MINISTRY OF HOUSING, TRANSPORT
AND ENVIRONMENT

# Environmental Impact Assessment Report

# HARBOUR DEVELOPMENT WORKS AT RASHDHOO, ALIFU ALIFU ATOLL




January 2010


Land and Marine Environmental
Resources Group Pvt Ltd, Maldives

**Declaration of the Consultant**

I hereby certify that the statements made in this environmental impact study for the development of harbour at Rashdhoo, Alifu Alifu atoll are true, complete and correct

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Date: 17 January 2010

## Table of Content

# List of Tables

## List of Figures.

# EXECUTIVE SUMMARY

1. This Environmental Impact Assessment (EIA) report is to fulfill the regulatory requirements under the Environmental Protection and Preservation Act of Maldives prior to the proposed harbor development at Rashdhoo in Alifu Alifu Atoll.

2. Rashdhoo harbor concept design was formulated after meeting by MHTE, president of Maldives and the island community during the visit by president to Rashdhoo.

3. Large natural deep lagoon and entrances are located at the northern quadrant of the island, which is used by the island community as the main access point to the island.

4. The proposed project involves construction of a 228.6m by 78.7m harbor facility at the northern side of the island, located west of the old jetty head. L shaped concrete elements (precast) will be used for the quay wall structure; and armored rocks will be used for the break waters. The harbor development will be funded by the government of Maldives under the Access Improvement Programme implemented by the Ministry of Housing, Transport and Environment (MHTE).

5. The harbor design incorporates the new harbor design concept (third generation harbor), which includes separate loading and unloading area constructed as a T jetty. Part of the basin will include existing deep lagoon area (eastern side of harbor) the rest will be located on shallow lagoon flat.

6. Sediment excavated to deepen the harbor basin would be disposed at either side of the harbor and back of the harbor (backfilling of the quay wall). The estimated volume of dredged sediment is sufficient for filling either side of the harbor and behind the quay wall only.

7. This report provides the results of the fieldwork carried out on Rashdhoo in September 2009 and January 2010 and associated public and community consultations that followed. The environmental impacts arising from the proposed developments are predicted based on the findings of the fieldwork along with the activities that cause these impacts during the construction and operational phases.

8. Existing environment was examined to identify significant environmental components that would be affected and to establish a baseline condition of the site. Available and relevant literature on environmental impacts associated with similar projects was evaluated to identify possible impacts. Oceanographic data and information on local hydrodynamics were qualitatively assessed to determine the current pattern around the island which was based on

monsoonal wind patterns, wind generated waves, tidal flushing, geographic setting, the topography of the lagoon and shape of the shoreline.

9. Three sites were selected to assess reef benthos and selected fish community as the baseline data which would also be considered for long-term monitoring program to monitor the impact of the project. In addition to the fish and benthic surveys, seawater quality was assessed in the lagoon at the north western side of the island (proposed harbor area).

10. The substrate of the lagoon is mostly abiotic. The area to be dredged is dominated with sand and rubble.

11. It is important to note that the most significant impact associated with the project would be impact on the marine environment from sedimentation. Dredging and excavation often carry a heavy load of sediments increasing sediment load in the water column causing discoloration due to suspended sediments of the impact area for a prolonged period. However, there is no established coral community that would be directly affected except perhaps a few isolated coral colonies in the lagoon area. Indirect impact area has high cover of live coral.

12. Environmental impacts associated with the proposed project are considered moderate to major. The significant environmental components that are likely to be affected are the coral community established on the reef flat and changes to littoral drift and near-shore coastal hydrodynamics. Impact on the coral community from sedimentation as a result of excavation is inevitable.

13. Mitigation measures are provided in the report for impacts that were categorized moderate to major. Impact mitigation measures and monitoring is carried out to compare predicted and actual impacts occurring from project activities to determine the efficiency of the mitigation measures. The environmental monitoring proposed here is to determine the effectiveness of the mitigation measures and long term change to the benthic community, especially coral community, where the baseline information was collected.

14. The participants of the consultation meeting held at Rashdhoo stressed the need for mitigation the severe erosion problem at the western side of the island.

15. With due consideration to main environmental components identified and the magnitude of impacts on these components from the proposed developments, the consultant concludes that the project components and designs are feasible and appropriate mitigation measures are given to correct and minimize unfavorable environmental consequences. Furthermore, the public and community consultation responses were in favor of the project due to the socio-economic benefits foreseen to the community from the harbor.

# 1. INTRODUCTION

Rashdhoo is located in North Ari Atoll (AA atoll), on small circular atoll north of main atoll. The proposed project involves construction of a 228.6m by 78.7m harbor. The harbor development will be funded by the government of Maldives under the Access Improvement Programme implemented by the Ministry of Housing, Transport and Environment (MHTE).

The contractor for the project is Amin Construction Company Pvt Ltd who had won the bid to design and construct 7 harbors and among them is Rashdhoo. The contractor engaged Land and Marine Environment Resource Group Pvt Ltd to carry out the EIA assessment for the proposed works.

## a) Purpose of the Report and Need for the EIA

This EIA covers the environmental reporting requirements in preparation for harbor construction as stipulated by the environmental regulations of Maldives. Coastal developments such as harbors that are likely to a have a significant impacts to the environment are required to submit an EIA report by Environmental Act of Maldives. Article 5 (a) of the Environmental Protection and Preservation Act of Maldives (Law No. 4/93) provides for an impact assessment study to be submitted to the Ministry of Housing, Transport and Environment (MHTE) before implementation of any activity that may have a significant impact on the environment. The Environmental Impact Assessment Regulation of Maldives (EIA Regulations, 2007) provides a list of development proposals requiring environmental impact assessment reports which are outlined in Schedule D where EIAs are mandatory for harbor development projects.

Therefore, in accordance with the above requirements and procedures to follow under the EIA regulations, a scoping meeting to discuss the development proposal (for 7 islands) and determine the Terms of Reference (TOR) for the EIA report was held between former MCPI, the Client, LaMer Group Pvt Ltd as the EIA Consultant and representatives from Environment Research Centre as the Regulator on 25th November 2007. This report provides the results of the field work carried out on Rashdhoo in September 2009 and January 2010 and associated public and community consultations that followed based on the TOR approved by ERC (present known as Environment Protection Agency, EPA).

## b) Structure of the Report

The structure of this report follows the Terms of Reference (TOR) discussed in the presence of the developer, the EIA consultant, representative from former Ministry of Construction and Public Works (now MHTE), former Ministry of Atolls Development (MoAD) and representatives of Environmental Research Centre (now EPA) as the EIA regulatory body.

Upon submission of a draft TOR by the EIA consultant it was approved by the former MEEW on 30th December 2007, based on discussions between the consultant, the client and the other stakeholders. The approved Terms of Reference (TOR) for this report is attached in Appendix 1 of this document. The TOR was also copied to former MCPI and former MoAD.

# 2. PROJECT SETTING

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 (MEEW, 2007) of the Maldives by a registered consultant. Furthermore, the EIA adheres to the principles underlined in the regulations, action plans, programs and policies of the following Government Ministries.

- Ministry of Housing, Transport and Environment
- Ministry of Finance and treasury (Department of Planning)
- Ministry of Home Affairs

## a) Environment Protection and Preservation Act of Maldives

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 (now known as MHTE).
- 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 MHTE 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 harbor development at Rashdhoo will fully abide by 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 at inappropriate locations in the local or the regional vicinity, but will be transported to a designated waste disposal site, in Male' Atoll or any other government approved disposal site. In any event, hazardous wastes such as oils and chemicals not allowed disposal at site, will be transported to Thilafushi for appropriate disposal.

### b) Second National Environmental Action Plan (NEAP II)

The aim of NEAP II (MHAHE, 1999) is to provide the necessary guidance for the protection and preservation of the environment of the Maldives and to sustainably manage its resources for the collective benefit and enjoyment of present and future generations.

The main strategies of 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 specifies priority actions in the following areas:

- Climate change and sea level rise; coastal zone management;
- biological diversity conservation; integrated reef resources management;
- integrated water resources management;
- management of solid waste and sewerage;
- pollution control and management of hazardous waste;
- sustainable tourism development;
- land resources management and sustainable agriculture; and
- human settlement and urbanization.

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

### c) National Biodiversity Strategy and Action Plan (NBSAP)

The goals of the National Biodiversity Strategy and Action Plan (MHAHE ,2002) are:

- Conserve biological diversity and sustainable utilization of 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.

### d) Protected Areas and Sensitive Areas

Under Article 4 of the Environment Protection and Preservation Act, the Ministry of Environment (now MHTE) is vested with the responsibility of identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation. At present there are no rules and regulations made available to the public on designation and protection of habitats and heritage areas.

Rashdhoo has no registered protected areas; initial assessment revealed that the island is devoid of swamps or mangrove habitats.

## e) Cutting down, uprooting, digging out and export of trees and palms from one island to another

Pursuant to law number 4/93 (Environment Protection and Preservation Act of Maldives), the Ministry of Environment, Energy and Water (now MHTE) has passed a by-law with the purpose of educating developers on the importance of trees. This includes best management practices for maintaining trees and provides standards for preservation of trees in the Maldives and set down rules and regulations to be adhered to prior to commencing of felling, uprooting, digging up and exporting of trees and palms from one island to another in Maldives.

The by-law states that the cutting down, uprooting, digging up and exports of trees and palms from one island to another can only be done if it is absolutely necessary and there is no other alternative.

It further states that for every tree or palm removed in the Maldives two more should be planted and grown on the island. The by-law prohibits the removal of the following tree types:

- The coastal vegetation growing around the islands extending to about 15 meters into the island are protected by this by-law;
- All the trees and palms growing in mangrove and wetlands spreading to 15 meters of land area is protected under this by-law;
- All the trees that are in a designated protected area;
- Trees that are being protected by the Government in order to protect species of animal/organisms that live in such trees;
- Trees/palms that are abnormal in structure

The harbor quay wall will be located off shoreline, and approximately 30m width of area will be back filled behind the harbor as harbor front therefore no vegetation will be impacted.

### f) Guidelines for land use planning

This guide, developed by the Ministry of Housing and Urban Development (present MHTE), stipulates the criteria and procedure to follow for location and construction of harbors. Clause 16.3.2 clearly states that the design and location of the harbors should consider the vulnerability of the shoreline of the island to coastal erosion. As such harbor construction should follow the environmental impact assessment procedure outlined in the EIA regulation developed under the environmental preservation act of Maldives. It states the preparation of land use plans for such islands shall be supervised by the relevant government office, in this case, Ministry of Planning and National Development (present Ministry of Finance and Treasury) and Ministry of Construction and Public Infrastructure (present Ministry of Housing, Transport and Environment). The guidelines also refer to a minimum of 20m wide Environmental Protection Zone (EPZ), consisting of vegetation to be provided around the outer periphery of the island between the beach and rest of the island. However, it also states the EPZs can be excluded from areas where the land use is for harbor frontage or for commercial use.

# 3. PROJECT DESCRIPTION

## a) Project Proponent

Project proponent of the proposed harbor development is Ministry of Housing, Transport and Environment. The project was bided as a design and built project. Financing of EIA works and Monitoring works during the construction stage will be provided by the contractor as stipulated in the Bid document. The contractor for the project is Amin Construction Company Pvt Ltd. The project is financed through Public Sector Investment Projects.

## b) The Project

The proposed development project involves development of a 228.6m long and 78.7m wide harbor (See Appendix 2 for site plan). The proposed harbor will have part of the basin located at the deep lagoon while moving westwards at the shallow lagoon. The harbor quay wall will follow the general shape of the shoreline. Breakwater section will be located at the western side of the basin while eastern side and either side of the harbor will be open. The harbor protection walls will be constructed using armor stones, while the wharves will be of "L" section concrete elements. Dredged material will be used for back filling at the back of the harbor, either side of the harbor. Revetment walls will be constructed at western and eastern sides of the harbor for additional protection.

## c) Need for the Project

Rashdhoo has a natural deep lagoon which at present can accommodates large vessels (average depth of the deep section of lagoon 9-11m). At present access to the island is from the western side (channel side) to the deep lagoon via natural opening. Almost all vessels from nearby resorts and other islands use this deep lagoon for access to the island. Two jetties are located at the northern tip of the island as access points.

According to the IDC and Island Councilor, during SW monsoon rough periods the western side of the island gets very rough, therefore mooring vessels or unloading and loading materials is very difficult. The deep lagoon receives wind waves making the western side of deep lagoon turbid.

The population of Rashdhoo is extensively involved in fishing industry and tourism sector. Many souvenir shops are operated at island, which is a major source of income to the community. At times during rough weather vessels experiences difficulty in berthing at the jetty, and sometimes cancel tourist excursion trips. Therefore due to this reason the community faces economic loses. Since the lagoon is deep conventional breakwaters are impossible to construct, which is the main reason why the community haven't tried to construct breakwaters.

Since Rashdhoo is the administrative capital of the atoll, almost all government establishments are located at the island, therefore many people from other islands often visit for various purposes (trade or medical purposes). Due to this reason a safe harbor facility is necessary at Rashdhoo.

Given the difficulties faced by the residents of the island, the policies of the Seventh National Development Plan 2006 -2010 (MPND, 2007) clearly outlines the possibilities of providing the required facilities for the inhabited islands. The related policy states: 'continue access improvement programs for inhabited islands' to 'facilitate the development of adequate harbors throughout the country'. The new government also outlines a transportation network as a priority, which also includes upgrading of harbors.

## d) Location and Extent of Site Boundaries

Rashdhoo is located in AA Atoll, approximately 58km from Male'. In terms of geographic coordinates, it is located at 04° 57' 47" N and 72° 59' 58" E. Rashdhoo sits in its own atoll (Rashdhoo atoll) located just north east of main atoll formation of Ari atoll. Nearest inhabited island is Ukulhas approximately 14.5km west of Rashdhoo at the main atoll. While the closest uninhabited islands are Madivaru (0.7km east) and Madivaru finolhu (0.8km) located north east of the Rashdhoo, separated Rashdhoo channel. Nearest Resort islands are Kuramathi Tourist Resort located 0.56km at the western side of Rashdhoo and Veligadu island Resort 4.1km north eastern of Rashdhoo.

The proposed harbor location is at the northern side of the island, partly encroaching on to the deep lagoon. The existing natural entrance (located at the western side) will be used for access to the deep lagoon and harbor basin. The harbor quay wall will be located 38m off the existing shoreline from the western side and 11m off from the eastern side. Breakwater section will be located only at the western quarter of the harbor basin, while eastern quarter will be open to the deep lagoon.

The proposed dredged material disposal area is along the back, either side of the harbor basin, volume removed from dredging works is estimated to be just about enough for backfilling works, therefore access sediment disposal is not required.

Possible sediment plume will be directed westwards during the NE monsoon, this would be coupled with the current and swell induced waves (swell waves received from the north eastern side of Rashdhoo atoll.

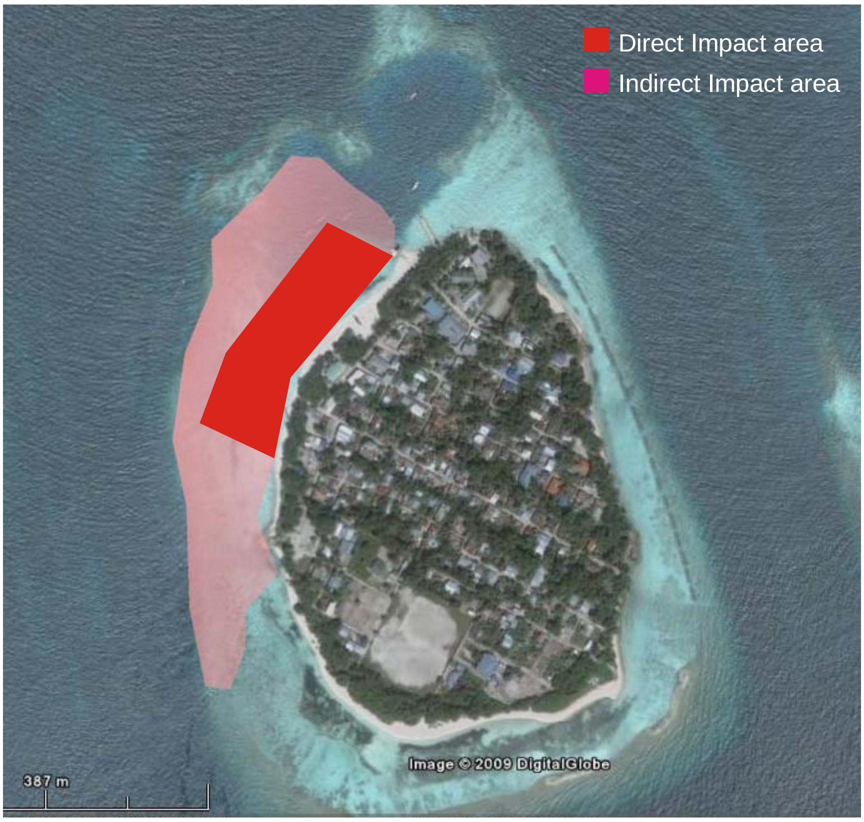



Figure 1 Proposed harbor location and extent of sediment plume envisaged during NE monsoon (time frame for the excavation component of the project)

Figure 2 Proposed harbor area viewed from east to west (left) and west to east towards the access jetty (right)

## e) Construction Phase and Schedule for Implementation

The harbor construction stage at Rashdhoo is estimated to last 6 months. Below are the major sub components of the construction phase. Table 1 provides the expected work program and work schedule for the project.

- Mobilization, material unloading
- Setting outwork
- Excavation of harbor basin
- Disposal of dredged material
- Construction of quay wall T jetty
- Construction of harbor walls and revetments

Table 1 Construction schedule for the proposed harbor development project at AA Rashdhoo

| No | Activity | Months | | | | | |
|---|---|---|---|---|---|---|---|
| | | February | March | April | May | June | July |
| 1 | Mobilization and material unloading | | | | | | |
| 2 | Setting out | | | | | | |
| 3 | Excavation of harbor basin | | | | | | |
| 4 | Excavation of shallow area at the western side natural entrance | | | | | | |
| 5 | Dredged material disposal/filling harbor area | | | | | | |
| 6 | Quay wall construction, basin quays and T Jetty | | | | | | |
| 7 | Construction of harbor wall, breakwaters and revetments | | | | | | |

## f) Major Inputs

### i) Construction material

The construction material used for the construction of the harbor is given as follows (Table 2).

Table 2 Material used for the construction of the harbor at Rashdhoo

| Type | Quantity |
|---|---|
| Boulders (armor rocks) | 20,000 metric tons |
| Cement | 600 bags |
| Aggregate | 1200 bags |
| River sand | 1800 bags |

### ii) Mobilization and material unloading

All material for the proposed project will be transported to the site on landing crafts and barges. Materials for harbor construction will be unloaded close to project site area using the existing entrance and deep lagoon. Already cleared area is close to the proposed location and this area (existing boat slipping area) can be used for site office and temporary storage of materials. Since the area is already cleared (inside vegetation and on wide beach) no vegetation clearance will be required.

Figure 3 Proposed location of temporary setup

### iii) Workforce

The total workforce for the project is estimated at 30-35 workers. All workers will be accommodated in existing residential houses. Food and other facilities will be met by existing facilities on the island. No additional temporary sheds or accommodation units will be constructed. A container based office unit will be located at the project site as the site office. Major concrete works will not be carried out at site (concrete elements will be casted in Thilafushi) and a small construction yard for metal and concrete works will be established near the project site.

### iv) Heavy machinery and power generation

Machinery used for the proposed project are, excavators (2 units), cranes, wheel loader and trucks (3 units). Excavators will also be used for construction of harbor protection walls and quay walls. Power for the project site will be met by the island's existing power house and portable generator. All fuel for the project will be stored in barrels (diesel for excavators, cranes and trucks).

## g) Construction methods

### i) Excavation method

Excavation works for the proposed development project will be done by excavators. Two excavator and two trucks will be used during this phase. Initially a bund wall will be reclaimed to trap sediment and reduce sedimentation impacts. Afterwards the harbor basin will be excavated to a depth of -3m (MSL).

The harbor basin excavation works will be done using excavators, and in the event an excavator alone is unable to dredge the harbor basin, a hydraulic hammer will be used to shatter hard rocks. In the event all available alternatives are exhausted, blasting will be carried. Since it will be difficult to identify the need for blasting at time of field surveys, this EIA report does not cover it. In the event blasting is required, a separate EIA will be carried out. The excavator will be operated on a barge at areas where depth exceeds 1.5m.

The existing natural entrance will be used as access to the harbor; this entrance has a shallow segment near the mouth of deep lagoon. This segment will be dredged to -3MSL. All dredge material will be loaded onto the barge and at the end of each day's excavation works; dredged material will be unloaded at the proposed disposal site i.e. back filling areas of the harbor.

### ii) Construction of wharf and harbor protection structure

The concrete elements for the quay walls will be cast at Thilafushi and transported to the site on barges. Therefore only minor concrete works will be carried out onsite. The element toe area will be deepened and leveled. After placing the elements, the toe area will be refilled. After placing the concrete element, tie rods will be used to fix and anchor the L section to anchor slabs. After placing the concrete elements the quay wall will be joined together with a capping beam. The area behind the quay wall will be back filled to the island ridge level. In similar projects by the former MCPI, the bid document states the quay wall should be 15cm above the ground level, while the back fill area should be at 1.5MSL (L. Maamendhoo Harbor Bid Document). The proposed harbor area has an average height of 1.0 MSL. Therefore this will be taken in to account when back filling the quay wall area.

Breakwater segment will be placed at the western side of the harbor; while the eastern side will be open (eastern side ends in deep lagoon). The breakwater will be constructed using armor stones (see Appendix 4). The stones for the filter layer will be made by sieving the dredged materials. A geotextile layer will be placed in between the filter layer and filled base. Revetment will be constructed at the eastern and western side of the harbor to protect the quay walls on these sides and T jetty section. The Revetments will be constructed using armor stones.

## h) Major Outputs

### i) Harbor design

The major output of the proposed project is the 228.6m x 78.7m harbor facility. The harbor basin will have a depth of -3MSL. Almost 50% of harbor basin will sit in existing deep lagoon, while the rest will on shallow lagoon where depths are around -1MSL. The access to the harbor facility will be from the western side using the existing natural entrance. Part of this entrance (near the mouth of deep lagoon) is shallow therefore this area will also be dredged to -3MSL. The harbor quay wall will include a loading and unloading area (T jetty) at the eastern side of harbor open to the deep lagoon. The T jetty section is 33.4m long and 15.2m wide.

The harbor will have a total length of 158.8m of breakwater and 125m of revetment. The revetments and breakwaters will be of armor stones (See Appendix 4 for breakwater detail). The quay wall length is 344.4m (including the T jetty section); the eastern and western side of the harbor will be open, therefore allowing maximum flushing.

## ii) Dredge material

Dredge material removed from the harbor basin will be transported to the disposal sites on trucks (dredged material will be used for back filling work between the harbor and existing shoreline, either side of the harbor for protection of quay wall). Dredge spoil generated deepening of harbor and entrance segment will be just enough for the back filling works. Approximately 22000$m^3$ (figures provided by design consultant) of dredged spoil will be generated by the dredging works; while approximately 10500$m^2$ of land will be backfilled (harbor front and either sided included).

## iii) Risks Associated with the Project

Major risks associated with the project are short term damage to the marine environment due to sedimentation by excavation and clearance (segment of existing natural entrance) works northern side of Rashdhoo. Chronic impacts such as this can be cumulative and long term. However, the proposed duration for the construction is short (estimated at 6 months) which is unlikely to lead to chronic or long term impacts. In addition to impacts to marine environment change in hydrodynamics and beach littoral movement due to construction of physical structures and modification to coastal line may cause erosion and at a worst case scenario lost of land. At present erosion is observed at western and western segment of the island, possibly due to geomorphic shape of the island. Due to construction of physical structures the sediment flow will be stopped at the western side, which may cause erosion elsewhere.

In terms of social impacts, positive impacts are envisaged by the proposed project. Positive social impacts include safety of people accessing the island, safe loading and unloading of materials and goods and possible economic opportunities due to usage of the harbor by fishing vessels operating in the area.

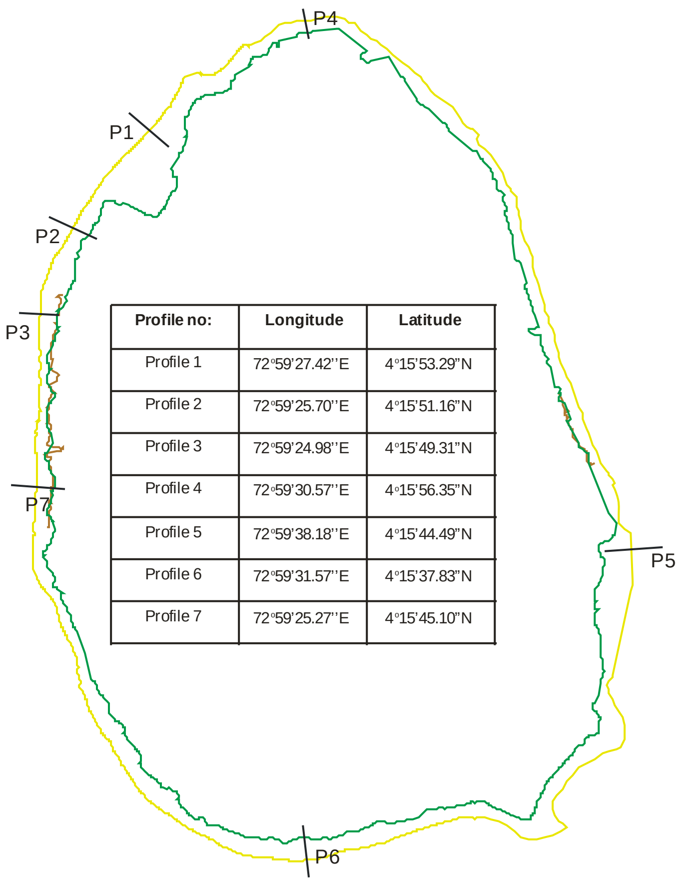
# 4. Methodology

The approach to data collection and compilation of this report includes;

- Consultation and discussion with the proponent with regard to design and work methodology that would be used to implement the proposed activities
- Examination of proposed project activities,
- Examination of the existing environment to identify significant environmental components that would be affected,
- Consultation with major stakeholders to exchange information on the project and to follow the procedures required for the report, and
- Evaluation of available and relevant literature on environmental impacts associated with similar projects.

Information on existing environment was collected during the field visit to the project site during September 2009 and January 2010. General information on the existing environment was based on available secondary data, such as climatic data for Ari atoll in general (National Meteorological Centre at Hulhule, Kaafu. atoll) because no site specific data was available. Due to the general uniformity of the climatic data along Maldives, climatic data from Hulhule were considered applicable to the site given the lack of availability of site specific data and also the short time available for the preparation of the report to collect such data. Oceanographic data and information used to determine the current pattern around the island was also based on monsoonal wind patterns, wind generated waves, tidal flushing, geographic setting, the topography of the lagoon and shape of the shoreline.

Beach profiles were taken using a digital level. Initially the beach toe of the island was mapped using precision GPS. Afterwards profile areas were selected based on possible impact areas due to the proposed project. Seven profiles were taken along the shoreline of the island (including the proposed harbor area). All beach profiles are aligned perpendicular to the beach. Location of beach profiles and GPS coordinates are given in Figure 4.




| Profile no: | Longitude | Latitude |
|---|---|---|
| Profile 1 | 72°59'27.42''E | 4°15'53.29"N |
| Profile 2 | 72°59'25.70''E | 4°15'51.16"N |
| Profile 3 | 72°59'24.98''E | 4°15'49.31"N |
| Profile 4 | 72°59'30.57''E | 4°15'56.35"N |
| Profile 5 | 72°59'38.18''E | 4°15'44.49"N |
| Profile 6 | 72°59'31.57''E | 4°15'37.83"N |
| Profile 7 | 72°59'25.27''E | 4°15'45.10"N |

Figure 4 Location of beach profiles and GPS coordinates

An underwater camera with housing was used to take a series of photographs for assessing reef benthic community. Photo quadrats were taken along a 50 meter transect line. Randomly selected 40 quadrats were sampled within a 5 meter belt along the 50 meter transect line. Qualitative assessment was carried out at the seagreass bed located southern side of the island. Three sites were selected for reef benthic community assessment: 1) northern side of the proposed harbor location (RF1), 2) south of existing natural entrance at the western side (RF2) and 3) south western side of the island (RF3). The ecological setting of the site RF1, RF2 and RF3 will act as a baseline for future reef monitoring while the other sites assessed is to estimate the ecological components at these sites. Coral point count with excel extension (CPCe) was used to assess the benthic cover.

Assessment of the selected fish community was also carried out at the same site which would also be considered the baseline for future monitoring of the impact of the project. Fish abundance and density surveys were based on visual fish census techniques described in English et al., 1997. The 50 meter long transect line used to assess the coral and other benthic substrate was used to assess the visual fish census. Three 15 meter length and 3 meter wide segments that were consecutive along the transect line were used to estimate the diversity and abundance of 11 targeted coral reef fish families that are commonly associated with the reef environment of Maldives, All surveys were carried out by snorkeling. The depth of survey areas ranged between

1 and 3 meters. Seawater quality was also assessed in the lagoon (proposed harbor basin) to establish a baseline for the physical and chemical parameters of seawater. Only qualitative assessment was carried out to identify vegetation types at the harbor area. The GPS coordinates of reef surveys and water sampling location are given in Figure 5.

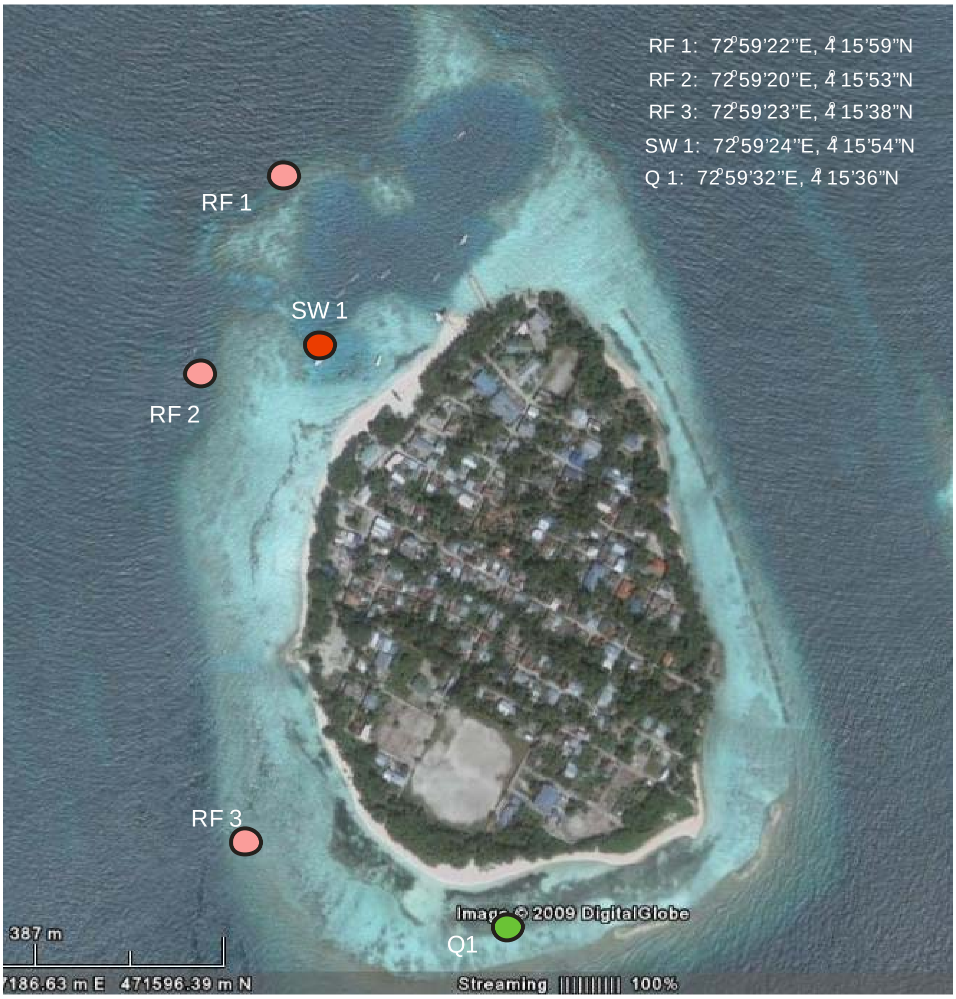



Figure 5 Sampling locations. RFs are reef benthos and fish survey locations, SWs are seawater sampling locations and Q1 is qualitative assessment area

# 5. Public Consultation

Public consultations as discussions and interviews were carried out with the relevant stakeholders of the project. Since the project was contracted to Amin Constructions Private Limited most of the harbor design and constructed details were discussed with them. The EIA consultant worked in close consultation with the project implementation agency, Ministry of Housing Transport and Environment. Several changes were brought to the harbor design and size during the evolution of the harbor concept to current agreement. The EIA consultant therefore worked in close association with the implementing agency and contractor and these has been reflected in the report.

Harbor construction in specific island communities to facilitate easy access to the island has been a priority by MHTE under ACCESS program. Shortlisting and island selection priority is generally set after close consultation with relevant agencies in the Maldives. Public consultation is therefore an integral part of the island selection, designing and construction period of this project.

## a) Institutional Arrangements

Rashdhoo is administratively located in Alifu Alifu Atoll. As with all other atolls of the Maldives, the island community governed through Ministry of Home Affairs. Day-to-day administrative and management of the island community needs together with routine reporting to relevant ministries or other institutions in Male' is managed by the island Councilor and with support from the Island Office administrative staff.

The Harbor Development Project is being carried out under the National Access Improvement Program implemented by the Government of Maldives. Provision of safe access and harbors to all the inhabited islands is a priority infrastructure development the government has committed to undertake as stated in the Seventh National Development Plan for 2006 -2010. Under the plan, the respective ministry of the Government of Maldives has committed to continue the access improvement program for inhabited islands and facilitate the development of adequate harbors throughout the country.

The National Harbor and Reclamation Programme includes the construction of major harbors and big reclamation projects, was initiated by the Government of Maldives in mid 80's. The implementation authority for the Government of Maldives is represented by the former Ministry of Construction and Public Infrastructure (at present Ministry of Housing, Transport and Environment).

## b) Community consultations and stakeholder meetings

Several community consultations were carried out regarding the construction of the harbor at various stages of developing and finishing the existing concept design. The EIA consultant carried out two levels of consultations. One was during the field survey works in September 2009 and specific community consultations meeting with relevant communities at the island level in January 2010.

Major community level stakeholders that were met to brief the design aspects, location of the harbor in the form of individual as well as a group discussions. Significant individuals that were met to discuss various aspects of the harbor are; Radhoo Island chief, Rashdhoo Councilor, members of the island committee and Harbor development committee. List of people met during both public and stakeholder consultations are given Appendix 5.

The general discussion points of the of the stakeholder consultations were;

- Location of the harbor
- Location of harbor entrance
- Design and size of harbor
- Plans to use and dispose excavated sediments from the deepening of the harbor basin
- New location for boat repair and maintenance
- Development plan for harbor front area after construction of the harbor basin
- Coastal erosion problems

The harbor design that has been completed by MHTE includes a 228.6m long and 78.7m wide harbor basin with a quay wall along the shore front with a small T jetty (concrete pier) on the right side. Small breakwater section is placed on the outer and left side of the harbor basin. Specific to this design is that the harbor is not enclosed (rectangular with an opening as an entrance channel) but rather open to an encroaching lagoon (existing natural harbor).

According to the stakeholders of the island, the location, size and orientation of the harbor is in line with what has been discussed and agreed between the relevant authorities in the island and MHTE. As mentioned earlier the harbor basin is open (without a breakwater) towards the deep lagoon facilitating open access to the harbor basin. Because of this openness some representatives at the meeting felt that there may be erosion at the downwind end of the harbor basin. Such an effect is unlikely due to this open end design but more likely due to groyne effect created by the southern end of the harbor. The shoreline of the island where the harbor basin ends at the south already has severe erosion problems. It should be noted that the harbor basin is constructed some distance from the natural shoreline (i.e. approximately 38m backfilled area).

Although the excavated material has been planned to use as backfill material for the harbor front, the community feels that the southern shoreline should also be modified to mitigate the severe erosion at this area. This would only be possible if there is adequate sediment available from the harbor basin excavation works. The community also feels that there should also be a shore protection component associated with this proposed shoreline modification to remediate the erosion problem in this area. It is noted that such a component has not been considered as part of the harbor or harbor associated construction. Without a coastal protection measure it is likely that the existing erosion problem at the area mentioned may be worsened. This judgment is based on the site condition during the field visits to the island, historical observations by the island community as identified through the consultation based assessment of the consultant based on the above two facts.

The community also feels that the breakwater length is too short to provide ample protection to the harbor basin especially during the north east monsoon. Although this may be the case there is very little option to remediate this effect. First because the harbor basin is open to the deep lagoon and there is not enough area to appropriately place a breakwater to provide wave protection. Secondly there is no shallow area to place a breakwater nearby to provide wave protection. Furthermore existing budget allocated for the project would not cover costs for any additional breakwater. Additional breakwater if required t can be identified after the construction of the harbor and seeing how effective the design is after few monsoon cycles. If needed such a construction should be based oceanographic data in the vicinity of the harbor.

A pressing issue the community is eager in is deepening of the small natural channel oriented to north, in addition to the channel that has been agreed to deepen by MHTE. This additional deepening area is more of a matter of convenience than a requirement. Channel deepening should therefore be considered by the contractor based on the depth contours at the two sites and chose the least environmentally damaging option. It should be noted that the western channel (primary option) is relatively wider compared to the north oriented channel.

The community is also very eager to develop the harbor front area to facilitate various utilities for the benefit of the traveler and harbor users. These facilities include toilet facilities, water supply, fuel supply, food outlets and small shops. Currently there is no budget to do this but a plan the community has. The community also feels that the harbor front area should be designed so that there is a drain water slope to the water front rather than in land. Such design consideration has been already incorporated in the harbor design criteria.

On the issue of construction workforce stationed at the island by the contractor the community feels that they should stay in rented places rather than constructing a specific camp. This is because such an option would inject more money to the local community although it is short term. If a separate construction site is required by the contractor then the island officials and community ensured that they will provide such a location in consultation with the community since the eventual benefit of the project is community specific. The contractor should make sure that that community social harmony is not compromised during or their behavior within the construction period.

Coastal erosion is a common issue in many islands in the Maldives whether the shoreline is modified with a harbor basin or not. Erosion scarps are present at several locations around the island. Community is very concerned with the existing erosion problems at the island and do not seek additional erosion due to the construction of the harbor.

### c) Design consultant

Consultation with design consultant was done during January 2010. During this meeting design consultant was briefed about the issues raised by the community. According to the design consultant the concept was done not by them but by MHTE, due to various political and social unrest that have occurred since the beginning of the Rashdhoo harbor project. In this regard the concept design was formalized by MHTE in consultation with Presidents office and island community (see Appendix 6; letters from MHTE).

The design consultant was briefed about the shallow segment at the existing entrance at the western side which would be used as an access to the proposed harbor. According to the design consultant if this area is shallow then excavation works will be done during project work. In regard to dredging or cutting an entrance at the northern side, design consultant informed that this would be very costly, since barges have to be used to operate the excavator. Design consultant also stated that western side natural entrance is a better location than the northern side. It has to be noted that a natural entrance is located at the eastern side as well that can be use dot access the deep lagoon.

### d) MHTE (construction department)

Consultation with MHTE was done during January 2010. The personnel from MHTE were briefed about the consultation meeting held at Rashdhoo. According to MHTE, the community has formally agreed to the proposed concept and this concept was formulated after the meeting by president and Rashdhoo community during his visit to the island.

# 6. Existing Environment

## a) General Setting

The Maldives archipelago consists of a double chain of coral atolls, 80 – 120km wide stretching 860km from latitude 7° 6' 30" N to 0° 41' 48" S and longitude 72° 32' 30 E to 73° 45' 54" E (Ministry of Construction and Public Works, 1999). The double chain of the Maldivian atolls lies on the parallel submarine ridges in the central part of Indian Ocean known as Lacadive-Chagos ridge. The archipelago comprises 25 natural atolls (Naseer, 2004) grouped into 20 administrative units (see Figure 6). The atolls are separated by east-west running deeper channels. The atolls vary in shape from circular and oval to elliptical. The atolls contain 1190 islands, of which only 198 are inhabited. The total reef area of Maldives is 4,493.85km$^2$ while the total land area is 227.45km$^2$ (Naseer, 2004). Approximately 80% of Maldivian land area is less than 1m above mean sea level.

The characteristics of reefs and coral islands of the Maldives vary considerably from north to south. The atolls to the north are broad banks discontinuously fringed by reefs with small coral islands and with numerous patch reefs and faros (the word faros is derived from the Maldivian word "*faru*") in the lagoon. To the south the depth of atoll lagoon increases, faros and patch reefs are rare in the lagoon, the continuity of the atoll rim is greater and a large proportion of the perimeter of the atolls is occupied by islands (Woodroffe, 1992). The islands have shallow reef flats on their seaward side, some with shingle ramparts at the seaward limit of the reef flat. The islands and the shingle ramparts owe their origin to the deposition of shingle or coral debris during storms. A number of islands can be found on a single reef. These islands may be separated by shallow passages that run across the reef flat. The width of some of these passages could be less 100m while some passages are over a few hundred meters wide.

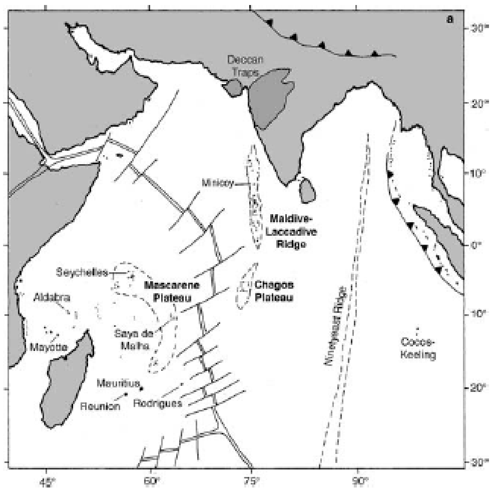



Figure 6 Geographic location of Maldives in Indian Ocean

## b) Geographical location and general setting of Rashdhoo

Rashdhoo is located in AA Atoll, approximately 58km from Male'. In terms of geographic coordinates, it is located at 04° 57' 47" N and 72° 59' 58" E. Rashdhoo sits in its own atoll (Rashdhoo atoll) located just north east of main atoll formation of Ari atoll. Nearest inhabited island is Ukulhas approximately 14.5km west of Rashdhoo at the main atoll. While the closest uninhabited islands are Madivaru (0.7km east) and Madivaru finolhu (0.8km) located north east of the Rashdhoo, separated Rashdhoo channel. Nearest Resort islands are Kuramathi Tourist Resort located 0.56km at the western side of Rashdhoo and Veligadu island Resort 4.1km north eastern of Rashdhoo.

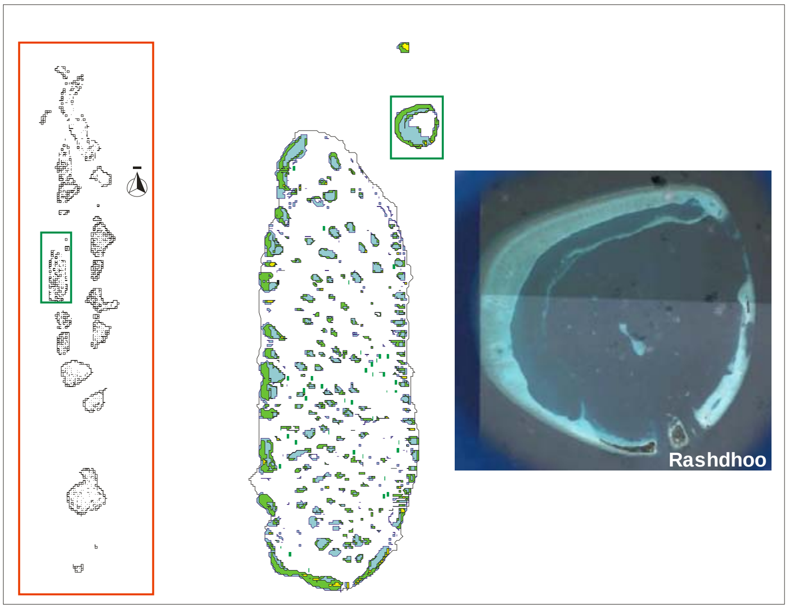



Figure 7 Geographic location of Rashdhoo in ALifu Alifu Atoll

## c) Climate and Oceanography

### *i) Wind climate*

Wind climate in the Maldives is dominated by the Indian monsoon climate South West (SW) monsoon and North East (NE) monsoon. The Indian monsoon system is one of the major climate systems of the world, impacting large portions of both Africa and Asia (Overpeck et, al., 1996). The monsoon climate is driven by the atmospheric pressure differences that arise as a result of rapid warming or cooling of the Tibetan Plateau relative to the Indian Ocean (Hastenrath 1991; Fein and Stephens 1987). During the summer of northern hemisphere the Tibetan Plateau warms rapidly relative to the Indian Ocean which results in an atmospheric pressure gradient (Low pressure over Asia and high pressure over the Indian Ocean) between the Asian landmass and the Indian ocean, which drives the prevailing wind from south to westerly directions. The period during which prevailing winds are from south to westerly direction is known as the SW monsoon. In the winter of northern hemisphere the continent cools relative to the ocean. This reverses the pressure gradient (low pressure over the Indian Ocean high pressure over the Asian landmass) and the prevailing winds become northeasterly. The period during which prevailing winds are from northeasterly directions is known as NE monsoon. The transitions from NE to SW monsoon and vice versa are distinctly different from SW or NE monsoon. During these transition periods the wind becomes more variable.

The SW monsoon lasts between May and September while the NE monsoon lasts between December and February. The period between March and April is the transition period from the NE monsoon to SW monsoon known locally as the Hulhangu Halha, while the transition period from SW monsoon to NE monsoon is known as Iruvai Halha. Iruvaihalha lasts from October to November (Table 3). The SW monsoon is generally rough and wetter than the NE monsoon. Storms and gales are infrequent in this part of the world and cyclones do not reach as far south as the Maldivian archipelago (Ministry of Construction and Public Works, 1999).

Table 3 The four seasons experienced in the Maldives

| Season | Month |
|---|---|
| NE-Monsoon | December<br>January<br>February |
| Transition Period 1 | March<br>April |
| SW-Monsoon | May<br>June<br>July<br>August<br>September |
| Transition Period 2 | October<br>November |

A detail analysis of the wind climate for Male Atoll was carried out using daily averaged wind data from Male International Airport from 2002 – 2006 (Figure 8). Since Hulhule is the only site where meteorological data is recorded in the central region of Maldives and also due to close proximity to project location, Hulhule wind data was used to assess the wind climate. In this analysis wind directions and speed were plotted as wind rose diagrams and the frequency distributions of the wind speeds from different directions were obtained. A spectral analysis of the wind speed data was also performed to determine the cyclic nature of the winds.

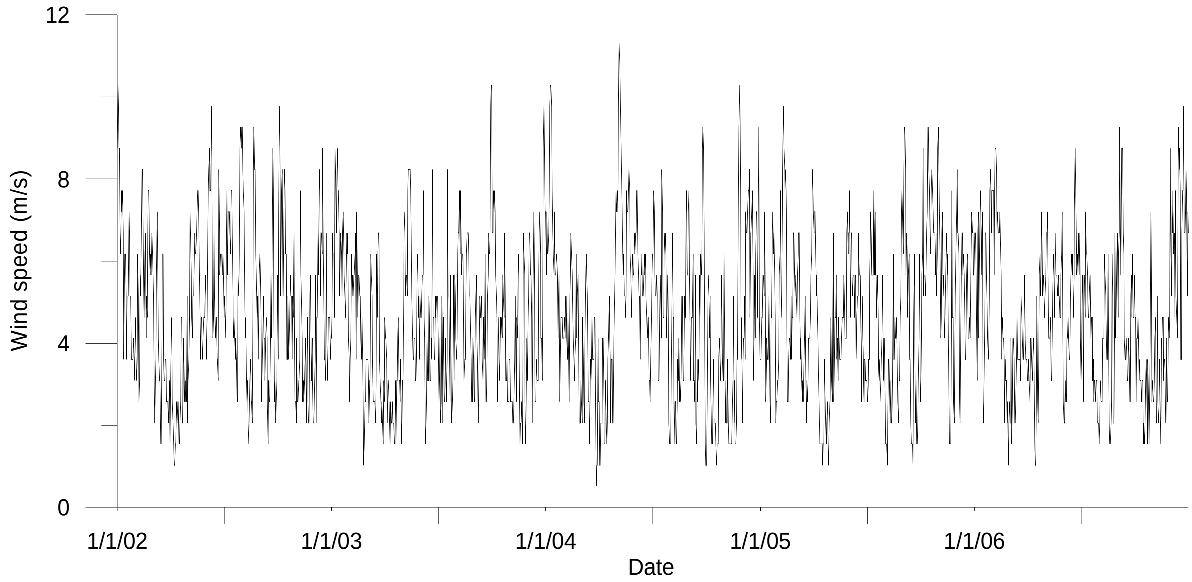



Figure 8 Time series plot of wind speed data from Jan 02~ Dec 06

Wind rose plot (Figure 9) and the frequency distribution of the wind speed (Table 4) shows that the prevailing directions of the westerly winds are between WSW and WNW. Wind from these directions sums up to 47.85% of the year. The prevailing directions of easterly winds are between ENE and E that sums up to 22.24% of the year. Winds from all other directions sums less than 30% of the year. These prevailing westerly and easterly directions are also the directions from which the strongest winds blow. Wind speed distribution (Figure 9) shows that for winds stronger than a light breeze (>8m/s), the westerly prevailing wind directions contribute up to 52.56% while the easterly prevailing directions contribute up to 39.49%. Based on these results it is evident that the winds at central region are almost confined to 5 directions, WSW, W, WNW, WNW and E.

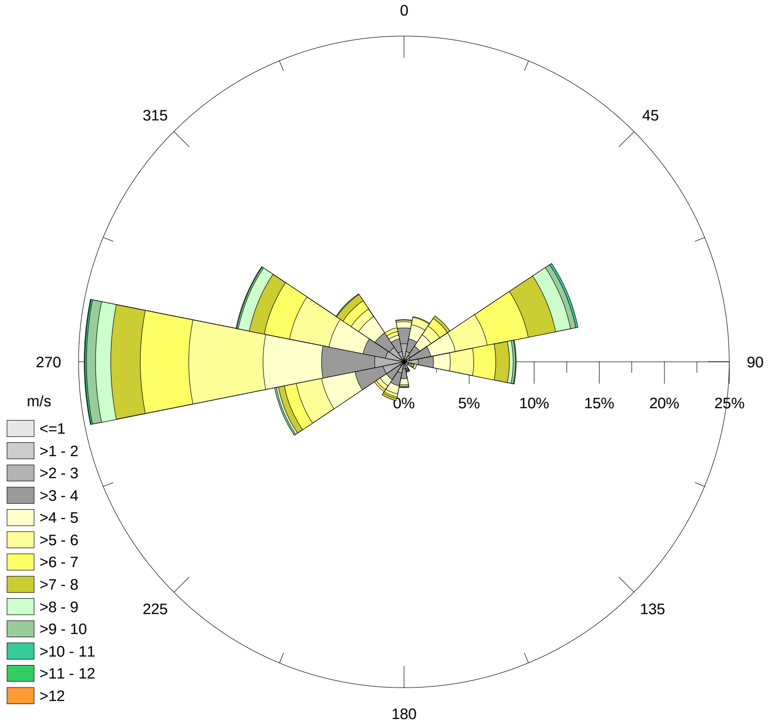



Figure 9 Wind speed and direction at Hulhule for various seasons

Table 4 frequency distribution of wind

| Wind Direction | Frequency of occurance Speed (m/s) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Sum (%) |
| N | | 0.06% | 1.34% | 1.22% | 0.47% | 0.12% | 0.06% | | | | | | 3.26% |
| NNE | | | 0.81% | 0.99% | 1.11% | 0.58% | 0.06% | | | | | | 3.55% |
| NE | | | 0.58% | 0.87% | 1.05% | 0.81% | 0.70% | 0.23% | | | | | 4.25% |
| ENE | | | 0.47% | 1.63% | 1.92% | 2.50% | 3.20% | 2.15% | 1.16% | 0.41% | 0.17% | | 13.62% |
| ENE | | 0.17% | 0.93% | 1.16% | 1.28% | 1.80% | 1.69% | 1.05% | 0.29% | 0.17% | 0.06% | | 8.61% |
| ESE | | | 0.35% | 0.29% | 0.12% | 0.06% | 0.17% | | | | | | 0.99% |
| SE | | | 0.06% | 0.06% | 0.23% | | | | | | | | 0.35% |
| SSE | | | 0.52% | 0.12% | 0.06% | 0.06% | 0.06% | | | | | | 0.81% |
| S | | 0.06% | 0.47% | 0.76% | 0.47% | 0.12% | 0.06% | 0.06% | | | | | 1.98% |
| SSW | | 0.06% | 0.81% | 0.99% | 0.64% | 0.23% | 0.12% | 0.17% | | | | | 3.03% |
| SW | | | 0.35% | 1.28% | 0.58% | 0.35% | 0.17% | | | | | | 2.74% |
| WSW | | | 1.63% | 2.21% | 2.62% | 1.98% | 0.93% | 0.47% | 0.17% | 0.12% | | | 10.13% |
| W | | | 2.27% | 4.07% | 4.48% | 5.70% | 3.73% | 2.27% | 1.16% | 0.70% | 0.12% | 0.06% | 24.56% |
| WNW | | 0.06% | 1.40% | 1.75% | 2.68% | 3.08% | 1.98% | 1.16% | 0.87% | 0.12% | 0.06% | | 13.15% |
| NW | | 0.29% | 1.05% | 1.34% | 1.51% | 0.70% | 0.76% | 0.58% | | 0.06% | | | 6.29% |
| NNW | | | 0.81% | 0.99% | 0.29% | 0.29% | 0.29% | | | | | | 2.68% |
| Sum (%) | | 0.70% | 13.85% | 19.73% | 19.50% | 18.39% | 13.97% | 8.15% | 3.67% | 1.57% | 0.41% | 0.06% | |

Spectral analysis of the wind speed data for the period between the years 2002 and 2006 indicates that the changes in seasonal wind patterns have very regular periods. The strongest four peaks on the power spectral density graph (Figure 10) Tp1, Tp2, Tp3 and Tp4 corresponds to periods of 4.0months, 6.1months, 2.4months and 1.6months respectively. The strongest of these periods is the 4 monthly period which has a magnitude 1.3 times higher than that of the 6 monthly period.

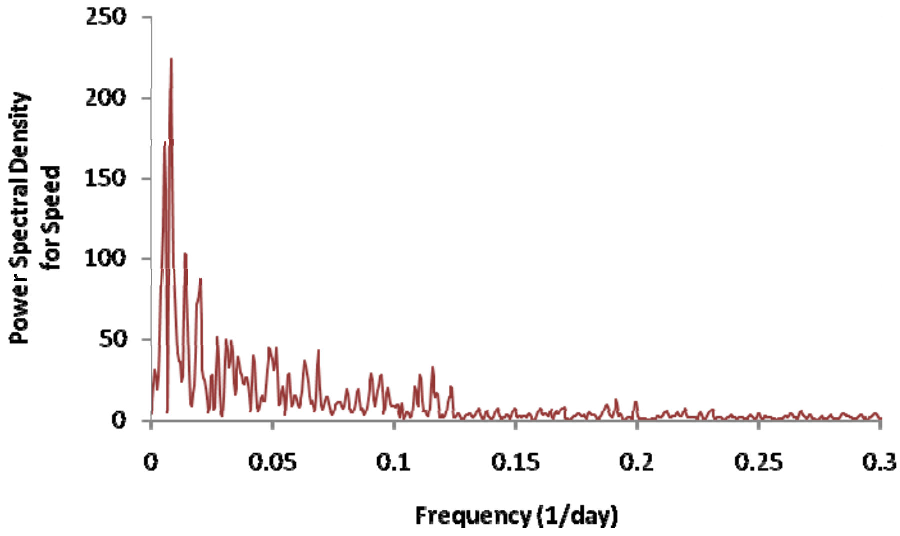



Figure 10 Power spectral density graphs for the wind speed data from Male International Airport for the period between the years 2002 and 2006

Examining the spectrum for the wind direction data (Figure 11) indicates that although the predominant period for wind speed is 4 months, the wind directions change on a predominantly 6 month period. The magnitude of the 6 month cycle on the wind direction spectrum is 1.7 times greater than that of the 4 month cycle. This evidently shows that the reversals in the wind directions occur on a biannual cycle rather than the commonly believed 8 months of westerly winds and 4 months of easterly winds.

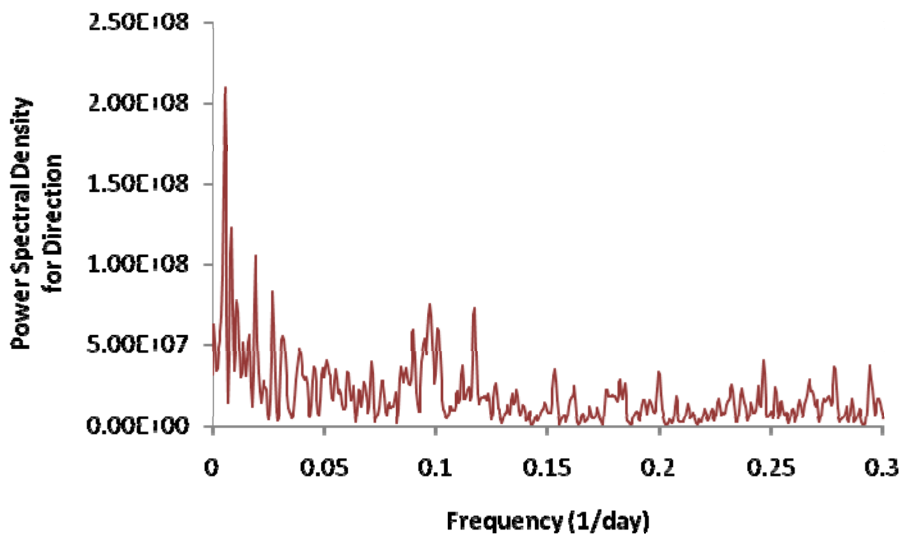



Figure 11 Power spectral density graphs for the wind direction data from Male International Airport for the period between the years 2002 and 2006

## ii) Wave and current

Information on the swells around Maldives is limited, but there have been a few studies carried out around Male' and Fuahmulak (southern region of Maldives). Wave data for Male' that were recorded for the period between June 1988 and January 1990 revealed that the maximum significant wave height ($H_s$) recorded for the month of June 1989 was 1.23m with a mean period ($T_m$) of 7.53s. For the month of July 1989 maximum recorded Hs was 1.51m and the corresponding $T_m$ was 7.74s. In June and July 1989 mean wave periods were 5.0 – 9.0s and the peak wave periods within 8.0 – 13.0s. Wave data for the period between September 1988 and July 1989 shows a probability of exceedence of Hs = 1.0 m was approximately 0.1 and of Hs = 1.5 m was approximately 0.0015 based on the wave data of period September 1988 to July 1989.

JICA, (1992) reported that the wave climate in Male region is generally higher in the months of June, July and August with a predominant wave direction of S (180°). During October to December the waves have a shorter period with wave directions varying from S and W (180° - 270°) (Figure 12).

According to DHI, (1999) the significant wave height (Hs) in the southern regions of Maldives exceeds 3m in about 0.1percent of the time (Figure 13). Figure 12 also shows that the highest waves are from W and S. From NW, N, NE and E, significant wave height exceeds 1m in less than about one per cent of the time.

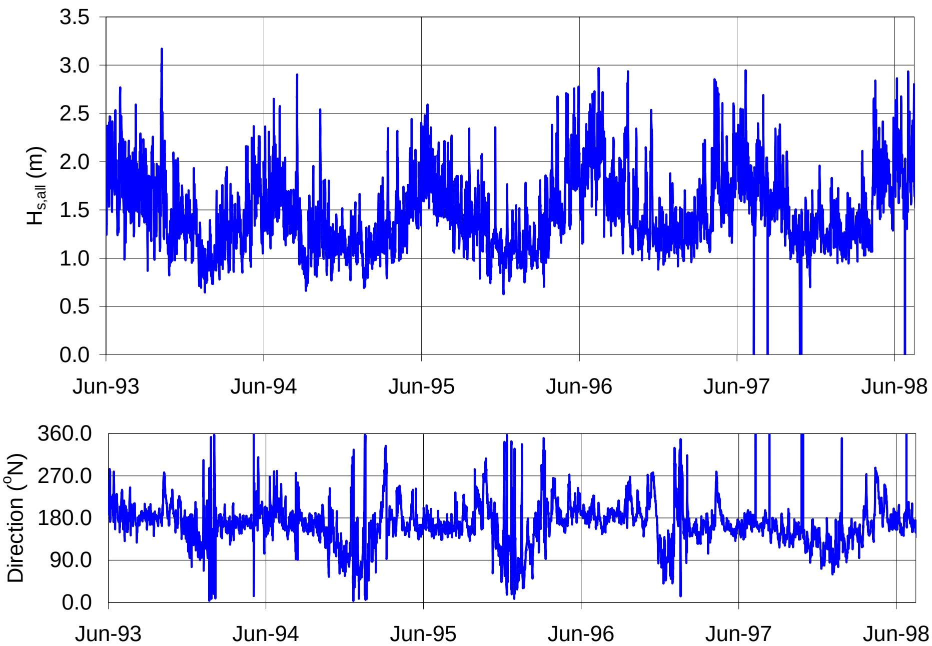



Figure 12Graph showing the significant wave height and wave directions in the southern region of Maldives

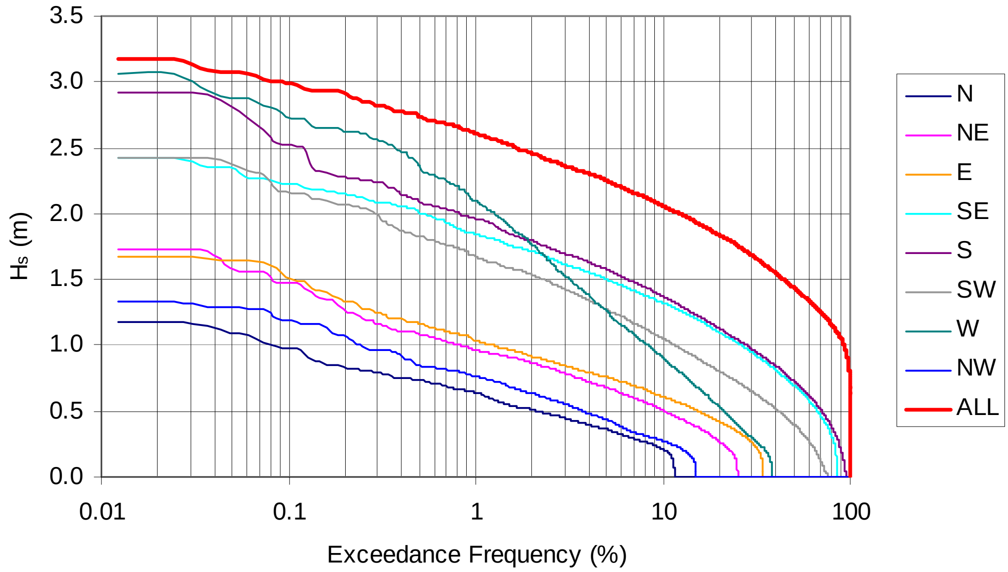



Figure 13 Wave height, Hs exceedence curves for southern region of Maldives (source DHI 1999)

The reef system is submitted to three main oceanic climate factors, swells waves from the south eastern side of the reef, the southwest monsoon wind waves and the northeast monsoon wind waves. Figure 14 shows assumed wave climate of the reef system.

During the NE monsoon, wind waves are experienced from north eastern quadrant, swell waves will be received almost from due east to south eastern direction. During the SW monsoon the wind waves will be in the northwest to western quadrant and rarely from due south (based on wind data from Male International Airport). Swell waves are received from SE quadrant and is also experienced at the western and eastern side due wrapping around of swell waves (through the channel), or refraction of swell waves. The erosion pattern at the island is probably due to the swell waves and monsoonal wind waves (western side of the island), major erosion is observed at the western and eastern side of the island. The eastern side of the reef is observed with a series of breakwaters, probably due to swell waves receiving during NE monsoon. It has to be noted that eastern side is more vulnerable to swell waves compared to western side, while western side is vulnerable to wind waves (SW monsoonal) compared to eastern side.

Wind wave induced currents flow north to south wards during NE monsoon and during SW monsoon west to east wards. According to the IDC, during periods when wind is from northerly direction, the deep lagoon gets very rough.


Figure 14 Assumed wave climate of the reef system

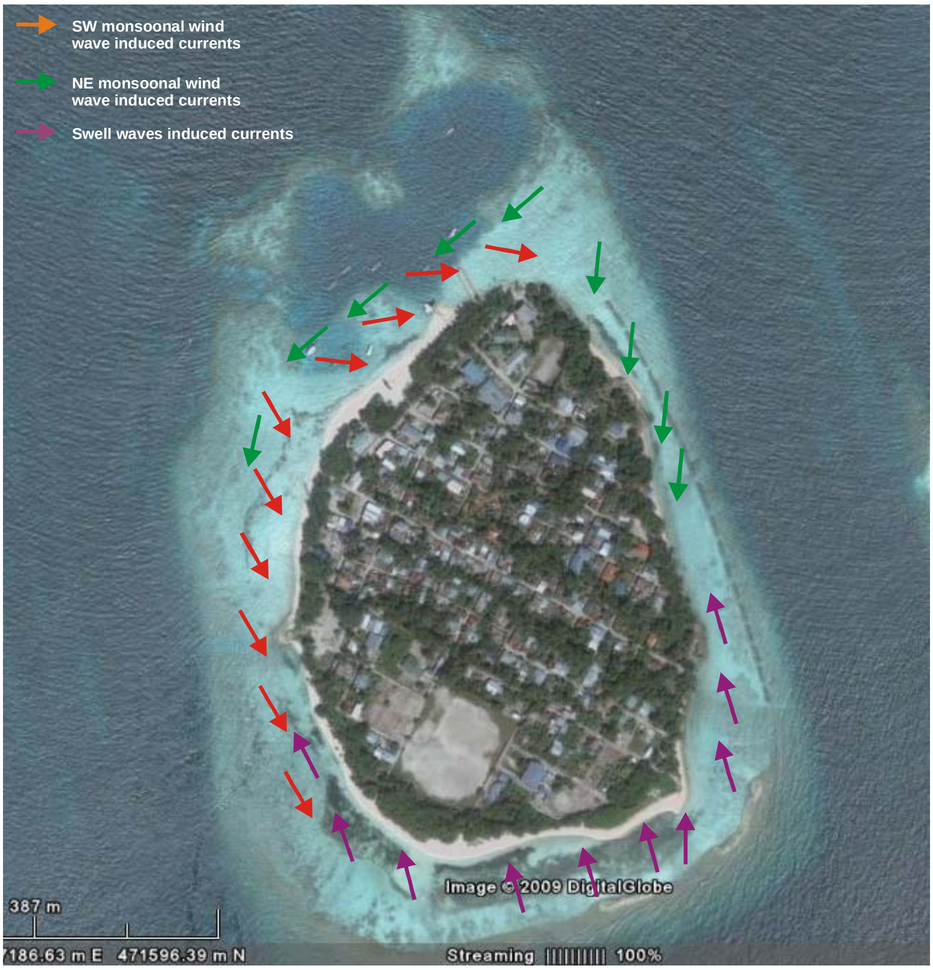



Figure 15 Envisaged current regime at Rashdhoo based on analyzed wind data

## iii) Tide

Long-term water-level records for Male International Airport are available from the web site of University of Hawaii. All coastal development projects require determination of the water level or water datum. Tide which consists of number of wave forms, termed tidal constituents generate many different water levels that are used as different datum. The most commonly used tidal datum in the Maldives is the Mean Sea Level (MSL). However, for designing the heights of the seawall, groynes and breakwaters the Highest High Water Level, Lowest Low Water Level Mean Higher High Water Level, Mean Lower Low Water Level, Mean Lower Low Water Level and Mean Higher Low Water Level are important tidal datum. The astronomical tide at Rashdhoo has been assumed to be same as that at Male International Airport (see Figure 17 for comparison of Hulhule tide and tide taken at site).

Spectral analysis of one years (year 2007) tidal records from Male International Airport (Figure 16) allowed establishment of the main tidal constituents M2 (Principal lunar semi-diurnal constituent), S2 (Principal solar semi-diurnal constituent), K1 (Luni-solar declinational diurnal constituent) and O1 (Lunar declinational diurnal constituent) (Table 5). Summation of M2, S2, K1 and O1 gave the approximate level of LLWL and approximate HHWL relative to MSL. Summation of M2 and S2 gave the approximate MHHWL and approximate MLLWL while the summation of K1 and O1 gave the approximate MLHWL and MHLWL relative to MSL (Table 6).

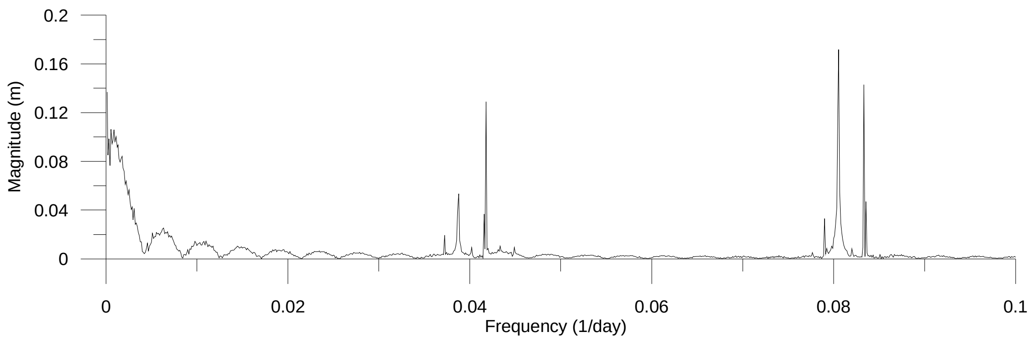



Figure 16 Spectral density for the tide (year 2007) from Male International Airport

Table 5 Magnitude of the dominant tidal constituents for the tide at Male International Airport

| Tidal Constituent | Magnitude (m) |
|---|---|
| M2 (Principal lunar seim-diurnal constituent) | 0.1716 |
| S2 (Principal solar semi-diurnal constituent) | 0.1427 |
| K1 (Luni-solar declinational diurnal constituent) | 0.1289 |
| O1 (Lunar declinational diurnal constituent) | 0.0535 |

Table 6 Table summarizing tide levels at Hulhule, Male' Atoll

| Tide level | Water level referred to Mean Sea Level (MSL) (m) |
|---|---|
| Highest Astronomical Tide (HAT) | +0.64 |
| Mean Higher High Water (MHHW) | +0.34 |
| Mean Lower High Water (MLHW) | +0.14 |
| Mean Sea Level (MSL) | 0.0 |
| Mean Higher Low Water (MHLW) | -0.16 |
| Mean Lower Low Water (MLLW) | -0.36 |
| Lowest Astronomical Tide (LAT) | -0.56 |

Data was taken at Rashdhoo for the period 16th October to 18th October 2009, below is the graph showing comparison of predicted tide (for Hulhule) and tide taken by tide gauge at site.

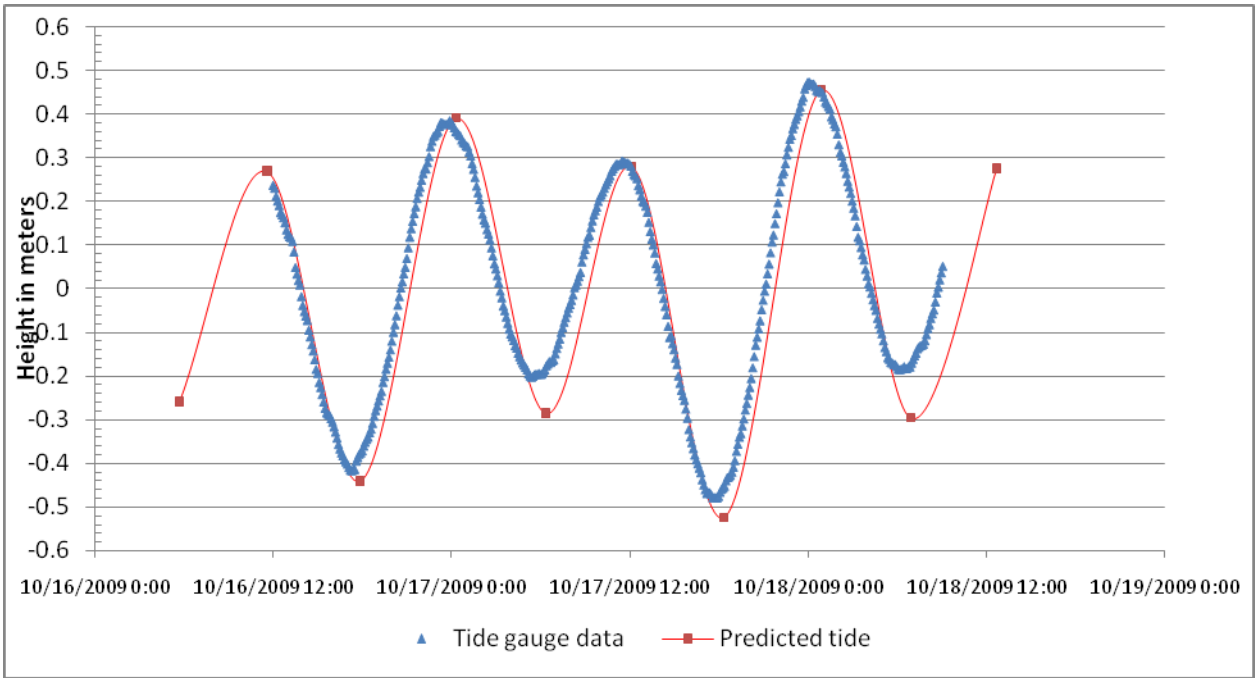



Figure 17 Comparison of predicted tide and tide data collected at site

## d) Beach Environment

Beach environment of Rashdhoo is defined by the hydrodynamic environment of the reef system. The hydrodynamic force affecting the reef system is the oceanic swells received from the SE direction. The Two channels at either side of Rashdhoo reef system transmits these refracted swell waves to inter atoll waters. The refracted swell induced currents from either side of the island pushes the sediment produced at the reef system northwards. The eastern and western side of the reef is observed with severe erosion. It has to be noted due to severe erosion, the community has made several coastal modifications over the years. The eastern side of the island is observed with a series of breakwaters construction offshore using coral rock, while at the south eastern corner of the islands revetment wall is observed.

At the western side, where the Dhiraagu plot is located, the boundary wall of the premise is at present almost at the high tide line, while at other areas several coconut trees were observed to be uprooted. Erosion at this area is highest during SW monsoon when the wind direction is west to north westwards. The beach profile taken at this area shows erosion scarps more than 0.5m high. The northern side of the island is observed with wide beach. According to the IDC this sand moves a little west or east depending on season. The southern and south western side of the island is observed with good beach, although the beach width is narrow.

Beach profiles were taken at 7 locations at Rashdhoo (including the proposed harbor area). It has to be noted that the island ridge level of thee island is relatively low, just over a meter in height (MSL). During the GPS survey, three zones with erosion is identified, these are the western quadrant, northern corner and the eastern central area.

Figure 18 Severe erosion observed at the western side of the island

Figure 19 Uprooted coconut trees observed at the western side of the island


Figure 20 Boundary wall of Dhiraagu plot (south western corner) is at present almost at the high water mark


Figure 21 Erosion observed at the northern side of the island, west of new jetty (left), northern corner (right)

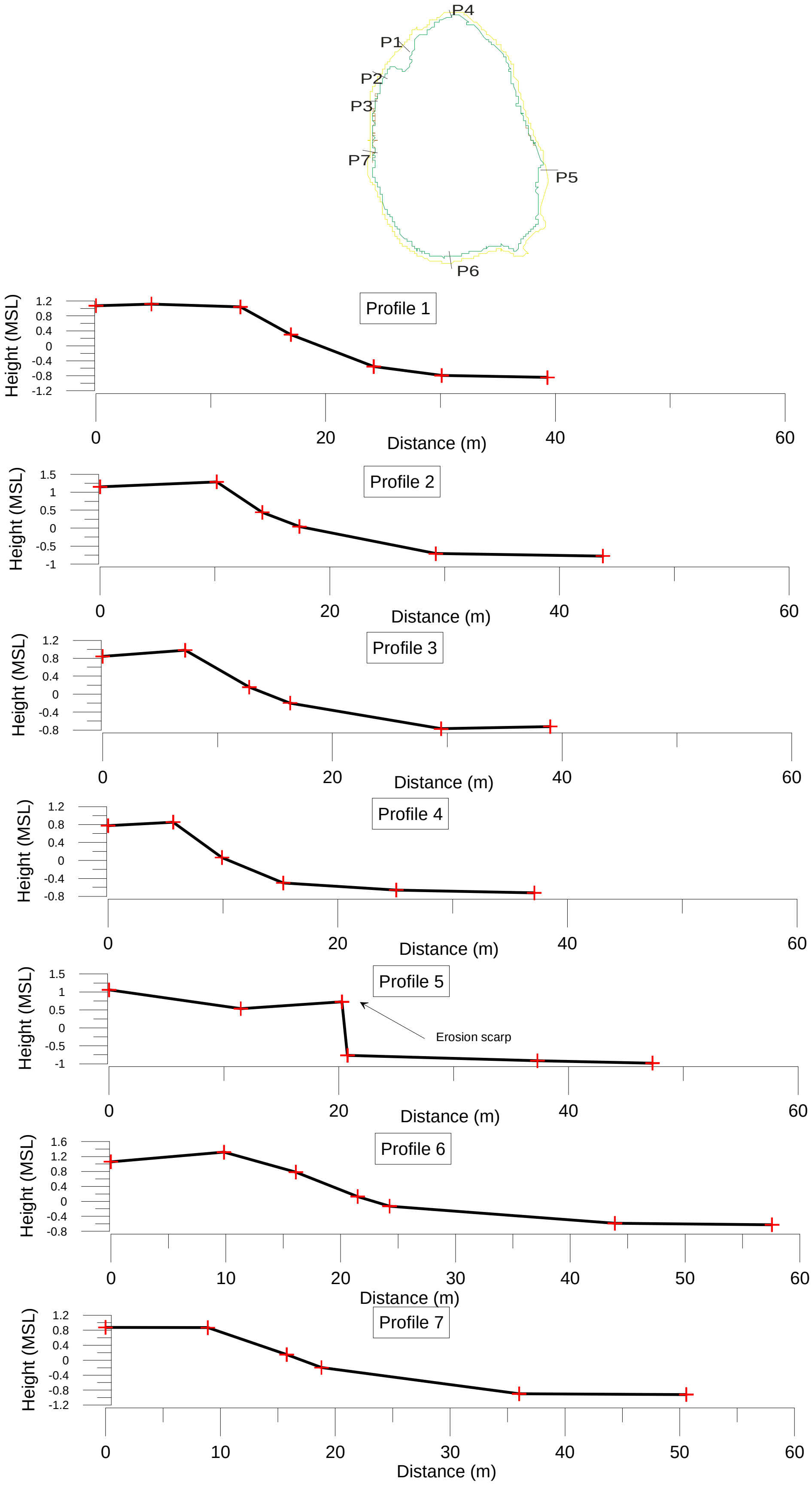



Figure 22 Summary of beach profiles taken at the western side beach, Height is given relative to MSL

## e) Marine Surveys

The status of the marine environment at the harbour construction site at Rashdhoo was carried out using standard marine survey methodologies to estimate the overall ecological condition of the reef. A brief description of the survey methods are given in Section 4.

### *i) Coral community*

Three sites were surveyed to establish a baseline for reef benthic community; one northern side of island in front of proposed harbor area (RF 1), one at the southern side of existing natural entrance at the western side (RF 2) and at the south western of the island (RF 3). Live coral cover at site RF1 was 49.9%, while abiotic categories such as rock, sand and rubble was 39% of total cover (rock 31%, rubble 7% and sand 3%). Among the dominant and common live corals include: Acropora which includes mainly tabulate forms (70%), Porites (11%) and Pocillopora (6%), while several other genera contributed to the remaining cover (Figure 23). Only 7 coral genera were recorded at this site (Figure 24).

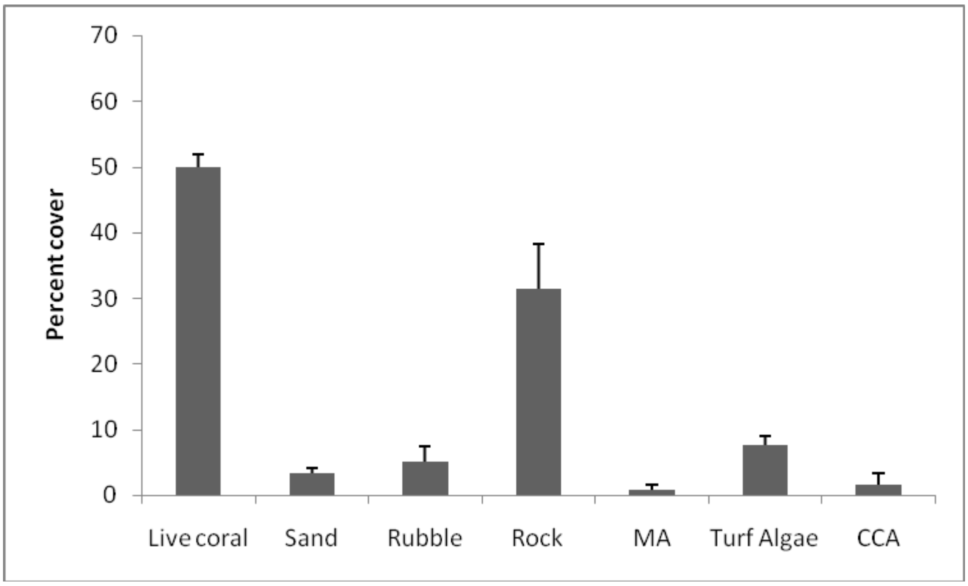



Figure 23 Estimation of benthic cover at site RF1. Values are mean percent cover and error bars are standard error of mean

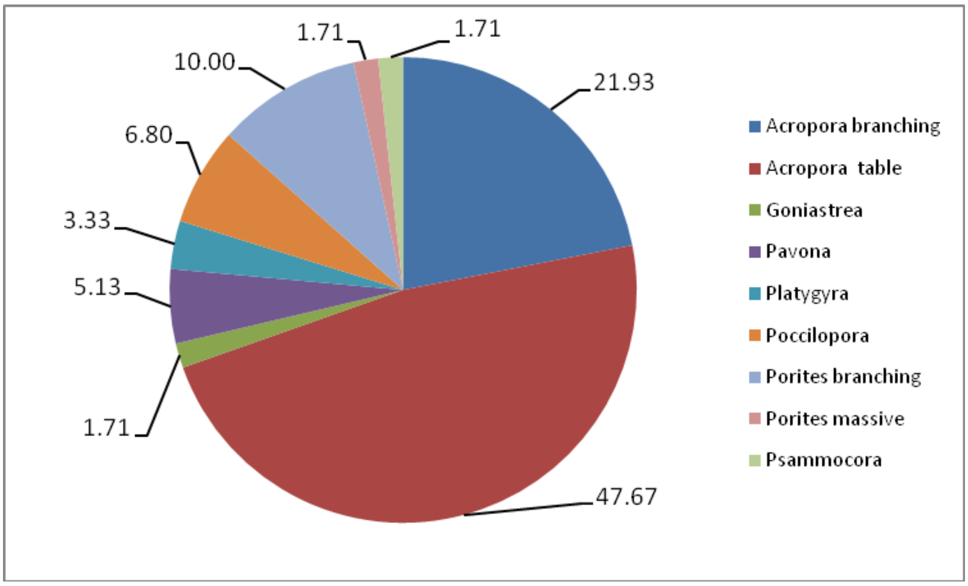



Figure 24 Comparison of the live coral community at site 1

Coral cover at siteRF2 was higher than site RF1, live coral cover at RF2 was 54.8% (Figure 25). Rrubble and rock cover was approximately 40%. Few recently dead coral colonies were also observed the area, these include mostly Pocillopora colonies (these colonies were not recorded on the transects. Unlike site RF1, Acropora cover at RF2 was lower (56%) followed by Porites (24.9%) and Pavona (19.2%), while other generas were in low abundance (Figure 26). Total of 6 coral genera was recorded at this site (Figure 26).

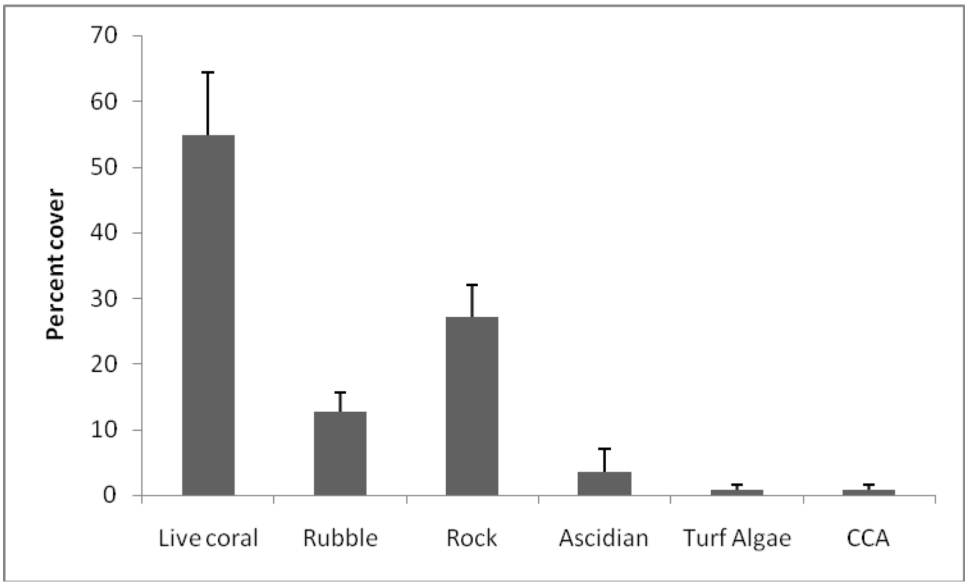



Figure 25 Estimation of benthic cover at site RF2. Values are mean percent cover and error bars are standard error of mean

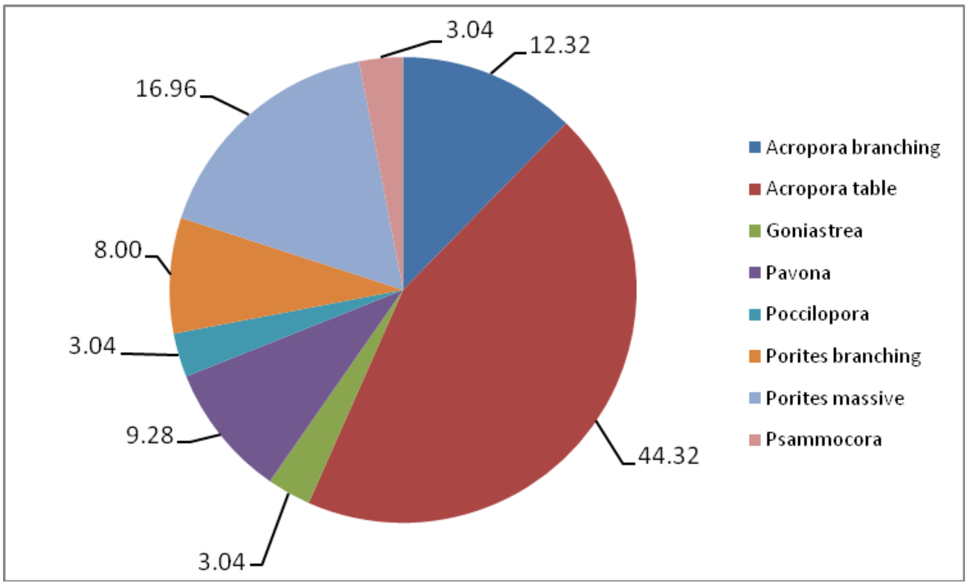



Figure 26 Comparison of the live coral community at site 2

Coral cover at site RF 3 was similar to site RF2, live coral cover at RF3 was 557% (Figure 27). Turf algal cover was approximately 4.1% while rubble, sand and rock cover was approximately 35.8%. Few recently dead coral colonies were also observed the area, these include mostly Pocillopora colonies. Similar to site RF2, live coral at RF3 was dominated by Acropora (57.8%) followed by Porites (27.2%) and Pocillopora (24%), while other generas were in low abundance (Figure 28). Total of 7 coral genera was recorded at this site (Figure 28).

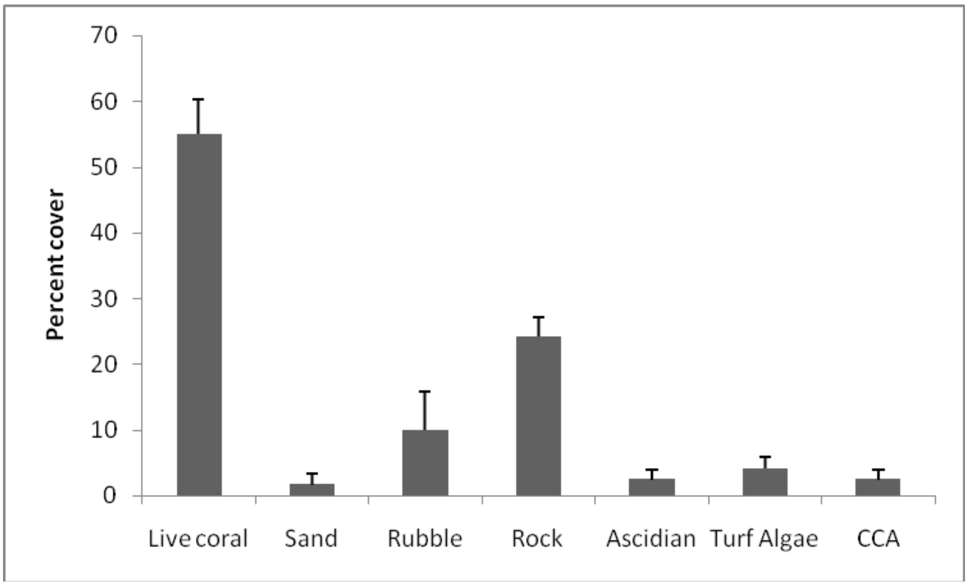



Figure 27 Estimation of benthic cover at site RF3. Values are mean percent cover and error bars are standard error of the mean

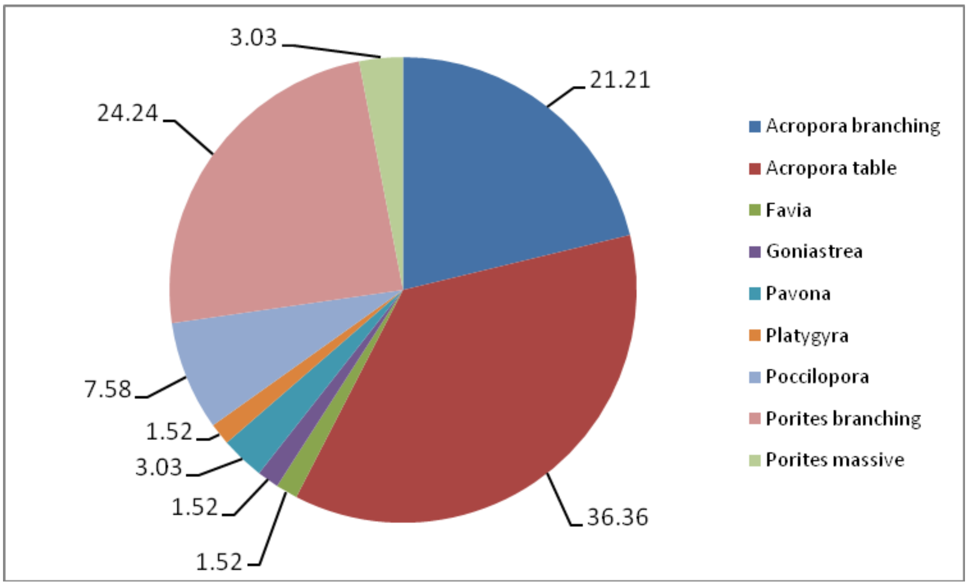



Figure 28 Composition of the live coral community at site 3

Figure 29 General condition of reef at site RF1, dominated by acroporids

Figure 30 General condition of reef at site RF2

Figure 31 General condition of reef at RF3, send image (right ) is taken from the slope area

Qualitative survey site is located at the southern side of the island at the sea grass bed. The sea grass meadow was dominated by single species *Thalassia hemprochii*. Few live coral species like small colonies of Porites (massive life form) and branching colonies of Psammacora was observed among the sea grass bed. Lethrinids, Scarids and Acanthurids juvenile fish were observed sheltering among the sea grass bed

Figure 32 Sea grass bed observed at the southern side of the island, single species *Thalassia hemprichii* was observed at the area

## ii) Reef fish community

The reef fish community at the reef survey sites during the time of the sampling consisted of 14 families, 20 generas and 34 species. The most dominant families are Acanthurids, Pomacentrids and Labrids. Majority of the reef grazers are among these three families. Among the Acanthurids *Acanthurus leucosternon*, and *Ctenachaetus striatus* were observed to be dominant, while *Pomacentrus* *chrysurus* and *Chromis dimidiata* were dominant representing the family Pomacentridae. Other reef grazers such as scarids are also present at the site but in low abundance. Most noticeably Herbivores species were dominant, indicating the algal dominance of the reef. The only areas where Acroporids were dominant, at site one and three, Chaetodontids were observed, although the most of the fish observed were juveniles. Reef fish diversity was highest at site one, where Acropora was dominant and live coral cover was highest.

At site one altogether 13 families of reef fish were recorded. Among the sites surveyed site one had the highest number of species. Site one was dominated by Acanthurids, Labrids and Pomacentrids. Among the Acanthurids, *Acanthurus leucosterno*n and *Ctenachaetus striatus*, and among Labrids, schooling juveniles of *Thalassoma amblycephalum* was dominant. Other species observed were in low abundance.

At site two altogether 9 families of fish were observed, abundance of reef fish was low at this site. But off the reef crest at the slope, schooling Blue triggerfish (Odonus niger) was observed in high numbers. Similar to site one, dominant families observed at site two were Acanthurids, Pomacentrids and Labrids.

Similar to site two, altogether 9 families of reef fish were recorded at site three, abundance of fish was low. This may be due to the turbidity of the area. Dominant family of reef fish observed at site three was Acanthuridae followed by Labridae and Pomcentridae.

Food fishes are low in abundance at the monitoring sites. Only one family of commercially exploited reef fishes, Serranidae was encountered. Serranids encountered at survey sites are *Cephalopholis argus* and *Aethaloperca rogaa*. Serrainids were observed at site one and site three.

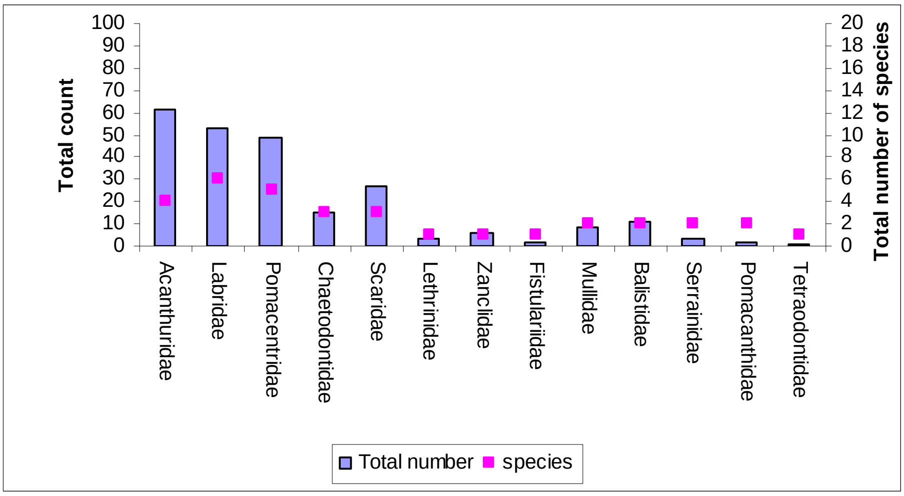



Figure 33 Reef fish composition at site RF1

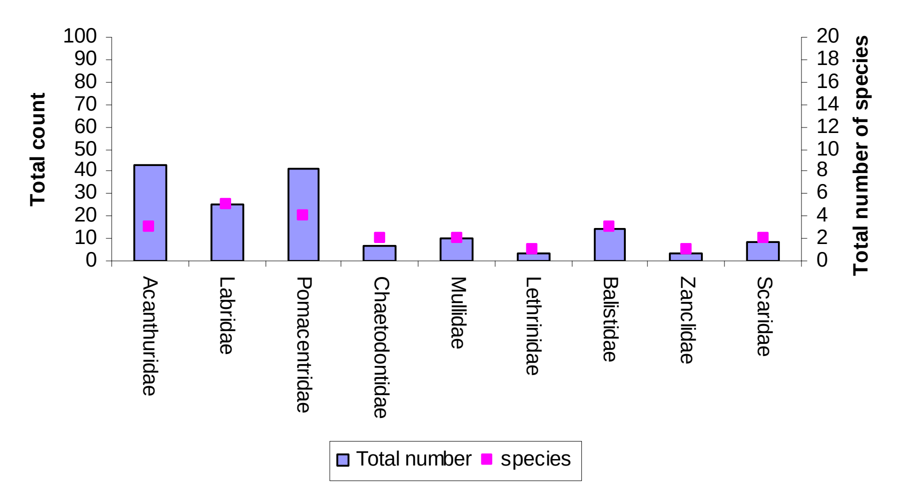



Figure 34 Reef fish composition at site RF2

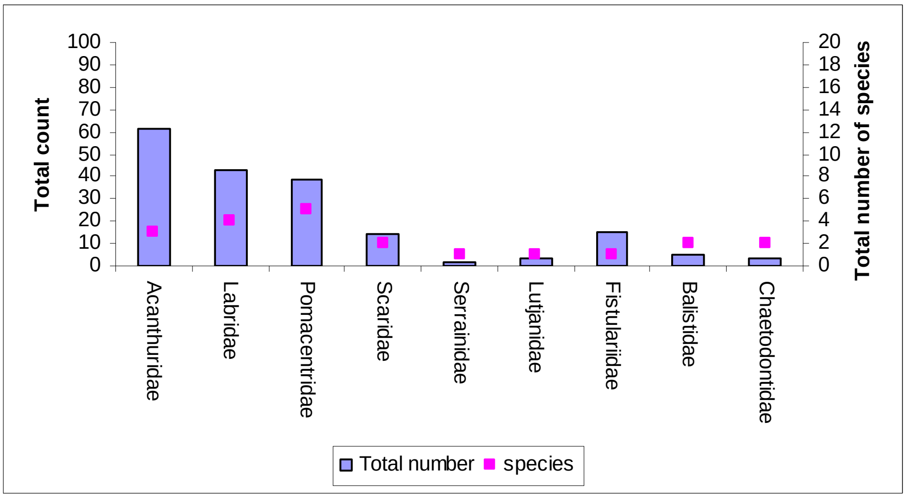



Figure 35 Reef fish composition at site RF3

In general, from the information derived from the fish census it can be concluded that the fish population at the survey sites is dominated by herbivorous fishes such as Acanthurids, Pomacentrids and Labrids. Herbivorous fishes as a functional group plays a vital role in controlling and maintaining the level of algal growth at the reef.

## *iii) Seawater quality*

The condition or quality of coastal water is important for ecological functioning of the organisms living in the habitat, for health and safety reasons and also for visual and aesthetic impacts. The water quality is generally determined by the level of nutrients. There are several sources that can lead to increased nutrients in coastal waters, e.g. sedimentation and terrestrial storm water runoff.

Sediment stirrup can also lead to release of nutrients within the sediments especially when there is large scale excavation and dredging involved.

The most important nutrients of concern in coastal waters are nitrates and phosphates. In excessive quantities these can cause rapid growth of phytoplankton and result in algal blooms. Visual quality of the water is also important, a beach environment is much more attractive when the water is clean and one can see the sea bottom. However, even clear water may sometimes be polluted. Dredging and excavation often carry heavy load of sediments increasing sediment load in the water column causing discoloration of the of the impact area for a prolonged period.

It is worthwhile to note here that there is no direct input source of nutrients in the coastal waters as a result of the proposed activities but rather a potential release of nutrients associated with dredging or excavation. Therefore the purpose of the assessment of water quality is to establish a baseline for the seawater quality, take as a standard to compare with any future water quality assessments.

Seawater sampling location is provided in Figure 5. The sampling site is located at the deep lagoon area of the reef where the part of proposed harbor basin will be located. A list of parameters tested and their values for sampling location are given in Table 7.

Table 7 Seawater quality parameters tested and their results at the sampling location at Rashdhoo. Data analysis was carried out by the National Health Laboratory, Maldives Food and Drug Authority and by using hand held water test meter

| Parameters | SW1 |
|---|---|
| Turbidity | 0NTU |
| Physical appearance | Clear |
| Apparent color | 1 TCU |
| pH | 8.2 |
| DO (mg/l)* | 5.2 |
| Nitrite (mg/l) | 0.000 |
| Nitrate (mg/l) | 0 |
| Threshold odor | Not detected |
| Salinity (mg/l) | 29800 |
| Phosphorus reactive (mg/l) | 0.00 |
| Total Dissolved solids (mg/l)* | 26640 |

** DO and TDS taken with portable water test meter Hanna HI 9828*

## f) Hazard vulnerability, area vulnerable to flooding and storm surges

Hazard vulnerability of Rashdhoo is assessed based on available literature and field data collection. The report prepared by the UNDP on disaster risk assessment of Maldives states that the Rashdhoo region falls into moderate risk category in terms of tsunami risk (Figure 36). Rashdhoo falls in to category 3, which is the mid risk scale given in the risk assessment.

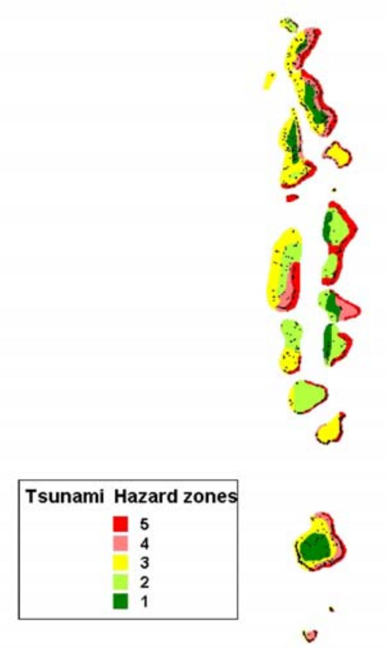



Figure 36 Tsunami Hazard Zones, catergory 5 is the highest risk zone while 1 is the lowest(figure derived from UNDP report on Disaster Risk Profile for Maldives November 2006)

Hazardous weather systems, other than general monsoons (heavy rain and strong winds) that affect Maldives are tropical storms (tropical cyclone) and severe local storms (thunderstorms/thunder squalls).Tropical cyclones are extreme weather events with positive and negative consequences. At times, these are very destructive due to associated strong winds (often exceeding 150 kmph), heavy rainfall (often exceeding 30 to 40 cm in 24 hours) and storm tides (often exceeding 4 to 5 meters). Strong winds can damage structures, houses, communication systems, roads, bridges and vegetation. Heavy rainfall can cause serious flooding. Storm surge is a sudden rise of sea level elevation along the coast caused by cyclonic winds. Sea level also rises twice daily due to astronomical reasons. The combined effect of surge and tide is knows as storm tide. Storm tides can cause catastrophes in low lying areas, flat coast and island territories such as Maldives.

The islands of Maldives are also affected by severe local storms (thunder storms/thunder squalls). Hazards associated with thunderstorms are strong winds (often exceeding 100kmph), heavy rainfall, lightning and hail. They give birth to tornadoes in some preferred regions (other than equatorial regions). In general thunderstorms are more frequent in equatorial regions compared to other areas (Figure 37). Land areas get more thunder storms compared to open ocean areas. However, thunderstorms close to the equator are less violent compared to those of other parts of tropics and extra-tropics. Maldives, being close to the equator, receive frequent thunderstorms but these are less violent. Strong winds generated by severe local storms consequently generate larger wind driven waves, which are hazardous to the islands of the Maldives.

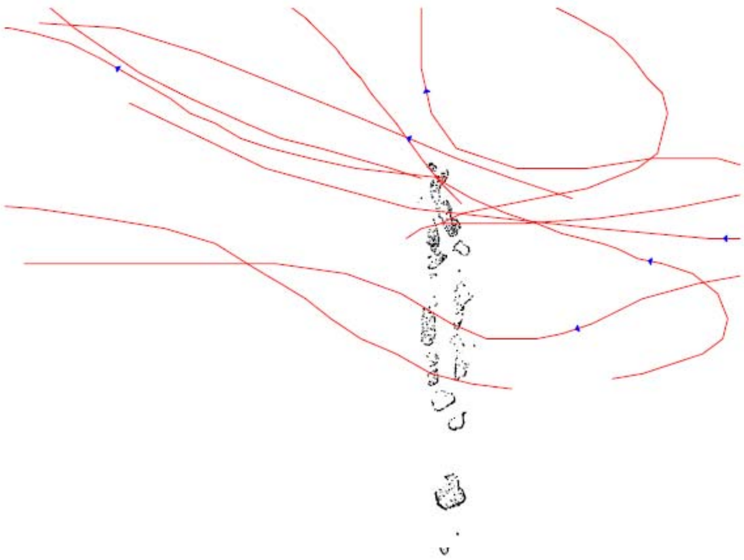


Figure 37 Track of severe storms affecting Maldives during 1877-2004

Rashdhoo falls into category 4, which is the high risk scale given in the risk assessment of cyclones or storms (see Figure 38). The major zones affecting are the mid and northern parts of the Maldives. During NE monsoon the entire eastern segment of the Rashdhoo atoll is very rough (Kaashidhoo kandu).

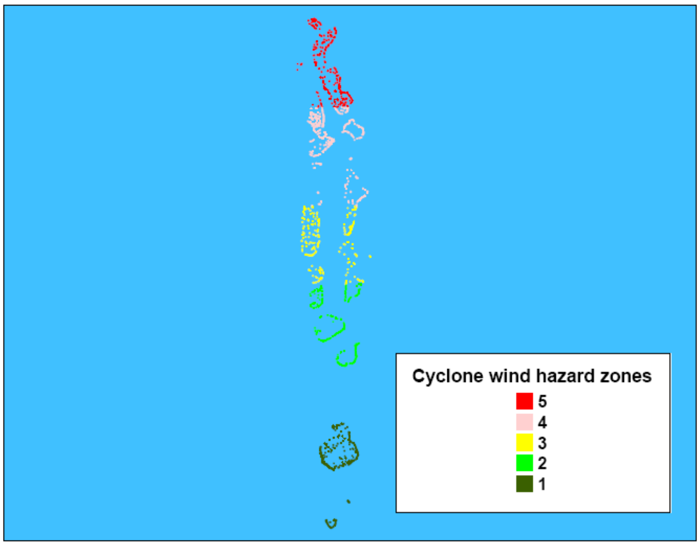



Figure 38 Cyclone Hazard Zone (figure derived from UNDP report on Disaster Risk Profile for Maldives November 2006)

Bathymetry around Maldives shows that the ocean slope close to the east coast is steep compared to the same on the west coast. This led us to conclude that eastern islands of Maldives are vulnerable to higher surge hazard compared to western islands. Rashdhoo region falls into zone 2 (low risk zone) in the cyclone hazard zoning categories (Figure 39).

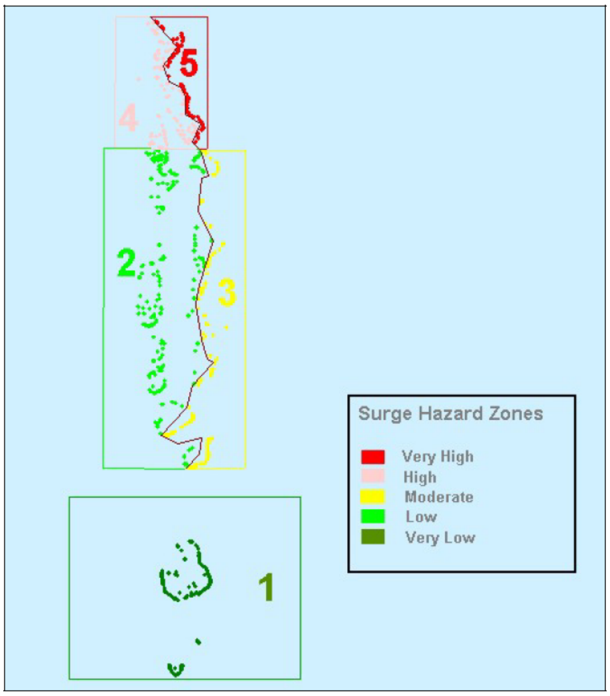



Figure 39 Surge Hazard Zones (figure derived from UNDP report on Disaster Risk Profile for Maldives November 2006)

## g) Social Environment

Ari Atoll is one the largest atolls of the Maldives. The atoll has an area of 2,271.75sqkm and has highest number of within the atoll reefs (Naseer and Hatcher, 2004), for administrative purposes the atoll is divided in to Alifu Alifu (AA) and Alifu Dhaalu (ADh) atoll. AA atoll consists of 12 uninhabited islands, 8 inhabited islands, 11 resorts and 2 picnic islands. The capital island of AA atoll is Rashdhoo. The total atoll population for the atoll stood at 6544 as of December 2008 according to figures on the AA atoll hospital website. The population distribution pattern of the island is shown in Figure 40. Rashdhoo is located in AA Atoll, approximately 58km from Male'. In terms of geographic coordinates, it is located at 04° 57' 47" N and 72° 59' 58" E. Rashdhoo sits in its own atoll (Rashdhoo atoll) located just north east of main atoll formation of Ari atoll. Nearest inhabited island is Ukulhas approximately 14.5km west of Rashdhoo at the main atoll. While the closest uninhabited islands are Madivaru (0.7km east) and Madivaru finolhu (0.8km) located north east of the Rashdhoo, separated Rashdhoo channel. Nearest Resort islands are Kuramathi Tourist Resort located 0.56km at the western side of Rashdhoo and Veligadu island Resort 4.1km north eastern of Rashdhoo.

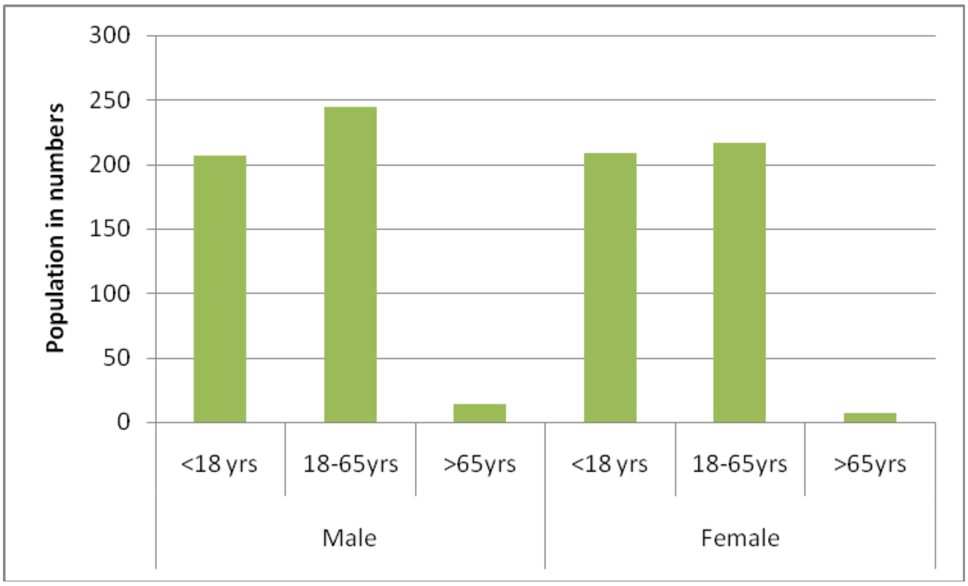



Figure 40 Population distribution of Rashdhoo (information derived from island fact sheet provided by island office)

The major economic activities of Rashdhoo are Fishery, construction work, carpentry, boat building and tourism industry related activities (information from island office). A total of 39 vessels are registered at the island of various sizes. Among them are 17 mechanized fishing vessels and two sail dhonis, details of other vessel types are given in Table 8).

Table 8 Vessels registered at Rashdhoo (information from island fact sheet)

| Sea Transport | | |
|---|---|---|
| **Vessel type** | **Total** | **Use of vessels** |
| Mechanized dhoni | 17 | Fishing |
| Sail dhoni | 2 | others |
| Sathari dhoni | 3 | Others |
| Speed boat | 5 | Others |
| Trolling dhoni | 2 | Others |
| Bokkura | 10 | Others |

**(source: island office fact sheet)**

Major environmental issues of the island are erosion at eastern and western side and solid waste management. Major erosion is observed at the western side of the island where boundary wall of some plots are now at the high water mark. Visual observation conforms areas of possible land loss at this side, while at the eastern erosion is less compared to western side. This is possibly due to the presence of offshore breakwaters at this side.

# 7. Environmental Impacts

Impacts on the environment from various activities of the development works (construction impacts) and operation of the harbor (operational impacts) have been identified through interviews with the island community, field data collection and surveys and based on past experience in similar development projects. Possible impacts arising from the construction and operation works are categorized into reversible and permanent (irreversible) impacts. The impacts identified are also described according to their location, extent (magnitude) and characteristics. Reversible and irreversible impacts are further categorized by intensity of impacts (negligible, minor, moderate and major) for identifying best possible remedial (mitigation measures) action to be taken. Below are the impact categories (Table 9).

Table 9 Impact prediction categorized

| Impact category | Description | Reversible/ irreversible | Cumulative impacts |
|---|---|---|---|
| Negligible | the impact has no significant risk to environment either short term or long term | Reversible | no |
| Minor | the impact is short term and cause very limited risk to the environment | Reversible | no |
| Moderate | Impacts give rise to some concern, may cause long term environmental problems but are likely short term and acceptable | Reversible | May or may not |
| Major- | impact is long term, large scale environmental risk | Reversible and Irreversible | Yes, mitigation measures has to be addressed |

Since the project is a new development, major impacts envisaged are impacts to marine environment due to various components of the construction phase. Impact on vegetation and sensitive environments are minimal. The directly impacted area during the construction phase from dredging and reclamation of the reef system is approximately 5% of the total reef area of the Rashdhoo reef system.

The severity of impacts is predicted by reviewing the design plans and construction methodologies and resources exposed to the impact. Impact categorization and their magnitudes are given in the impact matrix (Table 10). Mitigation measures are formulated in light of the information revealed by the project designers based on construction method of quay wall, excavation method and equipment or machinery used. Direct and indirect impact areas identified based on sediment plume based on dominant wind wave direction derived from wind data is given in section 3c.

## a) Limitation and uncertainty of impact prediction

Uncertainty of impact prediction are mainly due to the lack of long term data (shoreline, local currents and wave climate), Inherent complexity of ecosystem (reef environment, habitat and terrestrial environment although in a lesser extent) and lack of coordinated monitoring programs with inconsistent methodologies which can be used to predict outcomes or reliability of predictions of previous projects.

The impacts are predicted by reviewing the survey data collected during the field visits and information revealed by the designers and engineers. The data collected during the field visit is limited to 3-4 days, which limits the overall understanding of even the short term environmental conditions (wave condition, currents, and littoral movement).

The time limitation of EIA field data collection and report preparation is also a hindrance to properly understanding the environmental factors dictating the conditions of the habitat.

## b) Construction Impacts

Any development work involving excavation or dredging will have major impacts on reef, lagoon and coastal hydrodynamics. The Impacts of excavation can range from smothering of live coral to kill of live coral. Coastal modification involved in the construction of the harbor can have short to long term impacts. Potential direct or indirect impacts on the environment (on land and reef system) from the proposed works are limited to relatively small number of activities, these include:

- Excavation works at the harbor basin and entrance segment at the western side natural entrance
- Physical damage to the reef (lagoon) during loading and unloading (equipment and heavy machinery mobilization) using barges

- Direct loss of habitat and disturbance to the lagoon bottom and reef flat area by construction works at lagoon (harbor wall construction, construction of breakwaters and dredging works).
- Possible impact to vegetation during dredged material disposal works (minor impact, trampling of small bushes, no vegetation will be removed during disposal work)
- Impact on lagoon environment by the reclamation or dredged material disposal and

## i) Schedule, logistics and loading and unloading construction materials

All construction materials will be transported to the site on cargo *dhonis* and barges, and unloaded at the northern side of the island (existing access point and deep lagoon), the existing entrance at the western side can be used to access the deep lagoon. Material unloaded will be transported to the construction site. Initially heavy machinery will be brought to the island and once the dredging component is completed, construction materials will be transported to the island. Therefore backfilling areas either side of the harbor and harbor front can be used for storing armor rocks and other heavy materials. Impacts arising due to mobilization and unloading of materials include;

- Anchor damage by vessels mooring for material unloading
- Accidental spillage of construction materials (cement bags, rocks)
- Accidental oil spills (used for excavators and other heavy machinery)

No concrete work will be carried out at site, all "L" section concrete elements will be caste at Thilafushi or Hulhumale and transported to site. Armor stones will be brought to site once the harbor basin deepening works are completed, armor stones will be temporarily stock piled at backfilled areas. Armor rocks will be transported to the breakwater area by excavator when needed. Where depth exceeds 1.5m, barge will be used to transport armor rocks and excavator.

## ii) Construction materials and solid waste

Transportation of construction materials such as cement, timber, plywood, sheet pile, armor rocks and fuel for excavators and trucks to the site has the potential to aesthetically damage the marine environment especially the lagoon areas due to accidental spillage. Quite often construction waste finds their way into the marine environment during the course of their disposal unless necessary measures are taken to avoid this from happening.

Pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction site or from transportation vessels such as landing crafts and barges. Waste and residue arising from construction activities such as oil spills and other waste (used wooden moulds) may affect the marine environment.

All generated during the construction stage will be sorted and disposed accordingly. All materials that can be burnt (packing material, timber, paper) will be disposed at Rashdhoo waste disposal sites. The materials that are categorized as hazardous waste such as used oil filters and luboil should be transported to government designated disposal site (Thilafushi).

### iii) Impacts due to construction methods

Since excavators will be used for the deepening works, sedimentation is inevitable and this is an impact that will be unavoidable. Even if a sand bund wall is made initially before dredging the harbor basin, sedimentation or suspension of fine sediment will be unavoidable. Although it is unavoidable the impacts will be short termed. The current direction at the lagoon (proposed harbor location) is westwards during NE monsoon (projected dredging period). It is often the smaller corals and corals that exhibit laminar growth forms that are more vulnerable to extended sedimentation (acropora table corals).

Fine sediments with rapid rate of deposition are detrimental to certain corals especially the tabulate forms of corals. Such sediments blocks the coral polyps from feeding and the lack of nutrition and other physiological stress such as respiration eventually starves and suffocated the corals leading to death. Finely deposited sediments are often difficult to get rid of even with strong currents. The reef survey carried out at monitoring areas indicated that live coral over was moderate (50% at average) and dominated by branching and tabulate forms of acroporids. Therefore major impact is envisaged on the live coral at the area. Although this impact is categorized as major impact, this impact will be short termed, since strong currents are experienced at the area.

Major environmental concerns associated with dredging and reclamation works are direct habitat loss, sedimentation and deterioration in water quality. High levels of sedimentation and silt from dredging activities is a major source of reef degradation. The consequences of excessive sedimentation on corals are well known and include:

- direct physical impacts like smothering of corals and other benthic reef organisms,
- reduces light penetration, which has a direct effect on zooxanthellae photosynthesis and thus the net productivity of corals. It also reduces coral growth, calcification rates and reproduction.

- dredged silt may form false bottoms, characterized by shifting unstable sediments
- silt suspension may increase nutrient release, leading to eutrophic blooms
- silt may act as sink or trap for many pollutants, which are absorbed onto the sediments

Construction of wharfs and protection walls will be done using armor rock layers; sediment removed from the excavation works will be used for back filling work. Back filling work will be carried out by using excavator. The initial bund wall created will act as back filling; concrete elements will be placed inside the harbor, while rock layer will be laid out side. Bund wall is made in the first place to minimize sedimentation but still this also will cause sedimentation due to the wave action. This impact could have chronic impacts on the very few live coral observed at the area (this is an unavoidable impact). This impact is envisaged to be short termed since revetment and breakwaters will be constructed after the excavation works.

## iv) Impact on vegetation (harbor front area)

Moderate to minor impacts are envisaged on vegetation at harbor front area, this includes possible trampling impacts. Some of the trees might need to be relocation if they are obstructing operation of heavy machinery. All trees should be replanted at the harbor front area.

## v) Coastal structures

The impact of new physical structures such as breakwaters, access channels and harbors on the hydrodynamic regime, can be quite significant and often permanent. It can interfere with littoral sediment transport patterns and seasonal coastal dynamics resulting in a number of impacts. These include:

- Change of near shore hydrodynamic (currents and wave patterns)
- Erosion due to alteration of hydrodynamic regime of the reef system
- Sedimentation or increased turbidity due to movement of sediment around the structure (harbor walls or protection walls), which intern reduces light penetration, which has a direct effect on zooxanthellae photosynthesis and thus the net productivity of corals
- Alteration of substrate topography, hydrodynamic regime and the continual re-suspension of dredged sediments can result in increasing sedimentation and forming dredge silts

- Degradation of sea water quality due to turbidity

The prevailing factor dictating hydrodynamic regime at the reef system is the swell waves (refracted received from channels) and monsoonal wind waves. The western and eastern side of the island is observed with significant erosion which is mainly due to monsoonal wind wave impacts. Construction of physical structures may cause erosion elsewhere but most probably reduce erosion at the western side of the island, since the harbor side will act as a groyne feature.

### vi) Social impacts, noise and air pollution

Operation of heavy machinery and construction related equipment will contribute to noise pollution. Noise pollution during the dredging works will be mainly due to the operation of excavator and trucks. Construction noise at Rashdhoo will be dictated by the predominant wind direction (NE during NE monsoon). As the Dredging works will be finished first, estimated time of completion within two months, this falls on late March to April 2010. Therefore wind direction will be form NE. The nearest residential area is approximately 40m away therefore noise impact will be moderate. Dredging will be carried out during low tide; therefore noise level will not be sustained throughout the day. But it has to be noted that dredging has to be carried out during the night hours too (during low tide).

Air pollution due to the project will be mainly due to operation of heavy machinery like excavator, trucks and boats. But in since use of heavy machinery will be limited to a short period of time; impacts are envisaged to be minor.

Development of a harbor at Rashdhoo will have positive impacts in terms of easy and safe accessibility and wellbeing of community. At present access jetty at the northern side deep lagoon is used for material unloading and access, at times refracted swell waves and wind waves are experienced at the lagoon making unloading process difficult.

### vii) Effects on Groundwater Quality

No impact is envisaged on groundwater due to the proposed project.

## c) Operational Impacts

Environmental impacts associated from the operational phase of the current proposed development project are limited to a relatively few activities. These activities can cause short term to long term impacts on the reef environment. Below are some of the possible impacts:

- degradation of sea water quality from possible alteration of littoral sediment transport regime causing turbidity (short to long term impact)

- possible impacts due to accidental spillage of oil (by boats using the harbor)

- following construction, the proposed development may influence existing hydrodynamic patterns affecting water circulation and possibly leading to "dead spot" in the inner harbor areas where floating litter and other pollutants could accumulate (the breakwaters are constructed as porous structures, armor rock, therefore flushing would be satisfactory). Since the sides of the harbor basin is open, providing maximum flushing this impact will be minor.

- accidental spillage of waste (by loading and unloading vessels)

- Possible erosion problems at the north eastern side of harbor during SW monsoon, while accretion is envisaged at the existing erosion areas at the western side due stilling effect by physical structures at the area. It is envisaged that the presently found beach stretch at the northern side will shift to south western side of the island (based on wind pattern).

## i) Impact to hydrodynamic patterns

Development of harbor would inevitably have impacts on the hydrodynamic regime. The major impact is obstruction of natural current and sediment flow due to the coastal structures. At present coastal modification is observed at the south eastern side of the island, this was constructed to mitigate erosion at the area. The western side is observed with major erosion, some of the boundary walls are now sitting at the high tide line. The new structures will be placed almost half of this area, thereby mitigating the erosion problem. It is envisaged that due to these structures the western side will be sheltered during SW monsoon thereby reducing erosion.

Presently the northern side of the island is observed with minor erosion, but there is possibility of erosion at this area during NE monsoon. The sediment moves west wards at the northern side during NE monsoon forming the large sand spit observed during the field visit. At the time the old jetty area was filled up, up to the jetty head area. Therefore after construction this movement of sand will be stopped, and may spill in to the deep lagoon. This perhaps is an uncertain impact that has to be monitored during the operational stage of the project.

The design of the harbor is made different from most the harbors constructed in Maldives, this harbor is design based on latest policy of the government. The new concept design is based on the third generation harbor concept, where loading and unloading area is developed as a T jetty. The harbor sides are open on both ends therefore maximum flushing will be attained. Due to this reason impact of water flow will be reduced.

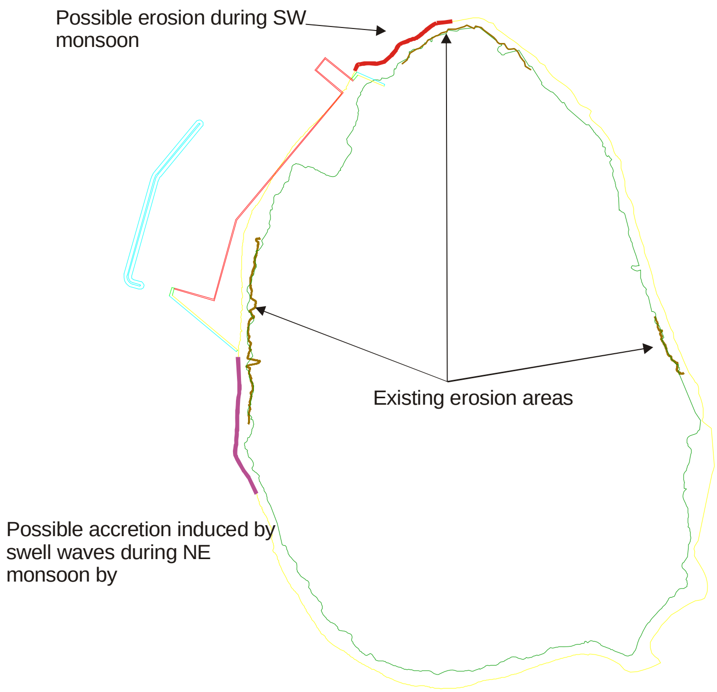



Figure 41 Schematic drawing showing possible erosion prone areas

## ii) Social impacts

Positive impacts are envisaged in terms of social aspects, the development of the harbor will increase the number of tourist visiting the island (according to IDC and shop owners) due easy access to the island. At present the lagoon gets very choppy during NE monsoon especially if wind is received from due north.

## iii) Wastewater Disposal or littering of harbour

Improper disposal of organic (fish waste, sewage, fuel) and inorganic waste (tins, cans, plastic bottles) to the harbor basin will cause degradation of the harbor basin waters. Dumping of fish waste and other organic waste will increase the nutrient levels of the harbor, facilitating proliferation of algae. Floating waste such as empty cans, plastic bottles, and plastic bags will be accumulated at the dead zones (corners). Proper harbor management plan has to be formulated to address the use of harbor. Sign boards have to be made, as an awareness tool to inform people using the harbor not to contaminate or dispose waste at the harbor basin. In addition to that dustbins should be placed at the harbor area. Dustbins are observed at road corners at the island, indicating that community is aware of proper waste management.

## Table 10 Impact matrix for the harbor development works at Rashdhoo

| Impact Source | Physical Environment | | | | | | | | | | Biological Environment | | | | | | | | | Social Environment | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Seawater quality | Groundwater quality | Air quality | Noise | Local hydrodynamic regime | Littoral movement | Sedimentation or smothering | Erosion | Damage to top soil | Lagoon bottom disturbance | Terrestrial habitats | Coral growth | Coral mortality/breakage | Fish fauna | Reef habitat/reef flat, crust area | Lagoon habitat/near shore habitat | Vegetation/terrestrial | Protected marine species | Protected birds | Waste management | Health | Employment | Public safety | Transport and navigation |
| Mobilization, unloading material and machinery and storage | Negligible | | Negligible | Negligible | | | Negligible | | | Negligible | | Negligible | Negligible | | | | Minor (negative) | | | Negligible | | | | |
| Excavation works of the harbour basin | Minor (negative) | Minor (negative) | Minor (negative) | Minor (negative) | Moderate (negative) | Moderate (negative) | Moderate (negative) | Minor (negative) | Minor (negative) | Moderate (negative) | Negligible | Minor (negative) | Minor (negative) | Negligible | Minor (negative) | Minor (negative) | Minor (negative) | | | Minor (negative) | | Positive | Positive | Positive |
| Construction of of harbour walls | Minor (negative) | | Negligible | Negligible | Moderate (negative) | Moderate (negative) | Moderate (negative) | Negligible | | Moderate (negative) | | Moderate (negative) | Minor (negative) | Negligible | Moderate (negative) | Moderate (negative) | | | | | | | | |
| Vegetation clearing | | Negligible | Negligible | Negligible | | | | | Minor (negative) | | Moderate (negative) | | | | | | Moderate (negative) | | | Negligible | | | | |
| Operation of heavy machinery (on land ) | Negligible | | Negligible | Negligible | | | | | Negligible | | | | | | | | | | | | | | Negligible | Negligible |
| Construction waste, solid waste | Negligible | Negligible | | | | | | | | Negligible | Negligible | Negligible | | | | | Negligible | | | Negligible | | | | |
| Construction work force | | | | | | | | | | | | | | | | | | | | | | Positive | Positive | |
| Reclamation/dreadged material disposal | Minor (negative) | Negligible | Negligible | Negligible | Negligible | Negligible | Negligible | | | Negligible | | | | | | Negligible | | | | | | | | |

Positive | Negligible | Minor (negative) | Moderate (negative) | Major (negative)

# 8. Alternatives

Ministry of Housing, Transport and Environment in consultation with the harbor committee and IDC has already decided the location of the harbor. Although this may be the case alternative site was surveyed during the EIA process).

The following are components where alternatives are discussed;

- Harbor Location
- Construction method
- Excavation method
- Entrance location
- No project scenario

## a) Considered alternatives

### *i) Location of harbour*

Alternatives for harbor location are;

- **Proposed location:** The proposed harbor location is the north western side of the island, including part of deep lagoon
- **Alternative location:** alternative location is northern deep lagoon (initially proposed location)

### *ii) Construction method*

Alternatives for construction method for harbor works are

- **Proposed method (harbor structures):** The method of harbor quay wall is L section concrete elements
- **Alternative method 1:** Sheet pile

### *iii) Excavation method*

- **Proposed method:** The proposed method of excavation is by using excavator

- **Alternative method:** By use of cutter suction dredger

### iv) Location of entrance channel

- **Proposed location of entrance channel :** The proposed location of entrance to harbor is from the western side natural opening to the lagoon
- **Alternative location:** northern side of the reef (proposed by former IDC during consultation meeting held at the island by the EIA consultants)

### v) The No project scenario

The no project scenario means avoidance of direct physical impacts to the reef and lagoon area where proposed harbor basin and associated structures will be constructed. The proposed project will have sediment related impacts and direct physical impacts of the reef habitat, while the modification of the coastal processes may have consequences elsewhere in terms of beach erosion or loss of land.

Considering socio-economic impacts due to no development is moderate, at present main access to the island is from the northern side using the existing natural entrances to the deep lagoon. At times the islanders face difficulty in unloading materials due to choppy waters especially if wind is received from a northerly direction. It has to be noted that during NE monsoon, during lowest low tide periods large vessels such as cargo dhonis will not be able to navigate some areas of the existing natural entrance at the western side, but maybe possible at the eastern side.

## b) Assessment of alternatives

Assessment of proposed methods and alternatives are given in Table 11. The disadvantages and advantages of the options are given in terms of feasibility, community acceptance, environmental point of view and cost.

Table 11 Assessment of proposed methods and alternatives

| Item | Option | Advantage | Disadvantage |
|---|---|---|---|
| Location of burrow site | Proposed location west of existing old jetty head | ➢ Since the land is scarce, construction of harbor at this area will generate maximum amount of dredged material which can be used for backfilling harbor front area<br>➢ Community in consent to the location<br>➢ Will fill part of western side worst erosion areas | ➢ Will have significant environmental impacts due excavation works at the shallow lagoon<br>➢ Will have significant impact on live coral and associated habitat at sediment plume dispersal area |
| | Alternative location: harbor aligned to the deep lagoon, incorporating entire deep lagoon as basin | ➢ Minimum impact on environment<br>➢ Hydrodynamic impacts will be low | ➢ Community not in consent to the alternative location, it has to be noted that civil unrest has happened during the initial stages of the project (late 2007) during visit by design consultants and personnel from former MCPI<br>➢ Distance from basin to island is longer<br>➢ Would not be possible to construction protection walls |
| Construction method: harbor structures | Proposed method: "L" section concrete elements | ➢ Have been successfully used in many harbors | ➢ Requires large area for casting the L sections. |

| | | | |
|---|---|---|---|
| | | ➢ Low maintenance or repair<br>➢ Cost lower compared to steel sheet pile<br>➢ Possible physical damage from vibration is not an issue since the structure is not needed to be driven into substrate<br>➢ Community in consent with this method | |
| | Alternative method: Sheet pile | ➢ Low maintenance | ➢ Need specialized machinery for driving the piles<br>➢ May cause vibration related impacts<br>➢ Cost of construction is higher compared to concrete sheet pile method |
| Excavation method | Proposed method: by using excavator | ➢ Low cost<br>➢ Ease of operation | ➢ Major impact to marine environment due to sedimentation involved in excavation<br>➢ Requires a interim bond (reclaimed) or barge |
| | Alternative method: by using cutter suction dredger | ➢ Low impact in relation to sedimentation<br>➢ Avoid need of blasting in the event blasting is required<br>➢ Avoid need of transportation of dredged | ➢ High cost of mobilization<br>➢ Difficulty in operating in tight conditions<br>➢ Not feasible for small scale projects |

| | | | |
|---|---|---|---|
| | | material since pipe line can be extended up to disposal site | |
| Location of entrance | Proposed location: existing entrance at the western side of the reef | ➢ Apart from a small segment of shallow area, entrance is deep enough for large vessels to navigate<br>➢ Since dredging component is minor, direct physical impacts and environmental impacts are low<br>➢ Community in consent to this location | ➢ Distance to basin is longer compared to alternative location |
| | Alternative location: northern side of the reef, where a narrow natural entrance is observed | ➢ Shortest distance to basin and deep lagoon | ➢ Will have significant impact on reef habitat, direct physical impact on coral<br>➢ Cost of dredging will be high compared to proposed location |
| No project scenario | No project option | ➢ Avoid major impact to reef habitat and live coral from dredging works<br>➢ Avoid indirect impact due to sedimentation<br>➢ Avoid alteration of lagoon hydrodynamic and littoral movement<br>➢ Avoid impact to vegetation at harbor front area (minimal impact) | ➢ Discontent of the island community<br>➢ Community not in consent to this option |

## c) Selected alternatives

### i) Location of harbour

The proposed location of harbor is at the western side of old jetty located at the northern side of the island, while the alternative site is the deep lagoon east of old jetty. The initial location proposed during 2007 was the deep lagoon area but due to discontent of community this location was later changed to now proposed location after meeting by MHTE, president and island community during the president's visit to the island.

Considering the two options, alternative location is much environmentally friendly compared to the proposed location, but it has to be noted that erosion at the island especially at the western side needs to be mitigated. The construction at proposed location would shelter the area thereby reducing erosion. Also almost half of this area will be filled as part of harbor front area. Therefore giving consideration to overwhelming social aspects the proposed location is selected.

### ii) Construction method

The construction method of quay wall is by placing pre-caste L section concrete elements and armor rock for the breakwater. Alternative can be Sheet pile for the quay wall. Both methods have been used and tested in Maldives. The positives of sheet pile method are fast implementation, compared to concrete element which has to be pr-caste and ease of implementation. The drawback is need for specialized machinery for driving in the sheet pile. Concrete element needs only an excavator or crane to place the "L" section in place. Both methods are feasible, the main reason for using concrete elements is because Ministry of Housing, Transport and Environment stipulated it in the design criterion.

### iii) Excavation method

The proposed method used for deepening the harbor is using excavator, will have significant impacts on the surrounding environment. One alternative to minimize this impact is to employ a cutter-suction dredge which reduces the amount of silt suspended in the water column. It will also eliminate the need for blasting should hard substrate be encountered. But unfortunately, the use of cutter-suction dredges for the small quantity of dredging involved in the proposed project is not economical due to the high costs of mobilization and operation.

Sand bunds will be use to reduce environmental impacts due to suspension of silt. Another alternative to this is the use of geo textile curtains to avoid the spread of suspended silt beyond the immediate area being dredged. However, from past experience, the coastal environment in the Maldives is far too dynamic and precludes the use of such barriers. Also it is economically not feasible in small projects such as the proposed harbor development works at Rashdhoo. Another alternative to sand bund is construction of the breakwater at the early stages of the project.

### *iv) Location of entrance channel*

The proposed location of entrance to the basin is at the western side natural entrance, while alternative is the northern side narrow natural entrance. Considering both options the proposed entrance location only needs minor dredging compared to the alternative, therefore this location is selected.

# 9. Mitigation Plan

There are a number of actions that can be taken to minimize the identified impacts. Those that are explored below emerged out of the discussions and consultations during this EIA and from the past experience of the consultant (Table 12). Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project.

Mitigation measures are discussed for the construction and operational stage of the project. During the construction stage it is important to take measures to minimize sedimentation impacts on the reef environment. A construction method that has the least impact on terrestrial or marine environment has to be utilized.

Table 12 Mitigation measures proposed for the harbor development works at Rashdhoo

| Possible Impacts | Mitigation measures | Location | Time frame (Phase) | Impact intensity | Institutional responsibility | Cost (MRF) |
|---|---|---|---|---|---|---|
| Littering on terrestrial and marine environment | Littering, accidental disposal and spillage of any construction wastes should be avoided by pre-planning ways of their transportation and disposal. Careful planning of the work activities can also reduce the amount of waste generated. | Reef flat, lagoon and land | During construction (6 months) | Minor to moderate, short term impact | Contractor | N/A |
| | During construction of protection walls and break waters, all construction related waste collected stored at project site, and later disposed at atoll waste management site or at Thilafushi | Lagoon, reef flat | During construction (6 months) | Minor | Contractor | N/A should be included in the project cost |
| Damage to reef by loading and unloading works | Awareness raising of project managers on environmentally friendly practices to minimize negative impacts. Conduct consultation meetings by island community advising environmentally sound workmanship | Reef flat and reef slope lagoon | During construction (1 month) | Minor, short term impact | MHTE contractor | N/A |
| | Careful planning to reduce time of the unloading process (avoid days of heavy traffic e.g. Fridays) | Lagoon | During construction (1 month) | Minor | Contractors | N/A |

| | | | | | | |
|---|---|---|---|---|---|---|
| Sedimentation and siltation on the reef and lagoon due to excavation works | Creation of a sand bund to reduce the sedimentation impact | Reef flat reef slope lagoon | During construction (2 months) | Major, short to midterm impact | Contractor, MHTE | N/A no additional cost |
| | Dredging works of the harbor basin and dredging at shallow area of entrance will be carried out during the low tide (which would reduce the amount of fines released into the water column). | Reef flat and lagoon areas | During construction phase (2 months) | Moderate, short term. | Contractor | N/A may increase the duration of the project, in turn increase cost of machinery |
| Disturbance to the near shore habitat at the dredge material disposal areas | Use of sand bunds made initially to transport dredged spoil to either side of the harbor | On land, lagoon | During construction (2 months) | Major, short to long term impact. | Contractor, | N/A No Additional costs (already included in the work plan) |
| Loss of habitat, damage or death of coral at the entrance area (shallow area), breakwater construction area | Stakes put at the corners of the harbor dredging area so the excavator operator can identify the perimeter of the harbor basin, thereby avoiding unnecessary loss of or trampling of live coral. | Reef flat, lagoon | During construction phase (6 months) | Major, short term, may have a positive impact on long term by creating additional substrate for coral growth | Contractor | N / A |
| | Since live coral cover is very low at the immediate project area, trampling by workers at protection wall areas will be minor | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Excavation works will be carried out during low tide to minimize sedimentation impact (since shallow lagoon area is intertidal therefore reduce height of water column). | Reef flat, lagoon | During construction (2 months) | Major, short term. | Contractor | N/A may increase the duration of the project, in turn increase cost of machinery |
| | Completing the excavation works as soon as possible. | Air | Construction phase (2 months) | Minor/short termed | Contractor | N/A |
| Noise pollution | Completing the excavation works as soon as possible, avoid work at night whenever possible | land | Construction phase (3 months) | Minor/short term | Contractor | N/A (may increase the cost of heavy machinery operation due to limit of operation time (timing the low tide window) |
| Flooding or storm water drainage at spoil disposal area | The reclamation area should be sloped towards the shore to allow natural drainage, the level of the reclamation should not be higher than the island ridge level or vegetation edge level | Land/beach area | Construction stage | Long term impact | MHTE/contractor | N/A already included in the project costing |
| Possible erosion at the north eastern side of the island due to obstruction of littoral sediment movement | Shoreline monitoring work done every 3 months in the first year and every 6 months in the coming year for identification of erosion | Established sites and shoreline mapping using precision GPS | Operational phase | Moderate, long term and unpredictable impact (time or severity) | MHTE | Included in the monitoring program (see section 10) |

It is recommended that toilet facilities, sign boards and employee for harbor cleaning works to be assigned since it is important to maintain the harbor. A clean harbor would reduce pollution by littering and disposal of organic waste. It has to be noted that funding for such activities by the island community is difficult since most of the funds comes from government or donors. Island chief of Rashdhoo stated that toilet facilities and other support facilities will be constructed at the area, but funding is yet not secured for these activities (outcome of consultation meeting at Rashdhoo).

# 10. Monitoring and Reporting

Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental variables associated with the development impacts. Monitoring is needed to;

- Compare predicted and actual impacts
- Test the efficiency of mitigation measures
- Obtain information about responses of receptors to impacts
- Enforce conditions and standards associated with approvals
- Prevent environmental problems resulting from inaccurate predictions
- Minimize errors in future assessments and impact predictions
- Make future assessments more efficient
- Provide ongoing management information
- Improve EIA and monitoring process

Impact and mitigation monitoring is carried out to compare predicted and actual impacts occurring from project activities to determine the efficiency of the mitigation measures. This type of monitoring is targeted at assessing human impacts on the natural environment. Impact monitoring is supported by an expectation that at some level anthropogenic impacts become unacceptable and action will be taken to either prevent further impacts or re-mediate affected systems. Mitigation monitoring aims to compare and predicted actual (residual) impacts so that effectiveness of mitigation measures can be determine.

The environmental monitoring proposed here is to determine the effectiveness of the mitigation measures and long term change to the benthic community (especially coral community). The reef survey sites established during the field surveys for EIA report preparation will be used for the monitoring program. All monitoring activities will be carried out under the supervision of an environmental monitoring and management consultant. The detail of the monitoring program is given in Table 13. Commitment to finance mitigation measures and monitoring work is submit as a general letter for all harbor projects to EPA by MHTE

Table 13 Monitoring program and cost for individual parameter

| Parameter | Methodology | Sampling frequency | Estimated cost for monitoring |
|---|---|---|---|
| Coral and other benthic cover | Photo quadrat at established baseline locations | During construction works and after six month | Rate per field survey USD 500.00 |
| Reef fish community, diversity and abundance | Fish visual census at established baseline locations | During construction works and after six month | Rate per field survey USD 500.00 |
| Coral recruitment, growth rates and mortality | Quadrate method including photo-quadrate methodology | During construction works and after six month | Rate per field survey USD 500.00 |
| Sedimentation rates | Quantitative assessment of sediment loading on the reef benthos sediment traps deployed at the predetermined locations | Every month during excavation and construction works and after six months | Rate per field survey USD 200.00 |
| Seawater quality | Water samples sent to Food and drug authority for analysis. Following parameters are to be tested; salinity, pH, turbidity, BOD, COD, suspended solids, dissolved oxygen, Nitrite, Nitrate, Phosphate | Twice( during and after completion of project) | Rate per test set USD 100.00 |
| Shoreline monitoring | Shoreline mapping by using high precision GPS (beach line, vegetation line, reclaimed area to identify possible erosion problems) | During construction phase, every three months after completion every 6 months | Rate per field survey USD 500.00 |
| | Beach profiles at established base line locations | | |

# 11. Conclusions

The long term environmental impacts associated with the proposed project are considered minor to moderate. This conclusion is based on the evaluation and various components of the proposed project, implementation methods discussed, finding of the existing environment and environmental components that are likely to be affected. The significant environmental components that are likely to be affected are possible changes to littoral drift and near-shore coastal hydrodynamics, sedimentation impacts on coral community from excavation and coastal protection works. Impact on the coral community and sea grass community from sedimentation as a result of excavation and burial is inevitable. Yet the extent of direct or indirect damage to the coral community can be minimized through the mitigation measures discussed.

Potential changes to the hydrodynamics were considered in the overall design of harbor (harbor sides are open allowing maximum flushing and water flow). Along with this design, mitigation measures and environmental monitoring of the shoreline would ensure that unfavorable outcome of the design and modification to the harbor are identified early on so that appropriated remedial actions can be taken. The monitoring program proposed after completion of the project would enable identification of short term impacts on beach and formulate mitigation measures. With the shifting of the harbor westwards to align with existing entrance, physical damage will be reduced, also additional sedimentation impacts minimized.

The socio economic justification for the project is the strongest, since the island needs a safe harbor. This is based on the outcome of the public and community consultations

Therefore, with due consideration environmental components the project is likely to effect the consultant concludes that the project components and designs are feasible and appropriate mitigation measures are given to correct and minimize unfavorable environmental consequences. Furthermore the public and community consultation responses were in favor of the project due to the socio-economic benefits.

Although beyond the scope of work, it has to be noted that the western side of the island needs immediate mitigation measures to counter the erosion issue. The proposed project will cover almost half of the erosion area at the western side, but the rest will remain as it is. Since the estimated sediment generated during the dredging works will be just sufficient enough for back filling harbor area, additional sediment will not be available for filling erosion area. The community stresses the need for mitigating this issue; therefore it is recommended that consideration be given to this issue.

# Appendices

# Appendix 1 Terms of Reference (TOR)

## Environment Research Centre

### Ministry of Environment, Energy & Water

Male', Republic of Maldives

# Terms of Reference for Environmental Impact Assessment

The following is the TOR is based on the points discussed in the scoping meeting held on the 25th of November 2007, for undertaking the **Environmental Impact Assessment (EIA) for the of the proposed harbor construction works in AA. Rasdhoo**

*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 appearance, taste and odour, pH, turbidity, nitrates and phosphates 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.*

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*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), 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:*

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

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

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

d)· *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-ordinating 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 harbor, 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.*

.......................................................

30 December 2007

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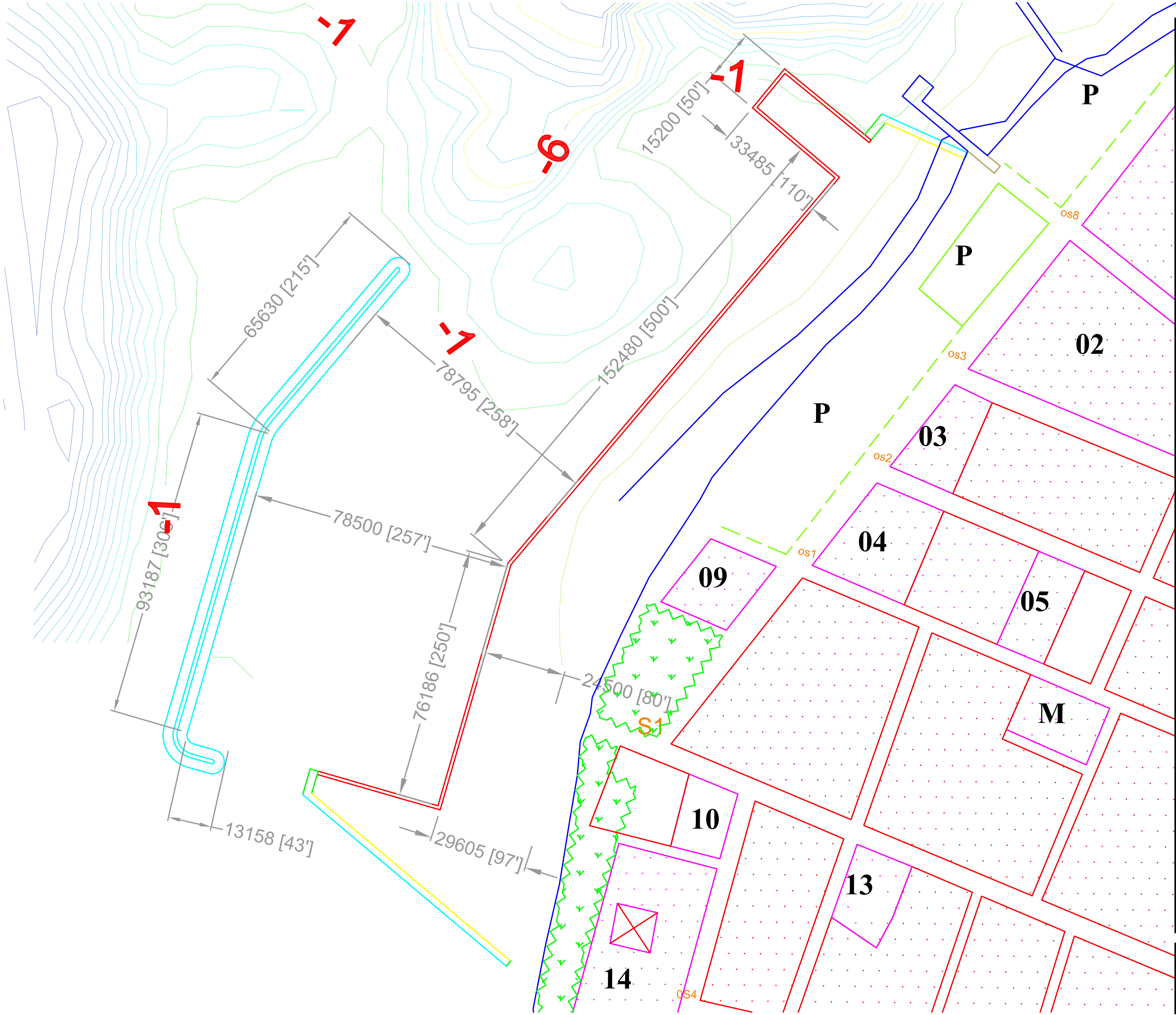
ENVIRONMENT RESEARCH CENTRE
Male', Republic of Maldives

# Appendix 2 Site Plan




AMMENDMENTS:

CONTENTS:

SITE PLAN

DWG NO:

PROJECT:

NATIONAL HARBOUR AND RECLAMATION PROGRAM AA. RASDHOO

CLIENT:

SURVEYED BY:

DIGITIZED BY:

DATE: AUGUST 2009

DRAWING NO:

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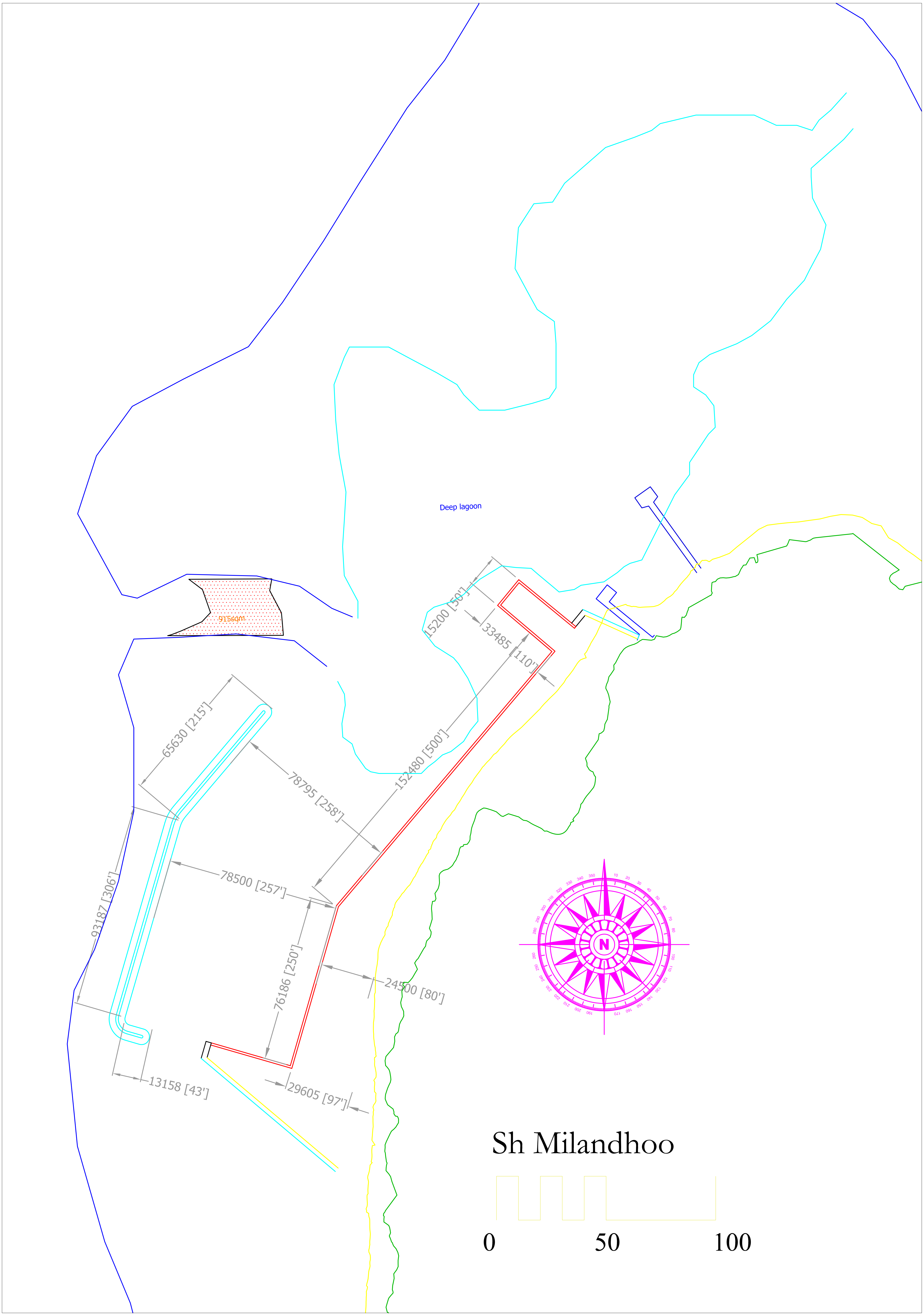
| FILE NO: | DRAWER NO: |

ENGINEERING SECTION
MINISTRY OF HOUSING, TRANSPORT AND ENVIRONMENT
AMEENEE MAGU MALE'
REPUBLIC OF MALDIVES
TEL: 3323234, 3323473, FAX: 3328300


Deep lagoon
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33485 [110']
152480 [500']
65630 [215']
78795 [258']
78500 [257']
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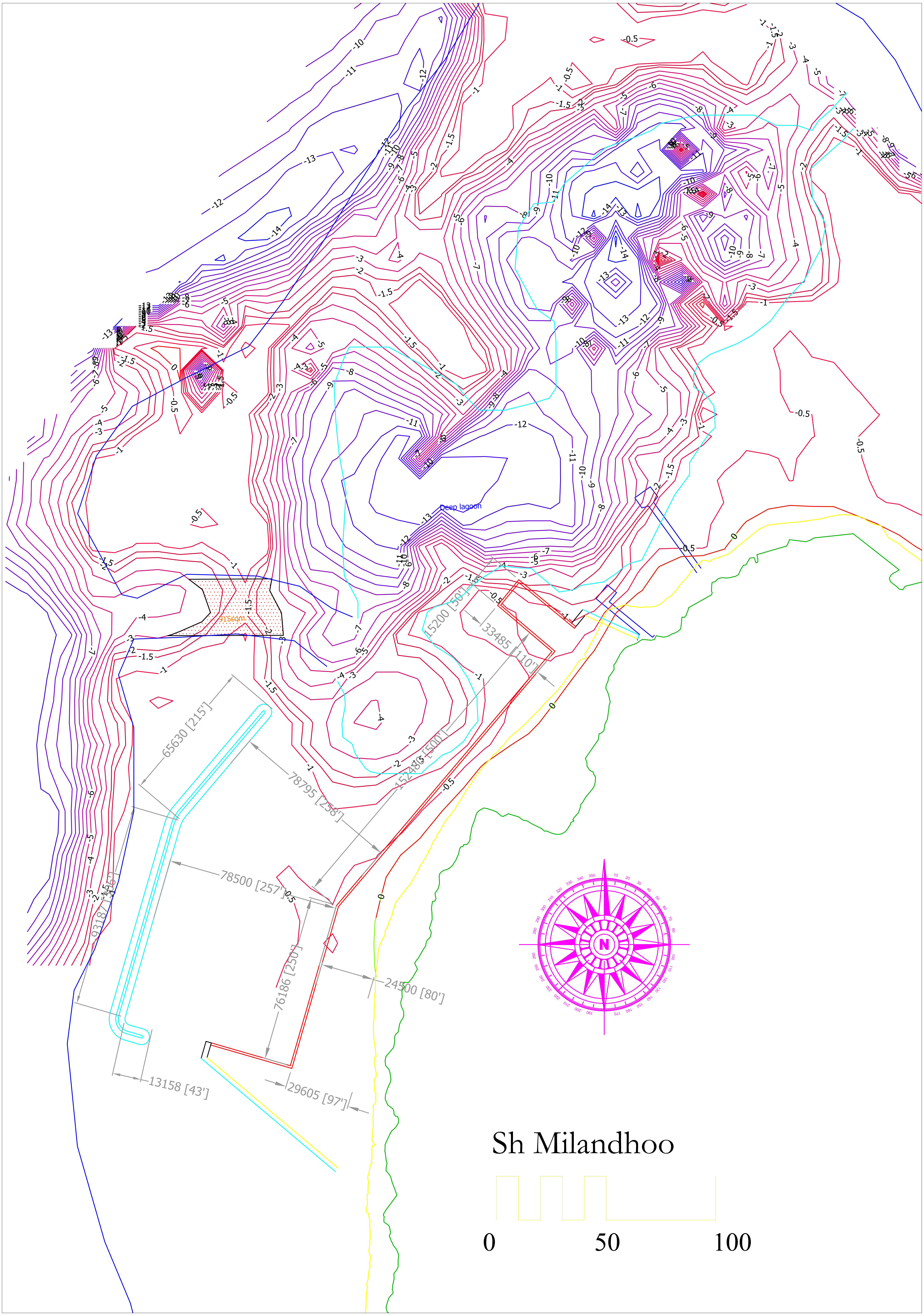
76186 [250']
24500 [80']
13158 [43']
29605 [97']
Sh Milandhoo
0
50
100

# Appendix 3 Bathymetry map


Deep lagoon
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78500 [257']
76186 [250']
24500 [80']
13158 [43']
29605 [97']
33485 [110']
15200 [50']
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Sh Milandhoo
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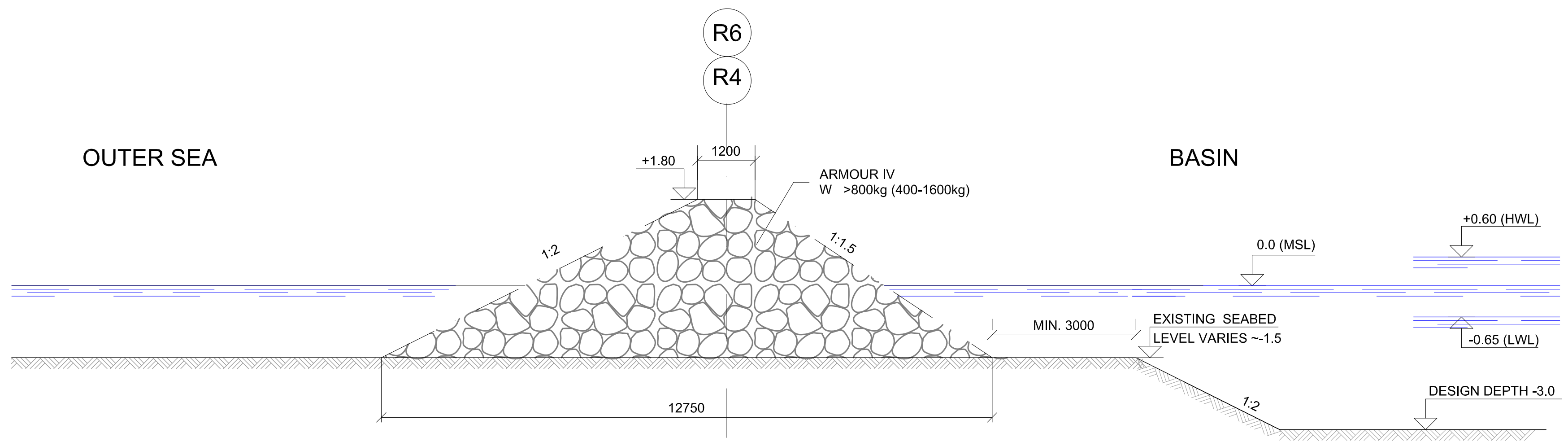
# Appendix 4 Breakwater details

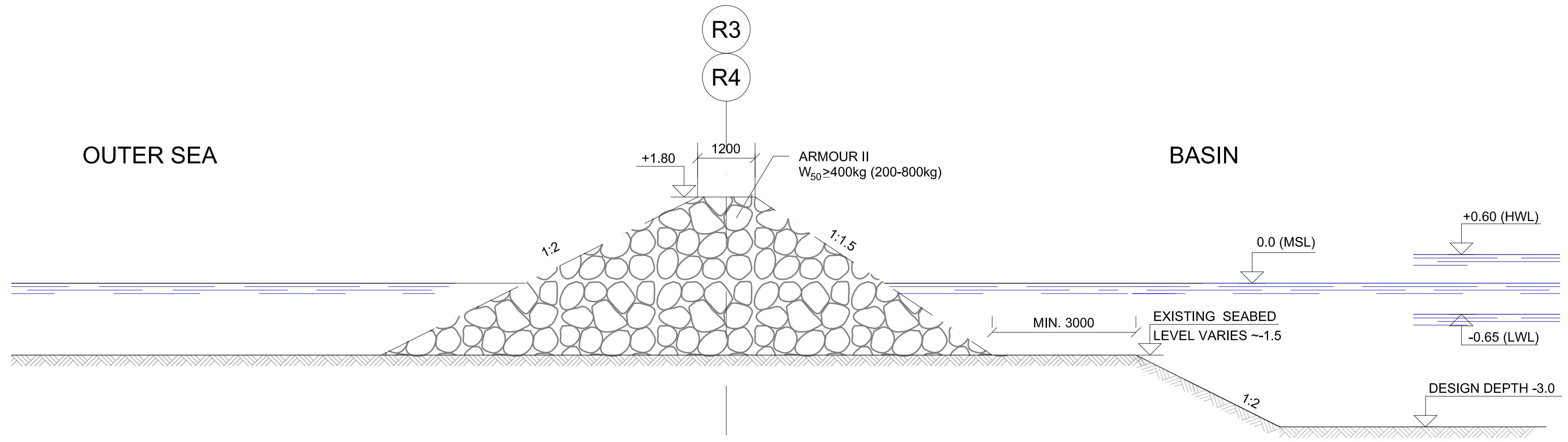



Cross Sec.area =23.2 Sq.M. Tones per L.M. =23.2 x 2 = 46.4 Tones

Quantity for L.M 32.6 = 46.4 x 32.6 = 1,513 Tones

SECTION D-D, 1:100

BREAKWATER HEAD

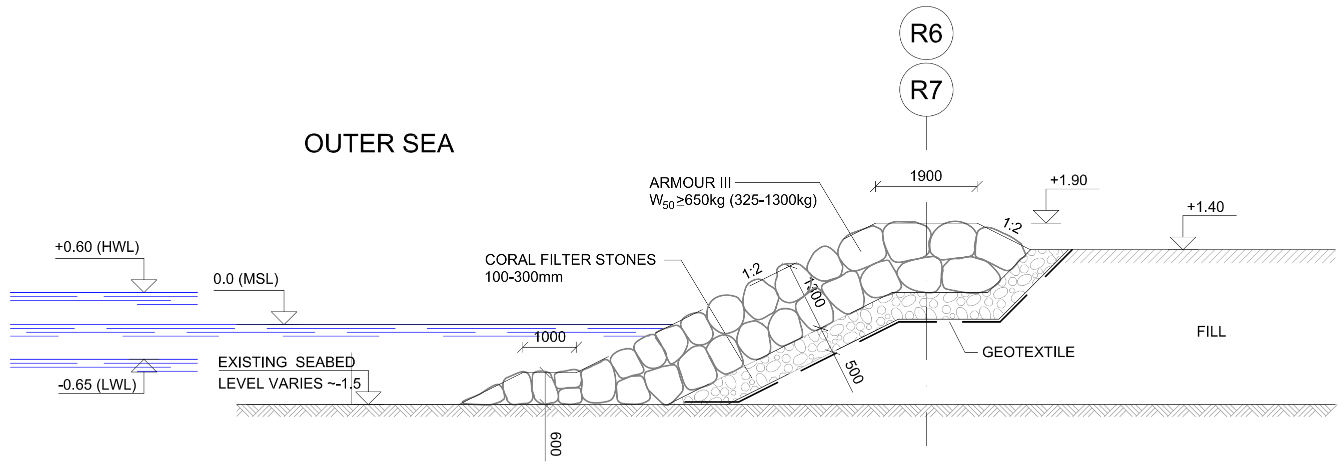



SECTION C-C, 1:100

BREAKWATER

Cross Sec.area =23.2 Sq.M. Tones per L.M. =23.2 x 2 = 46.4 Tones

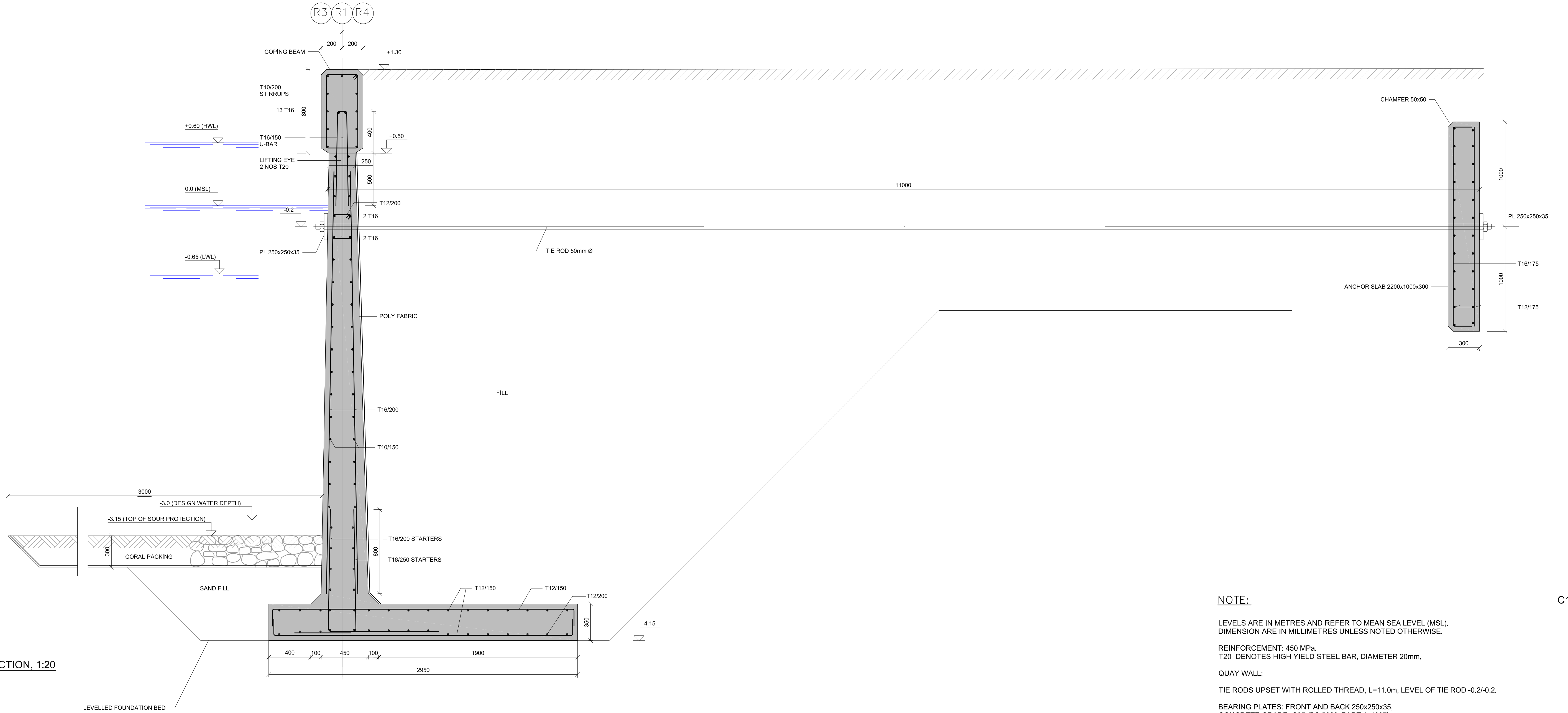
Quantity for 147.5 L.M = 46.4 x 147.5 = 6,844 Tones.



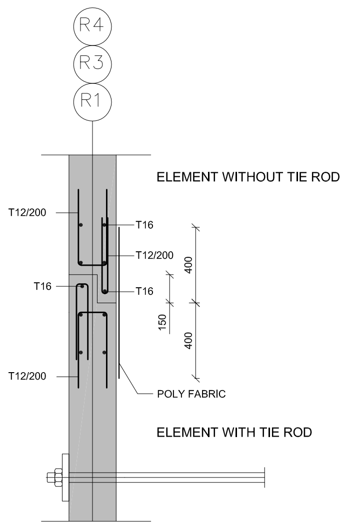

SECTION A-A, 1:100

REVETMENT, WEST

| | | | | | |
|---|---|---|---|---|---|
| 0 | DETAILED DESIGN | 2008-05-27 | MPi/HEI | TEB | MPi |
| No. | Revision | Date | Init. | Check | Approved |
| Job | AMIN CONSTRUCTION<br>DESIGN & BUILD OF 7 HARBOURS | Job No. | | | |
| Title | AA. RASDHOO<br>SECTIONS | Dwg. No. | | | C1-43 |
| | | Scale | 1:100 | | |

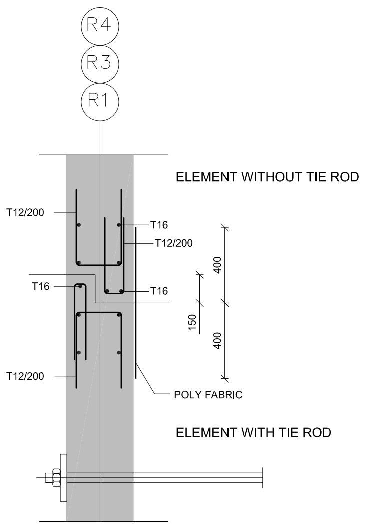



SECTION, 1:20



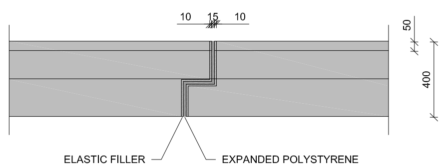

ELEMENT PLAN, 1:20

TOP

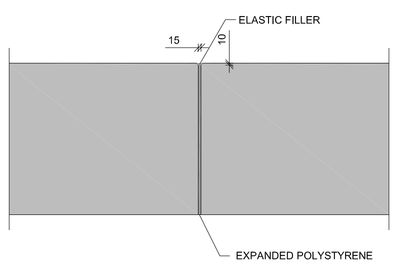



ELEMENT PLAN, 1:20

BOTTOM




COPING BEAM, EXPANSION JOINT, PLAN, 1:20




COPING BEAM, EXPANSION JOINT, SECTION, 1:20

NOTE:

C1-44

LEVELS ARE IN METRES AND REFER TO MEAN SEA LEVEL (MSL).
DIMENSION ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.

REINFORCEMENT: 450 MPa.
T20 DENOTES HIGH YIELD STEEL BAR, DIAMETER 20mm,

QUAY WALL:

TIE RODS UPSET WITH ROLLED THREAD, L=11.0m, LEVEL OF TIE ROD -0.2/-0.2.

BEARING PLATES: FRONT AND BACK 250x250x35.
CONCRETE GRADE: C35 (BS 5328, PART 1: 1997).
CONCRETE COVER TO REINFORCEMENT: 50mm.
EXPANSION JOINT TO BE IMPLEMENTED PER 10m FOR THE COPING BEAM.
THE SPACING AT THE JOINTS BETWEEN THE ELEMENTS SHALL BE MAX. 10mm.

ANCHOR SLABS:

CONCRETE GRADE: C25
CONCRETE COVER TO REINFORCEMENT: 50mm.

ASSUMED BEARING CAPACITY OF SOIL IS 150kn/m$^2$

| | | | | | |
|---|---|---|---|---|---|
| | | 2008.01.23 | | | |
| No. | Revision | Date | Init. | Check | Approved |
| Job | AMIN CONSTRUCTION<br>DESIGN & BUILD OF 7 HARBOURS | Job No. | 07.269.10 | | |
| Title | AA. RASDHOO<br>QUAY WALL DETAILS | Dwg. No. | | C1-44 | |
| | | Scale | 1:20 | | |

# Appendix 5 List of People Met

## Participant s of scoping meeting for AA Rashdhoo harbor development project held on 25th November 2007

| | | |
|---|---|---|
| Ahmed Saleem | Asst. Director General | ERC (presently known as EPA) |
| Zeenia Ahmed Hameed | Senior Architect | MCPI (presently known as MHTE) |
| Ahmed Rasheed | Asst. Director | MoAD (presently known as MoA) |
| Ahmed Asraf | Construction | Amin Pvt Ltd |
| Hussein Zahir | Consultant | LaMer Pvt Ltd |

## Personnel met from MHTE

| | | |
|---|---|---|
| Shifaz Ali | Senior Engineer | MHTE |

North Ari Atoll Rasdhoo Office
AA.Rasdhoo, Republic of Maldives.

އއ. ރަސްދޫ، ދިވެހިރާއްޖެ.

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| އިޖްތިމާޢީ ހަމަޖެހުން - މިޒައުދުގެރިނުން |
|---|

ވެދުން ސަލާމަށް ފަހު ދަންނަވަމެވެ.

މިރަށުގެ ބަނދަރާބެހޭގޮތުން ޚިޔާ އެންމެހާ ބޭފުޅުންނާ ބައްދަލުވުމެއް މަޝްވަރާ ކުރުމަށް ބޭނުންވާތީ މިއަދު 25 ސެޕްޓެމްބަރ 2009 ވާ ހުކުރު ދުވަހުގެ ( އާދެ ! މިއަދު ) 9:00 ގައި އއ.ތޮއްޑޫގެ މަޖިލީހުގެ ޖަލްސާ ކުރާ މާލަމަށް ދަޢުވަތުއްވުން އެދެމެވެ.

25 ސެޕްޓެމްބަރ 2009

| އަދަދު | ނަމާއި އެޑްރެސް | ދަޢުވަތުދިން ސޮއި | ހާޒިރުވި ސޮއި |
|---|---|---|---|
| 1 | އަލްފާޟިލް އަޙްމަދު އަބްދުﷲ ހާދީ ޖަނަވަރީމާގެ | | ✓ |
| 2 | އަލްފާޟިލް އާދަމް އިބްރާހީމް ސޯސަންރޯސް | | ✓ |
| 3 | އަލްފާޟިލް މޫސާ އަބްދުލްހާދީ ނިކަގަސްދޮށުގެ | | |
| 4 | އަލްފާޟިލް ޙަސަން އިބްރާހީމް ފެހިޖެ | | ✓ |
| 5 | އަލްފާޟިލް ޙަސަން މުޙައްމަދު ބަނަފްސާގެ | | |
| 6 | އަލްފާޟިލް މަޙްމޫދު އިބްރާހީމް ސަވަންސަވިން | | ✓ |
| 7 | އަލްފާޟިލް އަބްދުލްއަޒީޒު މޫސާ ގްރީންހައުސް | | ✓ |
| 8 | އަލްފާޟިލް މުޙައްމަދު ޝަރީފު ވައިލެޓްއިން | | |
| 9 | އަލްފާޟިލް ހާރޫން މުޙައްމަދު އަލިމަސްގެ | | ✓ |
| 10 | އަލްފާޟިލް އިބްރާހީމް ޙަސަނު ރަތްތެބީގޭގެ | | ✓ |
| 11 | އަލްފާޟިލް މޫސާ އަބްދުﷲ ކާމިލު ބިލަމަގަސްދޮށުގެ | | ✓ |
| 12 | އަލްފާޟިލް ހުސައިން ނާޞިރު ފެނިމާގެ | | ✓ |

| | | | |
|---|---|---|---|
| 16 | އަލްފާޟިލް އިސްމާޢީލް އަބްދުއްރަޙްމާން ކުދިމާގެ | | |
| 17 | އަލްފާޟިލް އިބްރާހީމް އާދަމް ޖަބުރުވެރިސްޓޯރުގެ | | ✓ |
| 18 | އަލްފާޟިލް އާދަމް ޝަރީފް އަސްރަފީގެ | | ✓ |
| 19 | އަލްފާޟިލް އިބްރާހީމް ރަޝީދު ފެހިވިނަ | | |
| 20 | އަލްފާޟިލް އަބްދުﷲ ޢަފީފް އައްސޭރި | | ✓ |
| 21 | އަލްފާޟިލް ހުސައިން ޒަކީފް ކަސްތޫރީގެ | | ✓ |
| 22 | އަލްފާޟިލް އަބްދުލް ވާރިޘް މޫސާ ހިރިނައިޖް | | ✓ |
| 23 | އަލްފާޟިލް ހަސަން ޒަކީފް ކަސްތޫރީގެ | | ✓ |
| 24 | އަލްފާޟިލް އަޙްމަދު ނާޞިރު ކަނޑިރީގެ | | ✓ |
| 25 | އަލްފާޟިލް އަބްދުއްރަޙީމް އިބްރާހީމް ސުނބުލި | | |
| 26 | އަލްފާޟިލް މުޙައްމަދު ނަސީމް ސަވިޖްނަސް | | |
| 27 | އަލްފާޟިލް އާނިސާ ޢަލީ ފުނަމާގެ | | |
| 28 | އަލްފާޟިލް އަޙްމަދު ޝަރީފް ގާޑަންހައުސް | | |
| 29 | އަލްފާޟިލް ޢަލީ ރަޝީދު އައްސޭރި | | ✓ |
| 30 | އަލްފާޟިލް ހަސަން މޫސާ ބިލަމުގެސްޓޯރުގެ | | ✓ |
| 31 | އަލްފާޟިލް މޫސާ ހަމީދު ހުދުވިލި | | ✓ |
| 32 | އަލްފާޟިލް އަބްދުއް ރަޝީދު އާދަމް ނިއަލި | | ✓ |
| 33 | އަލްފާޟިލް ފާއިޒް ޢަލީ ގަސްކަރަ | | |
| 34 | އަލްފާޟިލް މުޙައްމަދު އިބްރާހީމް ބޫލޫވޭ | | ✓ |
| 35 | އަލްފާޟިލް އަޙްމަދު އަބްދުލް ޤުދޫރު ބަގާރުގެ | | |
| 36 | އަލްފާޟިލް އަބްދުﷲ އާދަމް ~~ބިލަމުގެ~~ސްޓޯރުގެ | | |
| 37 | އަލްފާޟިލް އިލްޔާސް ޢަލީ އަންބަރީގެ | | ✓ |
| 38 | އަލްފާޟިލް ޢަލީ މަންސޫރު ހަނދުވަރީގެ | | ✓ |
| 39 | އަލްފާޟިލް އިބްރާހީމް ޝަރީފް ގާޑިނިއާ | | ✓ |
| 40 | އަލްފާޟިލް އަބްދުﷲ މުޙައްމަދު ރަތްވިލާގެ | | |

# Appendix 6 Letters by MHTE regarding Rashdhoo harbor

بسم الله الرحمن الرحيم

މިނިސްޓްރީ އޮފް ހައުސިންގ، ޓްރާންސްޕޯޓް އެންޑް އެންވަޔަރަންމަންޓް

Ministry of Housing, Transport and Environment

ނަމްބަރު: 138-HES/ 207/2009/18

މާލެ އުތުރު ފާޚަލީރުން ހިންގުމުގެ ޒަވާބު ހުންނަ މިނިސްޓަރ އޮފް ސްޓޭޓް ފޮރ ހޯމްއެފެއާޒް އަލްފާޟިލް މުޙައްމަދު ޝަރީފަށް،

ވެދުން ސަލާމަށްފަހު ދަންނަވަމެވެ.

**ބަނދަރު ހެދުމާއި ބިނާކުރުމުގެ މަޝްރޫއު - އއ. ރަސްދޫ ( U002/A1A )**

އެރިއައްކުރު އުތުރުބައި ރަސްދޫ ރައްޔިތުންގެ ކައުންސިލް 4 އޮގަސްޓް 2009 ގެ ...

[illegible]

ވީމާ، ބަނދަރުގެ މަސައްކަތް މި ...

[illegible]

އިޚްލާޞްތެރި ޚާދިމުކަމުން ...

21 ޝަޢުބާން 1430 ހ.

12 އޮގަސްޓް 2009މ.

ސިވިލް ...

ސީނިއަރ އިންޖިނިއަރ

މާލެ އުތުރު ފާޚަލީރުން އޮފީސް،

ކޮޕީ: އއ. ރަސްދޫ އޮފީސް

ކޮޕީ: މިނިސްޓްރީ އޮފް ހޯމްއެފެއާޒް

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Male', Republic of Maldives
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E-mail:admin@housing.gov.mv
Website: www.mhte.gov.mv

ހެޑް އޮފީސް
އަމީނީމަގު، 20405
މާލެ، ދިވެހިރާއްޖެ.
ފޯނު: 3323234
ފެކްސް: 3328300
އީމެއިލް: admin@housing.gov.mv
ވެބްސައިޓް: www.mhte.gov.mv

UNite to combat CLIMATE CHANGE
http://www.mhte.gov.mv/ 5th June 2009
http://unep.org/UNite/

بسم الله الرحمن الرحيم

މިނިސްޓްރީ އޮފް ހައުސިންގ، ޓްރާންސްޕޯޓް އެންޑް އެންވަޔަރަންމަންޓް

Ministry of Housing, Transport and Environment

ނަމްބަރު: 138-HES/ 207/2009/12

މިނިސްޓަރ އޮފް ސްޓޭޓް ފޯ ހައުސިންގ އެންޑް ... މުޙައްމަދު ނަޝީދަށް،

ވެދުން ސަލާމަށްފަހު ދަންނަވަމެވެ.

**ބަނދަރު ހެދުމާއި ބެހިގެންވާ މަޝްރޫޢު - އއ. ރަސްދޫ (U002/A1A)**

ސަރުކާރު ގައި ދެންނެވިފައިވާ މަޝްރޫޢުތަކުގެ ދަށުން އއ. ރަސްދޫ ބަނދަރު ހެދުމަށް މިމިނިސްޓްރީ އިން ހުށަހަޅާފައިވާ ޓެންޑަރުގެ ދަށުން އެއްއިރުން ހިންގުން ހަމަޖެހިފައިވާ ނުވަތަ، އެއްއިރުން ވަކި އޮޕަރޭޝަން ބޭނުންކުރާ ގޮތް މި މިނިސްޓްރީ ގައި 2009 ގެ 31 ވީ އޭޕްރީލް ދުވަހު ބޭއްވުނު ބައްދަލުވުމުގައި މަޝްވަރާ ކުރެވުނު ރަސްދޫ ބަނދަރު ފުރާލުމަށް ފޫޓު 750 ފޫޓުގެ ބަނދަރު ހެދުމަށް ނިންމާފައެވެ. އެއްއިރުން އިދާރާއިން ގަބޫލު ކުރެވިފައިވާ ގޮތަށް ކުރިއަށް ގެންދިއުމަށް އެދެން ފޮނުވީމެވެ.

މިހާ، މިކަމުގެ ބައްދަލު ކުރުމުގެ ދިގު ކޮށް ބަޔާންކުރެވި، ރަސްދޫ އާއިލާ ތަމުގެ ގެ ފަސޭހަ ފުރުސަތުގައި މިނިސްޓްރީ އަށް އެންގުމަށް ފޮނުވަމެވެ.

އިޙްތިރާމާއެކު ގަބޫލުކުރެއްވުން އެދެމެވެ.

08 ޖުމާދަލް އާޚިރާ 1430ހ.

02 ޖޫން 2009މ.

ޚާދިމުކުމް

ސިފައާ ...

ސިޔާސީ އެސިސްޓަންޓް

ގެ ހޭދަ ޓްރާންސްޕޯޓް އޮފީސް،

ށ. މާފަރު

ކޮޕީ: އއ. ރަސްދޫ އޮފީސް

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ފެކްސް: 3328300

މިނިސްޓްރީ އޮފް ހައުސިންގ، ޓްރާންސްޕޯޓް އެންޑް އެންވަޔަރަންމަންޓް

Ministry of Housing, Transport and Environment

ނަންބަރު: 138-HES/207/2009/10

މިނިސްޓަރ އޮފް ސްޓޭޓް ފޮރ ހޯމްއެފެއާޒް އަލްފާޟިލް މުޙައްމަދު ނަޝީދަށް،

ވުޒާރާ ސަލާމަށްފަހު ދަންނަވަމެވެ.

**ބަނދަރުހެދުމާއި ބިންހިއްކުމުގެ ގުޅޭ މަޝްވަރާ – އއ. ރަސްދޫ ( U002/A1A )**

ސަރުކާރުގެ ދެންނެވިފައިވާ ޕްރޮޖެކްޓްތަކުގެ ބަނދަރުގެ ޑިޒައިން ދެން ނިމިގެން ދިއުމާއި ގުޅިގެން، މި މަސައްކަތް ކުރުމުގައި ރައްޔިތުންގެ އެއްބަސްވުން މި މިނިސްޓްރީއަށް ނުލިބޭ ބޮޑުކަމުން. އެހެންކަމުން މިކަމާ ގުޅޭ ބައްދަލުވުމަކަށް އއ. ރަސްދޫ ރަށުކައުންސިލް ކޮމިޓީން ރައްޔިތުން ތަމްސީލުކުރާ 3 ފަރާތަކުން ޗީފް ފޮނުއްވުން އެދި ދަންނަވަމެވެ.

ތަން : މިނިސްޓްރީ އޮފް ހައުސިންގ ޓްރާންސްޕޯޓް އެންޑް އެންވަޔަރަންމަންޓް
އަމީނީ މަގު
މާލެ، ދިވެހިރާއްޖެ

ތާރީޚް : 31 މޭ 2009

ވަގުތު : ހެނދުނު 10:00

އިޙްތިރާމް ގަބޫލުކުރައްވަން އެދެމެވެ.

29 ޖުމާދަލް އޫލާ 1430ހ.

24 މޭ 2009މ.

ޚާދިމްކުމް

Abdulla Naushad

ޢަބްދުﷲ ނަޢުޝާދު

ޑިރެކްޓަރ ޖެނެރަލް

މެދު އުތުރު ޕްރޮވިންސް އޮފީސް،

ކ. މާފުށި

ކޮޕީ : އއ. ރަސްދޫ އޮފީސް

ކޮޕީ : މިނިސްޓްރީ އޮފް ހޯމްއެފެއާޒް

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