ENVIRONMENTAL IMPACT ASSESSMENT

For the proposed coastal protection and modification to the original concept at Moofushi Island Resort, South Ari Atoll, Maldives

Proposed by
Moofushi Development Limited

Prepared by
Abdul Aleem, & Ahmed Jameel

For Water Solutions Pvt. Ltd., Maldives

WS
July 2010
1 Table of Contents

1 TABLE OF CONTENTS 2
2 TABLE OF FIGURES 5
3 LIST OF TABLES 5
4 NON TECHNICAL SUMMARY ........................................................................................................ 6
5 INTRODUCTION 8

5.1 TERMS OF REFERENCE .................................................................................................................. 8

6 PROJECT SETTING 9

6.1 APPLICABLE POLICIES, LAWS AND REGULATIONS ...................................................................... 9

7 PROJECT DESCRIPTION 11

7.1 PROJECT PROponent ...................................................................................................................... 11
7.2 PROJECT LOCATION AND STUDY AREA ........................................................................................ 11
7.3 GEOGRAPHY ................................................................................................................................... 11
7.4 BRIEF DESCRIPTION OF THE PROJECT COMPONENTS ................................................................ 12
7.5 NEED AND JUSTIFICATION TO BRING THE MODIFICATIONS .................................................. 13

7.5.1 Need to modify the original concept .......................................................................................... 13
7.6 PROJECT DURATION AND BOUNDARY ........................................................................................ 14
7.7 DESCRIPTION OF THE PROJECT COMPONENTS ............................................................................. 14

7.7.1 Construction of a new swimming pool ...................................................................................... 14
7.7.2 Extension of the arrival jetty by 10 meters ................................................................................ 14
7.7.3 Coastal protection ...................................................................................................................... 15
7.7.4 Construction of new breakwaters .............................................................................................. 16
7.7.5 Construction of artificial headlands .......................................................................................... 17

7.8 CONSTRUCTION METHODOLOGY ............................................................................................... 27

7.8.1 Construction Strategy ................................................................................................................. 27
10.4.2  Replenishment of the beach................................................................. 37

10.4.3  Extension of the arrival jetty ............................................................ 38

10.4.4  Construction of the swimming pool ............................................... 39

11  STAKEHOLDER CONSULTATIONS.......................................................... 42

11.1  Consultation with the relevant government agencies .......................... 42

11.2  Consultation with the proponent ......................................................... 42

11.3  Consultation with long term staff ....................................................... 42

11.4  Consultations with a contractor .......................................................... 43

12  ALTERNATIVES  44

12.1  No Project Option .............................................................................. 44

12.2  Alternative borrow areas .................................................................... 44

12.3  Alternative methods to protect the beach .......................................... 45

  12.3.1  Submerged breakwater ............................................................... 45

  12.3.2  Continuous Re-nourishment of the beach .................................... 45

12.4  Alternative materials for breakwaters .............................................. 46

12.5  Preferred options .............................................................................. 46

  12.5.1  Mitigation measures for the proposed alternative ....................... 46

13  ENVIRONMENTAL MONITORING....................................................... 47

13.1  Introduction ....................................................................................... 47

13.2  Cost of monitoring ........................................................................... 47

13.3  Methods of monitoring ..................................................................... 47

13.4  Monitoring responsibility .................................................................. 47

13.5  Monitoring report ............................................................................. 47

13.6  Monitoring schedule ......................................................................... 47

14  CONCLUSION  48

15  DECLARATION OF THE CONSULTANTS ........................................... 49

17  REFERENCES  50

18  ANNEX: TERMS OF REFERENCE ....................................................... 52

19  ANNEX: SITE PLAN INDICATING THE EXTENSION OF THE ARRIVAL JETTY AND THE NEW SWIMMING
2 Table of Figures

Figure 1: Location of Moofushi in South Ari Atoll (Map by Water Solutions) .................................................. 12
Figure 2: Fill profile for the nourished area ..................................................................................................... 15
Figure 3: Two types of breakwater options for southern coastline ................................................................. 17
Figure 4: Beach replenishment methods and strategy ......................................................................................... 28

3 List of Tables

Table 1: Volume of sand required and borrow areas and their volumes ............................................................. 15
Table 2: Matrix of major inputs during construction period .............................................................................. 29
Table 3: Matrix of major outputs of environmental significance during construction stage ............................ 30
Table 4: Summary of the impacts and their characterization ............................................................................. 41
Table 5: Advantages and disadvantages of the no project option .................................................................... 44
4 Non Technical Summary

This report discusses the findings of an environmental impact assessment undertaken by Water Solutions Pvt. Ltd for undertaking the coastal protection works and bring minor modifications to the resort development concept. Moofushi island is currently under redevelopment. The redevelopment is being undertaken after obtaining the proper approval including the approval of the EIA. Since construction began in September 2005, the need arose to bring minor modifications to the original development concept, which includes the following components.

- Construction of a new swimming pool
- Extension of the arrival jetty by 10 meters
- Construction of new breakwaters for better coastal protection
- Modification and repair of some of the existing breakwaters for better coastal protection
- Replenishment of the eroded areas of the beach
- Removal of some groynes and seawall that are not functioning

Although Moofushi has coastal protection, they are not functioning entirely and some areas of the coastline are undergoing chronic erosion. Hence, new coastal protection measures have been suggested.

The proposed project conforms to all prevalent environmental and tourism legislation and thrives to achieve its objectives in the most environmentally friendly manner.

Environmental impacts were assessed for both the construction and operation phase of the project. Most of the environmental impacts of the project have been identified as resulting mainly from beach replenishment. The main impact would be that of sedimentation on the nearby reef areas. This impact is considered to be short-term and cumulative. Nevertheless, mitigation measures have been proposed for anticipated negative impacts.

Mitigation measures for these negative impacts have been identified and outlined in detail, especially sedimentation control methods. The most important mitigation measure is the use of bund walls in the replenishment areas. The proposed mitigation measures will have to be followed in order to minimize environmental damage. The measures proposed to minimize or mitigate environmental impacts may be considered to be quite appropriate, thereby minimizing the impact by about 90%. The main negative environmental impact of the proposed project would be sedimentation, which may cause death or partial death of corals.

The commitment by the proponent to undertake mitigation measures is proven by the summary monitoring reports undertaken by the client since the inception of the resort redevelopment stage in September 2009 (attached as an annex). Since construction began, Moofushi island’s environment has been monitored continuously as per the monitoring schedule outlined in the EIA of 2009, which was approved for the redevelopment.
The proponent also commits to undertake the monitoring programme set out in this EIA report knowing that monitoring will help to identify the effectiveness of the mitigation measures and take precautions to minimize any damage to the main tourist attraction of the island, which is its environment. Therefore, it appears justified from a technical, social, economic and environmental point of view, to carry out the proposed modifications.
5 Introduction

This Environmental Impact Assessment report (EIA) has been prepared to fulfil the requirements of the Environmental Protection and Preservation Act, law no. 4/93 for the proposed concept change and the coastal modification in Moofushi Island Resort, located in south Ari Atoll. The island of Moofushi is currently under redevelopment. Construction work for the redevelopment began in September 2009.

The report has been structured to meet the requirements of the EIA regulations 2007 issued by the Ministry of Environment, Energy and Water. This EIA report discusses the outcomes and findings with regard to coastal protection in Moofushi.

This EIA has been prepared by a local environmental consulting firm, Water Solutions. Water Solutions have been chosen by the proponent as the environmental consultants for this project. The team members were:

- Abdul Aleem, BSc, MPH – Mapping and GIS
- Ahmed Jameel, B. Eng (Environmental), MSc – Environmental Engineer
- Mohamed Riyaz, - surveyor
- Hamdhulla Shakeeb, Surveyor

5.1 Terms of Reference

Terms of Reference for the this assessment has been included in the Appendix of this report


# Project Setting

This section outlines the relevant environmental legislation pertaining to this project.

## 6.1 Applicable Policies, Laws and Regulations

<table>
<thead>
<tr>
<th>Relevant environmental laws for this project</th>
<th>Implications of the project and its relevance to the law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection and Preservation Act</td>
<td>The proposed project will fully abide to the Environmental Preservation and Protection Act. Disposal of dredge spoil (from pumping activities) will be strictly controlled and managed as per the project concept. No hazardous materials will be disposed in to the local or the regional environment. With regard to waste oil and other waste streams resulting from the coastal projection component, they will be strictly disposed to Thilafushi.</td>
</tr>
<tr>
<td>National Biodiversity Strategy and Action Plan</td>
<td>In implementing the proposed project activities due care has to be given to ensure that the national biodiversity strategies are adhered to. The proponent has committed fully on conservation and protection of the environment while undertaking this proposed project. More specifically, the coral reef and generally the marine environment have been assessed in detail in order to assess baseline values. Quantitative and qualitative surveys were undertaken to assess the biological diversity of the coral reef, especially in close proximity to the proposed development area. Hence, the coastal protection plan will take in to account the conservation of biological diversity. Practical mitigation measures and solutions have been identified to conserve and protect the biodiversity.</td>
</tr>
<tr>
<td>Waste management policy</td>
<td>Waste management for the proposed project has been considered during the construction and operational stage. Since the island is being redeveloped, measures are already in place to manage the waste during operational period, such as incineration and regular transfer of waste to Thilafushi. There is already an established waste management mechanism in the island. Similarly, during the redevelopment process, waste management strategies have been developed, details of which are outlined in the report. Therefore, this project will also confirm to this policy.</td>
</tr>
</tbody>
</table>
### Relevant environmental laws for this project

<table>
<thead>
<tr>
<th>Regulation on sand and aggregate mining</th>
<th>Implications of the project and its relevance to the law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neither sand nor aggregate will be mined for this project. This regulation would not have any implication on the proposed project. Sand will be pumped from designated areas from the lagoon to nourish the beach and control erosion. Sand will not be used for any other construction purpose in this project.</td>
<td></td>
</tr>
</tbody>
</table>

| Ban on coral mining | Coral and sand would not be mined in any stage of the project. The existing coral rubbles from which the groynes and sea walls are constructed will be disposed in the lagoon where new breakwaters are proposed. These corals will be disposed along the length of the new breakwaters in order to utilize them as a base. During the scoping meeting, it was discussed and decided that this coral rubble cannot be used for any purpose but may be disposed on the lagoon as a base. |

| Environmental Impact Assessment Regulation 2007 | The guidance provided in this Regulation was followed in the preparation of this EIA report. The EIA has also been prepared by registered consultants. |

| Post EIA Monitoring, Auditing and Evaluation | The environmental monitoring programme given in EIA reports is an important aspect of the EIA process. The monitoring programme outlines the objectives of the monitoring; the specific information to be collected; the data collection program, and managing the monitoring program. Managing the monitoring programme requires assigning institutional responsibility, reporting requirements, enforcement capability, and ensuring that adequate resources are provided in terms of funds, skilled staff, etc. The monitoring programme outlined in this report will comply with the EIA Regulations 2007. Attached in the annex are regular monitoring reports for Moofushi redevelopment EIA which was prepared in 2009 July. |
7 Project Description

7.1 Project Proponent

The project is presented by Moofushi Development Ltd (MDL), the Promoter. By virtue of a sub-lease Agreement entered between MDL and Moofushi Investment Ltd (MIL), MDL has the sub-lease rights over the island. MIL is a Maldivian Company, part of the Alia Group of Companies, a Maldivian group well known in construction and Hardware business.

MDL forms part of the Constance Hotels Experience (Constance Hotels Group) well known and fast expanding a Mauritian based Hotel Operating Company. Constance Hotels holds equity participation, sub-lease rights and management contracts for a number of hotels in Mauritius, the Seychelles, Madagascar and the Maldives. In the latter Country, Constance Hotels recently opened the Constance Halaveli Resort a five-star luxury hotel. At June 2009, this group employs approximately 2000 people in total.

7.2 Project Location and Study Area

The project takes place in the island of Moofushi located on periphery of south Ari Atoll (see Figure 1). The island has a registered land area of 64,007.07 m² as of August 2008. At present, Moofushi Island is under redevelopment and it is scheduled to be completed by end of September 2010.

7.3 Geography

Moofushi is a small isolated island formed on its own reef system approximately 57 kms south west of Male’. The island is located at about latitude of 03°53’04”N and longitude of 72°43’41”E. The island is formed on an isolated coral reef system, oval in shape with the widest area on the east – west axis and narrowest portion on the south-west. The island is roughly 2.01 km from the west rim of the reef system on which it is formed. The house reef on south eastern side is 40 m from the island. The island is located on western side of the atoll, and island is exposed to the swells from the ocean from western side during the south west monsoon.

The southern and eastern side of the island is prone to the effects of currents and strong winds during the two monsoons. As a result, coastal protection measures (sea walls, groynes and breakwaters) have been constructed on this side for several years. The arrival jetty is located on the east side which is exposed to strong winds in north east monsoons while the service jetty is on the north western lagoon, which is exposed to strong winds in both monsoons. The island is surrounded by three isolated reefs which are within a radius of 5km from the island.

The closest island to Moofushi is Himandhoo island, which is roughly 4.5 km north of Moofushi. The closest resort island is Athuraga which is located approximately 9 km east. The island is 25.5 km west of Mahibadhoo, atoll capital of South Ari Atoll. Moofushi has a beautiful and easily accessible house reef, In June 2008, the perimeter of the island from the shore line measured 1356.2 meters with a total area (officially registered) of the island accounting to 64,007.07 m² square meters (from the high tide line). The island is almost rhombus in shape.
7.4 Brief description of the project components

The proponent proposes to bring the following modifications to the original development concept.

<table>
<thead>
<tr>
<th>Proposed modifications</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of a new swimming pool on the south side.</td>
<td>A new swimming pool will be constructed on the southern side of the island. Refer to the site plan attached as an annex for details of the location.</td>
</tr>
<tr>
<td>Extension of the arrival jetty to another 10 meters</td>
<td>Refer to the site plan attached as an annex for details of the location.</td>
</tr>
<tr>
<td>Implementation of coastal protection measures which includes the following components</td>
<td>Refer to the following sections for further details.</td>
</tr>
<tr>
<td>- Construction of new breakwaters</td>
<td></td>
</tr>
<tr>
<td>- Rehabilitation and repair of some of the existing breakwaters</td>
<td></td>
</tr>
<tr>
<td>- Removal of some of the coastal protection measures such as groynes and sea walls</td>
<td></td>
</tr>
<tr>
<td>- Construction of revetment style headland in</td>
<td></td>
</tr>
</tbody>
</table>
7.5 Need and Justification to bring the modifications

7.5.1 Need to modify the original concept.

The growth in the tourism industry of the Maldives has various economic benefits as prescribed in the Second Tourism Master Plan. These include:

- Foreign exchange earnings – over 70% of all foreign exchange earnings is from tourism
- Income generation
- Employment
- Development of entrepreneurial activities
- Improved public facilities

In addition to its contribution to the overall development of the country and growth of the tourism sector, the development of Moofushi into a resort will bring numerous economic benefits to Maldives.

Moofushi has been under redevelopment since September 2009 and since then, the developers have realized the need to make minor modifications to the original development concept, mainly in order to improve the quality of services provided to the guests. The need for these modifications arose mainly due to changing market conditions and also implement measures to protect the island environment from chronic erosion and to adopt a better approach to manage the coastal erosion.

The proposed modification and their specific justifications are given below.

Extension of the existing arrival jetty by 10 meters.

The redevelopment of the island has been designed to renovate the existing arrival jetty. However, since during the south-west monsoon, the lagoon around the jetty gets considerably shallower due to heavy sediment shifting from the south side, it becomes difficult for larger boats to access the jetty, especially during low tide.

Hence, a further 10 meters of extension is proposed in order to extend the jetty head to deep waters.

A new swimming pool

A new swimming pool has been proposed as a result of changing market conditions and forecasts, that is to provide a more diverse range of services and facilities in the resort. Hence, the concept had to be changed, which requires construction of a new pool on the southern side of the island. No additional trees will be removed for this component as the pool will be developed between the vegetation line and the shoreline.

Coastal protection
Moofushi is exposed to strong winds and waves during both monsoons and as a result, coastal protection measures have been undertaken in the island. However, the coastal protection measure does not adequately address the southern side where erosion persists. Hence, modification to the existing coastal protection measures need to be undertaken and new structures have been proposed to manage the coastline. Thus it requires beach replenishment as an enhancement measure together with coastal protection.

To further justify the coastal protection, the environment of Moofushi, especially the coastal environment has been carefully monitored for the past three years (refer to the shoreline monitoring maps and regular monitoring reports attached as an annex). The results of the monitoring indicate that the southern coastline is undergoing chronic erosion and that some of the coastal protection measures such as groynes are not functioning. Hence, there is a need to modify the coastal protection around Moofushi that will include new structures as well as improvements to existing structures.

Refer to the EIA of Moofushi redevelopment – July 2010 attached as an annex to understand the details as to why coastal protection is necessary in Moofushi. Also refer to the attached monitoring reports for details.

7.6 Project duration and boundary

The proposed project modifications will be undertaken in two months and the project boundary is Moofushi island system, particularly the marine and coastal environment around Moofushi.

7.7 Description of the Project Components

7.7.1 Construction of a new swimming pool

A new swimming pool will be developed on the southern side of the island. The location of the swimming pool has been considered taking in to consideration not to cause any intrusion to the existing beach rooms and over water villas. The swimming pool is located on the south side of the island and would be constructed between the vegetation line and the shoreline. As this area is prone to erosion, it is anticipated that there will be erosion if adequate coastal protection measures are not implemented. Hence, new breakwaters have been proposed to be constructed on the southern side and the beach replenished in order to manage and compensate the erosion on the southern side. Once the swimming pool is constructed, beach replenished and the breakwaters in place, there will be minimal effect on the coastline, hence erosion would be controlled.

Refer to the site plan for the swimming pool location.

7.7.2 Extension of the arrival jetty by 10 meters

Arrival jetty will be extended to 10 meters using columns. No solid structures will be constructed to extend the jetty. Refer to the site plan for location details.
7.7.3 Coastal protection

7.7.3.1 Replenishment of the eroded beach

The main problem with the southern beach face is that the beach face has not been nourished with fine sand to maintain the loss that had occurred due to erosion on the southern side. Hence, it is proposed to replenish the beach with approximately 4,500 m³ of beach on the south side. The replenishment would be carried out so that the berm at the replenished area would have a height of at least 0.5m. Fill profile for beaches around the nourished area of the island is shown in Figure 2.

Figure 2: fill profile for the nourished area

Beach nourishment will be undertaken using a sand pump aided by excavators. This is to ensure that beach material is not compacted and that the beach is softer. It is generally considered appropriate that deposition of material should be along the upper beach, above the high water line and along the eroding berm face. Natural redistribution of the placed material along shore and cross-shore will occur, particularly for sand. The beach replenishment will be undertaken as such that the total increase of the beach will not be more than 10m from the existing high tide line of the island.

The material required for the beach nourishment works would be obtained from the proposed borrow areas. The total volume of material that needs to be obtained for beach nourishment is 6500 m³.

The following table outlines the volumes of sand required for the beach replenishment and the amount of sand required from the three borrow areas proposed.

<table>
<thead>
<tr>
<th>Total volume of sand required</th>
<th>6,500 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total material obtained from the three borrow areas</td>
<td></td>
</tr>
<tr>
<td>Borrow area 1</td>
<td>3000 m³</td>
</tr>
<tr>
<td>Borrow area 2</td>
<td>1500 m³</td>
</tr>
<tr>
<td>Borrow area 3</td>
<td>2000 m³</td>
</tr>
</tbody>
</table>

Table 1: Volume of sand required and borrow areas and their volumes
7.7.4 Construction of new breakwaters

It is proposed that emerged breakwaters be built on southern side of the island to protect the beach. In addition, one emerged breakwater will also be constructed on the north-east side (refer to the project concept for details and location of this breakwater).

Offshore breakwaters are structures built approximately parallel to the beach but some distances offshore. The purpose of offshore breakwaters is to reduce the intensity of wave action in near shore waters and thereby reduce coastal erosion. Emerged breakwaters are similar to natural reefs, with only the difference being that they will be visible above high tide line. Submerged breakwaters have not been considered for Moofushi on the southern side for reasons underline below.

Submerged breakwaters act like artificial reefs, unlike emerged breakwaters, allow sand to pass over their crest and aids long-shore transport between the reef and the shoreline. Then beach would be replenished with sand. This is good in the sense that it allows sediment transport along the coastline. However, in order for a submerged breakwater to function, they will have to have a very wide base. The whole idea of a submerged breakwater is to mimic a natural reef and it cannot do that unless the base is wide. Widening the base would increase the cost.

Secondly, submerged breakwaters are not efficient in controlling swell waves. If a coastline is exposed to swell waves, then the coastline is exposed to erosion and there is little a submerged breakwater can do.

The southern coastline of Moofushi is faced with this problem of strong waves, from both south-west and south-east side. Due to lack of coastal protection on this side, the southern coastline is exposed to erosion and without breakwaters, it would be very difficult to control erosion. The objective of protection on this side is to prevent erosion by reducing the wave energy to 99% and hence emerged breakwaters for this side has been considered instead of submerged breakwaters.

The beach would be monitored in the monitoring programme as outlined in the monitoring section. Refer to the concept plans to identify the location where the breakwaters will be placed.

Based on existing wave conditions in the area and the existing emerged breakwaters, the following two designs have been suggested. Any of the two designs can be adopted and will depend on the cost. The breakwaters will be 1.5 meters above mean sea level.
Breakwater Type 1

Figure 3: Two types of breakwater options for southern coastline

7.7.5 Construction of artificial headlands

Two revetment style headland structures have been considered for southern and north-east tip. Details of these headlands and their locations and cross sectional details are provided in the following diagrammes.

The proposed project concept is described in detail in the following pages.
7.8 Construction Methodology

7.8.1 Construction Strategy

The construction will be undertaken in the planned time period to reduce cost and also reduce the environmental damage. Construction of breakwaters will be completed in the order first starting from the north-east side and then completing the southern side.

7.8.2 Breakwater

A breakwater of approximately 100 meters long and 4 meters wide will be constructed on the southern side of the lagoon to provide coastal protection. Another breakwater of 20 meters will be created on the northeast side. The breakwater would be constructed with sand cement bags. Some of the coral rubble from the groynes and seawall will be spread on the lagoon as base for breakwater and then the remainder of the breakwater would be constructed using sand cement bags. During the scoping meeting, it was indicated that the coral rubble already used in the island for breakwater and sea wall construction cannot be used, but they can be disposed and spread on the lagoon as a base for coral growth or on top of which the breakwaters will be constructed. This is the only practical solution to utilize the coral rubble, as otherwise they would end up in Thilafushi where they will be picked and used for various purpose. Therefore this method of disposal is the most practical and appropriate way to dispose them.

There are also other choices and options for breakwater construction and they are geobags filled with sand or rock boulders. These have been considered as alternatives and may be used for construction of breakwaters depending on the cost.

7.8.3 Beach replenishment methods

Beach replenishment will be undertaken by pumping sand into the areas to be replenished. The pumped sand will be spread evenly at the end of pumping and spreading using excavators. The replenishment works for the beach will be undertaken in a similar manner to that described below.

- Mark the perimeter of the area to be replenished, which will be 10 m from the high tide line.

- Erect a temporary seawall of adequate height using sandbags around the area to be replenished to minimize sediment flow onto the reef.

- Pump sand within 5m from the sandbags to create an inner bund.

- Move sandbags as the inner bund progresses until the inner bund is complete.

- Remove sandbags and keep aside for use in top fill on the foreshore

- Continue pumping to fill the enclosed area.
The following figures outline the replenishment methodology.

**Figure 4: Beach replenishment methods and strategy**

### 7.8.4 Management of Waste

All wastes will enter the present waste management cycle in the island, which is stockpiling and then transferring them to Thilafushi.

### 7.8.5 Expected Environmental Conditions during the Project Implementation Period

The project activities will take place in south-west monsoons, and hence environmental conditions are expected to be both favourable and unfavourable during the construction period. Therefore, the strategy would be to complete the replenishment works after the construction of the breakwater.
7.8.6 Risks Associated with the Project

There are few risk factors associated with this project that could possibly have both financial and environmental implications. The most significant risk associated is not completing the work on time and causing delay in reopening the island.

There is also the risk of project delays caused by bad weather. The construction period falls in the south-west monsoon which is the wet season, unpredictable rainfall and storms are expected. This risk can be minimized if the works could be completed within the minimum period. The breakwater construction is undertaken in the lagoon with maximum depths of 2 meters and hence do not pose major difficulties. This risk will also be minimized by awarding the contract to only experienced contractors with experience in working in similar situations. Therefore, work delays will be least impacted.

The most important risk associated with this project is the possible damage to the marine environment as a result of not only construction of breakwater, but due to pumping of sand and replenishment of the beach. The areas where breakwater will be constructed does not have coral and is only fine sediment and hence, there is no direct coral reef damage due to breakwater construction. However, sedimentation will be an issue but will be minimized by limiting the pumping period as well as undertaking work during low tide hours.

7.9 Project Inputs and Outputs

7.9.1 Project Inputs

The types of resources that will go into the project and from where and how these will be obtained are given in table 1 & 2.

Table 2: Matrix of Major Inputs during Construction Period

<table>
<thead>
<tr>
<th>INPUT RESOURCE(S)</th>
<th>SOURCE/TYPE</th>
<th>HOW TO OBTAIN RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction workers 8</td>
<td>Maldivians and foreigners</td>
<td>Open bidding by advertising in local papers/other sources</td>
</tr>
<tr>
<td>Water supply (construction period)</td>
<td>SIREG 100m³/day desalinization unit</td>
<td>100 m³/day desalination plant</td>
</tr>
<tr>
<td>Already used in the island for construction.</td>
<td>Already used in the island for construction.</td>
<td>Already used in the island for construction.</td>
</tr>
<tr>
<td>Electricity/Energy</td>
<td>Existing Diesel generators in the island.</td>
<td>100 KVA generator</td>
</tr>
<tr>
<td>(construction period)</td>
<td>Already used in the island for construction.</td>
<td></td>
</tr>
<tr>
<td>Construction machinery</td>
<td>Concrete Mixer, excavators, sand pumps and general construction tool</td>
<td>Local suppliers</td>
</tr>
</tbody>
</table>
INPUT RESOURCE(S) | SOURCE/TYPe | HOW TO OBTAIN RESOURCES
--- | --- | ---
Telecommunications Already used in the island for construction period. | Island’s Phone Systems, Fax Machines, E-mail and internet facilities Already used in the island for construction period. | Already some of these services are available in the island and would require additional ones. |
Transport (sea) | Sea transport by dhoni and speed boats. Materials to be transported in cargo vessels/dhoni or large barges. All construction debris will be transported to Thilafushi via cargo vessels/dhoni | Already established. |
Food and Beverage during construction period | Mainly imported sources except a few locally available. | From the resort |
Fuel, Kerosene and LPG | Light Diesel, LPG Gas, Petrol, Lubricants | Local suppliers and from the resort |

7.9.2 Project Outputs

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

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

<table>
<thead>
<tr>
<th>PRODUCTS AND WASTE MATERIALS</th>
<th>ANTICIPATED QUANTITIES</th>
<th>METHOD OF DISPOSAL / CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>6,500 cbm</td>
<td>Replenishment of the beach</td>
</tr>
<tr>
<td>Breakwater</td>
<td>120 meters by 4 meters wide</td>
<td>Placement in the appropriate areas</td>
</tr>
<tr>
<td>Coral rubble</td>
<td>50 cbm</td>
<td>Disposed in the lagoon, where they will be spread as a base.</td>
</tr>
<tr>
<td>Noise</td>
<td>Localised to the island environment</td>
<td>No control required as the noise will not be an issue</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Limited quantities of dust</td>
<td>Mainly arising as a result of dust emission from the construction work such as cement mixing and pumping of sand. Localised to the island environment only.</td>
</tr>
</tbody>
</table>
8 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental components of the project under consideration are coastal environment areas and the marine environment.

8.1 General Methodologies of Data Collection

Conditions of the existing environment were analyzed by using appropriate scientific methods. The environmental components of the study area were focused for marine and coastal environment. The marine environment of the island covered the coral reef and the lagoon.

Coastal environmental data collection involved taking beach profiles from selected locations and assessing the coastal environment.

8.2 Mapping and Location Identification

The island, including shore line, vegetation line, reef lines, coastal defence structures were mapped for the assessment. Mapping was undertaken using hand held differential GPS and available aerial photos. The location of data collection sites were marked using handheld GPS. These data collection points include marine water sampling locations, marine survey locations, existing groynes and sea walls.

8.3 Marine Water Quality

One of the main environmental components that would be affected by implementing this component of the project would be marine water quality. Water quality was assessed by collecting samples and testing them at National Health Laboratory. Water quality was assessed from three locations. The locations, frequency and parameters to be monitored are given in the monitoring programme outlined later in the EIA report.

8.4 Marine Environment surveys

Marine environmental surveys were conducted to collect data on key environmental components (i.e. the coral reef system and the lagoon), that will be impacted due to the coastal protection works. For this EIA, Line Intercept transects (LIT’s) and detail photo transect analysis was used to assess the baseline condition of the three borrow areas and the areas where the breakwaters will be constructed.

8.5 Coastal Environment

Data collected on coastal environment included beach profiles, existing sea walls and groynes, beach composition, beach width, shore line and vegetation line. All beach profile locations were marked on GPS maps and their geographical coordinates were marked on a map. Beach profiles
were taken as baseline data to make comparisons during monitoring programme so that any changes resulting from the coastal component of the proposed project can be assessed accurately. Beach profiles were measured using auto levels and a staff.

8.6 **Bathymetry**

A detailed bathymetric survey was undertaken in the lagoon using Echosounder attached to a boat. The levels were then corrected for mean sea level and represented in a map. Bathymetric map is attached as an annex.

8.7 **Aerial photos**

Recent aerial photos acquired were used in the assessment. Aerials photos provide useful information such as assisting the analysis of marine environment, identifying wave patterns and changes to shoreline and also vulnerable areas of the island. Aerial photos were purchased from DigitalGlobe. They have been used extensively in this EIA and have been presented in different sections of the report.

8.8 **Available long term weather data**

Long term available weather data was obtained from the nearest weather station to Moofushi, which is based in Male’ International Airport, Hulhule. These data sets were used to develop a regional model in ArcGIS to assess the vulnerable areas of the island during both monsoons, thus helping the EIA team to assess the vulnerable areas of the island for erosion.

8.9 **Data from the resort redevelopment EIA – July 2009**

The EIA report prepared for the redevelopment f Moofushi undertaken in July 2009 was used as a basis for this EIA and to obtain information on the various aspects of the project.

8.10 **Data from long term monitoring**

Data from the long term monitoring of Moofushi environment was also used for this assessment.
9 Existing Environment

A detail EIA report was compiled in July 2009 for the redevelopment of Moofushi and the existing environment has been described in detail in this report.

For details of the existing environment of Moofushi, please refer to the EIA of Moofushi redevelopment – July 2009 attached as an appendix.

9.1 Existing Coastal Environment

For details of the existing coastal environment of Moofushi, please refer to the EIA of Moofushi redevelopment – July 2009 attached as an appendix.

9.2 Existing Marine Environment

For details of the existing marine environment of Moofushi, please refer to the EIA of Moofushi redevelopment – July 2009 attached as an appendix.

Also refer to the marine monitoring data attached as an annex.

The following illustration outline the marine data collection points for the coastal components and the results. For this EIA, marine environment surveys were focused on two areas, site A and B which are the two areas where the breakwater will be constructed and the three borrow areas from which sand will be borrowed. This is illustrated in the following figure
RESULTS OF THE MARINE ENVIRONMENT SURVEY
FOR COASTAL PROTECTION WORKS

Sand borrow area 1
Marine Site A
Sand borrow area 3
Marine Site B
Sand borrow area 2

Percentage benthic cover of the two sites where breakwaters will be constructed

<table>
<thead>
<tr>
<th></th>
<th>Live corals</th>
<th>Dead Corals</th>
<th>Sand</th>
<th>Bed rock</th>
<th>Coral Rubble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A</td>
<td>0</td>
<td>5</td>
<td>70</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Site B</td>
<td>0</td>
<td>1</td>
<td>74</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>
10 Environmental Impacts

10.1 Impact Identification

Impact identification has been undertaken by considering the proposed activities and examining the level of impact the new concept will have on the environment. Each activity was then examined in detail to identify the construction methods, technology and other factors that would determine the potential impact of the various activities.

10.2 Assessing Impacts

Environmental impacts of the proposed coastal protection work have been examined through a number of processes. These include consultations with the stakeholders, field surveys, observations and assessment, and field experience gained from similar development projects implemented throughout the country. Potential positive and negative impacts on the environment have been considered.

The impacts on the marine environment are going to be high as the proposed coastal protection and beach replenishment will increase the sedimentation levels. The impacts are categorized into short-term and long-term. Most of the short-term impacts are related to constructional phase, while the long-term impacts are associated with the operational phase.

Possible negative impacts on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in both constructional and operational phase. For example, the anticipated indirect impacts on the coral reef have been slightly exaggerated to account for uncertainties.

This EIA identifies and quantifies the significance of adverse impacts on the environment from the proposed project. Impacts on the environment were identified and described according to their location/attribute, extent (magnitude) and characteristics (such as short-term or long term, direct or indirect, reversible or irreversible) and assessed in terms of their significance according to the following categories: Negligible – the impact is too small to be of any significance; Minor – the impact is minor; Minor adverse – the impact is undesirable but accepted; Moderate adverse – the impact give rise to some concern but is likely to be tolerable in short-term (e.g. construction phase) or will require a value judgement as to its acceptability; Major adverse – the impact is large scale giving rise to great concern; it should be considered unacceptable and requires significant change or halting of the project. Positive – the impact is likely to bring a positive change in the sense that it is aimed at further minimizing the impacts as a result of the proposed actions.

10.3 Uncertainties in impact prediction

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological,
geomorphologic or social conditions in a particular place. There is also limited data and information regarding the particular site under consideration, which makes it difficult to predict impacts.

However, the level of uncertainty, in the case of Moofushi is expected to be low as many similar projects have been undertaken elsewhere in the Maldives. In the marine environment, there is slightly elevated degree of uncertainty as the marine environment is more sensitive in extreme cases such as severe weather conditions. The areas where coastal protection and beach replenishment will be undertaken is a sandy bottom and coral rubble. There is no live coral cover in this area.

Construction of breakwaters, and nourishment of beaches are developments that had been undertaken in other parts of the Maldives and their impacts are well known and have been well documented. Therefore, there is very little uncertainty involved in this project. Therefore, there is a high degree of accuracy in prediction of the impacts.

10.4 Impacts on the Coastal environment

The development of breakwater on southern side of the island would help to reduce the existing erosions, which the island is presently faced. The erosion of beach on southern side of the island during both monsoons will be mitigated with the construction of the breakwater and subsequent nourishing of the lost beach.

10.4.1 Breakwater construction

Impacts

The construction of the breakwater will have a significant positive impact on the southern side beach line in stabilizing the beach. The impact of proposed breakwaters would be mainly related to changes to hydrodynamics and sand transport. Since the breakwater can be dismantled and removed if necessary, the impact of constructing breakwaters is considered reversible. The impact on sand transport around this area would be significantly reduced, and hence the impact but a desirable one. Wave energy will be reduced by the breakwaters and therefore long shore transport sedimentation will be reduced resulting in the stabilizing of the shoreline. The breakwaters proposed on the southern side is therefore going to reduce the long shore currents and reduce erosion.

Mitigation Measures

It is important to undertake the placement of the breakwaters at the preferred location at low tide hours.
10.4.2 Replenishment of the beach

Impacts

The replenishment of the eroded beach will be undertaken by using sand pumped from the lagoon. Refer to the project description section for details of the locations and their volumes. Beach erosion is a critical environmental issue facing the island. Even at present, several large trees is under threat from erosion, mainly on the southern side.

Beach replenishment will be undertaken on southern side and north-east side of the island. Therefore, the lagoon in this area will be directly impacted due to complete alteration of the lagoon bottom and spreading of sediment plumes from the filling material.

Beach replenishment and filling is usually associated with the direct and permanent alteration of the fill area and indirect impacts resulting due to sedimentation. Turbidity increase is almost an unavoidable consequence but can be minimized. In general, the following impacts will be felt.

- Turbidity increase in the water column from spreading of silt plumes. When lagoon floor is disturbed by filling, fine sediment and silt may be released into the water column.

- Lagoon sediments consisting of varying sizes of particles may be suspended for hours in the water column cutting down light to photosynthetic reef benthos. The magnitude of this impact will depend on various factors such as size of particles; hydrodynamic conditions; and reef and lagoon topography. In addition to this many infauna and their habitats will be lost.

- Possible siltation and excessive sedimentation in the lagoon system

- Excessive sedimentation and siltation on coral reefs is detrimental to corals and other reef benthic organisms as it cuts down necessary light and physically smothers corals. It is not expected that the beach replenishment will have any significant direct impact on the coral reef system of the island.

Long-term ecological impact arising from the proposed work activities is not predicted to be significant as the proposed work is limited and localized in a small part of the island system. However, long-term monitoring is required to identify ecological impacts more completely and thoroughly.

Mitigation Measures

The mitigation measure to control sedimentation as it is the main factor that can cause the greatest impact on the reef. Hence, most of the mitigation measures proposed are centred around reducing sedimentation. More specifically the following measures will help to reduce the impacts.

- Working during low tide hours.
• Creating a bund wall around the replenishment area initially and then filling inside this bund using pumped sand. The bund will be removed after the beach replenishment work.

• Completing the filling works in the shortest possible time period.

• Only replenish the required area of the beach

• Using coarse material to make the bund rather than fines.

**10.4.3  Extension of the arrival jetty**

**Impact 1: Changes to sediment transport**

The construction of a series of additional footings and columns for the extension of the arrival jetty would disrupt sediment transport around this area to some extent, especially due to the wave attenuation these structures would offer during the north-east monsoon. This impact would help minimize net erosion on the western side of the island, but as the extension is going to be somewhat perpendicular in direction to the north-east monsoon waves, it is not going to be that significant.

**Mitigation:**

The extension of the jetty will be undertaken on columns. Strictly no solid structures are to be used on which they will be constructed.

**Cost of Mitigation**

No costs included. Mitigation measures have been taken during the engineering design stage.

**Impact 2: Siltation and water quality deterioration**

There will be very limited amount of sedimentation due to the construction work when footing and columns of the jetty are placed in the lagoon. This sedimentation will be minimal and unavoidable given the construction methods employed in similar construction in the Maldives.

Water quality deterioration would also occur as a result of suspended fines. However, due to the dynamic nature of the water body in the area, silt will be cleared almost immediately after the work is completed.

**Mitigation:**

Ensure appropriate supervision and monitoring during the works

Carry out the work in low tide hours during calm weather and sea conditions

Complete the work in the shortest period of time possible
Cost of Mitigation

No costs included.

Impact 3: Marine Environment

The surveys and assessment showed that the proposed extension of the arrival jetty would not have any impact on the coral reef as the extension is proposed in the lagoon with sandy bottom. Direct impact on coral reef is therefore expected to be nil. The only direct impact on the lagoon will be disturbance to the lagoon bottom in laying the footings of the villas. Indirect impact on the lagoon will be spreading of low level of sediment in the lagoon water column.

Mitigation:

Limit the working area within the boundary of the construction zone and avoid disturbing other areas. An ideal method would be to mark the area with tape to indicate the construction zone.

Create awareness and brief the workforce on how to minimize impacts.

During work, it is important to limit the working period to a minimum and concentrate the excavation work to low tide hours.

Cost:

Cost included in the monitoring programme

10.4.4 Construction of the swimming pool

Impacts

The construction of the swimming pool takes place on the southern side at the foreshore between the vegetation line and low tide line. Therefore, this structure is expected to have some degree of influence on the longshore sediment transport patterns. This structure will have the greatest impact on the shore processes and it may be necessary to consider beach nourishment up to the low tide line or end of the structure in such a way that erosion on the down drift side will be minimized. The shoreline monitoring undertaken for the past three years indicate that the sediment movement in this area is influenced by the two monsoons.

However, if coastal protection is provided on the southern side to control the influence of the two monsoons, namely long shore currents, then the sediment movement will be controlled in this area and the swimming pool construction will not have a major influence. Therefore, if beach nourishment is undertaken together with coastal protection, the sediment transport will be controlled.
Mitigation Measures

Undertake the coastal protection as planned.

Nourish the beach to 10 meters from high tide line.

Cost of Mitigation

Contractors will be required to undertake the mitigation measures, as most of these include measures that can be taken if carefully planned, such as nourishing the beach to the designed profile and length and placing the breakwaters in the appropriate positions and orientation.
Table 4: Summary of the impacts and their characterization

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Nature of impact</th>
<th>Magnitude of impacts (negligible/minor/minor adverse/moderate adverse/major adverse/positive)</th>
<th>Significance of the impact (low/moderate/high)</th>
<th>Duration of Impact</th>
<th>Reversibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of new swimming pool</td>
<td>Cumulative</td>
<td>Minor</td>
<td>Low</td>
<td>Short to long term</td>
<td>irreversible</td>
</tr>
<tr>
<td>Extension of arrival jetty</td>
<td>Cumulative</td>
<td>Minor</td>
<td>Low</td>
<td>Short to long term</td>
<td>irreversible</td>
</tr>
<tr>
<td>Construction of the break water</td>
<td>Cumulative</td>
<td>Major</td>
<td>High</td>
<td>Short to long term</td>
<td>irreversible</td>
</tr>
<tr>
<td>Impacts on the southern coastline</td>
<td>Cumulative</td>
<td>Positive</td>
<td>High</td>
<td>Long-term</td>
<td>irreversible</td>
</tr>
<tr>
<td>Impact of beach replenishment</td>
<td>Cumulative</td>
<td>Positive</td>
<td>High</td>
<td>Long-term</td>
<td>reversible</td>
</tr>
<tr>
<td>Impacts on the north-east coastline</td>
<td>Cumulative</td>
<td>Positive</td>
<td>High</td>
<td>Short-term</td>
<td>reversible</td>
</tr>
</tbody>
</table>
11 Stakeholder Consultations

For the purpose of this project, stakeholder consultations were limited to relevant government agencies, the proponent and the designer / Architects. Methodology for undertaking these discussions was through interviews and discussions. A detailed consultative process was undertaken for the Moofushi redevelopment and hence please refer to the Stakeholder consultation section in the attached EIA of Moofushi redevelopment – July 2010 as an annex.

For this project, only consultations were held with individuals ad agencies relevant to this project.

11.1 Consultation with the relevant government agencies

During the scoping meeting, the proponent, Ministry of Tourism and EPA officials participated and discussed the project in detail after which the scope of the project was outlined. During the meeting, EPA raised the issue of breakwater construction and especially beach replenishment and indicated that the beach length should not be more than 10 meters from the high tide line.

In general, there were no major issues raised and since the project concept was finalized by the Tourism Ministry, MOT, did not have any reservations for the project at all.

11.2 Consultation with the proponent

In general, discussions were held with the proponent to obtain information about the need for this additional enhancement and to justify the project. The major outcome of these consultations is outlined below.

- The main reason for developing the swimming pool arose due the changing market conditions that seek to provide more diverse facilities on the resort.
- The need to extend the arrival jetty arose as this area gets very shallow during south-west monsoon and hence it is difficult for boats to anchor, especially larger vessels. Hence the decision was made to increase the length.
- The proponent is not interested in reclaiming land, however does propose a beach replenishment program to recover the beach lost due to erosion.
- Construction of breakwaters to prevent beach erosion. Breakwaters will be emerged structures rather than submerged breakwaters as the submerged breakwaters will need to be created with a larger base and hence, the cost is going to be very high. As a result, the decision was made to construct an emerged breakwater so as to reduce the wave action and provide conditions on the leeward side of the breakwater to a level that erosion can be managed almost entirely.

11.3 Consultation with long term staff

Long term staff working in the island was also consulted to obtain his views on the development. The following are the main outcomes
• The island has been facing continuous beach erosion. At present, there is no coastal protection measures on the southern side and feel that breakwaters need to be constructed on this side.

• The northern side coastline is very stable and does not feel that beach replenishment is necessary on this side.

11.4 Consultations with a contractor

For this project, Hussain Mohamed of Island projects was consulted to obtain views on beach replenishment and coastal protection. Following is the outcome.

• Erosion cannot be controlled by beach replenishment alone, but need to be coupled with coastal protection in order to control and manage erosion totally.

• Beach replenishments that require sand quantities less than 10,000 cbm can be done cost effectively using sand pumps.
12 Alternatives

EIA Regulation requires two alternatives to be suggested for such developments and therefore two alternatives have been suggested in addition to the no project alternative. These alternatives are discussed below:

12.1 No Project Option

The no project option takes the following into account.

- The resort will be opened and operated with the existing coastal protection infrastructure.
- No additional coastal infrastructure will be introduced.
- Not constructing the swimming pool and not extending the arrival jetty.

The main advantages and disadvantages of these are given in Table 5.

Table 5: Advantages and disadvantages of the no project option

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow the resort to be operated with the present coastal infrastructure</td>
<td>Environmental problems related to additional coastal protection can be avoided No upgrading costs to the proponent, short term benefit</td>
<td>With the existing coastal infrastructure, erosion cannot be controlled and hence it is going to affect the marketability of beach and affect the operations.</td>
</tr>
<tr>
<td>Not constructing the swimming pool and extending the arrival jetty.</td>
<td>Environmental problems related to construction of new swimming can be avoided No upgrading costs to the proponent, short term benefit</td>
<td>Not extending the arrival jetty would mean that it would be more difficult for larger boats to access the jetty. Not constructing the swimming pool would mean that there will be limited facilities to the clients.</td>
</tr>
</tbody>
</table>

12.2 Alternative borrow areas

Three borrow areas have been proposed for this project as illustrated in the project description section. All these three borrow areas have their advantages. The existing entrance channel on the north side has been proposed as one of the borrow areas for the project as this channel has undergone filling overtime. Hence, this borrow area is preferred as one of the options as this would also provide the opportunity to deepen the filled entrance channel.
12.3 Alternative methods to protect the beach

There are a number of options for shore protection on the southern side of the island. Since wave action, resulting in long shore sediment transport is the main concern in Moofushi. A structure that protects the area in its lee from wave attack, i.e. a breakwater is considered as the most suitable solution. Some impractical options such as floating breakwater have not been considered.

Based on the above, the suitable alternative options that may be considered during the design are:

- Submerged breakwaters
- Near shore breakwaters or Artificial headland
- Artificial reef
- Seawall or revetment along the coast
- Continuous nourishment

12.3.1 Submerged breakwater

The emerged breakwaters are popular coastal protection features in the resorts. However, the emerged breakwater has an aesthetic impact that had become unpopular. The emerged breakwaters are designed to prevent overtopping of waves and keep the leeward side of it calm. The biggest disadvantage with emerged breakwaters is that the complete prevention of wave overtopping will make the leeward side too clam that sediment build up reaches to a level that will result in the beach connecting to the breakwater.

Submerged breakwaters on the other hand allow waves to flow over but with a reduced energy magnitude. For submerged breakwaters to be effective, they have to have a larger base. Their disadvantage is that they perform poorly in controlling swell waves and does not protect the shoreline adequately under such condition.

For an operational resort and from the perspective of managing the shoreline, emerged breakwaters provide a guaranteed solution with their characteristic disadvantages. Emerged breakwaters will ensure that erosion is totally or almost 100 percent controlled and for Moofushi, it is the wish of the client to ensure that erosion does not take place on the southern side and to alleviate the problem in most days of the year.

For this project, submerged breakwaters have not been preferred for these reasons.

12.3.2 Continuous Re-nourishment of the beach

Re-nourishment would be an ongoing process, but the proposed coastal protection measures such as the breakwaters would help to minimize the frequency of re-nourishment. It is estimated that re-nourishment will be required more than twice a year if no coastal protection is undertaken as the southern side is exposed to severe erosion. If erosion continues in this area, then it will become a burden for the operations as well as it would be very difficult for the management to market the resort as replenishment works during
operation is going to be an issue with most tour operators and clients. Continuous nourishment is also more environmentally damaging as periodic nourishment will create continuous sedimentation of the reef thereby preventing the reef from getting adequate time to recover.

12.4 Alternative materials for breakwaters

There are three options as materials for coastal protection structures. First, there is coral rubble as used in existing structures. However, coral mining is banned and this option shall not be considered. The reuse of coral used for existing structures may be considered. However, they would not be sufficient or may not provide adequate protection. Second option is the use of rock boulders or tetra-pods, which would be strong enough to survive strong waves.

The third option is the use of geotextile tubes or bags. Of these, the geotextile tube is a cost effective solution, but visually not appealing. The main advantage of geotextile containers over the rock boulders or rubble mound structures is that it can be manufactured in white colour to blend with the white sandy shores or sandy seabed of Moofushi at the proposed areas and that it is a very cost effective solution in places with lot of sand. However, despite their white appearance, they are visually not appealing as the material itself is artificial and does not blend with the environment unlike rocks, which is suitable for the coastal environment and natural. Hence, rocks blend in with the environment much better than geotextiles.

12.5 Preferred options

The preferred alternative for this project is to construct emerged breakwaters instead of submerged breakwaters.

12.5.1 Mitigation measures for the proposed alternative

Following mitigation measures are proposed for preferred alternative.

- They are to be constructed as per the proposed concept.
- Need to be undertaken with care so as to ensure that their dimensions are right.
- Undertake the construction during low tide hours.
- They should not be continuously placed, meaning that there should be gaps placed in between them to allow waves and water flow.
13 Environmental Monitoring

13.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. Monitoring will be carried out as part of the environmental impact assessment and monitoring requirements addressed in this EIA report. The following table summarizes the aspects of monitoring.

13.2 Cost of Monitoring

The proponent has committed fully for the monitoring programme outlined in this report. As part of the clients commitment to the redevelopment EIA of Moofushi – July 2009, the client has been undertaking the monitoring programme since the construction began. Please refer to the attached monitoring reports appended for details.

13.3 Methods of Monitoring

Environmental monitoring will be undertaken using standard methods described in the Methodology section. Monitoring is only recommended for marine and coastal environment. Summary monitoring reports are attached as an annex.

13.4 Monitoring Responsibility

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

13.5 Monitoring Report

A detailed monitoring report will be compiled after the completion of the civil works. During the construction period, which is at the end of September 2010.

The following table outlines the monitoring scheduled proposed in the July 2009 EIA. The coastal environmental components proposed in this report will be adequate for the proposed project and hence, the same monitoring report will be followed. Refer to the summary monitoring reports for Moofushi attached as an annex.

13.6 Monitoring Schedule

The monitoring programme in the redevelopment EIA – July 2009 will be followed as this monitoring programme already has the relevant components and aspects for monitoring the coastal changes. Refer to the monitoring programme outlined in the redevelopment EIA of Moofushi – July 2009 attached as an annex for details. Also refer to the attached monitoring reports which has been undertaken since the inception of the construction in Moofushi.
14 Conclusion

The proposed coastal protection measures and the modifications to the original concept to Moofushi redevelopment is both environmentally and economically justifiable.

Over the course of the redevelopment of Moofushi, the proponent has proven their total commitment for safeguarding the environment by undertaking regular monitoring during the construction stage. This itself is justifiable to allow the project to be approved.

Data from the past three years taken in Moofushi clearly indicate an urgent need for coastal protection.

The modifications proposed by the proponent are very minor adjustments to the design that does not foresee any significant environmental impacts. The extension of the arrival jetty and the construction of a new swimming pool will not bring any significant environment changes. The coastal protection together with beach nourishment around the swimming pool area which is the southern side coastline will prevent further erosion from this area.

If the coastal protection measures proposed in Moofushi is not undertaken, the resort will have significant operational and environmental issues when the resort goes into operation from September (the present planned date for opening). Environmentally, the erosion will threaten the island by destroying the coastal vegetation and inundation by waves on the southern side will pollute the groundwater of the island, in addition to erosion. This will not only be an issue for the plants, but the infrastructure nearby and the guest activities will be affected badly. The result would be to take temporary control measures which do not last long. In the event, the resorts operation will be heavily affected due to erosion. Guests will be unable to utilize these areas and hence put more burden on other areas of the coastline. This will reduce the usable beach in the island and it is something that no resort operations would want to experience.

The coastal protection in Moofushi has been proposed in order to totally control erosion on the southern side. This can be achieved by placing emerged breakwaters on the southern side. Although emerged breakwaters have their disadvantages, they are a guaranteed solution for coastal protection.

Based on the available long term data and experience, coastal protection of Moofushi is urgently required and the project is justifiable.
15 Declaration of the consultants

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

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

Name: Abdul Aleem (EIA 09/07)
Signature:

Name: Ahmed Jameel (EIA 07/07)
Signature:
17 References


*Environmental Guidelines for Reclamation in Coastal Areas*, Environment and Heritage Division, Department of Land, Planning and Environment, January 1999


Haveeru (7 December 2003), Overbookings result in tourists diverted away from the Maldives


*Maldives Recreational Diving Regulation* (unofficial translation), Ministry of Tourism 2003, Republic of Maldives


MPE (1993), The Environment Protocol, Ministry of Planning and Environment


18 Annex: Terms of reference
Terms of Reference for Environmental Impact Assessment

The following is the TOR based on the scoping meeting held on 23rd June 2010 for undertaking the EIA for the modification to the original concept and implementation of coastal protection for Moofushi, North Alif atoll, Maldives.

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.

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

   **Task 1. Description of the Proposed Project** – Describe the proposed developments with need and justification of the proposed developments.

   Provide a clearly labelled concept design and scaled site plan of the project boundary.

   Submit a detailed description of how the project activities will be undertaken. A detailed project schedule should be included.

   A matrix of inputs and outputs related to the proposed activities shall be included.

   Need and justifications for the proposed modification and coastal protection measures.

   **Task 2. Description of the Environment** - Where baseline data is to be collected, careful consideration must be given to the design of the methodology and sampling programme. Data collection must focus on key issues needing to be examined for the EIA. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable for use as a baseline for monitoring impacts.

   Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (including burrow areas), including the changes to the existing environment in light of monitoring conducted after the commencement of the initial project.

   Specific emphasis should be placed on the following environmental aspects of the project:

   - Coastal environmental impacts
   - Marine environmental impacts
   - Nourishment of beaches and sand pumping

ToR for Modification to the original concept and implementation of coastal protection for Moofushi, North Alif atoll, Maldives..
- Locations for sand pumping

As such the following field investigations must be considered for baseline data collection:

- Bathymetry of the island lagoon, especially in areas where coastal protection is proposed including the proposed areas for new groynes and breakwaters.
- Bathymetry of sand borrowing areas
- Seawater quality parameters shall specifically include: dissolved oxygen, salinity, pH, temperature and turbidity.
- Condition of the marine environment in the proposed area where coastal protection is proposed

Characterize the extent and quality of the available data, indicating significant information deficiencies and any uncertainties associated with the prediction of impacts. All available data from previous studies of the island, if available should be presented. Geographical coordinates of all sampling locations should be provided. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. The report should outline the detailed methodology of data collection utilized to describe the existing environment. Baseline conditions should be presented for the marine environment.

An average of at least 5 measurements must be given for each parameter tested and analyzed from a certified laboratory. Provide details of calibration for any onsite data analysis.

Task 3. Legislative and Regulatory Considerations - Describe the pertinent national and international legislation, regulations 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. Impacts - provide an assessment of the impacts including the constructional and operational impacts. In addition to negative impacts, positive socio-economic impacts shall be considered.

Task 5. Mitigation measures - Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to sediment control during beach replenishment and construction of coastal structures should be indicated. Discuss the feasibility, cost effectiveness of each mitigation measure, and provide the costs of mitigation and the commitment to it.

Task 6. Alternatives - This section must include the proposed development scenario evaluated against the no-project option and other alternatives. These include alternative construction methods, alternative technologies and materials that could be utilised as to achieve the objective of the development.

Task 7. Environmental Monitoring Plan - The monitoring programme should focus on monitoring needs prior during construction as well as during operational phase. The costs of monitoring, monitoring responsibilities and timing willingness/commitment to undertake long-term monitoring must be included.

Task 8. Stakeholder Consultation - Stakeholder consultation should be undertaken. These consultation needs to be conducted with the relevant ministries and government offices including Environmental Protection Agency, Ministry of Tourism, Arts and Culture.

Presentation - The environmental impact assessment report, to be presented in print and 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

ToR for Modification to the original concept and implementation of coastal protection for Moofushi, North Alif atoll, Maldives.
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.

**Timeframe for submitting the EIA report** – The developer must submit the completed addendum within 3 months from the date of this Term of Reference.

08 July 2010

---------------------

**ToR for Modification to the original concept and implementation of coastal protection for Moofushi, North Alif atoll, Maldives.**
Annex: Site plan indicating the extension of the arrival jetty and the new swimming pool
20 Annex: Bathymetry of the lagoon