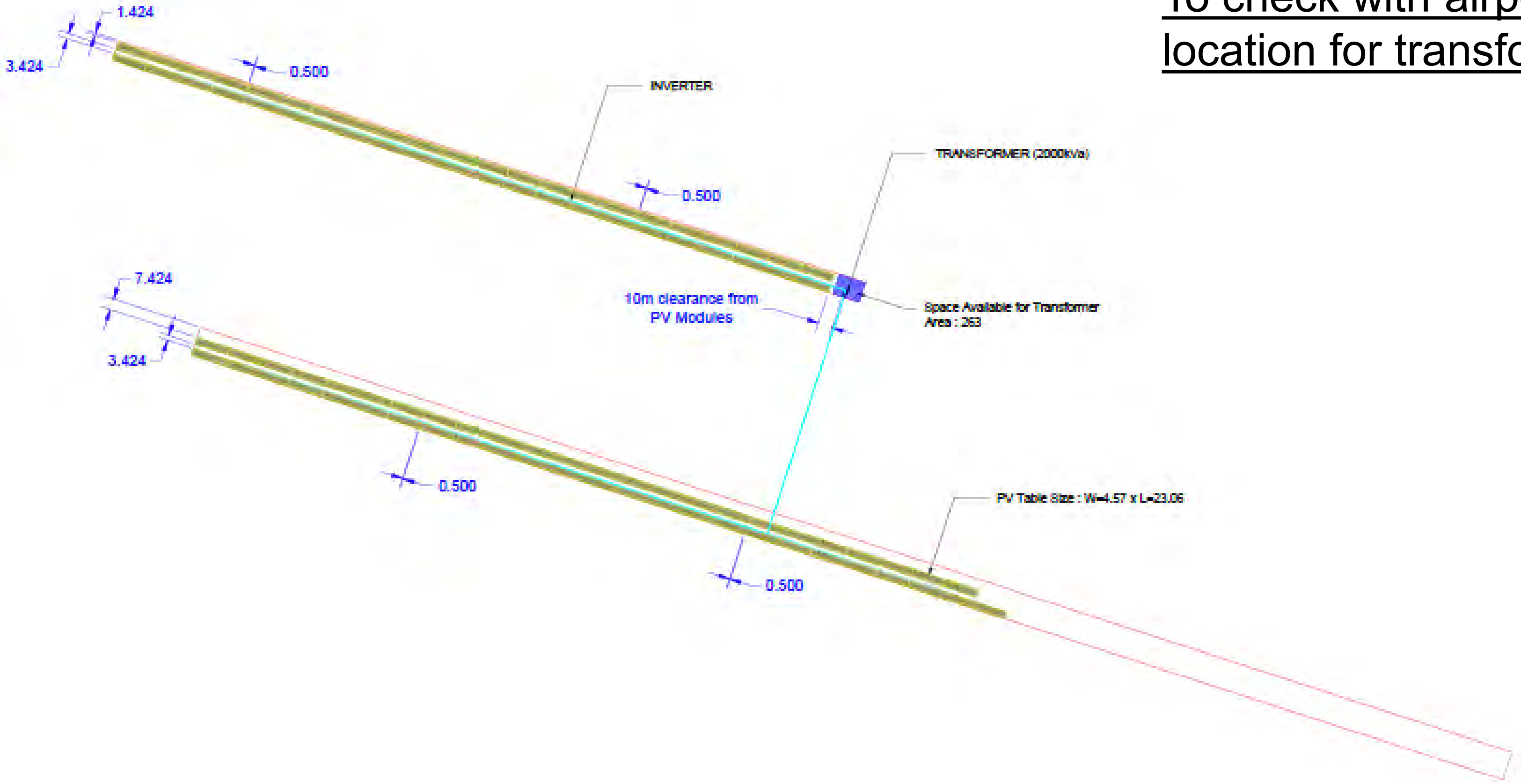


Table 0.12: Fuvahmulah Estimated Cable Requirements

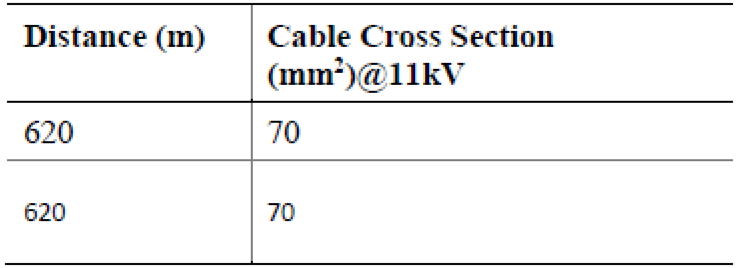
Distance (m)	Cable Cross Section (mm^2)@11kV
850	70



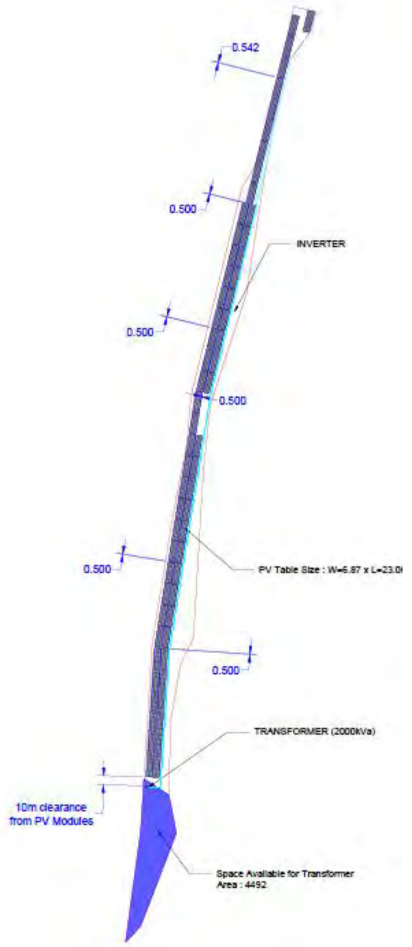
To check with airports & confirm location for transformer

Thinadhoo

Cables for PV interconnection under grid contract below



Distance (m)	Cable Cross Section (mm^2)@11kV
620	70
620	70

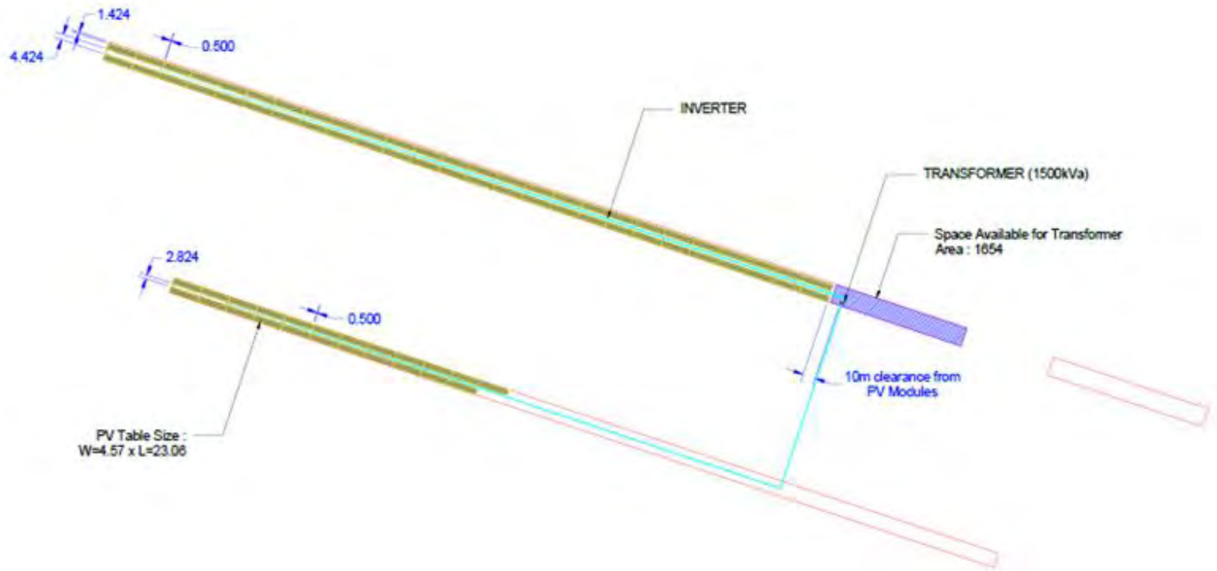


OK

Kulhudhuffushi

Cables for PV interconnection under grid contract below

Grid contractor will connect main feeder to Solar farm SS in the location marked as New Substation



Recommend to locate Solar farm Tx towards the Souther boundary of airport (Opposite side of that marked in HDEC's layout)

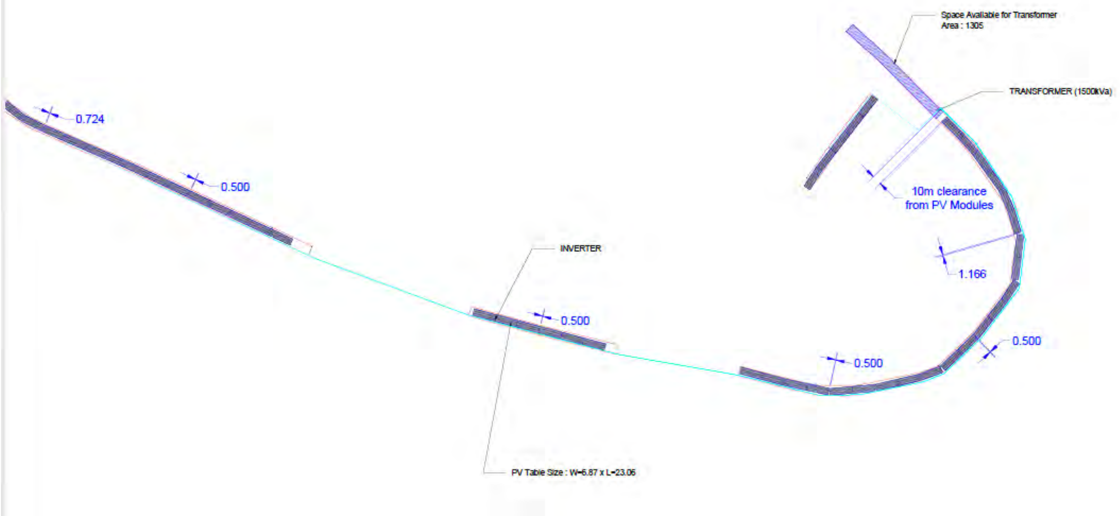
Eydhafushi

Cables for PV interconnection under grid contract below

Requirement: 3x Outgoing Solar RMU's, housed within solar site and placed in proximity to 11kV substations identified for PV grid connection.

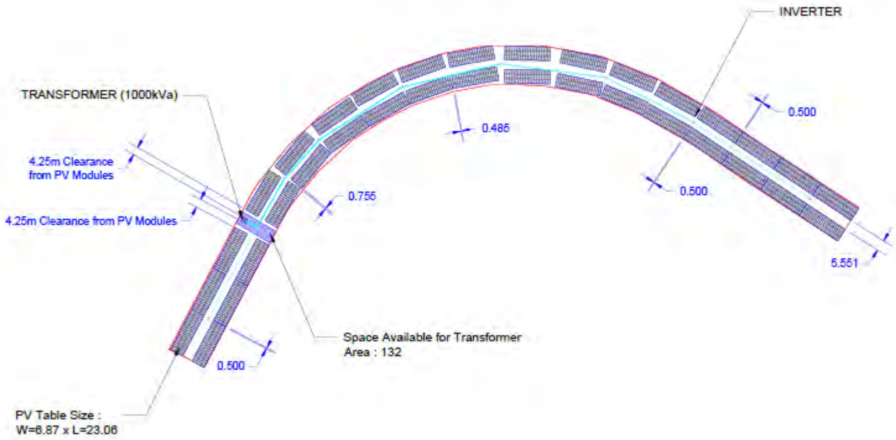
Cables for PV interconnection under grid contract below

Distribute connection to 3 Tx with 3 RMU’s as specified in bid . Check options of SS4, SS3 and SS2 (corresponding to revised layout)



Hinnavaru

Figure 0:12 Hinnavaru Island



OK

APPENDIX M – CV of Consultants

بسم الله الرحمن الرحيم

Environmental Protection Agency
Ministry of Environment

އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އެޖެންސީ
މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް

ތިމާވެށީގެ ކޮންސަލްޓަންޓްކަން ކުރުމުގެ ލައިސަންސް

Environmental Consultant License

License Number: **EIA P01/2020** :ލައިސަންސް ނަންބަރު

މިއީ ތިރީގައި ބަޔާންކޮށްފައިވާ ފަރާތަކީ ތިމާވެއްޓަށް އަސަރުކުރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓު ހެދުމާބެހޭ ގަވާއިދު 2012ގެ 3 ވަނަ އިސްލާހު (ނަންބަރު: 2016/R-66) ގެ ދަށުން ކެޓަގަރީ "އޭ" އަށް ޝަރުތު ހަމަވާކަން އެނގޭތީ ދިނުމުގެ ޝަރުތާއި، މި ލައިސަންސް އާއެކުގައިވާ ކޯޑް އޮފް ކޮންޑަކްޓް އާއެއްގޮތަށް މަސައްކަތް ކުރުމަށް ޝަރުތުކޮށް ދީފައިވާ ލައިސަންސެކެވެ.

This is to certify that the applicant, whose details given below, has qualified for Category "A" pursuant to the 3rd Amendment (Number: 2016/R-66) of Environmental Impact Assessment Regulation 2012, and with the condition that working under this license shall be according to the Code of Conduct attached with this license.

Name: Mr. Ismail Ajmal

Address: Ma. Fanaaru, Male`

NIC Number: A138645

Registration Date: 05th July 2020

Expiration Date: 05th July 2025

ނަން: އަލްފާޟިލް އިސްމާޢީލް އަޖްމަލް

އެޑްރެސް: މއ. ފަނާރު، މާލެ

ދ.ރ.ކ. ނަންބަރު: A138645

ރަޖިސްޓްރީ ކުރި ތާރީޚު: 05 ޖުލައި 2020

މުއްދަތު ހަމަވާ ތާރީޚު: 05 ޖުލައި 2025

ރަޖިސްޓްރާރ
Registrar

CV
ISMAIL AJMAL

Ma. Daylightvilla, 7th Floor
Dhidhi Goalhi
Male', Maldives
+960 7745 331
ajmal.isaju@gmail.com

Academic Qualifications

2010- 2013: Bachelors of Science with honours in Environmental Technology (upper second class)
University of Abertay Dundee, and Segi University. **Dual award*

Trainings

- **2020 (7 days):** *Online Study Tour on Waste Management*
  Ministry of the Environment, Japan
- **2020:** *Studying Cities: Social Science Methods for Urban Research*
  Erasmus University Rotterdam, Online
- **2020**: *Internet of Things.*
  GSM Association (GSMA), Online
- **2019 (4 days)**: *Making Cities More Liveable: Smart city in environment, equity, and economy.*
  Asian Development Bank, Seoul Housing & Communities Corporation
- **2018 (7 days)**: *Asian Circular Economy Leadership Academy.*
  Chulalongkorn University
- **2018 (2 days)**: *Training for Long-Range Energy Alternatives Planning System and Integrated Benefits Calculator*
  Stockholm Environment Institute
- **2015 (49 days)**: Introduction to Sustainable Consumption and Production in Asia
  United Nations Institute for Training and Research (UNITAR)
- **2014 (3 days)**: GIS training program on ArcGIS for Server Sharing GIS Contents on the Web
  ESRI India
- **2014 (5 days)**: ArcGIS for Desktop 1,2,3
  ESRI India
- **2007 (7 days)**: PC Troubleshooting & Configuration, Certificate 1
  IBS
- **2005 (7 days)**: Young Journalist Master Class on Photography
  UNICEF Maldives

Professional Licenses

Registered Environmental Consultant (Category A Licence)
Environmental Protection Agency

Academic Publications

Author: Simulation of energy harvesting from speed-breakers in Male', Maldives.
Asian Journal of Water Environment Vol.1. No.2 , 1-18

Publications and Reports

- **Critical Review:** Single Use Plastic Phase-out Plan 2020 -2023, Ministry of Environment
- **Co-Author:** National Action Plan on Air Pollution - 2019
  Ministry of Environment
- **Editor and Contributor:** *Pemphis,* Environmental Newsletter (edition 44 – 59: total 16 editions)
  Ministry of Environment and Energy
- **Co-Author:** National Implementation Plan to the Stockholm Convention on Persistent Organic Pollutants
  Ministry of Environment and Energy

- **Author:** An Environment Club Guideline - 2017
  Ministry of Environment and Energy

Environmental Impact Assessments, and Environmental Management Plans

- **Environmental Consultant:** Environmental Impact Assessment Report of the proposed 14 Storey Multipurpose Building in H. Fathangumaage, Male' (2022)
  Buildup International
- **Environmental Consultant:** Environmental Impact Assessment Report of the proposed International Cricket Stadium Complex in Hulhumale' (2022)
  Ministry of National Planning Housing and Infrastructure
- **Environmental Consultant:** Environmental Impact Assessment Report of the proposed upgrading of roads and storm water drainage system in M. Mulah. (2022)
  Road Development Corporation
- **Contributing Author:** Environment and Social Management Plan for the proposed establishment of an Island Waste Management Centre at Th. Madifushi (2021)
  Ministry of Environment, World Bank
- **Contributing Author:** Environment and Social Management Plan for the proposed establishment of an Island Waste Management Centre at Th. Buruni (2021)
  Ministry of Environment, World Bank
- **Environmental Consultant:** Environmental Impact Assessment Report of the proposed 12 storey multi-purpose building at H. Nooranmaage, Male' (2021)
  Million Trading & Contracting Company Private limited

Design and Layout

- **Layout Design:** Single Use Plastic Phase-out Plan 2020 -2023, Ministry of Environment
- **Logo Design: '**Students of Environment' (an environmental awareness initiative from the Ministry of Environment)
- **Logo Design:** 'Rahfehi' (A nationwide tree plantation event – 100 day pledge of the government)
- **Logo Design:** Saafu Raajje' (A nationwide clean environment and waste management initiative)
- **Logo Design:** Sixth Regional 3R Forum in Asia and the Pacific
- **Layout Design:** *Pemphis,* Environmental Newsletter of the Ministry of Environment
- **Layout Design:** National Implementation Plan to the Stockholm Convention on Persistent Organic Pollutants, Maldives
- **Layout Design:** An Environment Club Guideline
- **Layout Design:** National Action Plan on Air Pollution, Maldives

Professional Experience and Consultancy

July 2019 to Present: Senior Environment Analyst, Ministry of Environment

- Formulation, development, monitoring and evaluation of waste management projects
- Liaise with project management units of donor funded (Asian Development Bank, World Bank, International Renewable Energy Agency, OPEC Fund for International Development) waste management projects
- Project coordination and management of zone 1 (islands in the uppermost 3 atolls of the Maldives) waste management projects including OFID Zone 1 Waste Management Project
- Capacity building and knowledge management works with regard to waste and pollution control
- Research and development works with regard to waste and pollution control
- Policy formulation and direction
- Stakeholder engagement
- Member of *Breathe-Life Maldives* steering committee

- Member of the Statistics Committee of the Ministry of Environment
- Member of the Gender Equality Committee of the Ministry of Environment

Oct 2014 to July 2019: Environment Analyst, Ministry of Environment

- Environmental awareness project/program formulation
- Coordination of environmental awareness and outreach programs
- Alternative National Focal point to 10 Year Framework of Programmes on Sustainable Consumption and Production (SDG 12)
- National focal point to EU-SWITCH-Asia
- National focal point to Sustainable Consumption and Production for South Asia Co-operative Environment Programme
- Member of National Task Sub Committee on Anti-Microbial Resistance
- Organized awareness/training workshops, seminars and events.
- Preparation and review of public awareness materials

2018 – 2019 (12 Months): Emission Inventory Expert, Ministry of Environment

- Development of a National Emissions Inventory
- Gather statistical data and analyse the available data
- Baseline assessment and inventory on air pollutant sources
- Preparation of air pollution mitigation scenarios

2018 (7 Months): Member of GHG inventory and mitigation analysis team, BUR to UNFCC, Ministry of Environment

- Collaboration
- Data collection and analysis

2015 (8 Months): Capacity Building Coordinator (Persistent Organic Pollutants Project, Ministry of Environment and Energy

- Stakeholder engagement
- Contribution to the National Implementation Plan
- Awareness workshops and materials
- Awareness assessments

2014 (3 Months): Assistant Project Officer, Ministry of Environment and Energy

- Assisted in implementation of HCFC phase-out management plan
- Ozone depleting substances database management
- Reporting
- Stakeholder engagement
- Awareness

2013 – 2014 (3 Months): Sales, Engineer. Swimsol Maldives

- Coordination and Marketing
- Administrative works

2012 (3 Months): Intern (Industrial Training), Male' Water and Sewerage Company (MWSC)

- Administrative works
- Surveying

- Water network database updating
- Report writing

Project Management

- **July 2019 to present:** Management of Zone 1 Waste Management Project (20 Islands of H.A., H.Dh, Sh) - includes formulation of tender documents, project monitoring and evaluation, management of Environment Management Plan formulation, budget and finance management, management of the formulation of engineering documents, stakeholder engagement.

    - Island Waste Management Centre establishment of Ha. Ihavandhoo
    - Island Waste Management Centre establishment of Ha. Vashafaru
    - Island Waste Management Centre establishment of Ha. Filladhoo
    - Island Waste Management Centre establishment of Ha. Utheem
    - Island Waste Management Centre establishment of Ha. Kela
    - Island Waste Management Centre establishment of Ha, Baarah
    - Island Waste Management Centre establishment of H.Dh. Hanimaadhoo
    - Island Waste Management Centre establishment of H.Dh. Nellaidhoo
    - Island Waste Management Centre establishment of H.Dh Naivaadhoo
    - Island Waste Management Centre establishment of Sh. Narudhoo
    - Island Waste Management Centre establishment of Sh. Fokaidhoo
    - Island Waste Management Centre establishment of Sh. Funadhoo
    - Provision of Waste Collection vehicles to 20 islands

- **July 2019 to Present:** Project Management of Opec Fund for International Development (OFID) funded project of Solid Waste Management of 22 islands of Zone 1 (H.A, H.Dh. Sh)

    - Establishment of Island Resource Recovery Centres in 19 islands of Zone 1: review of tender documents and design concepts.
    - Formulation of initial documents and project formulation for the Zone 1 waste transfer facility to be established in H.Dh. Kunburudhoo
    - Stakeholder engagement and reporting

Software

- LEAP Software
- Microsoft Office Package
- IPCC inventory software
- Corel Graphics package
- ArcGIS
- SCREEN View – Lakes Environmental Software

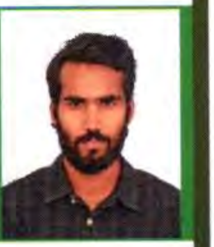
بسم الله الرحمن الرحيم

Environmental Protection Agency
Ministry of Environment, Climate Change
and Technology

އެންވަޔަރަންމަންޓަލް ޕްރޮޓެކްޝަން އެޖެންސީ
މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް، ކްލައިމެޓް ޗޭންޖް އެންޑް
ޓެކްނޮލޮޖީ

ތިމާވެށީގެ ކޮންސަލްޓެންޓުކަން ކުރުމުގެ ލައިސަންސް

Environmental Consultant License



License Number: **EIA-P(A)06/2022** :ލައިސަންސް ނަންބަރު

މިއީ ތިރީގައި ބަޔާންކޮށްފައިވާ ފަރާތަކީ ތިމާވެއްޓަށް އަސަރުކުރާނެ މިންވަރު ބަލާ ދިރާސާ ހެދުމާ ބެހޭ ގަވާއިދު 2012ގެ
3 ވަނަ އިސްލާހު (ނަންބަރު:2016/R-66) ގެ ދަށުން ކެޓަގަރީ "އޭ" އަށް ސަނަދު ހަމަވާކަން އަންގައި ދިނުމުގެ ގޮތުންނާއި،
މި ލައިސަންސް އާއެކުގައިވާ ކޯޑް އޮފް ކޮންޑަކްޓާ އެއްގޮތަށް މަސައްކަތް ކުރުމަށް ޝަރުތުކޮށް ދީފައިވާ ލައިސަންސެކެވެ.

This is to certify that the applicant, whose details given below, has qualified for Category "A" pursuant to the 3rd Amendment (Number: 2016/R-66) of Environmental Impact Assessment Regulation 2012, and with the condition that working under this license shall be according to the Code of Conduct attached with this license.

Name: Mr. Mauman Abdul Rasheed
Address: Sakkeyoge / B.Eydhafushi
NIC Number: A255017
Registration Date: 14th September 2022
Expiration Date: 14th September 2027

ނަން: އަލްފާޟިލް މައުމަން އަބްދުއްރަޝީދު
އެޑްރެސް: ސައްކެޔޯގެ / ބ.އޭދަފުށި
ދ.ރ.ކ. ނަންބަރު: A255017
ރަޖިސްޓްރީ ކުރި ތާރީޚު: 14 ސެޕްޓެންބަރު 2022
މުއްދަތު ހަމަވާ ތާރީޚު: 14 ސެޕްޓެންބަރު 2027

ރިފްޢަތު ނަޢީމް (ރަޖިސްޓްރާރު)
Rifath Naeem (Registrar)

Address: Sakkeyoge, B.Eydhafushi
Contact: +9607468460
Email: mauman.rashyd@gmail.com

Mauman Abdul Rasheed

Academic Qualifications

- 2021: Master in Global Environmental Studies, Sophia University, Japan
- 2012: Bachelor of Science (Microbiology, Biotechnology, Biochemistry) University of Mysore, India

Trainings

- Attended Training Course on Urban Pollution Control Technology for Developing Countries of Asia and Europe held from 6th May to 4th June 2014, organized by Suzhou University of Science and Technology, China
- Attended Excellence in Field Management of Natural Resources – A Technical Training for Rangers held from 24th to 27th July 2017 organized by IUCN Maldives
- Attended Training on Energy Efficiency Standards and Labels Program held from 25th to 28th September 2017 in New Delhi, India

Professional Experience

23 November 2020 – Present: Conservation Officer, Ministry of Environment, Climate Change and Technology

Responsibilities:

Main responsibilities include formulate and implement policies related to protected area management in the Maldives.

18 July 2013 to 22 November 2020: Project Officer, Ministry of Environment, Climate Change and Technology

Responsibilities:

The main responsibilities include implementation of the Montreal Protocol activities in the Maldives. The project activities include the Phase out of ozone depleting substances to facilitate Maldives compliance with the control targets for HCFC consumption and to implement a combination of interventions such as policy and regulations, technical assistance, training and capacity building, awareness and education, monitoring and management in the HCFC import and servicing sector contributing to achieve sustainable reduction and phase-out of HCFC consumption.

October 2014 to December 2015: Administrative Assistant for "Stockholm Convention on Persistent Organic Pollutants (POPs) Project", Ministry of Environment and Energy

Responsibilities:

- Overall, the Administrative Assistant responsible was daily communication with project partners and assigned project work (such as organizing workshops/meetings/training, preparation of background documents)
- Participate in project team and Steering Committee meetings, prepare the minutes of the meetings, and maintain the day-to-day records of project implementation

Publications as contributing author

Reports

- Co-Author: National Implementation Plan to the Stockholm Convention on Persistent Organic Pollutants, Ministry of Environment and Energy

Environmental Impact Assessments and Environmental Management Plans

- Contributing as a researcher: Environmental Impact Assessment Report of the proposed 12 storey multi-purpose building at H. Nooranmaage, Male' (2021) Million Trading & Contracting Company Private limited
- Contributing as an Environmental Consultant: Environmental Management Plan for the proposed Island Waste Management Center at Nolhivaranfaru, Haa Dhaal Atoll (2021)

Referees

Academic Supervisor:
Dr.Yoshinari Tanaka
Lecturer
Sophia University
1517 Bldg No.2, 7-1 Kioi-cho, Chiyoda-ku, Tokyo, 102-8554 Japan
Phone:+81-3-3238-4364
Email: y-tanaka-fo5@sophia.ac.jp

Work Supervisor:
Mr. Mohamed Zahir
Director General (Environment Department)
Ministry of Environment, Climate Change and Technology
Green Building, Handhuvaree Hingun, Maafannu, Male', 20392, Maldives.
E-mail: mohamed.zahir@environment.gov.mv

Saaif Mohamed Rasheed

Address: Ma. Fanaaru (4-A), Sayyid Kilegefaanu Magu, Male′ Maldives
Phone: +960 7444114
Email: saaifrasheed96@gmail.com

Profile

Having experience for more than 7 years in environmental conservation. I have worked in various roles and organizations, including as an Assistant Conservation Officer in the Ministry of Environment, Climate Change and Technology from May 2015 to March 2021, Monitoring and Evaluation Associate at IUCN Maldives from January 2022 to February 2023, and currently as an Environment Consultant at the Net Zero Initiative. In addition, working as a voluntary Consultant at Save the Beach Maldives an environmental NGO.

WORK EXPERIENCE

12/2022 - Present

ENVIRONMENT CONSULTANT – NET ZERO INITIATIVE

Responsibilities:

- Providing technical guidance on Carbon Offsetting and Climate change
- Provide Environment related content articles for the initiative

01/2022 - 02/2023

MONITORING AND EVALUATION ASSOCIATE – IUCN MALDIVES

Responsibilities:

- Development of the M&E plan for the project
- Prepare quarterly reports on work plan progress and activity and monitor deliverables and impact of the project
- Developing and maintaining M&E tools which can capture the necessary information for KPIs.
- Developing of weekly activity bulletins to be sent to the donors and provide a monthly compilation of activity bulletins to the Government of Maldives
- Preparing of other project related reports, such as Annual Report
- Compiling of a project closure document as an end result producing a video highlighting key achievements. Produced a video on protected areas of the Maldives.

05/2015 – 03/2021

ASSISTANT CONSERVATION OFFICER - MINISTRY OF ENVIRONMENT, CLIMATE CHANGE AND TECHNOLOGY

Responsibilities:

- Assist in the country reporting and implementation of biodiversity related conventions, and international agreements
- Co-ordinate and liaise with international organizations, and NGOs
- Administrative and technical support for development and implementation of 'Maldives as a Biosphere Reserve' project
- Support the implementation of the National Biodiversity Strategy and Action Plan
- Organizing awareness programs and workshops and conducting trainings
- Conducting ecological surveys and resource use surveys, and writing survey reports and other technical reports for policy development
- Support the implementation of UNEP Umbrella projects (Fifth National Report and NBSAP)
- Assisting in preparing project proposals to mobilise resources for biodiversity conservation and environmental protection

EDUCATION

Bachelor of Business Administration degree candidate.
anticipated completion September, 2023
Maps College, Male', Maldives

2013 - 2014
Advance Certificate in Human Resource Management,
Villa College, Male', Maldives

ADDITIONAL SKILLS

- Computer Skills
- Problem-Solving abilities
- Intensive knowledge on Native Environment and Biodiversity
- Research skills
- Data collection
- Drone mapping
- Certified Diver (Scientific Diver)

REFERENCES

ILHAM ATHO MOHAMED
Assistant Director
Ministry of Environment, Climate Change and Technology
ilham.mohamed@environment.gov.mv

NAJFA SHAHEEM RAZEE
Chief Technical Officer
International Union for Conservation of Nature
Najfa.razee@iucn.org

HASSAN AHMED
Chief Executive
Save the Beach Maldives
savethebeach.villingili@gmail.com

Other Experiences

WORKSHOPS, TRAININGS AND MEETINGS	• Mainstreaming Biodiversity into policies plan and strategies of private sector of Maldives Workshop • Ecological Training and Monitoring of Coral Reefs (BanyanTree Vabbinfaru) • "Waste Management and Renewable Energy" Seoul, Korea, 25 June– 15 July, 2017 • Regional Workshop for Asian Countries on the Clearing–House Mechanism 29 January – 3 February 2018, Bangkok, Thailand • Training on UAV and UAV Applications, Asian Institute of Technology, Bangkok, Thailand 10 -14 September 2018 • CBD – (COP 14), Biosafety (COPMOP9) and Nagoya Protocol (COP 3), Sharm Al Sheikh, 14 – 19 November 2018 • Practitioner to Practitioner forum on Strengthening Capacities of Public Administration in Island States, 20 – 24 August Colombo, Sri Lanka • 8th Meeting of Signatory States of the IOSEA Marine Turtle MOU, Da Nang, Viet Nam, 16 – 25 October • Thematic Workshop in Ecosystem Restoration, Rio De Janeiro, Brazil 4 – 8 November 2018 • IUCN Red List Assessor Training Workshop, Online 23 – 27 August 2020 • 2nd Asia park congress, Kota Kinabalu, Malaysia 24 – 29 May 2022
SURVEYS	• South Ari – Marine protected area survey, April 2017 • North Ari – Post bleaching coral recovery and resilience Survey, June 2018 • Kulhudhuffushi Wetland Restoration Survey, April 2019 • Ecological Assessment of Ha. Kelaa Wetland, March 2019

- Technical Report of the Ecological Assesment of Coral Reef Damage caused by the self-elevating platform (YUVRAJ) in Kaafu Villimale′ Reef, October 2022

REPORTS

- H. Nooranmaage, EIA Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- HDh. Nolhivaranfaru Waste Management Center, EMP Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- Ha. Vashafaru Waste Management Center, EMP Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- Ha. Utheemu Waste Management Center, EMP Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- Ha. Filladhoo Waste Management Center, EMP Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- Sh. Narudhoo Waste Management Center, EMP Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- H. Fathangumaage, EIA Report 2021 (Co-Author – Field Surveying and Social Environmental Analysis)
- Proposed Cricket Stadium Complex in Hulhumale′ – EIA Report 2022, (Project Monitoring)
- Technical Report of the Ecological Assesment of Coral Reef Damage caused by AM AAGAM (Barge) and AM ALPIT (TUG) in Kaafu Vaavehdhi Reef – (Surveyor, Co-Author) November 2022
- Environment Management Plan for the proposed Coral Propagation at Kuramathi, Maldives, (Surveyor, Co-Author) December 2022

CV

1. **Name:**

Ismail	Murushid	Ahmed
First	**Middle**	**Last**

2. **Position:** Architect – B.Arch reg no. BR2018309PA

3. **Education**: Bachelor of Arts in Architectural Design Faculty of Engineering Technology (Maldives National University) 2015-2017

4. **Nationality**: Maldivian

5. **Membership of Professional Associations**: Architects Association of Maldives

6. **Key Qualifications:**

   Bachelor of Arts in Architectural Design - 2015-2017

   In depth knowledge in current practices, practices for international standards & thorough contextual knowledge of Maldives from smallest scale to largest scale from 2013-2023.

7. **Languages**: English – Fluent, Dhivehi – Native,

8. **Employment Record**:

From: Jan 2021 to Jan 2023
Employer: Ministry of Gender, Family and Social Services
Position Held: Architectural Consultant
Summary: Oversee the foreign funded projects and provide feedback to the documents.

From: July 2019 to Dec 2022
Employer: Maldives Polytechnic / Villa college
Position Held: Part-time BArch / BAIad Lecturer
Summary: Plan and deliver the lectures related concerning the Architectural Design, Interior design and Communications Module.

From: Jan 2019 to June 2019
Employer: Maldives National University
Position Held: Part-time BArch Lecturer
Summary: Plan and deliver the lectures related concerning the Architectural Design and Communications Module.

From: October 2019 to Present
Employer: SM Associates Architects
Position Held: Senior Architectural Partner
Summary: Plan and oversee the design projects and provide directions to the design teams.

From: Jan 2018 to Present
Employer: United Development Pvt. Ltd.
Position Held: Senior Architectural Partner
Summary: Create the concept designs, detailed designs for the buildings (terminals, fire stations, control towers) for the domestic airports.

From: Aug 2016 to Jan 2018
Employer: United Development Pvt. Ltd**.**
Position Held: Assistant Architect
Summary: Assist design team with the architectural drafting works and 3D concept design visualization for the projects.

9. Work undertaken within past 10 years	
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Strengthening Gender Inclusive Initiatives 2021 to 2023 R. Ungoofaaru, Addu Hithadhoo and Feydhoo, K. Hulhumale, K.Male’ ADB/Government of Maldives 3 Domestic Violence shelters, 1 age care center and 1 daycare center Architectural Consultant Review the documents related to the project and provide feedback as required.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Manhattan Business Hotel 2021 Male’ Maldives Silver Spoon Pvt. Ltd. 28 story five-star tourist hotel Principal Architect Preparation of Design drawings of Hotel room, Restaurant and Banquet halls. Preparation of 3D visuals for submission. Prepare business proposal and price proposal for financing.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Office Design - Ministry of Transport and Civil Aviation 2020 Male’ Maldives Ministry of Transport and Civil Aviation Design of office space for the counter areas, back office and minister’s office Principal Architect Leading the Design and Preparation of 3d visuals and construction drawings with design team for the approval of Ministry officials.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Office Design - Ministry of Youth and Sports 2019 Male’ Maldives Ministry of Transport and Civil Aviation Design of office space for the back office and director’s cabins Principal Architect Leading the Design and Preparation of construction drawings with design team for the approval of Ministry officials.

Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Manhattan Fish Market Restaurant / New York Steak Shack 2019-2022 Male' Maldives Silver Spoon Pvt. Ltd. 2 International Franchise restaurant with seating capacity 180 - 250 pax. Principal Interior Architect Leading the Design and Preparation of 3D visuals, construction drawings with design team.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Madivaru Airport Project 2019 to 2021 Lh. Madivaru, Maldives Kuredu Holdings Pvt. Ltd. A 1200m runway Code 2C Airport with support facilities Senior Architect – Buildings Leading the design and documentation of 1000sqm passenger terminal, fire station and air traffic control tower.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Maafaru International Airport Project 2018 N. Maafaru, Maldives Abu Dhabi Fund for Development (ADFD) A 2200m runway Code 4D Airport with support facilities Design Assistant/ Draftsman Assisting in preparation of concept design and 3D illustrations for Passenger Terminal, VIP Terminal, VIP Hangar and speedboat dock.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Concept Development for 9 Regional Airports 2017 Ha. Maafinolhu, M. Muli, G.DH Faresmaathodaa, G.Dh Maavarulu, F. Nilandhoo, H.Dh Kulhudhuffushi, Sh. Funadhoo, Lh. Felivaru, R. Fainu Government of Maldives 1200m runway Code 2C aerodromes with support facilities to cater for ATR 72-600 model aircrafts Design Assistant/ Draftsman Drafting of concept drawings as per discussion of design team and check the design compliance with ICAO Annex 14 and MCAA Regulations.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Hanimaadhoo Airport Expansion & Resort Development Concept 2017 H.Dh Hanimaadhoo, Maldives Solaris Pvt. Ltd. A 2200m runway Code 4D Airport with support facilities Design Assistant/ Draftsman Preparation drawings as per discussion of design team and check design compliance with ICAO standards. Preparation of 3D visuals for Airport Expansion and City Hotel. Assist in preparation of price proposal for financing and Liaise with government agencies in reviewing the development concept.
Name of assignment or project: **Year:** **Location:** **Client:** **Main Project Features:** **Positions held:** **Activities performed:**	Residential & Interior Projects (Multiple Projects) 2013 to 2017 Throughout the Maldives Multiple Clients – ***refer to the work experience documentation*** Architectural Design multi storey projects and Interior Design Projects Architect/Interior Designer Create Architectural Design/ Interior design concepts with the detail designs. Create the design drawing required for approval and permits.

بسم الله الرحمن الرحيم

ދިވެހިރާއްޖޭގެ ޤައުމީ ޔުނިވަރސިޓީ
THE MALDIVES NATIONAL UNIVERSITY

ދިވެހިރާއްޖޭގެ ޤައުމީ ޔުނިވަރސިޓީ
THE MALDIVES NATIONAL
UNIVERSITY

Ismail Murushid Ahmed

having fulfilled the requirements of the University
has been awarded the

Bachelor of Arts in Architectural Design

އިސްމާޢީލް މުރުޝިދު އަޙްމަދު

ޔުނިވަރސިޓީން ކަނޑައަޅާފައިވާ ޝަރުތުތައް ފުރިހަމަ ކުރުމުން

ބެޗްލަރ އޮފް އާރޓްސް އިން އާކިޓެކްޗަރަލް ޑިޒައިން

އޭނާއަށް ދީފީމެވެ.

٢٦ جُمَادَى الآخِرَة ١٤٣٩
14 މާރިޗު 2018

Vice-Chancellor | ވައިސް ޗާންސެލަރ

Registrar | ރެޖިސްޓްރަރ

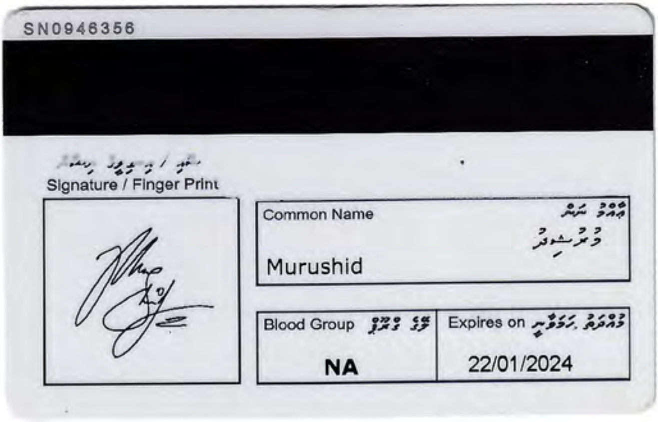
ދިވެހި ޖުމްހޫރިއްޔާ

REPUBLIC OF MALDIVES

NATIONAL IDENTITY CARD ދިވެހި ރައްޔިތުންގެ އައިޑެންޓިޓީ ކާޑު

Number: **A325467** ނަންބަރު:

Name ނަން އިސްމާއީލް މުރުޝިދު އަޙްމަދު Ismail Murushid Ahmed	
Sex ޖިންސު M ފ	Date of Birth އުފަން ތާރީޚު 03/09/1993
Address އެޑްރެސް ހުޅުމާލެ، ރިހިކުރި Hulhu Male'. Rihi Kuri Male' މާލެ	



SN0946356

ސޮއި / އިނގިލީގެ ނިޝާން
Signature / Finger Print

Common Name ޢާއްމު ނަން
މުރުޝިދު
Murushid

Blood Group ލޭގެ ބާވަތް	Expires on މުއްދަތު ހަމަވާނީ
NA	22/01/2024