MALDIVES

AGENCE FRANÇAISE DE DEVELOPPEMENT

POST-TSUNAMI INFRASTRUCTURE REHABILITATION PROJECT

REHABILITATION OF 6 SELECTED HARBORS

SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT FOR THE REHABILITATION OFTHE HARBOR IN MAKUNUDHOO ISLAND, HAA DHAAL ATOLL

SOG REFERENCE 1712517 R8D

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Non Technical summary

This report discusses the findings of a social and environmental impact study undertaken by Water Solutions Pvt. Ltd. and SOGREAH consultants of France upon request from Ministry of Construction and Public Infrastructure.

The project involves the rehabilitation of the existing harbour in Makunudhoo, Haa Dhaal Atoll with improved infrastructures. This project is initiated by the government of Maldives with funding from Agence Française de Dévelopement" (AFD) as part of the Tsunami rehabilitation programme. The harbour of Makunudhoo has been damaged to various extents and requires repair and upgrading, including deepening the harbour basin, and increasing slightly the size. A detail assessment of the environmental and social conditions was assessed based on which a rehabilitation project has been proposed. This EIA has been prepared to assess the social and environmental impacts of this proposed rehabilitation project.

Major environmental impacts of the project have been identified as resulting mainly from dredging and disposal of dredged materials. Dredging will be undertaken in the harbour basin and to some extent in the access channel. In view of the assessment, the environmental damages to marine resources have not been considered major due to the limited boundary of the project and also due to confined nature of the project. The impacts are likely to be felt on an estimated 5% of the lagoon and reef-flat of that extensive reef system. These environmental impacts were assessed for both construction and operation phase of the project.

Mitigation measures for these anticipated impacts have been identified and outlined in detail, including sedimentation control methods and other measures. These mitigation measures will have to be followed in order to minimize environmental damage. Stakeholder consultations were held with various groups, including the community and the client in order to incorporate the socio-economic components in the project. The proposed rehabilitation plans for Makunudhoo has been prepared after considering the needs and requirements from the community by assessing and incorporating the outcomes from the extensive community consultations held during the data collection stage.

It is inevitable that there would be some negative environmental impacts, especially when dredging is undertaken. However, these minor negative impacts out weight the socioeconomic benefits gained by rehabilitating the harbour. As a result, a comprehensive monitoring component has been suggested which takes in to consideration, the most important elements that require regular checks. This monitoring component will be adhered and will allow the assessment of long term changes, despite the limited nature of the impact. The most important consideration is the socioeconomic impacts that have been assessed mainly as positive in nature. Not only they are positive, but most importantly in the long term.

Therefore, it appears justified from a technical and from an environmental point of view, to carry out the proposed rehabilitation project if the island is to absorb the economic gains achieved by the project.

1 Introduction

This Environmental Impact Assessment report (EIA) has been prepared to full fill the requirements of the Environmental Protection and Preservation Act, law no. 4/93 for the proposed rehabilitation of the tsunami damaged harbour in Makunudhoo island, Haa Dhaal atoll, Maldives.

Following the tsunami of December 2004, the Republic of Maldives requested funding from the "Agence Française de Dévelopement" (AFD) to finance a project to rehabilitate the infrastructure of six harbours on six islands damaged during this major event. This report has been prepared for Makunudhoo island. The project proponent is the government of Maldives with the executing agency as Ministry of Construction and Public Infrastructure (MCPI).

After rehabilitation, the harbour is expected to have additional features, including more space, quay wall with constructed with reinforced L-shaped concrete walls, adequate depth, breakwaters with boulders, and dredging of part of the access channel. These modifications would enhance the harbour and be economically beneficial and accommodate the needs of the islands future development. The rehabilitation has been designed to accommodate future expansion and growth based on available data and current trends prevailing. The total cost of the project is estimated at the feasibility stage, to be 35 000 000 Rufiyaa.

This report will identify the potential impacts (both positive and negative) of the proposed project. The report will look at the project description in detail, existing environmental conditions in Makunudhoo, justifications given by the proponent for undertaking the proposed project components and alternatives. Alternatives to proposed components in terms of design and environmental considerations would be suggested. A mitigation plan and monitoring programme before, during and after the works would also be suggested. This will ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the natural environment of the island. Figure 1 shows an aerial view of Makunudhoo island.

Figure 1: Aerial view of Makunudhoo Island, Thaa Atoll.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site visit from 26 to 28th August 2007. However, due to unavailability of long term site-specific data, the impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment. Available long term data were collected from available sources, such as long term data on meteorology and climate from global databases.

This EIA has been produced in accordance with the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water on preparing Environmental Impact Assessment studies.

1.1 Aims and Objectives of the EIA

This report addresses the environmental concerns of the proposed redevelopment of the harbour in Makunudhoo island in Haa Dhaal Atoll. It helps to achieve the following objectives.

- Allow better project planning
- Assist in mitigating impacts caused due to the redevelopment without compromising environmental damage.
- Promote informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.

1.2 Methodologies

Internationally recognized and accepted methods have been used in this environmental evaluation and assessment. This EIA is based mainly on data collected during a field investigation missions from 26th to 28th August 2007 by a team from Water Solutions of Maldives and SOGREAH Consultants of France. The data collection methods are described in detail under "Methodology".

1.3 EIA Implementation

This EIA has been prepared jointly by a local environmental consulting firm, Water Solutions and SOGREAH consultants of France. The team members were:

- Abdul Aleem, BSc, MPH – Mapping and GIS
- Ahmed Zahid, BSc. – Environment management and Ecotourism Consultant
- Ibrahim Naeem, BSc. – Marine Biologist
- Hassan Shah –Environmental science (Team leader from Water Solutions)
- Aslam Shakir – Socioeconomist
- Mohamed Riyaz – Assistant Surveyor
- Mr. Marc de la Torre, –A specialist in maritime structures / SOGREAH (Team leader from SOGREAH)
- Mr. Adrien Leleu – A port economist / SOGREAH

1.4 Terms of Reference

The terms of reference for this EIA have been attached as an annex. This EIA has been prepared based on these terms of reference.

2 Project Description

2.1 General context of the study

Following the tsunami of December 2004, the Republic of Maldives requested funding from the "Agence Française de Dévelopement" (AFD) to finance a project to rehabilitate the infrastructure of six harbours on six islands damaged during this major event.

The six islands selected by the Government of Maldives for harbour reconstruction under this project are listed below an order of priority as given by the Ministry of Construction and Public Infrastructure (MCPI):

- Raa Ungoofaaru
- Noonu Manadhoo
- Alif Alif Mathiveri
- Haa Dhaalu Makunudhoo
- Thaa Hirilandhoo
- Baa Kendhoo

This report is prepared for **Haa Dhaal Makunudhoo island**. The rehabilitation project, which will benefit the 7420 people currently resident on the six islands, must propose the most suitable infrastructure with the aim of simplifying access to the islands and developing activities related to fishing and, possibly, other economic activities.

The project forms part of the "General reconstruction programme" being implemented by the National Disaster Management Centre that was subsequently taken over by the Ministry of Construction and Public Infrastructure (MCPI) and is supervised by a Project Management Unit (PMU) reporting to the Coastal and Civil Engineering Section of the MCPI. This management unit is responsible for supervising the design and construction phases of the project.

In this context, the AFD issued a call for tenders from French specialist consulting firms to carry out a feasibility study for the rehabilitation projects for these 6 harbours. At the end of this process, Sogreah was chosen by the AFD and Government of the Maldives to perform the feasibility study. This EIA is also prepared as part of the feasibility study.

2.2 Project Proponent

This project is proposed by the government of Maldives with MCPI as the lead executing agency. The project involves the rehabilitation of the tsunami damaged harbour in the island of **Makunudhoo, Haa Dhaal atoll**, Maldives.

2.3 Background of the Proponent

Ministry of Construction and Public Infrastructure is the government ministry responsible for the development and regulation of the construction sector of the country. It is also the agency which oversees the development of public infrastructure of the country (www.construction.gov.mv). All harbour development projects therefore fall under the responsibility of MCPI. MCPI has undertaken several harbour design and implementation projects throughout the Maldives and have also developed standards and criteria's for developing harbours in the Maldives.

2.4 Project Location and Study Area

The project takes place in the island of Makunudhoo island (see Figure 2). Makunudhoo is located in the north of Maldives in Haa DHaal Atoll, approximately 268 km away from the capital city, Malé. The island is the most westward inhabited island in the Maldives. The island is formed on separate geographical atoll known as Makunudhoo atoll which is narrow and long in shape. The atoll is approximately 8km in width and 25 kms in length. Makunudhoo is formed on the north-east corner of this atoll. The reef of Makunudhoo covers the entire reef of this atoll. Although the island is formed on a separate atoll, it is considered as part of Haa Dhaal atoll for administrative purposes. The geographical coordinates of the island are 6° 24' N longitude and 72° 42' E Latitude. The total area of the island is 60.7 hectares and has a population of 1042 people. Mankunudhoo has a rich history and was used as an island for banishment due to its isolation from the rest of the islands in Maldives. At present the island has a harbour which measures 229m x 76m and was constructed in 2000. The harbour quay walls were constructed using gunny bags filled with sand cement mixture. The breakwaters were constructed using coral debris removed from the reef or from dredging materials.

The harbour is at present located on the western side of the island whereas the access channel is located on the eastern side of the island. Boats have to travel a considerable distance from the access channel to reach the harbour, as it is not possible to enter from anywhere else (see Appendix 2 for a general plan view of the island showing the access channel and the harbour).

The island is well located strategically close to open sea which provides easy access to fishing grounds. As a result, there are already two private fishing companies that engage in purchase of fish from the local fisherman and also from other vessels. Currently there are plans to develop ice plants and increase the storage capacity

2.5 Project boundary

See Figure 11 for the project boundary. The project boundary is confined to the harbour, basin, the immediate lagoon, access channel, coral reef and the adjacent coastline north and south of the harbour. The coral reef on the eastern side of the reef edge is also contained in the project boundary.

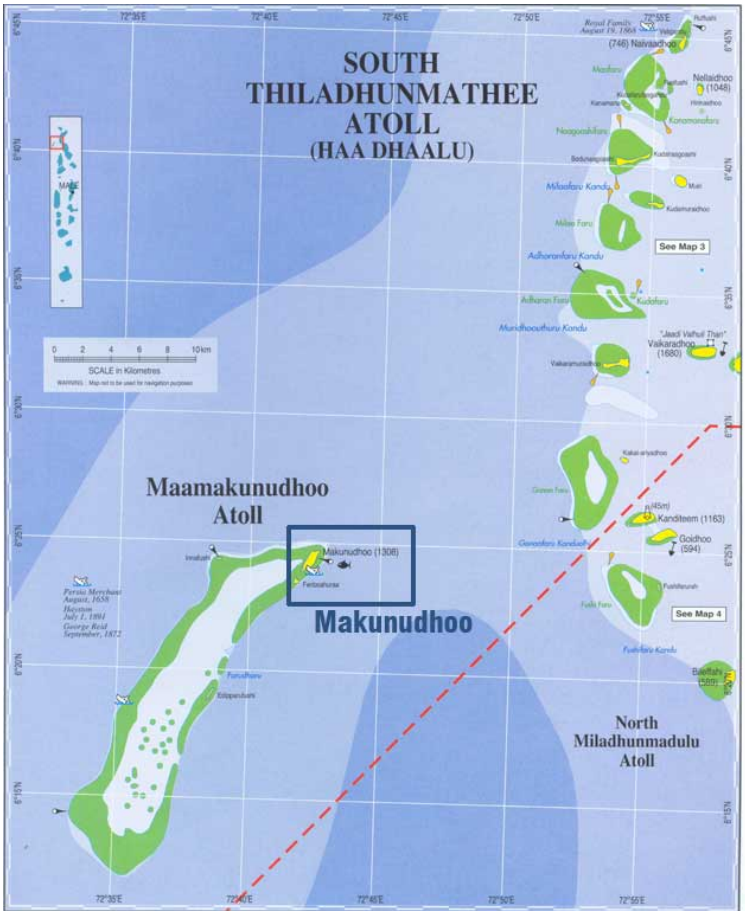
2.6 Geography and formation of Makunudhoo

Makunudhoo is a uniqu2.6e island that is geographically isolated from the main atoll chains in Maldives. It is approximately 18 km west of Haa Dhaal and Shaviyani western rim of atoll (see Figure 2). The island is formed on an atoll of its own which is known as Makunudhoo atoll. The entire reef system of this atoll is unified and Makunudhoo is formed on the north-eastern rim of the atoll. The western side of the island is protected by the atoll reef where as the eastern side of the island is exposed to north-east winds. The geographical coordinates of the island are 6° 24' N longitude and 72° 42' E Latitude. The reef system that houses Makunudhoo is oriented in a northt-south-west direction. Within the Reef system, there are only 3 more uninhabited islands. Makunudhoo atoll is surrounded by the open sea which is the primary reason why fishing is generally very good.

The island has a considerable shallow lagoon form both sides. The line is roughly 487 meters from the eastern side of the island where as it is 530 meters from the north of the island. Access to the island is achieved through an artificially created access channel that is approximately 1081meters east from the harbour. This access channel is roughly 1081 meters long and 15 meters wide. At

some places, it is as narrow as 9 meters. An artificial island has been created on the north and south of the access channel entrance from the dredged material. The geographical formation of Makunudhoo showing the harbour and the long access channel is illustrated in Appendix 2.

Figure 2: Location of Makunudhoo island.



2.7 Need and Justification for the rehabilitation

The primary justification to undertake this project is to rehabilitate the damaged caused by the December 2004 tsunami.

The Government of Maldives reported that the tsunami damaged or destroyed 36 jetties (totalling 1,600 metres in length); 4,200 metres of quay wall; 15,000 metres of harbour sea walls; 375,000 cubic metres of basin dredging; 145,000 cubic metres of entrance dredging; twenty-five 19-kilometre light beacons; sixty-five 2-mile reef markers; 120 (of 390) entrance markers and approximately 300 metres of causeway.

UNEP's field mission found relatively minimal damage to marine infrastructure. In general, maritime facilities located on the inner sides of the atolls experienced less damage from the tsunami than did other maritime infrastructure. Although UNEP did not observe widespread tsunami damage to harbour facilities, the government reported harbour damage on 104 islands. The UNEP mission did observe the silting-up of harbours (both before and after the tsunami) as well as damage to coral block breakwaters.

Makunudhoo island's harbour was one of those affected by tsunami and sustained various level of damage. Major repairs are needed for almost every aspect of the harbour. Quay walls have been damaged and dislocated, the breakwaters are damaged and require repair, access channel has filled up due to increasing sedimentation, the depth of the harbour basin has been reduced, especially along the quay wall due to sedimentation and the size of the harbour is not adequate for current and future use.

As mentioned earlier, Makunudhoo is a vital hub and the projections for future seem very promising and fishing related commercial activities, mostly large scale in nature are expected to take place in the island. This is already evident from the activities and investments by the two private companies that have setup their business in the island. Hdh. Makunudhoo is an island with a very good potential of development. The most compelling proof is that Processing industries such as ENSIS and EURO GLOBAL MALDIVES are investing in this island to provide a cold chain to improve quality of the product. During the stakeholder discussions with these companies, their current and future activities were discussed and highlighted. Not only is this important, the strategic location of the island gives her several advantages that attract other fishing vessels from almost every part of the country. Makunudhoo is a very well-known place for tuna fishing (Skipjack tuna and Yellow fish Tuna).

The fisherman and others vessels that use the harbour complain that the present harbour is not adequate. Development of the fishing activity is hindered down by the inadequacy of the infrastructures and by their status. They also have identified that the narrow access channel is a threat to fishing vessels. As a result of these factors, the harbour urgently requires repairs and rehabilitation if the development potential of the island is to be utilized fully. Without rehabilitating the harbour, there would be slow growth and economic activity.

2.8 Project duration

The project is expected to take eight (10) months.

2.9 Description of the existing harbour

A detail inspection of the harbour and the access channel was made during the field trip in August 2007 and are illustrated in Appendix 3.

Appendix 3 also provides a detail account of the structural damage observed in Makunudhoo harbour.

2.10 Description of project components

The rehabilitation project and the final layout of the finished harbour in Makunudhoo is illustrated in Appendix 5. The rehabilitation project will have the following main components, namely;

- Demolition of the existing quay wall.
- Reconstruction of the breakwater with boulders of 600-800 kg (coral debris will be used as core material. Debris from demolition of quay wall will be used). Breakwater will be re-constructed by extending to 60m northward to protect the entrance of the harbour against NE waves and to protect against siltation. The breakwater has been completely damaged. Corals have been used to construct the existing breakwater and due to the damage, it does not serve its purpose in protecting the harbour.
- Reconstruction of 242m of quay wall capable to withstand heavy loads generated by specific handling equipment such as crane (75 t) and conveyor (L-shaped concrete slabs). At present, the quay wall does not serve as a quay wall. More than 50% of the quay wall has been damaged and about 120 meters of it has been displaced in Appendix 4. The proposed rehabilitation project proposes the complete reconstruction of the quay wall as it has been damage beyond repair. The quay wall has been constructed using sand cement bags with a cement layer on top. At some places, caving of the quay wall was observed. As a result, the quay wall will be demolished and the debris will be used as core material for the breakwater construction.
- Reconstruction and extension of the jetties with suitable technique giving a life time of at least 30 years and providing better protection of the vessels (agitation + siltation). At present the jetties are damaged badly as illustrated in Appendix 4
- Dredging the harbour basin to -3.00 m at MSL. Siltation has occurred in the harbour basin resulting in reduction of water depth. This is most evident along the quay wall, where water depths are as low as -1 m at MSL. Refer Appendix 5,6 AND 7. It is estimated to generate 16000 m^3 of spoil.
- Dredging of the access channel to -3.00 m at MSL. The access channel in Makunudhoo is very long and also is not oriented in a linear manner. Towards the entrance of the channel, there are very narrow areas with adequate depth for large vessels to allow passage. This has been caused by siltation and sedimentation. As a result, these areas will be dredged to widen the channel (See Appendix 6 AND 7). It is estimated to generate 10,000 m^3 of spoil.

Once the rehabilitation project is complete, the harbour will be enhanced and will have a longer life span. The harbour will also be able to accommodate more vessels with improved facilities and capabilities. The proposed layout and rehabilitation plan for Makunudhoo is illustrated in Appendix 5.

Table 1 outlines a summary of major activities proposed for the rehabilitation project with their estimates, in terms of length and volumes of construction required. Refer to Appendix 5 together with Table 1.

Table 1: A summary of the major activities with quantitative linear and volume estimates

DESCRIPTION	UNIT	QUANTITY
Demolition of existing quay walls	m	360
L shaped reinforced concrete quay wall	m	470
Breakwaters with boulders	M^3	3,804
Dredging of the basin to -3.00 m at MSL	M^3	16,000
Dredging of the access channel to -3.00 m at MSL	M^3	10,000

2.11 Project Activities

The proposed project involves redevelopment of the harbour in Makunudhoo island with enhanced measures designed to improve the existing condition and with a greater life span.

New additional features of the harbour will include more space in the harbour basin, reinforced L-shaped quay walls that will last longer and be capable of withstanding greater loads, breakwaters with boulders and increasing the depth of harbour basin and access channel. The project activities have been divided in to coastal and marine based activities.

2.11.1 Coastal activities

The following coastal activities will take place in the island.

Activity 1: Demolition of 360 meters of the existing quay walls, that has been damaged beyond repair (see Appendix 5). The demolished debris will be used as fill material for the new breakwaters (see section A-A in Appendix 5). Hence, the debris will be utilized as core material for breakwaters.

Activity 2: Reconstruction of 242m of quay wall capable to withstand heavy loads generated by specific handling equipment such as crane (75 t) and conveyor (L-shaped concrete slabs).

Activity 3: Reconstruction and extension of the jetties with suitable technique giving a life time of at least 30 years and providing better protection of the vessels (agitation + siltation).

2.11.2 Marine based activities

The following marine based activities will take place on the island.

Activity 1: Reconstruction of the breakwater with boulders of 600-800 kg (used from existing coral debris as core material. Debris from demolition of quay wall will be used).

Activity 2: Dredging the harbour basin to -3.00 m at MSL

Activity 3: Dredging of the access channel to -3.00 m at MSL

2.12 Construction Schedule and methodology

The project is expected to be not more than 10 months for construction. A tentative construction schedule is attached as Appendix 8..

2.12.1 Construction strategy

The harbour redevelopment project will be undertaken in the planned time period to reduce cost and also reduce the environmental damage. Both coastal and marine based construction activities will be done in parallel to complete the work in the least possible time frame.

2.12.2 Work methods for coastal structures

Coastal structures for this project include jetty and quay walls. Existing jetty will be reconstructed to increase the width and area available for use. The coral debris from the quay demolition will be used as fill material for constructing the new breakwater using boulders (see section A-A in Appendix 5).

Quay wall will also be constructed similarly using L-shaped reinforced concrete walls (see section B-B in Appendix 5). These L-shaped concrete walls will be placed along the quay wall section where it will be placed upright with a tie rod and concrete slab to stabilize the quay wall when it is loaded. Loading and unloading will be carried by excavators and cranes. Once they are placed, a final top concrete beam will be placed on top which will form the quay wall. Once they are in place and completed, backfilling will be done using part of the sand dredged from the basin.

2.12.3 Works methods for marine based activities

Marine based activities will be dredging and reconstruction of breakwaters. Dredging of the harbour basin and access channels will be done by using excavators. Excavators placed on a barge will be used to dredge the harbour basin. Breakwater reconstruction will also be undertaken using excavators to remove the coral debris, placing and rearranging the boulders. See Appendix 5. for the final layout proposed.

2.12.4 Management of dredged spoil and its disposal

The project will produce a combined volume of 26,000 cubic meters of sand or dredged spoil which has to be managed in an environmentally acceptable manner. In Makunudhoo, the dredged spoil from the harbour basin will be used to reclaim the lagoon on the south of the harbour. This area has been planned for future expansion by reclamation. It has been proposed to develop fishing related industrial activities in this area (Appendix 9). A portion of the dredged material will also be used to back fill the quay wall and jetty once they are completed. Dredged material from the access channel will be disposed on the eastern side of the lagoon, where previously it has also been used for disposal.

These disposal sites have been thoroughly studied and baseline conditions of these areas have been assessed and discussed in the existing marine environmental section.

2.13 Project Inputs and Outputs

2.13.1 Project Inputs

The types of resources that will go into the redevelopment and from where and how these will be obtained are given in Table 2.

Table 2: Matrix of major inputs during construction period

INPUT RESOURCE(S)	SOURCE/TYPE	HOW TO OBTAIN RESOURCES
Construction workers (30+)	Maldivians	Open bidding by advertising in local papers/other sources
Water supply (construction period)	Well water from the island	From the community wells
Electricity/Energy (construction period)	Mobile Diesel generators	Contractors to provide
Construction machinery	Excavators, dredgers, barges, general construction tools, lorries, cranes, loader.	Contractors to provide
Telecommunications	Mobile Phones, Fax Machines, E-mail and internet facilities	Already this services is available in the island
Transport (sea)	Materials to be transported in carrier vessels or large barges.	contractors
Food (during construction period)	Obtained from the island.	local purchase by the contractor
Fuel,	Diesel, Petrol, Lubricants	Local purchase by the contractor

2.13.2 Project Outputs

The type of outputs (products and waste streams) and what is expected to happen to the outputs are given in Table 3.

Table 3: Matrix of major outputs of environmental significance during construction stage

PRODUCTS AND WASTE MATERIALS	ANTICIPATED QUANTITIES	METHOD OF DISPOSAL
Sewage and wastewater Grey water/laundry wastewater	Estimated to be at 150 litres/person/day	Construction workers will be housed in existing houses on rent basis. The island has onsite sanitation system and therefore wastewater will be treated using septic tanks.
Demolition of the existing quay wall	1203 cubic meters	Debris from the existing breakwater demolition will be used for fill material and core material if required for the new breakwater construction.
Waste oil and grease (hazardous waste)	Approximately 40 litres per month	Stockpiled and sent to landfill in Thilafushi after decommissioning. Alternatively they will be made available for local fisherman for free.
Noise	Only localised to the island environment	Unavoidable during the construction stage but will be minimized.
Air pollution	Limited quantities of dust in the construction area (harbour area).	Mainly arising as a result of dust emission from the construction work such as cement mixing, moving machinery and other processes. Only localised.
Dredged spoil	26,000 cubic meters	16,000 m^3 will be disposed on the southern side of the harbour to reclaim the land. 10,000 m^3 will be disposed at the old disposal side on the eastern side of the island. Part of the dredged spoil will also be used for backfilling behind the quay wall and the new jetty. See Appendix 8

3 Project Setting

3.1 Overview

The project conforms to the requirements of the Environmental Protection and Preservation Act of the Maldives, Law no. 4/93. The EIA has been undertaken in accordance with the EIA Regulation 2007 of the Maldives by registered consultants. Furthermore, it adheres to the principles underlined in the regulations, action plans, programmes and policies of the following Government Ministries.

- Ministry of Environment, Energy and Water
- Ministry of Agriculture and Marine Resources

These are discussed in detail in the following sections.

3.2 Applicable Policies, Laws and Regulations

3.2.1 Environmental Protection and Preservation Act

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management:

- Guidelines and advice on environmental protection shall be provided by the concerned government authorities.
- Formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions shall be carried out by MEEW.
- Identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.
- An EIA shall be submitted to MEEW before implementing any developing project that may have a potential impact on the environment.
- Projects that have any undesirable impact on the environment can be terminated without compensation.
- Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.
- Hazardous / Toxic or Nuclear Wastes shall not be disposed anywhere within the territory of the country. Permission should be obtained for any trans-boundary movement of such wastes through the territory of Maldives.
- The Penalty for Breaking the Law and Damaging the Environment are specified.
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

The proposed redevelopment project will fully abide to the Environmental Preservation and Protection Act. Disposal of oil, chemicals and other hazardous materials will be strictly controlled and managed. Such materials will not be disposed in to the local or the regional environment, but will be transported to designated waste disposal site. All mitigation measures will be fully implemented in the interest of the environment.

3.3 Second National Environment Action Plan (1999)

The aim of NEAP II is to protect and preserve the environment of the Maldives and to sustainably manage its resources for the collective benefit and enjoyment of present and future generations.

Main strategies of the NEAP II are:

- Continuous assessment of the state of the environment in the Maldives, including impacts of human activities on land, atmosphere, freshwater, lagoons, reefs and the ocean; and the effects of these activities on human well-being
- Development and implementation of management methods suitable for the natural and social environment of the Maldives, and maintain or enhance environmental quality and protect human health, while at the same time using resources on a sustainable basis
- Consultation and collaboration with all relevant sectors of society to ensure stakeholder participation in the decision making process
- Preparation and implementation of comprehensive national environmental legislation in order to provide for responsible and effective management of the environment
- Adhering to international and regional environmental conventions and agreements and implementation of commitments embodied in such conventions.

NEAP II contains environmental policies and guidelines that should be adhered to in the implementation of the proposed project activities.

The redevelopment of harbour in Makunudhoo will also be in accordance with the main strategies of the NEAP II. The proponent will, fully committed to the EIA and the proposed monitoring programme. The monitoring programme proposed in this report outlines the environmental management strategy and plan. This EIA has also been prepared in consultation with all the key stakeholders, especially the island community and MCPI. Therefore, these measures address the key strategies outlined in the NEAP II.

3.3.1 National Biodiversity Strategy and Action Plan

The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities due to care has to be given to ensure that the national biodiversity strategies are adhered to. The proponent has committed fully on conservation and protection of the environment while undertaking this proposed project. More specifically, the coral reef and generally the marine environment have been assessed in detail in order to assess baseline values. Quantitative and qualitative surveys were undertaken to assess the biological diversity of the coral reef, especially in close proximity to the proposed development area and also in the areas where dredged spoil will be disposed. Practical mitigation measures and solutions have been identified to conserve and protect the biodiversity.

3.3.2 Regulation on sand and aggregate mining

This regulation addresses sand mining from uninhabited islands that have been leased; sand mining from the coastal zone of other uninhabited islands; and aggregate mining from uninhabited islands that have been leased and from the coastal zone of other uninhabited islands.

Neither sand nor aggregate will be mined for this project. Aggregate and sand used for this project will be imported. This regulation would not have any implication on the proposed project.

3.3.3 Ban on coral mining

Coral mining from the house reef and the atoll rim has been banned through a directive from the President's Office dated 26th September 1990. According to these policies,

- coral mining is not to be carried out on island house reefs;
- coral mining cannot be carried out on atoll rim reefs and common bait fishing reefs;
- coral or sand mining is only allowed from designated sites, and approval from the concerned Atoll Office is required prior to the commencement of any mining operation.
- requests for coral or sand mining from residents of inhabited islands are required to be submitted to the Atoll Office through their respective island office
- the island office is required to estimate the quantity of corals required for the applied construction work and hence this ensures that permission is granted to mine just the required amount;
- Every island is required to keep a log book of the amount of corals mined.
- sand mining is not allowed on the beaches of inhabited islands, islands leased for industrial developments and tourist resorts and within the lagoons adjoining these islands.

Coral would not be mined in any stage of the project. The EIA report clearly outlines the impacts of dredging and a proper assessment of the affected environment has been undertaken. Rock boulders will be used for breakwater construction. Coral debris from the demolition of existing breakwaters and quay wall will be used as fill material for the new breakwaters. Only excavators will be used for dredging.

3.4 Environmental Impact Assessment Regulation 2007

The Ministry of Environment, Energy and Water has issued a new EIA regulation on May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Republic of Maldives – This guideline also provides a comprehensive outline of the EIA process, including the roles and responsibilities of the consultants and the proponents. This regulation outlines every step of the IEE/EIA process beginning from application to undertake an EIA, details on the contents, minimum requirements for consultants undertaking the EIA, format of the EIA/IEE report and many more .

The guidance provided in this Regulation was followed in the preparation of this EIA report. The EIA has also been prepared by registered consultants.

3.4.1 Post EIA Monitoring, Auditing and Evaluation

The environmental monitoring programme given in EIA reports is an important aspect of the EIA process. The monitoring programme outlines the objectives of the monitoring; the specific

information to be collected; the data collection program, and managing the monitoring program. Managing the monitoring programme requires assigning institutional responsibility, reporting requirements, enforcement capability, and ensuring that adequate resources are provided in terms of funds, skilled staff, etc.

The monitoring programme outlined in this report will comply with the EIA Regulations 2007.

3.5 International conventions, treaties and protocols

Some of the international conventions, treaties and protocols of relevance to the proposed project may be identified as follows:

3.5.1 United Nations Convention on Biological Diversity (UNCBD)

The objective of UNCBD is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding".

Maldives was one of the first nations to ratify UNCBD. Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002. Formulation of NBSAP was through wide consultation and extensive stakeholder participation.

The proposed project involves dredging and filling beach areas which may have impacts on some biological resources. The creation of breakwaters may also impact reef resources. These impacts and mitigation measures have been dealt with in this report.

3.5.2 Marpol Convention

International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 and includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes Prevention of Pollution by Oil; Control of Pollution by Noxious Liquid Substances in Bulk; Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form; Prevention of Pollution by Sewage from Ships; Prevention of Pollution by Garbage from Ships; and Prevention of Air Pollution from Ships.

This Convention has little or no relevance to the proposed harbour rehabilitation project in Makunudhoo. However, it is worthy of mention since Maldives is a party to the MARPOL and any establishment of appropriate port side facilities in the harbour in Makunudhoo will help ensure that the provisions in the MARPOL convention are fully enforced by ships and other vessels that travel in the territory of the Maldives and pollution of the Maldivian seas are prevented.

The Maldives has guidelines and regulations pertaining to pollution from ships and other vessels which may anchor at any harbour in the Maldives. Vessels requiring discharging slop from tank cleaning and dirty oil bilge should request local agent to provide reception facility. Port Authority does not have slop reception facilities. If any vessel discharges over board or in case any type of oil

spill is found in port, the officer in charge of the vessel is required to report to Maldives Ports Authority and Coast Guard to take immediate action.

Furthermore, Government regulation states as follows:

1) It is expressly forbidden for any vessel to dump or discharge into any harbour, lagoon, or into any part of the waters of the Republic of Maldives, refuse, bunker oil, sewage, noxious substances or any materials or substances whatsoever.

2) The Master of any vessel and / or its agents will be held directly responsible for any nature or degree of pollution of the water, lagoons and Islands of the Republic of Maldives through the dumping or discharge of any refuse and / or substances.

3) In the event of any nature or degree of pollution of Territorial Water of the Republic of Maldives due to the dumping or discharge of refuse and / or substances, the master and / or the Agent of the offending vessel shall be subject to an immediate fine deemed by the Authority concerned according to Maldivian Law.

4 Methodology

The section covers methodologies used to collect data on the existing environment.

The key environmental and socio-economic components of the project under consideration are:

Vital Environmental, Social and Economic Components

- Coral reef areas and the marine environment.
- Marine biodiversity
- Marine water quality
- Socio-economic context of the project.

Hence, data collection was undertaken for the above components. In order to study the existing environment of the island, the following data collection methodologies were used during the field visit undertaken between 26 th to 28th August 2007.

4.1 General Methodologies of data collection.

Conditions of the existing environment were analyzed by using appropriate scientific methods. The environmental components of the study area were divided into marine and coastal zone. Although terrestrial component was not considered as important for this project, baseline environmental conditions were appraised. The marine environment of the island covered the coral patches, the lagoon and the house reef of, especially around the area expected to have the greatest impact as a result of the proposed project. The coastal environment covered the coastline within the project boundary, the jetties and quay wall reconstruction.

The environmental conditions were assessed by dividing the tasks among different groups – marine, coastal and socioeconomics. The different methods used in assessing and reporting the conditions of the existing environment of the island are outlined in the following subsections.

4.1.1 Mapping and Location identification

The entire island, including reef line, shore line, vegetation line, coral patches and marine survey locations (in the project boundary), existing breakwaters and access channel/s were mapped for the assessment. Mapping was undertaken using hand held differential GPS. The location of data collection sites were marked using handheld GPS. These data collection points include water sampling locations, Beach profile locations, marine survey areas, and proposed dredging areas, reclamation of land and access channels.

4.1.2 Marine Water Quality

One of the main environmental components that would be affected by implementing the project would be marine water quality, especially within the harbour basin and the access channel. Water quality was assessed during the field trip in August 2007 by collecting samples and testing them at National Health Laboratory. Water quality was assessed at selected locations within the possible impact zone. The locations, frequency and parameters to be monitored are given in the Monitoring programme outlined later in the EIA report.

4.1.3 Coastal processes

Several beach profiles were taken from around the island by means of standard leveling techniques. These benchmarks would be used for long term monitoring. The measurement of beach profiles involves standard practice of surveying with a staff and a dumpy level.

4.1.4 Marine Environment

Marine environmental surveys were conducted to collect data on key environmental components (i.e. the coral reef system), sea grass beds that will be impacted due to the redevelopment. Purpose of the surveys was to define and establish marine environmental baseline conditions for impact evaluation during and after the proposed project. Surveys were based on standard marine environmental surveys so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities. Surveys include quantitative and qualitative surveys. Marine surveys were conducted in the project area where the impacts are likely to occur and also in locations identified for dredged spoil disposal. These methodologies are discussed in detailed under the Marine Environment.

4.1.5 Bathymetric survey

A detailed bathymetric survey was undertaken to assess the baseline condition of the harbour basin and also calculate the wave strength approaching the harbour. Bathymetric surveys were also used to determine the volume of dredging required for the basin and access channels Refer to Appendix 6 and 7.

4.1.6 Socio-economic data collection

The base line socio- economic condition of the island and the possible impacts of the project to the island community were studied by using various methods including, key informant interviews, utilizing existing data and maps, taking samples from cross sections of the community, focus group interviews and household surveys.

The proposed methodology was shared with the project client, the Ministry of Construction and Public Infrastructure. It was suggested to undertake the socioeconomic studies based on the existing data and community meetings. This was mainly due to political unrest and situation of the country.

The socio-economic studies undertaken in the island was targeted to get the in depth information of the community, their perception, values regarding the proposed harbour development project.

The specific objectives of the studies were:

1. to identify the existing socio economic conditions prevailing on the island;
2. to understand the perceptions that the islanders have towards the proposed harbour development project ;
3. to determine the parameters that requires future monitoring to gauge the impact of the proposed harbour development project.

In this regard a study team has visited the island from 26th to 28th August 2007, to conduct field surveys. The team has conducted socio-economic studies of the island and gathered the data based on the following:

1. Key informant's interviews,
2. Community meetings;
3. Date collection from island office.

The socio-economist has met the Island Chiefs, and other officials of the island office and collected baseline information of the island. This includes the population, growth, income generating activities, proposed development projects of the island, community issues.

The team has also attended community meeting organized by the island office, and represented by Island Development Committee, Women's Development Committee and Harbour Committee. A detailed discussion was held with the committees regarding the proposed development project and gathers the views and perception committee members.

A site inspection was also carried and gathered information about the socio-economic condition of the island.

5 Existing Coastal Environment

5.1 Chapter Brief

This chapter will look at the coastal zone of the island environment which is the area between the vegetation line and the reef flat, but within the identified project boundary. Therefore, this chapter will cover the following:

- General meteorological conditions in the Maldives (in gathering meteorological data, global satellite database and other local and international sources were used).
- Existing coastal environmental conditions of Makunudhoo, within the project boundary.
- The different proposed components of the project that will impact upon the coastal environment.

5.2 Existing Coastal Environment

5.2.1 Island Formation and Geography

Refer 2.6 for a description of the geographical formation of Makunudhoo.

5.3 General Meteorological conditions in Maldives

5.3.1 Climate and weather

Information was extracted from (UNEP, 2002).

The Maldives has a warm and humid tropical climate. The weather is dominated by two monsoon periods:

- The South-West (SW) monsoon from May to November (rainy period),
- the North-East (NE) monsoon from January to March (dry period),

when winds blow predominantly from either of these two directions.

The relative humidity ranges from 73% to 85%. Daily temperatures in the country vary very little throughout the year with a mean annual temperature of 28°C.

5.3.2 Wind conditions

5.3.2.1 General information

Wind directions are connected to the monsoons regime. Winds from the NE and ENE are predominant during December to February. During March and April, the direction varies with the general direction being westerly. But strong winds are associated with the SW monsoon season. Gales are uncommon and cyclones are very rare in the Maldives. Stormy weather is more frequent from May to July. Storm gusts of 50 to 60 knots have been recorded at Malé.

The wind and offshore wave climates occurring in the Maldives region, over the period 1993-2004, were extracted from the worldwide database developed by Globocéan. Figure 3 describes the methodology adopted to construct the statistical data for the Maldives and presents the annual, monthly and seasonal wind and offshore wave statistics. An analysis of this database is given hereafter.

It should be mentioned that the database used in this study is sufficient to perform a first assessment of the wind and offshore wave climate in the Maldives region in the case of this pre-project and feasibility study. However, these initial data should be detailed by means of a specific hind cast model during later steps of the project.

5.3.2.2 Annual wind climate

The joint distribution of the wind parameters:

- V10m: the average wind speed over 10 minutes at a 10 m level of reference,
- Dv: the wind direction associated with V10m,

is provided in the next table.

Figure 3 : Maldive Islands - Annual Wind Climate (Globocean database from 1993 to 2004)

Wind speed (m/s) / Direction (°N)	0 / 2	2 / 4	4 / 6	6 / 8	8 / 10	10 / 12	12 / 14	14 / 16	16 / 18	18 / 20	20 / 22	22 / 24	24 / 26	26 / 28	
345															
	0.870	2.464	1.091	0.046											**4.47**
15															
	0.920	4.055	3.023	0.791	0.070										**8.86**
45															
	0.931	4.452	4.372	2.046	0.522	0.031									**12.35**
75															
	0.897	2.799	1.929	0.670	0.108	0.011									**6.41**
105															
	0.734	1.386	0.391	0.037											**2.55**
135															
	0.696	1.071	0.347	0.027											**2.14**
165															
	0.694	1.587	0.732	0.031											**3.04**
195															
	0.987	2.833	1.918	0.258	0.001										**6.00**
225															
	0.923	4.520	6.353	2.783	0.563	0.077									**15.22**
255															
	1.088	5.527	9.123	5.942	1.365	0.130	0.020	0.001							**23.20**
285															
	0.967	3.750	4.502	1.966	0.311	0.014									**11.51**
315															
	0.861	2.202	1.025	0.143	0.010										**4.24**
345															
	10.57	**36.65**	**34.81**	**14.74**	**2.95**	**0.26**	**0.02**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100**

The corresponding wind rose is presented in Figure 3. Wind speed distribution and wind speed exceedance frequency are given in Figure 3**.**

The following points may be emphasised:

Occurrence frequencies in the prevailing directional sectors are the following:

- N15°–N105°: 27.6%,
- N225°-N315°: 49.9%.

Wind speed is lower than 6 m/s for 82% of the observations. However, it should be mentioned that no calm period (wind speed = 0) appears in the database.

Maximum wind speed is in the range from 14 to 16 m/s from the sector N255°-N285°.

10 m/s is exceeded for less than 0.3% of the database.

5.3.2.3 Seasonal distribution of wind statistics

The next table presents the seasonal distribution of the wind statistics. These results are presented graphically in Figure 4. The following periods were defined:

- December to March, corresponding to the NE Monsoon,
- April: transitional season No. 1,
- May to October: SW monsoon,
- November: transitional season No 2.

Figure 4: Maldive Islands -Seasonal wind statistics (Globocean database from 1993 to 2004)

WIND OCCURRENCE FREQUENCY PER DIRECTIONAL SECTORS (%)

Season >		NE Monsoon	Transitional season 1	SW Monsoon	Transitional season 2
Wind directional sectors		Dec. to March	April	May to Oct.	November
S1	N15°-N105°	71.35	15.28	1.43	23.96
S2	N105°-N225°	6.13	16.55	17.65	17.62
S3	N225°-N315°	8.42	56.74	77.61	41.11
S4	N315°-N15°	14.10	11.44	3.32	17.31

These results clearly indicate the prevailing directional sectors during the monsoon seasons:

- N15° to N105° during the NE monsoon, with about 71% of the observations,
- N225° to N315° during the SW monsoon, with about 78% of the observations.

5.3.3 Sea level

5.3.3.1 Seasonal fluctuation

Regional mean sea level is affected by a seasonal fluctuation of 0.2 m:

- increase of about 0.1 m from February to April,
- decrease of 0.1 m from September to November.

5.3.4 Tide levels

The tidal regime is semi-diurnal with diurnal inequalities (twice daily). That means 2 high tides and 2 low tides per day, with different heights. Typical spring and neap tidal ranges are approximately 1.0 m and 0.3 m, respectively.

Tidal levels given by the Admiralty Tables (2007) are presented in the following table.

Figure 5: Maldives tidal levels in mCD (Admiralty tide tables, 2007)

	Geo. Coordinates		LAT	MLLW	MHLW	MSL (ML)	MLHW	MHHW	HAT
	Lat. (°N)	Long. (°E)							
Standard Port: Cochin (West coast of India)	9° 58'	76° 16'	-0.2	0.3	0.6	0.6	0.8	0.9	1.2
Maldive Islands									
Ihavandhoo	6° 57'	72° 55'		0.3	0.6	0.68	0.9	1.0	
Goidhoo Atoll	4° 51'	72° 55'		0.3	0.5	0.6	0.8	0.9	
Girifushi	4° 19'	73° 55'		0.3	0.4	0.58	0.7	0.9	
Malé	4° 11'	73° 31'		0.3	0.5	0.65	0.8	0.9	
Vattaru	3° 15'	73° 24'		-	-	0.7	0.9	1.0	

With the following definition:

- LAT: Lowest Astronomical Tide,
- MLLW: Mean Lower Low Water,
- MHLW: Mean Higher Low Water,
- MLHW: Mean Lower High Water,
- MHHW: Mean Higher High Water,
- HAT: Highest Astronomical Tide.

5.3.5 Storm surge

Storm surge may increase the water level due to:

- the effect of atmospheric pressure variations. A water level variation of 10 cm occurs with a pressure variation of 10 HPa,
- wind effects, especially in shallow water areas.

An analysis of the available tide gauge measurements is necessary to assess the storm surge. This analysis may be obtained from:

- The National Meteorological Centre, Malé,
- Haa Dhaal Hanimaadhoo Meteorological Office,
- Laamu Kadhdhoo Meteorological Office.

Figure 6: Maldive Islands - Meteorological Centres geographical coordinates in the study area

	Latitude	Longitude	Tide gauge
National Meteorological Centre, Malé	04.19°N	73.53°E	Yes
Haa Dhaal Hanimaadhoo Meteorological Office	06.75°N	73.17°E	Yes
Laamu Kadhdhoo Meteorological Office	01.86°N	72.10°E	No

5.3.6 Wave setup

In the wave breaking zone, the water level is locally increased. As a first rough assessment, an increase corresponding to 10% of the deep water wave height can usually be considered.

5.3.7 Sea level rise

Analysis of data from tide gauges measuring sea levels at Malé and Gan meteorological stations shows that the Maldives coastal sea level is rising in the range between 3.9 (Gan) and 4.1 (Malé) mm/year (Khan et al, 2002).

According to the Intergovernmental Panel on Climate Change (IPCC) in its 4th report (2007), the global sea level rose by 1.8 mm/year between 1961 and 2003 and 3.1 mm/year between 1993 and 2003.

The latest predictions for the global sea level rise in the next century, provided by IPCC (2007), are in the range between 0.18 m and 0.59 m depending on the scenario modelled.

5.3.8 Currents

5.3.8.1 General currents

Currents tend to be monsoonal in origin, generally setting W during the NE Monsoon (January to March) and E during the SW monsoon (May to October). During the transition months, the currents are variable. Ocean currents flowing through channels between the atolls are driven by the monsoon winds. Current speeds of 1 to 1.5 knots are reported in the Admiralty pilot. However, the current in the E/W channels of the Maldives may attain 5 knots.

5.3.8.2 Tidal currents

Generally, the tidal currents are Eastward in flood and Westward in ebb.

5.3.9 Offshore wave conditions (in deep water)

5.3.9.1 General information

The swells and wind waves experienced by the Maldives are conditioned by the prevailing biannual monsoon and are typically strongest during April and July in the SW monsoon period. During this season, swells generated north of the equator with heights of 2-3m and periods of 18-20 seconds have been reported in the region. However swells originating from cyclones and storm events occurring well south of the equator may occur. Local wave periods are generally in the range 2 to 4 s and are easily distinguished from the swell waves.

An analysis of the wave climate was performed by using the sea state database developed by CREOCEAN. The simulated sea state cover Indian ocean with a 3°x3° resolution, every 3 hours in the time period 1993-2004.

5.3.9.2 Annual wave climate

The next tables present the joint distributions of the wave parameters:

- wave height (Hs) /Direction (Dir),
- wave height (Hs) /Peak period (Tp).

These results correspond to wave conditions in deep water.

Figure 7 : Maldive Islands – Annual wave climate (Globocean database from 1993 to 2004)

SIGNIFICANT WAVE HEIGHT/DIRECTION TABLE

Hs(m) / Dirp(°)	0 / 0.5	0.5 / 1	1 / 1.5	1.5 / 2	2 / 2.5	2.5 / 3	3 / 3.5	3.5 / 4	4 / 4.5	4.5 / 5	5 / 5.5	5.5 / 6	6 / 6.5	6.5 / 7	7 / 7.5	7.5 / 8	8 / 8.5	
345																		
	0.001	0.412	0.087															0.50
15																		
	0.001	0.185	0.164	0.007														0.36
45																		
	0.006	0.881	1.946	0.877	0.217	0.001												3.93
75																		
	0.019	0.742	0.652	0.120	0.016													1.55
105																		
	0.006	0.580	0.415	0.030	0.001													1.03
135																		
	0.123	9.493	10.196	6.507	2.316	0.351	0.014											29.00
165																		
	0.088	3.794	5.836	4.833	3.593	0.773	0.057											18.97
195																		
	0.070	10.371	14.201	7.810	3.913	0.914	0.080											37.36
225																		
		0.023	0.366	1.001	1.047	0.359	0.044	0.020										2.86
255																		
		0.047	0.510	1.330	0.995	0.304	0.073	0.024										3.28
285																		
		0.013	0.138	0.321	0.157	0.061												0.69
315																		
		0.355	0.098	0.013														0.47
345																		
	0.31	**26.90**	**34.61**	**22.85**	**12.26**	**2.76**	**0.27**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.00**

Figure 7 also presents the following information,

- the annual wave directional distribution,
- the distribution of wave heights (for all directions),
- the wave height exceedance frequency (for all directions),

while figure 4 presents the distribution and exceedance frequency of the peak periods.

The results of the analysis are the following:

- Prevailing wave directions in the annual wave climate are:
- SSE (N135° to N165°),
- S (N165° to N 195°),
- SSW (N195° to N225°).
- 85% of the total number of sea states in the database are included in these preceding sectors. Maximum wave heights in these sectors are in the range 3.0 -3.5 m.

- Waves from the sector N15°-N105° represent only 5.8% of the sea states. Maximum wave heights in this sector are in the range 2.5 -3.0 m.
- Waves from the sector N225°-N315° represent only 6.8% of the sea states.
- Maximum wave heights are in the range 3.5 to 4 m with an occurrence frequency of 0.04%. These waves come from the directional sector N225°-N285°.
- Wave heights greater than
- 2 m represent 15% of the annual sea states,
- 3 m only represent 0.3% of the annual sea states.

Figure 8: Significant wave height / Peak period table

Hs(m) / Tp(s)	0 / 0.5	0.5 / 1	1 / 1.5	1.5 / 2	2 / 2.5	2.5 / 3	3 / 3.5	3.5 / 4	4 / 4.5	4.5 / 5	5 / 5.5	5.5 / 6	6 / 6.5	6.5 / 7	7 / 7.5	7.5 / 8	8 / 8.5	
0																		
																		0.00
2																		
		0.211	0.113															0.32
4																		
	0.004	1.489	2.584	1.563	0.277	0.007												5.92
6																		
	0.123	3.529	2.080	1.162	0.672	0.201	0.043	0.006										7.82
8																		
	0.054	8.298	9.776	8.507	3.578	0.369	0.021	0.019										30.62
10																		
	0.087	5.230	6.682	4.399	4.255	1.362	0.150	0.014										22.18
12																		
	0.031	6.015	9.175	4.432	1.502	0.344	0.019	0.006										21.52
14																		
	0.007	1.815	3.669	2.304	1.628	0.355	0.031											9.81
16																		
	0.006	0.295	0.519	0.472	0.328	0.116	0.004											1.74
18																		
	0.001	0.014	0.013	0.009	0.016	0.010												0.06
20																		
																		0.00
22																		
																		0.00
24																		
																		0.00
26																		
	0.31	**26.90**	**34.61**	**22.85**	**12.26**	**2.76**	**0.27**	**0.05**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**100.0**

- Concerning the peak period parameter, about 75% of the sea states are in the range from 8 s to 14 s.
- Peak periods greater than 14 s are exceeded more than 10% of the time. Examination of the Hs/Tp tables per directional sector also shows that:
- 9.96% of waves with a peak period greater than 14 s come from the N195°-N225° directional sector,
- 1.64% of waves with a peak period greater than 14 s come from the N165°-N195° directional sector.

These correspond to swells coming from the Austral seas.

5.3.9.3 Seasonal wave climate

The next table presents the seasonal distribution of the wave statistics. These results are graphically presented on Figure 9. The following periods were defined:

- December to March, corresponding to the NE Monsoon,
- April: transitional season No 1,
- May to October: SW monsoon,
- November: transitional season No 2.

The results are presented for the same directional sectors as defined for the wind seasonal statistics.

Figure 9: Maldive Islands -Seasonal wind statistics (Globocean database from 1993 to 2004)

WAVE OCCURRENCE FREQUENCY PER DIRECTIONAL SECTORS (%)

Season >		NE Monsoon	Transitional season 1	SW Monsoon	Transitional season 2
Wave directional sectors		Dec. to March	April	May to Oct.	November
S1	N15°-N105°	17.17	0.38	0.00	1.23
S2	N105°-N225°	79.69	96.23	87.92	93.96
S3	N225°-N315°	0.30	3.09	12.08	4.81
S4	N315°-N15°	2.84	0.30	0.00	0.00

The conclusions concerning the seasonal wave climate are the following:

- In all seasons (even during the monsoons), the prevailing wave directional sector is N105°-N225° and more specifically N135°-N225° (the directional sector N105°-N135° represents less than 2% of the sea-states in each season).
- The following can be observed:
- the effect of NE winds during the NE monsoon, when waves coming from the directional sector N15°-N105° represent 17.1% of the sea-states during this period,
- the effect of SW to NW winds during the SW monsoon, when waves coming from the directional sector N225°-N315° represent 12.1% of the sea-state during this period.
- The most severe wave conditions appear during the SW monsoon, when wave heights greater than 2 m are the most frequent (30% of the sea-states during this season).

5.3.10 Extreme sea state conditions in deep water

5.3.10.1 Assessment of extreme wave heights

A first determination of the extreme wave conditions in deep water was performed by using the Peak Over Threshold (POT) method. The results are presented in the following table. Peak periods and directional wave sectors are associated with the wave heights assessed for the given return period.

Figure 10: Maldive Islands - Assessment of the extreme wave heights (in deep water)

Return Period (year)	Hs (m)	90% confidence interval (m)	Tp (s)	Directional sector (°N)
1	3.2	3.1 – 3.3	8 to 15	180 – 200 and 240 – 280
10	3.8	3.5 – 4.3	8 to 13	240 - 280
20	3.9	3.6 – 4.5	8 to 13	240 - 280
50	4.1	3.7 – 4.7	8 to 13	240 - 280
100	4.2	3.8 – 4.9	8 to 13	240 - 280

It can be observed that the extreme wave heights appear to be associated with peak periods between 8 and 13 s and appear to come from the N 240°-N280° directional sector. The wave height for the 100-year return period is estimated at 4.2 m.

However, a further analysis should be carried out for nearshore conditions to define the possible extreme wave heights per directional sector depending on the different harbour locations and orientations.

5.3.11 Examples of exceptional storm events

1987

The exceptional flooding of 1987 was due to high water levels which swept over the Maldives, inundated much of Malé and other islands. Flooding appears to have resulted from long distance swell propagation due to a storm located west of Australia (Goda, 1987). High waves of about 2.5 m height with a period of about 15 s hit the coast in association with high spring tides and SW wind.

May 2007

As a recent example of an exceptional storm event, the large swell waves that reached the Republic of Maldives in May 2007 originated from two subsequent storms initiated south of South Africa, propagating across the Indian Ocean north-east, away from the storm area, causing serious flooding in the exposed islands of the Republic of Maldives. A series of large swell waves estimated at 3-4.5 metres swamped some 68 islands in 16 atolls. This event caused damage in Réunion Island as well.

5.4 Cyclones in the Maldives

This paragraph presents information extracted from (UNDP- Developing a Disaster Risk profile for Maldives – May 2006) presenting the characteristics of cyclones in the Maldives.

The islands of the Maldives are less prone to tropical cyclones. The northern islands of the country have been affected by weak cyclones that formed in the southern part of the Bay of Bengal and the

Arabian Sea. The number of cyclones directly crossing the Maldives is small. Only 11 cyclones crossed the islands over the entire span of 128 years between 1877 and 2004.

Most of the cyclones crossed the Maldives north of 6.0°N and none of them crossed south of 2.7°N during the period. All the cyclones that affected the Maldives were formed during the months of October to January except one, which formed in April.

The Maldives have not been affected by cyclones since1993.

In the northern islands, the probable maximum storm tide due to cyclones has been estimated to be around 1.82m (storm surge of 0.84 m) for a return period of 100 years. This storm surge was computed taking into account probable maximum winds and probable maximum pressure drops.

5.5 Features of the Coastal Environment within the project location

The coastal environment of the island and in general the project area can be described as having four major characteristics illustrated in Figure 11. They are:

1. The harbour with the quay wall and breakwaters

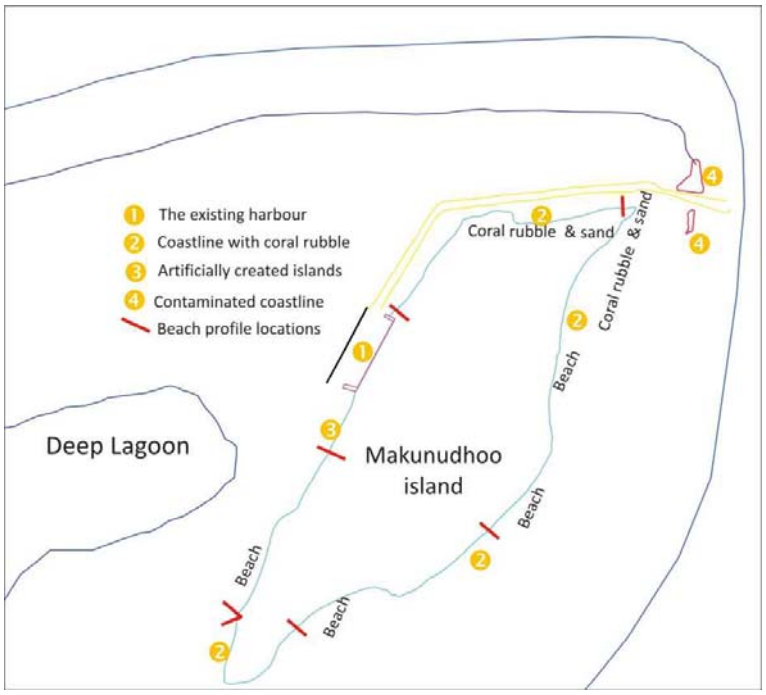
2. A dynamic coastline that varies along different parts of the island. The coastline is characterised by a mix of well formed beach, coral rubble coastlines, beach rocks. It is also observed that the elevation of the beach from MSL on the eastern side at the time of the surveys were more than 2.5m.

3. The coastline on the south of the harbour which mainly consists of coral rubble.

4. Artificially created islands on the base of the entrance channel which has been created from the dredged materials.

In order to assess the coastline, beach profiles were taken from selected locations within the project boundary illustrated in Figure 12.

Figure 11: Illustration of coastal environment and the project boundary.



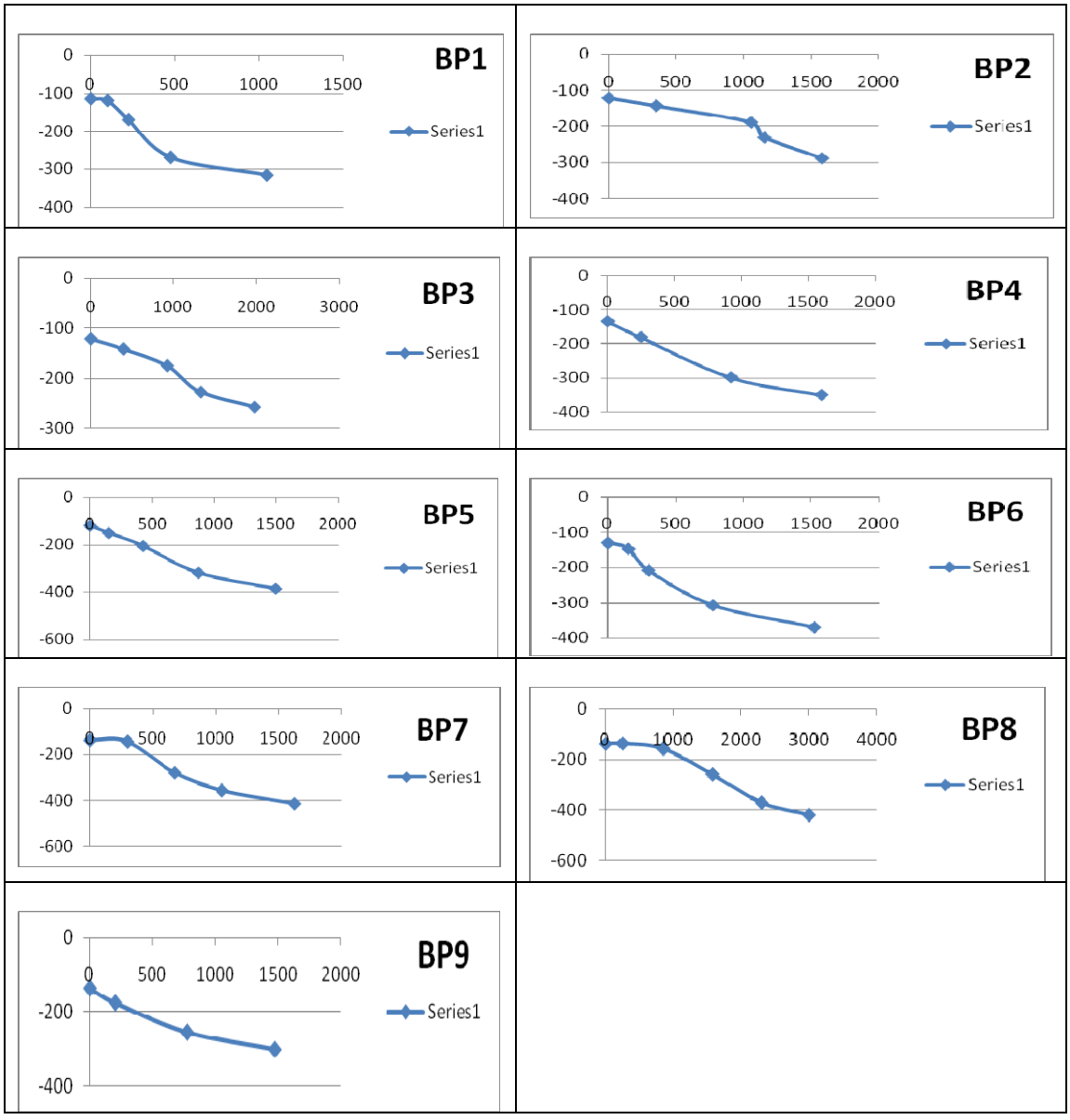
5.5.1 Lagoon

The lagoon in this project has been considered as the lagoon on the western side of the island. The existing harbour has been created on this lagoon. The lagoon system is characterised by a central portion of deep surrounded by shallow regions. On the north of the lagoon, before the surf zone, the lagoon get much slower as a result of the reef flat. These deep areas of the lagoon have very limited or no corals. The shallow lagoon has coral patches scattered. Refer Appendix 2 which illustrates the lagoon system around the island.

5.5.2 Beaches

Since this project is focusing mainly on the marine environment, no detail accounts of the beaches will be described here. However, an indication of the beach formation and types around the island are illustrated in Figure 11

Figure 12: Beach profiles taken at designated locations around Makunudhoo.



6 Existing Marine Environment

6.1 Chapter Brief

This chapter will look at the marine environment of H.Dh. Makunudhoo Island (see Figure 1) which may experience a direct or indirect impact from the proposed harbour development project. The chapter will cover the following:

- Methodologies used in data collection.
- Existing conditions of the marine environment of Makunudhoo with specific emphasis on the proposed development area and its possible impact area.

6.2 Marine Environmental Surveys

Marine environment was surveyed to assess and obtain baseline data of the existing environmental conditions. Major components of the marine ecosystems surveyed are the reef-flat, the coral thickets, other benthic communities, the fish communities, the seagrass habitats and the lagoon (*vilu*). The findings of the surveys were used for impact evaluation and mitigation during the proposed development. The survey methods used here are easily replicable and involve in-expansive techniques. These surveys will be repeated through out the life of the project and there after to monitor the changes occurring in the biotic and abiotic components of the environment.

6.3 Survey Methods

Both quantitative and qualitative methods were used to assess the benthic substrate and fish census at the survey sites. Where possible and appropriate line intercept transects (LITs) and visual assessments were used to quantify benthic types. Belt transects were used to assess the fish community structure. Same transect laid for LITs were used to carry out fish census. Visual assessment was used in sites where physical or weather conditions hinder the use of LITs or quadrat methods. This was mainly carried out using the 'timed swims' techniques.

This study was complemented with extensive underwater photographs of the areas in question. Methodologies adopted for these surveys are internationally accepted (English et al. 1997) and are widely used to assess the status of coral reefs in the Maldives as well.

6.3.1 Line Intercept Transects (LIT)

Line Intercept Transect (LIT) surveys was carried out to assess the benthic types and species at the survey sites. This method uses life form categories to assess the benthic sessile community of reefs and it is possible to incorporate taxonomic data as well. LIT surveys have been proven to be very efficient for studies of benthic coral reef communities (Loya 1978, English et al. 1997), and can be used to evaluate the community structure of corals in terms of species composition and diversity patterns in different zones on a reef. LIT method also provides a rapid estimate of percent cover of corals, algal cover, and cases of other prominent organisms as well as bare substratum.

Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. Disadvantages of this method include difficulty in standardizing the life form categories and the limitation of the data collected, to information on percent cover and relative abundance (English et al. 1997). LIT

surveys produce valuable data even though they are time consuming and require considerable effort and skills to record notes underwater (Segal & Castro 2001). A line transect of 50m length was used in each of the sites.

6.3.2 Timed-Swim Surveys

These surveys were carried out using snorkeling gear for both fish and benthic communities including live coral, dead coral, algae and other sessile organisms. Three swims on a straight path were done on the selected sites (Site 1, 2 and 3). These sites were GPS-marked and are shown in Figure 13: The marine survey sites and affected environment. Figure 13. The duration of each swim was 15 minutes for benthic cover and an additional 15 minutes for assessing mobile organism such as fish that are conspicuous. There is a tendency to underestimate fish when using this method of fish senses. This results due to rare species not being effectively sampled and failure to observe all the fish present. However this method represents a quick and easy way of obtaining data in a limited time frame. The data obtained is valid and dependable and can be replicated.

Figure 13: The marine survey sites and affected environment.

6.4 Description of Existing Marine Environment

H.Dh. Makunudhoo was formed on very large complex reef system that forms a small geographic atoll. (Figure 2) . This reef system contains some other small islands and complex ecosystems. Makunudhoo occupies a minute portion on the northeastern tip of this extensive reef system.

The marine environment around Makunudhoo is being somewhat modified since the construction of the inner harbour. The building of quay-walls and a very long entrance channel must have changed the hydrodynamic flow patterns in many respects. The environmental impacts of these

coastal modifications are not well documented since there was no systematic monitoring of the effects of these coastal modifications in the Maldives (Kench et al. 2006)

6.5 Coral Reef System

The reef around Makunudhoo is moderately developed with about 20 percent live coral cover around the harbour area and the entrance channel. The bottom of reef-flat was dominated by sand/rubble, dead coral remnants and un-consolidated rock. The reef slope on the eastern side forms a steep slope. On the western side there is an extended lagoon (*vilu*) which forms the intra-atoll basin of this geographic atoll.

The reef-flat on the west of the island is wide and stretched up to the edge of the atoll reef rim. The slope here is steep too. Reef slope condition here was better than the atoll-basin ward side in terms of coral cover and fish and other marine life. The westward reef slope is 800m away from the proposed development area. Therefore no surveys were conducted at this area. It is also worth noting that the predominant monsoonal current is from the west to east, therefore the proposed re-development work will have very little impact on reef-slope on the atoll-outer reef slope on the western side.

The coral reef system of Makunudhoo is in good condition in terms of diversity and percentage live coral cover. Live coral was mostly seen at the atoll rim reef's slope as well as on the reef-flat near the entrance channel. The LIT reef survey showed that the live coral cover to be about 20 percent (see Figure 14 and 5). Species richness and diversity of corals and fish were also good at the surveyed sites.

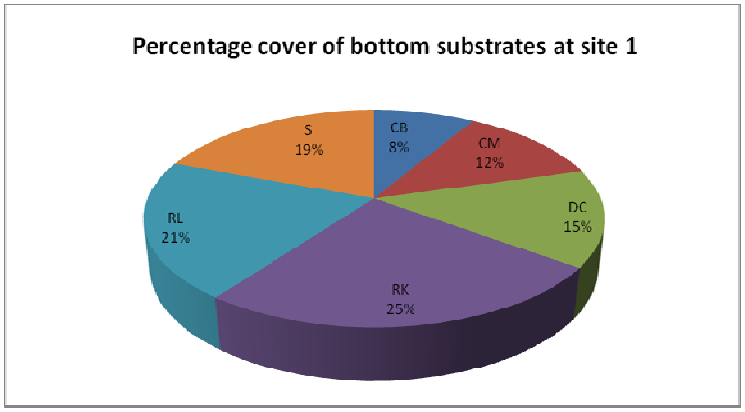


Figure 14: Percentage cover of benthic substrate present at site 1. The dominant forms of benthic cover are rock, rubble and coral sand. Branching forms of *Acropora* spp. (staghorn) corals predominates the live benthic cover. Massive types corals namely *Porites* spp., *Favites* spp. and encrusting type *Pavona varians* were also present. The benthic covers are given in percentages of the bottom area surveyed. CB = coral branching, CM = coral massive, DC = dead coral remnants, RK = rock, RL = rubble, and S = sand

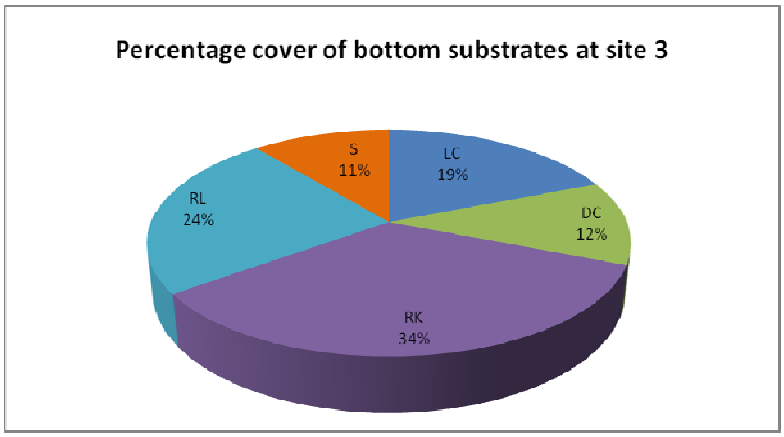
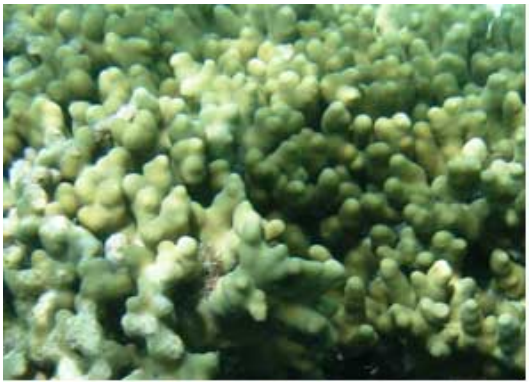


Figure 15: Percentage cover of benthic substrate present at site 2. The dominant forms of benthic cover are rock and rubble. Massive type colonies predominate this area. Branching forms of *Acropora* spp. (staghorn) corals were also present. The benthic covers are given in percentages of the bottom area surveyed. LC = live coral, DC = dead coral remnants, RK = rock, RL = rubble, and S = sand.

Based on the survey data of the two sites, sandy, rocky and rubble areas were found to be approximately 80 percent. The photographs below (Figure 16) shows provide an idea of benthic cover present at the survey sites.

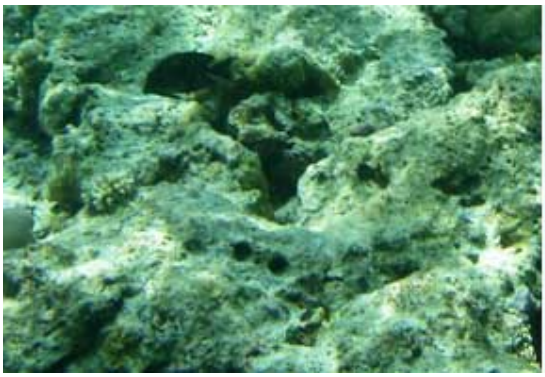


Coral digitate (*Porites* sp.)

Coral branching (*Acropora* sp.)

Solitary corals (*Fungia* spp.)

Massive coral (*Porites* sp.)



Rock

Rubble

Figure 16: Benthic substrates observed at the surveyed area.

6.6 Assessment Fish Communities in the Surveyed Area

The result of 30 minutes swim for fish count along transects at sites 1 and 3 reveals that the abundance and diversity of fish is moderately good on the proposed re-development area. This may be due to the presence of a number of live coral colonies. Since most of the area was covered with rock and rubble, fishes associated with this type of environment were encountered. The dominant fish taxa observed in the surveyed area included surgeon fishes, wrasses (see Table 4) parrotfishes and damselfishes. The presence of *Acropora* coral colonies was associated with the occurrence of butterfly fishes. These fishes are an indicator of reef health. It is likely that the reef-flat is recovering from the 1998 severe coral bleaching event. Some of the conspicuous fish encountered are shown in Figure 17.

Table 4: Results of the fish encounter survey in number of individuals seen (Sites 1 & 3)

Family	Species	S-1	S-3
Acanthuridae	*Acanthurus leucosternon*	7	4
Acanthuridae	*Acanthurus tennenti*	8	4
Acanthuridae	*Acanthurus triostegus*	30	25
Acanthuridae	*Ctenochaetus* sp.	13	7
Acanthuridae	*Naso lituratus*	1	-
Acanthuridae	*Zebrasoma scopas*	2	1
Balistidae	*Balistapus undulatus*	1	-
Balistidae	*Rhinecanthus aculeatus*	-	3
Chaetodontidae	*Chaetodon auriga*	3	2
Chaetodontidae	*Chaetodon citrinellus*	1	-
Chaetodontidae	*Chaetodon collare*	4	-
Chaetodontidae	*Chaetodon falcula*	-	1
Chaetodontidae	*Chaetodon trifasciatus*	4	2
Chaetodontidae	*Chaetodon anthocephalus*	2	2
Chaetodontidae	*Henioches* sp.	-	1
Labridae	*Coris* sp.	1	-
Labridae	*Helichoeres hortulanus*	2	2
Labridae	*Hemigymnus bifasciatus*	-	1
Labridae	*Labroides dimidiatus*	1	3
Labridae	*Thalassoma hardwicke*	2	4
Labridae	*Stethojulis albovittata*	-	1
Lethrinidae	*Gnathodentex aurolineatus*	>20	>30
Lethrinidae	*Monotaxis grandoclis*	10	12
Lutjanidae	*Lutjanus bohar*	1	4
Lutjanidae	*Lutjanus gibbus*	1	1
Lutjanidae	*Lutjanus kasmira*	1	1
Mullidae	*Parupeneus barberinus*	-	1
Mullidae	*Parupeneus bifasciatus*	1	-
Mullidae	*Parupeneus cyclostomus*	1	2
Nemipteridae	*Scolopsis bilineatus*	3	1
Penguipedidae	*Parapercis* sp.	1	1
Pomacentridae	*Abudefduf* sp.	2	1
Pomacentridae	*Pomacentrus nagasakiensis*	2	3
Pomacentridae	*Chrysiptera brownriggii*	2	3

Pomacentridae	*Stegastes* sp.	1	-
Scaridae	*Cetoscarus bicolor*	4	6
Scaridae	*Scarus* sp1.	20	15
Scaridae	*Scarus* sp2.	10	6
Scaridae	*Scarus* sp3.	8	12
Scaridae	*Scarus* sp4.	15	4
Serranidae	*Epinephelus merra*	-	1
Serranidae	*Epinephelus ongus*	1	-
Tetraodontidae	*Arothron hispidus*	1	-
Zanclidae	*Zanclus cornutus*	1	1

Figure 17: Some of the fishes encountered in the survey.

A - *Chaetodon trifasciatus,* B - *Chaetodon meyeri,* C – *An assemblage of Acanthurids, Siganids and Scarids,* D - *Gnathodentex aurolineatus,* E - *Parupeneus bifasciatus,* and F - *Arothron hispidus*

6.7 Reef invertebrates

Four species of mollusks and four species of echinoderms were encountered. One species od sponge was also seen (see Figure 18). However due to the nocturnal nature of mollusks they are hardly seen during the day. What is observed during the timed swims are:

- *Mitra mitra*
- *Tridacna* sp.
- *Conus* sp.
- Common star fish
- Cushion-star
- Diadema urchin
- Black sea cucumber

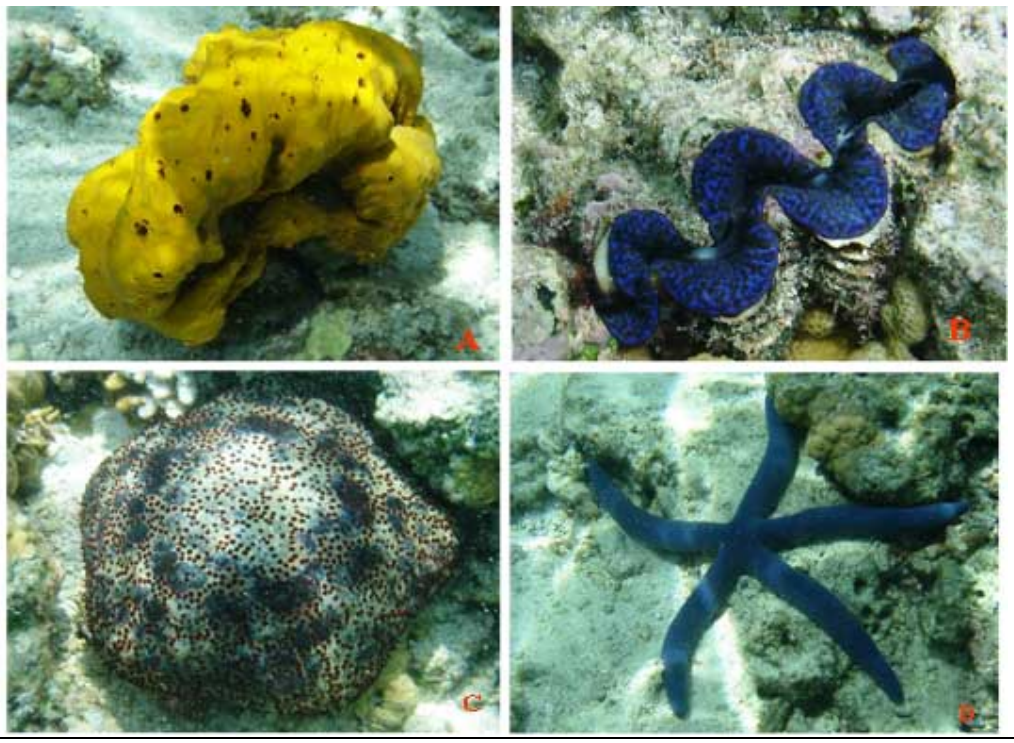


Figure 18: some of the invertebrates encountered in sites 1 and 3. A – A type of sponge, B – Giant clam (tridacna), C- Cushion star (*Culcita* sp.), D - Starfish

6.8 Lagoon System

The lagoon here refers to what is known in as the 'vilu' in the Maldivian Language. The average depth ranged from 4-6m inside the lagoon. The bottom substrate of the lagoon consisted of mainly fine sand.

The lagoon survey using visual observation was concentrated on western side of the island where the possibility of moderate impact from the proposed development exists.

The benthos of the lagoon bottom was not assessed in detail however; lagoon bottom fauna assessments elsewhere showed that the lagoon bottom environment consisted of mainly burrowing polychaete worms, copepods, mollusks, echinoderms and other crustaceans.

The nektonic life of the lagoon consisted of only few species of fishes including travellies, goatfishes, emperors and rudderfish. This was only a visual observation made during the survey. Rare or endangered species were not observed in the locality.

6.9 The seagrass ecosystems

Seagrass beds are known to have high ecological value as they provide important food resources to a range of fish and invertebrates (King 1981; SunAqua 2002), both directly (grazing by fish and turtles) and indirectly (through detrital food chains, or provision of shelter to other associated flora and fauna). Furthermore, seagrasses provide structural habitat, shelter and nursery areas to a range of marine flora and fauna, including many species of invertebrates and fish of fisheries value (e.g., King, 1981; Haywood 1995; SunAqua 2002). This may be true for the extensive seagrass beds found in neritic environments. The significance of seagrass ecosystems to Maldivian environment and biodiversity has not been studied yet. However, it is known that seagrass beds play a very important role in protecting shoreline erosion. In the cases Maldives the presence of seagrass around an island has been linked to the eutrophication in coastal areas. The presence of seagrass in the reef-flat of many fishing island is an indicator of this.

Seagrass was observed almost all around Makunudhoo. Only one species of seagrass (*Thalassia hemprichii*) was recorded on the seagrass bed. The density of the sea grass varied depending on the locality. The density of the sea grass is controlled by wave energy and strong current in some areas.

In many cases presence of seagrass in the Maldives has been linked to the eutrophication in coastal area. The presence of seagrass in the reef-flat of many fishing island is an indicator of this.

A visual observation was conducted on the site 2 which is one of the dense seagrass areas near the harbour. The results are shown in Figure 19.

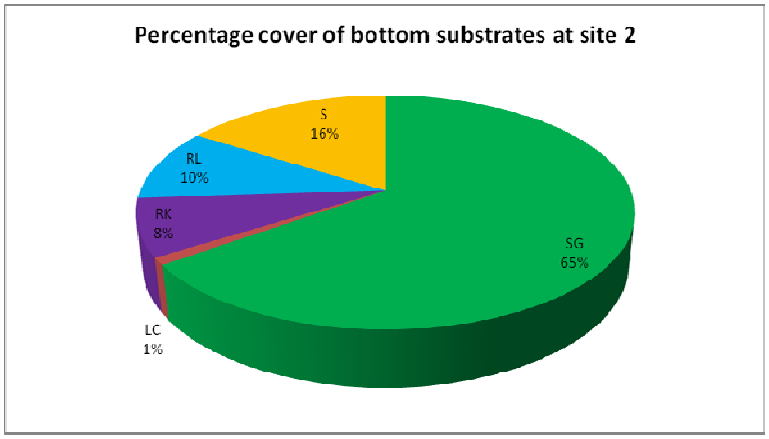


Figure 19: Bottom composition of site 2 – sea grass area.

Nearly 65% of the area was covered by seagrass. The rest of the area was covered mostly with rock, rubble and sand. Live coral species recorded were massive and encrusting life forms of *Porites, Psammacora* and *Pavona*.

A ten minute encounter survey was conducted for fish, molluscs and echinoderms at the area. A total of 16 species of fish belonging to 9 families were recorded on this survey.

Table 5: List of fish species (and their families) encountered on seagrass beds.

Family	Species
Sygnathidae	Corithoichthys haematopterus
Gerreidae	Gerres sp.
Lethrinidae	Lethrinus harak
Labridae	Helichoeres scapularis
	Labroides dimediatus
	Cheilinus fasciatus
	Cheilio inermis
	Coris sp.
Acanthuridae	Acanthurus triostegus
	Zebrasoma scopus
Mullidae	Parupeneus barberinus
	Parupeneus bifasciatus
Pomacentridae	Abudefduf sp.
	Pomacentrus nagasakiensis
	Stegastes sp.
Balistidae	Rhinecanthus aculeatus
Tetraodntidae	Canthigaster benetti

The emperor fish *Lethrinus harak* may be considered as an indicator species of the health of the seagrass area. This species generally inhabits in healthy seagrass beds. Most other species that were observed are herbivores that graze on epiphytes.

Only a few invertebrates were observed within the seagrass zone. This may be due to the timing of survey, since most of the mollusc and other echinoderms are nocturnal. Thick growth of sea grass

also camouflages them making it hard to find. Some of the invertebrates observed at the seagrass area included String-of-beads sea cucumber (*Synapta* sp.), Money cowry (*Cyprea moneta*), magnificent sea anemone (*Heteractis* sp.) and some bivalve species.

6.10 Environmental condition of the dredged material disposal sites

The dredged material disposal sites of Makunudhoo are the south of the existing harbour, adjacent to the southern side quay-walls and used as backfill behind the quay walls and jetty (see Appendix 9). This is the area where the dredged spoil will be disposed from the materials dredged from the harbour basin. Dredged spoil from the Additional materials will be disposed at old disposal area on the northeast of the island, on the eastern side (see Appendix 9). The bottom of this areas consisted mainly fine sand and rubble. No significant benthic life was encountered during the visual observation. The nektonic life consisted of few sand associated species of fish belonging to the families Mullidae, Acanthuridae, Bothidae and Pinguipedidae. Total number of fish encountered was only 17 during the 10 minutes visual observation.

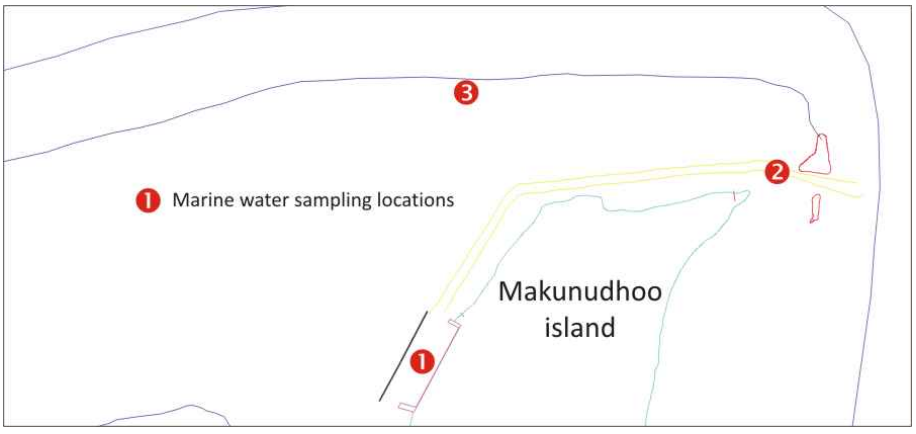
6.11 Marine water quality

Table 6 outlines the marine water quality results undertaken in August 2007. These locations are illustrated in

Table 6: Marine water sampling locations

	LOCATION OF SAMPLE		
PARAMETER TESTED	**HDH.MAKUNUDHOO HARBOUR**	**HDH.MAKUNUDHOO CHANNEL ENTRANCE**	**HDH.MAKUNUDHOO REEF**
Physical appearance	clear	clear	clear
Nitrate	0.0 mg/L	0.0 mg/L	0.0 mg/L
Dissolved Oxygen	5.2 mg/L	5.1 mg/L	6.3 mg/L
Turbidity	0 NTU	0 NTU	1 NTU
PH	7.3	8	
Phosphate	2.23 mg/L	0.27 mg/L	2.2 mg/L

Figure 20: Marine water sampling locations.



7 Existing Socio-economic environment

7.1 Chapter Brief

This chapter will look at the socio economic environment of H.Dh. Makunudhoo Island. The chapter will cover the following:

- Socioeconomic profile of Makunudoo and the region.
- Outcome of the public consutations.

7.2 Introduction

Makunudhoo harbour was built by Government to facilitate access to the island, including loading and unloading of goods, facilitate access of locals and visitors to the island and unloading of fish catches of the locals into the island. The growth of population, increased economic activities and demand for goods has caused more stress on the existing harbour and make it unable to meet the growing need and demand of the community.

The harbour project is one of the most important development projects, which is to be undertaken in the island. The project mainly aims to rehabilitate the damages caused by the Indian Ocean Tsunami of December 2004. This causes difficulties for the island community to access the island, loading and unloading of goods. The government of Maldives has developed Tsunami Recovery and Reconstruction Programme to build the damaged infrastructure and other facilities including the harbours. In this regard, Makunudhoo Harbour building and improvement project will be under taken under the tsunami recovery and reconstruction programme.

This report presents the socio-economic status of the island, views of the community of Makunudhoo and the government's responses on the way forwarded for building the harbour and related facilities.

7.3 Socio-Economic Profile of Makunudhoo

7.3.1 Introduction to Haa Dhaalu Atoll

Haa Dhaalu Atoll is 2nd most populous atoll of the Maldives after Addu Atoll. The atoll has a population of 22,489 people living in 16 inhabited islands. Kulhudhufushi is the capital island of the atoll with a registered population of more than 6500 people. Kulhudhufushi is the most populous island of the atoll with more facilities compare to other islands of the atoll. Kulhudhufushi has the northern secondary school, regional hospital, atoll office, northern regional harbour, campuses of Maldives College of Higher Education and other facilities run by the government. Nolhivaranfaru was the old administrative capital of the atoll, where the atoll office was located in the island until 6th May 1992.(Luthfee, 1995) There are 35 uninhabited islands in the atoll, most of which are leased to the atoll people as it is in other atolls of the Maldives.

The government has built a regional airport on Hanimaadhoo island during early 90's, which currently serves the most northern 3 atolls. There are daily flights operates from the capital Male' to Hanimadhoo. The islands including Hanimadhoo, Nolhivaranfaru, Nolhivaramu, Finey, Naivaadhoo, Kurinbi, Keylakunu, Makunudhoo and Kulhudhufushi are islands with historical and archeological values. Although there are no proper assessments done to monitor the historical and

archeological values of these islands, until today there are remains of old sites existing in some of these islands. (Luthfee 1995).

Total No. of Islands	35
Inhabited Islands	16
Capital	Kulhudhufushi
No. of Women	11043
No. of Men	11446
Total Population	22489

Table 7: Quick Facts of Haa Dhaalu Atoll

The main income generating activities in the atoll are mainly limited to fishery, Tourism and Agriculture. The government has currently leased new islands from the atoll for tourism development and agriculture. This aims to create more job opportunities for the locals. The number of inhabited islands with small population has become one of the main challenges of the atoll. There are plans to relocate people from some of these islands to Hanimaadhoo and Nolhivaranfaru. The relocation programme started by the government in Nolhivaranfaru is believed to bring people from 2-3 small islands to the island.

The Indian Ocean tsunami of December of 2004 has caused damages to most of the islands of the atoll.

7.4 The Island of Makunudhoo

7.4.1 Setting

Maknudhoo is located 261 km away from the capital Male'. Makunudhoo is an average island with an area of 60 hecters. The island is located at 72^0 42' 20" E and 06^0 24' 24" N. The average length and width of the island is 200m and 500m respectively. The closest inhabited islands to Makunudhoo from the atoll are Vaikaradhoo and Neykurendhoo. Makunudhoo is the only inhabited island located on the Maamakunudhoo atoll, which is among one of the 26 geographic atolls of the Maldives. The nearby seas of the island are known as good fishing grounds during the north-east monsoon. (Luthefee, 1995)

7.4.2 Population

Makunudhoo is the fourth most populous island of the atoll with average growth rate of -0.49 (Census 2006). The island has a registered population of 1408 people.

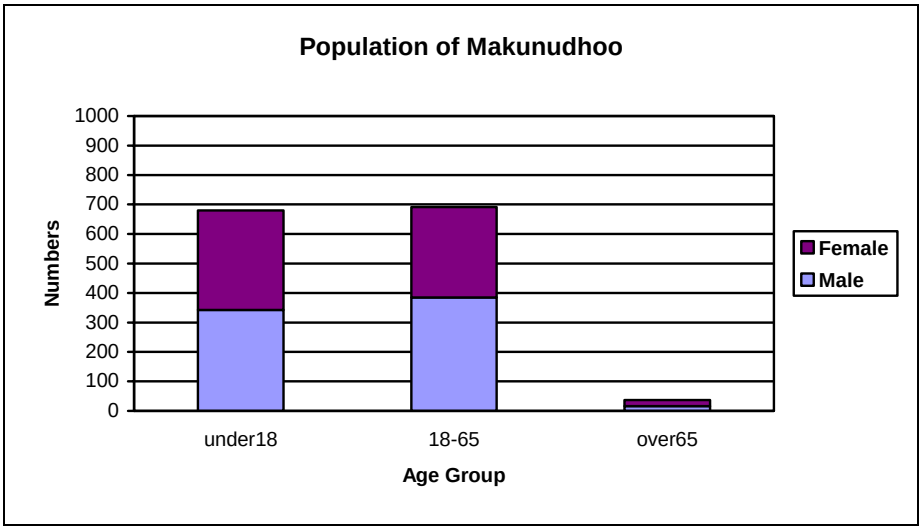


Figure 21 : Population of Makunudhoo

The census 2006 has revealed that Makunudhoo stands at the fourth most populous island of the atoll after Kulhudhufushi, Nolhivaramu and Vaikaradhoo. The population density of Makunudhoo is 23 persons per hectre, which is less than the national average, which stands for 25 persons per hectare.

The total male population of the island is 52.8% and the female stands at 47% of the total Reviewing the population by major age groups reveal that 48% of the population is under 18 years while 49% of the population is between 18 years and 65 years and the rest, (2.6%) is above 65 years.

In terms of sex ratio Makunudhoo stands at 95 males per 100 females, which is the highest sex ration in the atoll (Census 2006).

In the past the island was used as one of the main islands for exiling prisoners, mainly due to isolation of the island. The current president of the Maldives Mr. Maumoon Abdul Gayyoom was also expelled to the island during late 80's.

7.4.3 Employment

The major income earning activities of the island people are recorded as fishing. Small scale agriculture and tourism also contributes to island economy.

Fishing is the main occupation of the island people, whereas more than 19 fishing dhonis and traditional fishing vessels are used by the local fishermen. The fish catch are sold to the collector vessels and to the island. The government of Maldives represented by Ministry of Fisheries, Agriculture and Marine Resources has leased, the island Huvahandhoo from Haa Alifu Atoll for fish processing and other fishery related work for 25 years. The winner Jausa Fisheries Company Pvt Ltd has started to develop the island after; it was on hold for more than 3 years. This will give more opportunities the local fishermen from the most 3 northern atolls to sell their daily catches to the collector vessels of the company. The women also practice fishery related income earning activities such as dry fish making. Tourism is also one of the sectors where youth population of the island are employed.

The island has leased lands for making fish storage facilities. Currently, there are two parties building storage facilities to store frozen fish prior to sell to the customers. There local and expatriate workers working on these sites.

There are 15 retail trade shops in the island, which also contributes income earning opportunities for the people and help people to get their goods from the island. The two Dhonies which operate between Male' and island supply the goods and construction materials to these shops and also to the people.

There are government employees who work at Island Office, Court, and Health Centre, who are paid by the government.

7.4.4 Health

The island has a Health Centre with technical, administrative and support staffs. Makunudhoo health centre has 1 physician, 2 nurses, 1 community health worker, 1 family health worker, 2 mid wives. There is only one pharmacy in the island. The quality and availability of better health care services and facilities are one of the main concerns the island people. This makes them to travel to Kulhudhufushi Regional Hospital for consultation after spending huge amount money for the travel.

7.4.5 Education

Makunudhoo has government run school which teaches to London GCE O'Level. Most skilled teachers of the school are expatriates. Almost all local teachers of the school are unskilled teachers without any form of teaching education. The island also has a private owned pre-school which teaches from kindergarten to UKG level.

Quality of education and lack of trained local teachers are one the main concern of the island people. This is perhaps one of the reasons why people migrate from the island to the Capital Male'. The students who sit in the GCE O'level exam rarely get good results, indicating the poor quality of educating and facilities available at the island school.

7.4.6 Housing

Makunudhoo is big island compared to the island population. Therefore availability of land is not a concern in the island. The island has a land area of 60 hecters, which is an average of 23 hecters per person.

The island office records show that, there are 458 plots allocated in the island and from which 226 are boundary marked houses, 75 house boundaries are not marked, and 226 houses has not been fully built. It was also noticed the island still has 500 plots available to meet the future demand of the people.

There is a greater need to develop appropriate land use and land management plans for the island to utilize the available lands on sustainable manner and to avoid any issue that will perhaps arise in the future.

7.4.7 Utilities

Most utilities and services available in the island are run by the community through the Island Office.

7.4.8 Water

There is no community water supply network in the island. The population depends on rain water, harvested from roof tops as the main source of potable water. There are 193 rain water storage tanks owned by the households. It was found that the island has received 20 number of 5000 litre tanks and 15 number of 2500 litre tanks after the tsunami. The increased number of community tanks helps the public to depend on these tanks during the dry period. Water collected in the public tanks are also used by the local fishing dhonis for drinking and cooking. The island is supposed to receive more household water tanks as part of government's scheme on increasing access to safe water in the outer islands. Ground water is consumed for potable purposes during the dry period. The ground water is mainly good in most parts of the island. The increasing number of water sealed latrines and installation of home made septic tanks are contributing ground water pollution and salinization.

7.4.9 Sewerage

There is no island wide sewage network for the island and all households have their own system of sewage disposal. The main method of sewage disposal in the island is household septic tanks with soak pits, which are made locally. The condition of the tanks and soak pits causes ground water contamination due from sewage and waste water. There are more than 120 water sealed toilets in the island. There are no outfalls connected to the sea.

7.4.10 Solid waste disposal

There is no engineered solid waste disposal location in the island. All types of waste generated from the houses are disposed either in waste disposal locations identified by the island office, or buried within the plots. The waste is either burnt or buried

7.4.11 Electricity

Makunudhoo has a public power house run by the island community. The Island Office manages the power house under the guidance of Island Development Committee. Electricity is provided to all house holds and community building on tariff basis. Income generates from electricity supply is utilized for the operation and maintenance of the power house and electrical network. The power house contains 3 generator sets of 35, 70 and 100 KV. Almost all houses of the island use LPG for cooking. LPG is supplied by local traders. There are some houses which depends on fire wood for cooking

7.4.12 Transport

The island size does not require having land vehicles and other modes of land transport. This makes people prefer to walk rather than using motorize vehicles. Foot bikes are widely used by the islanders. There are few motorized land vehicles including few motor cycles, pickups and one taxi. Most of which are used for carrying goods and construction materials. There are many sea vessels in the island. Most of which are used as fishing vessels. The island has more than 29 fishing vessels. There are two local boats which travel between the capital Male and the island. These vessels mainly carries goods and construction materials from Male' to the island. The boats are also used by locals as passenger vessels. There are new boats building in the island and most of which are made from fibre materials. These vessels need more space which cannot be accessed to the existing harbour.

7.4.13 Telecommunication

There are no land line telephone facilities available in the island. However the island office and island court are equipped with telephone and fax facilities. The population has access to mobile telephones provided by two local service providers including Dhiraagu and Wathaniya. Prepaid telephone cards are available from local shops. Internet facilities are available at the Health Centre. Radio sets, Television sets and Video facilities are available in almost all households of the island. Satellite TV systems are also connect to most of the houses. There are Computer systems in some houses, which are mainly used by school children for educational purposes.

7.5 Public consultation

Consultation with the major stake holders of the beneficiary community forms an important part of the process of assessing the environmental and socio-economic impacts of the proposed harbour development project. The consultation process has been used to confirm the issues which need to be considered in the assessment of effects. The consultation process was conducted under the guidance of the client and limited to the following form:

- Meetings and interviews with island chiefs; and
- Meetings with Island Development Committee and Women's Development Committee.

The meetings were conducted and assisted by the island chiefs and staffs of island office. The following are the summary of issues raised during the meetings held with island chiefs and island committees.

7.5.1 Meeting and interviews with island chiefs

The meeting was held at island office and attended by the environmentalists, socio-economists of the EIA team and official of the Ministry of Construction and Public Infrastructure.

The following issues have emerged from the consultation with island office officials

- Difficulties in using the existing harbour facility;
- lack of proper sea walls and anchoring facilities on the existing harbour;
- The size of the existing harbour is insufficient for the island due to increase in number of sea vessels;
- The harbour was damaged during the tsunami and no maintenance work has been done so far;
- Continuous concerns and complains of the island community over the slow upgrading work of the harbour ; and
- The island is one of the main island where fishing dhonis come from all parts of the northern region due to closeness of the good fishing grounds. These dhonis are also facing difficulties to enter the harbour due to lack of space and shallowness.

7.5.2 Meeting with Island Development Committee and Women's Development Committee

The community meeting was guided by the island chief and officials of the island office. The consultant has explained the committees about the assessments and explained that the process involves mobilizing the funds for upgrading the harbour. It was also briefed to the committees that work can only be started, when and if the funds are allocated after the assessments and receive of funds.

The following main issues have been raised during the meeting.

- The existing harbour was not constructed in accordance with requirements of the island community;
- The existing harbour committee mandates and responsibilities can not be enforced due to lack of proper procedures and funds;
- The new harbour size shall meet the demand of the vessels and future economic development of the island, since the island is known as a major spot for fishing dhonis from all parts of the northern region. Therefore the harbour shall address these issues and make provisions for providing services to these vessels and which creates more income generating activities for the locals;
- Uncertainties and delaying in construction of the new harbour facility as the proposed upgrading work and new harbour project has already been informed to the community in several occasions, and surveys and assessment were also conducted earlier. ;
- There are new boats building in the island, and these boats can not use the existing harbour mainly due to the size.

8 Environmental and Socioeconomic Impacts and Mitigation measures

This section will look at the impacts of the proposed harbour rehabilitation programme on the coastal and marine environment. Furthermore, measures to mitigate impacts would be suggested so that overall environmental improvements and damage could be minimized. The following paragraphs outline the coastal and marine impacts that have been identified. The impacts have been identified for both the construction and operational stage.

8.1 Prediction of impacts on the coastal environment

Impacts on the marine environment from the proposed coastal modification have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analyzed to predict the extent and significance of the impacts that may arise from the proposed harbour rehabilitation project's activities. The assessment was also based on area calculations of the coastline that fall within the project boundary and anticipated to be impacted.

8.2 Prediction of impacts on the marine environment

Impacts on the marine environment from the proposed coastal modification have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analyzed to predict the extent and significance of the impacts that may arise from the proposed harbour rehabilitation project's activities.

8.3 Uncertainties in Impacts Identification

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorpholical or social conditions in a particular place.

Although measures will be taken to mitigate known impacts, there is always the probability that an unforeseen impact will occur. It is also important to note that some of the impacts predicted may turn out to be far greater than predicted. This will make mitigation measures ineffective. To avoid or reduce the chances of such events, it is vital to monitor key important parameters at the vicinity of the project.

8.4 Impacts on the Marine Environment from the Proposed Harbour Rehabilitation Project

Impacts on the marine environment from the proposed coastal modification have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analyzed to predict the extent and

significance of the impacts that may arise from the proposed harbour rehabilitation project's activities.

Four components of the marine environment that will be impacted are identified as the lagoon, the reef-flat, the seagrass beds and the coral reef system. Quantitative assessment of potential direct and indirect impacts due to the proposed development was based on area calculation of the lagoon and coral reef.

Impacts from these activities will be due to disturbance to the lagoon, seagrass and reef-flat bottom in construction activities and release of fine sediment to the water column.

Indirect impacts will be felt to the pelagic organisms inhabiting these areas that are close to the re-development zone. Indirect and long term impacts on the marine environment will be more accurately assessed by long term monitoring and assessment as part of this environmental assessment.

8.5 Impacts on the Marine Environment

Harbour dredging or rehabilitation projects have both construction and operational impacts on the marine and coastal environment. These impacts may be either short term reversible or long term irreversible damage or alteration to the marine and coastal environment. The impacts identified here will be according its location and magnitude. The intensity or severity of the impacts is further grouped into negligible, minor, moderate and major. This will help in identifying and carrying out remedial and mitigation measures. A description of the impact categories are presented below (LaMer 2006).

- Negligible: no significant impact on environment
- Minor: the impact is short term and cause little impact on the environment which may be reversible on the long run.
- Moderate: Impacts significant, may cause long term environmental concerns but are likely short term, acceptable and justifiable
- Major: long term impact, large scale environmental alterations

Potential environmental impacts predicted for the development will the impacts during construction and irreversible modifications as a result of dredging and excavation. These impacts are presented together with mitigation measures in the (Table 9).

Dredging and excavation generally lead to major impacts on reef habitats, lagoon and coastal hydrodynamics. The Impacts of excavation and dredging may range from smothering of live corals and other flora and fauna. Coastal modification involved in the construction of the harbour can have short to long term impacts on the on the coastal processes and beach profiles of the island. Specific impacts on the marine environment arising from the proposed project will be mainly an alteration of the bottom of reef-flat where dredging is done and a minor impact on the sediment movement along the shoreline and near the entrance channel, and a minor impact on the benthic and nektonic communities that inhabit in the possible impact area. The predicted impacts are minor because this project is a rehabilitation project. The proposed dredging areas and spoil disposal sites were already sites that were used during the initial construction of the harbour.

8.5.1 Mobilization Impacts

The transport and supply of construction material, the excavator and other heavy duty equipments may have an impact as a result of increased traffic with barges and other large vessels. The impacts may arise from:

- Accidental spillage of construction materials (cement bags, timber, iron bars).
- Accidental oils and other chemical spills.
- Accidental grounding of large vessels.
- Propellers' wake can break fragile corals.
- Anchor damage from the vessels.

8.5.2 Impacts from Construction Materials and Other Waste

Construction materials such as cement, timber, and fuel for excavators and trucks have the potential to damage the marine environment. Pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction.

The dredge material will be disposed at the area located at the map (see Figure 22). Disposing dredge material at the shoreline would have minor irreversible impacts on the near shore habitat since the project will dispose materials on the old disposal sites. Disposal of dredge material at these sites may have a short term positive impacts. This can reduce the rate of beach erosion. However, the long term possible alterations in coastal processes of the area will not be clear only after long term monitoring.

During the construction of the quay-walls, leaching of cement will have short term minor impact on the immediate area. Once the cement is hardened, re-colonization of marine fauna and flora will take place.

8.5.3 Impacts due to Construction Work

Deepening work of the entrance channel and harbour basin will be carried out using excavators. Therefore the negative impact of sedimentation is unavoidable even with the construction of sandy bund walls. The impacts of sedimentation are short termed since the monsoonal currents will aid in the dispersal and removal of fine suspended materials. Growth and recruitment of live corals may have moderate short term impact due to sedimentation. Nevertheless this impact could be reduced by imposing silt screen protection around barges carrying the excavator to prevent turbidity outside the nearby location of the barges.

The impacts of excessive sedimentation on corals include:

- Direct physical impacts like smothering of corals and other benthic organisms,
- Reduced light penetration reducing the productivity of corals.
- Formation of false bottoms due to unstable shifting of sediments.
- Eutrophication due to increased fine sediments leading to algal blooms.
- Formation of anoxic (black) bottoms under the fine sediments.

Construction of wharfs and protection walls may have impacts on the reef-flat habitat by seepage of cement material. Construction of protection wall include a lot of manual transport of cement bags and other materials, trampling and breakage of live coral is possible at the seaward side of the harbour basin and the sides of the entrance channel.

8.5.4 Monitoring Turbidity levels during dredging and reclamation

Given that the water quality in marine environment of the Maldives is very good, the turbidity levels behind zone of mixing in dredging operations shall be less than 10 NTUs.

The compliance locations given in the monitoring section of this report shall be considered the limits of the temporary mixing zone for turbidity allowed during construction. If monitoring reveals turbidity levels at the compliance location indicated above is greater than 10 NTUs (or 10%) above the associated background turbidity levels, whichever is greater, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels.

The following measures shall be taken by the Proponent whenever turbidity levels at the limit of the mixing zone exceed the limits given in this report.

- Immediately cease dredging/reclamation works
- Modify the work procedures or wait for turbidity to clear in the compliance location
- Continue to undertake turbidity tests as given in the monitoring programme
- If the problem persists, use physical barriers to reduce the effects of sedimentation

8.5.5 Impacts of Built Coastal Structures

The impact of anthropogenic physical structures such as breakwaters, access channels and harbours on the coastal processes and marine flora and fauna, can be quite significant and often permanent if they are undertaken in sensitive environments. Most of the coastal works are construction of sea wall and jetty which are at a considerable distance away from the coral reef. Impacts are therefore going to be minor.

8.5.6 Impacts due to Harbour Operation

Impacts associated with the harbour operation can be considered as minor to moderate and short to long term. These impacts include (but are not limited to):

- Poor water quality due to siltation and stagnation of water.
- Impacts due to accidental spillage of oils, other chemicals and waste.
- Hydrodynamic changes forming dead zones in the inner harbour where litter may accumulate

8.6 Significance of the Impacts

Impacts that may arise from activities of the proposed harbour rehabilitation project were categorized into the characteristics mentioned in Table 8

The significance of impacts was determined based on these characteristics and analysis of the impacts from this project and other analogous projects. These impacts correspond in the worst case scenario and after mitigation measures were taken.

Table 8 shows the main impacts that will arise from the proposed project activities and their significance based on impact characteristics.

Magnitude of impact is calculated in relation to the total area of the lagoon and the coral reef (see Figure 22). Direct geographic range of impact felt will be the immediate proposed development area and indirect impacts will be felt on a larger area due spreading of fine sediment. Duration of the impact is predicted in terms of severity of impacts. The impacts are likely to be felt on an estimated 5% of the lagoon and reef-flat of that extensive reef system. Estimated error of these predictions may vary significantly due to uncertain weather conditions.

Figure 22: Possible impact areas of the proposed harbour rehabilitation project

Reversibility of impacts was predicted based on natural recovery of the habitats affected. The coral reef naturally takes longer to recover than the lagoon habitats. Significance of the impacts is predicted based on the nature, geographic range where impacts are felt, magnitude, duration and reversibility of the impacts.

Table 8: Significant impacts of the proposed harbour rehabilitation project

Impact characteristics	Harbour basin re-dredging	Reclamation / Dredged spoil disposal (on the southern beach and on the old disposal area south of the entrance channel)	Channel re-dredging
Nature of impacts	Cumulative, long term	Cumulative, long term	Cumulative, long term
Magnitude of impacts	Minor- negative	Minor- negative on coastal ecosystems. Minor +ve on socioeconomic aspects: more land	Minor-negative
Geographical range and environmental attributes	Direct impact on 7360m^2 of the harbour basin Direct impact on seagrass bed 0m^2 Indirect impact on 1000m^2 of reef-flat and lagoon	Direct impact on 2000 to 3000m^2 of beach Indirect impact on 1000m^2 of reef-flat and lagoon	Direct impact on 75m^2 of lagoon Indirect impact on coral reef on 300m^2 Indirect impact on seagrass bed 200m^2 Indirect impact on 3000m^2 of reef-flat and lagoon
Duration of impacts	Short term on coral reef and lagoon and long term on reef-flat, seagrass beds and beach	Permanent alteration of physical and biological system of the sea bed and marine life.	Short term on lagoon and long term on reef-flat and seagrass beds.
Reversibility of impacts	Permanent alteration of physical and biological system of the harbour basin, Short term reversible impacts on coral reefs, lagoon and reef-flat and seagrass beds adjacent to the harbour basin	Irreversible impact on the benthic life of the filled area	Permanent alteration of physical and biological system of the entrance channel basin and sand dumping site, short term reversible impacts on coral reefs, lagoon and reef-flat and seagrass beds adjacent to the entrance channel basin
Significance of the impacts	Minor impacts on the harbour basin, shore-line and beach, moderate impacts on the adjacent areas of reef-flat and other environmental attributes	Moderate impact on benthic communities. Impacts to hydrodynamic process unclear.	Minor impacts on the entrance channel basin and sand dumping site, moderate impacts on the adjacent areas of reef-flat and other environmental attributes

8.7 2.4. Mitigating the Impacts

Several actions can be taken to minimize the above mentioned impacts. Expert consultations, past experience and local knowledge are essential in reducing the impacts. Mitigation measures are

employed to eliminate or reduce the severity of any predicted impacts. This will ultimately improve the environmental outcomes of the project. The predicted impacts on the coastal environment of Makunudhoo can be mitigated by joint cooperation and careful environmental planning. All parties, the Island authorities and the contractors must work carefully to eliminate or reduce the identified risks. Given the magnitude of impacts for this project, the adverse effects can be mitigated at virtually no cost if best environmental practice and precautionary principles are used.

Supervision and inspection of the project activities are imperative to minimize adverse impacts. Therefore, competent environmental consultants with experienced in same or similar work in the local environment will be consulted and allowed to inspect and monitor the work activities of the project life-cycle.

Supervision of work will be carried out by a competent and independent party with experience of similar work and its possible impacts to the environment. Supervising party will not be in anyway related to the contracted party to ensure that mitigation measures were taken even at extra project costs. Supervising party will carry out compliance monitoring and reporting to ensure that the predicted impacts are not exceeded. If predicted impacts were exceeded, the work will be halted and impacts re-assessed and reported.

Proposed project's work will be carried out to coincide with low tide and easterly current so as to minimize effects of sediment on the reef. The work will be carried out in calm weather and sea condition.

Machinery, equipment and vessels used in the project activities will be maintained in good condition and operated in a manner that they do not pose a risk of the environmental degradation.

All work activities will be kept to the minimum period of time to reduce impacts on the environment.

The monitoring programme specified in this report will be followed and reported in both work phase and operation phase.

Table 9 provides more information on potential impacts during construction and operation of the harbour rehabilitation project and mitigation measures (LaMer 2006).

8.8 Socio economic impacts of the proposed project

8.8.1 Easy accesses to the island.

The proposed harbour will make it easier for the island fishermen, visitors and local traders and public to have easy access to the island. The existing harbour has limitations in terms of access to the island due to lack of proper facilities including proper anchoring facilities. The existing harbour area cannot be access by large vessels due to inadequate depth and lack of minimum width in some areas of the access channel. The island being located near the good fishing grounds, dhonis from all parts of the northern region visits the island and which will help the island people to make more income if necessary services and facilities are available.

8.8.2 Protection for fishing and other vessels

The local fishermen have started to build bigger fishing vessels to meet the demand of more fish catch. The existing harbour cannot be accessed by bigger fishing vessels, since it has limited area. This has become the major concern of the local fishermen. The harbour has no proper seawalls

causing damages to vessels during high seas. The proposed new harbour development project will address the issues.

8.8.3 Decrease accidents during access

The lack of anchoring facilities, proper landing jetty and size of the harbour causes the vessels to use smaller boats to access the harbour. This method is used to load and unload the goods. This very often causes accidents whereby causing greater losses to the goods and sometimes to the workers. Although proper data is not available on the number of accidents and losses causes to the goods and workers, it is believed that this can be very much reduced after completion of the new harbour.

8.8.4 Other impacts

There are other positive impacts which can be summarized but not limited as described below.

- Create a service market after providing water and fuel for vessels;
- Increase visitors for the island due to easy access especially from tourist resorts;
- Increase fishing catch by using larger fishing vessels;
- Increase income of local community

8.8.5 Other issues

The main negative impact would be dissatisfaction of the community due slow progress of the project and lack of proper harbour management procedures. These issues need to be addressed to avoid any community unrest and future operation and maintenance of the harbour and its facilities.

Table 9: Summary of Potential environmental impacts during construction and operation of the harbour rehabilitation project and mitigation measures identified to minimize the impacts

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Littering on and marine environment	Avoided by proper planning in ways transportation and disposal. Use 3R- reduce, re-use, recycle. Proper disposal	Reef-flat, lagoon, seagrass and land	During construction	Minor to moderate, short term -ve impact. Reversible	Contractor, Island authorities	N/A
Damage to reef by Loading/unloading works	Raising awareness and utilizing environmental best practice, careful planning	Reef-flat and reef-slope, seagrass and lagoon	During construction	Minor, short term –ve impact. Reversible over long run	Contractor, Island authorities	N/A
Sedimentation and siltation on the reef and lagoon due to excavation works	Creation of a sand bund to reduce the sedimentation impact, carried out in low tides and use of silt screen around barges during excavation works	Reef-flat and reef slope lagoon	During construction	Minor, short term –ve impact. Reversible over long run	Contractor, Island authorities	N/A
Loss of habitat, damage or death of coral at the entrance area, harbour basin and protection wall area	Clearly marking the areas to be excavated. Dredging will be carried out mainly on already dredged areas	Reef-flat, seagrass and lagoon	During construction	Minor, short term –ve impact since these are re-dredging sites	Contractor, Island authorities	N/A
Loss of habitat at the spoil disposal site at	The material will be disposed at the existing island created	Reef-flat, seagrass and	During construction	Minor, long term –ve impact.	Contractor	N/A

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
the entrance channel	before when the channel was first cut	lagoon		Most likely irreversible.		
Loss of habitat at the spoil disposal site on the beach located south of the existing harbour	The material will be disposed on an reclaimed area where the dredging material were disposed during the construction of the harbour	Beach	During construction	Minor, long term –ve impact. Most likely irreversible.	Contractor	Bund to be forecasted to prevent high turbididty level for the return flow (cost already included in the project cost)
Habitat modification at the spoil disposal site at beach line and coastal vegetation of Makunudhoo	Only the minimum amount will be disposed to contour with the shoreline. The existing beach is already an old disposal area used during the construction of the harbour	Reef-flat, and beach	During construction and Operational phase	Minor, long term –ve impact. Most likely irreversible. Positive impacts due to a reduction of coastal erosion.	Contractor, Island authorities	same as above
Impacts of storm-water drainage and coastal flooding.	The spoil will be disposed at sites adjacent to the areas where spoil has been disposed before. The elevation will be maintained at the same level of the adjacent areas.	Coastal area	During construction and Operational phase	Minor to moderate, impacts not fully clear. Most likely no change. It must be studied during detailed design phase	Contractor, Island authorities,	Sedimentological expertise to be included in the detailed design phase
Impact of dredging works on the existing	Dredging will be carried in a manner that will not	Entrance channel and	During construction	Minor, –ve impacts on the operation of the	Contractor, Island authorities	N/A

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
operations of the lagoon	interfere with the operation of the harbour	harbour		harbour		
Air pollution	Completing the excavation works as soon as possible.	Air	During construction	Minor, short term –ve impact. Reversible	Contractor	N/A
Noise pollution	Completing the excavation works as soon as possible, avoid working at night	Land	During construction	Minor, short –ve term impact. Reversible	Contractor	N/A
Possible erosion due to obstruction of littoral sediment movement	Keep part of the dredge material on the island to supplement areas showing erosion and undertaking maintenance dredging regularly	Beach and harbour basin	Operational phase	Minor and unpredictable impact. Most likely no change	Island authorities,	Cost is difficult to estimate since the timing of impact unpredictable Sedimentological expertise to be included in the detailed design phase
Solid waste	Employee a staff for monitoring and cleaning the harbour	harbour	Operational phase	Minor, long term –ve impact Reversible	Contractor	monthly salary equivalent to 2000.00
Accidental spillage	Put up sign boards	harbour	Operational phase	Minor, short term –ve impact Reversible	Island authorities	1000.00 -1500.00
Waste debris from the demolition of quay	Debris will be used as core materials for breakwater	Coastline and beach	During construction	Minor, short term –ve impact. Most likely	Contractor, Island authorities	No cost. A clause will be included in

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
wall may impact the environment if they are not disposed properly.	construction or as filling material behind quay wall.			Reversible.		the contract document for the contractors to utilize the debris.
Construction of new breakwaters, jetties and new L-shaped quay wall using reinforced concrete prefab walls.	Construction works other than dredging will be mainly quay wall and jetty construction using pre-fab L-shaped concrete walls. Impacts of these works on the marine environment will be negligible as they will be executed on dry land. Proper construction methods to ensure that only work are confined within the designated areas.	Harbour area, mainly along the quay wall and breakwater length.	During construction	Minor, short term –ve impact. Most likely Reversible.	Contractor	No cost. A clause will be included in the contract document for the contractors to use debris.
Changes to southern coastline	Disposing the sand on the lagoon so that it contours with the beach. Compacting sediment to minimize sand loss caused by erosion.	Immediate lagoon and coastline south of the harbour	After construction	Minor to moderate. Irreversible	Contractor, Client	No cost. Ongoing monitoring will be done. Sedimentological expertise to be included in the detailed design phase

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Impact on coastal stability of adjacent shore line.	Same as above	Coastline and beach	During operational stage	Moderate, long term	-	Not possible at this stage as this is a feasibility study. However, monitoring cost has been included in the project.

9 Stakeholder Consultations

This project involves various stakeholders at different levels. From the initial project planning stage, stakeholder consultations have taken place at various levels. For this EIA, stakeholder consultations were undertaken with the client and the community extensively at various stages. During the consultations with the client, their plans and expectations were noted while at the same time, the community consultations were used as a mechanism to gather information for the proposed rehabilitation programme. As the harbour comes under the jurisdiction of MCPI, the formal channel of communication in place will be directly between the MCPI and the island community. However, for this study, the consultants engaged in direct communication with the client, the community and other relevant agencies. Once the project goes in to implementation, then MCPI will be the lead government agency overlooking the works.

Stakeholder consultations were held with the following agencies and groups.

9.1 Consultation with the proponent

The proponent for this project is Ministry of Construction and Public Infrastructure. Consultations were undertaken at various stages of the project. Initial consultations were conducted with the client and the funding agency AFD on 22 August 2007. Discussions were focused on gathering preliminary data and information from the client before the field visit. The project consultants, SOGREAH outlined the study and the data collection methodologies that would be undertaken during the field visit. The client was also briefed about the environmental components and how the data would be collected. The client briefed about the present policies and construction practice of the government for harbour projects. A final costing for the project was finalized after consultation with SOGREAH and the client.

A second meeting was held the client, AFD and the project consultants, SOGREAH on 14th November 2007. The purpose of this meeting was to present the findings of the technical study and obtain clients approval for the proposed rehabilitation programme. During the meeting, the project consultant presented the study and the findings for each island. For each island the proposed rehabilitation programme for the harbour was presented. The client and AFD provided their input for the proposed project in terms of revising the costs and proposed layout. In general, the proposed layouts and rehabilitation programme was accepted by the client with few minor modifications.

Brief environmental presentations were also presented by the projects local partners, Water Solutions Pvt. Ltd. The presentation focused on the environmental components of the study that mainly focused on the structure and the content of the EIA report.

9.2 Consultations with the Project Consultants

As environmental consultants, Water Solutions also undertook consultations with the project's lead consultant to discuss environmental issues related to the project. The major environmental concern for Makunudhoo was identified as the use of dredged material from the harbour that will be used as a fill material on the south of the harbour as illustrated in

Appendix 8. The dredged materials from the access channel will also be disposed in to the lagoon where previously the area has been used for dredge spoil disposal. Discussions were undertaken for the proposed rehabilitation project so that the environmental damage could be minimized by allowing methods and materials to be reused in the new project. Hence, detail calculations were undertaken by the lead consultant to assess the amount of dredging required and to use them productively in the rehabilitation project so that they will be disposed in an environmentally acceptable manner. It should be noted also that the chosen disposal area have been already used during the construction of the harbour. The southern beach is a reclaimed area build with the excavated material and the disposal area located south of the entrance channel was also used as disposal area. On the satellite photograph, it is easy to see these two disposal areas (dark zone on the south of the entrance channel and grey zone showing the reclaimed area for the beach located south of the harbour. Detail calculations were made and have been illustrated in Appendix 9..

9.3 Consultations with the local community

Comprehensive Informal and formal consultations and discussions were held with the community through randomly discussing with the islanders, fisherman and also by means of a formal community meeting. Generally, consultations were held to assess and identify the different socio-economical aspects of the project. The discussions were also used as a means to identify what the community / local fisherman considered as the most significant difficulties, constraints and what aspirations they have regarding the project. These consultations also helped to gather other information that are usually not documented in the island office such as harbour traffic at different periods of the year.

More details of the socio-economic aspects have been presented in the “Socio-economic” section of the report.

9.4 Consultation with Private companies

Ensis and Euro Global are two private companies that are engaged in fishing activities in Makunudhoo. Discussions were held with ENSIS to obtain their views and inputs to the project. Following are the summary of the outcomes of this consultation.

- Both companies view the harbour rehabilitation as an important project that will benefit the local economy greatly.
- Current infrastructure of the harbour is not adequate for expansion and needs major upgrading.
- Access channel is a problem for large vessels and has to be dealt with as soon as possible.
- The island is favoured not only by them, but by many fisherman due to its location.

9.5 List of persons consulted

Following are the names and designation of persons consulted.

NAME	DESIGNATION	OFFICE
Mr. Abdulla Naushad	Director-General	Ministry of Construction and Public Infrastructure
Mr. Marc Delatorre	Maritime Engineer	SOGREAH, France
Mr.Ibrahim Ismail	Island Chief	Makunudhoo Island office
Mr. Mohamed Waseem Ismail	Managing drirector	Ensis
Mr. Addulla Saeed	Director	Ensis
Members*		Harbour Committee
Members*		Women's Development Committee
Members*		Island Development Committee
Members*		General public including fisherman and boat owners

*Note: Names and contact address of all those who participated were recorded. However it has not been listed in this EIA due to the long list.

10 Alternatives

In this project, there are very few alternatives that can be suggested. Since the EIA Regulations require two alternatives to be suggested, two alternatives have been suggested in addition to the no project alternative. These alternatives are discussed below:

10.1 No Project Option

The no project option takes the following into account.

- The existing harbour continues to deteriorate in quality.
- No additional measures or upgrading are proposed
- The future development of the island cannot continue

The main advantages and disadvantages of these are given in Table 10.

Table 10: Advantages and disadvantages of the no project option

Strategy	Advantages	Disadvantages
Allow the existing harbour to deteriorate in quality	Environmental problems related to upgrading can be avoided No upgrading costs to the Proponent and hence there is a short term benefit	No upgrading means that the islanders and other users of the harbour will have difficulties, especially as traffic increases. Sedimentation in the harbour basin will be a threat to boats during low tide. Sedimentation of the access channel will increase and may result in damage to vessel and even to the extent of preventing access to large vessels. It will disrupt the future development of the island. Other industrial activities such as fishing and boat building cannot be expanded. The two private companies that have invested in Makunudhoo will not be able to expand their services and hence, the island will not benefit economically.
Extend the harbour by moving the breakwater north wards and dredging the harbour basin.	Environmental problems related to sedimentation can be avoided. No upgrading costs to the	Value of the island may deteriorate. The island will not be preferred by other vessels

	Proponent and hence there is a short term benefit	mainly fishing and safari vessels. Fishing activities cannot grow and be developed. The island community will not get the economic benefit from expansion.
Reconstruction of quay wall, break waters and jetty	Cost can be eliminated.	The quay wall will not last for many years and the resulting deterioration will be more costly to rehabilitate. Quay wall cannot take greater loads. Already 120 m of the quay wall is displaced Breakwaters will not serve what they are intend for. Jetty cannot serve the vessels that require heir use.

10.2 Design Alternatives

It is not practical to relocate the harbour as the environmental and economic consequences would be much more. Therefore, at the design stage, alternative options were considered which is discussed below.

10.2.1 Sheet piling the quay wall.

Sheet piling the quay wall will allow greater live load carrying capacity. This option, although it was considered has been rejected as it is not predicted that the island will have traffic and cargo that require sheet piling in the near future. If it is required, then the harbour will have to be upgraded with more facilities. Sheet piling will also be environmentally more damaging. Therefore, this option was also rejected (see Appendix 10).

10.3 Alternative locations

The present location is most suitable for Makunudhoo, despite it being on the western side. During the south west monsoon the large lagoon and the reef will protect the harbour. Other alternative location would be the eastern side, but this location is not preferred as there is no protection during the north-east monsoon. However, a more preferable location is the south-east side of the harbour. Although this is a preferred location, the economic and environmental consequences cannot be justified for this project for several reasons. First, the environmental damage caused by creating another harbour would be significant. Secondly, there are no settlements in this area and therefore locating a harbour in an isolated area would be economically unjustifiable.

10.4 Alternative Disposal location

One of the alternatives for disposal of dredge spoil would be to eliminate the south of the harbour and stockpiling sand on land.

10.5 Preferred alternative

Several alternatives have been preferred including no project options and design alternatives. An alternative location has not been considered as the environmental and economic considerations cannot be justified for this project. Hence, with the limited options and alternatives, the preferred alternative for this project is to avoid filling the area south of the harbour and stockpile them on land. However, this will require the dredge spoil to be disposed in a considerably large area. Therefore, mitigation measures have been proposed for this. Nevertheless, it can be reminded that the area located south of the harbour is already a previous reclaimed area as it can be easily see in the aerial photograph.

10.5.1 Mitigation measures for the proposed alternative

Following mitigation measures are proposed:

- Dispose the dredge spoil by assessing baseline condition of the disposal area. They can then be stockpiled for later use.
- Stockpiling the dredged material in a way to avoid surface runoff during rain. This is important to prevent them from entering marine waters.
- Stockpiling them away from the main populated area and away from economic activities where it can become a nuisance if kept for too long.

11 Environmental Monitoring

11.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are most relevant for monitoring the impacts that may arise from the proposed harbour rehabilitation project are included in the monitoring plan. These include turbidity and nutrient, sedimentation, beach profile and live coral cover and nektonic fauna. Monitoring will be carried out as part of the environmental impact assessment and mitigation of possible negative impacts from the proposed project.

The objectives of the monitoring plan are to measure:

- live coral cover and nektonic fauna
- the amount of sedimentation on the reef
- water quality and visibility
- beach profile and hydrodynamic changes only in the project boundary
- impacts are accurate and mitigation measures taken are effective and
- the thresholds are kept within the baseline limits predicted.
- Assess socioeconomic changes

Table 11 summarizes the various aspects of the monitoring program and the costs.

11.2 Cost of Monitoring

The proponent has committed fully for the monitoring programme outlined in this report. The cost indicated below is for monitoring the project during the construction stage and operational stage. Monitoring will be undertaken by subcontracting the work to an independent consultant or a consulting firm.

The amount indicated is the total cost of monitoring during the construction and operational phase (2 years after the construction). Monitoring will include, Marine and Coastal environmental monitoring plans identified in the report. Summary monitoring reports will be provided every two months and final report will be provided at the end of the construction stage and will adhere to Schedule M of the EIA Regulations, 2007.

11.3 Methods of monitoring

Environmental monitoring will be undertaken using standard methods described in the Methodology section.

As socioeconomic changes take more time to materialize, socio-economic monitoring will be undertaken using qualitative and quantitative surveys done after 18 months of project completion. One survey will be sufficient to assess the impacts. Quantitative monitoring will mainly focus on the indicators outlined in the baseline socio-economic assessment outlined in this report, which can be obtained from:

- Household surveys
- The island office, health facility
- Published reports, surveys, and studies.

Table 12 outlines the indicators for socioeconomic monitoring. These indicators in the table are not limited but have been considered as the important aspects of monitoring.

Table 11: Aspects of the social and environmental monitoring program with cost breakdown

Monitoring Attribute	Indicator	Methodology	Monitoring Frequency	Estimated Cost
Coral and other benthic cover.	Percent cover	LIT	Upon completion of the project and once a year there after.	US$ 100 per survey
Diversity and abundance of fish communities	Number / percentage of fish present	Visual fish census	Upon completion of the project and once a year there after.	US$ 100 per survey
Siltation/ Sedimentation	Quantity of sediment	Quantitative assessment of sediment loading using Sediment traps	Prior and during the project works; and after 2 months, there after once a year	US$ 150 per survey
Seawater quality	DO, nutrients and turbidity	Lab analysis	Twice during the project, 2 months after the completion, there after once a year	US$ 100 per test performed
Beach profile	Beach dynamics	D-GPS tracks along the beach	Once during the project, 2 months after the completion, there after once a year	US$ 100 per survey
Hydrodynamic	Changes in the current movements	Drouge tracks at a recording interval of 60s	Once during the project, 2 months after the completion, there after once a year	US$ 100 per survey
Socio-economic survey	Outlined in Table 12	User survey	Once, preferably after 18 months from the completion of the project.	US $ 750

Table 12: Indicators for socioeconomic impact monitoring.

CATEGORY	INDICATOR	METHOD
Service quality	Efficiency of operation and maintenance of harbour.	User survey
	Services available to vessels	User survey, island and atoll administration data
	Five main operation and maintenance problems.	User survey.
	Care and use of harbour facilities.	User survey evidence of facilities
Financial sustainability	Income generated from the harbour and related activities.	Financial statements/audit reports, user surveys
	Safety of harbour.	Safety standards enforced by MCPI and Transport Minsitry
Safety	Records of accidents or injuries.	Health record and island office records.
	Advocacy of users.	User interviews
Institutional arrangements	Functioning of Harbour management committee	Island and Atoll office /line Ministry
	Participation of public.	Minutes of Island Development Committee Meetings/
	Regulatory / management regime	Island and atoll office. MCPI and atolls ministry.
	Complaints dealt	Correspondences/records
Mobility of vessels /traffic analysis	Development plans	Island and atoll office/line agencies
	Vessel types, size and numbers	Island office
	Frequency of use	Island office
Employment	New employment created as a result of the harbour rehabilitation	Island office, interviews, published reports
Demography	Population	Island office, census data
	Population migration	Island office, census data

Table 13: Detail cost of monitoring during construction period and for two years

DESCRIPTION	UNIT COST (US$)	TOTAL (US$)
Logistics (A total of 4 trips to be made during the construction stage and during the 2 years monitoring period)		
Return air transport (2 people) to Haa dhaal atoll via air.	80 x 2 x 4	**640.00**
Return Sea transport to Makunudhoo from Hanimaadhoo airport, Haadhaal Atoll.	400 x 4	**16,00.00**
Food and accommodation for two (3 days)	60 x 2 x 4	**480.00**
Survey costs		
Cost of undertaking the environmental surveys during the project construction stage and for the first year	2,350.00	**2,350.00**
Cost of undertaking the environmental surveys during the second year	650.00	**650.00**
Social survey (once after 18 months from completion of the harbour)		**750.00**
Sub Total		**6,470.00**
10 % contingency (to account for variation in transport costs)		**647.00**
Grand total for monitoring during construction stage and for two years (Seven thousand one hundred and seventeen US Dollars only)		**7,117.00**

11.4 Monitoring responsibility

Monitoring responsibility will be with the client and financial provisions will be made in the project to undertake the monitoring.

11.5 Monitoring Report

A detail monitoring report will be compiled after the completion of the civil works based on the data collected for monitoring the parameters included in the monitoring program. This report will be submitted to the relevant government agencies for compliance.

The report will include details of the site, data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

12 Conclusion

This EIA report has identified the major impacts of the proposed rehabilitation project in Makunudhoo. The project will only have its environmental impacts on the project boundaries which are confined to a limited area in the marine and coastal environment of Makunudhoo. Environmental impacts don't appear to be major, as this is only a rehabilitation project and not a new development. Similarly, the scale of the activities and the locality is limited to the project boundary only. Socioeconomic impacts have also been assessed in depth and it is evident that there would be several positive socioeconomic impacts.

The major impacts have been identified as resulting from the dredging works, which has been proposed in the harbour basin and also the access channel. Environmental impacts of this activity not only related to dredging, but also the disposal and management of the dredged spoil. The report has identified baseline conditions of the predicted impact zones of the marine environment and they appear to be very minor as the reef itself has limited live coral coverage. Furthermore, the coral reef areas, which are significant to this project is at a considerable distance from the project site. The assessment has indicated that the impacts are likely to be felt on an estimated 5% of the lagoon and reef-flat of that extensive reef system in Makunudhoo island. However, due to the disposal of dredged spoil, the sea grass beds on the southern side of the existing harbour will be affected. Similarly, the disposal location on the eastern side of the island, where dredged materials from the access channel will be dredged will also have environmental impacts. These disposal locations have been studied carefully to assess the potential impacts on them. Nevertheless, it should be noted that the disposal areas chosen are those which were already used during the construction of the harbour.

During the dredging stage, good care should be taken to allow only a pre-determined minimum of suspended sediments to escape from the working areas. Mitigation measures, such as screens and bunds should be employed as outlined in the report. Although several alternatives to the proposed project were considered, these alternatives cannot be implemented for various reasons. Alternative locations cannot be considered for this project, as the harbour is already located in the most suitable location and environmental consequences of creating a new harbour in a new location cannot be justified.

The monitoring programme for this project will mainly focus on marine components and for this reason, sedimentation levels on the reef, water quality and visibility and the coral cover has been considered in the monitoring programme. A socioeconomic survey has also been suggested to be undertaken as part of the monitoring after 18 months of project completion.

It appears justified from a technical and from a developmental point of view, to carry out the proposed rehabilitation project in light of the existing socio-economic developments and forecasts made on the harbour use and traffic increase. There are good reasons from an economic and environmental point of views, to excavate sand from the harbour basin, and disposing them on the southern lagoon. There would definitely be some environmental impacts, but they are also unavoidable and achieved by economic gains on the other hand. The adverse environmental effects of the project therefore appear to be limited and acceptable, including the effects of dredging the basin and disposing the dredged spoil to fill the southern side lagoon, assuming that the mitigation measures proposed is implemented.

13 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water. The EIA was carried out by a multidisciplinary consulting team representing Water Solutions Private Ltd and SOGREAH of France. In preparing this report, no data has been manipulated. All data has been collected by field visits.

I certify that the statements in this Environmental Impact Assessment study are true, complete and correct.

Name: Abdul Aleem (EIA 09/07)

Signature:

Date: 8 November 2007

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Appendix 1: Terms of Reference

The following is the TOR for undertaking the EIA of the proposed harbour dredging works in R. Ungoofaaru, B. Kendhoo, N. Manadhoo, HDh. Makunudhoo, AA. Mathiveri and Th. Hirilandhoo.

1. Introduction - Identify the development project to be assessed and explain the executing arrangements for the environmental assessment. Describe the rationale for the development and its objectives

2. Study Area - Specify the boundaries of the study area for the assessment as well as any adjacent or remote areas that should be considered with respect to the project (e.g. dredged material disposal site/s).

3. Scope of Work - The following tasks will be performed:

Task 1. Description of the Proposed Project - Provide a full description of the relevant parts of the project, using maps at appropriate scales where necessary. This is to include: quality and volume of sediments to be excavated in each area to be dredged; type of dredging equipment to be used and the manner of deployment including handling, transportation, and disposal of dredged material, sediment containment settling and turbidity control measures; alternative dredging methods considered; project schedule; and life span.

Task 2. Description of the Environment - Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (and disposal sites), including the following:

a) Physical environment: geomorphology, meteorology (rainfall, wind, waves and tides), sea currents and bathymetry, surface hydrology, marine receiving water quality, and ambient noise.

b) Biological environment: terrestrial and marine vegetation and fauna, rare or endangered species, wetlands, coral reefs, and other sensitive habitats, species of commercial importance, and species with the potential to become nuisances or vectors.

c) Socio-cultural environment: boating activities and use of the harbour, population, land use, planned development activities, employment, and community perception of the development.

d) Hazard vulnerability; vulnerability of area to flooding, and storm surge.

Characterize the extent and quality of the available data, indicating significant information deficiencies and any uncertainties associated with the prediction of impacts.

Task 3. Legislative and Regulatory Considerations - Describe the pertinent 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.

Task 4. Determine the Potential Impacts of the Proposed Project – Identify impacts related to dredging, spoil disposal and possible land filling. Distinguish between significant impacts that are positive and negative, direct and indirect (= triggering), and short and long term. Identify impacts that are cumulative, unavoidable or irreversible. Identify any information gaps and evaluate their importance for decision-making. Special attention will be paid to:

· *Effects of the project (dredging and spoil disposal) on water quality and existing coastal ecosystems and resources,*

· *Effects of storm water drainage from proposed spoil disposal sites, including potential for off-site flooding,*

· *Effects of dredging on the coastal stability of adjacent shorelines,*

· *Effects of dredging works on the existing operations of the lagoon,*

Task 5. Analysis of Alternatives to the Proposed Project. – Describe the alternatives examined for the proposed

project that would achieve the same objective including the "no action alternative. This includes dredging vessel types and disposal sites. Distinguish the most environmentally friendly alternatives.

Task 6. Mitigation and Management of Negative Impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to dredge spoil disposal and dispersal/sedimentation control. Cost the mitigation measures, equipment and resources required to implement those measures.

Task 7. Development of a Monitoring Plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for dredging/disposal operations.

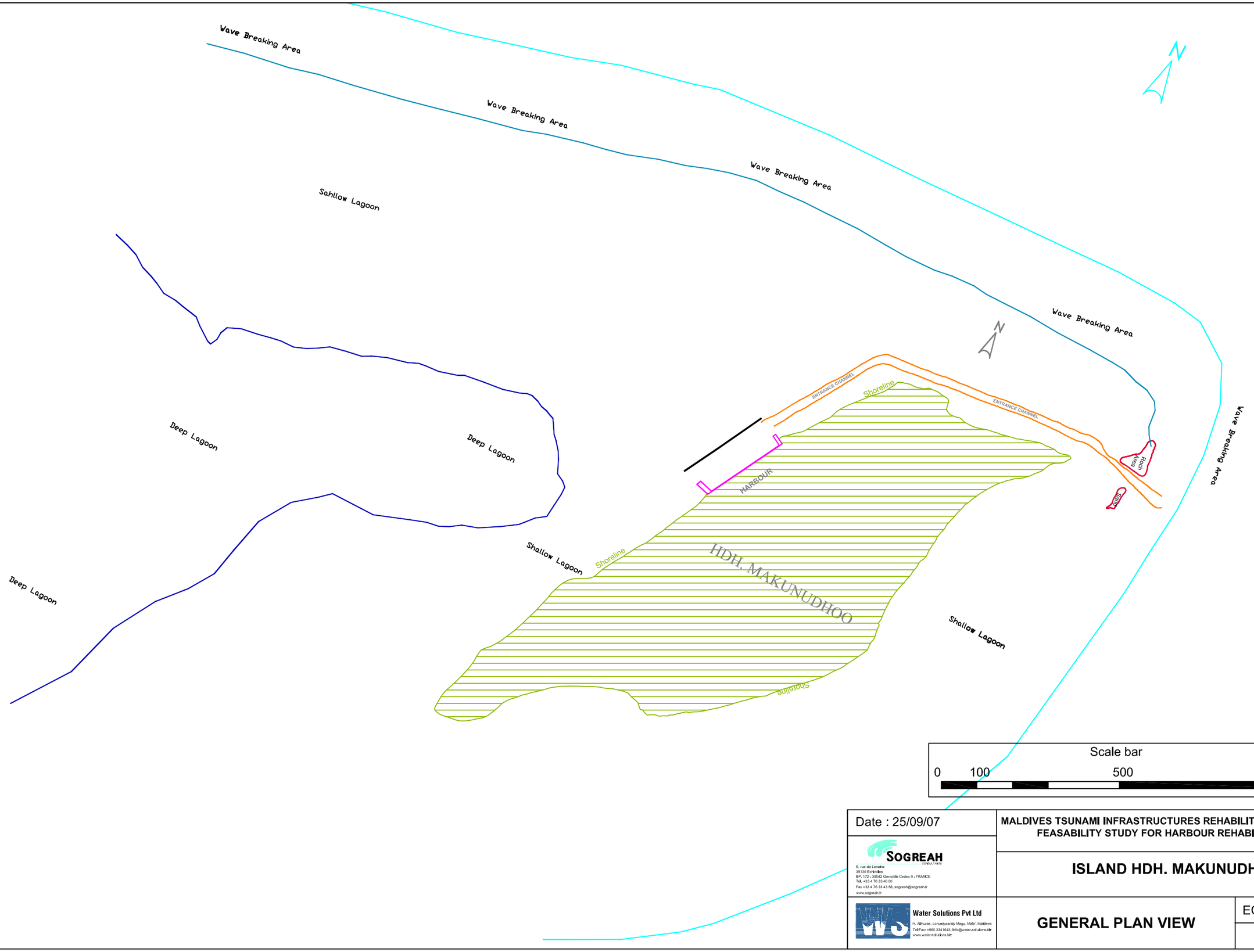
Task 8. Assist in Inter-Agency Coordination and Public/NGO Participation – Identify appropriate mechanisms for providing information on dredging activities and progress of project to stakeholders. Assist in co-coordinating the environmental assessment with the relevant government agencies and in obtaining the views of local stakeholders and affected groups. (It is anticipated that there will be considerable public interest concerning issues of location of the harbour, sediment disposal and turbidity with and the economic benefits to be derived from the project.)

Presentation - The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will 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 Report, 2007.

…….

(04 September 2007)

Appendix 2: General Plan view of Makunudhoo showing Existing harbour and project boundaries



Dessiné par : LVx Contrôlé par : MDt

Date : 25/09/07

SOGREAH
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alkhuras, Lonuziyaaraiy Magu, Malé', Maldives
Tel/Fax: +960 3341643, info@water-solutions.biz
www.water-solutions.biz

MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

GENERAL PLAN VIEW

ECH : 1 / 10 000

N° 02

Appendix 3: Existing condition and visual Inspection of Makunudhoo Harbour

Date : 19/09/07

SOGREAH CONSULTANTS
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alfhuras, Lonuttiyaaraly Magu, Male', Maldives
Tel/Fax: +960 3341643, info@watersolutions.biz
www.watersolutions.biz

MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

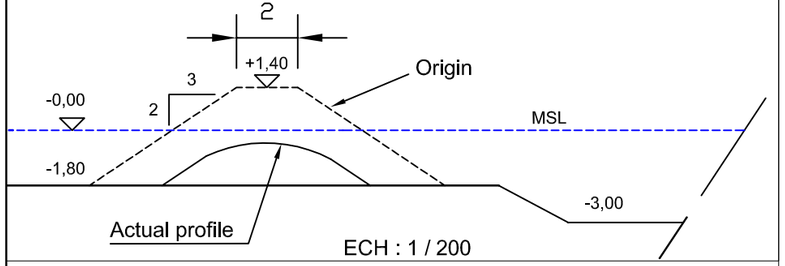
ISLAND HDH. MAKUNUDHOO

VISUAL INSPECTION OF THE HARBOUR INFRASTRUCTURES

ECH : 1 / 1 000

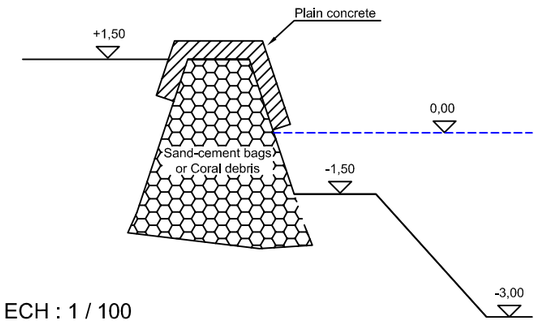
N° 04

Section A-A



ECH : 1 / 200

Section B-B
Quay wall with sand-cement bags capping without reinforcement



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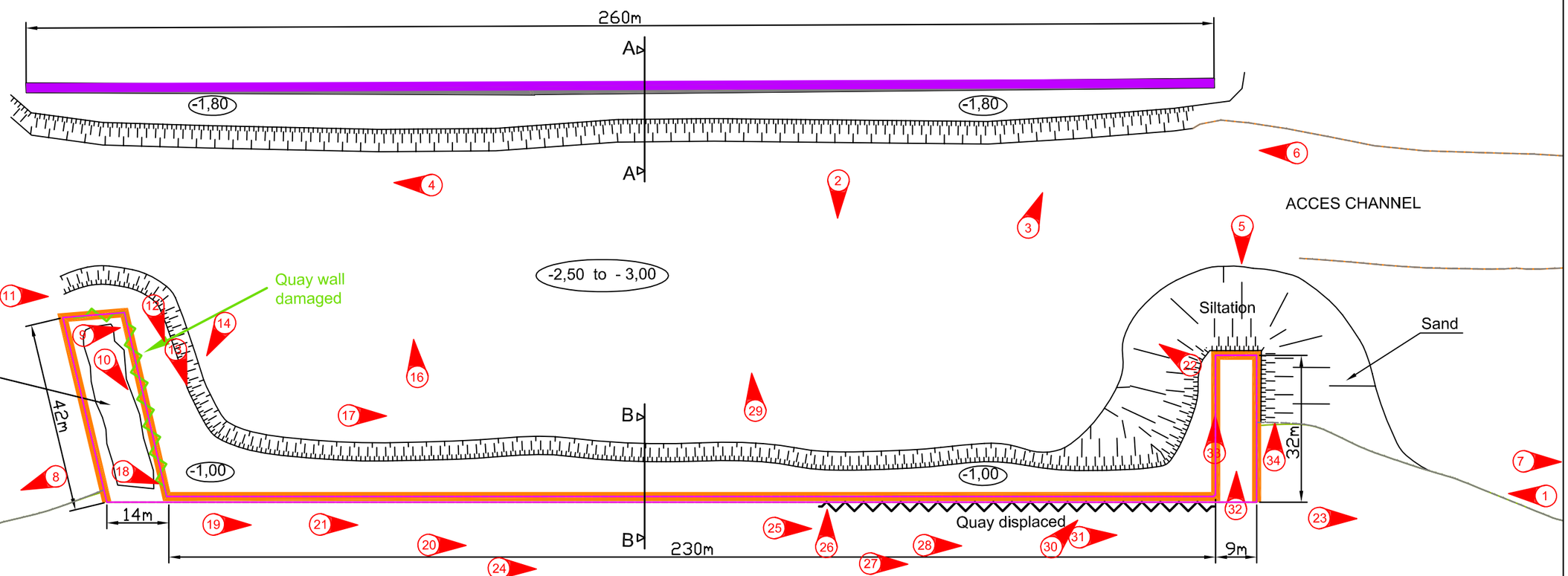


HARBOUR

Contrôlé par : MDt

Dessiné par : LVx

LEGEND

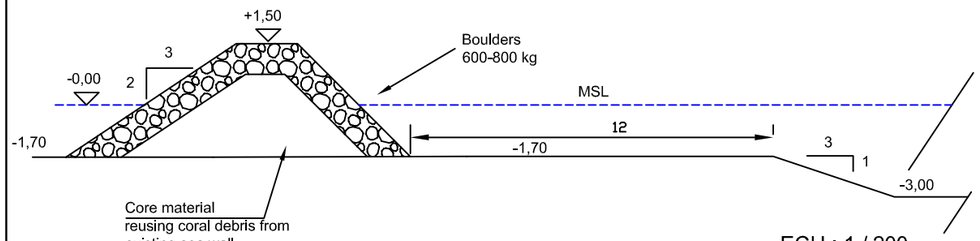
- Quay wall constructed with debris coral
- Breakwaters constructed with debris coral
- Photographs : see plans n°06, 07, 08 and 09

Scale bar

0 10 50 100 m

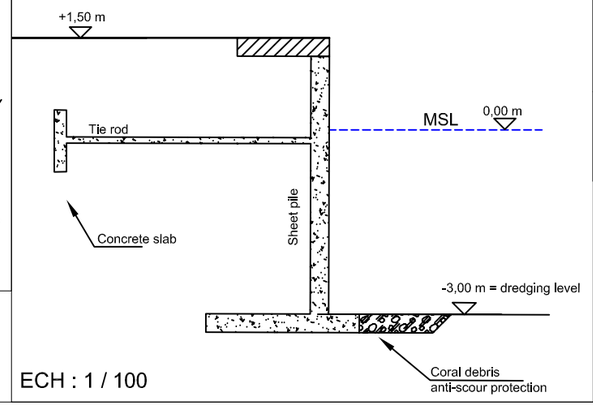
Appendix 4: Proposed Layout and Rehabilitation Plan for Makunudhoo Harbour

Section A-A



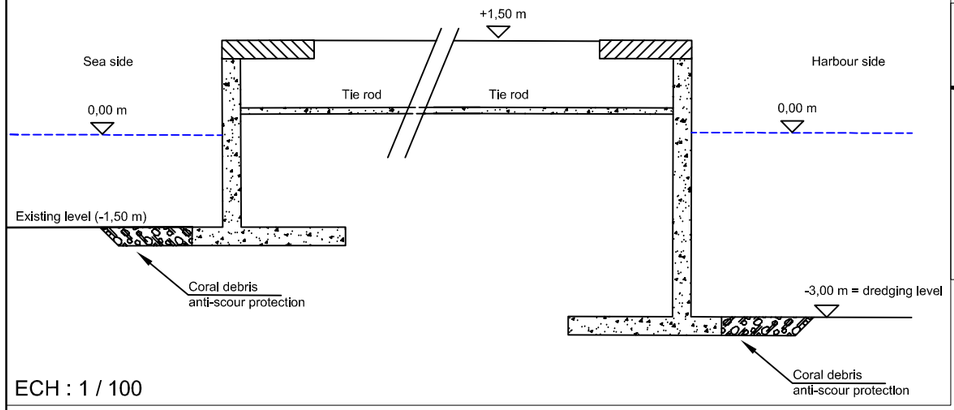
ECH : 1 / 200

Section B-B



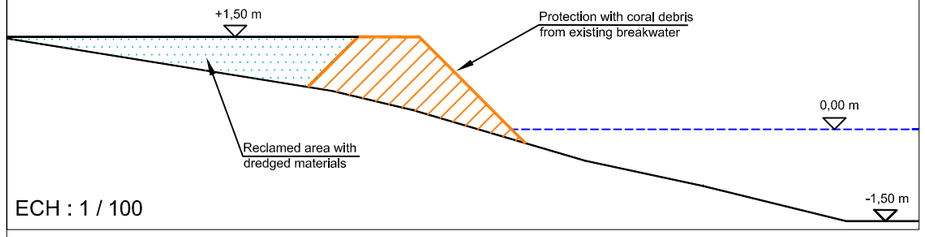
ECH : 1 / 100

Section C-C
L-Shaped quay wall



ECH : 1 / 100

Section D-D



ECH : 1 / 100

Date : 19/09/07

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6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alfhuras, Lonuttyaaraly Magu, Male', Maldives
Tel/Fax: +960 3341643, info@watersolutions.biz
www.watersolutions.biz

MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

PROPOSED LAYOUT AND REHABILITATION PROGRAM ALTERNATIVE 2

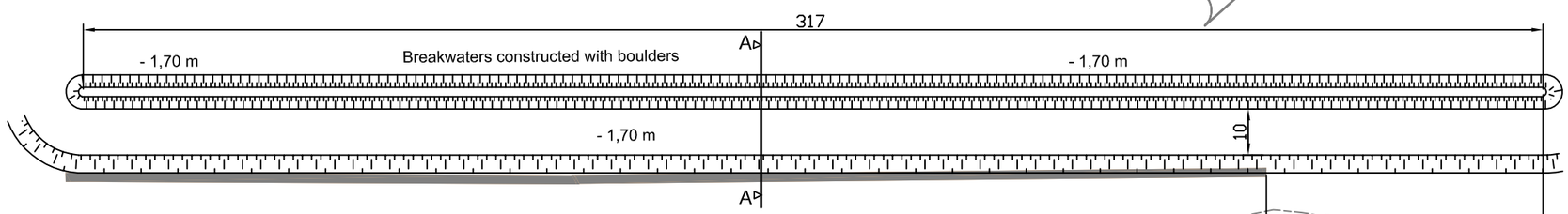
ECH : 1 / 1 250

N° 05b

Scale bar

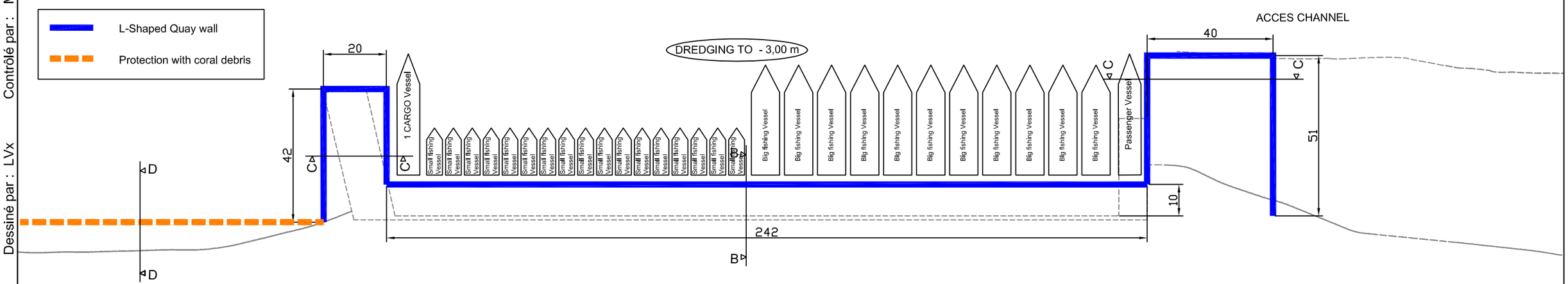
0 12,5 62,5 125 m

		Number of vessels accomodated
CARGO Vessel	100 Feet	1
Passenger Vessel	100 Feet	1
Small fishing Vessel	50 Feet	17
Big fishing Vessel	100 Feet	11
	TOTAL	30



LEGEND :

- L-Shaped Quay wall
- Protection with coral debris



Contrôlé par : MDt

Dessiné par : LVx

Appendix 5: Bathymetric Survey of Makunudhoo Lagoon

Date : 19/09/07

SOGREAH CONSULTANTS
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alhuras, Lonuttyaaraly Magu, Male', Maldives
Tel/Fax: +960 3341643, info@watersolutions.biz
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MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

BATHYMETRIC SURVEY (1)

CARRIED OUT IN AUGUST 2007

ECH : 1 / 4 000

N° 03-a

N

Roch Area

Sand

ENTRANCE CHANNEL

TRANSITION CHANNEL

Shoreline

HARBOUR

Shallow Lagoon

HDH. MAKUNUDHOO

NOTE:
- Topographic and bathymetric survey have been carried out by WATER SOLUTIONS in August 2007 ;
- All levels refer to MSL datum ;
- Tide levels : (estimation)
  - MLLW = - 0,3 m MSL
  - MHLW = - 0,1 m MSL
  - MLHW = + 0,1 m MSL
  - MHHW = + 0,3 m MSL

The map is georeference to WGS 84 (Datum UTM Zone 43 North)

Scale bar
0 40 200 400 m

Contrôlé par : MDt

Dessiné par : LVx

Appendix 6: Bathymetric Survey of the existing Harbour

Date : 19/09/07

SOGREAH CONSULTANTS
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alhuras, Lonuttyaarafy Magu, Male', Maldives
Tel/Fax: +960 3341643, info@watersolutions.bit
www.watersolutions.bit

MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

BATHYMETRIC SURVEY (2)

CARRIED OUT IN AUGUST 2007

ECH : 1 / 1 000

N° 03-b

Contrôlé par : MDt

Dessiné par : LVx

N

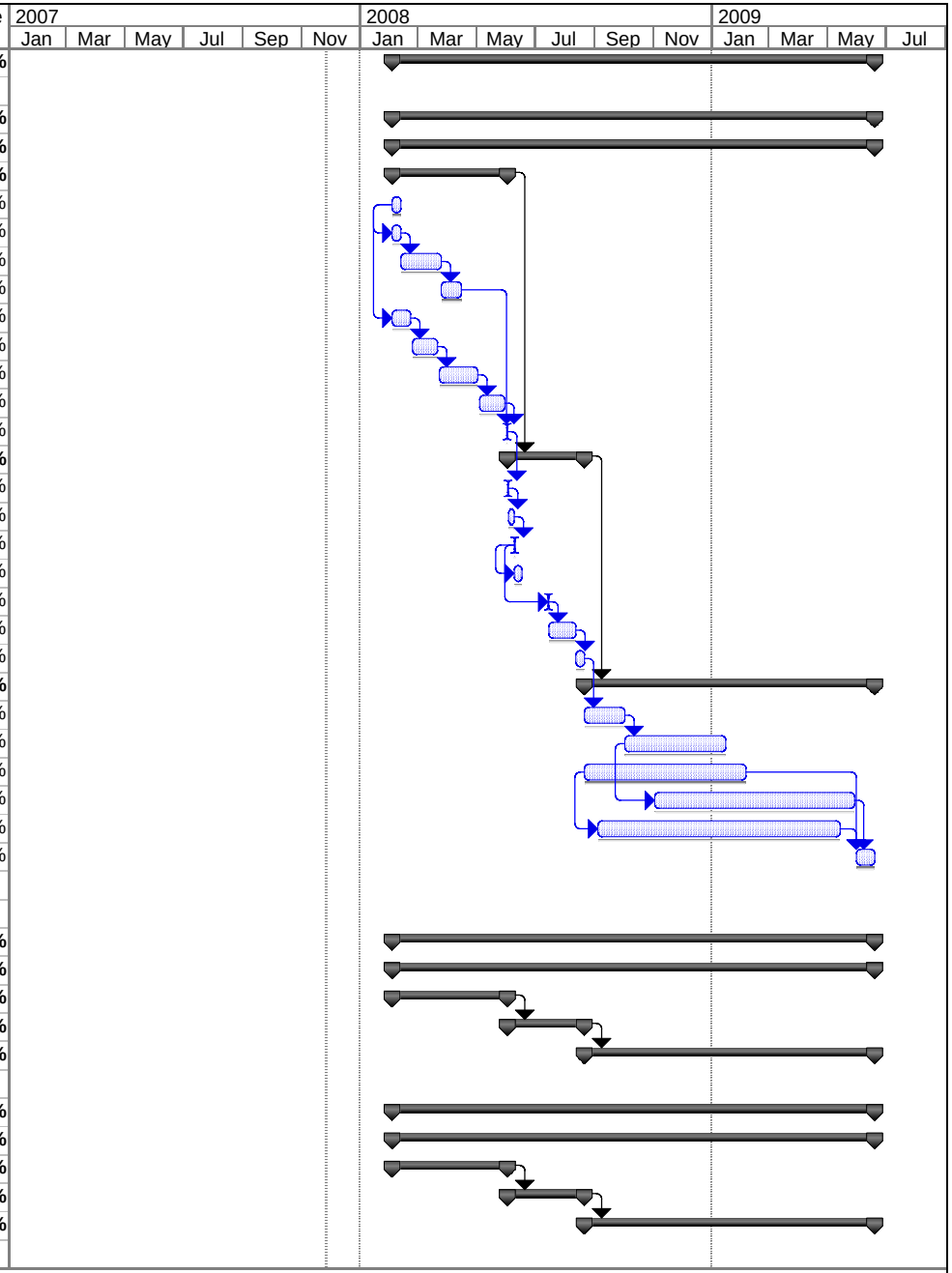
HARBOUR

Scale bar

0 10 50 100 m

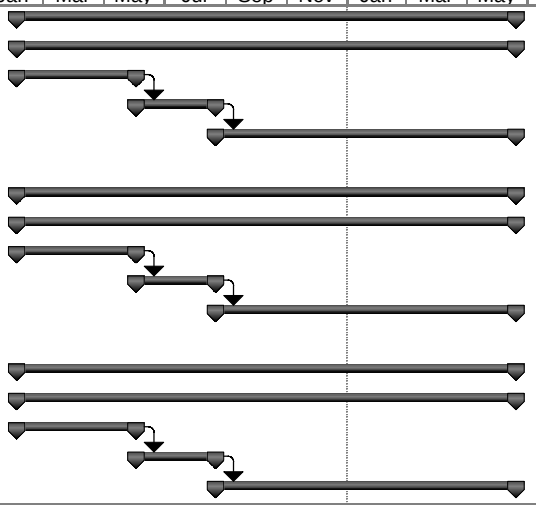
Appendix 7: Construction Schedule

ID	Task Name	Duration	Start	Finish	% Complete
1	**Harbour Reconstruction under AFD Funding**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
2					
3	**Raa Ungoofaaru**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
4	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
5	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
6	Reconaisance visit	7 days	Mon 2/4/08	Tue 2/12/08	0%
7	Hydrographic survey	7 days	Mon 2/4/08	Tue 2/12/08	0%
8	Design of key elements	30 days	Wed 2/13/08	Tue 3/25/08	0%
9	Design approval from GoM	15 days	Wed 3/26/08	Tue 4/15/08	0%
10	Collect information for EIA	15 days	Mon 2/4/08	Fri 2/22/08	0%
11	Prepare EIA document	20 days	Mon 2/25/08	Fri 3/21/08	0%
12	Submit EIA for approval from MEE	30 days	Mon 3/24/08	Fri 5/2/08	0%
13	Bid document preparation	20 days	Mon 5/5/08	Fri 5/30/08	0%
14	Submission to tender board	1 day	Mon 6/2/08	Mon 6/2/08	0%
15	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
16	Announce for Bidding	1 day	Tue 6/3/08	Tue 6/3/08	0%
17	Issuing of Tender documents	4 days	Wed 6/4/08	Mon 6/9/08	0%
18	Pre bid meeting	1 day	Tue 6/10/08	Tue 6/10/08	0%
19	Clarify pre bid queries	6 days	Tue 6/10/08	Tue 6/17/08	0%
20	Bid opening	1 day	Tue 7/15/08	Tue 7/15/08	0%
21	Evaluation and Awarding	20 days	Wed 7/16/08	Tue 8/12/08	0%
22	Contract signed	7 days	Wed 8/13/08	Thu 8/21/08	0%
23	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**
24	Mobilization	30 days	Fri 8/22/08	Thu 10/2/08	0%
25	Precast works	75 days	Fri 10/3/08	Thu 1/15/09	0%
26	Dredging works	120 days	Fri 8/22/08	Thu 2/5/09	0%
27	Quay wall construction	150 days	Mon 11/3/08	Fri 5/29/09	0%
28	Breakwater contruction	180 days	Fri 9/5/08	Thu 5/14/09	0%
29	Demobilization	15 days	Mon 6/1/09	Fri 6/19/09	0%
30					
31					
32	**Noonu Manadhoo**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
33	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
34	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
44	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
52	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**
59					
60	**Haa Dhaal Makunudhoo**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
61	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
62	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
72	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
80	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**
87					



Intended Time Schedule for AFD Project

ID	Task Name	Duration	Start	Finish	% Complete
88	**Alif Alif Mathiveri**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
89	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
90	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
100	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
108	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**
115					
116	**Baa Kendhoo**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
117	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
118	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
128	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
136	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**
143					
144	**Thaa Hirilandhoo**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
145	**Consultancy period**	**360 days**	**Mon 2/4/08**	**Fri 6/19/09**	**0%**
146	**Initial Stage**	**86 days**	**Mon 2/4/08**	**Mon 6/2/08**	**0%**
156	**Tender for Contractor**	**58 days**	**Tue 6/3/08**	**Thu 8/21/08**	**0%**
164	**Construction Stage**	**216 days**	**Fri 8/22/08**	**Fri 6/19/09**	**0%**



Intended Time Schedule for AFD Project

Appendix 8: Dredge spoil disposal locations

Date : 19/09/07

SOGREAH CONSULTANTS
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr

Water Solutions Pvt Ltd
H. Alfuras, Lonuttiyaaraly Magu, Malé, Maldives
Tel/Fax: +960 3341643, info@watersolutions.biz
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FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

ENVIRONMENTAL ISSUES ZONES WITH DIRECT IMPACT (ALTERNATIVE 2)

ECH : 1 / 1 250

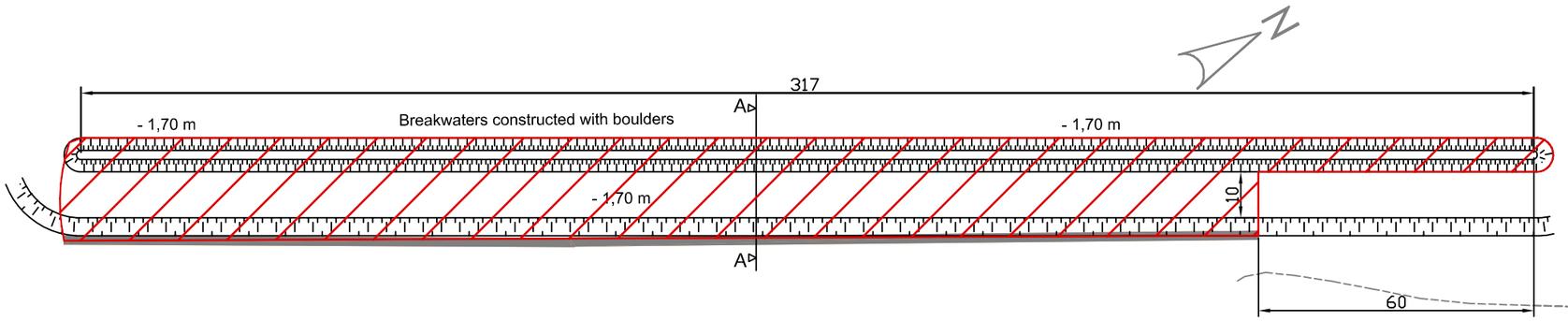
N° 05c

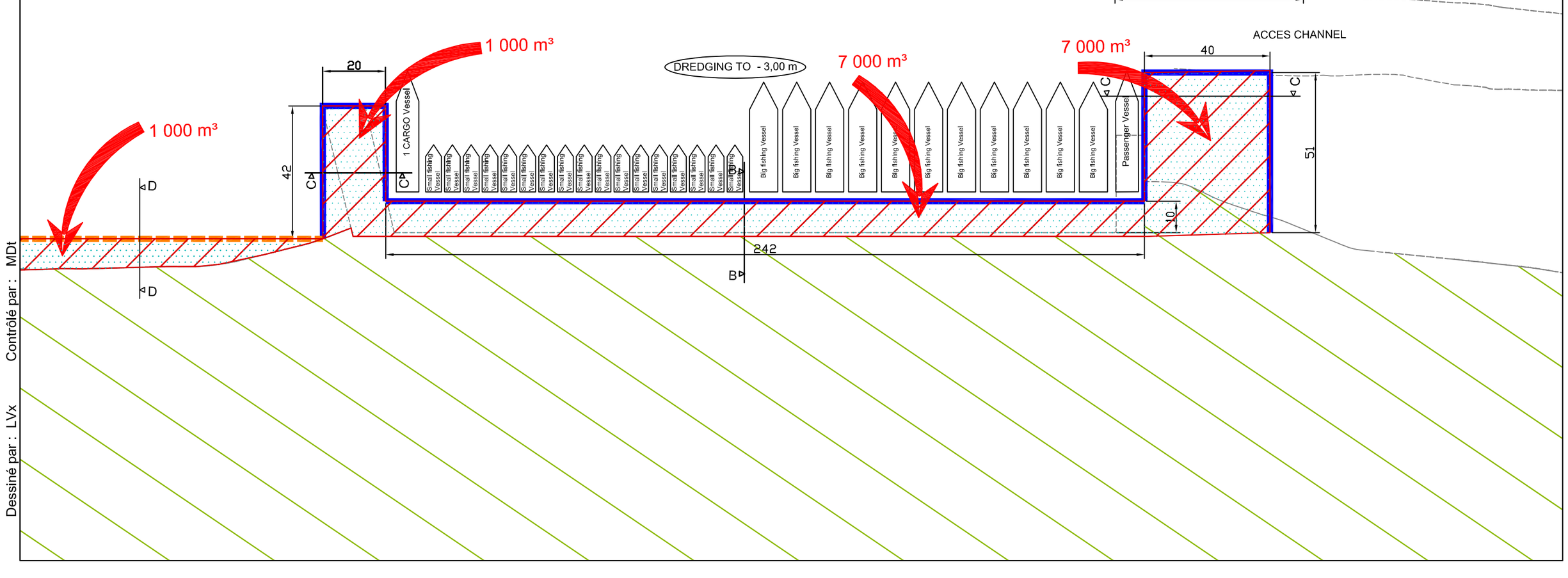
Legend :

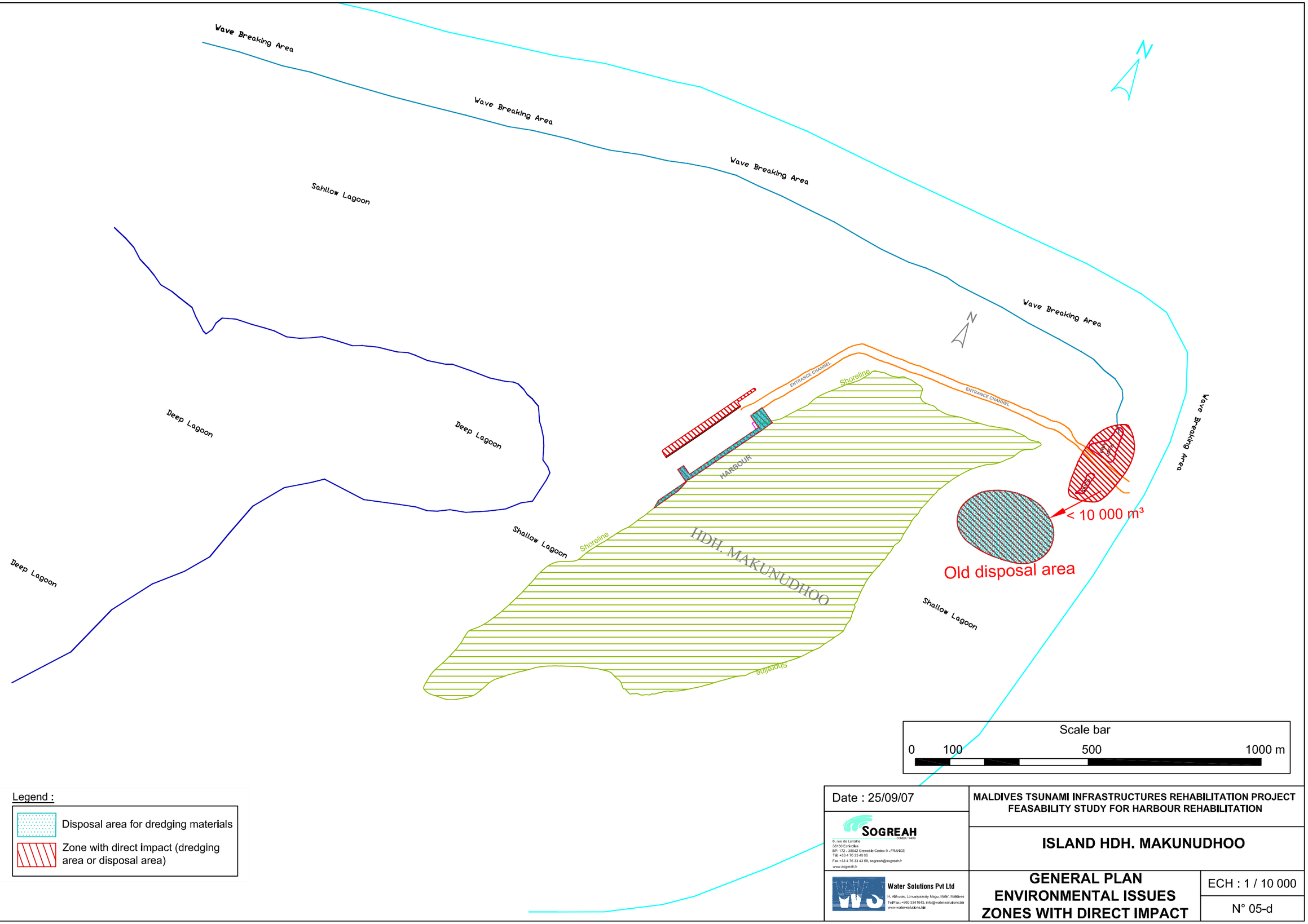
- Disposal area for dredging materials
- Zone with direct impact (dredging area or disposal area)

Scale bar

0 12,5 62,5 125 m

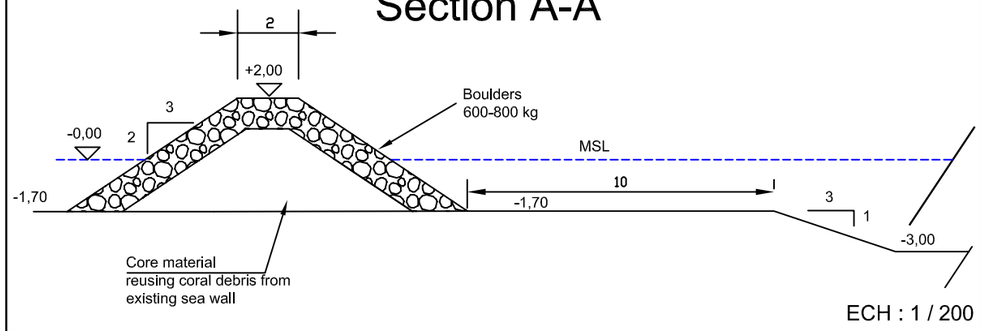





Wave Breaking Area
Wave Breaking Area
Wave Breaking Area
Wave Breaking Area
Wave Breaking Area
Shallow Lagoon
Deep Lagoon
Deep Lagoon
Deep Lagoon
Shallow Lagoon
Shallow Lagoon
Shoreline
Shoreline
Shoreline
HDH. MAKUNUDHOO
ENTRANCE CHANNEL
ENTRANCE CHANNEL
HARBOUR
< 10 000 m³
Old disposal area
Wave Breaking Area
N
N
Scale bar
0 100 500 1000 m
Legend :
Disposal area for dredging materials
Zone with direct impact (dredging area or disposal area)
Dessiné par : LVx
Contrôlé par : MDt
Date : 25/09/07
SOGREAH
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
www.sogreah.fr
Water Solutions Pvt Ltd
H. Alkhuras, Lonuziyaaraiy Magu, Malé, Maldives
Tel/Fax: +960 3341643, info@water-solutions.bt
www.water-solutions.bt
MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION
ISLAND HDH. MAKUNUDHOO
GENERAL PLAN
ENVIRONMENTAL ISSUES
ZONES WITH DIRECT IMPACT
ECH : 1 / 10 000
N° 05-d

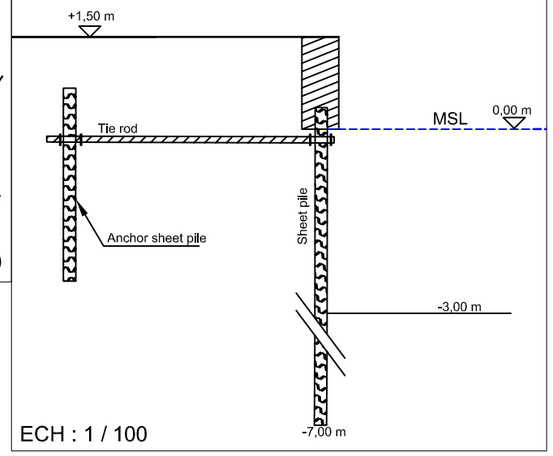
Appendix 9: Alternative Designs for the harbour construction.

Section A-A



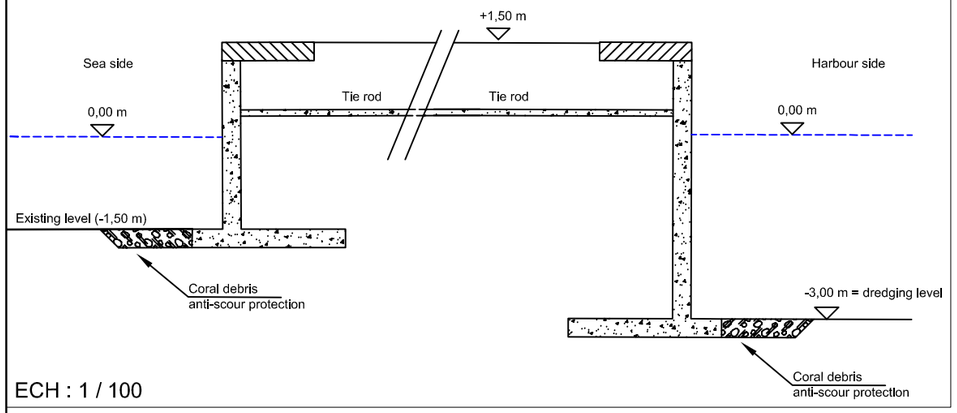
ECH : 1 / 200

Section B-B



ECH : 1 / 100

Section C-C
L-Shaped quay wall



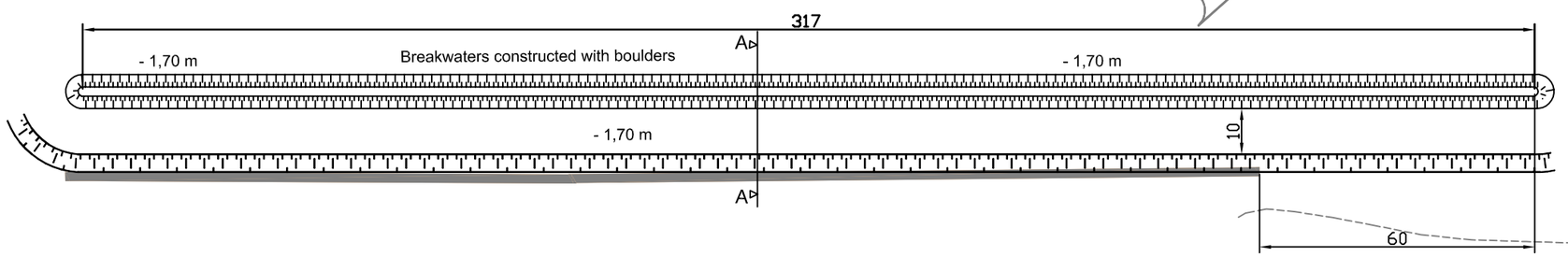
ECH : 1 / 100

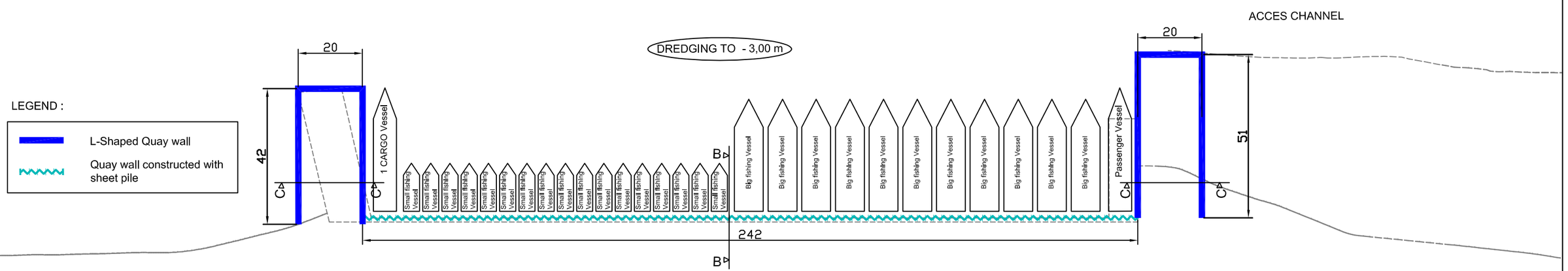
Date : 19/09/07	MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT FEASABILITY STUDY FOR HARBOUR REHABILITATION	
SOGREAH CONSULTANTS 6, rue de Lorraine 38130 Echirolles BP. 172 - 38042 Grenoble Cedex 9 - FRANCE Tél. +33 4 76 33 40 00 Fax +33 4 76 33 43 58, sogreah@sogreah.fr www.sogreah.fr	ISLAND HDH. MAKUNUDHOO	
Water Solutions Pvt Ltd H. Alfhuras, Lonuttyaarafy Magu, Malé, Maldives Tel/Fax: +960 3341643, info@watersolutions.biz www.watersolutions.biz	PROPOSED LAYOUT AND REHABILITATION PROGRAM ALTERNATIVE 1	ECH : 1 / 1 250 N° 05a

Scale bar

0 12,5 62,5 125 m

		Number of vessels accomodated
CARGO Vessel	100 Feet	1
Passenger Vessel	100 Feet	1
Small fishing Vessel	50 Feet	17
Big fishing Vessel	100 Feet	11
	TOTAL	30





LEGEND :

- L-Shaped Quay wall
- Quay wall constructed with sheet pile

Dessiné par : LVx Contrôlé par : MDt

Appendix 10: Photographs of the harbour

Date : 19/09/07

SOGREAH CONSULTANTS
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
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Water Solutions Pvt Ltd
H. Alhuras, Lonuttyaaraly Magu, Male', Maldives
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MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

PHOTOGRAPHS

TAKEN DURING SITE VISIT OF AUGUST 2007

N° 06

Photograph n°1

Photograph n°2

Photograph n°3

Photograph n°4

Photograph n°5

Photograph n°6

Photograph n°7

Photograph n°8

Dessiné par : LVx Contrôlé par : MDt

Date : 19/09/07

SOGREAH
6, rue de Lorraine
38130 Echirolles
BP. 172 - 38042 Grenoble Cedex 9 - FRANCE
Tél. +33 4 76 33 40 00
Fax +33 4 76 33 43 58, sogreah@sogreah.fr
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Water Solutions Pvt Ltd
H., Alifuras, Lonudiyaanlu Magu, Malé', Maldives
Tel/Fax: +960 3341643, info@water-solutions.bz
www.water-solutions.bz

MALDIVES TSUNAMI INFRASTRUCTURES REHABILITATION PROJECT
FEASABILITY STUDY FOR HARBOUR REHABILITATION

ISLAND HDH. MAKUNUDHOO

PHOTOGRAPHS

TAKEN DURING SITE VISIT OF AUGUST 2007

N° 09

Photograph n°29

Photograph n°30

Photograph n°31

Photograph n°32

Photograph n°33

Photograph n°34

Dessiné par : LVx Contrôlé par : MDt

Appendix 11: Names and Registration Certificate numbers of the EIA consultants

Abdul Aleem – EIA Registration no: EIA09/07

Ahmed Zahid – EIA Registration no: EIA08/07

Aslam Shakir – EIA Registration no: EIA11/07

Ibrahim Naeem - EIA Registration no: EIA13/07

Hassan Shah – EIA Registration no: EIAT 02/07

Appendix 12: CV's of unregistered consultants

Curriculum Vitae

Proposed Position: **Port Economist and Financial Analyst**

Name of Firm: **SOGREAH Consultants**

Name of Staff: **Adrien LELEU**

Profession: Economist

Date of Birth: 9 September 1980 Nationality: French

Years with Firm: 3

Key qualifications:

- Economist, geographical and spatial project analysis
- Economic, financial and institutional evaluation
- Formulation of decision-aid resources

Education:

- International Development Studies and Research Centre (CERDI-CNRS), University of Auvergne
- DESS postgraduate diploma in Development Economics and Project Analysis, University of Auvergne
- Advanced studies in economics, specialising in international economics, Paris University I (Panthéon-Sorbonne)
- Senior technician's certificate in international commerce, Amiens education authority

---

Employment Record:

Present position: General economist in Sogreah's Maritime Division

2003-2004 Engineer Economist in charge of studies at the Economy and Finance Department, Phnom Penh City Council, Cambodia, 2003-2004: Identification of wealth creation areas; Economic and spatial monography; Formulation of decision-aid resources; Monitoring of funding agency projects; Sector analysis.

Experience over the last ten years:

General Economic Studies

- France, 2006-2007 - Study of protection for the coastline between the rivers Têt and Agly. Socio-environmental assessment of all coastal activities and uses. Analysis of the impacts of the recommended solutions. Guidelines for the developments so as to preserve or encourage certain uses. Client: Perpignan urban area authority – Economist.
- Persian Gulf States, 2006-2007 - GCC Water Grid - Feasibility study of the project to interconnect the water supply networks of the Persian Gulf states. Financial analysis of the various technical alternatives. Financing arrangements of the solution selected. Client: Gulf Cooperation Council – Economist.
- Indonesia, 2006 - Aceh & Nias Post Tsunami Recovery Program (ANTERP 1). Technical Assistance to the Agency for Rehabilitation and Reconstruction (BRR). Infrastructure Program Management team to work with BRR to manage the overall program of project preparation: priority services of roads, drainage, water supply, waste water management/sanitation and solid waste management. As socio-economist he was involved in the preparation of medium- and long-term population and water demand forecasts.

Economic Studies in the Field of Port and Coastal Development

- Qatar, 2006-2007 - Operating study of Messaied port. Responsible for port planning, organisation and optimisation studies for the new storage and handling terminal, notably with regard to handling equipment (gantry and yard equipment). Client: Total-Qatofin – Economist.
- France, 2006-2007 - Assessment of the added value of port development policies. This analysis shows how State and public authority investments in ports can be justified by the common public interest of these facilities, beyond profitability alone. Client: Ministry of Transport and Infrastructure – Economist.
- France, 2006-2007 - Updating of the Port Réunion Master Plan. Responsible for the traffic studies and the comparison of scenarios for Port Réunion. Proposal of new guidelines for investments. Client: CCI Réunion – Economist.

- France, 2006 - Technical and economic study of the development of an unloading platform at Saint-Louis de la Réunion. Responsible for the general economic studies, proposal of scenarios, site analysis and development proposals – Economist.
- France, 2006 - Study for the extension and rehabilitation of Charles Ornano port. Implementation of the diagnosis phase, notably the assessment of economic potential (the pleasure boating market). Proposal of the extension development scheme. Client: Ajaccio Municipal Council. Economist.
- Black Sea – Bosphorus, 2005-2007 - Project to create a new hydrocarbons terminal on the Black Sea (Samsun – Turkey) – Client: Technip. Responsible for the economic and technical simulations. Use of the ARENA simulation model. ARENA Economist/Programmer.
- Madagascar, 2005-2006 - Feasibility study for Tamatave boat ramp. Client: GAPCM/Agence Française de Développement. Updating of the rate of return analysis resulting from the study of Tamatave boat ramp in 2001. Socio-Economist.
- France, 2005-2006 - Technical and economic feasibility study concerning the development of coastal shipping around Réunion island. Client: Réunion Regional Council. Project engineer – Economist.
- France, 2005 - Impact study concerning the extension project for the port of Caen. As part of the project to extend the marina, fishing harbour and ferry terminal at Ouistreham, study of economic spin-offs in the with-project situation. Study of project economic rate of return. This study will be used as a basis for the statutory studies (public enquiry). *Responsible for the economic spin-off analysis and rate-of-return analysis. (In association with AEI)*.
- France, 2005 - Port of Granville. Study of economic spin-offs from the port of Granville (marina, fishing, commercial and passenger harbours) in the existing situation (2004) and with-project situation involving a 1000-place extension to the marina and the creation of a new terminal for commerce and passengers. Optimisation study for the project and its components. *Responsible for the economic spin-off analysis. (In association with Act-Ouest and Cofrepêche)*.
- France, 2005 - Seine-Nord Europe project. Technical and hydraulics studies to define the final route for the future large-gauge river link (4000 tonnes) between the Seine and Scheldt basins. Modelling of centralised management and operation of the river link. *Responsible for the river traffic flow simulation model using the ARENA model*.
- Madagascar, 2004-2005 - Feasibility study for a lifting system for fishing ship maintenance on the west coast of the island. Technical study (choice of location, definition of lifting equipment, preliminary design of the infrastructure) and economic study (market study and definition of project criteria, analysis of the organisation and operation of the platform, analysis of financial rate of return). *Responsible for the market study and analysis of financial rate of return*.
- Congo Brazzaville, 2004-2005 - Feasibility study for the container terminal and timber terminal at the Port of Pointe-Noire. Technical and economic study with a view to reorganising and extending Pointe-Noire container terminal, in order to make it a transit harbour and hub for the countries in the sub-region. Reorganisation of the timber terminal (rough and sawn timber). *Responsible for the economic study (economic rate of return). (In association with Catram and PAH)*.
- Morocco, 2004 - Optimisation and sizing study for the port of Tangiers-Mediterranean, a project to create a new container hub in the Straits of Gibraltar. Use of the ARENA simulation model. *ARENA programmer*.

Languages:

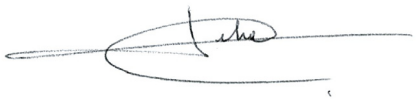
French: Mother tongue

	Speaking	*Reading*	*Writing*
English:	Good	Good	Good
German:	Good	Good	Good

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, the information contained herein correctly describes myself, my qualifications, and my experience. I understand that any wilfull misstatement described herein may lead to my disqualification or dismissal if employed.

Signature of Staff Member *Date: 14th June 2007*



Curriculum Vitae

Proposed Position: **Port Civil Engineer, Project Manager**

Name of Firm: **SOGREAH Consultants**

Name of Staff: **Marc DE LA TORRE**

Profession: Civil Engineer

Date of Birth: 22 September 1964 Nationality: French

Years with Firm: 15

Key Qualifications

Mr De la Torre started his professional career as Project Engineer with Bouygues contractors. From 1988 to 1991, he was responsible for the construction of several buildings (main frame and finishing work)

Since 1991, Mr De La Torre has specialised in studies of maritime structures at Sogreah:

- Acting as Project Leader of ports, petrochemical terminals and civil engineering projects comprising:
  - . port planification and master plan,
  - . marine works design at basic design and detailed design level,
  - . tender documents preparation,
  - . works supervision.
- Providing technical assistance for the design of breakwaters and maritime defences for public works and/or engineering companies, comprising:
  - . sizing of structures and alternatives,
  - . scale-model studies using wave tanks and flumes,
  - . technical assistance on sites.

Education:

- MASTER DPE – INSA Lyon 2005
- University Diploma of Technology in Civil Engineering from the "Institut Universitaire de Technologie", Grenoble, 1986.

Additional Training:

1991: Intensive English course,
1992: AUTOCAD,
1993: Hydraulics course,
1994: Training in the design of quays and retaining walls,
2000: Training in geotechnics.

Computer systems

Computation software:

- BREAKWAT: design of rubble-mound breakwaters
- REPLA: determination of wave heights at structures
- STABL: slope slip stability
- GEOSLOPE: slope slip stability
- ROBOT: reinforced concrete design

Computer-Aided Drawing: AUTOCAD

Various Windows applications: Lotus, Excel, Microsoft Project, Word, Freelance, Paintshop, Wordperfect.

Experience:

Present position: Engineer and Project Manager in SOGREAH Maritime, Maritime Structure Division
1988-1991 Site Engineer with Bouygues contractors.

Experience over the last ten years:

- Qatar, 2006-2007 – Qatofin project - Owner's Representive in the Construction phase of the marine works to be built in the framework of an EPC contract: a new cooling water system to distribute seawater to existing and future plants (a 30 000 m3/h pumping station, intake chamber, onshore piping system, offshore piping system with outfall pipes); berth extension to accommodate container vessels; yard extension to accommodate the future increase of containerized traffic, with all buildings and equipment; container handling equipment (technical specifications); roads and pavements. *Project leader.*
- Iran, 2006 – Pars methane terminal project - Engineer responsible for the dimensional design of the defences for the area reclaimed from the sea (16 km). *Expert Engineer.*
- France, 2005-2006 – Aix-les-Bains harbour - Feasibility study of a new harbour basin to create a 250-berth marina. The aim of the study is to: specify the physical, economic, environmental and statutory constraints governing the project, present one or more solutions indicating the layout and surroundings of the harbour, assess the cost, and check the feasibility of the operation. *Project leader.*
- Qatar, 2004-2005– Qatofin Project - Basic design and Tender documents (hydraulic, electrical, mechanical and civil works) for EPC project for:
  - a new cooling water system to distribute seawater to existing and future plants containing : a pumping station of 36 000 m3/hr, an intake chamber, an onshore piping system, an offshore piping system with outfall pipes.
  - a berth extension to accommodate containers vessels.
  - a yard extension to accommodate future increase of containerized traffic with all building and equipment.
  - container handling equipments (technical specifications).
  - roads and pavements.

  Project Leader
- Qatar, 2004 – Qatofin Project - Port planning study – Determination of berth extension and its reclamation are to accommodate increase in containerized traffic for exporting polymer product by containers including:
  - study of container yard operation.
  - study of handling equipment (Gantry crane and container handling,
  - equipment containers and other traffic,
  - study of interference with other existing traffic.

  Project Leader
- Libya, 2003-2004 - Complete designs for the new Garabulli fishing harbour:
  - definition of hydraulic conditions (waves, wind),
  - onshore wave propagation study,
  - wave disturbance study,
  - 3D scale model study,
  - sedimentological study

  Project Leader
- Libya, 2003 – Definition study of the new overall layout of Sirte harbour. Economic study and definition of the areas on land for container and cargo activities. *Project Leader*
- Libya, 2003 - Detailed design study of the basin and the berthing structures of the new Sirte harbour:
  - study of wave disturbance in the harbour,
  - detailed design study of quays (gravity quays and pile-mounted quays) and inner protection (rockfill).

  Project Leader
- Qatar, 2003 - Feasibility study of a pile-mounted jetty to accommodate 5000 to 70 000 DWT ships carrying (liquid) chemicals in Messaied harbour. The study comprised:
  - civil engineering and foundation design,
  - mooring study,
  - navigation study.

  Project Leader
- India, 2002-2003 - Design study of construction of the Dahej breakwater. Study of construction phases with 3 to 4 m/s currents.
  Project Leader
- Congo, 2002-2003 - Study of the investment programme for priority works to rehabilitate the port of Pointe Noire. Technical and economic study, feasibility study, diagnostic study of port infrastructure and networks, preliminary design study of port rehabilitation.
  Project Leader

- Madagascar, 2001-2002 - Complete engineering services for works to rehabilitate the lighterage quay (90 m) and the seagoing vessel quay (110 m) of Tulear harbour. *Project Leader*
- France, 2001-2002 - Study of dredging to deepen the accesses to the Fos sur Mer container terminal. Complete study for the dredging of 18 million m3 of material including:
  - feasibility study,
  - preliminary and detailed designs,
  - tender documents and assessment of bids.

  Project Leaser
- Madagascar, 2001-2002 - Engineering services for works to extend Majunga harbour, comprising a 180 lm pile-mounted container quay and rehabilitation of the container storage area. *Project Leaser*
- Ivory Coast, 2000-2003 - Widening of Vridi Canal. Sketches, preliminary and detailed design for the rehabilitation of the west breakwater of Vridi Canal and creation of a new breakwater east of the canal. *Engineer responsible for the dimensional design*
- Morocco, 2000-2001 - Rehabilitation of the breakwater in Jorf Lasfar harbour. *Project manager responsible for defining the investigation campaigns, preliminary and final designs and preparation of tender documents*
- Iran, 2001 – Water intake and outfall structures for the Asaluyeh project. Basic design. *Infrastructure engineer*
- Libya, 2001 – Saba marina. Preliminary and detailed design studies of the breakwaters and quays. *Responsible for infrastructure works*
- Libya, 1999-2000 – Sirte harbour. Development plan for the harbour. Detailed design of the harbour infrastructure (protection works, breakwaters, pile-mounted wharves, block quays and jetties), and dredging works. *Responsible for all infrastructure works and preparation of technical specifications. Monitoring of site work to construct the pile-mounted wharf (loading tests)*
- Morocco, 1998-1999 – Extension of the container terminal in the port of Casablanca. 225m of caisson quay and enclosing breakwater. Preliminary and detailed design studies, tender documents. *Project manager*
- Morocco, 1998, Rehabilitation of Moulay Youssef jetty. Preparation of preliminary and detailed designs and Tender documents. *Project manager*
- Albania, 1998, Rehabilitation of the port of Durres. Preparation of preliminary and detailed designs and Tender documents. *Project manager*

Languages:

French: Native

	Speaking	*Reading*	*Writing*
English:	Fluent	Good	Good
Spanish:	Notions	Notions	Notions

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, these data correctly describe me, my qualifications and my experience.

Signature of Staff Member Date: 11 December 2007