ENVIRONMENTAL IMPACT ASSESSMENT

For the proposed Upgrade and Redevelopment in Olhahali, North Malé Atoll, Maldives

Proposed by

Olhahali Investments Pvt. Ltd

Signature:

Prepared by

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For Water Solutions Pvt. Ltd., Maldives

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Non Technical summary

- This document reports on the findings of the environmental impact study undertaken by Water Solutions Pvt. Ltd. for undertaking the proposed upgrade and redevelopment project in the picnic island of Olhahali.

- This project is proposed by Olhahali Investments Pvt. Ltd. to develop 8 deluxe overwater anchorage pavilions, 6 Family Spa Land Pavilions, One Royal Overwater Anchorage Pavilion, main restaurant, Spa Complex, Dive Centre, Arrival Pavilion, Arrival Hut, Main Jetty, Service Jetty, Executive Accommodation, Manger's Accommodation, Back of House and coastal protection through construction of submerged breakwaters using reef balls.

- The redevelopment will mainly consider the improvement of the environmental infrastructure of the island by addressing the beach erosion and accessibility issue of the island. This includes the creation of a new reef entrance channel as to allow safer and easy access to boats in all weathers, building of breakwaters to provide calmer mooring conditions for the boats, building near shore breakwaters to provide protection to the existing structures, and nourishing the beach with sand that would be excavated from the reef entrance channel dredging work to create a buffer beach that would provide adequate protection and increasing the vegetation cover of the island.

- This report has identified that the major impacts of the project will be felt on the coastal and marine environment as almost all the new structures proposed will be constructed over water and the majority of the remaining impacts will be on the coastal environment. Impacts on the marine environment will be felt through direct impact on corals and sedimentation and siltation caused by the construction activities to the lagoon and channel dredging activity on the coral reef, during the construction period. Baseline data has, therefore, been collected in order to monitor the changes to the marine environment which will be identified in periodic monitoring reports. The most significant impact will be felt on the reef flat and lagoon bottom.

- Alternatives to the project have also been considered in detail and several alternatives to the proposed project were considered, including alternative methods of spa pavilion construction and alternative locations for the over water structures and breakwaters. Due to various reasons, these alternatives have not been considered. The advantages and disadvantages of these alternatives have been discussed.

- Eventually, a monitoring programme has been suggested which mainly covers the coastal and marine environment. These include coral cover and marine water quality among many other parameters. As most of the impacts are felt on the coastal and marine environment, it is important to undertake this monitoring.

1 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 upgrade and redevelopment of Olhahali island, located in North Malé atoll.

1.1 Structure of the EIA

The report has been structured to meet the requirements of the EIA regulations 2007 issued by the Ministry of Environment, Energy and Water.

The major findings of this report are based on the observations and the qualitative and quantitative assessments undertaken during the site visit in December 2009, January 2010 and April 2010. The impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment and available long term data.

1.2 Aims and Objectives of the EIA

The objective of the report is to:

- Assist in mitigating impacts caused due to the construction of additional over water structures and undertaking the coastal protection measures.
- Promote informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.
- To fulfill the obligations of the proponent to undertake an EIA under Clause 5 of the Environmental Protection and Preservation Act of the Maldives and requirements of the Tourism Regulations.
- Undertake the project work with minimum damage to the environment.

1.3 EIA Implementation

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:

- Ahmed Jameel, Environmental Engineer (EIA Registration No: EIA 07/07)
- Abdul Aleem, Environment Consultant (EIA Registration No: EIA 09/07)
- Verena Wiesbauer, MSc (Zoology /Marine Biology) Marine Biologist
- Amir Mustafa, Environmental Engineering Student
- Mohamed Mazin, Surveyor
- Hamdulla Shakeeb, Survyor
- Mohamed Riyaz, Assistant Surveyor

1.4 Terms of Reference

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

2 Policy, Legal and administrative Framework

2.1 Overview

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

2.2 Applicable Policies, Laws and Regulations

2.2.1 Environmental Protection and Preservation Act

Article 5. (a) of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the submission of an EIA. It states that an EIA shall be submitted to MEEW before implementing any developing project that may have a potential impact on the environment.

2.2.2 Protected Areas and Sensitive Areas

Under Article 4 of the Environment Protection and Preservation Act, the Ministry of Environment 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.

There are no protected sites or resources such as protected birds, reefs and trees in the island environment.

2.2.3 Regulation on sand and aggregate mining

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

This regulation will be strictly respected and there would not be any sand and aggregate mining except that which is required and approved under the terms of this Environmental Impact Assessment.

2.2.4 Ban on coral mining

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

- coral mining is not to be carried out on island house reefs;
- coral mining cannot be carried out on atoll rim reefs and common bait fishing reefs;
- coral or sand mining is only allowed from designated sites, and approval from the concerned Atoll Office is required prior to the commencement of any mining operation.
- requests for coral or sand mining from residents of inhabited islands are required to be submitted to the Atoll Office through their respective island office
- the island office is required to estimate the quantity of corals required for the applied

construction work and hence this ensures that permission is granted to mine just the required amount;

- every island is required to keep a log book of the amount of corals mined.
- sand mining is not allowed on the beaches of inhabited islands, islands leased for industrial developments and tourist resorts and within the lagoons adjoining these islands.

This project does not involve coral mining. Mined coral would also not be used.

2.3 Waste management policy

The EPA has developed the framework for a national waste management policy. The key elements of the policy include:

- Ensure safe disposal of solid waste and encourage recycling and reduction in waste generated.
- Develop guidelines on waste management and disposal and advocate enforcing these guidelines through inter-sectoral collaboration.
- Ensure safe disposal of chemical, industrial and hazardous waste.

The key objective of the waste management policy would be the formulation and implementation of guidelines and means for solid waste management to maintain a healthy environment.

Waste management in the proposed project has been considered during the construction and operational stage. Measures are going to be in place to manage the waste during construction period, such as incineration and regular transfer of waste to Thilafushi. There is already an established waste management mechanism in the island. Therefore, this project will also confirm to this policy.

2.3.1 Tourism Act (Law no. 2/99)

This Act provides for the determination of zones and islands for the development of tourism in the Maldives. This EIA has been developed in accordance with the Tourism Act

2.3.2 Ministry of Tourism Regulations and Circulars

The Tourism Regulations in the Maldives ensure that carrying capacity of the island and atoll ecosystems are well within limits and the negative effects of the development are minimal. The Ministry also issues circulars on several occasions and when necessary to discourage activities such as sand and coral mining, developing on the coastal environment and waste disposal which may cause harm or damage to the natural environment, which is the main tourism product.

Tourism regulations strictly discourage modifications to the natural movement of sand around the islands. Therefore, Tourism Regulations require that special permission from the Ministry of Tourism, Arts and Culture be sought before commencing any coastal modification works on any tourist resort. It is also stated that hard engineering solutions are not encouraged and construction of solid jetties and groynes be controlled and shall only be undertaken after conducting an Environment Impact Assessment study. Similarly, design of boat piers, jetties and other such structures are required to be in such a way that these shall not obstruct current and sediment circulation patterns of the island.

The Ministry also issues circulars on several occasions and when necessary to discourage activities such as sand and coral mining, developing on the coastal environment and waste disposal which may cause harm or damage to the natural environment, which is the main tourism product.

The proposed redevelopment at Olhahali has been proposed in conformity to tourism regulations. The conceptual plan has been approved by the Tourism Ministry. All coastal defence structures will be developed after studying the sand movement patter of the island.

2.3.3 Environmental Impact Assessment Regulation 2007

The Ministry of Environment, Energy and Water issued the EIA regulation on May 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.

3 Project Description

3.1 Project Proponent

The Project is presented by Olhahali Investment Pvt. Ltd. The management of the property will be undertaken by Grand Meridian Pvt Ltd. Grand Meridian Pvt Ltd (GMPL) was registered on 12th of May 2008 in Maldives, registration number C-291/2008 as special purpose company for managing operations on Olhahali Picnic Island. GMPL is 100% foreign owned company. GMPL bought sublease right for Olhahali Island from Soneva group to develop upscale retreat which combine yacht and land experience for the guests

3.2 Project Location and Study Area

The project takes place on the island of Olhahali, located in North Male' Atoll. Olhahali is a picnic island that is a relatively small, vegetated sand cay with a registered total land area of 16,906.32 square meters. However, the total lagoon area including the house reef and the deep lagoon is approximately 1,270,151 square meters. The study undertaken for the purpose of the Environment Impact Assessment (EIA) takes this entire area into consideration and includes the various environmental impacts confined to this area specifically, in addition to general impacts in the local and global scale.

Figure 1: Location of Olhahali in North Malé Atoll (Map by: Water Solutions)

3.3 Geography and Formation

Olhahali is a small isolated island formed on its own reef system, at the northern periphery of North Male' Atoll. The island is located at about latitude of 04°41'22.81'' N and longitude of 73°27'03.94" E, between Eriyadhoo Island Resort and Gaafaru Island. The closest local community to Olhahali is found in Gaafaru Island, which is north east of Olhahali and 7.5km away.

The vegetation at Olhahali Island is dense, although extremely limited to coastal species. The island has a poorly developed high salinity water lens. A deep lagoon is found west to the island with an average depth of approximately 8 m. The average depth of the rest of the lagoon is approximately 1.5 m. The island is roughly 0.22 km away from the eastern rim of the reef, and 1.09 km away from the south western edge of the reef. The reef is triangular in shape with the widest area towards the east. The coral reef system on which the island is formed is in a triangular shape with two distinct deep lagoons on formed on the west of the island. The rest is shallow lagoon.

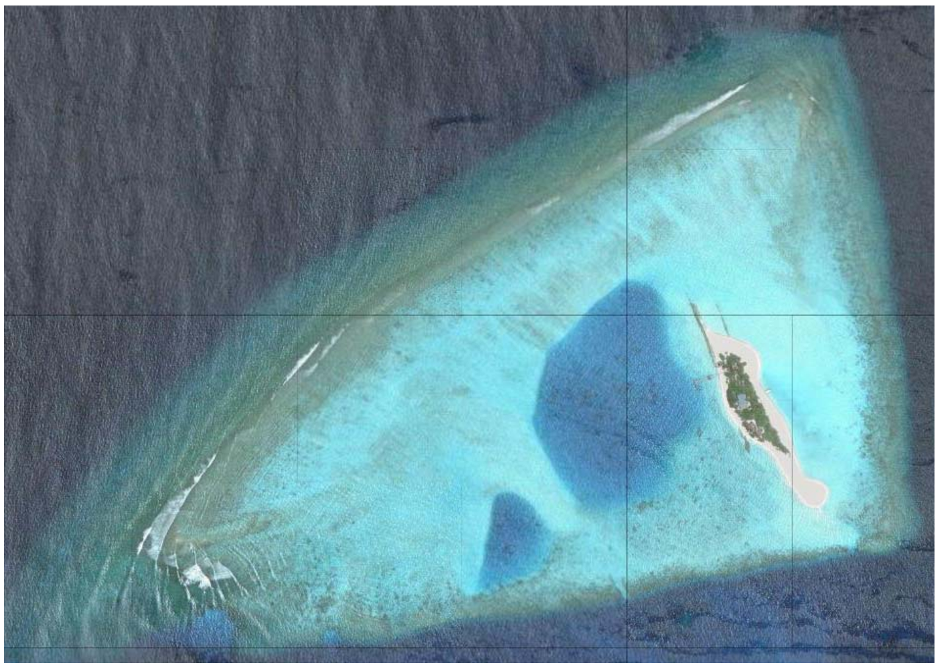


Figure 2: Aerial photo of Olhahali (Photo: Google Earth)

3.4 Need and Justification

3.4.1 Need to Redevelop and Upgrade the Resort

Picnic Islands are relatively few and have generally been under developed in the Maldives compared to resort islands. Such islands are generally conceived as distant sanctuaries with few resources and facilities, and are usually developed in the same mould. However, with the current expansion of tourism in the Maldives, the tourism industry is in need of a large variety of resorts and other facilities to entertain a diverse range of guests.

Tourism in the Maldives had been rapidly expanding with tourist arrivals increasing at about 60% between 1990 and 1995 and about 50% from 1995 to 2000. Following the control of SARS outbreaks and following the aftermath of the terrorist attacks in the United States, the world travel and tourism industry started to show a rapid increase. However, the tsunami of December 2004 had left the industry crippled requiring additional infrastructure and investments. Therefore, there is a need to create added capacity to cater for the growing tourism industry. In addition to its contribution to the overall development of the country and growth of the tourism sector, the development of Olhahali in to a picnic island will bring a further diversity to the Maldivian tourism industry and additional economic benefit for the region along with it.

Furthermore, a redevelopment phase was needed to implement coastal protection infrastructure at the island. Olhahali, being a young island is very vulnerable to the changing monsoons and climate in general. Currently there is not sufficient coastal protection infrastructure on the island and thus, there is a need to protect the natural beauty of the island by undertaking coastal protection measures that have already been implemented and utilized in the Maldives.

Therefore, the need for the redevelopment arose due to changing market conditions and also to further protect and sustain the coastal environment at Olhahali.

3.4.2 Development Objectives and Targets

The primary design objective of the redevelopment is to create a setting which would blend with the natural setting of the island without breaking the islands natural integrity, while upgrading and providing more facilities for the island staff and guests.

The natural beauty of the island and the privacy the island provides, play the most crucial role in attracting tourists to the island and therefore it is in the best interest of the management to sustain its environment and maintain a similar atmosphere during and after the redevelopment phase. All over water deluxe pavilions have been designed with the ability to dock and moor private yachts. This is a new concept in Maldives that will provide the ultimate luxury and privacy to a level that has never been catered for.

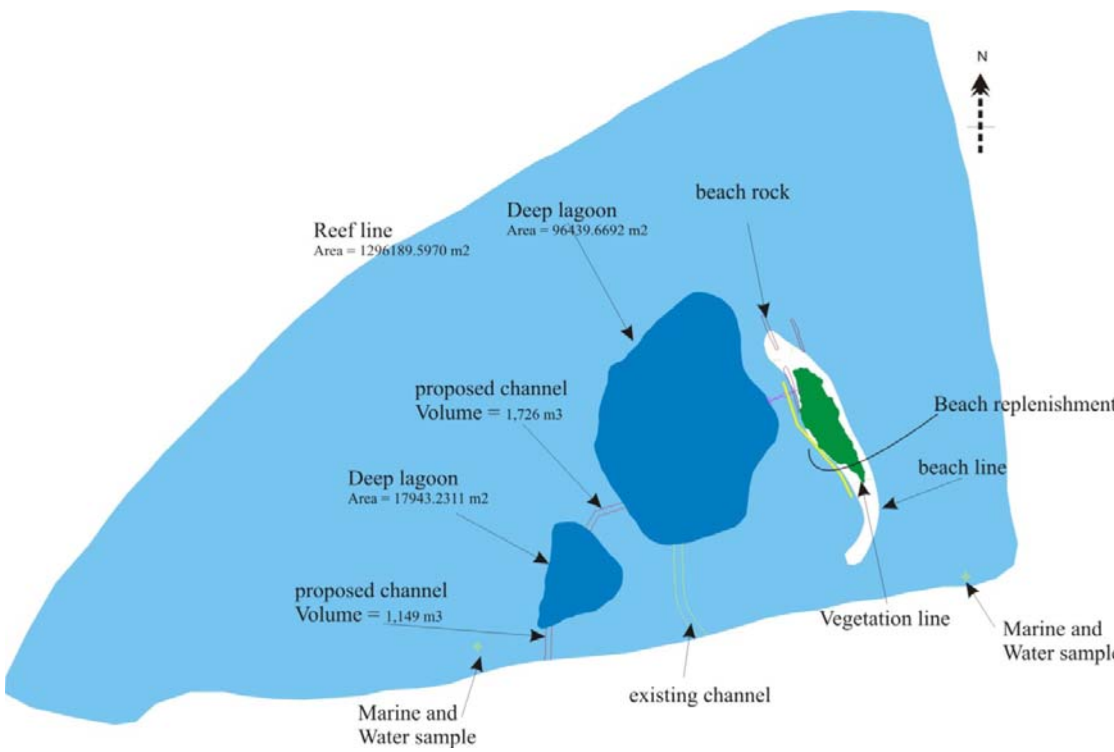
3.5 Project duration

The project is expected to take eighteen months starting after the compilation of the tender. A tentative schedule is outlined below. It is estimated that the work will begin in September 2010. A tentative schedule is attached as an annex.

3.6 Project boundary

This project is limited to Olhahali and its reef and the following components will be undertaken as part of the redevelopment refer to the site plan and the following figure for details.

- Development of over water structures (Over water pavilion, over water pavillion access jetties, over water spa and service jetty
- Refurbishment of land structures
- Submerged breakwaters using reef balls
- Dredging of a new entrance channel
- Replenishment of the west coast to compensate for erosion after placing submerged breakwaters.
- Obtaining additional sand from the deep and shallow lagoon interface to replenish the beach



3.7 Existing infrastructure in the island

Olhahali is a picnic island which is presently been operated under a picnic operation license issued by Ministry of Tourism. Being a fully operational picnic island, it currently has several facilities fully functional including; GM Quarters & F&B Quarters, reception office, food service centre to F&B, admin office and library, sunset deck & beverage centre to dive centre & water sports, garden dining facilities, staff accommodation, staff mess, kitchen, recreational facilities for staff, cold and general storage, mosque , powerhouse and control room, desalination house, pump room and laundry, fuel storage and workshop, water storage tank, arrival platform deck, walkway jetty, arrival pavilion and an empty space dedicated as the beach volleyball area. A site plan indicating the existing structures on the island has been attached as an annex.

Of these 14 facilities are to be refurbished, while 6 facilities are going to be demolished.

3.8 Description of the project components

This project involves two components; upgrading and redevelopment component. See the attached site plan appended.

3.8.1 Upgrading of existing facilities

3.8.1.1 Powerhouse

The redevelopment will install 2 sets of 350 to 450 kVa range generators and 200 kVa generator with a secondary residential silencer with attenuation of better than 85 dB (A) at 1 meter. The soundproofing would ensure a total free field sound level of not more than 85 dB (A) at full load outside the power house.

3.8.1.2 Desalination System

The redevelopment will install 2 sets of 40 MT/Day reverse osmosis desalination plant. The plant can produce fresh water from sea water with TDS of 375,000 ppm at 25 °C. The water produced from the plant would have a quality TDS<500 ppm at a pressure of less than 2 Bar. The system efficiency shall be not less than 35%.

3.8.1.3 Water and fuel storage

The proposed redevelopment will increase the water and fuel storage available at the island. it is proposed that 2 tanks of each with 60 cubic meters would be build to store desalinated water and 2 steel tanks of each 30 cubic meters to store fuel.

3.8.1.4 Sewerage Treatment System

Currently, the island's waste water is treated using septic tanks buried underground. With the new redevelopment, a brand new treatment system, with a capacity of treating 60 m^3 per day will be installed. Existing septic tanks will be sealed and disconnected from existing sewerage system. After completion of New STP plant and its installation, remaining sludge in existing septic tanks will be emptied to the septic tanks of the STP system and will be treated accordingly.

The sewage network will collect wastewater from the individual rooms and other buildings and transport them to the treatment plant where wastewater will be treated. Water, not used for irrigation will be discharged to the sea via the existing sea outfall located on south-eastern side of the island. The location of the sea outfall is indicated on the site plan, attached as an annex.

3.8.2 Redevelopment Components

3.8.2.1 New Over water structures

The proposed development include the construction of an over water spa, 8 deluxe overwater anchorage pavilions and a royal over water anchorage pavilion, arrival jetty and service jetty.

3.8.3 Coastal protection

3.8.3.1 Replenishment of the eroded beach

The main problem with the beach face is that the beach face has not been nourished with fine sand to maintain the loss that had occurred due to erosion. Hence, it is proposed to replenish the beach with 3,273 m^3 of beach sand, both on the east and west 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 on the western and eastern side of the island are shown in Figure 3.

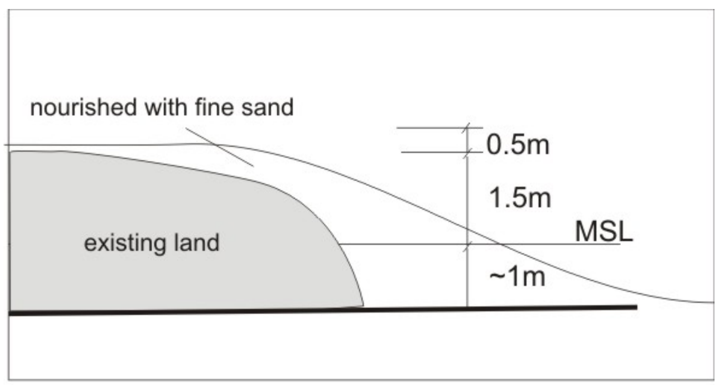


Figure 3: fill profile for the nourished area

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 at the island.

The material required for the beach nourishment works would be obtained from the material excavated from the proposed channel and by excavating or pumping sand from the western lagoon as the material obtained from the channel excavation is not enough. The total volume of material that may be obtained from the excavation of the channel is about 2875 m^3, assuming that the channel would be dredged to a depth of -3 m at mean sea level. This leaves the total volume of material to be pumped from the western lagoon to about 397 m^3.

The following table outlines the volumes of sand excavated from the channel and the beach replenishment details.

	Area (sq.meters)
Total area of the reef system measured from the reef line	1,296,189.60
Deep lagoon on the west side of the island	96,439.67
Deep lagoon on the far west of the island	17,943.23
Beach length(in m) on western side (with a width of 10 meters)	~ 100 m
Beach length (in m) on eastern side (with a width of 10 meters)	~ 150 m
Volume of sand that can be obtained from the channel on the south side in cubic meters (cbm)	1,149.20
Volume of sand that can be obtained from the channel in between the two deep lagoon in cubic meters (cbm)	1,726.20
Total volume of sand that can be obtained from the channel dredging in cubic meters (cbm)	**2,875.40**
Total additional volume of sand required for nourishment of the beach to approximately 10 meters on the eastern and western in cubic meters (cbm)	**397.60**

Table 1: Volume of dredging and beach replenishment details

3.8.4 Construction of a submerged breakwater

It is been proposed that submerged breakwaters be built on western side of the island to protect the beach. 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. Submerged breakwaters are similar to natural reefs. Submerged breakwaters or 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. The beach would be monitored in the monitoring programme as outlined in the monitoring section. The following figure outlines the locations where reef balls will be placed.

Based on existing wave conditions in the area, the following design has been suggested.

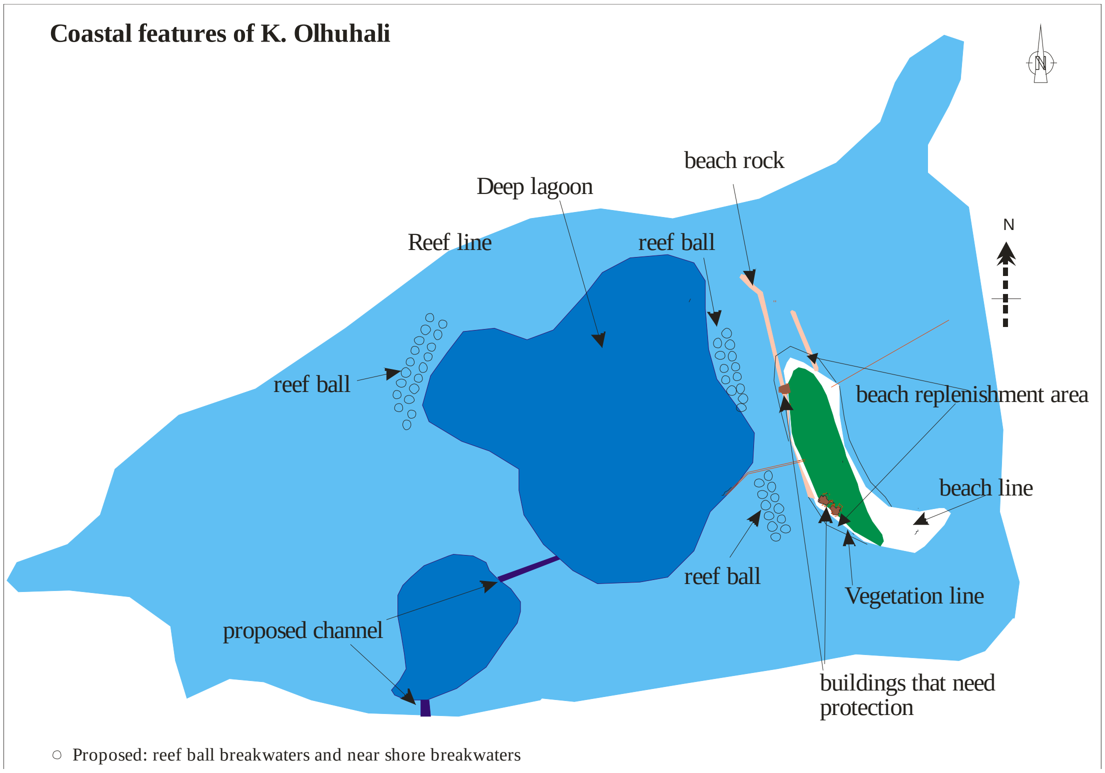


Figure 4: coastal protection plan for Olhahali Island Resort

Figure 5: cross-section of a reef ball to make a breakwater

The breakwater has been designed to create an artificial reef using reef balls. The reef balls will be constructed at the site and then transported to the breakwater location using an excavator. The height of the reef balls will be as such that it would be only visible at mean and low tide. The reef balls will be placed in two rows. The distance between rows would be 3 - 5 meters. The distance between reef balls in a row would be about 3 – 5 meters. Figure 4 shows the location of the submerged breakwaters and their possible orientation.

3.8.5 Creating a new channel

A new channel would be dredged on south western side of the island. This channel will consist of two parts. The first part will allow entry in to the island reef system and in to the smaller deep lagoon and the second part will connect the two deep lagoon as shown in Figure 4. The following table outlines the volume of sand that will be generated from the channel.

Volume of sand dredged from the channel on the south side	1,149.20 m^3
Volume of sand dredged from the channel in between the two deep lagoon	1,726.20 m^3
Total volume of sand obtained from the channel dredging	**2,875.40** m^3

Table 2: Volume of sand dredged from the channel

The location of the channel has been adopted by integrating the natural environment of the location. The total length of the new channel would be 75 m. The new design for Olhahali includes greater accessibility to the island by marine vehicles such as catamarans and other similar types of vessels. Currently, the existing entrance channel is approximately 1.0 m deep, and is situated in an inconvenient location considering the positioning of the over water structures after the redevelopment. This would cause a significant hindrance to the development of the island due to lack of direct accessibility for the guests or clients. Relocating the entrance channel to south western side of the island and deepening the entrance channel to about 3 m will provide the much needed accessibility to the island for larger vessels.

The dredging of the channel would be carried out using an excavator with a bucket size of 1.5 m^3. Sand pumps will also be used to compliment the dredging. Dredging phase will be carried out in the southwest monsoon period. This is to minimise the impact of the dredging on the reef environment of the island. See diagram below for the cross section of the dredging cut of the channel

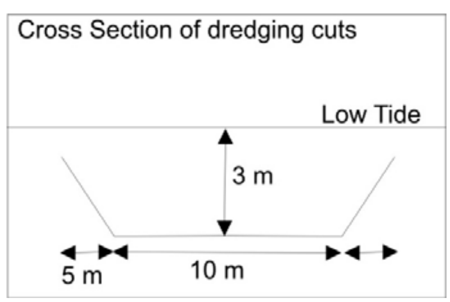


Figure 6: Cross section of the dredged channel

The material excavated will be loaded on barge and barge will carry it the beach for the nourishment. The impact of dredging will be monitoring as outlined in the monitoring plan.

3.9 Construction schedule, process and methodology

As soon as the EIA is approved and a decision note is issued, the upgrade and redevelopment project will begin at Olhahali. Mobilisation will start as the first activity of the project. The construction will be undertaken in the planned time period to reduce cost and also reduce the environmental damage.

3.9.1 Work methods for new structures

All overwater structures will be constructed on concrete columns and footings. This method involves constructing the concrete columns and footings on land and then transporting them to the lagoon by a high rise excavator. Then the footings will be placed on their fixed locations. The locations of the footings will be undertaken by a set out survey. The columns will then be connected by the supporting horizontal beams. Once these horizontal beams are in place, then construction of the overwater structure will be undertaken. Afterwards, plumbing, electrical and fire networking lines will be laid.

3.9.1.1 Management of waste

The executive arrangement in place for managing construction stage waste is simply by stockpiling the waste for the shortest duration possible, in the island. The residual waste then transport immediately to facility or place identified by the Ministry of Housing, Transport and Environment and communicated to the developer through the Decision statement issued for this EIA. This operation is not expected to be disrupted and the management of the waste will not be a significant issue as waste is regularly transferred to Thilafushi even at present

3.9.2 Montreal Protocol

The upgrade and redevelopment considers the Maldives commitments to the implementation of the Montreal Protocol on Substances that depletes the Ozone Layers. The accelerated HCFC phase-out schedule for Maldives for consumption and production of HCFC as agreed Montreal Protocol is presented in table below. Hence the new infrastructure that would be added for the development in the area of cooling and refrigeration systems would comply with the national requirements that had been outlined and communicated by the Ministry of Tourism.

Control measure	**Schedule**
Baseline	Average of 2009 & 2010
Freeze	2013
90% (10% reduction)	2015
65% (35% reduction)	2020
32.5% (67.5% reduction)	2025
0% (100% reduction in manufacturing)	2030
Annual average consumption of 2.5% (for servicing)	2030 to 2040

3.9.3 Carbon Emission

The upgrade and redevelopment will demand, daily additional 4000 L of diesel to generate power for the island. It is estimated, using reference approach as outlined by IPCC, that additional 12,604

Gg of carbon dioxide will be emitted from the proposed redevelopment. The actual carbon emission from the energy sector from the increasing in demand would be 3,437 Gg.

3.9.4 Expected environmental conditions

Since the project will take place in south-west monsoon, environmental conditions can at times influence the work. But June and July, being the worst period of south-west monsoon, working conditions is not expected to be of any significance as the construction will most likely take place in August. Despite this, the strategy would be to complete the construction of water villa columns as soon as possible. This would give more window for construction workers to undertake other works rather than causing delays due to bad weather. The most difficult part of the construction would be placing the concrete columns of the water villa footings and the dredging of the entrance channel.

3.9.5 Risks associated with the project

There are few risk factors associated with this project that could possibly have financial and environmental implications. First, there is the risk of project delays caused by bad weather as the construction period falls within the south-west monsoon. This risk can be minimized if the footings of the water villas could be completed within the minimum period. 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. Secondly, there is the risk that the marine environment can be damaged severely if the construction process is not carefully managed. This can occur if unskilled labours are used and also if the workforce is not briefed about the sensitive environment.

3.10 Project Inputs and Outputs

3.10.1 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 3: Matrix of major inputs during construction period

INPUT RESOURCE(S)	SOURCE/TYPE/QUANTITY	HOW TO OBTAIN RESOURCES
Construction workers (150)	Maldivians and foreigners	By the contractor
Water supply (construction period)	Existing Desalination plant in the island for construction period	20 m3/day desalination plant
Electricity/Energy (construction period)	Existing Diesel generators in the island for construction period	50kva, generator
Construction machinery	Concrete Mixer, barge, excavators, sand pumps and general construction tool	By the contractor
Telecommunications	Island's Phone Systems, Fax Machines, E-mail and internet facilities	Already this services is available in the island
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 a facility identified and communicated by Ministry of Environment via cargo vessels/dhoni	Setup already established.
Food and Beverage during construction period	Mainly imported sources except a few locally available.	Already setup available
Fuel, Kerosene and LPG	Light Diesel, LPG Gas, Petrol, Lubricants	Already setup available

3.10.2 Project Outputs

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

Table 4: Matrix of major outputs of environmental significance during construction stage

PRODUCTS AND WASTE MATERIALS	ANTICIPATED QUANTITIES	METHOD OF DISPOSAL / CONTROL
Sewage and wastewater Grey water/laundry wastewater	Estimated to be at 100 litres/person/day	A temporary outfall will be constructed for the construction period
Construction waste from construction activities, mainly timber and other building materials.	5 to 10 cubic meters of debris weekly during the construction period and general construction waste. This includes, timber, empty cement bags, aggregate, steel bars etc.	Debris sent to waste management facility identified by Ministry of Environment and communicated through the Decision Statement

PRODUCTS AND WASTE MATERIALS	ANTICIPATED QUANTITIES	METHOD OF DISPOSAL / CONTROL
Waste oil and grease	5 to 10 L (monthly) as only small excavator will be used to place the villa footings.	waste management facility identified by Ministry of Environment
Noise	Localised to the island environment	No controls are need as the level of noise would not be significant. Only localised to the island environment only.
Air pollution	Limited quantities of dust .	Mainly arising as a result of dust emission from the construction work such as cement mixing, and other processes. Only localised to the island environment only.
Dredged material	5,429 cubic meters	Use in the replenishment of the beach

4 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental components of the project under consideration are coral reef areas, the marine environment and the coastal environment. The following data collection methodologies were used during the field visit undertaken in December 2009, January 2010 and April 2010.

4.1 General Methodologies of data collection

Conditions of the existing environment were analyzed by using appropriate 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.

4.2 Mapping and Location identification

The island, including shore line including the low tide line, mid tide line and high tide line and vegetation lines were mapped for the assessment. Mapping was undertaken using hand held differential GPS and available satellite photos. The location of data collection sites were marked using handheld GPS. These data collection points include marine water sampling locations, marine survey locations and beach profile locations.

4.3 Marine Water Quality

Water quality was assessed during the field trip in January 2010 and April 2010 by collecting samples and testing them at National Health Laboratory. The locations, frequency and parameters to be monitored are given in the monitoring programme outlined later in the EIA report.

4.4 Marine Environment surveys

The purpose of the marine survey is to define and establish marine environmental baseline conditions for the evaluation of success or failure of the coral enhancement project. Surveys are based on standard marine environmental surveys so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities. They include quantitative and qualitative methods.

Three methods were primarily used to collect data, namely:

- Detailed LIT at Sites A and B for sessile benthic community estimation
- Fish census
- Qualitative surveys through visual observations of the channel and the lagoon

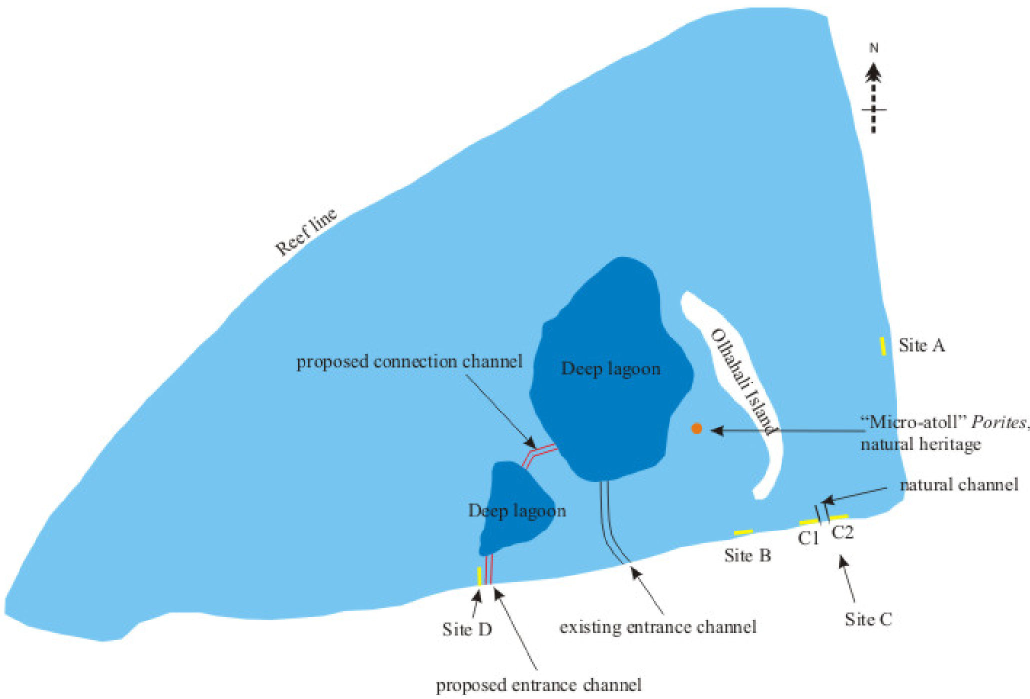


Figure 7. Marine survey sites A - D around Olhahali Island. Marine transects are marked with yellow bars.

4.4.1 Line Intercept Transects (LITs)

Line Intercept Transect (LIT) surveys were carried out to assess the benthic types and species at the surveyed sites. This method uses life form categories to assess the benthic sessile community of reefs and it is possible to incorporate taxonomic data as well. LIT surveys can be used to evaluate the community structure of corals in terms of species composition and diversity patterns in different zones on a reef. LIT method also provides a rapid estimate of percent cover of corals, algal cover, and cases of other prominent organisms as well as bare substratum.

Quantitative percent cover of the reef community can be obtained using this method and it can be repeated to obtain changes over a period of time. Disadvantages of this method include difficulty in standardizing the life form categories and the limitation of the data collected, to information on percent cover and relative abundance (English et al. 1997). LIT surveys produce valuable data even though they are time consuming and require considerable effort and skills to record notes underwater (Segal & Castro 2001).

To demonstrate the existing situation of the shallow benthic community of Olhahali's southern and eastern house reef, transect lines of 20m length were placed at Sites A – C (see Figure 7) in order to evaluate live coral coverage. At Site C, the transect was separated into two 10m LITs which were laid westwards (C1) and eastwards (C2) of a natural ten meters long sandy channel at 4° 41' 14.21" N, 73° 27' 10.26" E. At site D, one transect of 25m length was laid perpendicular to the reef crest into the proposed channel.

Transects were laid on the shallow reef crest in 0,5 (reef) – 1m (bottom) depth (MSL), parallel approximately 10m (Site A) and 5m (Site B and C), respectively, away from the reef slope. Transect D was laid into the proposed channel 25 meters into the reef flat.

At Sites A and B, 39 data samples were obtained from each transect by recording the substrate every 50cm under the measuring tape. The starting and end points of the transects were permanently marked with a square plastic marker (A1 and A2 for Site A, B1 and B2 for Site B) and a sub-surface buoy for further monitoring studies. At Site C and Site D, 20 and 50 sampling points, respectively, were obtained per transect by recording the substrate every 50cm of the tape. These sites were not permanently marked in situ.

GPS Coordinates for all sites are as follows:

Transect	Length	GPS
A	20 m	4° 41’ 23.56” N, 73° 27’ 10.16” E
B	20 m	4° 41’ 15.15” N, 73° 27’ 05.95” E
C_1 and C_2	2 x 10m with 10m gap of natural channel	4° 41’ 23.56” N, 73° 27’ 10.16” E
D	25m	4° 41’ 15.15” N, 73° 27’ 05.95” E

4.4.2 Reef fish Visual Census

Under water counts of reef fishes or underwater visual census (UVC) method was used to assess the fish population at the surveyed sites. Visual counts appear to give reasonably reliable results provided that they are applied to fish that are non-cryptic and either diurnally active or at least evident by day. In this method, the surveyor swims along the transect paths above the reef, counting fish that were observed within 1.5m either side of the transect and above up to the water column. The same transects line for the LITs were utilized to carry out the fish census. Fish were counted along the 20 m transect path (that is in a belt of 5 m on either side and up to the water surface). To count the fish, the surveyor swam slowly along, counting fishes that were seen within the defined band transect, 20m long by 3m wide (i.e. one with a total area of 60m²). All fish encountered were recorded at least up to family level, some up to genus and species level, noted on the underwater slate immediately after they were seen. Counting any fish more than once was avoided by training and experience. Speed at which the path was swum was controlled so as to standardize the efficiency of search. If the surveyor swims too fast it is easy to miss fish, especially of smaller species, that may be temporarily obscured by corals or rock or be taking shelter. Experience shows that the slower the surveyor swims, more fish that is recorded up to a point. However, the highest number recorded by moving along very slowly may actually be an over estimate of fish density. Hence it is necessary to standardize swimming speed to a slow but not too slow pace. The standard speed of swimming practiced was at a mean rate of 8m a minute. For results, fish families representing one of the following functional groups were taken into account: herbivores (Acanthuridae, Scaridae), omnivores (selected Labridae), corallivores (Chaetodontidae) as well as habitat specialists (Pomacentridae).

4.5 Coastal environment

Data collected on coastal environment included beach profiles, existing coastal defence structures, 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 proposed project can be assessed accurately. Beach profiles were measured using Auto levels and a staff.

4.6 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.

4.7 Aerial photos

A satellite photo was 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. Satellite aerial photos were from Google Earth. This has been used extensively in this EIA and has been presented in different sections of the report.

4.8 Available long term weather data

Long term available weather data was obtained from the nearest weather station to Olhahali, which is based in 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.

5 Existing Environment

This section discuss the existing environmental conditions. In doing so, the section will begin with an outline of the general environmental conditions in Maldives, including the climatic settings, tides, wind and wave. As there are no specific such data for individual islands, these data will form the basis for describing the conditions for the islands of the Maldives. The data collection on climate and sea level are undertaken from weather stations based strategically throughout the Maldives, including Male', international airport, Hulhule. The nearest weather station to Olhahali is located in Hulhule Island.

Describing and analysing climate and weather information will provide projections and baseline conditions for islands that are close to a specific weather station. Existing coastal and the marine environments are described later. Therefore the climatic data from Hulhule has been applied for Olhahali as it is the closest weather station.

5.1 Physical environment

5.1.1 Climatic Setting

The Maldives, in general, have a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. There is considerable variation of climate between northern and southern atolls, while the northern atolls will be given more emphasis for the purpose of this report. Table 5: provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 5: Key meteorological information

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 °C in November 1973 31.7 °C in April
Extreme Air Temperature	34.1 °C in April 1973 17.2 °C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

5.1.2 Monsoons

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the Northeast (*Iruvai*) and the Southwest (*Hulhangu*) monsoon. Monsoons can be best characterized by wind and rainfall patterns. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November.

5.1.3 Rainfall

Annual average rainfall in Maldives is about 1900mm. There is a marked variation in rainfall across Maldives with an increasing trend towards south. The annual average rainfall in north is 1977mm and for south is 2470mm. The southwest monsoon is known as the wet season with monthly average rainfall ranging from 125-250mm. The northeast monsoon is known as the dry season with average monthly rainfall of 50-75mm.

Rainfall records indicate an average annual rainfall of 2500mm. The intensity of rainfall is a concern in the Maldives since intensity is high with low frequency.

5.1.4 Temperature

Daily temperatures of Maldives vary little throughout the year with a mean annual temperature of 28°C. The annual mean maximum temperature recorded for Male' during the period 1967-1995 was 30.4°C and the annual mean minimum temperature for the same period was 25.7°C. The highest recorded temperature for Male' was 34.1°C on 16th and 28th of April 1973. The hottest month recorded was April 1975 with a maximum monthly average temperature of 32.7°C, the next highest being 32.6°C in April 1998. The lowest minimum average temperature of 23.7°C was recorded in July 1992.

5.1.5 Wind

Wind has been shown to be an important indirect process affecting formation, development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore winds are important here, as being the dominant influence on the sediment transportation process (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too. These aspects have ramification on the seasonal sediment movement pattern on the islands and also the delivery/removal of sediments from the reef platform/island. These also determine where structures such as jetties and mooring areas in resorts are located and this data is vital in determining this at the design stage.

The two monsoon seasons have a dominant influence on winds experienced across Maldives. These monsoons are relatively mild due to the country's location close to the equator and strong winds and gales are infrequent. However, storms and line squalls can occur, usually in the period May to July; gusts of up to 60 knots have been recorded at Male' during such storms.

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives. Wind speed is usually higher in central region of Maldives during both monsoons, with a maximum wind speed recorded at 18 $m.s^{-1}$ for the period 1975 to 2001. Maximum wind speed recorded in the south was 17.5 $m.s^{-1}$ during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind speed was in general lower and more uniform throughout the year in the southern region. Wind analysis indicated that the monsoon was considerably weaker in the south. During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

5.1.6 Waves

Wave energy is important for sediment movements and settlement, and it is also a crucial factor controlling coral growth and reef development. Waves have been attributed to the diversity and the abundance of coral and algal species. These aspects have implications for the type and perhaps the supply of sediments into the island.

Studies by Lanka Hydraulics (1988a & 1998b) on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system off west coast of Australia and had a significant wave heights in the order of 3 metres.

In addition, Maldives has recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP, 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than one occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Choi *et al*, 2003).

Olhahali is exposed to waves generated by swells combined with short-wind-generated waves travelling within the atoll during both monsoons. Waves breaking on the north and eastern side may be considered to be stronger because of the narrow reef extent on this side in comparison to the western side.

Waves breaking on the south and western side may be less strong because this side has a large lagoon in comparison to the north and eastern side. The island has been observed for some time, it has been observed that sediment movement takes place during both seasons causing erosion on one side and accretion on the other side. However, it is observed that south western side of the island is experiencing a net erosion due to loss of sand.

During the NE monsoon when the wind blows from the north and east side, there is considerable amount of erosion on the north and east side and accretion observed on the south and western side. The beach on the south of the arrival jetty on western side of the island has lost significant amounts of beach during the past few years. In March 2009, this area was severely eroding, exposing the beach rock formation on this side.

5.1.7 Tides

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

5.1.8 Currents

Studies on current flow within a reef flat in Male' Atoll suggests that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie Black & Veatch, 2000). However, available information suggests that tidal currents are not strong due to small tidal range.

Generally, current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April the westward currents flow are weak and eastward currents flow will slowly take place. Similarly in December, eastward currents flows are weak and westward currents will take over slowly.

Data on current speed and direction around Olhahali was measured on the day of the field visits. The current speed measured on northern side was 0.2 m/s to west, 0.1 m/s north west on southern side of the island and 0.03 m/s west on western side of the island. The following figure illustrates the currents around Olhahali.

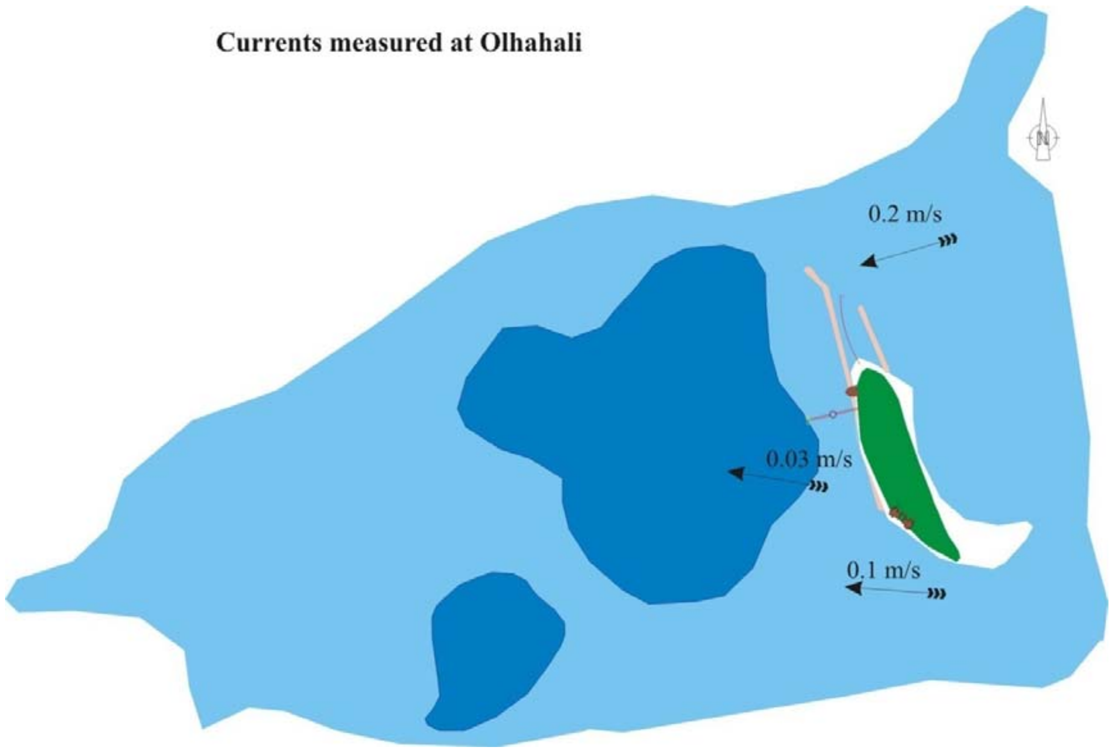


Figure 8: Currents measured around Olhahali in December 2010

5.2 Terrestrial environment

The flora of the island is not diverse. The southern end of the island, Magoo (*Scaevola taccada*) was dominate while species and Boakashikeyo (*Pandanus tectorus*) was abundant in the centre of the island.

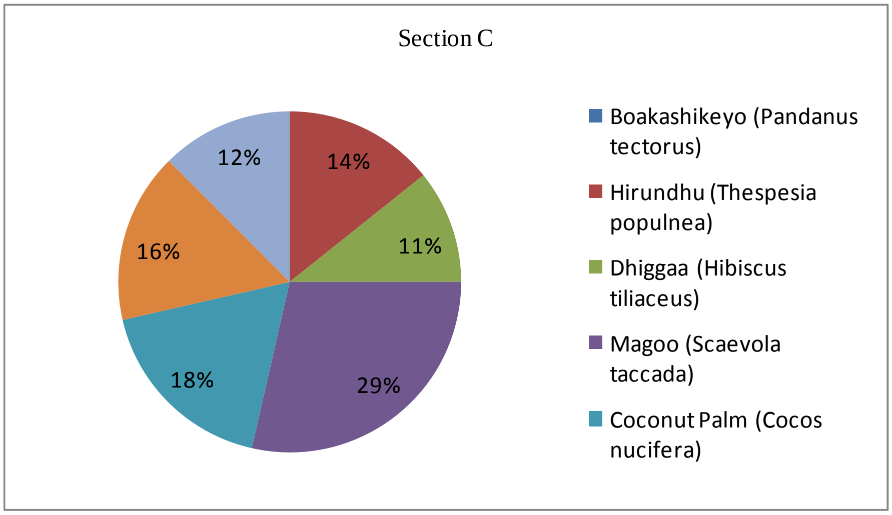


Figure 9: Diversity of vegetation on southern side of the island

The extent of floral preservation can be observed from the eastern side of the island. When approaching the island from the east side, the coastal vegetation almost resembles that of an uninhabited island due to minimal clearing. Only very few rooms are visible from this side. In general, very few areas of the coastal vegetation have been cleared.

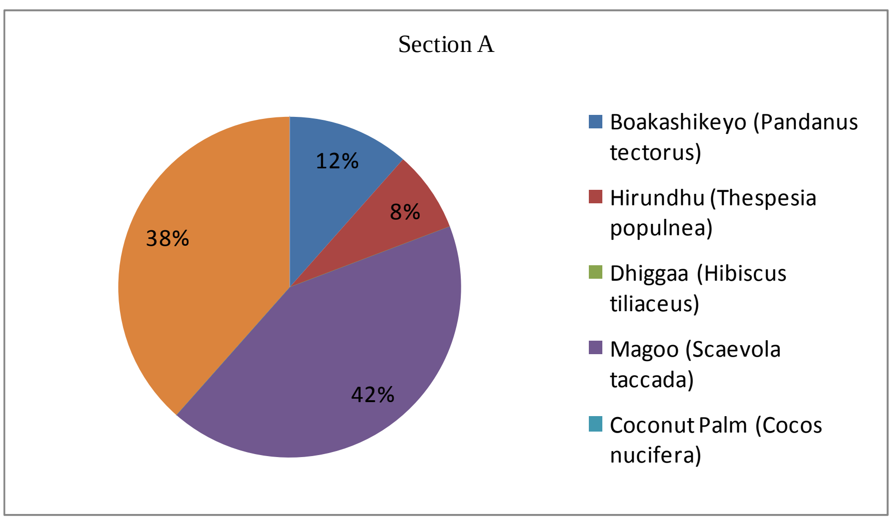


Figure 10: diversity of vegetation on western side of the island

5.2.1 Groundwater

The groundwater of the island is outlined in the following table.

Parameters	Value
Physical appearance	Pale yellow
pH	7.4
Electrical Conductivity (µS/cm)	30,600
Nitrate (mg/L)	0.0
BOD (mg/L)*	4.4
Ammonia (mg/L)	2.85
Sulphate (mg/L)	1,750
Phosphate (mg/L)	0.1
Salinity (mg/L)	16,200
Phosphates (mg/L)	0.040

Table 6: Baseline Groundwater Condition

5.3 Existing Coastal environment

5.3.1 Geological Setting and Island Formation

The project takes place on the island of Olhahali, located in North Male' Atoll. Olhahali is a picnic island that is a relatively small, vegetated sand cay with a registered total land area of 16,906.32 square meters. However, the total lagoon area including the house reef and the deep lagoon is approximately 1,296,189 square meters. The study undertaken for the purpose of the Environment Impact Assessment (EIA) takes this entire area into consideration and includes the various environmental impacts confined to this area specifically, in addition to general impacts in the local and global scale.

5.3.2 Geography and Formation

Olhahali is a small isolated island formed on its own reef system, at the northern periphery of North Male' Atoll. The island is located at about latitude of 04^{o}41'22.81'' N and longitude of 73^{o}27'03.94" E, between Eriyadhoo Island Resort and Gaafaru Island. The closest local community to Olhahali is found in Gaafaru Island, which is north east of Olhahali and 7.5km away.

The vegetation at Olhahali Island is dense, although extremely limited to coastal species. The island has a poorly developed high salinity water lens. Two deep lagoons are found west to the island with an average depth of approximately 8 m. The average depth of the rest of the lagoon is approximately 1.5 m. The island is roughly 0.22 km away from the eastern rim of the reef, and 1.09 km away from the south western edge of the reef. The reef is triangular in shape with the widest area towards the east.

Geographically, Olhahali island's coast is divided into six parts: the northern sand spit, northeast ocean coast, southeast coast, southern sand spit, southwest coast and north west coast. The north and the south sand spits are very dynamic and have been observed to be very reactive to the monsoonal changes. These features are illustrated in the following figure.

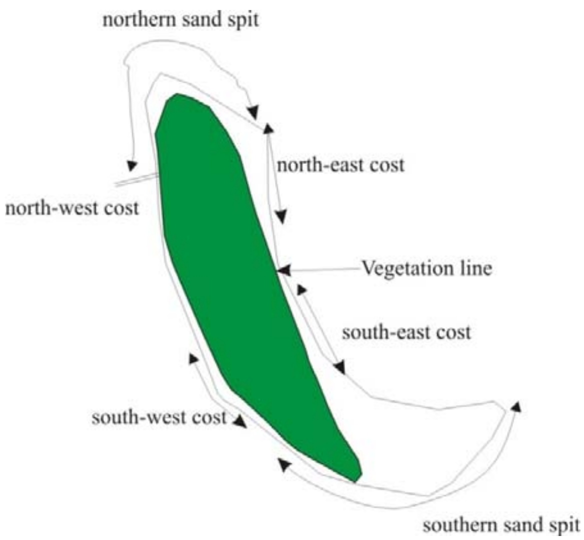


Figure 11: Coastal zones of Olhahali

5.3.3 Features of the Coastal Environment

The coastal environment of Olhahali comprised of mainly white sandy beaches, natural coastal defence structures and shallow lagoon (*falhu*). The reef flat and reef patches (in the lagoon) are not covered in this chapter as it will be covered in the Marine Environment section.

Figure 12 represents the different features of the coastal environment of Olhahali and a description of these different features is given in the following sections.

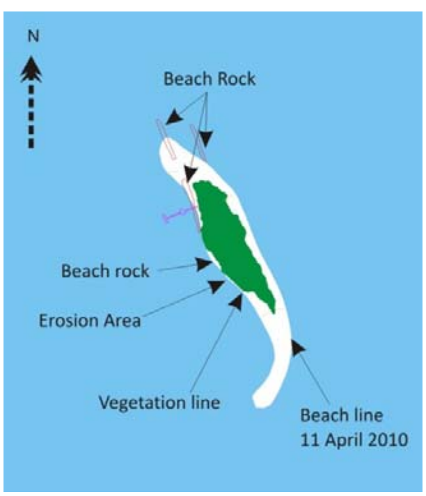


Figure 12: Features of the Coastal Environment

5.3.4 Lagoon

A considerably large shallow lagoon exists around the whole island, almost triangular in shape and slightly wider on the western side. The depths of the lagoon vary from 0.5m to 2m. Within the reef system, two deeper lagoons exist on the west of the island. The largest of this lagoon has an area of 96439 m^2 and the smallest 17943m^2. The narrowest lagoon extent is on the southern side where reef extent roughly 73 meters from shore.

The lagoon around the island consists of sandy bottom and coral patches that are more prominent from the reef flat. Between the reef flat and the shore, the lagoon is mostly white sand with some isolated coral patches (patch reefs) but mostly fine sand and coral rubble. A detail bathymetric survey of the lagoon is attached as an annex.

5.3.5 Beach

There is no distinctive variation in beach composition around the island. However, the beach extent can be seen to vary, especially in the two seasons. The beach material is mainly composed of loose skeletal carbonate sediments, mainly fragments of green calcareous algae Halimeda sp., encrusting and branching red algae, molluscs, foraminiferans, echinoderms and bryozoans. Beach on the eastern side is much wider than the western side and a very dynamic sand spit exists on both the north and the southern tips of the island. This eastern side beach diminishes in size during south west monsoon, as this area is exposed to strong winds, inducing erosion. The following table outlines the changes to the beach and approximate beach length measured from the vegetation line during different months of the year.

	Jan 2010	April 2010
Approximate Beach length on the eastern coastline	11 to 20 meters	11 to 17 meters
Western coastline	2 to 4 meters	1 to 3 meters

Table 7: Changes to the coastline observed during different months of the year.

The beaches of Olhahali can be classified into two types

1. Type 1 : beach rock with partial cover of loose sediment
2. Type 2 : sand covering all of the beach.

Type 1: Type 1 is distributed throughout the east and north coastline. Most of the beach rock is poorly cemented conglomerate or conglomerate limestone. In south west monsoon, the beach rocks on the north and the western coastline are most exposed. The distribution of the beach rock almost coincides with the geographic division of the island's coastline. The beach rock is formed mainly along the west of the island.

Type 2: Type 2 is distributed throughout the east, north east and southern sand spit. This type is classified with beach material consisting of only fine sand with occasional loose coral rubbles.

<table>
<tr><td></td><td></td></tr>
<tr><td>Northern sand spit and the beach rocks formed on the north and north-west side.</td><td>Beach rock on the northern end of the island.</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Beach rocks on the western side</td><td>Southern sand spit</td></tr>
</table>

Figure 13: Photos of the coastline

5.3.6 Coastal Defence Structures

No artificial coastal infrastructures have been constructed at the island. Naturally formed beach rocks are the most distinct natural coastal defence structures on the island that are formed on the northern tip and the western side of the island. (see Figure 12 and site plan attached as an annex). Other than the beach rocks, the reef, most notably the reef flat provides protection for the coastline. However, during the southwest monsoon, the large lagoon extent on the western side and the presence of a deeper lagoon exposes the western side resulting in chronic erosion on this side. Although wave energy is dissipated by the north-western reef flat, the waves regenerate on the western lagoon resulting in dissipating most of the wave energy on the western shoreline that result in beach erosion on this side.

The impact of south-west monsoon on the western coastline is clearly visible from the erosion scarps and the exposure of the beach rocks. Although the beach rocks act as a near shore breakwaters on the western side providing protection, the net erosion caused by the annual seasonal change is an issue for the island as far as beach length is concerned. Hence, the developers have opted to provide coastal protection on the western side, details of which are given later in the report.

5.3.7 Changes to the coastline of Olhahali

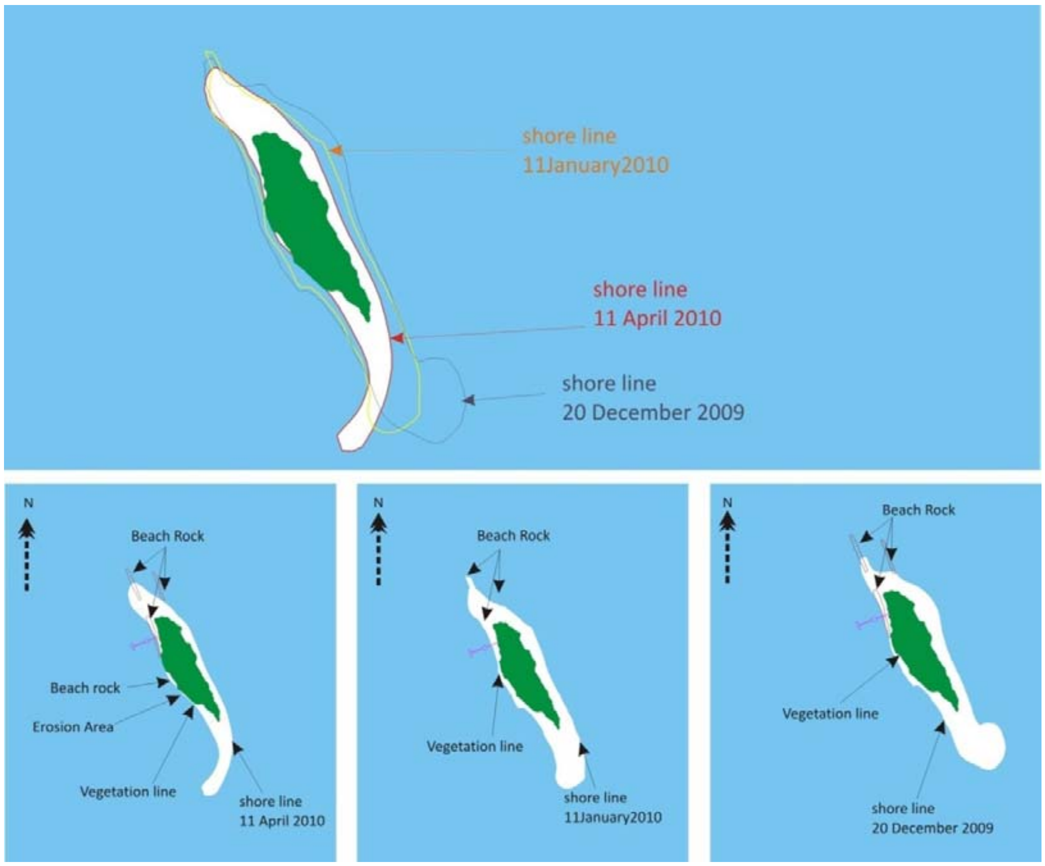


Figure 14: Changes to the coastline recorded from December 2009 to April 2010

Figure 15: Behaviour of Olhahali island's shoreline in August 2005, which is in mid south-west monsoon (Photo: Google Earth)

Historical data available for Olhahali indicate the dynamic nature of the coastline. However, the sediment dynamics is most active on both northern and southern sand spit area as seen in the above figure. Although the two sand spits are the most dynamic, both the eastern and western coastline is also influenced by the two monsoons. In south west monsoon, the northern sand spit shifts towards the east creating a considerable beach on the north-east side. This effect is caused by the movement of sand stimulated by monsoonal winds inducing long shore currents that shift the sediments eastward. This phenomenon exposes the beach rock on the northern tip of the island. The most dramatic changes to the shoreline are seen at the southern side. Between December and April, the sand spit moves considerably indicating the shift in the two monsoons (refer to the above figure). Similarly, in northeast monsoon, the eastern side coastline recedes due to long shore currents that shift the sediments towards south and north resulting in a smaller beach on this side and vice versa in the southwest monsoon.

Erosion of the coastline is mainly induced by the two monsoons. The most severe erosion occurs on the northwest and southwest coast during the southwest monsoon. Distances measured during the field survey from December 2009 to April 2010 indicate 2-3 m of shoreline retreat on the north and south west coastline. In the April 2010 survey, erosion scarps and undercutting were common features on the west side. Some of the trees on this side are almost in the water due to erosion of the beach as indicated by the following photo. Exposed tree roots and soil suggest erosion of at least 2 to 3 meters. By examining the shorelines from December 2009 to April 2010, it clearly indicates that the sediment deposition from the south-western sides towards the southern sand spit.

Figure 16: Figure of eroding areas on the east side

On the eastern side, the coast is mostly stable than the western side. Beach profiles and shoreline surveys from December 2009 to April 2010, a span of 5 months confirm that natural processes act to generate fluctuating coastline. Approximate horizontal shift ranges on both east and west sides are illustrated in Table 7. Although the available data sets are good enough to understand the coastal changes, money likely to be spent on future coastal protection work may be saved now if the types and magnitudes of coastal changes are more fully understood. In order for this to occur, long term data collection is necessary.

The following figure illustrates the sediment movement pattern observed in southwest monsoon. The movement of sediment around the island is observed mostly emanating from the north, northwest towards south easterly direction that shifts the sediments to east as well as south. This is considered to be the result of waves that break and dissipate the energy on the reef from north side resulting in the corresponding transfer of energy towards the shoreline. As is the case that the northern reef extent is the narrowest, the impact of waves from this direction is also the greatest observed.

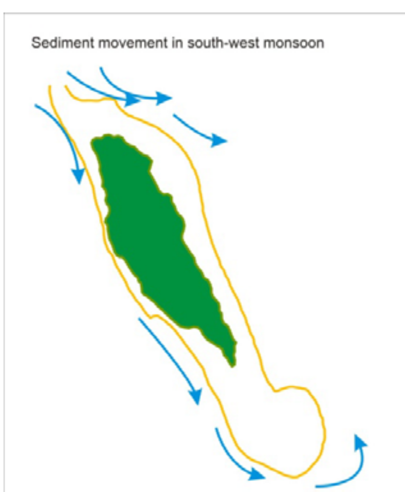


Figure 17: sediment movement around the island observed in SW monsoon

5.3.8 Project Components that Affect Coastal Zone

For this project, there are several components that affect the coastal zone, they are:

1. Over water structures, namely over water pavillions, over water pavilion access jetties and the service jetty
2. Replenishment of the beach using sand excavated from the proposed channel
3. Construction of submerged breakwaters

Details of these are discussed in detail under the project description section.

5.4 Existing Marine Environment

Marine Environment

Lagoon system

Since Over water pavilions are proposed to be constructed along the deep lagoon adjacent to the western side of the island, the benthic life in this habitat was of great importance during the field study. The shallow lagoon on the south-western side, starting from the existing channel up to the island, was inspected for live coral coverage. The lagoon floor mainly consisted of sand and loose coral rubble, which is believed to have been left behind after the 1998/99 coral bleaching event. Living corals, most of which belong to the *Acropora* genus, are of the branching type and barely survive in the lagoon. The bases of such colonies are dead with only the tips alive. Towards the island, one can find more live coral patches scattered across the lagoon. The attraction of the lagoon is a large *Porites* colony with an attached branching Acroporid colony, located at 4°41'17.98"N, 73°27'01.46"E. This 'micro-atoll', which is eroded on the top and attracts a number of fish, is approximately 5m in length and 3 m in width. It does not reach the sea surface during low tide but lies only about 30cm under it.

Entrance channel

The existing entrance channel for boats (see Figure 7) is a shallow path filled with only sand and coral rubble with the exception of one established digitate *Acropora* colony. The coral reef on the northern and southern side of the channel consists of mainly coral rock and rubble. From the channel down the reef slope, only a few live corals can be found; rubble and sand dominate the benthos.

The new entrance channel (Site D, see Figure 7) is proposed to enter the second deep lagoon area on the western side of the island. This channel consists to a large extent of coral rubble (74%) and coral rock (18%); live corals are represented only with 8% of the benthic cover in the 25m transect. Nevertheless, a few large *Porites* colonies can be found in the channel along with large dead coral colonies.

House reef system

The reef flat at Site A, located on the eastern side of the island, is dominated by dead coral rock and sand, whereas live coral coverage is rather low at 23% (see Figure 18), dominated by Acroporidae and Faviidae. Due to its shallowness, the area is not suitable for safe snorkelling during low tide. Surgeonfish (Acanthuridae) and Damsels (Pomacentridae) dominate the fish community at this site, followed by the Wrasses (Labridae).

At Site B, located between the sand spit and the entrance channel on the southern side of the island, consists of an even lower live coral coverage (2.6%) and is to more than 60% dominated by dead coral rock. Fish assemblages were dominated by Surgeonfish (Acanthuridae) and Damsels (Pomacentridae), whereas Parrotfish (Scaridae) were not observed at all during the count.

Parrotfish became more abundant towards the channel, where also Siganidae, Lethrinidae (*Monotaxis grandoculis*) Fusiliers (Caesionidae) and Snappers (Lutjanidae) were observed between three and five meters depth. The reef crest and slope are generally sandy and filled with coral rubble, with a few exceptions of rather massive than branching live corals.

Site C is not far from Site B and shows a similar distribution of dead matter (Coral Rock and Rubble) and live coral coverage (LCC). Both transects C1 and C2 reveal that LCC at this site is between 15 and 20% (see Figure 18); the transects are separated by a natural sandy 10m wide channel free of live corals.

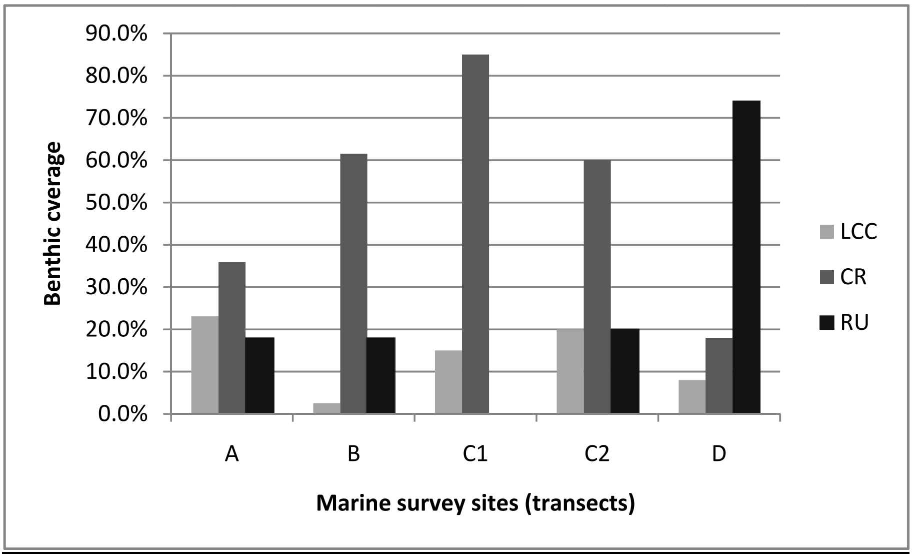


Figure 18. Benthic coverage at selected survey sites. LCC - Live coral coverage. CR - Coral Rock. RU - Coral Rubble.

5.4.1 Bathymetric survey

A detailed bathymetric survey was undertaken to assess the depths around the lagoon jetty area and areas for potential construction of over water structures and the channel. The detailed bathymetry is attached as an annex.

5.4.2 Marine water quality

The primary objective of the marine water quality sampling was to determine the baseline conditions of the marine water quality of the lagoon. Qualitative and quantitative assessments were made on sea water taken from four sides of the island. Samples were taken from 1 m below sea level using a clean bottle from the designated sites. The geographical coordinates were also recorded using a handheld GPS and the relevant positions are shown in Fig XXX. The qualitative assessment indicates that the sea water is clean and clear. To confirm this, quantitative water quality tests were done at the National Health laboratory, Male'. The results as shown in Table indicate no pollution from any human activities or any other source.

Parameters	Pos. A	Pos. B	Pos. C	Pos. D
Physical appearance	Clear	Clear	Clear	Clear
pH	8.3	8.3	8.3	8.3
Temperature	27.2 ^{o}C	27.1 ^{o}C	27.2 ^{o}C	27.2 ^{o}C
Turbidity	2 NTU	2 NTU	3 NTU	2 NTU
Nitrate	0.0 mg/L	0.0 mg/L	0.0 mg/L	0.0 mg/L
Phosphates	0.22 mg/L	0.30 mg/L	0.12 mg/L	0.10 mg/L

Table 8: Baseline Marinewater Condition

5.5 Socio-economic Environment

The Picnic Island is expected to be closed for upgrade and redevelopment in September 2010. It is expected that the redevelopment will create additional employment opportunity to community of Gaafaru. It is expected that additional 100 jobs would be created with the new development.

The management of the development encourages hiring dhonies which are owned by people of the neighbouring island Gaafaru for transportation during the construction period. The management of the development it is as well encouraged to get supply's of fish from the local fishermen's of the neighbouring island Gafaru during the construction as well as after the reopening.

5.6 Hazards and Disasters

5.6.1 Vulnerability to Natural Disasters

The islands of the Maldives are less prone to tropical cyclones and are only impacted in the northern part of the country by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. Since 1877, only 11 cyclones crossed the archipelago (Maniku, 1990). Most of the cyclones crossed Maldives north of 6.0^{o} N and none of them crossed south of 2.7^{o} N during the period. All the cyclones that affected Maldives were formed during the months of October to January except one, which formed in April (UNDP, 2006).

Map 1: Cyclonic Wind Hazard Map (source: UNDP, 2006)

The northern atolls have a greater risk of cyclonic winds and storm surges. This reduces gradually to very low hazard risk in the southern atolls (see Map 1). The maximum probable wind speed in Zone 5 is 96.8 knots (180 kilometres per hour) and the cyclonic storm category is a lower Category

3 on Suffir-Simpson scale. At this speed, high damage is expected from wind, rain and storm surge hazards (UNDP, 2006).

Figure 19 shows historical earthquakes around Maldives; and three events of magnitude above 7.0 struck the region which had their sources in the Indian Ocean (UNDP, 2006).

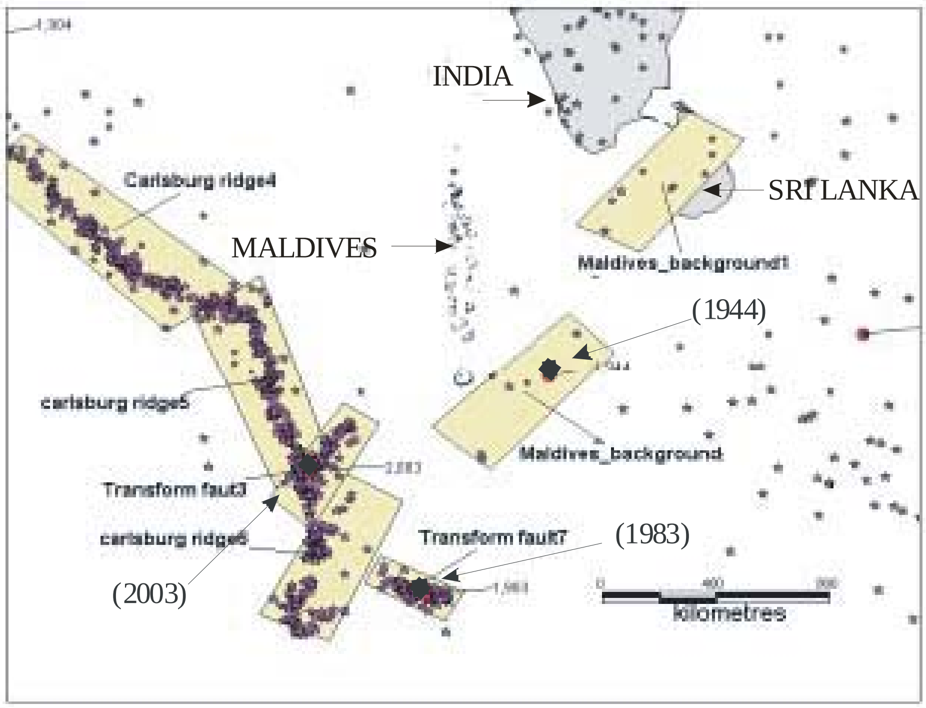


Figure 19: Earthquake Epicentres around Maldives (Source: UNDP, 2006)

UNDP (2006) identified that hazard risk from earthquake is low for the Maldives and considered as a disaster risk for only islands located in the south of the country. See **Error! Reference source not found.**above figure.

Figure 20: Earthquake Hazard Zone (source: UNDP, 2006)

Maldives faces tsunami threat largely from the east, and lower threat from the north and south. Islands along the eastern fringe of the atolls are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe experience a relatively low tsunami hazard. Historically, Maldives has been affected by three earthquakes which had their sources in the Indian Ocean. Of the 85 tsunamis generated since 1816, 67 originated from the Sumatra Subduction zone in the east and 13 from the Makran Coast Zone in the north and Carlsburg Transform Fault Zone in the south. The probable maximum tsunami wave height is estimated at 4.5 metres.

Figure 21: Tsunami Hazard Zones (adopted from UNDP, 2006)

5.6.2 Natural Vulnerability of the Island of Olhahali

The islands of the Maldives have natural characteristics which make them vulnerable to disasters such as tsunami. An island's Natural Vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island like the side of the country where the island is located, the formation of the island, location of the island respect to the atoll, orientation of the island, region of the country where island is located, level of shadow to the island from the reefs and other islands; area of the inland lake found on the island, width of the island's house reef, coastal defence structures on the island, shape of the island and the area of the island. A Model to Integrate the Management of Hazards and Disasters in the National Sustainable Development Planning of the Maldives which was developed as part of the Masters of Science (Hazard and Disaster Management) thesis at the University of Cantebruy (Jameel, 2007) identified the relationship between natural characteristics of the island and the *natural vulnerability* of the islands using the data that was collected following the Indian Ocean Tsunami.

Based on this research, the natural vulnerability of the Olhahali was found to be low for flooding disasters such as caused by tsunami or high waves approaching the island from the east.

6 Environmental Impacts and Mitigation

6.1 Impact Identification

Impact identification has been undertaken by considering the proposed activities and examining the level of impact the new construction 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.

6.2 Assessing Impacts

Environmental impacts of the proposed redevelopment 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 moderate to high as the proposed modifications take place on the lagoon. 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 phases. 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.

6.3 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 Olhahali 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. Overwater structures have already been developed on similar island environment and therefore, the impact of constructing additional Over water pavilions can be fairly accurately predicted. The areas where Over water pavilions will be developed are mainly covered with sandy bottom and occasional live corals. The live coral cover cannot be considered high in these areas.

Development of overwater structures, construction of breakwaters, and creation of channels and nourishment of beach 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 with regard to the construction of Over water pavilions. Therefore, there is a high degree of accuracy in prediction of the impacts.

6.4 Impacts on the Coastal environment

The development of submerged breakwater on western side of the island would help to reduce the existing erosions which the island is presently faced. The erosion of beach on western side of the island during the south west monsoon will be mitigated with the construction of the submerged breakwater and subsequent nourishing of the lost beach.

6.4.1 Submerged breakwater

Impacts

The construction of the submerged breakwater will have a significant positive impact on the western 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 the island would be a significant impact but a desirable one. Wave energy will be considerably reduced by the breakwaters and therefore long shore transport sedimentation will be reduced thereby stabilizing the shoreline.

Mitigation Measures

It is important to undertake the placement of the reef balls at the preferred location of the breakwaters at low tide hours.

6.4.2 Replenishment of lost beach

Impacts

The replenishment of the eroded beach will be undertaken by using the excavated material from the channel deepening and the sand pumped from the lagoon western side of the island. Beach erosion is a critical environmental issue facing the island. Even at present, several large trees and a two bungalows is under treat from erosion.

Beach replenishment will be undertaken on western side and eastern 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. Approximately 2,500m² of the lagoon will be directly impacted during filling period.

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 an 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 fill area initially and then filling inside this bund using excavated material. 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 dredge material to make the bund rather than fines.

6.4.3 Overwater Structures

Impact 1: Changes to sediment transport

The construction of a series of footings and columns for the Over water pavilions and water villa jetties would disrupt sediment transport around the island, especially due to the wave attenuation these structures would offer during the southwest monsoon. This impact would help minimize net erosion on the north western side of the island.

Mitigation:

The water villas will be built 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 some sedimentation due to the movement of excavators on the seabed during the construction phase when footing and columns of the water villas are placed in the lagoon. The engineers have designed the Over water pavilions as such that 750mm of the Over water pavilions footing need to be buried into the lagoon floor after excavation. This will be minimal and unavoidable given the construction methods employed in water villas 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 construction of over-water structures would impact the coral reef indirectly and the lagoon directly and indirectly. Direct impact on coral reef is expected only in the area where the channel will be dredged as the rest of the development of the Over water pavilions will be undertaken on the lagoon (see the Master Plan). Direct impact on the lagoon will be disturbance to the lagoon bottom in laying the footings of the overwater structures. Indirect impact on the lagoon will be spreading of low level of sediment in the lagoon water column. Direct impact on the reef will be the destruction of the reef habitat and live corals in the area where the channel will be developed. This area has roughly 8 percent live corals.

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 channel excavation, 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

6.4.4 Arrival and Service Jetty

Impacts

During the construction phase, the impact on the island environment would be sedimentation due to the movement of excavators on the seabed and the excavation of seabed's to place the footings of the jetties column. During the operation phase of the development, the impact on the island's environment would be disrupt sediment transport around the island, especially due to the wave attenuation these structures would offer during the southwest monsoon

Mitigation Measures

To mitigate the impact of sedimentation, the working methodology would be adjusted as such that foot placing would be carried out at low tide.

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.

6.4.5 Spa

Impacts

The spa is proposed to be built in clear shallow lagoon on north western side of the island. The main impact of the spa building will be to the lagoon floor during the construction phase of the development. The spa building is supported by the columns, where the footing of the columns will be buried 750mm into the lagoon floor. The columns will be placed using an excavator and sedimentation would be resulted due to the process.

Mitigation Measures

The mitigation measures would be to raise the height of the spa jetty, especially from the mean tide line so that the beams would have less impact on the sediment movement. It is also important to keep the spa as far away from the beach line as possible. The current location is appropriate given the smallness of the reef extent in this area.

Cost of Mitigation

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

Contractors will also be required to undertake the mitigation measures, as most of these include measures that can be taken if carefully planned.

6.4.6 Submerged breakwater

A submerged breakwater using reef ball is proposed to be built on western side of the island. The submerged breakwater would reduce the erosion faced on beach on western side of the island by creating calmer conditions for beach to accrete even in south west monsoon. The breakwater is expected to impact on the long shore current around the island.

6.4.7 Creation of a new entrance channel

Impacts

Most of the negative impacts on the marine environment arising from the proposed project will mainly be from excavation of the entrance channel. In this project, excavators will be used to deepen the entrance channel and therefore sedimentation will be an ultimate outcome which will be unavoidable. Despite this, it has to be noted that this is only a short term effect and will only last during the excavation period. The entrance channel will be excavated to a depth of 3 meters at in low tide. An indirect impact will be felt on the nearby reef due to sand smothering.

Both work phase and operation phase will have direct and indirect negative impacts. Direct impacts during work phase will result from the removal of lagoon bottom areas to deepen the lagoon and make the navigation channel. This impact will include damage to lagoon bottom benthos namely burrowing worms and crustaceans. Indirect impacts will result from release of sediment to the water column and increase in turbidity during the work phase. Lagoon bottom is an important habitat for certain organisms such as worms, molluscs, amphipod etc. which are important food sources for bottom feeders such as certain species of fishes. By removing sand from the lagoon bottom would disturb habitats of these organisms.

Proposed Mitigation Measures

Following are the specific mitigation measures that will be taken to mitigate negative impacts on the marine environment that are likely to arise from the proposed project activities.

- Channel deepening will be restricted to the required width of the channel.
- Undertaking work during low tide.
- The monitoring programme specified in this report will be followed and reported in order to take necessary mitigation measures.
- Channel will be deepening to the required depth of – 3.5 m at low tide.
- Sedimentation and siltation resulting from the proposed work activity will be minimised and contained within the area by using appropriate techniques such as undertaking the works in low tide to reduce spreading of sediment and silt plumes to the lagoon floor, lagoon water and the coral reef.
- The excavated material will be transported to the island and will be used as a beach replenishing material.

Table 9: Summary of the impacts and their characterization

Environmental Aspect	Nature of impact	Magnitude of impacts (negligible/minor /minor adverse/moderate adverse/major adverse/ positive)	Significance of the impact (low/moderate/high)	Duration of Impact	Reversibility
Construction of over water structure	Cumulative	Moderate adverse	High	Short to long term	Reversible
Construction of SPA	Cumulative	Minor	Low	Short to long term	irreversible
Construction of arrival and service jetty	Cumulative	Minor	Low	Short to long term	irreversible
Construction of the break water	Cumulative	Minor	Low	Short to long term	irreversible
Relocation of existing channel	Cumulative	Major adverse	high	Long-term	irreversible
Construction of the sewage treatment plant	Cumulative	positive	Low	Long-term	reversible
Noise and air pollution	Cumulative	Moderate adverse	Moderate	Short term	reversible
Generation of construction debris	Cumulative	Minor	Low	Short term	reversible
Impacts on the western coastline	Cumulative	positive	high	Long-term	irreversible
Impact of beach replenishment	Cumulative	positive	high	Long-term	reversible
Impacts on terrestrial environment	Cumulative	Minor	Low	Short-term	reversible

7 Stakeholder Consultations

For the purpose of this project, public consultations were limited to relevant government agencies, the proponent and the designer / Architects. As the project is a redevelopment of an existing picnic island, these key stake holders were identified relevant to undertake public consultations. Methodology for undertaking these discussions was through official meetings, interviews and discussions.

7.1 Consultation with the proponent

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

- The main concern for the redevelopment arose due the changing market conditions and interest in sustaining the environment by implementing coastal protection measures.
- To implement over water spa pavilions, mainly because of the need to provide a better service for higher end clients and to keep up with the diversifying tourism industry.
- To Increase profitability for the picnic island, the proponent emphasised that it does not mean that it is only beneficial for the proponent and that it will naturally increase the government's revenue.
- The proponent is not interested in reclaiming land, however does propose a beach replenishment program to recover the beach lost due to erosion.
- If the new over water pavilions overlap live corals, then the proponent is willing to shift the Over water pavilions to the lagoon in order to avoid harm to the live coral.
- The live corals in the Over water pavilions jetty area will be relocated if such a need is required.
- Trees will not be removed; however, the proponent wishes to implement a tree planting program to increase the vegetation of the island.
- Construction of breakwaters to prevent beach erosion. Breakwaters will be submerged reef balls.
- Creating a new channel to make the island more accessible to guests instead of the existing channel has been decided in order to avoid boat movements too close to the new Over water pavilions that will be developed on the south-western lagoon. The furthest of these villas is very close to the existing entrance channel, hence the decision was made to create a new entrance channel.

7.2 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

- Marine environment and coastal related issues were the most important aspect that was discussed.

- The island has been facing continuous beach erosion. At present, there is no coastal protection measures in place. The sand pit on southern side of the island has been shifting with high frequency.

- Upgrading will definitely be good for the picnic island as the market segment is changing rapidly.

- Feels that most of the island's infrastructures require upgrading. However, he feels that demolition of existing structures should be kept to a minimum.

7.3 Consultations with the Ministry of Tourism, Arts and Culture

Consultations were held with officials of Ministry of Tourism and Civil Aviation at the Ministry. Following are the main outcome.

- This project has been approved by the ministry including all the concepts.
- Regarding the redevelopment proposed for Olhahali, as long as there are no major environmental issues, the ministry has no objection.
- The issue of whether there is a serious environmental impact or not will have to be addressed in the EIA. Hence, by undertaking an EIA for the proposed modifications, the proponent will be able to justify the modifications.
- Tourism Ministry is generally positive and supportive of such modifications as long as they are justified and in line with the international and local rules and regulations.

7.4 Consultations with Ministry of Housing, Transport and Environment

Consultations were held with Mr. Mohamed Zahir, Director General at the Ministry. Following are the main outcome.

- All the development in the tourism industry would have to do EIA before the project is given approval.

- EPA is the main institution which oversees the EIA work under the Ministry

- The redevelopment shall refrain from the removal of any trees and importation of trees from other island shall be undertaken accordance with the regulation under the Ministry.

- Environment Ministry's interest lies in protection of the environment at the same time allowing development to take place. This means, that developers should implement all mitigation measures and also undertake regular monitoring.

- New developments need to take into consideration the goals outlined in the new Third National Environment Action Plan and the National Sustainable Development Strategy. The development shall try to aim to reduce the carbon emission. Reduction of carbon emission from private sector would help to achieve the carbon neutral policy of the government.

7.5 Consultations with the Architect

Consultations were held with Mr. Hannan Yoosuf. Following are the main outcome.

- Feels that this development is considerably small since it is a picnic island, and the major task is only related to the construction of the new over water structures.
- Over water pavilions will be developed on concrete pads and columns. These will be pre-casted in the island.
- Discussions continued with regards to the most ideal location to place the over water structures.
- Consideration was made to replenish the beach on south western side, and the location and depths of the entrance channel.
- There is a very great need to complete the picnic island at the earliest in order to make this property a profitable one. The project is planned as to open the Upgraded Picnic Island for business by next winter season.

7.6 Consultation with the Marine Biologist

Consultations were held with Ms. Verena Wiesbauer. Following are the main outcome.

- Attention shall be given to the protection of the marine environment during the construction stage of the development. Marine environment could be impacted, during the construction phase, when workers are not properly educated. Therefore, creating awareness to the workers, through an orientation, could help to minimise the impact on the marine environment.
- It is essential to protect the ancient corals located within some areas of island's the shallow lagoon
- Care should be taken to minimize development on areas where live corals exist.

7.7 List of persons consulted

Following are the names and designation of persons consulted.

Name	Designation	Office
Mr. Mohamed Adhlee	Assistant Director	Ministry of Tourism, Arts and Culture
Mr. Mohamed Zahir	Director-General	Ministry of Housing, Transport and Environment
Mr. Dmitry Bourtov	Proponent	Grand Meridian Pvt. Ltd
Mr. Artem Reyznek	Director of Operations	Grand Meridian Pvt. Ltd
Mr. Ibrahim Faisal	Boat Captain	Grand Meridian Pvt. Ltd

Name	Designation	Office
Ms. Verena Wiesbauer	Marine Biologist	Water Solutions

8 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:

8.1 No Project Option

The no project option takes the following into account.

- The Picnic Island will be operated with its existing infrastructure.
- No additional infrastructures/services are introduced, therefore, price cannot change and profit margin will decrease year by year. At present, the island does not generate negative any profits.

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

Table 10: Advantages and disadvantages of the no project option

Strategy	Advantages	Disadvantages
Allow the picnic Island to be operated with the present infrastructure	Environmental problems related to additional development can be avoided No upgrading costs to the Proponent, short term benefit	With the existing infrastructure, the island can only be marketed to certain markets. Target clientele cannot be diversified.
Existing facilities would be left as it is	Environmental problems related to construction of new Over water pavilions and relocation of the entrance channel can be avoided No upgrading costs to the Proponent, short term benefit	Profit cannot be increased. Modifying the existing land villas would be more costly, as most of them are not specially designed to suit the current market.

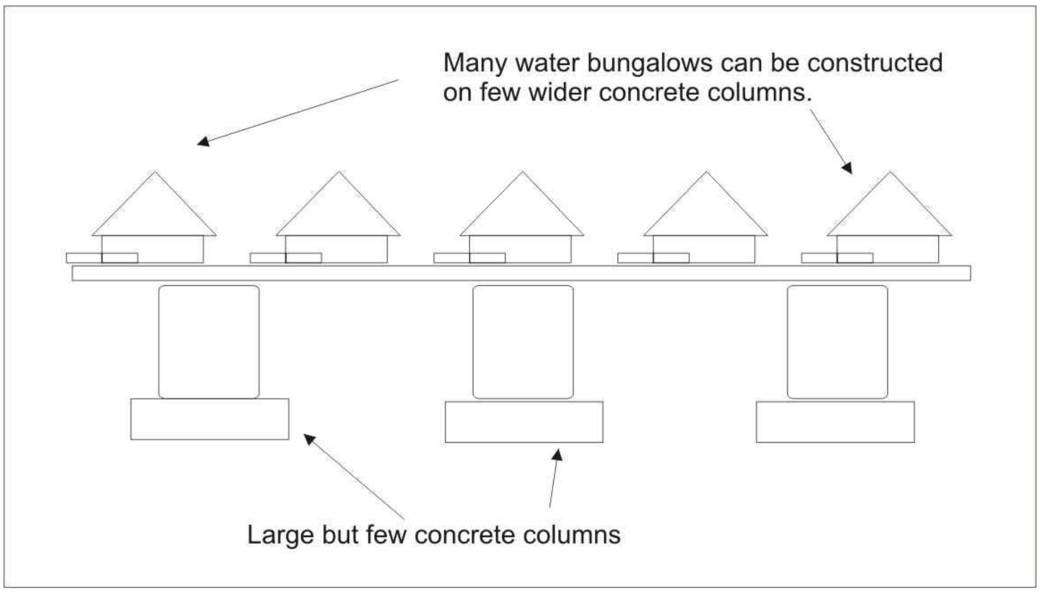
8.2 Design Alternatives

During the EIA process, a number of alternatives were considered, mainly for the construction of the Over water pavilions and their location. They are discussed below.

8.2.1 Construct multiple water villas on few large columns

An alternative method of water villa construction was considered at the planning stage. This method involves constructing large, but few concrete columns on the lagoon and then building multiple water villas on them. This method is illustrated in Figure 22. This method was rejected for several reasons. First, this is a very new concept for Maldives and hence requires a greater degree of uncertainty. Secondly, the large columns would be very unattractive and will not blend with the existing water villa columns. There would be lot of negative visual perception. Thirdly and very importantly, the large surface area of the columns will disrupt the sediment movement greatly than if it was constructed sing standard column sizes. Hence, there would be a greater degree of sediment disruption and at present; there is very limited information and experience within Maldives as far as this method is considered.

Figure 22: Alternative construction method for water villas.



8.3 Alternative locations

8.3.1 Location of the Overwater Deluxe Anchorage Pavilion

There are few alternative locations for these pavilions, but the most practical alternative is on the western side shallow lagoon. However, the existing planning regulations prevent the construction of structures 600 m away from the shoreline of the island. The disadvantage of moving overwater anchorage pavilions to this side of the island is that, this will be further away from the island and hence will not block the view from the island. There are no other alternative locations as the area allowed by the existing regulations of Tourism and Environment is limited.

8.3.2 Location of the Royal overwater Anchorage Pavilion

There are few alternative locations for this pavilion. The present location of this Pavilion on south eastern corner of the island reef system provides adequate shelter in either monsoon. If the Pavilion is moved to eastern side, then the pavilion would be exposed in north east monsoon and vessel cannot anchorage in that monsoon. Similarly, if is moved to southern side, then the location would be again exposed in south west monsoon.

8.4 Alternatives to construction technologies

The foundations or the footings of the overwater anchorage pavilions, spa and jetties will be constructed using concrete pads on columns. All structures will then be constructed on them. During the concept development stage, drilling the sea bed to a depth of 6 m to erect the columns were considered in order to ensure that water villas and the jetty will be structurally strong. However, the cost of this operation would be much more.

The proposed methodology involves constructing footings on the island. Drilling will involve the use of heavy machinery and hence, not very suitable for this situation in terms of cost and the impact on the environment. Therefore, this alternative has not been considered.

8.4.1 Deepening the existing entrance channel

The current project proposes to relocate the existing channel to 100m west. The existing channel is very shallow and hence, the channel cannot be accessed during medium and low tide. Hence deepening the existing channel would help to improve the accessibility to the island. However, the proposed concept has few anchorage pavilions located near to the existing channel. Since, the channel needs to deepened, it is beneficial, if the entrance channel could be relocated. The new channel would have depths which would allow vessels which have a draft of 3.5 m to access the island.

8.4.2 Method to relocate the existing channel

A new channel can be made using an excavator where the excavator is placed on a barge. This method will have significant logistical difficulty during the construction stage. One alternative to minimize this impact is to employ a cutter-suction dredge which will be easy to operate and will reduce the amount of silt suspended in the water column. However, the use of cutter-suction dredger is not very suitable for such a small scale project, and therefore is not economically justifiable due to high cost of mobilization and operation.

The other option would be to use a sand pump. Sand pumps are less costly and causes less sedimentation. Even if sand pumps were to be used, the sand shall be pumped onto barge and transported to land as the distance to cover if the pump were to pump directly to land would reduce the efficiency of the pump. Also, similar to the dredger the pumped sand would be more compact than excavated sand. Therefore, excavator is preferred over the sand pump to minimize compaction and ensure that the sand can be easily sorted or sieved and used for future beach replenishment, etc.

The best option though would be to use a combination of sand pump and excavators to deepen the channel.

8.5 Alternative methods to protect the beach

There are a number of options for shore protection on the western side of the island. Since wave action is the main concern in Olhahali, a structure that protects the area in its lee from wave attack, i.e. a breakwater is considered the most suitable solution. Some impractical options such as floating breakwater and regular beach replenishment have not been considered.

Based on the above, the suitable options that may be considered during the design of the second phase are:

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

8.5.1 Emerged breakwater

The emerged breakwaters were popular coastal protection features in the resorts. However, the emerged breakwater has an aesthetic impact that had become unpopular. The emerged breakwater functions like a submerged breakwater but these are designed to prevent overtopping of waves and keep the lee 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. This is a result that is not desirable. Hence, emerged breakwaters are not considered.

8.5.2 Artificial headlands

The natural headlands of a pocket beach restrict long-shore sand transport. Such headlands act as groynes. Artificial headlands can be constructed to achieve a similar effect. On the open coast, this form of protection requires large and expensive structures. Consequently, their use has been restricted to more protected shallow areas with less severe wave conditions. Therefore, it is not considered suitable for Olhahali Yet, these would be given further consideration during the final design of the second phase of the proposed project.

8.5.3 Seawall or revetment

Instead of submerged breakwaters or groyne field, a seawall, low retaining wall or a revetment along the entire length of the western shoreline may be considered. The seawall is considered inappropriate for the resort because it is seen at all times, whereas a low retention wall would be seen only when exposed after a storm event or following wave attack during the southwest monsoon. A revetment is similar to seawall but is inclined according to the profile of the beach. In Olhahali, revetments on western side would have to be made quite strong if they were to be kept intact. Hence, revetments, seawalls and low retention walls are considered inappropriate for Olhahali. However, they will help to protect the properties behind them from the threats of erosion. A more desirable option for revetments would be to have them as a second line of defence after submerged breakwater.

8.5.4 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 may be required once a year if no coastal protection is undertaken.

8.6 Preferred alternative

Several alternatives have been Discussed including alternative locations for the proposed new over water anchorage pavilion, Spa Complex, relocation of existing channel and construction technologies. Constructing over water anchorage pavilion and associated jetties using pile drilling have not been selected as alternative construction method for the supporting columns.

The preferred alternative for this project is to deepen the existing channel.

8.6.1 Mitigation measures for the proposed alternative

Following mitigation measures are proposed for preferred alternative.

- The existing entrance channel has one living Acropora colony. This colony should be relocated to a safe location where no work will take place prior to the deepening of the channel.

- Undertake the construction in the shortest possible time to minimize sedimentation as well as any disturbances to the sea bed and the marine environment.

- Undertake the construction during low tide hours.

- Completely avoiding walking or any construction activity on the reef flat.

9 Environmental management and monitoring plan

9.1 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.

9.2 Cost of Monitoring

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

9.3 Aspects of monitoring

Monitoring will include marine aspects and coastal aspects only. Monitoring report will be provided at the end of the construction stage and will adhere to Schedule M of the EIA Regulations, 2007.

9.4 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.

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

Monitoring Attribute	Indicator	Methodology	Monitoring Frequency	Estimated Cost (US$)
Marine water visibility in the lagoon	Visibility	Secchi Disc & Tow line distance	Every other day during work. Every 6 month thereafter	No cost. Contractor to undertake this during construction period.
Coral cover at survey sites A to D	Percentage live cover	Qualitative & Quantitative	Once during the construction stage. Once a year thereafter .	3,000.00 per survey
Marine water quality	suspended solids, pH, temp , COD, DO, Salinity, turbidity, nitrates, phosphates,	Onsite or Lab analysis	Every three months during work; twice a year thereafter.	US $ 50 per test.
Siltation	Sediment deposited on reef substrate	Qualitative	Every other day during work. Every 3 month thereafter	No cost. Contractor to undertake this.
Beach profiles	Changes to the beach	Using auto level	Every 3 months after construction	750 per annum
Currents	Changes to the current	Using drogues	Every 3 months after construction	500 per annum
Shoreline	Changes to the shoreline. Erosion and sand accretion levels.	Using GPS	After completion of the beach replenishment	Every 3 months thereafter

9.5 Monitoring responsibility

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

9.6 Monitoring Report

A detailed monitoring report will be compiled after the completion of the civil works. This report will be based on the baseline data collected for monitoring the parameters included in the monitoring program. This report will be submitted to the relevant government agencies for compliance. The report will include details of the site, data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

10 Conclusion and Recommendations

This EIA report has identified the major impacts of the proposed additional construction work.

It has been assessed that the most significant negative impacts from the proposed development will be on the lagoon bottom as a result of constructing new over water pavilions and construction of the breakwaters. The relocation of the entrance channel would have an impact on the reef flat and reef environment. The most significant impact period will be during construction stage as a result, several mitigation measures to reduce the impact on the marine environment have been proposed during the construction stage. These measures include measures such as undertaking work during low tide hours and also limiting the construction duration as much as possible. In addition, several other mitigation measures such as proper supervision have also been proposed.

Since the island lagoon is, to a great extent, free of live corals, the construction of over water pavilions should not cause too much damage. However, a small amount of corals grow in the lagoon and the ones that would be directly affected should be relocated prior to the excavation works. These corals could be transplanted back to their original site once the work is finished. Usually, resorts in the Maldives require live corals to rehabilitate destroyed areas of their house reef or lagoon. By saving them in the first place, no corals will have to be removed from the house reef after the completion of the redevelopment.

The large *Porites* colony at 4°41'17.98"N, 73°27'01.46"E (see **Figure 7**), due to its size estimated to be a few hundreds of years old, should stay in its original place and should be completely avoided from the work since it cannot be relocated safely. It is recommended to secure an area of at least 3m radius around this colony. The same procedure should be applied for similar large coral heads. Such slow-growing, large live coral colonies should enjoy special protection as natural heritages and will, in return, be appreciated by resort guests.

Sewage disposal location (Site C)

The sewage pipe is recommended to be laid through the natural channel at 4° 41' 23.56" N, 73° 27' 10.16" E since no live corals have to be removed there. (see **Figure 7**).

Proposed entrance channel (Site D)

Since coral growth is apparent in the proposed entrance channel through the reef flat, albeit low (8%), as many live corals as possible should be spared during the excavation of the new entrance channel. The connection channel between the two deep lagoon areas does not project any major environmental impacts as it consists of sand only.

Although the social impacts of the project were not assessed in detail, relevant stakeholders were consulted to obtain their views and opinion about the project. The project is also expected to have positive impacts, including the diversification of the services and increased revenue to the Picnic Island and to the country as a whole.

The monitoring programme for this project will mainly focus on marine and coastal environment and for this reason; specific parameters have been outlined for monitoring. Additionally, beach profiles will be taken to monitor long term changes to the beach. It therefore, appears justified to undertake this development.

Various alternatives were considered including alternative locations for the Over water pavilion and alternative methods of constructing over water pavilion and coastal protection. Based on the assessment, it is recommended to urgently implement the coastal protection component to mitigate the existing erosion problem faced to the island.

11 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.

We certify that the statements in this Environmental Impact Assessment study are true, complete and correct, to our best of our knowledge and ability.

Name: Abdul Aleem (EIA 09/07)

Signature:

Name: Ahmed Jameel (EIA 07/07)

Signature:

12 Commitment from the proponent

13 References

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14 Annex: Terms of Reference

15 Annex: Proposed Master plan of the resort

16 Annex: Details of new Over water anchorage pavilion

17 Annex: Cross sectional Drawings

18 Work Schedule

19 Annex: Bathymetry of the lagoon

20 Annex: Beach profiles and their locations