ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Sewage Outfall and Minor Coastal Modifications

Huraa, Kaafu Atoll, Maldives

Proponent: Secretariat of the Huraa Council

Sandcays

December 2017

Table of Contents

Table of Figures

Table of Tables

Lead Consultant's Declaration

This EIA has been prepared according to the EIA Regulations 2012. I certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of my knowledge and abilities.

Hussain Fizah

EIA Registration No. EIA01/2014

Proponent's Declaration

As the proponent of the proposed development I guarantee that I have read the report thoroughly and that to the best of my knowledge all information provided here is accurate and complete.

Secretariat of the Kaafu Atoll Huraa Council

Executive Summary

This report discusses the findings of an environmental impact study under the proposed sewage outfall of the existing sewerage system and minor coastal modifications at Huraa, Kaafu Atoll. The project is proposed by the Secretariat of K. Huraa Council.

The project entails a sea outfall from the collection chamber of the existing sewerage system and minor coastal modifications including the excavation for deepening of the Huraa wetland and installation of concrete piles for a restaurant on the shorezone. The proposed incorporation of sea outfall involves a pumping station and modification or replacement of fiber tanks in the existing sewage treatment plant. The outfall will extend to a depth of at least 7m, as per guidelines. The wetland has been declared by EPA as a Protected area to protect the mangrove forest and the Council feels it important to deepen the water-logged area, especially the inter-tidal opening between the wetland and the lagoon which has been shoaled over the years. The dredge material is to be placed on the eastern side beach area, slightly south of the pumping station location.

Environmental impacts were assessed for both the construction and operational phase of the project. Most of the environmental and socio-economic impacts identified for the proposed development were positive to include reduction in smell around the treatment plant, energy consumption for wastewater treatment, minimized groundwater pollution, improved management/ maintenance of the sewerage system and enhanced water circulation in the water-logged areas of the wetland. The negative environmental impacts of the project would include temporary loss of groundwater quality during the construction phase due to dewatering and large siltation in the wetland area and small amount of sedimentation around house-reef induced from installing the outfall. The latter could be regarded as insignificant due to its small magnitude and spatial distribution while the sedimentation or siltation from dredging of the wetland area could be quite significant depending on the method of dredging. Silt and dirt on the dredge material disposal location would also be of concern.

Since the project has minor negative impacts, a detailed investigation of alternatives was not considered necessary. Furthermore, there are no feasible alternatives to the outfall or excavation of the water-logged area of the wetland. Therefore, only alternative work

methods have been discussed in the report, which include alternative methods of laying the outfall pipeline, alternative methods of excavation, etc.

The environmental impact mitigation measures for this project were also of lesser importance due to the scale and low impact. Some of the general construction controls such as working during low- tide as much as possible and rigorous supervision have been discussed. As for the operational phase, implementation of backup systems and trained maintenance staff to service the Sewage Treatment Plant (STP) and regular check-ups were suggested in addition to monitoring seawater quality around the outfall location, wetland water quality and groundwater quality at designated locations around the island. The Proponent is willing to undertake monitoring during and after the construction phase in addition to undertaking the mitigation measures proposed by the consultants.

In conclusion, it appears justified from a technical, administrative and environmental point of view, to carry out the proposed project. However, the alternative methods of excavation of the water-logged wetland areas proposed to be excavated may be considered and the works are recommended to be done in the least damaging manner.

ހުލާސާ

މި ރިޕޯޓަކީ ކ. ހުރާގައި ޤާއިމް ކުރެވިފައިވާ ނަރުދަމާ ނިޒާމަށް ބައެއް ބަދަލު ގެނައުމުގެ ގޮތުންނާއި ރަށުގައި ހިމާޔަތްކުރެވިފައިވާ ކުޅިން ފެން ބޭރުކުރުމާއި ގޮނޑުދޮށުގައި އަޅާ ގްރޮއިންގެ ތަނބުތަކެއް އެޅުމުގެ ސަރަހައްދުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަލާނުކުރުމުގެ ގޮތުން ތައްޔާރުކުރެވިފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫޢުގެ އެދިއާރީ ކ. ހުރާ ކައުންސިލްގެ އިދާރާއެވެ.

މި މަޝްރޫޢުގައި އެކުލެވިގެންވަނީ މި ވަގުތު ބޭނުން ކުރެވެމުންދާ ނަރުދަމާގެ ނިޒާމަށް ބަދަލު ގެނައުން ފަރުން ބޭރަށް ނަޖިސް ބޭރު ކުރުމަށް ބޭނުންވާ ހޮޅި އެޅުމާއި އެކަމަށްޓަކައި ޕަމްޕިންގ ސްޓޭޝަން ގާއިމް ކުރުމެވެ. މި އައުޓްފޯލް ގާއިމުކުރާ އުސޫލުން ފަރުން ބޭރަށް 7 މ އަށްވުރެ އަޑިއަށް ފުން ހަމަޖެހިފައިވާ ގޮތުގައެވެ. ހުރާ ކުޅި ސަރަހައްދަކީ ހިމާޔަތްކުރެވިފައިވާ ސަރަހައްދެއް ކަމަށް އީ.ޕީ.އޭ އިން ކަނޑައަޅާފައިވާ ސަރަހައްދަކަށް ވުމާ، އެތަނުގެ ފެނުގަނޑު، ގްރައުންޑްވޯޓަރ ފަޅާގެ ހިސާބުން، ތިމާވެށްޓަށް ދަތި ފުންކުރެވޭ ގޮތަށް ކަމެއް ކުރަން ހުރާ ކައުންސިލަށް ފުރުޞަތުދެވިފައެވެ. މިގޮތުން ކޮންމެ ސަކަށް ފަސް އަހަރު ހަމަޖެހިފައިވާ ރަށުގެ އިރުމަތީ ފަރާތު ގޮނޑުދޮށެވެ.

މި މަޝްރޫޢުގެ ސަބަބުން ތިމާވެށްޓަށް ފޯރާ ބޮޑެތި ކުރާނެއެވެ. އޭގެ ތެރެއިން ބޮޑު ފެން ފެނަށް ބަލާއިރު މިންވަރު ކުޑަވެގެން އެކި ޖީބީޖަންތު ޖާގަ ސަރަހައްދުން ދުވާ ނަބަތާތް ކަނޑައެޅެނީއެވެ. ކުޑަ ފެންގަނޑު އެއްވެގެން އިތުރުވާ ފެން ދަތިކުރެވުނުއިރު ކުޑަ ފެނުން ބައްޓަން މިންވަރާ ކުޑަކުރެވޭނެއެވެ. މި މިބަޝްރޫޢު ގެ ސަބަބުން ނޫނީވާ އަސަރުތަކަކީ ކުރި ކަމުގައި ވި ނަމަވެސް، އަސަރުތަށް ކުޑައެވެ. އޭގެ ތެރެއިން ޑްރެޖް ސްޓޭޝަން ގާއިމު ބިމުން ފެން ދުރުގެ (ޕްލެޓްފޯމުގެ) ސަބަބުން ބިމުގެ ފެން ފަރަށް ވެއްޓޭ ގޮތުން ނުރަވުން ހުރުން ހިފާނެއެވެ. މީގެ އިތުރުން މަދުކުރި ކުޑަ އެހެނިހެން ކަންތައްތަށް ވަރަކަށް ފެންގަނޑުގައި ޖެހުމުގެ ބަލިން އެކަށީގެންވާ ނަމަވެސް ފަރުގެ ދިރުމަށް މަޑުކުރަން ނުބޭ ދަތި ފާސްދޭ ބައެއް ފެނަށް ކަމަށް ނެރެފައި ކުރިން ކުރިއެރުމެވެ. ނަމަވެސް، ކުރީގެ ފެންގަނޑު ފެނުގެ ކުރިއަށް ކަނޑަ އިރު، ގްރައުންޑްވޯޓަރ އެކަށީގެން ގޮވާލުން، ފެނުގެ ކުރިއަށް މިންވަރަކަށް ކުރެހުމުގެ އަސަރުކުރާނެއެވެ. އަދި ކަނޑަ ފެރި އަދި ގަނޑުކުރުމަކުން ކުރީގެ އަސަރުކުރާނެއެވެ.

މަޝްރޫޢުގެ ސަބަބުން ތިމާވެށްޓަށް ކުރާނެ ނޭދެވޭ އަސަރު ކުޑަކަމަށް ބެލެވޭ، މަޝްރޫޢުގެ އޮޕަރޭޝަން ފޭސް އަށް ތަފްސީލުކޮށް ބަލައިލުމުގެ މުހިއްމުކަން ކުޑައެވެ. އަދި ނަޖިސްފެން ބޭރުކުރާ ސަރަހައްދާއި ކައިރީގެ ފަރުގަނޑު ފެން ކުރުމަށް އިތުރު އޮޕަރޭޝަނަލް ޚަރަދު ކުރެވޭ ނުބެލެވޭނެއެވެ. ނަމަވެސް، މަސައްކަތް ކުރުމުގައި ބަލާނެ ގޮތްތަކަކަށް ކުރިއެރުން ކަނޑައަޅައިދީ ސަމާލުކަންދެވޭ ކަމަށް މިއީ ބަލާނެ ގޮތް ބަލާ ގޮތެވެ. ބަލަން މި ރިޕޯޓުގައި އަލިއަޅުވައިލައިފައިވާނެއެވެ.

މަޝްރޫޢުގެ ސަބަބުން ތިމާވެށްޓަށް ކުރާނެ ނޭދެވޭ އަސަރު ކުޑަކުރުމަށް ފިޔަވަޅުތައް ހުށަހަޅާއިރު ކުރުމުގެ ކުރާނެ ޙާލަތު ނަތީޖާތަކާއި ފާރަވެރިކަން ބެލެހެއްޓުމެވެ. ނަމަވެސް، އާއްމުކޮށް މި ފަދަ މަޝްރޫޢުތަކުގައި ކަންކުރާ އުސޫލުތައް މަތިން ރޭވިއަޅައިގެން ކުރިއަށް ގެންދިޔުމަށް ތައްޔާރުކުރުމަށް ނުއުޅޭ އެހީތެރިކަން ފަރާތް ގެއްލުން ކުރެ އަދި ސަރަހައްދު އެދެވޭ ކުރެވޭ ގޮތަށް އެކަން ކުރުމަށް ބޭނުންވާ ގޮތެއް މަސައްކަތް ނުކުރުން ނިޒާމު އަޅަމަށް ވާ ޖާގަ މަސައްކަތު ނުކުރުން ވާނުވާ ގުޅޭ ނުކުރުން ފަދަ ކަންކަން ހިމެނެއެވެ.

މި މަޝްރޫޢުގެ ސަބަބުން ފަރުބަޔަށް އެންމެ ބޮޑަށް އަސަރުކުރާނެ ބަދަލުތަކެއް ދިމާވެދާނެ ގޮތް މަދުވާނެ ގޮތްތަކެއް ބާކީ އެއްވެސް ސަރަހައްދުގެ ފެންވަރު ކަނޑު އަދި ކުރީގެ ފެންވަރު ކަނޑައެޅުމަށް އެންމެ ބޭނުންތެރިކަމެވެ.

މި ރިޕޯޓުގައި ހުށަހަޅާފައިވާ ކަންކަމާ ގުޅޭ ސަބަބުން ތިމާވެށްޓަށް ކުރާ ނޭދެވޭ އަސަރު ކުޑަ ނުވަތަ ނޭދެވޭ އަސަރެއް ކަމަށް ކަނޑައަޅާ ދެމެހެއްޓެނިވި ކަންކަމަކަށް މަޝްރޫޢުގެ ސަބަބުން މައިގަނޑު ތަޖުރިބާ އިތުރު އެއްޗެހި އަދި އާސާރުތަށް ގާއިމް ބެލެހެއްޓުން ފެންނަނީ، މި މަޝްރޫޢު ހުރިހާ ފަރާތަކުން ރަނގަޅު ގޮތެއް ގެންދިއުން އެންމެ ރަގަޅު ކަމަށް ފެނެއެވެ.

1 Introduction

1.1 Introduction

The Environmental Protection and Preservation Act (Law No. 4/93) of the Maldives emphasizes on preparation of Environmental Impact Assessment report for any development project that may cause impacts on the fragile environment of the Maldives. Particularly, clause 5 of the Act highlights the importance of Environmental Impact Assessment (EIA). This EIA report is prepared as per the requirements of the National Environmental Protection and Preservation Act of the Maldives and the EIA Regulations of the Maldives.

This EIA report will identify the potential impacts of the proposed sewerage system upgrading works and coastal modifications including the excavation of the shoaled areas of the (water-logged area of the) wetland area to be carried out at Huraa, Kaafu Atoll. Emphasis has been placed on the recommendations for mitigating the impacts that arise during the project period and after completion of the project. This EIA will also discuss on project justification, alternatives to methods of undertaking project components such as sea outfall. The report will further, provide a mitigation plan and a monitoring programme which can be implemented during and after completion of the proposed development works.

The EIA was compiled based on qualitative and quantitative data collected from Huraa during the site inspections and assessments carried out in July 2017. It has to be noted that the limitation on collecting and compiling the data on a very short period due to logistical and other issues such as unavailability of long-term baseline data has made the consultants to restrict the report on data collected recently from the field, personal judgments and experiences gained from similar projects. Similarly, long-term data on some aspects such as meteorology and climate were collected from secondary sources through previously published reports and global databases.

This report has been compiled in accordance with the EIA Regulations 2012, which is enforced by Environmental Protection Agency (EPA) of the Maldives.

1.2 Background to the EIA

This EIA is prepared in accordance with the Terms of Reference (TOR) approved by the Environmental Protection Agency (EPA) 17 July 2017. It is a legal requirement that new projects having potential for environmental impacts gain environmental clearance or approval prior to construction and operation of such projects.

The principal environmental institution that implements EIA process in the country is Environmental Protection Agency. Additionally, the Ministry of Environment and Energy provides policy guidance and directions while Atoll Councils and Island Councils also provide approvals before projects are implemented.

1.3 Scope of the EIA and Approach

The main scope of this EIA report as per the approved TOR is to broadly assess, identify, predict and document potential environmental impacts from the proposed sewerage system upgrading and coastal modification works in K. Huraa. The initial scope covered the sewage outfall, however, the excavation of the water-logged areas of the wetland area and construction of concrete piles for a restaurant near the harbour has been included in order to avoid doing a separate EIA for those components due to their small scale.

This EIA will give importance to document these project components in detail, identify the main environmental impacts that are associated with the proposed project components and address the legal requirements that need to be taken into consideration while implementing this project. This document also addresses the existing environmental condition of the project site(s) and assess possible ways in which potential environmental impacts will be managed, mitigated and reduced.

1.4 Relevant Studies and Experiences

In order to prepare this EIA, relevant EIA reports for sewerage system development including separate assessments done for the inclusion of outfalls in those islands with treatment facilities without even emergency outfalls such as R. Ungoofaaru, F. Nilandhoo, Dh. Meedhoo and N. Manadhoo were undertaken by Zahid and team. The team has also been involved in several coastal modification projects in local inhabited islands as well as resorts, which have been considered. However, there are no studies done earlier to excavate wetland

areas except the works carried out for shrimp fisheries by MIFCO, the EIA of which was done by Zahid and team but not submitted. There are a few wetland modifications done in some of the islands with wetlands including Fuvahmulah, where the Consultants undertook a recent study involving ecotourism. While the wetland ecosystem of Fuvahmulah has unique fauna in addition to the mangroves, the wetland ecosystem of Huraa is protected primarily for the mangrove ecosystem.

1.5 EIA Team

The EIA report was compiled by Ahmed Zahid, who is a registered EIA consultant with over 20 years of experience and has been involved in numerous water supply and sewerage projects in the Maldives and various other projects such as resort development project, reclamation, shore protection and harbour projects. He was assisted by Hussain Fizah, a registered EIA consultant (EIA01/14). Trained environmental surveyors at Sandcays namely Mohamed Visham and Hassan Jameel were involved in the baseline surveys along with Fizah.

1.6 EIA Methodologies

This study was based mainly on data collected during field investigations undertaken by a team from Sandcays Pvt. Ltd. and published literature on similar settings and projects. Established and widely accepted methods have been applied in this EIA study. Field studies have been undertaken using methods generally employed for EIA studies in the Maldives. The field assessment methodologies are briefly described in Section 4.2 of this report.

The methods used to identify, predict and assess impacts are based on matrices that have been established by the Consultants over a long period. In the matrix, the consultants assign a likert-scale number to represent the magnitude, significance, duration and spatial extent of the potential impact for each project activity against the key environmental and socio-economic components that the specific project activity may have an impact on. The product of the magnitude, significance, duration and spatial extent for each activity and component is summed up to measure the exact nature of the impacts by each activity and the overall impact of the proposed project is the sum of all activities.

The approved Terms of Reference (TOR) for this EIA has been given in Appendix 1.

2 Project Description

2.1 Introduction

This section of report is to describe the project in terms of the need and justification of the project, location and boundaries of the project, project schedule, main inputs, project mobilization as well as project construction activities. In addition, this section presents materials and resources that will be used as well as the main output of the project.

2.2 The Proponent

The Proponent of the proposed project is the Secretariat of the K. Huraa Council. The Council has the primary function of fostering development of the island through development planning, community participation and provision of necessary public services such as water, sewerage and electricity while taking necessary measures to establish a safe and peaceful environment on the island in collaboration with the police.

2.3 Project Location and Study Area

The project takes place at the island of Huraa in North Malé Atoll. Huraa is located at 4°20.243'N, 73°36.151'E. Huraa is one of the few inhabited islands of Malé Atoll, which is the central atoll, where the capital city, Malé is located. Huraa has a population of approximately 600 people. It has a growing guesthouse industry with the northern end of the island allocated for a guest house by the Ministry of Tourism. On the south and north of Huraa are two renowned resorts namely Four Seasons Kuda Huraa and Club Med Kanifinolhu respectively.

The proposed outfall and associated facilities such as the pumping station is located towards the centre of the eastern periphery of the island. The wetland area which is to be excavated is found towards the middle of the island whereas the restaurant is on the southwest corner of the island southwest of the harbour. These project locations including project impact boundaries are indicated in magenta in Figure 2-2.

Figure 2-1: Location of Huraa in North Malé Atoll

Figure 2-2: Project components and impact boundaries in magenta

2.4 The Project

The proposed project involves the following components

- Installation of a 465m long outfall on the eastern side extending to -7m depth at MSL with pumping stations to bypass the existing treatment plant in Huraa, which is considered to have maintenance issues. The treatment plant is also energy-intensive and considered an unnecessary burden on such a small population.
- Excavation of the water-logged areas of the wetland which connects to the western lagoon. This excavation will be done to gain a depth of about 1m from MSL. At present the average depth in the wetland is about 0.4m with a large spit of sand accreted at the mouth between the wetland and the lagoon. Therefore, this area would be the primary area to be excavated while other water-logged areas inside the wetland would also be excavated.
- Understanding the impact of the installation of concrete piles for the construction of the restaurant, part of which is in the lagoon. This area has a concrete revetment and does not appear to have any sand beach areas in its lee or windward sides. The piles have already been constructed and the restaurant is nearing completion.

2.4.1 Environmental considerations

The proposed project will consider the following environmental issues while making the final designs:

- Social acceptance;
- Improving water quality and healthy ecological system in the wetland; and
- Sustainable operation and maintenance.

2.4.2 The Outfall

There has been simple upgrades to the existing sewerage system in Huraa based on increasing demand and maintenance issues. One of the primary concerns is the maintenance of treatment plant and its operational cost due to high electricity cost for the operation of the treatment plant. Furthermore, since there is no emergency sea outfall in the system, it has become a requirement. Thus, it was considered worthy, due to the long pumping distance and the added cost of pumping to bypass the treatment process and pump the wastewater effluent off the reef as in many islands in the Maldives. Given the small volume of the wastewater generated for

such a small population, it is considered environmentally as well as economically more feasible to have such a system in place.

The proposed location is the most practicable location for the outfall. The depth of discharge is based on the requirements set out by the Environmental Protection Agency. The proposed location would have enough dilution potential to render minerals and biological components in raw sewage harmless to the marine environment. The currents along the reef should carry the sewage away from the island and ideally away from the reef environment to a large extent. Additionally, the disposal is at suitable depth (over 7m) as not to have raw sewage floating around.

2.4.3 Raw material transportation

Sea transport will be used to carry materials needed for the project. All the activities will be carried according to a planned schedule which will be prepared before commencing the operation.

Construction materials will include PVC pipes, pumps for the pump station, cement, electrical cables, reinforcing steel bars, river sand, aggregates, PVC conduits, fuel, PVC adhesive, timber etc.

Machinery may be used for the excavation of the wetland area while the laying of the sewage outfall would be carried out mainly by manual means. Experienced divers will install the pipeline at the deep area.

2.5 Construction Phase Activities

In the construction phase key activities include mobilization of materials, labour and equipment, material transport, site preparation for repairing the STP and installation of pumping station, land surveys for proper levelling, excavations for laying the outfall.

2.5.1 Site preparations

The project will take place at the existing STP site. Setting a location for material storage and administrative work is important to start the construction work. This is already in place as the contractor is at site. Other important preparation works include:

- Identification of exact locations for pump stations and sewer outfalls;

- Carry out ground level surveys and build a level profile for proposed pipeline networks.
- Appoint staff for site management and material stock control; and
- Make access to areas where work will be carried out (e.g. locations for pump stations)

2.5.2 Workforce and services

This is one of the key components that need appropriate management on site during the construction phase. In the proposed project, an estimated number of 15 staff including labourers, engineers and supervisors will be stationed on the island. Rest of labour force will be obtained locally.

2.5.3 Material transport

All materials that are required for the implementation of the proposed project need to be transported to the island. The transportation will mainly be on *Dhoni*. Transportation of materials is considered to be one of the activities that cause impact to environment mainly due to accidental spills and direct/indirect physical damage to coral reefs due to careless boating/mooring activities and emission of greenhouse gases which will be further discussed under impact analysis.

2.5.4 Waste management

As the existing site of STP has no vegetation, site clearing would not be required, hence no green waste. There will be no damage to trees in or around the project areas during the excavation of the water-logged wetland area. In fact, there are no trees in the excavation areas and hence vegetation would not be affected.

Other waste generated during the construction phase will include construction material waste such as cement, pieces of PVC pipes, scrap metal and general domestic waste from staff. All the waste generated will be disposed of safely using existing waste management system on the island.

2.5.5 Health and Safety

Health and safety is also an important aspect that needs careful consideration during the implementation phase. Protection of employees from likely adverse effects will be one of the

core duties of the proponent or contractor. All machineries and equipment must be operated by trained and experienced personnel wearing necessary safety gears.

Appropriate measures will be in place to ensure safety of workers and public. Safety signs will be placed at necessary work areas. Machinery will be operated with outmost care to maintain safety.

2.6 Operational phase activities

Key activities identified during the operation of the proposed sewerage development works would be sewage effluent disposal and operation of pump stations/lift stations. There are no operational activities for the other two components, i.e. excavation of the water-logged area of the wetland and installation of concrete piles for the restaurant. However, both of these activities will need some environmental monitoring to understand the environmental benefits or impacts associated with these.

2.6.1 Effluent disposal

Wastewater including black and grey water generated in the island is conveyed to the sewage treatment plant through a gravity flow sewer network using small lifting stations. The treated water is disposed of to the ground. There is no emergency outflow. Therefore, effluent disposal in such circumstances is difficult, hence an emergency outfall is necessary. Therefore, it has been decided to dispose the wastewater effluent without treatment using an outfall disposing to over 7m into the ocean.

2.6.2 Operation of the pump stations

The operation of the pump stations is an energy-intensive process. With the treatment plant the energy requirement is more than tripled. Since the island has a small population and sewage and wastewater is predominantly domestic in nature, the need for treatment is not felt sewage can be disposed appropriately into the ocean. Therefore, the operation of the pump stations will continue to reduce the energy requirements for sewage disposal and would have lesser trouble in operation and maintenance, according to the operators.

2.6.3 Environmental monitoring

The project will need to ascertain that it has had a positive impact or understand any negative impacts by studying the changes that occur over a period of time directly as a result of the proposed project components. Therefore, the monitoring programme given in the EIA report would be strictly adhered to.

2.7 Project duration

The project is expected to start soon after the approval of this EIA report, which is expected to take less than 4 weeks from submission. The proposed works are expected to take no more than 6 months including mobilisation and demobilisation.

A tentative work schedule is given in Table 2-1 below.

Table 2-1: Tentative work schedule

	Month 1				Month 2				Month 3				Month 4				Month 5			
Task/Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Mobilization																				
Site preparation																				
Construction of pump station																				
Laying out outfall																				
Excavation of wetland areas																				
Final inspections																				
Demobilization																				

2.8 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is treated effluent. Furthermore, treated sludge can be used as fertilizer for gardening or landscaping. These inputs and outputs are summarised in Table 2-2 and Table 2-3.

Table 2-2: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Construction workers	Contractor's responsibility
Management and maintenance staff	Appointed by proponent
Construction materials: timber, cement, electrical cables, reinforcing steel bars, river sand, aggregates, PVC pipes, fuel, etc.	Import and purchased where locally available at competitive prices – Contractor's responsibility
Water (during construction)	Groundwater extracted for construction, bottled & rain water for consumption for workers

Water (during operation)	*Ground water for flushing*
Electricity/Energy (during construction)	Diesel-based electricity- *diesel* generators
Electricity/Energy (during operation)	Diesel-based electricity- *diesel* generators
Machinery and equipment	Contractor's responsibility
Sulphate resistant cement	Imported or locally purchased
Fuel (e.g. diesel, petrol)	Locally purchased
PVC Adhesives	Imported or purchased locally
Submersible pumps	

Table 2-3: Matrix of major outputs

Products and waste materials	**Anticipated quantities**	**Method of disposal**
Waste oils from machinery	Minute	Re-used *for* other applications
Wastewater effluent	major	Disposed into sea where dilution and dispersion happens
Timber, cardboard, gunny bags and scrap metals (construction site waste)	Moderate	Recovered, reused , recycled
Used oil (waste oil), grease	minute	Reused
Solid waste (kitchen waste, waste from workers)	Moderate/minor	Taken for disposal through island SW system
Sand and debris from excavation	*2,000-2,500m^3*	*Disposed to coastal area on the southeast side of the island*

2.9 Need and Justification

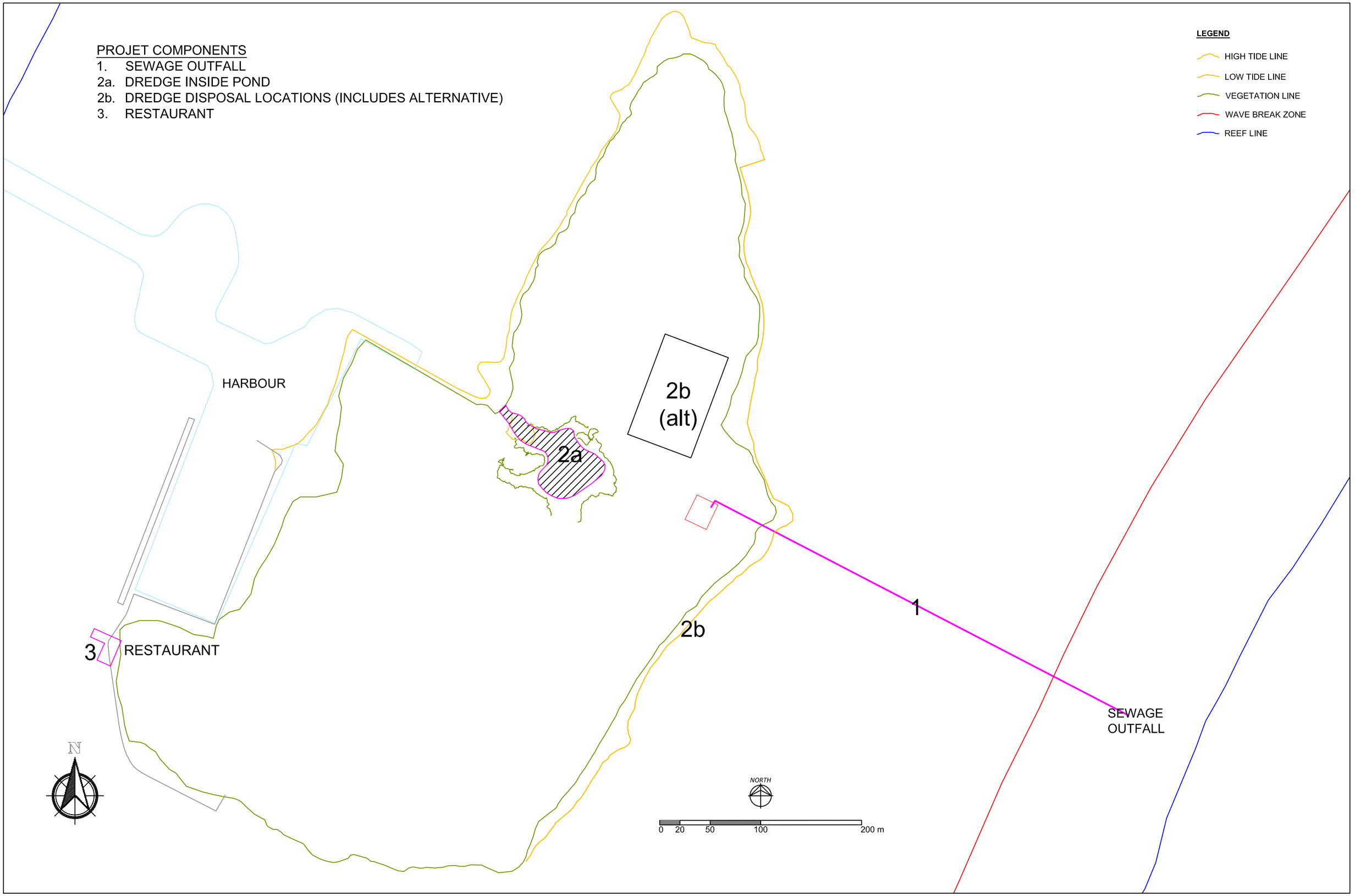
A proper sewerage facility was established in Huraa with the assistance from IFRC around 2009, as part of the rehabilitation program after devastating Indian Ocean Tsunami of December 2004. Even before the salinization of groundwater aquifer caused by the Tsunami, a large number of household groundwater wells had shown signs of pollution related to improper sewage disposal as ammoniac smell and change of colour has been observed. At the time, water treatment and disposal of treated effluent to ground was considered necessary. However, it has been found that the treatment process is an unnecessary cost for such small communities as Huraa. A recent study carried out by AlHabshi Consultants of Kuwait found that in communities where treatment has been included, the treatment plant has been seen as a financial burden while it also had operational difficulties for small communities. For small communities where wastewater is predominantly domestic in characteristics, ocean outfalls located appropriately are considered to be more feasible. In fact, systems with sewage treatment plants would still require emergency sewage outfalls, whereby the cost of the project increases.

In many islands where sewage is treated and treated effluent disposed to sea, the smell in the disposal area and maintenance issues have caused the operator to create a temporary outfall to the nearshore environment with the help of the island council. This setup pumps raw sewage

into shallow lagoon area. Although an in-depth public health assessment has not been carried out, there is a slight possibility of spreading diseases within the island community if the practice continued as in some islands the temporary outfalls were located close to an area used by the public for swimming. Hence, proper ocean outfalls have been constructed in these islands later. This has become accepted practice as the volume of the effluent being disposed is small and the ocean provides the perfect conditions with waves and currents to dilute and disperse the minerals while salt water kills bacteria within a short distance before it can reach nearshore areas.

The proposed deepening of the wetland area is considered to improve water circulation within the wetland. At present the mouth of the wetland, which connects the wetland and the lagoon is nearly closed due to sand collection at this area. This area has been shoaled to a large extent while the water-logged area of the wetland has also become slightly shallower in some areas. Therefore, the reconnection of the lagoon and wetland by removing the shoaled area and by deepening the wetland area is expected to improve the overall health of the wetland area. This will remove the smell in the areas surrounding the wetland due to the deteriorating water quality of the wetland. The project is not expected to cause any negative impacts on the mangroves in the wetland as this has been done in the past and has had acceptable results.

Figure 2-3: Proposed project components



3 Regulatory Aspects

This section will identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. The proposed project is expected to conform to all the policy and regulatory aspects outlined here. This section outlines and summarizes key policies, applicable laws and regulations and regulatory bodies that the Proponent must comply with and be answerable in terms of implementing the project.

3.1 National Policy Guidance

3.1.1 Third National Environment Action Plan

NEAP 3 sets out the agenda for environmental protection and management in the Maldives for the five-year period 2009-2013. This plan is targeted to achieve measurable environmental results that matter to the people of the Maldives.

The aim of developing NEAP 3 is to protect and preserve country's environment and properly manage natural resources for sustainable development of the country and encompasses ten principles, six strategic results with targeted goals to be achieved under each result.

The key principles of the NEAP 3 are:

Principle 1: Environmental protection is the responsibility of every individual

Principle 2: Achieve results

Principle 3: Promote and practice sustainable development

Principle 4: Ensure local democracy

Principle 5: Inter-sectoral co-ordination and co-operation

Principle 6: Informed decision making

Principle 7: Precaution first

Principle 8: Continuous learning and improvement

Principle 9: Right to information and participation

Principle 10: Environmental protection complements development

The six strategic results of NEAP3 are: resilient islands; rich ecosystems; healthy communities; safe water; environmental stewardship; and a carbon neutral nation with 30 result oriented environmental goals that will be achieved in the span of the NEAP 3.

3.1.2 Maldives National Strategy for Sustainable Development

The Maldives National Strategy for Sustainable Development (NSSD) outlines the key objectives, principles and goals that the country will embark toward achieving sustainable development. Hence, the overall direction of the NSSD is to build a nation which appreciates the true value of the natural environment, utilizes its natural resources in a sustainable manner for national development, conserves its limited natural resources, has built the capacity to learn about its natural environment and leaves a healthy natural environment for future generations.

The guiding principles outlined in the NSSD are:

Principle 1: Promotion and protection of fundamental human rights

Principle 2: Equity within and between generations

Principle 3: Democratic and open society

Principle 4: Full participation of businesses and civil society

Principle 5: Policy coherence and coordination

Principle 6: Use best available knowledge

Principle 7: Precaution first

Principle 8: Make polluters pay

While the country will be steered in accordance with the underlying principles of NSSD, the country aims to achieve very important environmental goals, including; adapting to climate change, protecting coral reefs, achieving carbon-neutrality in energy, ensuring food security,

establishing a carbon neutral transport system, protecting public health and achieving full employment and ensuring social security.

3.2 Administrative arrangements

This EIA process will be subjected to the EIA Regulations of the Maldives implemented by the Environmental Protection Agency. As per the EIA Regulations, the Proponent will be responsible for the implementation of the Environmental Impact Assessment, conducting the overall monitoring of the project's environmental performance, and ensuring the proposed activities are in compliance with the EIA and investments are sustainable. The Council may seek support from the Atoll Council/Government in the management of the facilities, construction supervision and monitoring. Monitoring of implementation progress will be carried out periodically and annual monitoring reports submitted to EPA.

3.3 Applicable Laws and Regulations of the Maldives

3.3.1 Environmental Protection and Preservation Act

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management, which are relevant, understood and adhered to in the proposed project.

- An EIA shall be submitted to EPA before implementing any developing project that may have a potential impact to the environment.
- Project that has any undesirable impact on the environment can be terminated without compensation.
- Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.
- The Penalty for Breaking the Law and Damaging the Environment are specified in the Law.
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

Moreover, the project Huraa Kulhi area and the associated mangrove forest was protected under article 4 of the Act.

3.3.2 Environmental Impact Assessment Regulation

The EIA Regulation, which came into force in 2007, has been recently revised and the revised EIA Regulation 2012 is currently in force since May 2012. This EIA is subjected to the EIA Regulations 2012.

The EIA Regulation 2012 is currently only in Dhivehi and an official translation is awaited. The Regulation sets out the criteria to determine whether a development proposal is likely to significantly affect the environment and is therefore subject to an EIA. Schedule D of the EIA Regulations defines the type of projects that would be subject to Environmental Impact Assessment. Ecotourism facilities are not strictly in the list, however, due to the sensitive ecological habitat in which the proposed ecotourism facilities are being developed, EIA is required.

The main purpose of this Regulation is to provide step-by-step guidance for proponents, consultants, government agencies and public on how to obtain approval in the form of an Environmental Decision Statement.

3.3.3 Regulation on Landuse Planning and Management

This Regulation, which sets out the regulatory framework for land use planning and land management in the Maldives, has no specific relevance to the project. However, with the advent of the Regulation, land for residential and institutional areas is located away from industrial zones. Yet, in some of the islands, poor zoning or land use planning has a negative impact on schools and other noise, dust or smell sensitive environments.

3.3.4 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was issued by the Ministry of Environment in 2006. Clause 5 (a) of the Regulation states that prior to the commencement of any project(s) that would require the indiscriminate removal and transplanting of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the Regulation to prepare an Environmental Impact Assessment report.

Article 8 (a) requires permission be obtained from Ministry of Environment, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are

cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (now Island Council) (Article 8 (c)).

This regulation also provides particular protection to the following:

- coastal vegetation extending 15 meters into the island;
- all trees and palms growing in and within 15m around mangrove and wetland areas;
- all trees and palms growing in protected areas; and
- trees and palms that are unique in shape, structure or character

The proposed project does not involve removal of trees at any of the sites.

3.3.5 Regulation on Environmental Damage Liabilities

The Environmental Liability Regulation (Regulation 2011/R-9) came into force on 17 February 2011 and covers a wide range of issues which enable charging penalties and compensation due to environmental pollution and environmental damages. Apparently, the key objective of the environmental liability regulation is to practice polluter pay principles in the Maldives. The proposed project will cut down on environmental liabilities and polluting practices will be almost completely abandoned.

3.3.6 Waste Management Regulation

The Waste Management Regulation (Regulation No. 2013/R-58) came into effect in August 2013. The objective of Waste Management Regulation is to implement the National Waste Management Policy; through which it aims to protect the environment by minimizing the impact of waste on the environment, including the impact of waste on human health, establishing an integrated framework for minimizing and managing waste in a sustainable manner and establishing uniform measures to reduce the amount of waste generated. The regulation also ensures waste is reused, recycled and recovered in an environmentally sound manner before being safely treated and disposed. The regulation covers the management of general, hazardous and special waste. Wastes arising from paints and chemical solvents are considered as special waste.

Clause 1.4 of this regulation is of relevance to the projects under consideration. This clause is for construction waste and it states that;

a. Building construction works shall be planned and organized in a manner that there is minimal waste

b. Measures shall be in place to minimize construction waste

c. Reusable or recyclable waste among demolition/construction waste shall be reused or recycled

d. Construction waste shall be kept at the demolition site until demolition is completed

e. Demolition of buildings shall be done with minimal disturbance due to dust and emissions to the environment and people living in the vicinity.

This regulation was effective from 6 January 2014 and EPA would be responsible for the implementation this regulation.

3.3.7 Dewatering Regulation

Dewatering regulation (2013/R-1697) has been in effect from 1 February 2014. The Regulation covers the following:

- Exceptions under the Regulation including dewatering for cleaning household wells and extraction for agricultural purposes.
- Application for dewatering permits including application form, information required such as size, water quality, work schedule, method of dewatering and disposal location.
- Fees for dewatering permits including MVR500.00 for administrative fees, MVR500 per day for the first 28 days, MVR1000 per day for first extension, MVR1500 per day for second extension and MVR 2000 per day for third extension.
- Water quality testing requirements including parameters that has to be tested
- Provision of information (in writing) regarding dewatering to entities within 30m from the dewatering location and ensuring that in case of difficulty in getting water from neighbouring wells, providing 250litres or RF30 as compensation for each household.
- Provisions for disposal of dewatering effluent.
- Reporting requirements.

- Procedures for termination of work and fines levied.

This regulation would be of relevance if dewatering is required for pumping stations. Dewatering will be undertaken according to this regulation. In fact, there are no groundwater wells within the generally recommended 30m radius of the pump station location.

3.4 International conventions, treaties and protocols

The major global issue facing the Maldives is climate change, global warming and subsequent sea-level rise. The small size of the islands and their low elevation above MSL makes possible impacts of it very serious. Consequently, the country plays a prominent role in fore-fronting environmental issues faced by many other small islands developing states including the Maldives in the international arena. The Maldives is therefore, a party and signatory to various international conventions and declarations. These include:

- UN Convention on the Law of the Sea – UNCLOS (1982)
- International Convention for the Prevention of Pollution of the Sea by Oil (1982)
- Vienna Convention for the Protection of the Ozone Layer (1985)
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
- Basel Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal (1989)
- The London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990)
- Agenda 21 and the Rio Declaration of the United Nations Conference on Environment and Development (1992)
- Convention on Biological Diversity (1992)
- United Nations Framework Convention on Climate Change (1992)
- The Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1992)
- The Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1997)
- The Beijing Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1999)
- Washington Declaration on Protection of the Marine Environment from Land-Based Activities
- Kyoto Protocol to the United Nations Framework Convention on Climate Change (1998)
- Cartagena Protocol on Biosafety (Maldives acceded on 2 September 2002)
- United Nation Convention to Combat Desertification (2002)

The Maldives is also a key player in formulating and adopting various regional plans and programmes to protect the environment by continuously participating in various activities organized by regional bodies such as SACEP, ESCAP and SAARC. As a result the Maldives is committed to the following.

- SAARC Environment Action Plan adopted in 1997 in Male'
- SAARC Study on Greenhouse Effect and its Impact on the Region
- South Asian Regional Seas Action Plan and Resolutions concerning its implementation (1994)
- SAARC Study on Causes and Consequences of Natural Disasters, and
- South Asian Seas Programme initiated by SACEP
- Male' Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia (1998)

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

- United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol which aims at minimising greenhouse gases to reduce or combat potential impacts of global climate change, global warming and associated effects such as sea level rise, which are thought to have devastating impacts on the Maldives, a fragile small island nation. The aspects of the proposed project that apply to this convention are the use of diesel-based power, possible use of small excavators, especially their emissions as well as the use of pumps which consume electricity. These are inevitable impacts; however, efforts should and have been made to minimize all such impacts. These are discussed in the impacts mitigation section.
- United Nations Convention on Biological Diversity (UNCBD) with the objective of "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding". Maldives was one of the first nations to ratify UNCBD. Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002. Formulation of NBSAP was through wide consultation and extensive stakeholder participation.

4 Existing Environment

4.1 Introduction

Study areas existing environment conditions were analysed using appropriate scientific methods. Field surveys were carried out to get further understanding of the existing environment of the project areas. These surveys were carried out during field visit to the island in July 2017 to gather baseline data.

The following components of the existing environment were assessed;

- Terrestrial environment including vegetation cover in the project areas
- Groundwater quality near the STP
- Wetland water quality
- Spot depths of the wetland area
- Bathymetry of the outfall location
- Visual inspection of the coastal area around the restaurant
- Marine surveys at proposed outfall location
- Marine water quality at the lagoon and outfall location

4.2 Methodologies

This section covers methodologies used to collect field data on the existing environment of Huraa. During the field investigation terrestrial, marine, groundwater and socio-economic aspects of the island and its surrounding environment were assessed based on established procedures.

Appropriate scientific methods and field surveys were used to analyse the existing environmental conditions of the study area. The following components of the existing environment were assessed.

- Terrestrial Environment: groundwater quality, wetland and other environmentally sensitive areas, terrestrial flora and fauna
- Social environment: Population, existing sewerage system…etc.
- Marine Environment: bathymetry, marine ecological parameters, marine water quality, protected species, endangered species etc.

4.2.1 Groundwater Quality

YSI and Hatch portable water quality testing hand held meters were used test the groundwater quality in locations used in the initial EIA survey done for the establishment of the existing sewerage system. Parameters tested include, electrical conductivity (µs/cm), dissolved oxygen (mg/l), salinity (%), total dissolved solids (mg/l).

4.2.2 Topographic levels

Topcon GR-5 integrated GPS and echosounder were used to measure the island topographic levels and bathymetry of the outfall. The readings are related to Mean Sea Level (MSL) by relating to the tide data provided by Maldives Meteorological Centre for Malé area. Beach profile was taken at the proposed dredge material disposal location using auto level. Spot depths of the wetland area was taken using handheld GPS (Trimble GeoExplorer 6000) and levelling staff.

4.2.3 Marine Water Quality

YSI water quality logger was used to test the marine water quality at selected locations. YSI water quality logger can measure pH, electrical conductivity (salinity and TDS) and dissolved oxygen (DO), Turbidity (NTU) of the water. Water quality testing was done at two selected marine locations: one in the lagoon on the west close to the mouth of the wetland and the other at the outfall on the east.

4.2.4 Ocean Currents

On updrift and downdrift locations of the proposed outfall, drogues were done to assess currents. A purpose-built drogue with GPS was used to measure the speed and direction of the currents on the day of the field visit.

4.2.5 Condition of the house reef

Marine environment was surveyed using both quantitative and qualitative methods to assess and obtain baseline data of the existing marine environmental conditions at the outfall. Assessment of the benthic substrate at the survey sites including Manta Tow survey, quadrats and visual assessments were used to quantify benthic types.

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

4.2.5.1 Photo-Quadrat Survey

To assess the benthic types and coral species at the survey sites quadrat sampling was carried out. It was carried on two different sites including proposed out fall location around the reef line. It is one of the very common survey technique applied for ecological sampling.

Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. In this EIA study during the field visit, a quadrat measuring 1m x 1m was used for reef sampling.

4.2.5.2 Fish Counts

A video transect was used to assess fish community at the surveyed sites; Site 1, Site 2 and Site 3. A surveyor would swim along the reef-line for one and half minutes with a hand-held underwater video camera. The videos were later examined, all the fish species found in the video were identified and abundance calculated.

4.3 Climate

4.3.1 General climatic conditions

Maldives is in the Monsoonal Belt in the North Indian Ocean. Therefore, climate in the Maldives is dominated by south-west (Hulhangu) and north-east (Iruvai) monsoons. The southwest monsoon is the rainy season which lasts from May to September and the north-east monsoon is the dry season that occurs from December to February. The transition period of the south-west monsoon occurs between March and April while that of the northeast monsoon occurs from October to November. These monsoons are relatively mild due to the country's location on the equator and strong winds and gales are infrequent in the Maldives. However, storms and line squalls can occur, typically in the period May to July. The winds usually get stronger in the south west monsoon especially during June and July. During storms, the impact is greater on the northern atolls than the southern atolls.

Table 4-1: Summary of Monsoons in Maldives

Season	Months
North East-Monsoon (Iruvai)	December to February
Transition Period - 1 (HulhanguHalha)	March to April
South West Monsoon (Hulhangu)	May to September
Transition Period - 2 (IruvaiHalha)	October to November

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25ºC to 30ºC 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 some variation of climate between northern and southern atolls. The table below provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were considered during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 4-2: Key meteorological information (Maldives)

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

4.3.2 Temperature

The temperature of Maldives varies little throughout the year with a mean daily maximum temperature of about 32°C and mean low of 26°C and are rarely below 25°C or above 33°C. The highest temperature ever recorded in the Maldives was 36.8°C, recorded on 19 May 1991 at Kadhdhoo Meteorological Office. Likewise, the minimum temperature ever recorded in the Maldives was 17.2°C, recorded at the National Meteorological Centre on 11th April 1978. The highest recorded temperature for Male' was 34.1°C on 16th and 28th of April 1973. The hottest month of the year is usually April reaching a peak around 24 April.

The figure below represents daily average low (blue) and high (red) temperature with percentile bands: inner band from 25th to 75th percentile and outer band from 10th to 90th percentile (source: weatherspark.com) based on the historical records from 1998 to 2012 at Hulhulé weather station.

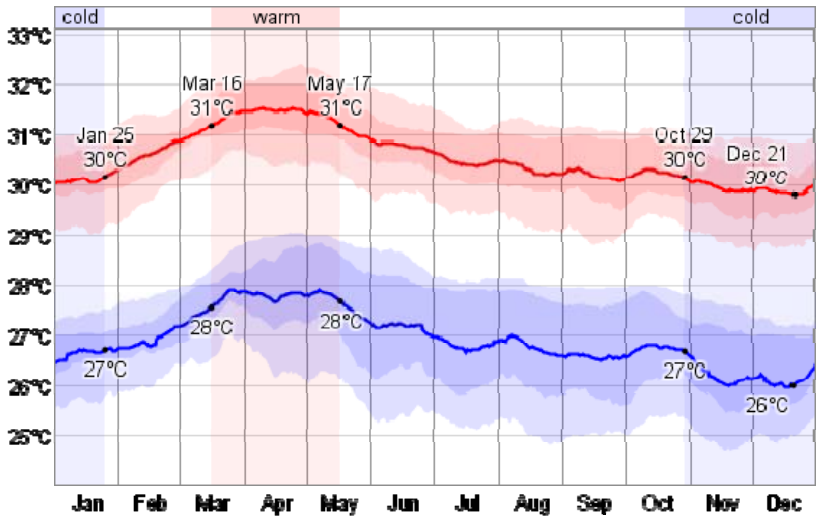


Figure 4-1: Daily average temperature for Central Maldives with percentile bands

The hottest day of the last 12 months was January 5, with a high temperature of 38°C. For reference, on that day the average high temperature is 30°C and the high temperature exceeds 31°C only one day in ten. The hottest month of the last 12 months was April with an average daily high temperature of 32°C.

The longest warm spell was from January 9 to January 30, constituting 22 consecutive days with warmer than average high temperatures. The month of June had the largest fraction of warmer than average days with 93% days with higher than average high temperatures.

The coldest day of the last 12 months was July 9, with a low temperature of 24°C. For reference, on that day the average low temperature is 27°C and the low temperature drops below 25°C only one day in ten. The coldest month of the last 12 months was November with an average daily low temperature of 27°C.

The longest cold spell was from February 24 to March 5, constituting 10 consecutive days with cooler than average low temperatures. The month of December had the largest fraction of cooler than average days with 48% days with lower than average low temperatures.

4.3.3 Rainfall

Annual average rainfall in the 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.

The following figure illustrates the likelihood that precipitation may occur at some point in the day on a given day, based on the historical records from 1981 to 2012 at Hulhulé weather station (weatherspark.com).

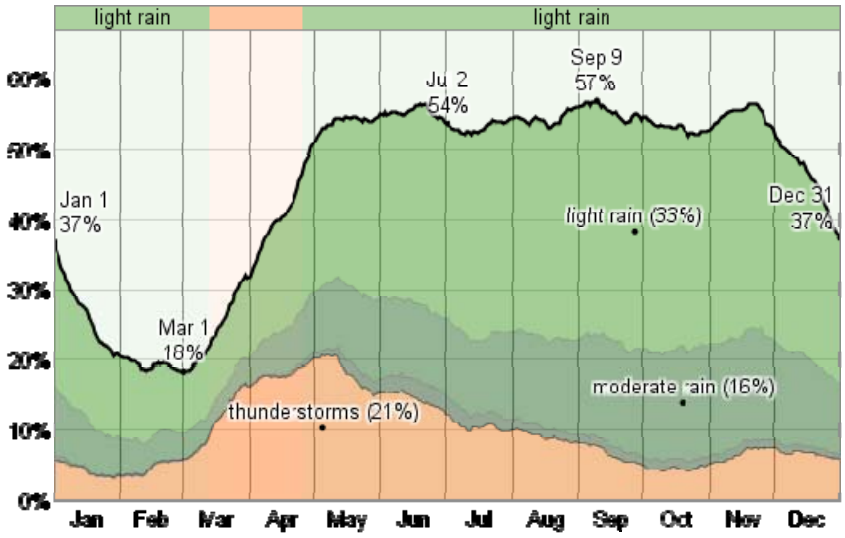


Figure 4-2: Probability of precipitation at some point in the day for Hulhulé, Maldives

4.3.4 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.

The two monsoon seasons have a dominant influence on winds experienced across the 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 (Naseer 2003). Wind speed is usually higher in central region of the Maldives during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975 to 2001. Maximum wind speed recorded in the south was 17.5 m/s 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 (Naseer, 2003). During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

Table 4-3 summarizes the wind conditions in the region throughout the year and Figure 4-3 provides the wind-rose diagram typical to the atoll (adapted from windfinder.com). This analysis represents wind data from Hulhule Airport taken between 07/2002 and 03/2017 from 0700 to 1900hrs local time.

Table 4-3: Summary of general wind conditions in Malé region

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant wind direction	◢	◢	◢	➤	➤	➤	➤	➤	➤	➤	➤	◢	➤
Wind probability >= 4 Beaufort (%)	55	40	15	16	48	47	34	34	34	39	23	38	**35**
Average Wind speed (kts)	11	10	8	7	11	11	10	9	10	10	8	10	**9**
Average air temp. (°C)	30	30	31	31	31	30	30	30	30	30	29	29	**30**

Wind has very little to do with the proposed project components except that the works would be best carried out during the southwest monsoon when the outfall location as well as the proposed dredge material disposal location is on the leeward side of the island making it easier to work.

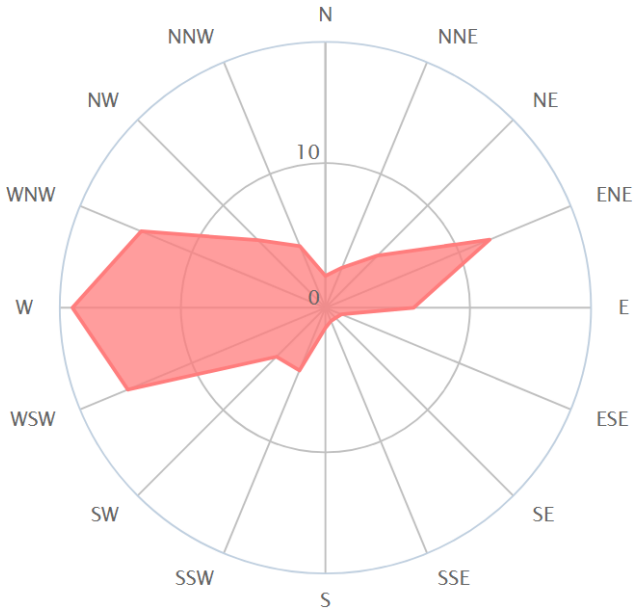


Figure 4-3: Windrose diagram based on data from Hulhulé

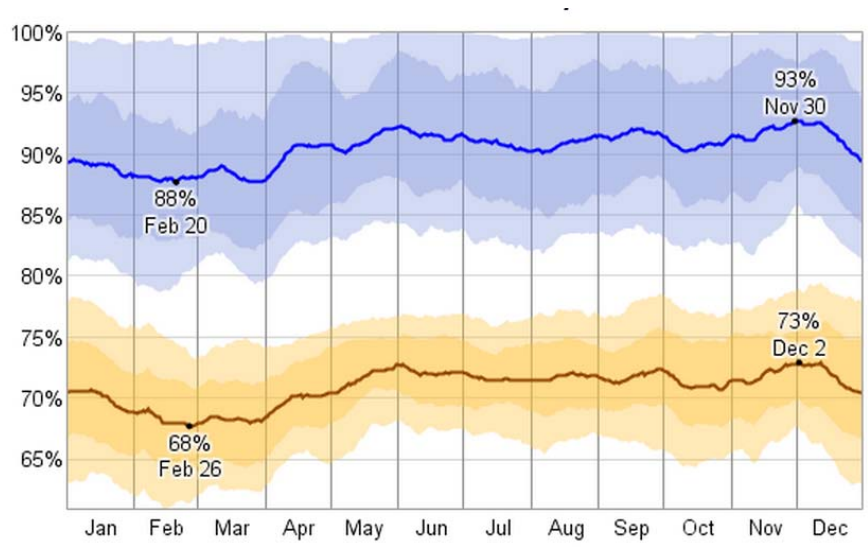
4.3.5 Humidity and Evaporation Rates

Based on data obtained from Hulhulé weather station over a period of 14 years from 1998 to 2012 given in Figure 4-4 (weatherspark.com), the relative humidity typically ranges from 68% (mildly humid) to 93% (very humid) over the course of a year, rarely dropping below 61% (mildly humid) and reaching as high as 100% (very humid).

The air is *driest* around February 26, at which time the relative humidity drops below 71% (humid) three days out of four; it is *most humid* around November 30, exceeding 89% (very humid) three days out of four.

Over the course of a year, the dew point typically varies from 23°C to 27°C and is rarely below 21°C or above 28°C.

Open water evaporation and transpiration from vegetation are very high. The high rates of evaporation and transpiration, especially owing to global warming, may be considered to add further to the evaporation rate and cause sea levels to fall in the future (Morner *et al* 2004). Evaporation rates are influence by wind, temperature and humidity and level of particulates in the air, studies of pan evaporation rates may yield misleading results as pan evaporation rates are influenced by the amount of sunlight hitting the pan, rather than other meteorological factors (Dawson and Spannagle 2009).



The average daily high (blue) and low (brown) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile).

Figure 4-4: Relative humidity over a period of 1 year

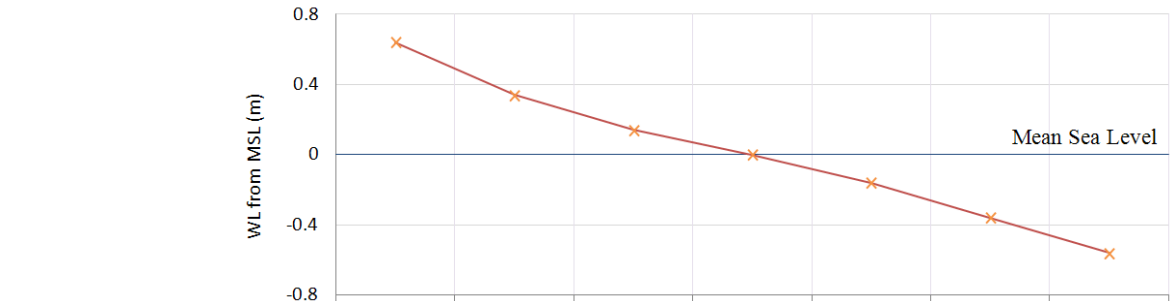
4.4 Hydrography

4.4.1 Tides

Tides affect wave conditions, wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives where the tidal range is small (1m), tides may have significantly important influence on the formation, development, and sediment movement process around the island. Tides also may play an important role in lagoon flushing, water circulation within the reef and water residence time within an enclosed reef highly depends on tidal fluctuations.

Semidiurnal tides are experienced in the Maldives that is two high tides and two low tides a day. The tide varies slightly from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year.

The following figure shows the astronomical tidal variation recorded in the country with respect to the mean sea level. Astronomical tides are related to the motion of the earth-moon-sun system, and have a range of periodicities. The highest astronomical tide was recorded as 0.64 cm above the mean sea level and the lowest astronomical tide was recorded as 0.56 below the mean sea level. Tidal variation of 1.2m from lowest to the highest tide levels were recorded in the country.



	Highest Astronomical Tide (HAT)	Mean Higher High Water (MHHW)	Mean Lower High Water (MLHW)	Mean Sea Level (MSL)	Mean Higher Low Water (MHLW)	Mean Lower Low Water (MLLW)	Lowest Astronomical Tide (LAT)
Water Level referred to MSL (m)	0.64	0.34	0.14	0	-0.16	-0.36	-0.56

Figure 4-5: Astronomical tidal variation in the Maldives

Based on the above tide table and levelling and bathymetry surveys undertaken at site, the proposed outfall shall be below low tide level to minimize damage due to wind and waves and the excavation of the wetland area shall be done to about 0.3m below the lowest astronomical tide to allow appropriate circulation in all tides.

4.4.2 Currents

Studies on current flow within a reef flat in Malé 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.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef platforms, which are capable of transporting sediments on them. Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoon ward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-

lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the back-reef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally, zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

The currents at the outfall location was measured on the day of the field visit, both updrift and downdrift locations of the outfall. These are given in Figure 4-19. However, spot data taken on a single day would not yield sufficient data to understand coastal dynamics. Aspects relating to currents have a direct impact on the sediment transport, especially in understanding the movement of effluent and sediment plumes and the location of the outfall and dredge material disposal. However, due to the small scale of the project, long term monitoring of currents is not necessary but a conclusive assessment could be made based on general current patterns.

4.4.3 Bathymetry

Bathymetry of relevant areas of the project sites is given in Figure 4-20. The bathymetry of the outfall and that of the area to be excavated from the wetland has been given. The depths in the wetland area indicates shallow depths while the depths at the reef flat area indicate the need to bury the pipeline in the shallow reef flat areas in order to minimize the damage.

4.5 Terrestrial Environment

The island of Huraa is an average-sized island. Most of the vegetation has been cut down to build houses and other buildings except for the narrow northeast end starting from the protected wetland area. The wetland area has thick vegetation surrounding its periphery and the northern end now has a guesthouse/hotel for which most of the vegetation has been cleared.

4.5.1 Geological setting and hydrogeology

The islands of Maldives are small, low lying with average height of less than 2.5m above mean sea level and relatively flat (Riyaz *et al.* 2010). The groundwater in Maldivian islands occurs in the form of "freshwater lenses", which are highly susceptible to saline intrusion and vulnerable to pollution from surface and subsurface activities particularly from sanitation practices (Falkland, 2001b). However, the quantity of fresh groundwater in these islands

depends on island size, recharge rate and ease of transmission of freshwater through the aquifers (White *et al.*, 2007). Narrow atolls with transmissive aquifers have limited potential for viable fresh groundwater and the only viable option that remains for these islands are rainwater harvesting and desalination (Falkland 2002).

Generally, the islands of the Maldives have superficial groundwater lenses below about a metre of coralline sandy soil with a very narrow humus layer on top. The groundwater lenses so formed are formed due to density differences between percolated rainwater and saltwater beneath the island. The freshwater lens floats on top of the saltwater. This makes it extremely fragile and prone to saltwater intrusion due to over-abstraction.

The height of ground water lens above mean sea level on islands is deciding factor of the depth of the fresh water lens or aquifer. The typical ratio between the height of the water lens above mean sea level compared to the depth of freshwater below mean sea level is of the order of 1:20. Groundwater levels above mean sea level on small islands may be 0.10 to 0.50m above sea level, resulting in a freshwater lens depth of 2-10m thick. Measuring absolute water level elevations is difficult in small flat islands, so the investigation techniques used target the thickness of the freshwater lens and its aerial extent. The water lens in small islands is illustrated in Figure 4-6.

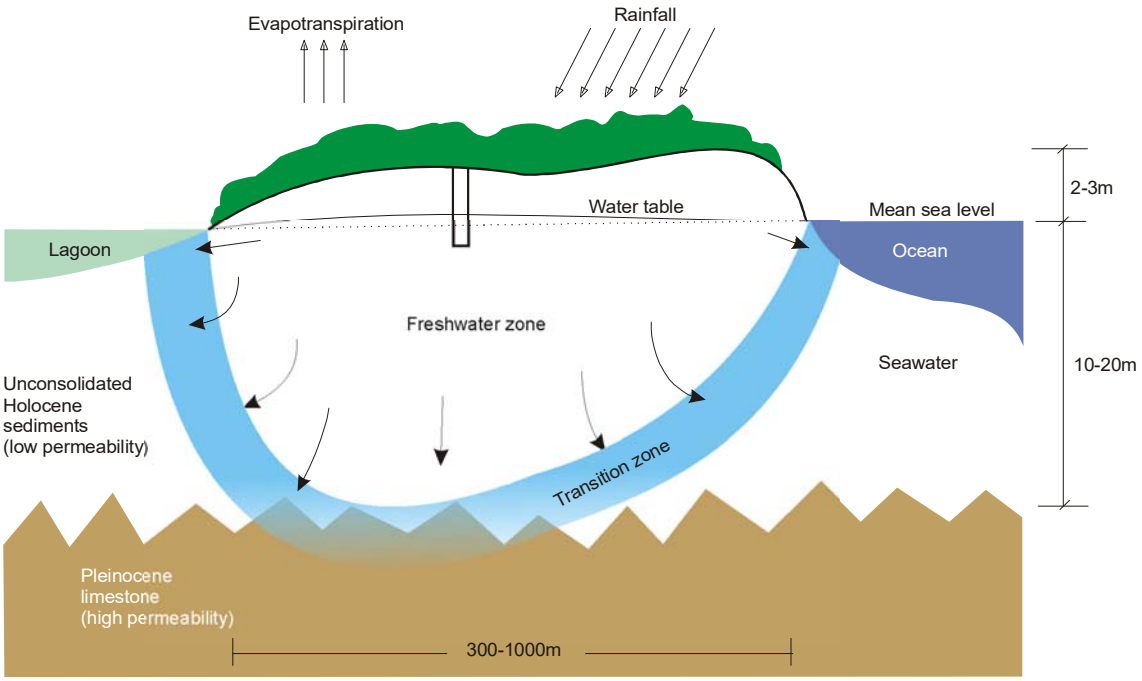


Figure 4-6: Conceptual Illustration of freshwater lens in a small coral island

The above illustration is typical of most of the islands. Borehole test carried out in Malé (MWSC site) indicates an upper zone with loosely packed sandy soil increasing in permeability until a very permeable zone is reached at about 20m below the surface. The freshwater lens is generally formed up to a depth of about 10m and a brackish transition zone occurs below this depth up to about 20m, below which it is saltwater. A detailed assessment of Huraa water lens has been carried out as part of this EIA. The assessment has indicated that the average area of the fresh water lens is about 14 hectares and it is about 50% area of the island. The average sustainable yield per capita of the island is 44 litres per person per day. The average per capita per day of water demand is 90 litres per person per day. This indicates that the freshwater lens of the island would not be able to yield the required volume of freshwater for an average demand even for the current population. Any increase in population will deteriorate the water lens further.

A comparison of a normal case against the best-case scenario for Huraa indicates that the water lens of Huraa would be able to meet the average daily demands of a population of no more than 700 persons. This is illustrated in the figure below.

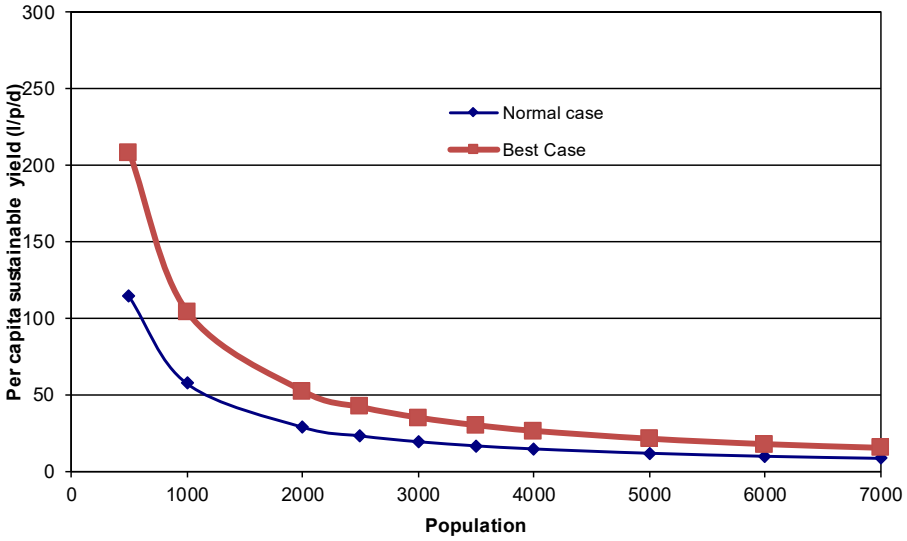


Figure 4-7: Sustainable yield from the groundwater lens for a given population

4.5.1.1 Groundwater quality

During the EIA filed work, ground water testing from 3 different location of island were done. The investigation was aimed to assess the groundwater quality with particular emphasis on salinity changes with respect to the increasing demand.

Table 4-4: Groundwater quality results

Parameter	Units	GW1	GW2	GW3
GPS Location	WGS84 UTM			
Temperature	°C	28.56	28.23	29.12
E. Conductivity	uS/cm	1,330	3,840	973
Total Dissolved Solids	mg/l	856	2,530	632
Salinity	ppt	0.64	2.1	0.48
Dissolved Oxygen	mg/l	7.47	5.06	7.36
pH	8.16	8.02	8.19	7.89

4.5.2 Existing sewage disposal practices

The existing sewerage system in Huraa comprise of a gravity sewer system with lift stations pumping to the treatment plant with collection chambers. The treated effluent was initially disposed to ground but due to smell in the area, the effluent is now disposed to lagoon near the plant using a lagoon outfall.

Even though treatment was included in the design, due to STP failure, raw sewage is pumped directly to the lagoon. There is a visible film of wastewater around the discharge location and signs of eutrophication with increasing growth of seagrass. Except for the visible raw wastewater and bad smell there does not seem to be any other noticeable implication of the practice on the environment.

Figure 4-8: Existing sewage disposal location

4.6 Ecology

4.6.1 Floral Landscape

The wetland area is the only "forested" area with thick vegetation surrounding its periphery. The previously vegetated northern end now has a guesthouse/hotel for which most of the vegetation has been cleared.

A tree survey was not considered necessary as none of the project components affect the vegetation of the island. The mangroves of Huraa Kulhi are of significance and one of the protected attributes of the Protected Area. Therefore, it is important to highlight on the different species of mangroves found in Huraa Kulhi. The main mangrove species found on the banks of the kulhi and the shallows are the Bruguiera (kandoo) while there are some Rhizophora (randoo) with its prop roots sticking high out of water. The secondary mangroves of the kulhi include Hibiscus tiliaceous (dhiggaa) and coconut palms.

4.6.2 Terrestrial Fauna

No terrestrial fauna of significance was observed on the island during the time of the survey. However, according to Saleem and Nileysha (2008), 3 species of reptiles, several species of insects, 10 species of crabs, 4 species of fish, one species of shrimp and 9 species of birds have been observed during their visit to Huraa. Their record of the 9 species of birds observed by them is listed in the table below reproduced from the report.

Table 4-5: Common birds found in the mangroves

Latin Name	Common Name	Local Name
Calidris ferruginea	Curlew Sandpiper	Bondana
Caharadrius sp.	Mongolian Plover	Fidhana
Babulcus ibis	Catter Egret	Iruvaihudhu
Ardea alba	Great Egret	Laganaa
Ardea cineria rectrostris	Eastern Grey Heron	Maakanaa
Nycticorax nycticorax	Black-Crowned Night Heron	Raabondhi
Arenaria interpres	Ruddy Turnstone	Rathafai
Anas clypeata	Northern Shoveler	Reyru
Ardeola graii phillipsi	Maldivian Pond Heron	Kanbili

The Kulhi is known to inhabit several mangrove crabs, only a few of which have been observed during the field visit although several crab holes can be found on dry and inter-tidal areas of the kulhi. Migratory birds have been reported to be observed occasionally. These

include grey heron/*maakanaa* (*Ardea cinerea*), Maldivian little heron/*raabondhi* (*Butorides striatus albidulusi*) and common sandpiper/*findhana* (*Tringa hypoleucos*).

Figure 4-9: Mangrove crabs encountered during field visit

4.6.3 Protected areas and sensitive sites

As per the requirements of the TOR, Protected Areas (MPAs) and ecologically important or sensitive sites such as breeding or nursery grounds for protected or endangered species have been considered. Towards the northern end of Huraa and occupying a large area towards the middle of the island of Huraa opening to the western lagoon is a protected mangrove wetland area. It has been protected since 14 June 2006. It is the only protected mangrove wetland in Malé Atoll, for which reason it is of significance. With the growing population, and the increasing demand for land in some islands, wetland areas have been reclaimed and mangrove trees felled. While wetlands such as that in Huraa may be a habitat for migratory birds, it is also of high ecological value and is becoming an increasingly important avenue for ecotourism. Therefore, its preservation and enhanced management is of utmost importance.

4.6.4 Endangered species

Two or three species of endangered mangrove trees exist in the protected wetland area of Huraa. They are Bruguiera (*kandoo*), Rhizophora apiculata (*thakafathi*) and Rhizophora mucronata (*randoo*). There are also protected birds that visit the mangrove area.

4.6.5 Marine environment

Marine environment was surveyed to assess and obtain baseline data of the existing marine environmental conditions. Both quantitative and qualitative methods were used to assess the benthic substrate at the survey sites including, quadrats and visual assessments were used to quantify benthic types.

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

Figure 4-10 shows attributes of the housereef within the project areas, their extent, quantitative photo quadrate reef survey sites and status of the reef in terms of percentage of benthic cover at these sites. Photo quadrates were conducted near the proposed outfall and following attributes were recorded.

- Live corals of different coral categories
- Dead Coral with Algae
- Turf
- Rubble
- Sand
- Fish and their relative abundance

The following sub-sections provide results of the quantitative assessment, including reef slope and the reef flat area at the outfall in terms of percentage benthic cover, fish count and general status of the reef.

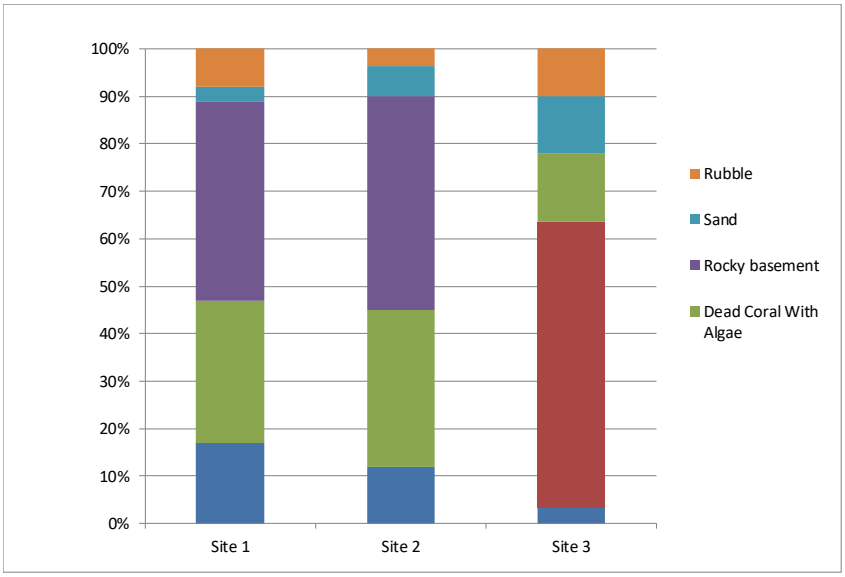


Figure 4-10: Attributes of marine environment at the outfall locations

4.6.6 Marine Ecological Survey Results

The biotic and abiotic benthic components of all the sites were examined using photo quadrates. All the live coral colonies were identified to at least their genus level. The cover percentages given from CPCe is then examined and results given below.

The abundances of fish were estimated using video transects. All the fish were identified to their species level.

4.6.6.1 Site 1

Marine transect, Site 1 was located on the shallow reef slope of the proposed outfall. Benthic substrate was dominated by bedrock (42%) and dead corals and rubble (38%) while live corals were few (less than 20%); most of which were found to be from *Acropora* digitate and coral massives.

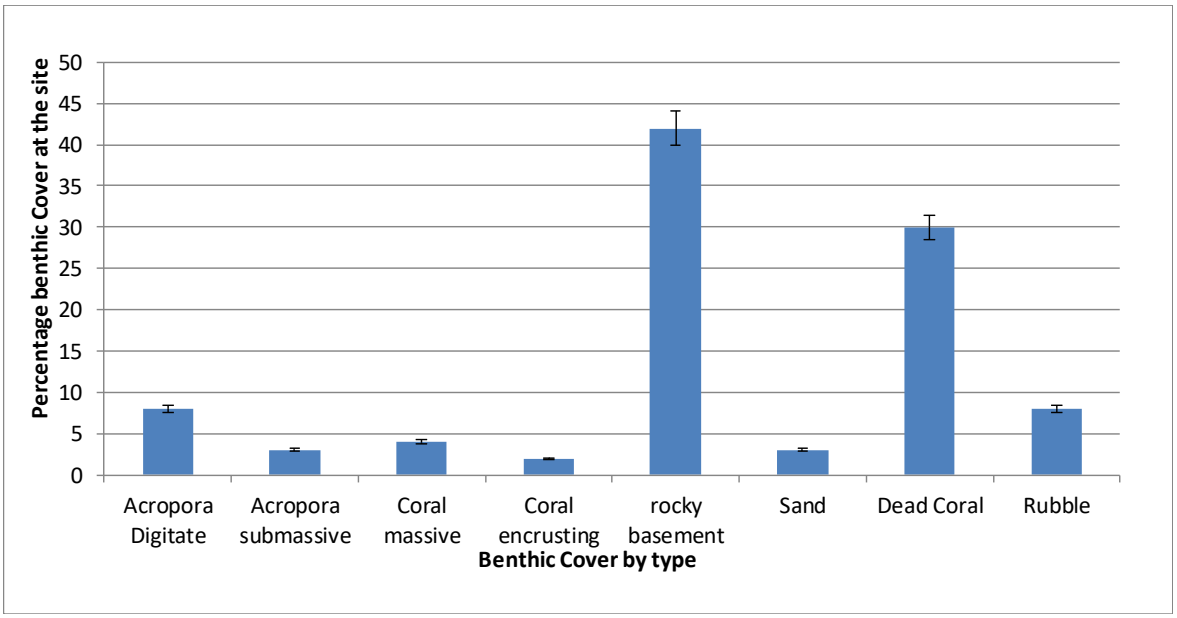


Figure 4-11: Composition of benthic cover at Site 1

Figure 4-12: Photos of Site 1

The fish community was characterized by an abundance of small reef fish such as red toothed triggerfish.

Table 4-6: Fish survey results, site 1

Common Name	Scientific Name	Abundance
Peacock Rock Cod	*Cephalopholis argus*	4
Checkerboard Wrasse	*Halichoeres hortulanus*	5
Longnose Butterflyfish	*Forcipiger longirostris*	4
Lined Bristletooth Surgeonfish	*Ctenochaetus striatus*	12
Powder-blue Surgeonfish	*Acanthurus leucosternon*	7
Bird Wrasse	*Gomphosus caeruleus*	3
Indian Triggerfish	*Melichthys indicus*	10
Moorish Idol	*Zanclus cornutus*	2
Red-toothed Triggerfish	*Odonus niger*	50+

4.6.6.2 Site 2

This transect was on the north of the proposed outfall which is at a location updrift of the proposed outfall most of the time. This site is similar in benthic cover to Site 1.

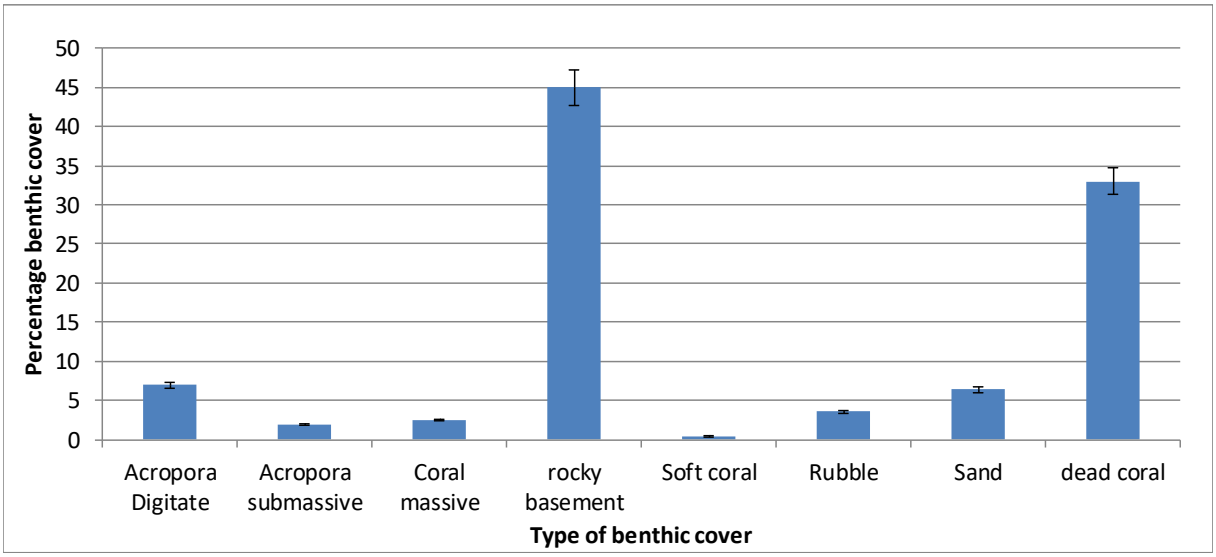


Figure 4-13: Composition of benthic cover at Site 2

This site has lesser number of reef fishes with 2 species of wrasse dominating the fish community at the time of this survey.

Table 4-7: Fish survey results, Site 2

Common name	Scientific name	Abundance
Moorish Idol	*Zanclus cornutus*	2
Peacock Rock Cod	*Cephalopholis argus*	2
Six-barred Wrasse	*Thalassoma hardwicke*	6
Bird Wrasse	*Gomphosus caeruleus*	4
Zigzag Wrasse	*Halichoeres scapularis*	12

Common name	Scientific name	Abundance
Eye-stripe Surgeonfish	*Acanthurus nigricauda*	5
Orangespine Unicornfish	*Naso elegans*	4
Indian Triggerfish	*Melichthys indicus*	8
Red-toothed Triggerfish	*Odonus niger*	30
Blunthead Wrasse	*Thalassoma lunare*	100+

Figure 4-14: Photos of Site 2

4.6.6.3 Site 3

Site 3 was located on the reef flat area of the pipeline route. This site has a few discrete corals, most of which were dead on sandy floor with rubble and covered by seagrass. The site mainly consists of sea grass, sand and dead corals. Most of the coral have algae indicating they have been dead for a considerable amount of time.

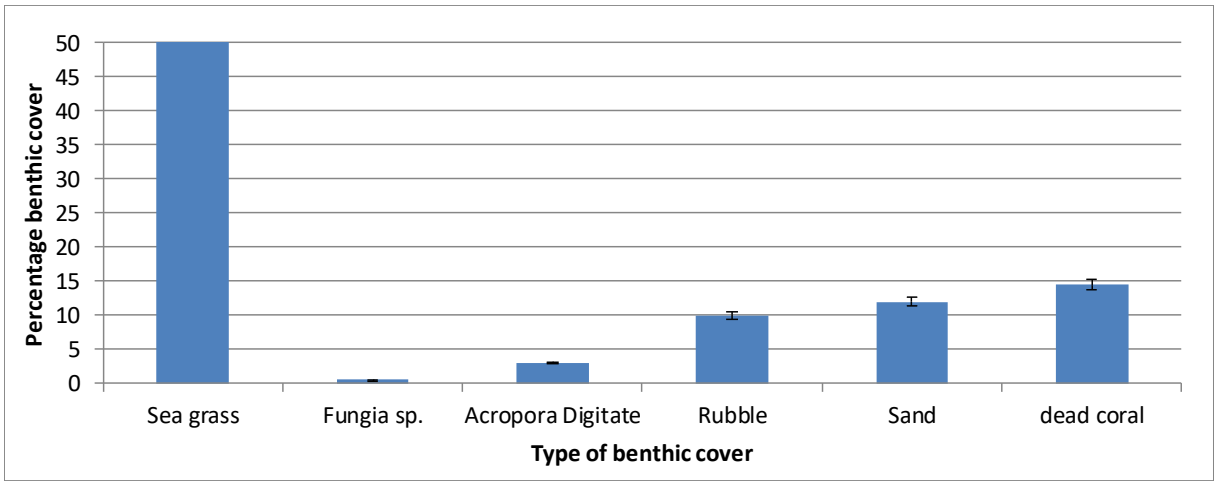


Figure 4-15: Composition of benthic cover at Site 3

Fish population was found to be low and few juveniles were observed.

Table 4-8: Fish survey results, Site 3

Common name	Scientific name	Abundance
Twospot Damselfish	*Chrysiptera biocellata*	6
Peacock Rock Cod	*Cephalopholis argus*	1
Indian Damselfish	*Pomacentrus indicus*	2

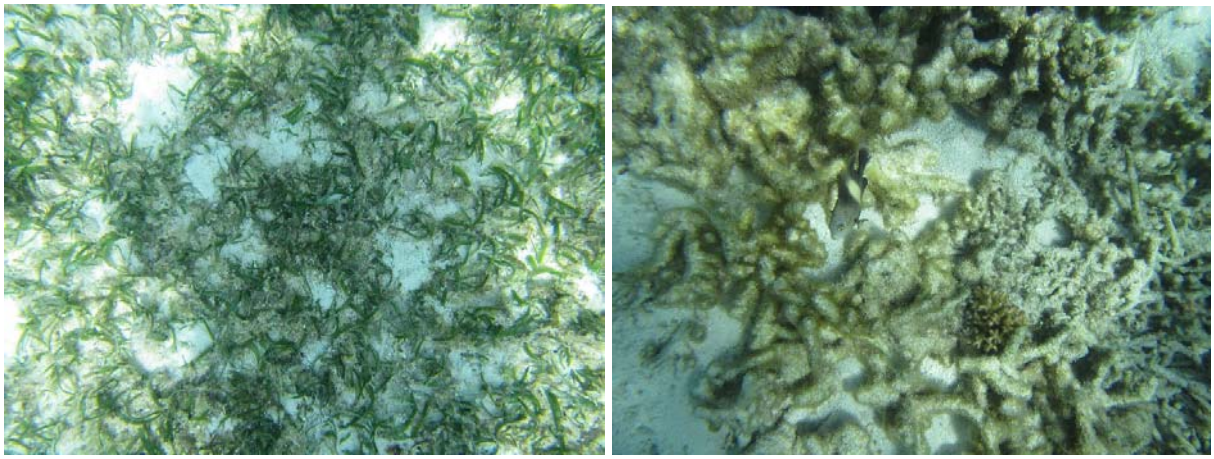


Figure 4-16: Photos of Site 3

4.6.7 Marine water quality

Water quality was tested at the two transect locations and in the lagoon near the wetland as shown in Figure 4-19. The water quality results indicate that the marine water quality is in good condition with acceptable levels of dissolved oxygen.

Table 4-9: In-situ water quality results

Parameter	Units	MWQ1/Site 1	MWQ2/Site 2	MWQ3
GPS Location	WGS84 UTM	345358.42E 478934.35N	345452.84E 479123.48N	344682.85E 479328.90N
Temperature	°C	29.06	28.42	30.13
E. Conductivity	uS/cm	54,330	54,140	52,130
Total Dissolved Solids	mg/l	34,980	35,310	34,250
Salinity	ppt	35.72	35.13	34.88
Dissolved Oxygen	mg/l	4.12	4.87	5.88
pH	8.16	8.31	8.33	8.05
Turbidity	NTU	0.44	0.76	0.94
Total Suspended Solids	mg/l	0	0	1

4.7 Socio-economic environment

Male Atoll being the central and capital region has the highest population per atoll. The total population of the Atoll as per 2014 preliminary census data is 26,305 including the foreigners working in the Atoll. The number of local population in Malé Atoll is 16,906. The census data of 2006 shows that the local population stood at 15,441 denoting that there is a 10.7% increase in population from 2006 to 2014. The 2014 preliminary results show male:female ratio is 2.01 male per female.

With a total registered population of 8,417 (Census 2014), there are a total of 6 inhabited islands in North Malé Atoll. This does not include the capital Malé and the Greater Malé Region. The inhabited island with the largest population in North Malé Atoll, is Kaashidhoo existing as a separate natural atoll north of North Malé Atoll. It has a population of about 1860. All of these inhabited islands in North Malé Atoll are seeing a boom in the recently introduced guesthouse industry with several guesthouses operating in Huraa. On either ends of Huraa, sharing the same reef, are renowned resorts namely Club Med Kanifinolhu on the north and Four Seasons Kuda Huraa on the south followed by Cinnamon Dhonveli.

All of the other islands in the North Malé Atoll has been leased as tourist resorts including most of the lagoons where resorts are being developed by reclamation of islands. There are over twenty operational resorts in North Malé Atoll.

Table 4-10: Island level Demographic statistics of Alifu Dhaalu Atoll (Census 2014)

Island	Total			Maldivians			Foreigners		
	Both Sexes	Male	Female	Both Sexes	Male	Female	Both Sexes	Male	Female
Kaashidhoo	1,865	960	905	1,715	821	894	150	139	11
Gaafaru	1,066	569	497	1,010	519	491	56	50	6
Dhiffushi	1,053	548	505	966	467	499	87	81	6
Thulusdhoo	1,408	811	597	1,127	552	575	281	259	22
Huraa	1,300	758	542	1,014	495	519	286	263	23
Himmafushi	1,725	1,241	484	1,328	861	467	397	380	17

The total employed population of Malé Atoll, including South Malé Atoll is around 9000. Most of the people work in the tourism industry (resorts and restaurants) while least percentage of the working population is involved in extra-territorial organization and real estate business. This picture must have changed considerably now with the booming local tourism industry.

4.8 Natural hazard vulnerability

Huraa is on the south-eastern rim of North Malé Atoll at a location where oceanic swells from the east can have a large impact. Thus, the eastern shoreline is prone to stronger wave attack. However, there is good protection afforded by the superficial reef flat (dry at low tide in most areas) and the shallow lagoon.

The height of the island is at an average of 1.3m above MSL at the eastern side while it is slightly lower on the western side. This is quite low, however, there is low potential for tidal surges. Therefore, the existing height is sufficient to render the island safe from tidal inundation under normal tidal surge conditions. Apart from that there are no natural hazard concerns.

Following the tsunami event of December 2004, UNDP carried out a detailed assessment of the natural vulnerability of the islands and atolls of the Maldives to potential hazards using appropriate models to understand the risk factors of the country. The summary below is based on this natural vulnerability assessment.

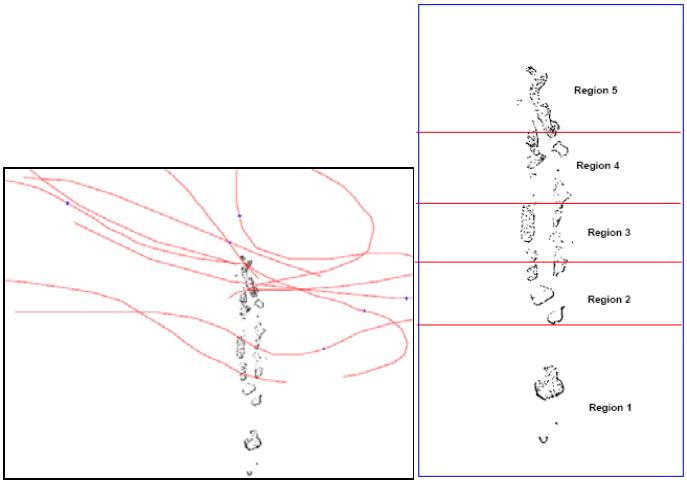
An island's natural vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island and location of the island with respect to the country, the formation of the island, location of the island respect to the atoll,

orientation of the island, region of the country where island is located, level of protection 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 defense structures on the island, shape of the island and the area of the island. Although Maldives is generally considered to have moderate risk to natural hazards or disasters, islands across Maldives experience varying degree and magnitude of natural disasters.

The stormy weathers around the world are affecting coral reef systems directly and indirectly due to global climatic changes. Intense storms can wipe out the natural coral "recruitment" process (Daily Science, April 29, 2008) as a direct effect of climatic change. Healthy coral reef systems are vital assets to many economies around the world on which large numbers of island communities, including the Maldives, depend on a range of fisheries activities. In the Maldives, for instance, according to NAPA (2006), local demand on reef fishery has increased in recent years. Therefore, the concerns due to natural hazard vulnerability of coral reefs in the Maldives are very high, which needs a solution through local and global effort.

Besides heavy rains and strong winds during monsoons, hazardous weather events which regularly affect Maldives are tropical storms or 'tropical cyclones', and severe local storms. At times, tropical cyclones hitting Maldives are destructive due to associated strong winds that exceed a speed of 150 kilometres per hour, rainfall of above 30 to 40cm in 24 hours and storm tides that often exceed four to five meters (UNDP 2006).

Cyclonic winds sometimes can cause a sudden rise in sea-level along the coast, leading to a storm surge. The combined effect of surge and tide is known as 'storm tide'. Storm tides can cause catastrophe in low-lying areas, flat coasts and islands such as Maldives.



Hazard Zone	Probable Maximum Wind Speed (knots)	Saffir-Simpson Scale
1	0.0	0
2	55.9	0
3	69.6	1
4	84.2	2
5	96.8	3

Figure 4-17: Cyclonic wind hazard zones (adapted from RMSI/UNDP 2006)

Referring to Suffir-Simpson Scale given in Figure 4-17, Huraa is in a moderately high vulnerable zone when cyclonic winds and storm surges over the Maldives are concerned and low risk when tsunamis and earthquakes are concerned. The island falls under hazard zone 4 at Suffir-Simpson Scale 2, the maximum probable wind speed expected to be at 84.2knots as shown in the above figure.

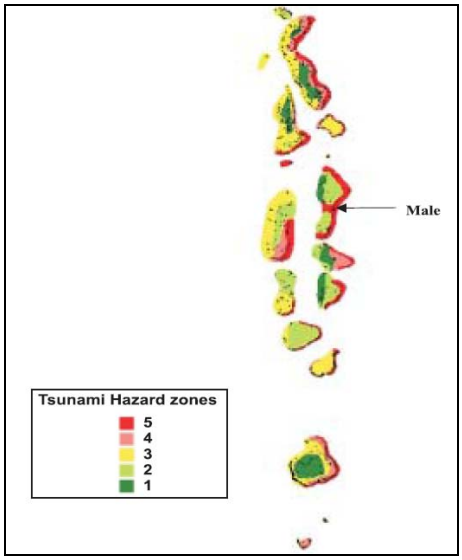


Figure 4-18: Tsunami hazard zones

Figure 4-18 show that Maldives faces tsunami threat largely from the east and relatively low threat from the north and south. So, islands along the eastern fringe 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. This map is produced based on the experience of

the tsunami in 2004 and also occurrence of historic tsunami events in the greater region where most of the events have identified to have occurred from the Sumatra Region (UNDP 2006).

Maldives is also affected by severe local storms-thunder storms/thunder squalls. Hazards associated with thunder storms are strong winds, often exceeding a speed of 100 kilometres per hour, heavy rainfall, lightning and hail; they also give rise to tornadoes in some regions. In general, thunderstorms are more frequent in the equatorial region than elsewhere, and land areas are more frequently hit by thunderstorms as compared to open oceans. However, thunder storms close to the equator are less violent when compared with those in the tropical regions and beyond. Maldives being close to the equator; thunder storms are quite frequent but less violent here. Strong winds generated by severe local storms generate large wind-driven waves which are hazardous for Maldives (UNDP 2006).

Vulnerability of the islands of the Maldives to flooding and storm surges and possibly complete inundation is high due to increasing vulnerability to the effects of global warming such as melting of polar ice caps. As a result, sea level rise due to climate change has uniform hazard throughout the country (RMSI/UNDP 2006). However, there are theories that support that high rates of evaporation in the tropical Indian Ocean may cause water levels to go down although pan evaporation studies may indicate of only evaporation due to sunlight falling on the pan excluding other meteorological factors.

Rainfall in the Maldives is such that regular flooding caused by heavy rainfall is a somewhat annual occurrence especially for those islands with low lying areas towards the middle of the island. For Huraa, such flooding is not considered to be a cause for concern as the residential areas within the island are level and the island does not cup towards the middle of the island except the low-lying wetland area, which connects to the sea.

Figure 4-19: Survey locations

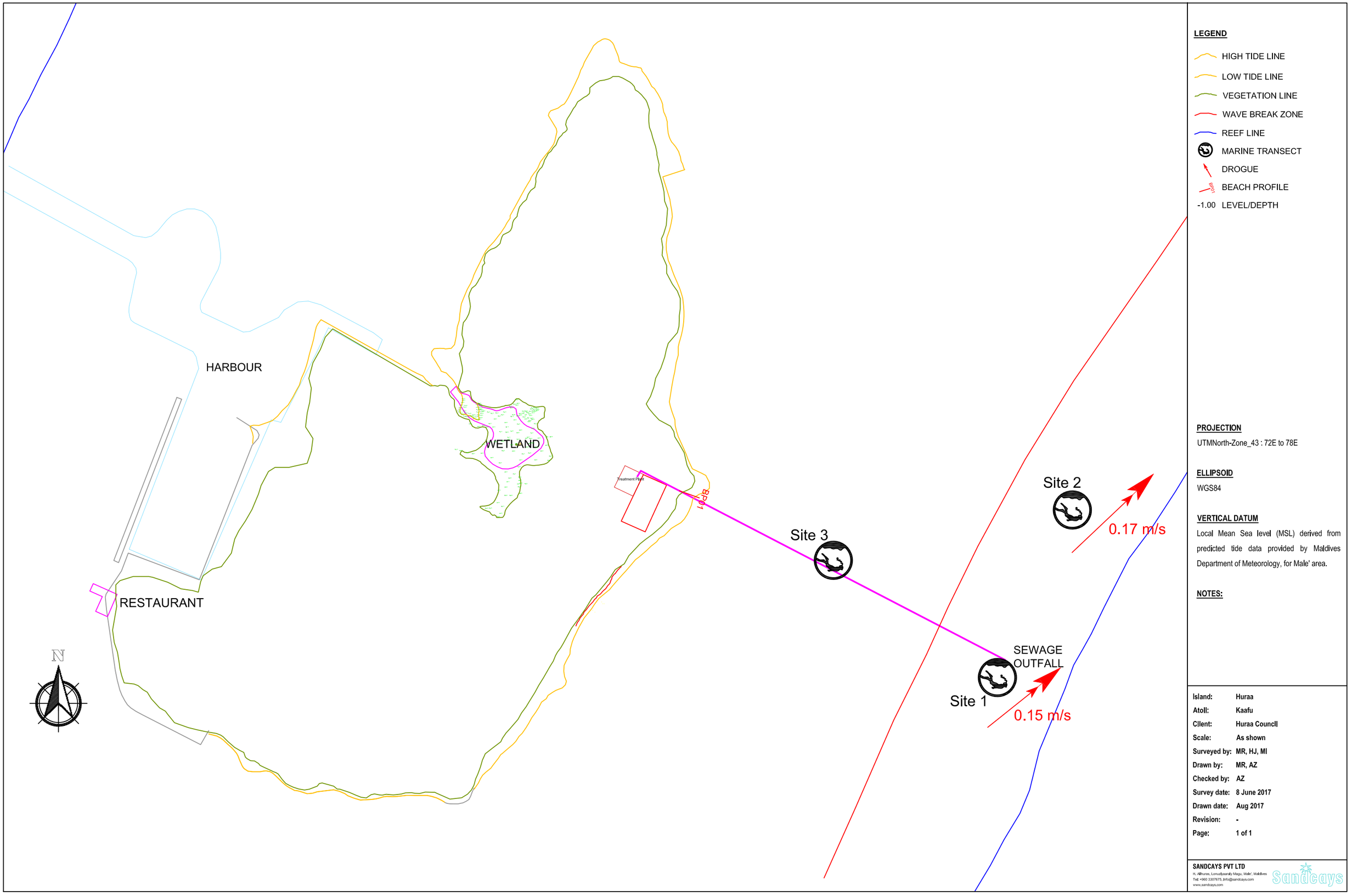
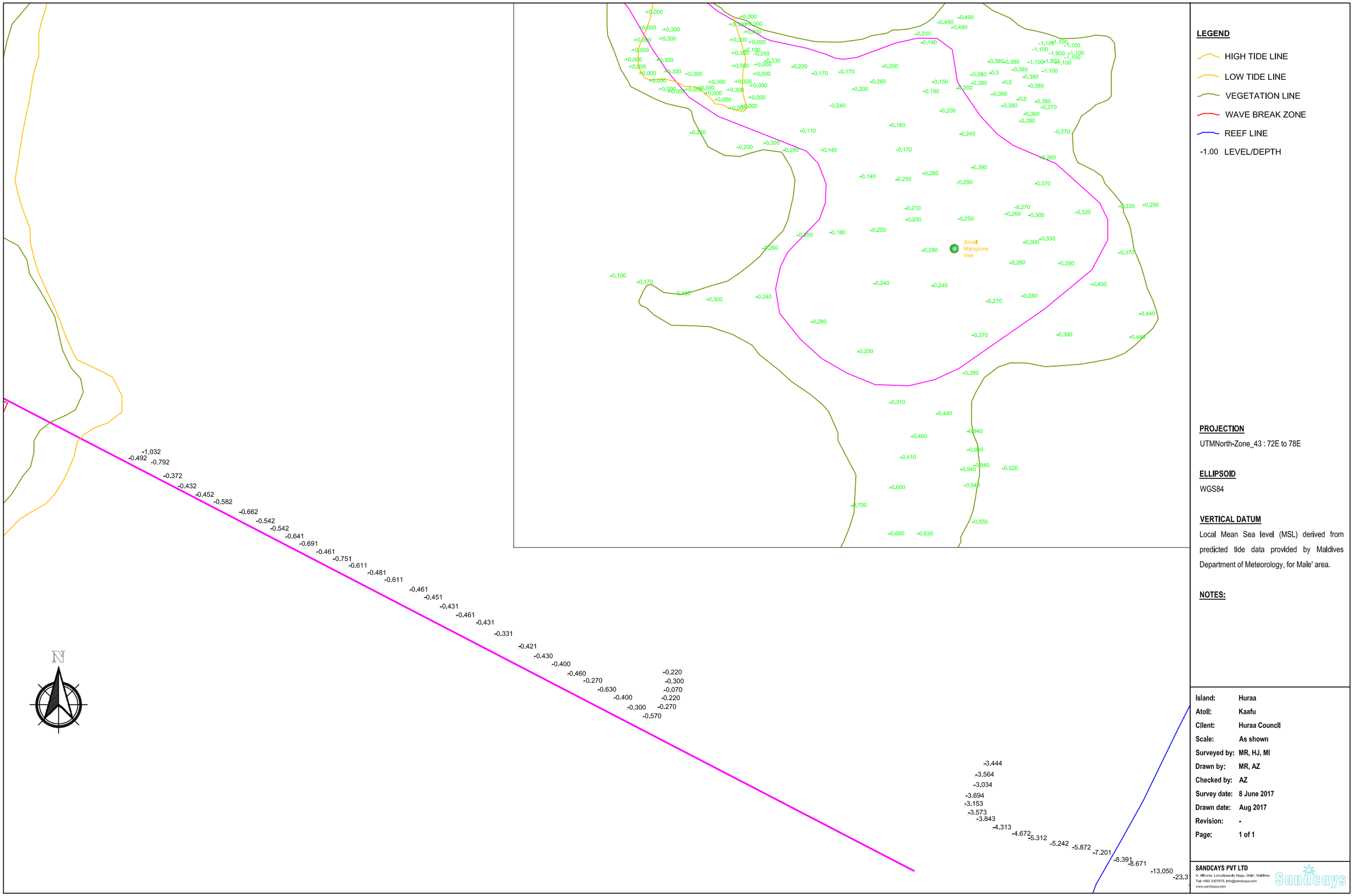


Figure 4-20: Bathymetry



LEGEND

- HIGH TIDE LINE
- LOW TIDE LINE
- VEGETATION LINE
- WAVE BREAK ZONE
- REEF LINE
- -1.00 LEVEL/DEPTH

PROJECTION

UTMNorth-Zone_43 : 72E to 78E

ELLIPSOID

WGS84

VERTICAL DATUM

Local Mean Sea level (MSL) derived from predicted tide data provided by Maldives Department of Meteorology, for Male' area.

NOTES:

Island:	Huraa
Atoll:	Kaafu
Client:	Huraa Council
Scale:	As shown
Surveyed by:	MR, HJ, MI
Drawn by:	MR, AZ
Checked by:	AZ
Survey date:	8 June 2017
Drawn date:	Aug 2017
Revision:	-
Page:	1 of 1

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www.sandcays.com

Figure 4-21: Photographic summary of the coastal area including the wetland

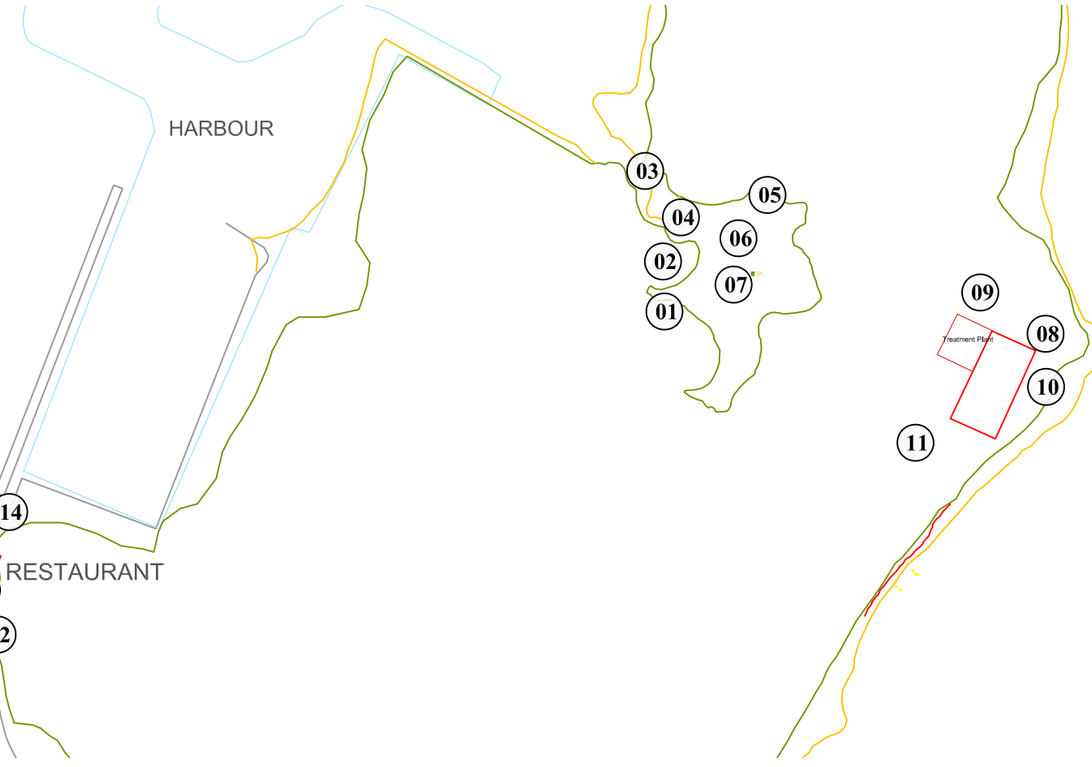
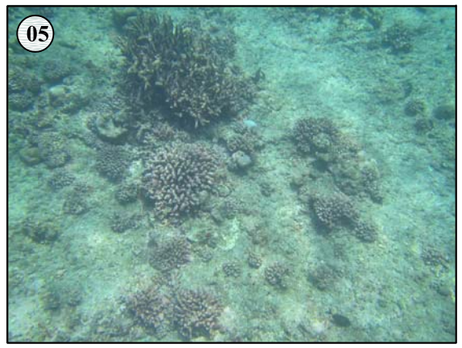
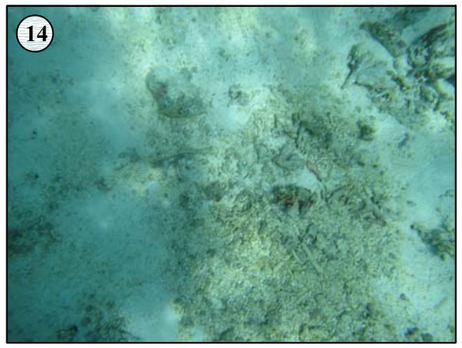
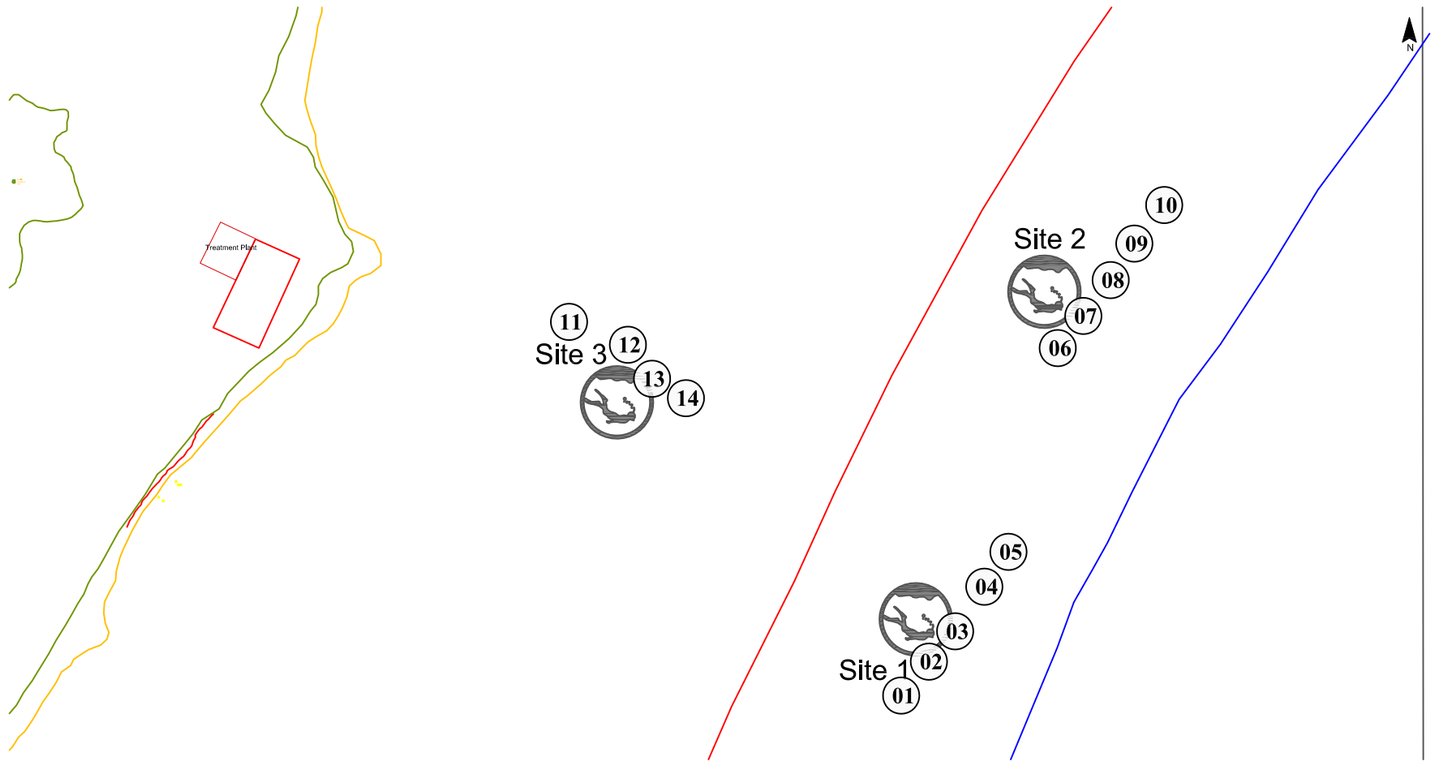
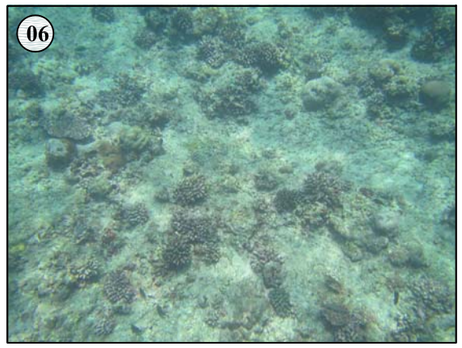


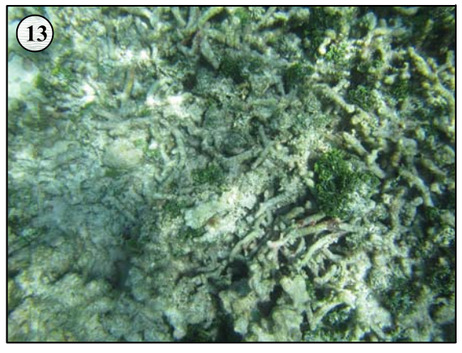
Figure 4-22: Photographic summary of marine survey sites 1 to 3

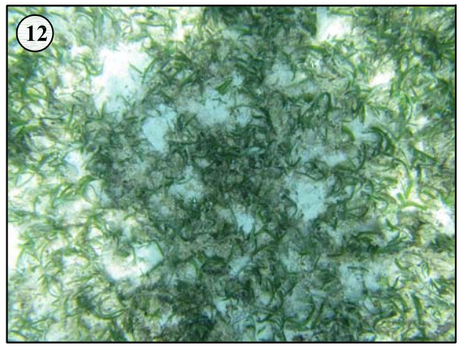


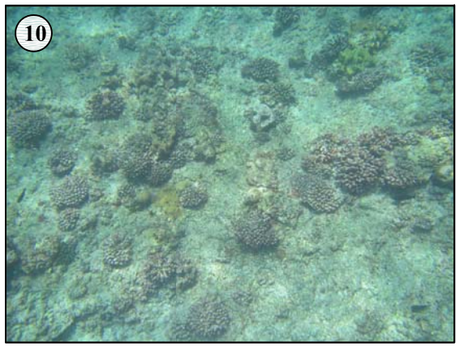


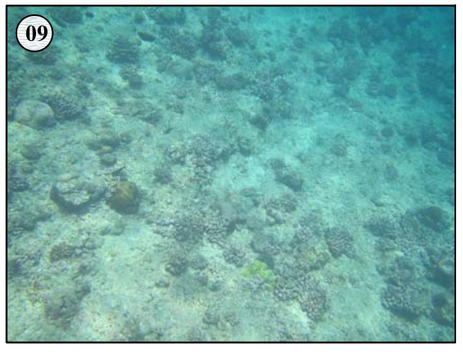


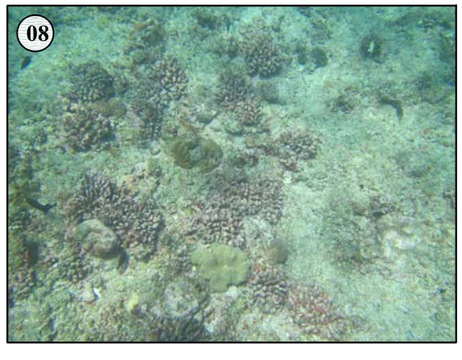












5 Stakeholder Consultations

The key stakeholders of the project include the Island Council, Ministry of Environment and Energy, Environmental Protection Agency, Ministry of Housing and Infrastructure, Proponent Contractor and Project Engineers, Consultants and general public. The approved Terms of Reference for the EIA report specifically asks consulting the following parties.

- Ministry of Environment and Energy (Water Department)
- EPA (water and ERC sections)
- Health Protection Agency (HPA)
- Four Seasons Kuda Hura Resort

These parties have been specifically discussed and views of NGOs and local guesthouses in the vicinity have also been consulted. These consultations have been undertaken jointly by the Island Council (the Proponent) and the consultants. The key points that were noted during discussions are outlined in the subsections below. The list of people consulted are given in the table below.

Table 5-1: List of people consulted

Name	Designation	Office	Contact
Riffath Naeem	Assistant Director	EPA	riffath.naeem@epa.gov.mv
Ali Mishal	Enginering	EPA	
Moosa Hameed	Sen. Public Health Officer	Health Protection Agency	
Eesa Ahmed	President	Huraa Council	7777644
Fayaz Ibrahim	Vice President	Huraa Council	7993018
Ahmed Asif	Budget Officer	Huraa Council	7794300
Kevin Sudanprigi	ADOF	Four Seasons Kuda Huraa	9302
Bahan Marzen	Director of Engineering	Four Seasons Kuda Huraa	9500
Zaid	House Keeping Supervisor	Four Seasons Kuda Huraa	7777004
Ibrahim Naseem	Managing Director	Altec Maldives Pvt. Ltd.	7773387

5.1 Environmental Protection Agency

Riffath Naeem and Ali Mishal from EPA were consulted by the Huraa Council members and the EIA consultant. The following points were noted.

- EPA requested to minimize machinery use in the coastal zone.
- EPA required checking if the sand in the wetland pond is suitable for use in beach nourishment, if not find alternative use. Council suggested the alternative would be to use the sand to level the football field.

- EPA wanted to ensure that the outfall pipeline is appropriately anchored and to consider an anchoring methodology that is acceptable to EPA.
- EPA stated that the details of excavator movement for the deepening of the wetland shall be provided.
- EPA wants the Proponent to provide a work schedule, which the EPA will follow during construction.
- EPA wishes to ensure that good waste management practices are adopted. Council members stated that there is a Waste Management Center established in the island.
- EPA requested to identify mitigation measures for erosion and accretion after excavation of the wetland pond.
- For the disposal of sewage and wastewater from an ocean outfall, there would be no issue as long as currents can disperse the effluent appropriately.

5.2 Health Protection Agency

Mr. Moosa Hameed, Senior Public Health Programme Officer from the Health Protection Agency reported that there are no regulatory requirements set out by the Health Protection Agency with reference to sewage and wastewater disposal in the country at present. Environmental Protection Agency under the Ministry of Environment and Energy has set standards and is developing the regulatory framework for sewage and wastewater disposal. However, Health Protection Agency has the mandate to work towards the protection of public health and hence would recommend ensuring that the health impacts of the proposed sewerage system in Huraa have minimal health impacts. He noted that the proposed outfall would help to minimize the health impacts related to nearshore sewage disposal and would be beneficial for human health.

5.3 Four Seasons Kuda Huraa Resort

A meeting was held with staff from Four Seasons Kuda Huraa resort to discuss their concerns regarding the different components covered in this EIA report. The discussions were initiated by the Council. Four Seasons Kuda Huraa does not have any concerns with regard to the deepening of the wetland pond, however, raised concern regarding the outfall and restaurant protection component. They identified that there could be issues related to smell from discharged sewage if the outfall was on the eastern side as proposed to consider the western

side as an alternative. The resort staff also identified their concern that the use of concrete blocks for the proposed restaurant may affect the view of their guests. It was agreed that trees will be planted on both sides to minimize the aesthetic impacts.

5.4 Consultations in the field

The Island Council carried out discussions with guesthouses and other concerned parties in Huraa. The Council noted that none of the participants had any concerns regarding the proposed project activities and are eager to see the project components proceed. The Council's letter regarding the community consultations is given in the Appendices.

6 Environmental Impacts

6.1 Introduction

Development projects involving infrastructure development in island environments are believed to generate a series of environmental impacts, of which some can be felt immediately on the surrounding environment while others can be felt continually and can be far reaching. By far and large the most significant environmental impacts are those that are felt on the immediate environment. Terrestrial environment is directly affected from removal of vegetation resulting in loss of habits. Also, coral reef environments are sensitive and highly susceptible to immediate changes that will be incurred from most of the development activities. Therefore, all the development activities must take into consideration the understanding of the environment and changes as well as implications that it will bring about to the environment and surrounding.

The following account describes potential environmental impacts that will be associated with the proposed upgrade of the existing sewerage system, both during construction and operation phases of the development

6.2 Methods and Limitations

The prediction and evaluation methods of environmental impacts methods used here may not be most comprehensive methods as they are quite prescriptive. The main disadvantage of using this method is that only assumptions have been made to predict the impacts which may or may not be accurate. The degree of these impacts being accurate or not, uncertainties and natural variability factors depend on the accuracy of the method. Nonetheless, the methods used are concise and provide a general overview as well as the range of impacts that can affect the environment. Also, the EIA report has taken into consideration similar studies undertaken in the Maldives as well as expert judgment in identifying the main environmental impacts that may be associated with the proposed sewerage system upgrade.

6.3 Impact Identification

Impacts on the environment from various activities of the proposed development have been identified through:

- A consultative process within the EIA team and the Proponent
- Purpose-built checklist
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Baseline environmental conditions described in Chapter 4.
- Consultant's experience of projects of similar nature and similar settings

A purpose-built matrix has been used to evaluate the overall impacts of the proposed project. The impacts of the project have been evaluated according to the following criteria:

- Magnitude (or severity): the amount or scale of change that will result from the impact
- Significance: importance of the impact. Reversibility is considered part of its significance
- Duration: the time over which the impact would be felt
- Extent/spatial distribution: the spatial extent over which the impact would be felt

The scales associated with the above criteria are given in the table below.

Table 6-1: Impact evaluation scale

Criteria	Scale	Attribute
Magnitude Change caused by impact	-3	Major adverse
	-2	Moderate adverse
	-1	Minor adverse
	0	Negligible
	1	Minor positive
	2	Moderate positive
	3	Major positive
Significance/Reversibility Impact implications / Reversibility of impact's effects	0	Insignificant
	1	Limited implications / easily reversible
	2	Broad implications / reversible with costly intervention
	3	Nationwide or global implications / irreversible
Duration Duration / Frequency of Impact	0	Immediate
	1	Short term/construction period only
	2	Medium term (five years of operation)
	3	Long term/continuous
Extent/Spatial Distribution Distribution of impact	0	None/within 1m from point of discharge/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

Based on the above scale, an impact matrix was developed for the proposed development to determine the overall impact of the proposed project. This matrix is given in Table 6-2.

An impact potential index was then developed from Table 6-2.

The impact potential index table represents a product of the magnitude (M), significance (S), duration (D) and extent/spatial distribution (E) given in the above table. The sum of all key component specific indexes for one activity (i.e. sum by rows) provides the Activity Potential Impact Index (API) and the sum of all activity specific indexes for one key component (i.e. sum by column) provides the Component Potential Vulnerability Index (CPVI) which gives an indication of the vulnerability of each key component to activity related impacts. Table 6-3 represent the impact potential indices for the proposed project.

6.4 Overall impacts of the proposed project

The environmental impacts that maybe associated with the proposed outfall and coastal modification works are summarised by using a simple matrix. The matrix given in the following table (Table 6-2) shows the types of environmental impacts that may be associated with the proposed works throughout the project period including implementation and operation. Although the restaurant has already been constructed, its impacts have been

identified. As described in Section 6.3 values were given to every impact based on its magnitude, duration, significance and spatial distribution.

Table 6-2: Score of all the impacts in each category

	KEY COMPONENTS									
	Environment					Socio-Economic				
PROJECT ACTIVITIES	Reef/mangrove habitats	Soil and groundwater	Water quality	Land/seascape	Air/Noise	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer
Construction										
Dredging water-logged area of wetland	0	-1 0 1 1	-2 1 1 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 1	0	-1 1 1 1
Dredge material disposal	-1 0 1 1	-1 0 2 1	-1 1 2 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 1	0	-1 1 1 1
Outfall installation	-1 1 2 1	0	-1 1 1 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 2	0	-2 1 1 1
Construction of pumping station	0	0	-1 0 1 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 2	0	-2 2 1 1
Restaurant piles (concrete)	0	0	-1 0 1 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 2	0	-1 1 1 1
Machinery and construction equipment	-1 0 1 1	-1 0 1 1	-1 0 1 1	-1 0 1 1	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 1	0	-1 1 1 1
Workforce	-1 0 1 1	-1 0 1 1	-1 0 1 1	0	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 3	0	-1 1 1 1
Operation										
Use of wetland area for recreation/eco-tourism	-1 0 2 1	0	2 1 3 1	2 1 3 1	0	1 1 3 1	1 1 3 1	1 2 3 1	1 2 3 1	1 2 3 1
Operation of pumping station	-2 0 3 1	-1 1 3 1	-1 0 3 1	-1 0 3 1	-1 0 3 1	1 1 3 1	1 2 3 1	1 1 2 1	1 2 3 1	-1 1 3 1
Operation of restaurant	-1 0 2 2	-1 0 3 1	-1 0 2 2	1 1 2 1	-1 0 3 1	1 2 1 1	1 1 3 1	1 2 3 2	1 2 3 1	-1 0 2 1

KEY: M S Magnitude Significance
D E Duration Extent (spatial)

The overall impact of the proposed development is slightly positive due to its low negative impact on the environment and some positive socio-economic impacts. Most of the environmental and socio-economic impacts identified for the proposed development were positive to include reduction in smell around the treatment plant, energy consumption for wastewater treatment, minimized groundwater pollution, improved management/ maintenance of the sewerage system and enhanced water circulation in the water-logged areas of the wetland. The negative environmental impacts of the project would include temporary loss of groundwater quality during the construction phase due to dewatering and large siltation in the

wetland area and small amount of sedimentation around house-reef induced from installing the outfall. The latter could be regarded as insignificant due to its small magnitude and spatial distribution while the sedimentation or siltation from dredging of the wetland area could be quite significant depending on the method of dredging. Silt and dirt on the dredge material disposal location would also be of concern.

The impact identification matrix measured a positive score of 0.86 for the overall project (Table 6-3).

Table 6-3: Overall score of individual components and the project

	KEY COMPONENTS										
	Environment					Socio-economic					
PROJECT ACTIVITIES	Reefs incl. live bait	Soil and groundwater	Lagoon/seawater	Land/seascape	Air/Noise	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer	**TOTAL API**
Construction											
Dredging water-logged area of wetland	0	0	-0.02	0	0	0.01	0	0.01	0	-0.01	-0
Dredge material disposal	0	0	-0.02	0	0	0.01	0	0.01	0	-0.01	-0
Outfall installation	-0.02	0	-0.01	0	0	0.01	0	0.02	0	-0.02	-0
Construction of pumping station	0	0	0	0	0	0.01	0	0.02	0	-0.05	-0
Restaurant piles (concrete)	0	0	0	0	0	0.01	0	0.02	0	-0.01	0.02
Machinery and construction equipment	0	0	0	0	0	0.01	0	0.01	0	-0.01	0.01
Workforce	0	0	0	0	0	0.01	0	0.04	0	-0.01	0.04
Operation											
Use of wetland area for recreation/eco-tourism	0	0	0.07	0.07	0	0.04	0.04	0.07	0.07	0.07	0.43
Operation of pumping station	0	-0.04	0	0	0	0.04	0.07	0.02	0.07	-0.04	0.12
Operation of restaurant	0	0	0	0.02	0	0.02	0.04	0.15	0.07	0	0.3
TOTAL CPVI	-0.02	-0.04	0.02	0.09	0	0.17	0.15	0.37	0.21	-0.09	0.86

API = Activity Potential Impact Index
CPVI = Component Potential Vulnerability Index

6.5 Project Specific Impacts – Construction Phase

Implementation phase will have the major, direct short-term impacts and some secondary long-term impacts on the environment. The proposed sewerage system upgrading works will mainly involve construction of the new pump station, repairing the receiving tanks and construction of ocean outfalls, the impacts of which will be short-lived and spatially small.

The excavation of the water-logged area of the wetland would create a large amount of silt or sedimentation, which needs to be carefully carried out. Transport of materials for the construction and waste would be less compared to other projects done in Maldives since the project site is close to the capital city and industrial island, Thilafushi. There will be no need for major vegetation removal since the project area is already clear of vegetation.

The restaurant is already constructed and the impacts on the beach is low as there is a seawall and no beach in the area.

6.5.1 Production of waste during construction

Some waste materials will be generated during the construction period of the proposed project. These will mostly consist of non-biodegradable waste such as PVC pipes and leftover construction materials. Organic waste from vegetation removal would be almost negligible while other waste would be dealt with effectively with proper means via the existing waste management system on the island.

6.5.2 Excavation of the wetland area

The water-logged area of the protected wetland is to be excavated by using excavator or dredge pumps. If excavators are used, there will be high degree of siltation on the bottom. If, on the other hand, a dredge pump were used, the level of siltation would be low and silt will be pumped out too. However, in the latter case, the siltation at the disposal location would be higher.

In addition to siltation, there would be impacts on the few species of fish and crabs found in the wetland area. The crabs are generally found in the peripheral areas and fish would move out of the way as excavation progresses. Therefore, the impact on these would be low.

The proposed excavation is expected to enhance water circulation in the water-logged areas of the wetland minimizing foul smell due to nitrification. There will be water input even at low tide when the shoaled area at the mouth of the wetland where it connects with the lagoon, which has depths of 1 to 1.5m is deepened.

The improved water quality and tidal flushing is also expected to enhance the clarity of the water within the wetland. The recreational use of the water-logged area and ecotourism potential of the wetland for canoeing, kayaking, riding paddle boat and other such uses would

have social and economic benefits that have scenic and non-consumptive value associated with the wetland ecosystem.

6.5.3 Discharge of excavated material

The excavated material from the wetland area will have some degree of dark humus material and fine sediments. Therefore, it may not be suitable for placing directly on the beach as the quality of the beaches may be affected. Therefore, disposal at the beach shall be carried out in such a manner that the darker sand is placed on the backshore and white sand on the foreshore.

6.5.4 Excavation for laying the sewer components

Most of the proposed facilities are already built and hence would not require major excavations. However, for the new pump station and laying out the outfall, small scale-excavations would be done. Furthermore, most of these excavations are not expected to be extended below the water table, hence de-watering would be minor, if not unnecessary.

However, such dewatering is not of concern since the engineers shall ensure that dewatering is controlled. Dewatering is expected to induce salinization of the groundwater lens; however, such salinization will be mainly point specific and may affect vegetation in the zone of influence. Such salinization will return to normal after rainfall. Therefore, the spatial and temporal extent of this impact is small; the impact is insignificant. Also, there is no vegetation or household wells in the 30m radius of influence, which makes impacts insignificant.

Construction of pump station and outfall pipeline on land could affect the quality of those receiving waters at or near construction sites. Construction activities may carryout grading, and soil compaction which can alter a site's ability to absorb and retain water, which can cause erosion and sediment loading to surface waters. But because there won't be removal of vegetation the impact of this alteration would be minor. In addition, construction runoff including debris from demolition such as lime and cement, petroleum fuels, and construction chemicals can degrade the water quality of the receiving environment.

Accidental spills of petrochemicals and construction chemicals could also occur, although there is little likelihood of such spills because of normal precautions taken to prevent them.

Excavation carried out for laying the outfall can also be carried out by adopting manual means. Excavators and other heavy machinery will be of minor use, if it is at all used.

6.5.5 Installation of sewage outfall

The key impacts of sewage outfall installation would be degradation of marine water quality due to sedimentation, discharge of sewage effluent, damages to coral reefs and loss of habitat. Construction of sewer outfall would impact coastal water, lagoon bottom and reef. During construction and mobilization of equipment would cause re-suspension of bottom sediments. Depending on the current movement, the suspended fine sediments may move to healthy corals which in turn may get killed due to excessive sedimentation. However, this is not likely to happen at the proposed location as currents would generally be towards the island.

6.5.6 Health and safety

The main health and safety issues during the construction stage would be in the operation of heavy machinery and equipment such as excavators with the risk of toppling. Falls and accidents due to carelessness in the project site has been a concern in many construction sites and must be addressed during the planning and implementation stages.

Noise levels felt by workers can be a health issue too. However, noise levels at the project site would not be too high and would be intermittent and not continuous. Therefore, acceptable average daily exposure levels would not be exceeded for construction workforce.

6.6 Project Specific Impacts – Operational Phase

6.6.1 Use of Sewage Outfall

As describe in the earlier section, disposal of sewage to the sea will cause eutrophication in certain circumstances. However, the proposed location of the emergency outfall has been selected as to minimize this impact. The area has extremely strong currents and the outfall will be constructed over 7m below the drop-off. The faecal bacteria cannot survive in saltwater for long and the strong currents will spread the minerals reducing chances of eutrophication greatly. In addition, the outfall will be used only during emergencies; hence the impact would be for a very short period even if such an emergency arises.

There will be an indirect positive impact on the marine environment from this project. With the outfall, the current practice of disposing raw sewage to the lagoon will come to a stop; hence further degradation of the lagoon environment and related health hazards will be prevented. Furthermore, the aesthetic value of the lagoon will be restored. The problem of smell in the area will be resolved.

One of the most positive impacts of the proposed modification to the sewerage system is the reduction in the energy cost due to treatment, which adds to the burden of gaseous emissions due to burning of fuel. This also reduces the cost of operation and caters for cost-effective operation and management of the sewerage system.

6.6.2 Impacts of using deepened wetland area

The deepening of the wetland area will not only enhance the water quality and clarity due to improved circulation and flow but also create appropriate conditions for safe use for ecotourism activities such as canoeing. This may increase the non-consumptive and scenic value of the mangroves. In turn, it could also create better awareness and the need to preserve and better manage the wetland environment.

6.6.3 Impact of the piles of the restaurant

The restaurant has been built at a location where there is a revetment on the coastline and, therefore, no beach. Hence, the impact of the concrete footings and piles on the longshore sediment transport would be small. The number of concrete piles with the restaurant structure, may help sand to deposit on the lee of the restaurant. However, this impact is not visible at present. Therefore, monitoring the coastal area updrift and downdrift of the restaurant would be important to understand the impacts.

6.7 Impacts of the Alternatives

The preferred alternative of using dredge pumps to manage the shoaling of the wetland area, especially the lagoonward opening of the wetland has the benefit of reducing sedimentation in the wetland, which improves the water quality and clarity of the water. It also minimizes the noise levels and subsequent impact on the different avian species inhabiting the wetland environment.

However, the excavation using sand pump will take longer than the use of excavator and may not be able to achieve a levelled bottom. Therefore, it has to be done carefully to minimize uneven seabed. In lagoon areas, uneven areas will become even due to currents, whereas that would not be the case in the wetland area where currents are low.

6.8 Uncertainties in Impact Prediction

Environmental impact assessment 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, geomorphological or social conditions in a particular place. The level of uncertainty, in the case of the proposed outfall, may be expected to be low due to the experience of similar projects in similar settings in the Maldives. However, impacts of the excavation of the wetland area has not been documented although such excavations as well as reclamation had occurred in many wetlands in the past. Excavation is also reported to have been undertaken in the past for Huraa wetland but no monitoring data is available to quantify or understand the potential impacts.

Given that environmental monitoring is lacking for most of the projects implemented in the country, as a result of which uncertainties in impacts of projects still exist, it is proposed that the Proponent shall undertake voluntary monitoring as described in the monitoring programme given in the EIA report.

7 Project Alternatives

7.1 Introduction

This section looks at alternative ways of undertaking the proposed project. There are two basic options: (1) leave the problem as it is (no project option), or (2) take measures to resolve the problem (undertake the project options). If the project were to continue, it would be necessary to take economic, ecological and social aspects of the project into consideration and ensure that these concerns exist within a delicate balance. Neither the economic benefits nor the social and ecological concerns can be avoided. Therefore, it is important to consider all options and ensure that the best available option(s) is/are chosen to solve the issues/problems.

Not all the impacts of a project can be completely prevented, however, with the use of appropriate technology and management measures; the magnitude of most of these impacts can be either reduced or minimized. Nevertheless, the effectiveness of these technology and mitigation measures highly depends on the environmental condition and procedures in which they are applied in the field. On the other hand, there are complex and sophisticated procedures of minimizing environmental impacts by means of alternative methods to some of the activities. Often, alternative means are not economically competent with the extent of the project itself. However, to some of the activities where predicted impacts and its magnitudes on the environment are very adverse, alternate means must be applied considering long-term benefits from use of alternatives, as short-term environmental restorations can become very costly.

The following section describes and evaluates some alternatives in terms of locations and various project activities and methods of construction for the proposed project.

7.2 No Project Option

No development option refers to not carrying out the proposed project. This is the baseline against which all the other alternatives and development proposals are assessed. For the proposed outfall, the outfall is a requirement under current EPA requirements as emergency outfall even if treatment plant was included. Furthermore, the current practise deteriorates the natural environment. Therefore, the no project option for the outfall is not feasible.

The no project option may be considered feasible for the excavation of the wetland areas. However, since there are several residential areas and other developments in the vicinity of the wetland area and the opening of the wetland's mouth for improved circulation has yielded improvements in water quality of the wetland and reduced smell in the vicinity, this is considered to have several social benefits. Furthermore, the proposed deepening of the water-logged areas are not considered to affect the protected characteristic of the wetland, which is the mangrove forests. However, there are no studies done in the past, therefore, a conclusive argument cannot be supported. Hence, it is recommended to consider monitoring of any changes due to the proposed works.

7.3 Alternative Disposal Options

For the islands of the Maldives, it is preferable to adopt simple and environmentally sound technologies that require minimum maintenance. The following options which may be adopted for Huraa have been selected after careful consideration of socio-economic, technical and environmental aspects. At present sewage collected by the existing system is treated and disposed to the ground. There is no method of disposing sewage in emergencies such as an emergency outfall. The way operator has dealt with the current situation was to construct a temporary outfall to dispose raw sewage to the beach. There are few alternatives to this component of the sewerage system, as discussed below.

7.3.1 Disposal to Ground

During emergencies where the STP fails to treat the sewage, raw sewage could be drained to the ground directly. This is a common practice in the Maldives for islands where a proper sewerage system has not been established. However, the main reason behind establishing a sewerage system and incorporating a treatment plant is to avoid disposal of raw sewage directly to the ground polluting the freshwater aquifer. Hence, constructing an emergency disposal to the ground may slightly deviate from one of the main goals of the project. In terms of economic cost, this option would be cheaper than the proposed. However, environmentally, this option would be very costly. Discharging large amounts of raw sewage at a single point would have a significant effect on the aquifer. However, this procedure will be used only in emergencies; therefore, temporal scale of the impact would be small. Furthermore, if this is carried out away from the populated area, it would reduce impact on the community as well. However, there is a high probability of a significant drop in groundwater quality of the island

temporarily if this option is used. The community rely on groundwater for daily utilities such as showering, cleaning and laundry. Even a temporary groundwater pollution could very well cause severe health hazards and would be socially unacceptable.

Most importantly, even though it is called an emergency option, an 'emergency' could last for quite some time depending on the nature of damage to the system. Replacing major components of the STP would be very expensive; hence it may take months before STP can be functional again (e.g. the current situation). Therefore, this alternative of discharging raw sewage to ground would render the entire sewerage system meaningless as the temporal extent of effects cannot be considered 'short' in similar cases as the present.

7.3.2 Disposal to lagoon/Beach

Even though this method is relatively inexpensive compared to disposal to sea, it has potential to cause problems like lowering aesthetic value of the beach, eutrophication and bad smell. This is the method currently in use at Huraa and has been in use for a few years. Consequently, instead of contemplating potential outcomes of this option, realistic impacts of the procedure could be seen from the existing setup.

Eutrophication of the lagoon around Huraa is quite extensive due to improper disposal of fish waste and raw sewage in the past. This has deteriorated and would further deteriorate the quality of the tourism experience for the several guesthouses recently opened and many more coming up in Huraa. In fact, the eutrophication of the lagoon environment due to improper disposal of waste at Huraa has caused extensive growth of seagrass in the two resorts on either ends of Huraa.

Therefore, there is an immediate requirement for Huraa to cease the disposal of any kind of waste into the nearshore environment especially on the western side.

7.3.3 Disposal to sea

Disposal to sea has been considered as the most practicable method. For this reason, emergency by-pass outfalls have been proposed for systems (without treatment) under the *Design Criteria* prepared by EPA. Disposal to sea means disposal to an appropriate location off the reef edge and at a suitable depth that mixing and dilution ensures that sewage is diluted before it reaches the surface and also does not directly dispose onto the seabed or reef.

Disposal to sea is naturally a suitable option due to its dilution potential and its characteristics such as adequate flow and salinity which ensure that faecal coliforms would not survive for longer periods and distances as in groundwater and lagoon water. However, disposal to sea would be more expensive than disposal to ground or lagoon, yet have clear long term benefits that would over-ride the cost implications. This option is most appropriate for Huraa and is the proposed option as well.

7.4 Outfall location alternative

The proposed sea out fall location is the shortest route from the existing treatment plant to reef edge through the nearby road. It is also in an appropriate location considering the existing location of the discharge facility on land and the dilution potential of the receiving water. Hence, no alternative location has been considered.

7.5 Alternatives to deepening of wetland area

7.5.1 Alternative excavation methods

It is considered easier and practicable to use an excavator and dump truck for the excavation of the wetland area and disposal of excavated material. The alternative would be to use a sand pump, which will take longer but cause a lesser degree of sedimentation and better cleaning. The excavated material, in this case, can be pumped to the nearby beach area and the dry sand carried to other beach areas, where beach is to be made.

7.5.2 Alternative dredge spoil disposal

The dredge spoil would have some amount of silt and humus material especially at the top layer. Therefore, the dredged material may not be suitable for beach fill except for backshore areas. Therefore, a practicable alternative would be to use the dredge spoil to level the football field (as suggested by the Huraa Council) or roads and other low-lying areas near the wetland.

The other alternative would be to use the material on the beach areas on the northwest of the island closer to the wetland, where beach has been eroded. However, shore protection structures may be required to retain the sand here.

8 Mitigation Measures

8.1 Introduction

It is evident that island and coral reef environments are susceptible to changes and implications that will be brought about from the development of the proposed sewerage system. As described earlier, some impacts are felt largely while others are localized. However, most of the environmental impacts associated with the proposed sewerage system development are minor and with proper environmental management can be reduced even further. It should also be noted, even though some of the impacts are regarded as minor, without proper monitoring and management they can escalate into significant environmental impacts.

The following section describes key environmental mitigation measures that will be undertaken during the construction and operation of the proposed project components.

8.2 General Construction Phase Mitigation Measures

8.2.1 Mobilization, Machineries and Materials

Precautionary measures need to be in place while loading and unloading of materials and machineries at work sites under supervision at all times throughout the cycle of the project.

Efforts must be made to avoid accidental spillages from machinery including overtopping leading to severe spillages. Machines must be operated by experienced operators and make sure machines are clean all the time. Avoid throwing of cleaning materials and changed oils into the environment.

Efforts must be made to avoid any contamination of the environment in particular, while handling of fuel, chemicals, and construction materials. Workers and helpers must be provided information. Other aspects to be considered include to

- Avoid boating activities in low tide
- Avoid damage to coral reefs through proper navigations
- Avoid loading, unloading and boating activities at night times

8.2.2 Waste Management

Waste management procedures will be implemented to minimize potential impacts on the environment. This may be achieved by consideration and application of the following:

- Avoid and/or minimize waste generation wherever practical by altering the site procedures
- Maximize the opportunity for reusing/ recycling/ recovering materials and thereby negate/minimize the disposal requirements (e.g. by waste segregation according to type, separation of recyclable materials such as metal, maximize reuse of timber framework wherever possible, utilization of excavated material for filling or landscaping); and
- Ensure that all treatment and disposal options comply with all relevant guidelines and standards.

The following practices will be followed to minimize waste generated from construction activities;

- Segregate waste materials according to types to facilitate re-use;
- Segregate different materials at source as far as practical;
- Co-ordinate material deliveries to minimize storage times on site to avoid damage and
- Provide training to site staff in waste minimization practices
- It will be ensured that construction debris will be reused on site to the maximum extent possible.

The following measures will be implemented to mitigate the likely adverse impacts to the environment.

- Stockpile material and sites will be covered to prevent washout and erosion during heavy rainfall.
- Dust suppression techniques will be adopted;
- Designated areas for stockpiling will be fenced.

A temporary refuse collection facility will be set-up by the contractor and wastes will be stored in appropriate containers prior to collection and disposal.

The waste management plan for construction phase has been summarized in Table 8-1.

Table 8-1: Waste management plan – construction phase

- minimization of waste generation for disposal (via reduction/ re-use onsite);
- segregating waste materials according to type to facilitate re-use;
- separation of inert construction materials;
- co-ordinate material deliveries to site;
- training site staff in waste minimization practices;
- transport of wastes off site as soon as possible;
- maintenance of comprehensive accurate waste records;
- use of re-useable metal boarding / signboards;
- no on-site burning will be permitted

8.2.3 Excavation of wetland area

To mitigate the impacts of excavation of the water-logged area of the wetland environment, and disposal of dredge material, the following mitigation measures are proposed.

- Excavation shall be undertaken at low to mean tide, especially if excavator is used.
- There is one young mangrove tree within the proposed dredge area. It is important to dredge around this area keeping a 5 to 10m radius around it.
- The dredge or excavation area has to be marked with a buffer of no less than 5m from the vegetation.
- The dredge depth shall not exceed 0.4m from low tide. An average of no more than 1m is to be maintained at all dredge/excavation areas while the dredged depth is best kept at about 0.5m at the lagoon/pond interface so that the saltwater input is maintained.
- Dredging or excavation shall start from the inner areas moving to the opening to be dredged close to the lagoon. This is to ensure that the initially dredged material with humus and other debris is placed at the backshore of the fill location and white sand is placed on the foreshore.
- The material to be moved in trucks shall be left to dry at a designated location before being taken to the disposal location.

8.2.4 Excavation and dewatering

To mitigate the impacts from excavation of the sump well, pipe ducts, etc., the following measures can be employed.

- Manual excavation of sump wells and pipeline ducts without the use of machinery such as excavator.
- Watering plants in areas where dewatering will occur so as to minimize effects due to salinization of the groundwater lens in the area.
- Safety signs and safety tape around the pits to avoid accidents and falls.
- Ensure appropriate supervision and monitoring.
- Complete the work as soon as possible.
- Keep the workers informed of the environmental aspects to minimize the impacts.
- Avoid mass extraction of water at one time.
- Avoid excessive excavation.
- Wear safety and protection measures (personnel protection equipment).
- Provide necessary safety signs and warnings to public.

8.2.5 Construction of Outfall

The mitigation measures include:

- To ensure appropriate supervision and monitoring.
- Carry out the work at low tide.
- Complete the work as soon as possible.
- Keep the workers informed with these aspects to minimize the impacts.
- Avoid construction of solid structures inside water.
- Avoid washing tools, equipment etc. into lagoon.

Additionally, proper anchorage of the outfall pipe has to be ensured. Currents in the area and wave action should be in-cooperated into the ballast weight calculations and anchor designs. Proper material should be used to minimize anchor failures due to erosion by seawater and hydrodynamic factors of the area. Most commonly used such material for ballast weights are reinforced concrete. Even though there are different designs of ballast weights, flat-bottomed ballasts are generally preferred if the submerged piping is likely to be subjected to significant currents, tides or wave forces because they help prevent torsional movement of the pipe. Additionally, experience has shown that in certain marine applications where tidal or current activity may be significant, it is feasible for the pipe to “roll” or “twist”. This influence combined with the mass of the individual ballasts may lead to a substantial torsional influence

on the pipe. For these types of installations, an asymmetric ballast design in which the bottom portion of the ballast is heavier than the upper portion of the ballast is recommended.

One of the most common causes of anchorage failure in marine outfall designs is corrosion of bolts used to hold ballast weights and pipe together. Therefore, particular care must be made to use proper saltwater corrosion resistant material for bolts.

8.2.6 Human Environment

Considering the nature of work, proper equipment and safety gears shall be provided to the workers. To minimise the risks associated with health and safety issues, the project proponent will be responsible to ensure that adequate health care arrangements will be available at the site throughout the construction period.

Noisy equipment shall not be operated at night at or close to noise sensitive locations. Lights are also of concern when working in the wetland area and, therefore, working at night should be strictly avoided in the wetland area. Works, however, may be carried out at night, if necessary using floodlights in the lagoon and STP area.

8.2.7 Air

Mitigation measures to minimize emissions from machinery and vehicles related to the project including mobilisation and operational phase include:

- Use light fuel (with low sulphur content) as much as possible.
- Avoid unnecessary operation of vehicles, machines and boats.
- Keep in place appropriate transport management system.
- Minimize mobilisation by planning the mobilisation. In most of the projects undertaken near residential areas, several mobilisations happen to not only increase the cost of the project but also the environmental impact. Appropriate planning is the key.
- Keep in place appropriate logistic management system during construction and operation phase.

8.3 Mitigation Measures – Operational Phase

The proposed components have low environmental impacts in the operational phase. The excavation of the wetland area would not involve environmental impacts in the operational phase except that of the use of the wetland for increased ecotourism activities, in which case the Proponent will need to monitor and manage the uses so that that the activities take place in a controlled manner with minimal impact on the flora and fauna. As suggested by EPA, it may be helpful to minimize the shoaling of the opening of the wetland pond to the lagoon by structural protection in future. However, this would be difficult to assess at this stage and within the scope of the current study. Hence, it is suggested to carryout regular monitoring to understand the erosin-accretion patterns around the interface and the surrounding areas.

There are no additional mitigation measures for the sewage outfall and the restaurant during the operational phase. However, as suggested by Four Seasons Kuda Huraa, it would be important to minimize the aesthetic or visual impact of the restaurant for Huraa guests by planting trees from the onset of the project. Also, regular monitoring is recommended for these components as well as the wetland component.

9 Environmental Monitoring

9.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. These include water quality, shore dynamics, live coral cover and nektonic fauna.

Monitoring would ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

The purpose of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods. This will help to minimize environmental impacts of projects in future.

The monitoring plan shall target to measure:

- groundwater quality
- odour/air quality
- benthic cover at outfall and control location
- marine water quality
- changes in project area usage patterns
- impacts are accurate and mitigation measures taken are effective
- the thresholds are kept within the baseline limits predicted

9.2 Recommended Monitoring Programme

Outlined in Table 9-1 is a project specific monitoring programme. This monitoring programme for the proposed project includes three monthly and six-monthly monitoring.

9.3 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this report. EPA may submit the report to the relevant Government agencies in order to demonstrate compliance of the Proponent.

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

The report will cover the following:

- Details of the site
- Details of methodologies and protocols followed
- Strategy of data collection and analysis
- Sampling procedures and quality control measures
- Monitoring results
    - Water quality results
    - Benthic cover at baseline locations
    - Drogues or current data
    - Volume estimates of dredged sand
    - Fuel consumption data
    - Land use changes
    - Stakeholder concerns/complaints
- Compliance with relevant standards and requirements of the EIA
- Performance of the different project components in achieving the project objectives
- Conclusions and recommendations

Table 9-1: Proposed annual monitoring schedule with costs

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (MVR)	Total (MVR)
1	Wetland and marine water quality (50m within the sedimentation impact zone)	Water quality: Turbidity, TSS	Every 2 months for first 6 months and every 3 months thereafter	5		5		5			5			5		25	75.00	**1,875.00**
2	Wetland and marine water quality at the outfall locations	Water quality: Nitrates and phosphates	Every 2 months for first 6 months then every 3 months	4		4		4			4			4		20	100.00	**2,000.00**
3	Coral and benthic cover at baseline locations, 1, 2 and 3	Benthic cover and fish survey - Photo quadrates/LIT and fish survey	Every 6 months	2							2					4	250.00	**1,000.00**
4	Currents/hydrodynamics (5 locations around the project areas)	Drogue tracks	Every 3 months	5				5			5			5		20	150.00	**3,000.00**
5	Shoreline changes near the wetland, restaurant and disposal location	High tide line and low tide line using differential GPS	Every 2 months for first 6 months then every 3 months	2		2		2			2			2		10	200.00	**2,000.00**
6	Depth variations at restaurant and wetland areas	Bathymetry or spot depths	Every 6 months	2				2			2			2		8	250.00	**2,000.00**
7	End of construction stage monitoring report		Construction phase only						1							1	5,000.00	**5,000.00**
8	Annual monitoring report		Annually												1	1	7,500.00	**7,500.00**
TOTAL																		**24,375.00**

Note:

M indicates Month

The costs given does not cover travel, food and accommodation as well as other site logistics during field investigations

10 Conclusions

In conclusion, the project component of upgrading the existing sewerage system is justified from a technical as well as environmental and especially a social point of view. The main negative impacts of the proposed development include changes in local groundwater quality due to de-watering, impacts associated with increased operation of machinery and vessels during the construction period and impacts on marine environment from construction of the outfall across the reef. These are usually minor or short term environmental impacts and spread across a small spatial extent.

The project component to excavate the water-logged area of the protected wetland is justifiable as it is targeted at improving the water quality and clarity resulting from improved water circulation within the water body. Since it is an open wetland, the opening between the wetland and the island lagoon on the west, where it has been largely shoaled, the shoaled area needs to be deepened to allow water input and improve circulation and flushing. It is recommended to use sand pump of adequate capacity rather than excavator in order to minimize sedimentation. Furthermore, it is also important to pump the material to a confined space to minimize sedimentation of fill location. Dry sand may be moved to fill location and placed in such a way that dirty dredge spoil is kept on the backshore and white sand on the foreshore.

The restaurant component mainly involves undertaking monitoring along with monitoring of environmental changes related to other components. The restaurant has been constructed already and being in an area with a seawall, there is no sediment deposition in the area.

In conclusion, the project components are justifiable and may be allowed to be undertaken given the low environmental impact. However, monitoring is recommended to be undertaken for at least 2 years.

11 Acknowledgements

The author wishes to acknowledge the work of several people who have contributed to this report. The following people have been mentioned due to their specific contributions. Thanks are also due to those who participated in the different meetings, interviews, discussions although their names have not been specifically mentioned here.

- Ibrahim Naseem for his support and helping the survey team gather necessary data in the field.
- Huraa Island council, for providing relevant information and assisting with stakeholder consultations.

The technical team of Sandcays who gathered field data, analysed the data and presented some of the data in the report are worthy of credit. Thanks to Mohamed Visham and Hassan Jameel for going to the field with the Consultant and assisting in field data analysis.

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13 Appendices

Appendix 1: Terms of Reference

Appendix 2: Commitment letter

Appendix 3: Huraa Land Use Plan

Appendix 4: Council letter regarding community consultations

Appendix 5: Receipt from Atoll Council

بسم الله الرحمن الرحيم

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No: 203-EIARES/334/2017/5

Terms of Reference for Environmental Impact Assessment for the Sea Outfall and Minor Coastal Modifications at K. Huraa

This is the Terms of Reference (ToR) following the scoping meeting on 08th June 2017 and letter sent from Proponent on 12th June 2017, for undertaking the EIA for the proposed sea outfall for the sewerage system and deepening of the water-logged area of the salty marsh/wetland and a restaurant on the beach at Huraa, North Malé Atoll. **The proponent of the project is Kaafu Atoll Huraa Council.**

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

1. **Introduction to the project** – Describe the purpose of the proposed components and, if applicable, the background of the project and the tasks already completed. Clearly identify the rationale and objectives to enable the formulation of alternatives.

2. **Study area** – Submit a minimum A3 size scaled site plan with indications of the proposed project components. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location, size and important elements of the proposed project. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including site preparation, construction and decommissioning phases. The following tasks shall be completed:

   Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the project, using maps at appropriate scales where necessary. The following should be provided (all inputs and outputs related to the proposed activities shall be justified):

   - Concept level details of the sea outfall design and installation;
   - Details of excavation of the protected wetland area
   - Concept level details of the proposed restaurant
   - Machinery, equipment and labour requirements;
   - Project management;

   Sea outfall pipeline

   - Justify outfall site selection including the distance from the reef and depth of the pipe using oceanographic and ecological information. Currents and waves ought to quickly disperse the discharged water with minimum impacts on marine ecosystems and economic activities. Illustrate the extent of the sediment plume. The public and stakeholders should support the location of the outfall site;

- Describe equipment needed and construction methods for laying the offshore pipeline including handling and transportation.

Excavation of the wetland area

- Justify the need for the excavation including water circulation needs, filling of the inter-tidal mouth/estuarine area of the wetland, etc.
- Area and depth of excavation
- Location where the excavated material will be disposed
- Vegetation including mangroves in the wetland, if any, that fall within the area proposed to be excavated and the measures to protect/preserve those trees
- Type of machinery, if any that will be used for the excavation

Proposed restaurant

- Location of the restaurant and the extent of the beach (crest and toe) within the affected boundary
- Foot print area of the restaurant including coastal vegetation within the footprint
- Type of foundation or piling requirements, if any

Task 2. Description of the existing environment – Assemble, evaluate and present the environmental baseline studies/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such, all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects, vegetation transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

General climatic conditions

- Temperature, rainfall, wind, waves, evaporation rates (including extreme conditions)

Geology and geomorphology

- Offshore/coastal geology and geomorphology (use maps);
- Spot depths (at the proposed outfall location and alternative locations)
- Spot depths at the location of the restaurant and the wetland area

Hydrography/hydrodynamics (localized maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Sea water quality measuring these parameters: temperature, pH, electrical conductivity/TDS, salinity, dissolved oxygen, total suspended solids and turbidity.

Ecology

- Identify the extent of the protected wetland area with an overview of the important flora and fauna in the wetland area
- Provide the location, size and species of any plants within the area proposed for excavation

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- Study the coastal vegetation cover at the proposed restaurant area
- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector.
- Marine habitat status including coral reef health, seagrass beds and benthic and fish community description at the project site. Select a control site far from the outfall location and a test site at representative distances from the outfall discharge site:

Socio-economic environment

- Demography: total population, sex ratio, density, growth;
- Economic activities;
- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);

Hazard vulnerability:

- Vulnerability of areas to flooding and storm surge.

Existing sewerage system

- Brief description of the existing sewerage facilities including household septic tanks, soak pits, collection tanks, treatment plant, etc.

Hydrogeology

- Brief description of aquifer characteristics
- Groundwater quality for parameters such as pH, TDS, E. Conductivity, dissolved oxygen, faecal and total coliform
- Water quality of the wetland area to include pH, electrical conductivity/TDS, dissolved oxygen, nitrates, phosphates, total suspended solids and turbidity

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project.

Task 4. Potential impacts of the proposed project– The EIA report should identify all the impacts (direct, indirect and cumulative) and evaluate the magnitude and significance This shall include:

Impact from installing the sewage outfall pipe

- Impacts from marine habitat destruction which may affect fish stocks and species diversity and density of invertebrates,
- Increased turbidity and changes in sediment transport due to pipe introduction when pipe is on the sea bed;
- Equipment, technical and spillage impacts during construction;

Operational phase impacts from outfall discharges

- Sediment plume extent should be delimited so that effects from nutrient inputs (water quality changes) on local reefs, fish and invertebrate communities can be identified;

Impacts due to excavation of the protected wetland area

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- Impacts on water quality, water input and circulation
- Impacts on the vegetation found in the wetland area
- Impacts on the fauna
- Impact of discharge of dredge spoil at designated locations

Impacts of the proposed restaurant

- Impacts on the nearshore sediment transport due to the restaurant

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

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"*. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternatives for environmental, social and economic considerations. The report should highlight how the location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. Mitigation measures must also be identified for both construction and operation phase. Cost of the mitigation measures, equipment and resources required to implement those measures should be specified. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for:

- Physical parameters such as ground and sea water quality assessments and oceanographic studies, if relevant.
- Biological parameters such as reef health monitoring and fish community census at outfall and control locaitons.
- Monitoring of the changes to wetland species over a given period
- Monitoring the shore-zone configuration updrift and downdrift of the restaurant

Monitoring reports shall be submitted to the EPA to evaluate the damages after project completion and as per monitoring schedule specified in the EIA report. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring programme including the physical and biological parameters for monitoring, cost commitment from Proponent to conduct monitoring in the form of a commitment letter, reporting schedule, costs and methods of undertaking the monitoring program must be provided.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – EIA report should include a list of people/groups consulted and what were the major outcomes. Identify appropriate mechanisms to supply stakeholders and the public with information about the development proposal and its progress. The following parties must be consulted:

a)Ministry of Environment and Energy (Water Department)
b) EPA (Water and ERC sections)
c) HPA
d) Four Seasons Kuda Huraa Resort

Presentation- The environmental impact assessment report shall be concise and focus on significant environmental issues. It shall contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations f or any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations 2012

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.

17th July 2017

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Secretariat of the Huraa Council,
Male' Atoll, k. Huraa
Rep. of Maldives

Ref. No.: 334/203/2018/1
Date: 2nd January 2018

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Male', rep. of Maldives

Dear Sir,

This is in reference to the Environmental Impact Assessment (EIA) for the proposed sea outfall and minor coastal modifications at Huraa, Kaafu Atoll, Maldives.

As the Proponent of the project, we assure you our commitment to undertake the proposed mitigation measures and implement the monitoring programme given in the EIA report.

Yours Sincerely,

Easa Ahmed

President of the Council

OUTLINE CHART

LEGEND

PROPOSED

- ENVIRONMENT PROTECTION ZONE (EPZ)
- TOURISM DEVELOPMENT ZONE

EXISTING

- RESIDENTIAL ZONE
- INSTITUTIONAL & COMMUNITY ZONE
  - 1- SCHOOL
  - 2- ISLAND COUNCIL
  - 3- COMMUNITY CENTER
  - 4. HEALTH CENTRE
  - 5, 6 MOSQUE
  - 7- CLUB HOUSE (HURRIYYA)
  - 8- HURAVEE INNOVATIVE YOUTH
  - 9- RANIKANBAA
- FUTURE RESIDENTIAL ZONE
- COMMERCIAL ZONE
- SPORTS AND RECREATIONAL ZONE
  - 10- STADIUM
  - 11- MINI STADIUM
  - 11.1- TENNIS COURT
  - 12- YOUTH CAMP
  - 13- CADET CORP
- INDUSTRIAL ZONE
  - 14- FISH FACTORY
  - 15- BOAT REPAIR & STORAGE
- UTILITY & MUNICIPAL ZONE
  - 16- POWER HOUSE
  - 17- DHIRAAGU
  - 18- WATANIYA
  - 19- CEMETERY
  - 20- WASTE MANAGEMENT
  - 21- SEWERAGE PUMP STATION
- COMMERCIAL ZONE
  - 22- FOURSEASONS STAFF QUARTERS (LEASED)
  - 23- SHOPS
- KULHI
- HABOUR BASIN
- LOADING AND UNLOADING

بسم الله الرحمن الرحيم

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ސޯންޖެކޯސް ޕްރައިވެޓް ލިމިޓެޑްގެ މެނޭޖިންގ ޑިރެކްޓަރ އަލްފާޟިލް އަޙްމަދު ޒާހިދު.

ވެދުން ސަލާމަށްފަހު ދަންނަވަމެވެ.

11 އޮކްޓޫބަރ 2017 ދުވަހު މިއިދާރާގައި ބޭއްވުނު ބައްދަލުވުމުގައި، މިރަށުގައި ގާއިމުކޮށްފައިވާ ނަރުދަމާގެ ސީއައުޓްފޯލް އާއި މިރަށު ކޮރަން ޖަމާވެފައިވާ ފެނިގަސް ނެގުމަށާއި ވަންސްޓޮޕް ޝޮޕް ޕްލާޒާ ޓެކް އަދި ދޫކޮށްފައިވާ ބިމުގައި އަދި ރެސްޓޯރަންޓްގެ ތަރުތީބު ދުރަށް ޖަހާފައި ހަދަންޖެހޭ އެންވަޔަރަމަންޓް އިމްޕެކްޓް އެސެސްމަންޓް ރިޕޯޓް (އީ.އައި.އޭ ރިޕޯޓް) ހެދުމާއި ގުޅޭގޮތުން ރަށުގެ ރައްޔިތުންނާއި ވިޔަފާރިވެރިންނާއި ގެސްޓްހައުސް ހިންގާ ފަރާތްތަކާއެކު މަޝްވަރާ ކުރެވިފައިވާ ކަމުގައި ދަންނަވަމެވެ. އަދި މިކަމާއި ދެކޮޅަށް އެއްވެސް ފަރާތަކުން އެއްވެސް ހުށަހެޅުމެއް ހުށަހަޅާފައި ނުވާ ކަމާއި، މިކަންކަން ކުރިއަށް ގެންދިއުމަށް ތާއީދުކުރާ ވާހަކަ ދަންނަވާލަމެވެ.

ވީމާ ވީހާވެސް އަވަސް މުއްދަތެއްގައި އިސްވެދެންނެވިފައިވާ އީ.އައި.އޭ ރިޕޯޓް ހަދައިދެއްވުން އެދި ދަންނަވަމެވެ.

އިޙްތިރާމާ ޚިދުމަތުގައި ހުރީމެވެ.

04 ސަފަރު 1439
24 އޮކްޓޫބަރ 2017

ހާދިމްކުމް

ޢީސާ އަޙްމަދު
ކައުންސިލްގެ ރައީސް

ސޯންޖެކޯސް ޕްރައިވެޓް ލިމިޓެޑް،
ކ.މާލެ، ދިވެހިރާއްޖެ

EIA report of K.Huraa sewage outfall and Minor coastal Modification.

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Sent: 1/2/2018 11:51 AM

To: secretariat@kaaf.gov.mv

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Dear Sir
please find the attached EIA report of K.Huraa sewage outfall and Minor coastal Modification.

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Attachments: Huraa outfall and minor coastal modifications EIA.pdf