Environmental Impact Assessment for Establishment of an Integrated Water Management System in HDh. Nolhivaranfaru

August 2017

Proposed by: Ministry of Environment and Energy

Consultant: Development Advisory Services Pvt Ltd

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Acknowledgment

The author would like to acknowledge the kind support and assistance given by the proponent, the technical team and the residents of Hdh. Nolivaranfaru in conducting the surveys and obtaining the relevant information to complete this report.

Consultants Declaration

As the lead consultant of this EIA,

This EIA has been prepared according to the EIA Regulations. I hereby, declare that the content in this EIA is complete, true, and correct to the best information that I had while compiling this EIA.

Name: Ali Shareef (EIA 19/11)
Signature:

Executive Summary

This non-technical summary presents the finding of the Environmental Impact Assessment of the proposed Integrated Water Recourse Management system development project at Nolhivaranfaru Island in Haadhaal (HDh.) atoll by the proponent Ministry of Environment and Energy. This EIA report is prepared in accordance with Environmental and Protection and Preservation Act and Environmental Impact Assessment Regulation 2012. The purpose of this EIA is to fulfil the requirement of the Law and to conduct an assessment of possible impacts on ecological, biophysical environment and socioeconomics arising from the proposed resort development.

The main rationale of this project is to develop and operate an Integrated Water Resource Management System on HDh. Nolhivaranfaru. The specific objectives are to Development of the necessary infrastructure for the functioning of Integrated Water Resource Management System to provide safe water to the community. Implementation of the project bring economic and social benefit to the community.

The project will involve the construction and operation of Integrated Water Resource Management System. Construction involves construction of operation building, installation of RO plant, construction of storage tanks, lining of water collection and distribution network, construction of infiltration galleries for ground water skimming and rain water harvesting system. Once the project is completed the Integrated Water Resource Management System will be handed to the proponent for operation.

Key impacts

The impacts of the project result mainly from construction activities such as land clearance, construction of the water treatment facilities, and construction pipeline network installation of brine outfall. During construction of water treatment facilities and lining of pipeline network have negative impact to the terrestrial environment of the island. It is estimated that approximately 50 coconut palm needs to be removed or relocated. Construction of the brine outfall increase in turbidity and sedimentation which can impact the marine environment. Baseline environmental marine conditions indicated that the live coral cover was very poor and fish count is negligibly less, showing minimum impact on marine habitat. Indirect impact may also occur from silting which is a short term impact.

The major socioeconomic impact is found to be positive. Construction of Integrated Water Resource Management System will create a lot of job opportunities during the construction and operation of the system. Establishment of this project will improves public health, socio-economic well-being of the island community and also it improves the ground water quality should there be less groundwater usage.

Mitigation measures

Mitigation measures were taken by conducting appropriate field surveys and environmental assessment of the island, proposed and alternative locations for development water

treatment facilities and brine outfall location of the project and its associated infrastructure. Installation of brine outfall would be done during low tides to minimize the erosion and washing away of the material. The necessary announcements and proper use of sign boards will be used to minimize the difficulties caused during the construction works. A detailed hydrogeological survey of the area where infiltration gallery would be installed is suggested to be carried before construction begins.

Care would be taken so as not to take any construction work near the coast. The generated waste would be stock piled on a frequent basis and waste segregation would be done to sort out the hazardous waste which will be transferred to Waste Management Centre. Moreover, a proper waste management facility would be established and the transfer vessels would be EPA approved and licensed vessels for waste handling. The water and sewerage facilities would be undergoing routine monitoring for the effluent water quality so that minimal to no damage would be done to the marine environment.

Alternate locations and technology

Alternative technologies of construction methods and alternative locations have also been considered during the assessment. Alternative locations for the construction of treatment facilities and alternative methodologies for the brine outfall was also considered. Some of the alternative technology are not recommended either due to expensive process or the available technology not suitable to the environmental conditions.

Environmental management and monitoring

An environmental management plan with environmental monitoring was developed taking into consideration the impacts and mitigation measures to be implemented. The important elements that require checks such as sediment dynamics, coral cover and water quality will be monitored according to the developed monitoring program during construction and operation period.

Although the project involves inevitable negative environmental impacts, such impacts are not serve as to not undertake the project. Mitigation measures have been proposed to adequately minimize the significant impacts. Hence, the project is justifiable in light of the socioeconomic conditions and anticipated benefits from the project which clearly outweigh the negative environmental impacts.

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ސާދާ ހުލާސާ

މި ސާދާ ހުލާސާގައި މިދެންނެވެނީ ހދ. ނޮޅިވަރަންފަރުގައި ޤާއިމުކުރައްވާ ފެނުގެ ނިޒާމު ތަރައްގީކުރުމަށް، މިމަޝްރޫއު ކުރިއަށް ގެންދިޔުމުގެ ކުރިން، މިމަޝްރޫއުގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ވަޒަންކުރުމުގެ ގޮތުން ތައްޔާރުކޮށްފައިވާ ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓުގެ ހުލާސާއެވެ.

މި ރިޕޯޓަކީ ހދ. ނޮޅިވަރަންފަރުގައި ޤާއިމުކުރައްވާ ފެނުގެ ނިޒާމު ނަމަކީ "އިންޓެގްރޭޓެޑް ވޯޓަރ ރިސޯސް މެނޭޖްމަންޓް ސިސްޓަމް" އެއް ތަރައްގީކުރާ ހިންގުމުގެ ކުރިން، މިމަޝްރޫއުގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ވަޒަންކުރުމުގެ ގޮތުން ތައްޔާރުކޮށްފައިވާ ރިޕޯޓެކެވެ. މިރިޕޯޓް އެކުލަވާލެވިފައިވަނީ ދިވެހިރާއްޖޭގެ ތިމާވެށި ހިމާޔަތްކޮށް ރައްކާތެރިކުރުމުގެ ޤާނޫނު ގެ ދަށުން އެކުލަވާލާފައިވާ ތިމާވެށްޓަށް ކުރާ އަސަރު ވަޒަންކުރުމުގެ ގަވާއިދު ތަކާ އެއްގޮތަށެވެ. މި މަޝްރޫއުގެ އިދާރާއަކީ މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީއެވެ.

މިމަޝްރޫއުގައި ހިމެނޭ މުހިންމު ބައިތަކަކީ، ވާރޭފެން އަދި ބިމުން ނަގާ ފެން ނުވަތަ އިންފިލްޓްރޭޝަން ގެލަރީ ބޯރުކުރުން އިމާރާތާއި އެއާއި ގުޅުން ހުރި އެހެނިހެން ފެސިލިޓީތައް ގާއިމުކުރުން މިގޮތުން ފެންފުރާ ޓޭންކީތަށް ހެދުން ފެސިލިޓީތައް، ފެންފެން ސާފުކުރުމަށް ބޭނުންވާ ފެސިލިޓީތައް ހިމެނެއެވެ. މީގެ އިތުރުން ފެންފެން ޖަމާކޮށް އަދި ބޯވީ ކުރާފެން ރައްކާކުރާން ފެސިލިޓީތައް، ފެން އާންމު ރައްޔިތުންނަށް ފޯރުކޮށްދިނުމުގެ ނިޒާމު ހިމެނެއެވެ. ފެންފެން ބިމަށް ހިންގުމުގެ ގޮތުން ގާއިމުކުރާ ނިޒާމު މިމަޝްރޫއުގައި ހިމެނެއެވެ. މިމަޝްރޫއުގެ ފެސިލިޓީ ނަމަ ބޭސްކުރުމުގެ ނިޒާމު، މިނިޒާމު ހިފުމާ ދިމާވާ މިމަޝްރޫއުގެ އިދާރާ ރާއްޖެތެރޭ ހުރިހާ ވަރުގަދަ ވަރުތަކެއްވެ.

މި މަޝްރޫއުގެ ސަބަބުން ތިމާވެށްޓަށް އެންމެ ނުރައްކާ އަސަރެއް ފޯރާނީ އިމާރާތްތައް ބިނާކުރުމުގައި ފެންފެޔޮތަކުރަނިވިޔާއި ގާއިމު ކުރަންޖެހޭ ހޮޅިތައް އެޅުމަށް ބިން ސާފުކުރުމުންނެވެ. ފެން ޕަމްޕްކުރާ ބޯރު ފެން ބޯރުކުރުމުގެ ކުރިން ފެނުގެ އަދަދު ކުޑަ އަދަދަކަށް ހައްދައިލެވެ. އިމާރާތްތައް ބިނާކުރާއިރު އޭގެ ފެންހިންގުން ގާއިމުކުރާ ހޮޅިތައް އަޅައިރު ގިނަ އަދަދެއް ގަސް ނުގަޅާ އޭގެ ބަދަލުގައި ބިންތަކުގެ އަޅާގަހަށް ބަރަހަކަތް ވާނެއެވެ. 50 ގަސް އަދި ބޮޑެތި ބިންތަކުގެ ޖާގަ ކުރަންޖެހޭ ޖާގަތައް ދިމާވެއެވެ. މިގޮތުން ނަގާ ބޭއްވުން ކަމަށް ރިސޯސްތަކާ ބަރަހަކުރަމުންދާ ނަމަވެސް ރައްކާތެރި އަދި ބަރަހަކުރެވޭ ފަރާތްތަކާ ބަރަހަ ދިރުމަށް ކަރުދާ ކުރިއަށް ހިންގާވާނެއެވެ. މިތަން ހުރި އެއްގޮތަކީ ސަބަބުން ޕްރޮސެސްކުރުމުގެ ފެން ހިފުމުގެ ސަބަބުން އެއްގޮތަކީ ދުރުން ހިފާ ބަރުގަދަ ގޮތުގައި ތަރައްގީވެއެވެ. މިކަންކަމުގެ ސަބަބުން ތިމާވެށްޓަށް ކުރާ އަސަރުތަކާ ގުޅޭ ކުރުން ކުޑަކުރެވޭ ގޮތެއް އެކި އެކި ވަސީލަތްތަކުގެ ކޮންމެ ރައްކާތެރިކަމާ ގުޅޭގޮތުން އަސަރު ކުޑަކުރުމަށް ފާހަގަކުރެވިފައިވެއެވެ. މިގޮތުން ކުރެވޭ ކުރިއަށްގެނައުމުގައި އެހެން ހިމެނޭ ވަސީލަތްތަކާ ބެހޭ ޕްލޭން ތަފާސް ރަނގަޅުކަމަށް ކޮންކޮން ހިމެނެއެވެ. ވަސީލަތްތަކާ ކޮށް ބިލަށް ފަރާތް ހިމެނުމުގެ ދެކޭ ކުރުމުގެ އެކި އެކި ޕްރޮގްރާމުތަކުގައި ތަކެތި ފާހަގަކުރެވިފައިވެއެވެ. އަދި ބިމުގެ ފެނުގެ އަސަރެއް ވަސީލަތްތަކާއި ގުޅޭ ކުރުމުގެ ކުރުމަށް ބިލަށް ފުރިހަމަ ވަކި ކުރުމާއި، ކުރިއަށް ވޯޓަރފާތަކާ އަދި ކުރުމުގެ ގާއިމުކުރާ ކުރުމަށް ސިސްޓަމް ގެންދިއުމަށް ކުރިއަށް ދިޔުމުގެ ރިޕޯޓު ތައްޔާރުކުރުމަށް ކުރިން ގެންދިއުމުގައި އީ.ޕީ.އޭ ގެ ހުއްދަ އެކަމަށް ދިނުމާއި ޕަބްލިކްސް ދިނުމަށް ބައިވެރިކޮށް ބޭނުންކުރަން ޖެހޭނެއެވެ.

މިމަޝްރޫޢުގެ ސަބަބުން އާންމު ސިއްޙަތާއި، އިޖްތިމާޢީ ގޮތުން އަދި އިޤްތިޞާދީގޮތުން ގިނަގުނަ ފައިދާތަކެއް އާންމު ރަށުރައްޔިތުންނާއި ރަށަށް ކުރާނެކަމަށް ބެލެއެވެ. މިގޮތުން އިތުރު ވަޒީފާތައް އުފެދުމާއި، މީގެ އިތުރުން ދަނޑުވެރިކަމާއި މަސްވެރިކަމާއި އެހެނިހެން ވިޔަފާރި ތަކަށް ވެސް އިތުރު ފުރުޞަތުތައް ހުޅުވި ނަފާ އިތުރުވެގެންދާނެއެވެ. މީގެ ސަބަބުން ދުނިޔޭގެ އިޤްތިޞާދަށްވެސް ރަނގަޅު އަސަރުތަކެއް ކުރާނެއެވެ. އަދި ފެން އުފެއްދުމުގައި، 3 ވައްތަރުގެ ފެންބޭނުންކުރެވޭނެ އުފެއްދުމުން ފެންއުފެއްދުމުގެ ހަރަދު ކުޑަވެގެންދެއެވެ. އަދި ހުރިހާމޫސުމުގައި ފެނަށް ދަތިވުމުގެ މައްސަލައަށް ހައްލެއް ލިބިގެންދާނެއެވެ.

މި މަޝްރޫޢުގެ ސަބަބުން ރަށުގެ ވެއްޓަން ކޮންމެވެސް މިންވަރަކަށް ބަދަލުތަކެއް އައުން އެކަށީގެންވާނެއެވެ. ނަމަވެސް ރަށުގެ ތިމާވެއްޓަށް އިޞްލާޙުކުރެވޭފަދަ ބޮޑު ގެއްލުންތަކެއް މި ދިރާސާއަކުން ނުފެނެއެވެ. މިމަޝްރޫޢު ސިފާ ރައްޔިތުންނާއި ގުޅުންހުރި މަޝްރޫޢަކަށް ވުމާއި، މިމަޝްރޫޢު ކުރިއަށް ގެންދިޔުމަށް އެކަމުގެ ފައިދާ ރައްޔިތުންނަށާއި، ރާއްޖޭގެ އިޤްތިޞާދަށް ކުރާނެކަމަށްވާތީ، މިމަޝްރޫޢު ކުރިއަށް ގެންދިޔުމަކީ ރަނގަޅުކަމެއްކަމަށް ފެނެއެވެ.

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1. Introduction

1.1 Purpose of this EIA Report

This Environment Impact Assessment (EIA) report has been prepared in order to meet the requirements of the Environmental Protection and Preservation Act of the Maldives (Law No 4/93) especially Regulation on Preparation of Environment Impact Assessment Regulation (2012/R-27). This regulation has been used as the basis for preparing this document.

This EIA report is an evaluation of the potential environmental impacts of the proposed project. This report provides the background to the proposed project components and assessment of their likely environmental and social impacts. This report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be suggested. The proposed enhancement and mitigation measures are outlined where necessary together with an environment management plan and a monitoring programme.

1.2 Project Proponent

The proponent of this project is a Ministry of Environment and Energy (MEE). The project is being funded by the Green Climate Fund. The project is funded through Green Climate Fund. Details of the Proponent are as follows:

Ministry of Environment and Energy, Green Building, Handhuvaree Hingun, Maafannu, Malé, ,20213, Republic of Maldives.

1.3 Scope of the EIA and Terms of Reference

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 project. The main components of the proposed project involve establishment of an Integrated Water Resource Management (IWRM) on the island. Importance is importance is given to document the whole project proposal in detail, identify the main environmental impacts that are associated with the proposed development 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 island and foresees the ways in which potential environmental impacts will be managed, mitigated and reduced.

The assessment more specifically adheres to the Terms of Reference (TOR) issued by Environment Protection Agency (EPA). The TOR is based on scoping meetings held between the stakeholders. A copy of the TOR is attached in Appendix A.

The EIA report contains the following main aspects:

- A description of the project including the need for the project, how the project will be undertaken, full description of the relevant parts of the project, methodology used in the assessment, implementation schedules, site plans and summary of project inputs and outputs
- A description of the pertinent national and international legislation.
- Information about the exiting baseline environmental conditions of the site. These include coastal and marine environment of the site and natural hazard vulnerability of the site
- An assessment of the potential impacts during both construction and operational stages of the project as well as identification and cost of the potential mitigation measures to prevent or reduce significant negative impacts during both construction and operation stages of the project
- Assessment of alternatives for the proposed project
- Environment Management Plan
- Details of the environmental monitoring plan
- Conclusions

1.4 Project Aims and Objectives

The aim of this project is to provide water security to people of *Hdh. Nolhivaranfaru*. The specific objectives are to Development of the necessary infrastructure for the functioning of IWRM.

1.5 Review of similar projects

The following Environmental Impact Assessment reports have been reviewed as background information and for familiarization of project of similar nature. These reports were reviewed as a part of literature review for preparation of this EIA report;

- Environmental Impact Assessment for the proposed Integrated Water Resource Management Project in Adh. Mahibadhoo.
- Environmental Impact Assessment for the proposed Integrated Water Resource Management Project in Gdh. Gahdhoo.
- Environmental Impact Assessment for the proposed Integrated Water Resource Management Project in Ha. Ihavandhoo.

All these EIAs were conducted for Integrated Water Resource Management (IWRM) projects which had components similar to the proposed IWRM project. Hence, these EIAs were used as a reference to understand the environmental impacts along with expert judgment involved with installation of a reverse-osmosis plants, establishment of a piped water network and deployment of infiltration galleries for ground water.

2. Project Description

2.1 Introduction

The economic, social and environmental benefits of the society is very much depended on the sustainable uses of the water. With the increasing demand of water over the years, the water resources are not used in most sustainable fashion. This resulted in implications over the quality and quantity of the available water for consumption of human kind (WWAP 2015). The Maldives is not immune to the global problem of water resources. Historically Maldives is known as islands which have used water in a more sustainable way. However, increased urbanisation and evolving technologies in water extraction has put the water resources in an unsustainable pathway. Moreover, the 2004 Indian Ocean Tsunami that hit Maldives along with many of the Asian and African counties have contaminated the ground water aquifers. Thus the communities are compelled to find alternative ways to manage water resources in a more sustainable way to address the growing concern of water security in the country. Hence this project aims to address the water security of northern island of Maldives (*Hdh*. *Nolhivaranfaru*) by integrating water supply management to provide safe water. This EIA is undertaken to identify environmental, social and economic implication of undertaking this project in *Hdh. Nolhivaranfaru*. This chapter aims to discuss the proposed project with justification and need of the project as proposed.

2.2 Project location and study Area

The project location is at *South Thiladhunmathi* or *Haa Dhaalu* atoll. It is located on the northern east rim of the atoll. The island is geographic location of *Hdh. Nolhifaranfaru* is 6°41'49" N and 73°07'12" E (see Figure 1). The island measures approximately 3.8 km in length and 0.9 km in width with a total area of 172.0 Ha. Similar to all the inhabited islands the island has many basic infrastructures including school, healthcare centre and mosques. The island is situated in a reef system of its own. The closest island to *Nolhifaranfaru* is *Nolhivaramu* to the south west which is about 5 km and *Hanimaadhoo* which is about 7 km at the north east of the atoll rim. Table 1 below shows key information about the island.

Table 1: key information about the proposed *Nolhifaranfaru* Island

Island Name	***Hdh. Nolhifaranfaru***
Location	6°41'49" N and 73°07'12" E
Length	approx. 3.8 km
Width (at the widest)	approx. 0.9 km
Distance to *Hanimaadhoo* (Airport)	approx. 5 km
Area	172.0 Ha
Nearest inhabited island and distance	*Nolhivaraum* 5 km to south west
Nearest resort	*Island Hideaway Beach Resort and Spa* 18 km

Figure 1: Location of *Hdh. Nolhifaranfaru* (source: isles).

2.3 Justification

Fresh water in the Maldives is a scare resource. Groundwater aquifers and harvested rainwater are the traditional source of water usage in the country. Increase in urbanisation, over extraction of water and salinization, over the years the quality and quantity of water extracted from these sources have deteriorated significantly. There are cases in Maldives where groundwater has completely transform to saline water. The trend for this transformation is now increasing drastically in the outer islands.

In addition to salinization of island fresh water lenses, the septic tanks in many islands of the country was washed during the 2004 Indian Ocean tsunami. This has resulted in increasing in contamination of the ground aquifers making them for unfit for portable and other household purposes. Thus, to meet the increasing demand of water during these emergency situations, government undertook highly costly method of supplying water to these islands.

Moreover, changing climate pattern have negative consequences on the rain water harvesting in islands, particularly northern islands of the Maldives. Furthermore, increasing the duration of dry spell in the country. In order to overcome the problems associated with the water security in islands, many desalination plants were installed in many countries. These plants were not able to cater to the growing demand of islands. Hence the importance of integrated water resource management is essential and proposed in the island of *Nolifaranfaru*.

The proposed project will provide water network for all the populated areas of the island with an extraction point at each individual house. Furthermore, the proposed concept is based on the principles of Integrated Water Resources Management (IWRM) by tapping into multiple water resources (conjunctive use) to provide water for the end user. It is proposed to use desalinated water complimented by rainwater collected from public roof tops. This would reduce the operating cost once the system is established and contribute to the sustainability

of the service. In addition, this will create a hub in different regions to produce safe drinking water where these will act to provide drinking water to other islands during dry periods. The proposed project will bring many benefits to the community of *Nolhivaranfaru* including addressing water security for the island. Some other benefits associated with the proposed project are;

- Improvement of community health, with reduce water borne diseases outbreak;
- Promote of the island vegetation with proposed ground water recharge in the island;
- Reduce the impact or flooding or flooding in its kind due to proper infiltration gallery that is installed as proposed;
- Availability of adequate, sustainable and predictable safe water for the community;
- Reduce burden on the national budget for provision of emergency water supply in the island;
- Improvement of the overall standard of living in the island/community.

2.4 The Project

The proposed project aims to ensure provision of safe, sustain and adequate supply of fresh water to the community of *Nolhivaranfaru*. In this sense as mentioned above, an Integrated Water Resource Management (IWRM) system would be installed on the island. The proposed IWRM is more environmentally sound solution for the community. This proposed project is approved by the Ministry of Environment and Energy.

The project is designed to last for next 35 years, also it considers the annual growth of the island population. Figure 2 shows the population trend and projected population of *Hdh*. *Nolhivaranfaru*.

The proposed project consists of following components.

1. Rainwater Harvesting (RWH);
2. Reverse Osmosis (RO) for desalinisation water;
3. Infiltration gallery;
4. Water treatment plant;
5. Storage tanks; and
6. Water distribution network.

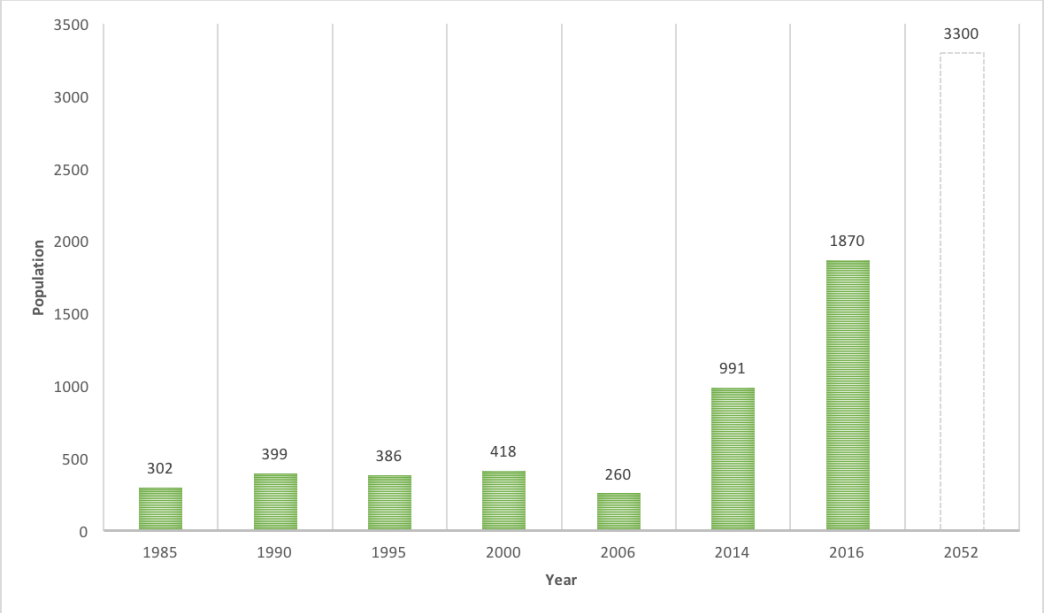

Figure 2 Population of Hdh. Nolhivaranfaru from 1985 – 2014.

2.4.1 Existing Water Demand and Supply

The water demand of the island is calculated based on the *"Guidelines and Manual for Rainwater Harvesting in the Maldives"* published by Ministry of Housing, Transport and Environment in 2009. The following formula is used

Water Demand = **water use** x **family members** x **365 days**

Water usage: 20 liters/day
Family members: 6
Project Population: 3300

Water requirement for drinking and cooking purpose = 0.0733 MLD

Water requirement for institution = 0.0073 MLD

Therefore, the total water requirement for *Nolhivaranfaru* = 29.443 ML /Year
= 2.454 ML /Month
= 0.081 ML/Day

Rainwater being the primary source of drinking water in the island. Rainfall data is used to estimate the water supply availability of the island. The rainfall data used in this estimation is data from *Hdh. Hanimaadhoo* as there is no long-term climate data collection in the project location. The water supply is calculated by the following formula.

Water Supply = **Rainfall** (mm/year) x **Area** (sq.m) x **Runoff co-efficient**

Therefore, the water availability = 3.87 ML /year

These estimates indicate that water collected during rainfall does not meet with the demand of water. Hence more techniques need to be utilized to meet the growing water demand. These information was used in the project components.

2.5 Project boundary and impact zone

The project boundary is the whole island and to the east of the island where the brine outfall is located. As the construction phase of the project will involve pipe laying throughout the entire island the impacts zone would be the entire island and the marine environment.

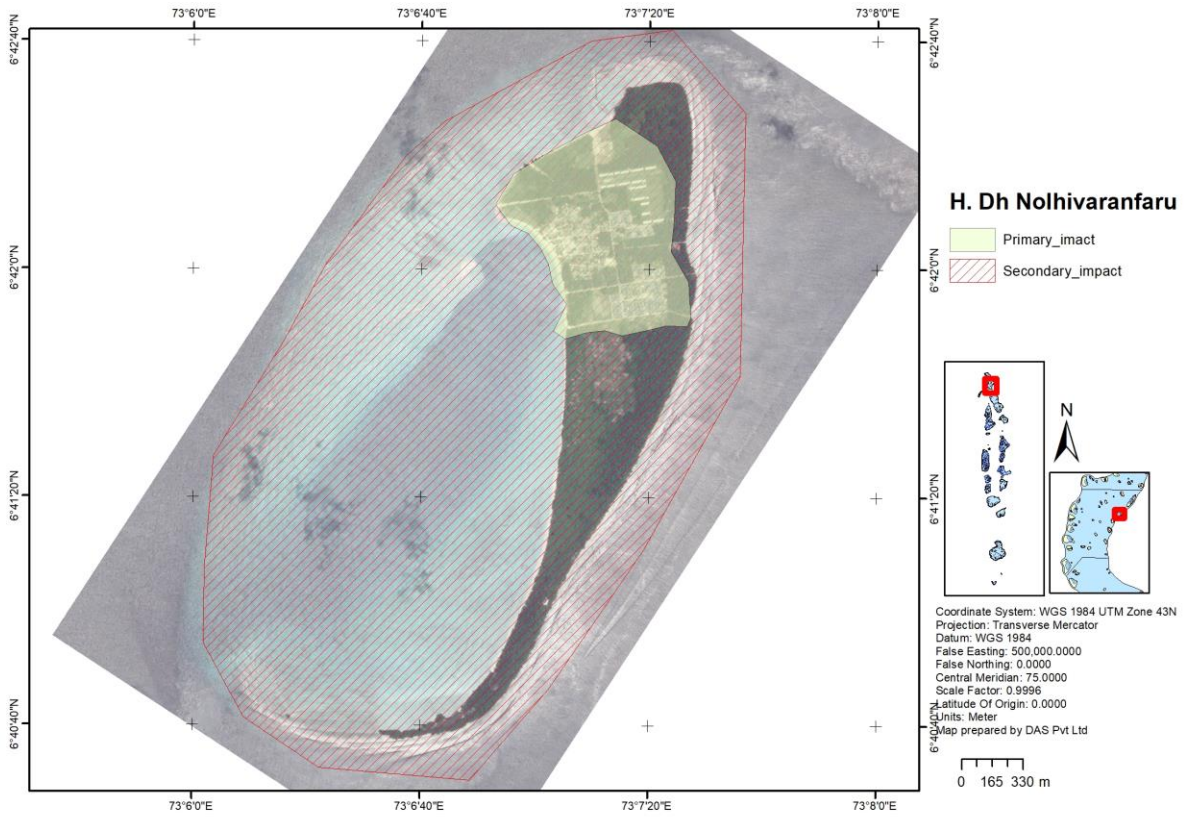

Figure 3: Project boundary with possible primary and secondary impact boundaries

2.6 Rainwater Harvesting

Rainwater Harvesting (RWH) is traditional technology that Maldivian have used for a long time. The simplistic and locally appropriate technology is widely practiced in the Maldives. It employs collection of rain water that falls on impervious surface such as roof. These water is either stored in storage tanks or used to recharge ground water aquifers. In most of the case excess water after storage is let to infiltrate into ground water aquifer.

The community of *Nolhivaranfaru* currently practice RWH technique for portable purpose (drinking and cooking). Individual or private RWH systems are in place in almost all the household of the island. Most of the household have one to two storage tanks of 2500 litres capacity. The household which do not have luxury of installing their individual RWH system uses water from community water tanks located in most of the public buildings. There are 10 such tanks in the island. However, the demand of water is not met with the current RWH systems. Hence the project proposes further enhancement of RWH in the island with proper design.

The total runoff from the roof is estimated by the following formula.

$$Q = CIA$$

The components of RWH system are as follows.

2.6.1 Roof catchment

Rainwater can be collected on many surface. However, the most recommended roofing used for rainwater catchment is corrugated mild steel. As they provide means of most cleaner water harvesting material over the traditional roofing such as thatched roofing. The criteria used for determination of best catchment area is through the runoff coefficient. Table 2 shows the runoff coefficient of different types of roofing used in the Maldives. The total community roof catchment is approximately 0.32956 ha.

Table 2 Types of the roofing materials with their respective runoff coefficient.

Roof Material	Runoff coefficient
Sheet metal	0.8 – 0.85
Cement tiles	0.62 – 0.69
Clay tiles (Machine Made)	0.30 – 0.39
Clay tiles (Hand Made)	0.24 – 0.31

2.6.2 Gutter and down take pipe

Gutters channels the water that is collected by the catchment area or roof. The gutters are usually fixed on the edge of the catchment area to ensure the water is properly collected without much waste. Additionally, slope and size of gutters to that of roof catchment area are factors which contributes to the overall efficiency of the system. The slope of the gutter should be approximately 1:200.

Table 3 below shows estimated gutter width to the roof area. Gutters come in many shapes, however the most common type of gutters used in Maldives are semi-circular and box types. These gutters are constructed either with PVC or metal sheets. Despite efforts to make the catchment area clean and ready for the RWH, during rain leaves and other materials may fall to the collection system, hence to avoid inflow of such materials wire mesh is generally constructed around the gutters.

Table 3 Roof area to gutter width and down pipe sizes

Roof Area (m^2)	Gutter width (mm)	Down pipe (mm)
17	60	40
25	70	50
34	80	50
46	90	63
66	100	63
128	125	75
208	150	90

2.6.3 First flush

First flush is known as the water at the start of the rainfall. This water is not collected during the first few hrs as the collected water may be contaminated with pollutants such as bird droppings, sand and durst particles. This technique is widely practiced in the Maldives to prevent further contamination of storage water. In Maldives two types of first flush device mechanism is used. A fully mechanical system and semi-mechanical system. Fully mechanical system involves removal of the down pipe connection to the storage tank manually during the first hours of rain. The semi-automatic system involves introduction of "T" junction between storage tank and gutter. The 'T' junction is manually open during the first hours of rain and then after few hours at the end of first flush 'T' is closed. Once 'T" is closed water will continuously flow into the storage tank.

2.6.4 Filter unit

The water collected from the roof catchment area enters through the down pipe into the filtration unit. The unit comprises of chamber either filled with coarse sand, charcoal or coconut fibres. As the water dripples through this filtration unit, collected water will be filtered for many debris and some of the microbes. Alternative to this filtration unit, many Maldivians use fine cloth.

2.7 Reverse Osmosis for desalinated water

The Reverse Osmosis (RO) Desalination Plant is installed in the island as a backup. This would provide water to community as the cost effective technologies such as RWH and groundwater recharge alone cannot meet with the demand. Hence, two RO plant will be built on the island having capacity to produce 0.045 ML/Day each. Figure 4, show a schematic diagram of RO plant.

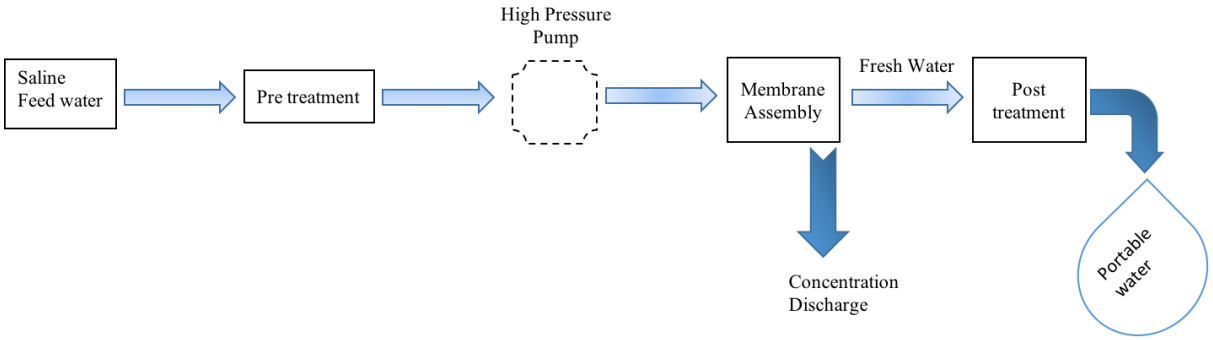

Figure 4 Schematic diagram of the RO.

2.7.1 Feed water

Brackish water will be fed to the RO Plant from the boreholes. The boreholes are proposed to be drilled near the desalination plant area. This is to prevent further loss of inlet water into the system. These boreholes will be drilled with experienced contractor to ensure that no damage is made to the fresh water lens of the island. Conductivity level will be monitored as

the drilling is continued. Conductivity is used as an indicator to ensure fresh water is not damaged. Drilling should be undertaken to a depth of 30 to 40 m with conductivity level of 50 – 60 mS/cm. Upon the completion of drilling, the drilling probe shall be removed quickly and installation and borehole should be installed. The water extracted from the borehole will be directly fed into the RO plant for desalination purpose.

2.7.2 Brine outfall

The high concentration of the rejected water of RO plant will be discharged at the brine outfall. The outfall is located east of the island. The outfall pipelines will be constructed with High Density Polyethylene (HDPE) of minimum class PN16. Diffusers will be installed at the termination point of the outfall. The construction and installation of the brine outfall will comply with all the EPA requirements, guidelines, guidelines as well as would take into consideration of the international best practices.

2.7.3 Infiltration galleries and groundwater

2.7.3.1 Infiltration gallery

Infiltration gallery is a horizontal drain made from open jointed or perforated pipes or a block drain which laid below the water table and collects groundwater. Infiltration galleries need soils that are permeable to allow sufficient water to be collected. The gallery will be surrounded with gravel pack to improve flow towards it and to filer any large particles that might block the perforations.

Infiltration galleries will be sued to collect or skim the surface water from the water table and laid just below the low water level. Gallery will be used in conjunction with other water sources as a means to increase the water supply. Infiltration galleries has been tested and are in use in some of the similar islands in the small island states in Tarawa islands (Falkland 2015) and Kiribati (GWP 2014).

In this project, the galleries are used as a pilot test system. The gallery would be constructed with pipes with perforations underneath the pipe where the perforations would be wrapped and covered with a geo-textile used to filter the stream of water going into the pipe through the perforations. The surface water would be skimmed through the perforations and drawn into a collection well where it would be pumped into a filter system. The collection well would be sealed from the bottom to ensure that no water other than water from the connected galleries enter into the well. The gallery pipes would be connected to the well via gravity flow. A float switch will be placed in the collection well to monitor the level of water being collected and to control the amount of water being pumped.

In addition to the collection well, another vertical PVC pipe sealed at the surface will be connected to the gallery. This pipe will be installed with salinity meter and connected to a surface logger and monitored for any salinity shifts of the water being collected into the pumping well. As a control, a standalone well separate from the gallery also will be constructed and installed with a salinity meter within the proximity of the gallery. This will

enable to monitor and compare the salinity of the surrounding to that being collected in the gallery. This will determine the rate and control the amount of water being pumped from the well. The water being pumped goes into the slow sand filter for further filtration and go into a chlorination chamber for bacterial treatment before it goes into the main distribution storage tank.

In contrast to the water being pumped directly from the water table as done in the conventional pumping wells, use of infiltration galleries would put less pressure to the water table. In the conventional pump wells, water is being drawn from the aquifer directly and due to high pumping rates, it creates a vertical pressure gradient with a coning effect near the suction pipe. This causes saline water to enter into the aquifer. However, with the galleries being just placed at the surface of the low tide level, water will infiltrate into the gallery via the perforations and gets collected to the collection well which is sealed from the bottom so that no water can enter into the well from the bottom. The only water in the well will be those being collected from the galleries. Therefore, water being pumped will not create any vertical pressure gradients on the water lens for saltwater intrusion into the aquifer. This method is safer than the conventional pumping wells. However, the risk of salinization of the water lens is still there if water will be overdrawn.

As this is a pilot system, the quality and quantity of the water being collected via the gallery will be monitored. If there is any degrading in the quality of the water, if there is a drop in the yield of water, the system would stop collecting water. As the gallery would be a separate pipe network connected to the storage tank, it could easily be shutoff or isolated from the other sources should there be any problem with the gallery system. This will enable for smooth and easy operation and maintenance of the IWRM system.

2.7.3.2 Design considerations of infiltration galleries

The length of the proposed infiltration system is 204m. Three infiltration galleries with a length of 102m each is proposed for this project. Pump will be provided in the centre of each infiltration gallery. The proposed pumping rate is as the following;

- For small limestone island – less than 0.25m^3/day/m of gallery and
- In the case of very fragile lenses; it should be less than 0.1 m^3/day/m of gallery.

Manholes of a diameter 1m will be constructed using suitable corrosion resistant materials such as prefabricated cylinders made of fiberglass, concrete, ferro cement. The Figure 5 is an illustration of the arrangement of the proposed infiltration galleries and Figure 6 is a cross-sectional diagram of the proposed infiltration gallery.

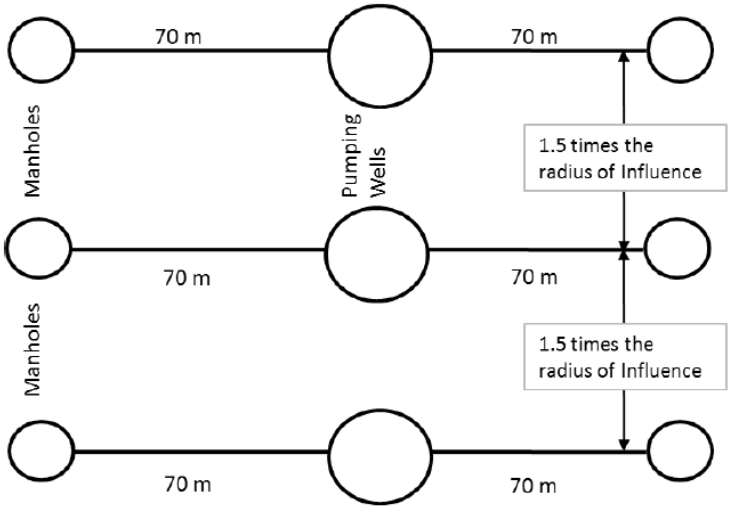

Figure 5: The proposed arrangement for the infiltration gallery including the manholes and the pumps. Galleries would be connected to the pumping wells via gravity flow.

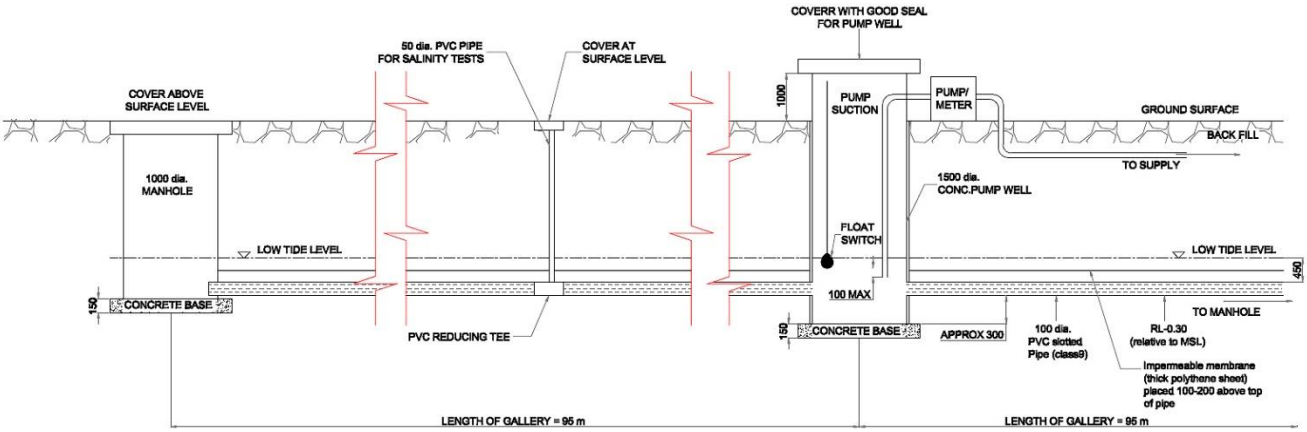

Figure 6: Schematics of cross-sectional diagram of the proposed infiltration gallery

2.7.3.3 Engineering criteria used in design

Discharge through infiltration gallery Darcy's law – The discharge from the gallery can be computed by using Darcy's law as:

Q = k I A, where k – permeability of soil

i - Gradient

A – Area of Infiltration

Or

$$Q = kL\left(\frac{H^2 - h^2}{2R}\right)$$

Where, k – permeability of soil

L – Length of Gallery

H – Height of water available above gallery

h – Height of water available for extraction

R – Radius of Influence.

Length of gallery: will be calculated as below:

- Hourly rate of Pumping (known)
- Rate of infiltration (assumed)
- Area of Infiltration = Rate of pumping / Infiltration rate
- Type of Gallery = Circular of pipe., D

Length of Gallery = Area / (π. D. (H-h)), where (H-h) = Drawdown, limited to 50 mm.

Slot width should not be greater than 1.5 mm and the entrance velocity at the slot is such that to prevent clogging.

2.7.4 Sustainable yield estimates

Sustainable yield of the fresh groundwater on an atoll island is the amount of freshwater that can be extracted without causing long-term depletion of the lens. The sustainable yield can be a small proportion only of recharge as much of the recharge is required to maintain the ground water by allowing water to flow through the lens thus controlling the natural mixing of fresh water and underlying saline water.

An estimate method used by Falkland 2000 used here. Falkland also estimated that there is a linear relationship between the size of the island and the size of the aquifer. Similarly, Carter et al 2001, the size of the groundwater lens is directly related to the size of the island and the intensity of precipitation (heavy or light rain). Studies in Maldives have shown that generally a sustainable yield to be between 25% and 50% of recharge with low values being associated to low rainfall and vice versa. Maldives receives a rainfall of more than 2000 mm per year which is sufficient to recharge the ground water. According to Falkland 2001, the estimated groundwater lens area and area of island is typically 0.45.

Estimate area of groundwater lens = 0.45 172 ha = 77.4 ha

Assuming a recharge of 35%, and using the estimates above, a sustainable yield of approximately 148.43 m^3/day is calculated for this island.

Should the government decide to continue on the using the groundwater with the infiltration galleries, a thorough assessment of this estimate needs to be established to be compared to the extraction rates designed for the gallery system.

2.8 Water treatment plant

The water from the pre-treatment storage tanks are fed into filter to remove and treat water before storage and distributions. Slow sand filters and other treatment is proposed for treating water before distribution. Figure 7 below shows layout of the treatment facility.

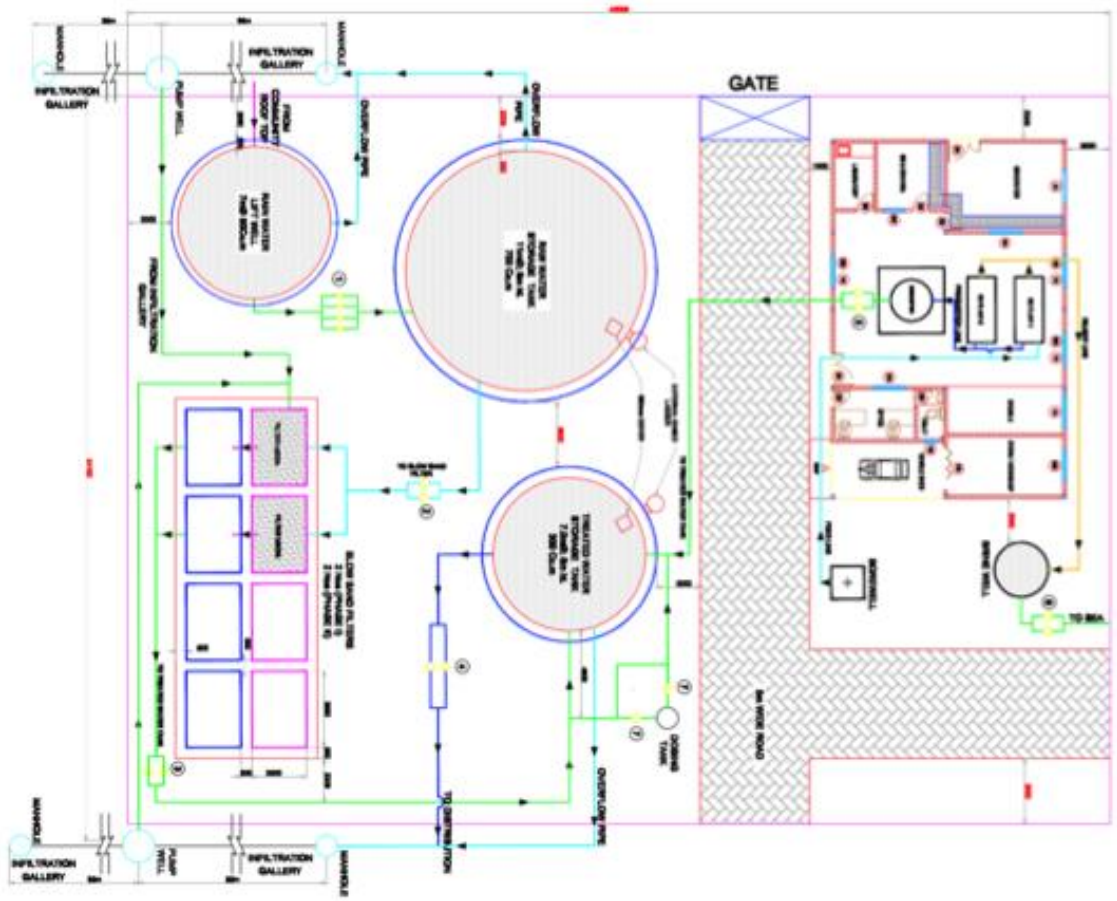

Figure 7 Layout of the Treatment Facility

2.8.1 Slow Sand Filters

Slow Sand Filters are used as they are most effective to remove both microbial activity and organic pollutants from the water. The water that have passed through this filtration mechanism will be approximately 99% free from harmful microbes. In addition to this the turbidity of water would be significantly reduced through oxidation of ammonia and other organic matter. Figure 8 below show a typical schematic diagram of Slow Sand filters that are proposed for the project. Table X shows quality of product water from Slow Sand filter.

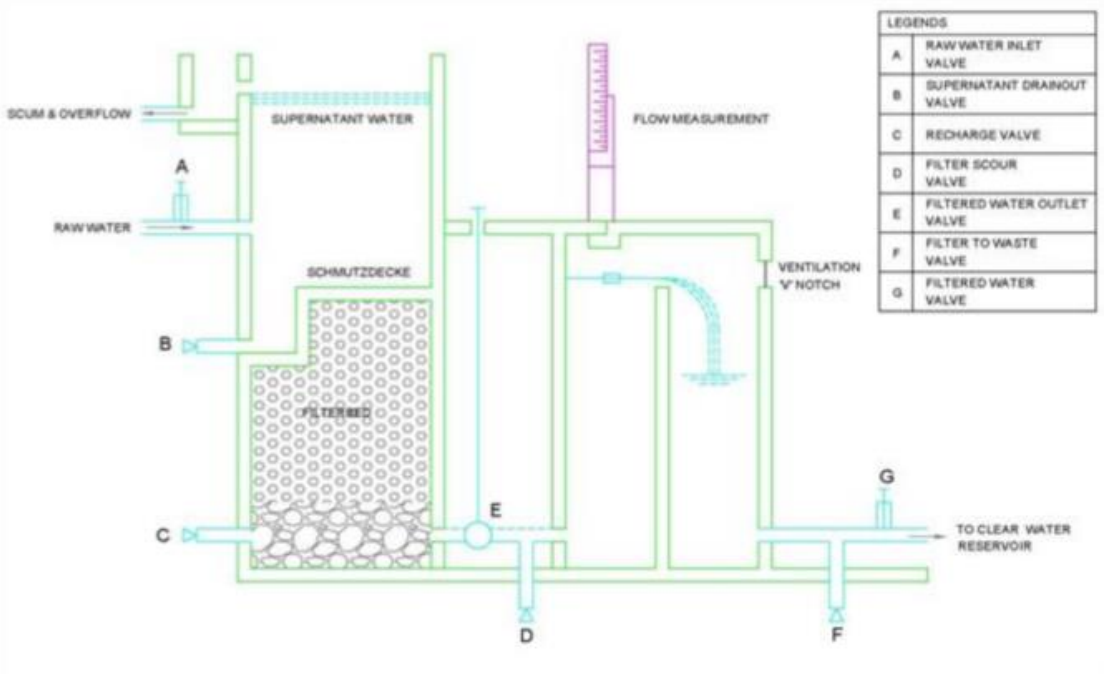

Figure 8 Schematic diagram of the Basic elements of Slow Sand Filter

Table 4 Quality of product water passed through the Slow Sand Filter

Water Quality Parameters	Purification effect
Colour	30% to 100% reduction
Turbidity	< 1NTU
Faecal Coliform	99% to 100% reduction in the coliform level
Viruses	Virtually complete removal
Organic Matter	60% to 100% reduction in COD
Iron and Manganese	Largely removed
Heavy metals	30% to 95% reduction

2.8.2 Disinfection

Disinfection is a process of killing the inactive microbial activity to a level which would less harm humans. In this system, two types of disinfections are used in the proposed project, they are;

1. **Ultraviolet radiation:** This infection measure is undertaken in water which is free from suspended solids and are clear in colour. The process usually free water from all the harmful bacteria and viruses. The process is integrated with the proposed RO plant, hence the product water from the plant will be treated with ultraviolet.
2. **Sodium Hypochlorite (NaOCl):** This is a chemical based disinfection. It involves mixing a known amount of NaOCl in known amount of water. At the point of saturation the solutions is further diluted as desired and then mixed in the storage tanks, before distributing to communities. Table 5 below shows the estimation of NaOCl for this project.

Table 5 Estimation of NaOCl Dosage

*Average Temperature:*25^{O}C

Chlorine content: 14.5%

Storage duration: 4 weeks. Chlorine content 10.52%

Applicable dosage: 1.5 mg/l (cm^3/m^3)

Description	Water Demand (m^3/day)	Dose (cm^3/m^3)	Daily Requirement	Storage for 4 weeks (l)
Short term	26.5	(1.5 x 100/10.5) = 14.28	0.378	10.58 ≈ 11
Medium term	40.0	14.28	0.571	15.98 ≈ 16
Long term	53.0	14.28	0.756	21.16 ≈ 22

2.9 Storage tanks

The conveyance system is designed taking account of a rainfall of 55mm/hr and the rainwater is collected in the raw water tank prior to treatment and supply. The capacity of the raw water tank/rainwater holding tank was determined using the following assumptions;

- Only 15% of the water demand is met through rainwater;
- 80% of the rainwater is collected from the rooftops;
- Carrying out water balance using monthly demand and supply/ rainwater available;
- No initial storage is considered.

The project proposes construction of two storage tanks, with total capacity of 1100 m^3. The estimations for storage were made based on the available data such as annual rainfall and demand of the community for water. Two Pumps will be placed in the storage tanks to control water flow from tanks to either Slow Sand Filters or distribution network or overflow. These automatic pumps will take turns to ensure that there is always backup.

The first tank is known as **Raw water storage tank**, used to collect rainwater from the designated catchment areas. Approximately 800 m^3 capacity is required for this purpose. The second tank is known as **Treated water storage tank** with a total capacity of 300 m^3. The storage capacity of this tank is estimated based on 7 day water demand for the island.

2.10 Water distribution network

The purpose of the water distribution system is to deliver water to the communities from the storage tanks. Underground piping will be used to layout the network for water distribution. As mentioned above, the water demand of the island is estimated as 0.082 MLD. The total length of the network is estimated as 14 km. Table 6 below provides salient characteristics of the proposed distribution network. Figure 9 shows the propose network of the island. It is to be noted that in this IWRM system, the three sources of water being collected into the treatment and storage comes from their own separate and standalone networks. This will

enable to better control the amount and type of source water being provided and also will ensure continuity of water to the public during maintenance shutdowns of different sources. Additionally, this will enable easy isolation of the source of water if any problem is detected before being pumped to the storage tanks.

The proposed IWRM project is aimed to establish a piped water network which will have household connections. A ferrule will be used on the main lines to control the flow of water into the house service connections. The ferrule is sufficiently throttled to deliver required flow at the contemplated pressure. The size of the ferrule shall not be more than ¼th of the nominal diameter of the main pipe and also be less than the diameter of the connecting pipe. In addition, a stop cock will be provided in the beginning of house connection pipe to control the supply or to facilitate temporary disconnection. A meter is installed beyond the stopcock for measuring the flow. A layout of the proposed water distribution system attached in the appendix of this report.

Table 6 Salient Characteristics of the Proposed Water distribution network

Features	
Design Period	35 years
Peak factor	1.5 x Average day demand or 2.25 x Average day demand
Length of Network	14 km
Minimum zine of pipe	63 mm
Pipe Material	Poly Ethylene (PE) or High Density Poly Ethylene (HDPE). All the mains will be HDPE and laterals will be PE
Maximum Pressure	30 m
Minimum Pressure	15 m
Head loss	1 – 4 m/km at peak flow
Minimum cover over pipe	0.6 m
Maximum depth of excavation	1.5 m
Bedding material	Sand
Fire Hydrant	At every 300 m
Sluice values	Shall be provided on each branch
Washout values	For draining the pipe line at dead ends.
Air valves	Shall be installed at peaks in the pipeline
Fire flow	Two fire flow at a time at 10 l/sec for duration of 2 hrs at maximum day demand
Pipes size of single house connection	18 mm
Pipes size of high rise building connection	75 – 90 mm
Water meters	Households should be metered
Bulk water meters	Installed at entry of main reservoir

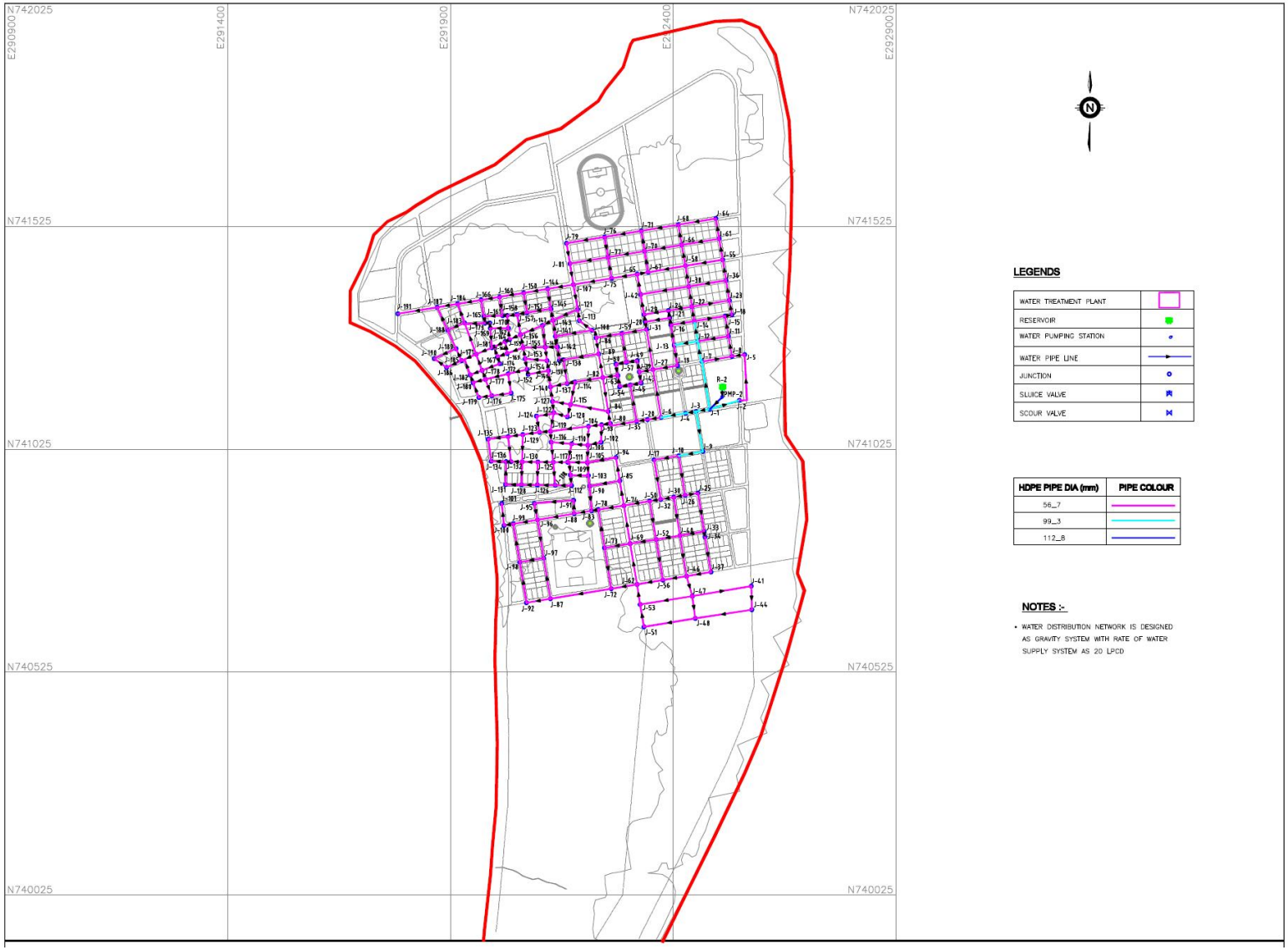

Figure 9 Water distribution network of the island

2.11 IWRM in the Island

The proposed Integrated Water Resource Management (IWRM) cannot be overemphasised in addressing to the needs of the community. This management tool enables that water security is enhanced and communities are more resilient to water stress or dry spells. The use of three water sources (rain, ground and desalinated water) eliminates risk of overdependence on availability of single source of water for consumption and other purpose. Figure 10 below provides proposed schematic diagram of the proposed IWRM. Three major steps are involved in the IWRM they are;

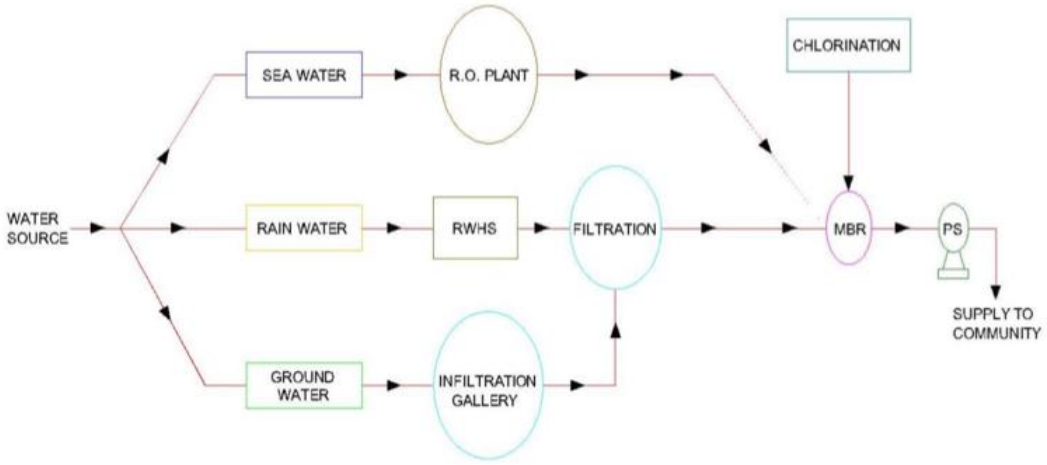

Figure 10 Schematic diagram of the proposed IWRM

1. **Source:** Salt, rain and ground water is used as primary water source. The sea water is purified through the RO plant. While the collected rain water directly collected in Raw water storage tanks. Additionally, the ground water pumped through the infiltration gallery get into the slow sand filter for further treatment.
2. **Treatment:** The product water from RO plant will be maintained to domestic consumption level hence it is directly channelled to the Treated water storage tank ready for distribution. However, both rain and ground water needs to be further treated. This treatment will be undertaken by both Slow Sand Filters and water is pumped into Treated water storage tanks. At the Treated water storage tank level, the water is further chlorinated before distribution to communities.
3. **Distribution:** Through a piped, metered and pressure controlled network the treated water is connected with the individual household.

2.12 Plan, Operation Building and Laboratory

The proposed desalination plant, infiltration gallery, borehole for feedwater and the main water storage will be located in the proposed site allocated for the IWRM project. Schematic diagram for the project site is attached in the appendix. The following infrastructure will be constructed in the project site include the following;

- Desalination plants
- Infiltration Gallery
- Raw water storage tank
- Treated water storage tank
- Operation Building

2.12.1 Operation Building

A building will be constructed at the project site for installation of the desalination plant. This building will include administrative office, accommodation for the operators, generator room, laboratory, washrooms and store rooms. The building will be properly landscaped and provided with fencing around the premises, security guard room, potted plants and security lighting around the premises.

2.12.2 Laboratory

A fully equipped laboratory will be established in the operation building. However, this laboratory will be provided with limited chemicals and reagents which will be required to perform water quality test for some important criteria. These chemicals are required for regular testing of the water in the treated water tank.

The parameter which will be tested in the laboratory includes pH, electrical conductivity, salinity, Total Dissolved Solids (TDS), temperature and turbidity. A digital colorimeter will be used to determine the level of chlorine.

2.13 Project Implementation

Different types of activities will take place as during the construction phases and the operational phase. The environmental and social dimensions of the island and the community needs to be adjusted during and after the completion of the proposed project. Thus project implementation for the purpose of EIA preparation is classified into construction and operational phases.

2.13.1 Construction Phase

2.13.1.1 Site preparation

Preparation of site is a key step prior to the construction of any proposed project. The site preparation includes undertaking the following activities.

1. Identification of the proposed location for construction of Treatment Facility, storage tanks, RO plant and rainwater catchment areas;
2. Undertaking of ground surveying and ground trothing;
3. Clearance of vegetation at project sites. In this case RO plant and treatment facility is located in highly vegetated areas;
4. Construction of temporary work areas/hut and staff areas if needed.

2.13.1.2 Mobilisation of work at the construction site

All the equipment including heavy machinery needed for excavation and construction need to be transported to the island. Moreover, since most of the work are undertaken by contractor a high amount of labour force will be also mobilized to the island for implementation of the project. It is estimated that around 20 staff would be needed to complete the project. These staff will include labours, engineers, supervisors and environmental safeguard coordinators. As the island is a well populated island, the employees will be accommodated in the local houses or guest houses.

In addition to these constructions tools, materials used for constructions such as piping, tanks and other concreate casts need to be transported to the island. These materials will be transported to the island by sea. Since most of the islands are accessed by sea transport measures needs to be taken to avoid impacts during the transportation of goods and materials to the islands. These impacts ranges from possible oil leakage from the vessel (*dhoni*) which damages coral reef ecosystems to emission of greenhouse gas.

2.13.1.3 Management of Waste

The main types of waste expected to be generated for this project include material waste and waste from packages of various materials. However, these wastes are expected to be small quantities and the contract are expected to reuse some of these waste materials.

The project site has few vegetation, hence site clearance will generate minimal amount of green waste. To the greatest extent possible the soft material (leaves, shoots, etc.) would be separated and composted on site for later reuse during the landscaping phase. Harder and woody material (tree trunks branches) would be stockpiled and removed from the site for disposal at R. Vandhoo.

2.13.2 Health and Safety Issues

Health and safety of the workers is indispensable for execution of a successful project. The contractor of the project holds the prime responsibility to ensure that precaution measures are taken by the workers. One of the most important aspect of the using the Personal Protection Equipment (PPE). Appropriate PPE should be worn at all times. This will typically include hard hats, eye protection, protective trousers, gloves and reflective clothing. Hearing protection, masks and wet weather clothing will be available for use where necessary. In addition, the following safety measures will be in place;

- First aider will be on site at all times;
- All plants will be operated by competent certified operators. Plant to be inspected regularly and have the appropriate certification;
- Manual lifting operations will be kept to minimum by the use of mechanical means;
- Certified chains and slings will be used at all times

2.13.2.1 Power and water requirements

Electric power from the island power grid will be taken as main power supply during construction and operation. As per the government's policy on providing all the utility services

on an island through one SOE utility company, the existing electricity service provider, FENAKA Corporation will also be maintaining the system in operational phase.

As part of the power provision, it is also planned to use solar PV as a source of power production to the facility. The solar cells will be installed on the roofs of the facility. The size of the panels would be determined at the later stage of the project. Solar Photovoltaic will have a greater initial investment cost. It is estimated that USD 70,000 will be required to install PV for desalination purpose. The estimated 1500 m^2 of area will be required to install PV system which is required to generate the electricity required for RO plant operation. Since, this IWRM project utilize roof space for rainwater harvesting and the island lacks large public roofs or open areas and it is highly difficult to dedicate and area of 1500 m^2 for installation of solar panels. The size of the panels will be determined once the system is established since the primary source of power will be diesel. The wind power is a source which require similar installation costs and require large area for installation. Hence, one of the most preferable option is a combination between diesel generation and PV system.

Water requirements during the proposed project will be met from rainwater or bottled water during construction.

2.13.3 Operational Phase Activities

The key activities during the operation of the IWRM project includes the following;

- Rainwater harvesting;
- Storage facilities;
- Pumping;
- Brine Disposal;
- Feedwater from boreholes

The following activities are expected to have the most significant impacts on the natural environment of the island.

2.13.3.1 Brine Disposal

The reject brine concentrate from the desalination process of the seawater will be disposed to the eastern site of the island into the lagoon. The reject brine will be kept in brine well for aeration purpose in order to minimize the adverse impact of the reject brine on coral and fish communities at the brine outfall location. The location was chosen since a significant damage was already given to the eastern side lagoon during the airport construction and a very minimal marine life was observed within the lagoon. In addition, there is an existing brine outfall from the RO plant operated by the airports facility. This location offers the best conditions for mixing and hence will have the minimal impact of reject brine concentrate of the exiting marine environment.

2.13.3.2 Feed water intake

The feed water intake will be from a borehole drilled with in the premises of the project site. The borehole will be connected directly to the desalination plant via a feed line. A submersible pump will be used to facilitate uptake of brine from the borehole. The main reason for using a borehole rather than obtaining brine from lagoon is that the marine water quality is better

in water obtained from a borehole and will increase the lifetime of the membranes of the RO plant as the water from the boreholes would be brackish less saline water.

2.13.3.3 Decommissioning

Prior to operationalisation of IWRM, decommission will take place. The contractors will remove all the temporary structures from the island. Similarly, all the heavy machineries will be transported back. Recyclable waste and other waste will be also shipped back to regional waste management facility for recycling. The contractor will be remove all its foot print from the island and IWRM facility will be handed over to the Government. The government will initiate the process of desalination plant registration.

During operational of IWRM project in Nolhivaranfaru the following activities will be in progress.

1. Monitoring and management of rainwater harvesting catchments and its associates;
2. Monitoring and management of the works of infiltration gallery;
3. Monitor quality of intake and brine discharge; and
4. Evaluate and analyse quality of product water that is supplied to the community.

2.13.3.4 Health and Safety Measures

During operation health and safety of the staff who maintain IWRM should be managed. In this regard, all the health and work safety guidelines should be met including provision of first aid facility at the site. Staff who checks on quality of water needs to follow all the guidelines and Standard Operating Procedures of the facility as designed by the consultant.

2.13.3.5 Power requirements

The power requirements of IWRM shall be met by FENEKA cooperation of the island.

2.14 Project duration and schedule

The project is expected to be carried out in 18 months according to the schedule once the EIA clearance is given. Details are attached in the appendix.

2.15 Project Management

The project will be managed by local and international consultants contracted with the Client. A significant role by the project management unit with the Ministry of Environment and Energy will played in collaboration with the island council and the FENAKA during the construction of the facilities. FENAKA cooperation will handle the operations and maintenance of the facility once the facility is fully functional.

2.16 Risks associated with the project

There are financial and environmental risk factors associated with the project. The most significant risk is, unable to finish the project according the planned schedule causing delay in demobilizing from the island and inconvenience caused due to this. This could be caused by

changes in weather conditions, delays in obtaining the material for construction, financial restrictions and due to social issues. The risk factors could be minimized by proper planning of the activities taking into account the changes in the natural phenomena such as weather and better collaboration among the stakeholders.

The project involves establishment of an infiltration skimming gallery. As the gallery would be sitting in the water table, there is a risk of over drawing of ground water from the gallery. The ground water would be recharging during the rainy monsoon where plenty of fresh water could be skimmed from the surface. However, during the dry monsoon when there is no fresh water to be recharging the water table and if the water from the galleries could be over drawn, this could increase the risk of salt water be drawn in to the water table. However, if the pipes and the manholes are properly sealed, this risk of salt water pumping could be minimised with careful monitoring of the infrastructure.

Another risk which needs to be considered is the risk of clogging of the galleries. As the galleries would be covered with geo-textile material, this could get clogged in time with mud and other material degrading the quality of the fresh water going into the collection tanks. This risk also could be minimised as the pipe network for the galleries is a separate network and this could be easily isolated from the main network for cleaning and maintenance.

2.17 Emergency provision of water

This is in an integrated water system. Although this integration system would be placed, water collection from the individual households would continue. Should there be a failure of the system there should be means to provide water during an emergency. Since this system is made of three distinct networks until the distribution tank, failure in any network would be compensated by increase of supply through other available network. In addition, the pumping stations will have to be with backup pumps. Moreover, this the facility would be operated and maintained by the utility company attending and rectification of issues identified would be easy and quick as the necessary equipment and training would be given to the technicians.

2.18 Project Inputs and Outputs

This project has human resource, natural resource and machinery input. Main output of the project is the economic development and other indirect social benefits to the local community. The following tables summarize the input and outputs

Table 7: Project inputs

Phase	Major inputs/outputs	Source/Type	Remarks
Construction Phase	Construction materials	Building materials such as reinforcement steel bars, river sand, cement aggregates, cement, timber, roofing materials, electrical cables and wires, PVC pipes, waste treatment	Almost all construction materials will be purchased in bulk from abroad and will be brought to island in containers. Machines and equipment will also be purchased from abroad.

		system, RO plants, generator sets, waste management equipment, etc	
	Heavy Machinery	Heavy machinery such as excavators, lorries, dumpers, concrete batching plants, cranes and other machines utilized for construction purposes will be locally available	Will be provided by the contractor either locally purchased or imported.
	Workforce approximately 15 - 20 labourers	Most semi-skilled workers will be foreign labourers. Priority will be given to local subcontractors from the region for various works. Engineers and Supervisor will be employed by contractors.	Main contractor is responsible for the workforce during construction period.
	Water	Water needed during the construction phase will be obtained from existing community water tanks.	The water required for the project will be obtained from rainwater harvesting.
	Electricity	Diesel generators	The electricity demand for the project will be obtained from the existing electricity grid. The power house is in close proximity to the project location hence minimal connection will be required during the construction phase.
	Fuel	The main types of fuel to be utilized for the project work include petrol and diesel.	The fuel requirement for the project activities will be met via locally purchased fuel.
Operational Phase	Electricity	30 kW of electricity will be needed to power the operations of the Reverse Osmosis Plant.	
	Greenhouse Gas	46.65 tCO_2eq/yr of GHG will be emitted from the operation of the Reverse Osmosis Plant for 90 days annually.	At global scale an insignificant volume. The potential for utilization of the PV system will be explored.
	Workforce	At least 3 staff including an RO plant operator, Engineer and Security guard will be employed during operations phase.	Priority will be given to locals in hiring staff for the resort.
	Portable water	72,000 litres of portable water will be produced for the dry period of 90 days. 400 tonnes of water will be stored in treated water storage tank	Two 72 tonne RO plant will be installed.
	Brine	Two 72 tonne RO plant will produce 432 tonnes of brine per day when the RO plant is operational (assuming 3:1 ratio)	Brine will be discharged to open ocean
	Diesel	Approximately 2.1 million litres of diesel per year will be needed	

Table 8: Project outputs

Type of Waste	Expected Quantities	Method of Disposal
Waste oil from machinery	Minute quantities	Re-used for other applications
Green Waste (from the clearance of the project site)	Small quantities	Natural Decomposition and hard material such as shoots will be discarded using the existing waste management system of the island.
Construction waste such as card board, scrap metals etc	Small quantities	Recycled or managed through existing solid waste management system in the island.
Used oil and grease	Minute quantities	Reused by local garages or the contractor
General Waste (Kitchen waste or human waste)	Small to moderate quantities	Disposed through existing solid waste management system in the island.
Drilling bentonite	Moderate quantities	Will be used as construction waste or will be disposed to Vandhoo waste facility
Brine reject	Large quantities	Disposed into the sea after aeration treatment in the brine well. The brine will be diluted and dispersed.

3. Applicable Policies, laws and regulations

3.1 Introduction

This project will be carried out in the context of the Maldivian laws and regulations. This section outlines the environmental regulations which are related to this project. All the activities during both development and implementation stage of the proposed harbour development project will be carried out in accordance to the legislations, policies and laws outlined below.

3.2 Related Laws

3.2.1 Maldives Constitution

It is important to note that the Article 22 of the Constitution of Maldives provides guidance on the protection of the environment and sustainable development. According to this Article no development project will go ahead if its impacts are detrimental to the environment.

The environment law, Law No.4/93 Environment Protection and Preservation Act of Maldives was enacted in April 1993 as an umbrella law to protect and preserve the environment of the country. The articles and clauses of the law are given below.

3.2.2 Environmental Protection and Preservation Act of Maldives (EPPA)

Environment protection and Preservation Act came into effect in 1993, is the umbrella law, which provides the key environmental guidance on the protection and management of environment in the Maldives. The following articles of the law are relevant to the proposed project and all activities of this project will be carried in accordance with the guidelines provided in the law.

Article 4

Under the Article 4, the Ministry of Environment is responsible for identifying protected areas and natural reserves and formulating necessary rules and regulations for their protection and preservation. All the necessary steps will be taken to ensure the proposed project would cause no significant negative impact on protected areas.

Article 5 (a)

Under the Article 5(a), an EIA is mandatory requirement before implementing any development project that may have a potential impact on the environment. This EIA report has been prepared and submitted to the EPA in compliance to this article.

Article 6

Under the Article 6, Ministry of Environment has the authority to terminate any project that has any undesirable impacts on the environment. In this report, all the significant negative impacts of the proposed project are identified, and all the necessary mitigation measures will be taken to reduce all negative impact from the proposed project.

Article 7

Under the Article 7(a), disposal of any type of waste, oil, poisonous gases or any substances that may have harmful effect on the environment is prohibited. And in case where disposal of such waste becomes absolutely necessary, they should be disposed only within the areas designated for that purpose and necessary steps should be taken to avoid any harm to the health of the population. A waste management plan is included in the report describing how the waste produced in the proposed project will be disposed off.

Article 8

Under the Article 8, disposal of any hazardous or toxic or nuclear wastes that is harmful to human health and environment is prohibited. Any such waste produced from the proposed project will be managed carefully and disposed off according the standards set by the regulations.

Article 9

Under the Article 9, the penalty for breaking the law and damaging the environment are specified. The project proponent is aware of this provision and all the activities of the proposed project will carried out in accordance with the guidelines set by the government agencies.

Article 5 (a) addresses the submission of an EIA. It states that any developing project that may have a potential impact on the environment requires an EIA submission.

3.3 Related Regulations

3.3.1 Protected Areas and Environmentally Sensitive Areas

Under article 4 of the Environment Protection and Preservation Act of Maldives, the Ministry of Environment is vested with the responsibility of identifying and designation of protected areas and natural and drawing up rules and regulations for the management of protected areas and natural reserves in the country.

The proposed project does not propose development in a protected area and there are no protected sites in the vicinity of the site. The site surveys also showed that there no environmentally sensitive areas close to the proposed site.

3.3.2 Regulation on the Preparation of Environmental Impact Assessment Report 2012 (Regulation no: 2012/R-27)

The Environmental Impact Assessment Regulation 2007, which came to effect in 2007, has been revised and published as Regulation on the Preparation of Environmental Impact Assessment Report 2012 in 8th may 2012. Regulation is formulated under the Environment Protection and Preservation Act 9 (Law no 4/93). The purpose of this regulation as stated in regulation is to provide a step-by-step guidance for proponents, consultants, government agencies and general public on how to obtain approval for a development proposal.

Schedule D of the Regulation on the Preparation of Environmental Impact Assessment Report 2012 has stated a list of development proposals requiring an Environmental Impact Assessment study, which includes dredging and reclamation activities.

Hence, this EIA report is subjected to the Regulation on the Preparation of Environmental Impact Assessment Report 2012 and follows the guidelines and procedures provided in the regulation.

3.3.3 Regulation on desalination

According to the Desalination Regulation under the EPA, all the desalination plants operation in the Maldives for public and commercial purpose needs to be registered with the EPA.

This project requires use of desalination plants and thus would need to comply with this regulation.

3.3.4 Waste Management Regulation (Regulation no. 2013/R-58)

Waste Management Regulation is formulated under the Environment Protection and Preservation Act (Law number 4/93) and was published in 2013. The key purposes of this regulation as stated in the regulation are to;

- Minimize the direct and indirect negative impact caused to human health and environment due to waste.
- Compile the national standards to be maintained in relation to waste management in the Maldives.
- Establishing and environmentally friendly, safe and sustainable waste management system through an integrated waste management structure.
- Implementing polluters pay principle, and
- Introducing extended producer responsibility.
- This regulation provides the standards for the following waste management activities;
- Waste collection.
- Land and sea transport of waste.
- Waste treatment.
- Waste storage.
- Management of waste disposal centers.
- Landfilling.
- Hazardous waste management.

Waste generated in the islands of Maldives should be disposed only in areas that are designated and authorized for the purpose by the implementing agency. And dumping of any waste on the following areas under any circumstance is prohibited by the regulation.

- Protected areas declared under Environment Protection and Preservation Act (Law number 4/93)
- Mangroves/ Wetlands and marshes.
- Lagoon area of islands
- Reefs.

- Lagoons.
- Sandbanks.
- Beaches of islands.
- Vegetation line of islands.
- Parks
- Roads.

Dumping of waste or littering to places other than areas authorized by the implementing agency is considered as an offence under the regulation.

List of waste management activities that requires permission from the implementing agency and the procedure for obtaining the permission are specified under the Article 16 of the regulation.

Penalties for breaching the guidelines specified in the regulation are stated under the Article 34 of the regulation.

This report has a comprehensive waste management plan describing the management of waste generated by the proposed project. All the waste will be handled and managed according to the guidelines prescribed in the Waste Management Regulation.

3.3.5 Regulation on coral mining

Coral mining from the house reef of islands and the atoll rim reefs is banned through a directive from the President's Office dated 26th September 1990. According to this policy coral mining shall not be carried out from house reefs of islands and atoll rim reefs and common bait fishing reefs. Coral and sand mining is only allowed for house construction from designated sites and approval from the concerned authorities is required prior to mining activities. Request for coral and sand mining from residents of inhabited islands are required to be submitted to the Atoll Offices through the respective island offices. The island office is required to estimate the quantities of coral or sand required for the applied construction work of houses to ensure that the permission is grated for minimum amounts required. Every island is required to maintain a log book of permissions granted and the amounts mined and the site where mining was carried out.

This proposed project involves construction of RO plant facility, infiltration gallery, however since coral mining is banned in Maldives under this regulation no corals from the reef shall be used for any constructional work.

3.3.6 Regulation on sand and aggregate mining

This regulation addresses sand mining from islands and bird nesting sand bars. Sand and aggregate mining from beaches of any island whether inhabited or uninhabited is banned for protection of the islands. Permissions for sand and aggregate mining from other areas shall be obtained from the relevant authorities.

Sand mining in Maldives is allowed only in designated area. Hence sand needed for construction of facility shall be sourced from those sites and not from the island or its lagoon area. This is to adhere to this regulation mentioned above.

3.3.7 Regulation for the Chopping, Uprooting, Removing and Transfer between islands, of Palms and Trees

This regulation is formulated under the Environment Protection and Preservation Act (Law number 4/93). This regulation provides the guidelines for chopping, uprooting, removing and transfer between islands of palms and trees. The main objective of regulation is to minimize the negative impacts from the chopping, uprooting, removing of palms and trees on the natural environment of the islands by setting out the proper guidelines and discouraging the action. According to the regulation, Palms and trees should be chopped or removed or uprooted out of mere necessity and for every palm or tree chopped or removed or taken out of the island, two palms for each palm removed and two trees for each tree removed should be planted on that island.

According to the Article 3 of the regulation, it is prohibited to remove:

- All forms of palms and trees within 15 meters inward to an island, from the outermost trees closest to the beach
- All forms of palms and trees within 15 meters outward of ponds and wetlands
- All forms of palms and trees on an area declared by the government as a protected area and all forms of palms and trees protected by the government for the purpose of preservation of biodiversity.

According to the Article 5 of the regulation, an EIA report should be submitted before chopping, uprooting or removing palms and trees from a large area of land, for the purpose of transferring to another island; for agricultural purposes; for building of social centres; or clearing the vegetation for any other purposes.

Removal of any palms or trees for purpose of the proposed project will be carried out in accordance with the guidelines provided in this regulation.

3.3.8 Regulation for the determination of penalties and obtaining compensation for damages caused to the environment (Regulation number: 2011/R-9)

This regulation is formulated under the Environment Protection and Preservation Act of the Maldives (Law number: 4/93) and came to effect in 2011. The objective of the regulation as stated in the regulation is to stop violations of Act 4/93; to prevent the repetition of such violations; to penalize and obtain damages caused to the environment.

According to the Article 7 of the regulation, if an incident occurs while conducting a project or other work, that is likely or estimated to cause damage to the environment, proponent or in charge of the project should report to the implementing agency and should take immediate action to stop the damage or cause of the damage.

Under the Article 14 of the regulation, any party, from whom the implementing agency requires information relating to an investigation or for other purposes of this regulation, should provide such information.

The schedules of the regulation describe the factors to consider when determining the fine to be charged on a party causing damage to the environment and formulas to measure the magnitude of the damages caused to the environment.

3.4 Related Policies

3.4.1 Waste management policy

MEE has developed a framework for a national waste management policy. The main components of this policy includes safe disposal of solid waste, ensuring safe disposal of chemical industrial and hazardous waste. Waste management of this project will be in line with this policy.

3.4.2 National biodiversity strategy and action plan

The goal of the National Biodiversity Strategy and Action Plan (NBSAP) are:

- Conservation of biological diversity and sustainable utilization of biological resources
- Build capacity for biodiversity conservation through strong governance framework and improved knowledge and understanding
- Foster community participation and support for biodiversity conservation

Consideration of the goals of NBSAP shall be taken into account in implementation of the project activities for minimizing potential loss of biodiversity in the area. The proponent has committed on conservation and protection of environment while undertaking this project. Qualitative and quantitative surveys were undertaken to assess baseline coral reef and marine environment biological diversity. Practical mitigation to minimize the impact and monitoring strategies have been identified to protect the biodiversity.

3.5 International conventions, treaties and protocols

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

3.5.1 United Nations Convention on Biological Diversity (UNCBD)

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

3.5.2 The Marpol Convention

International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. Pollution and that from routine operations - and currently includes Prevention of Pollution by Oil; Control of Pollution by Noxious Liquid Substances in Bulk; Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form; Prevention of Pollution by Sewage from Ships; Prevention of Pollution by Garbage from Ships; and Prevention of Air Pollution from Ships.

3.5.3 United Nations Framework Convention on Climate Change

The main objective of this convention is to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system. Convention entered into force in 1994. This convention was complemented by the Kyoto Protocol, a legally binding treaty under which member countries have committed to reduce their emissions by an average of 5 percent by 2010 against 1990 levels. UNFCCC encourages all its member countries to take action to prevent and limit further climate change by developing, gathering and sharing information on greenhouse gas emissions, national polices and best practices and to protect and adapt to the impacts of climate change by launching national strategies.

3.5.4 Sustainable Developed Goals

In 2015 the world leaders agreed towards a new international development agenda known as 2030 Agenda for Sustainable Development: Sustainable Development Goals (SDGs). This new international agenda is a successor of the Millennium Development Goals which was agreed in year 2000. The SDGs comprises of 17 goals. Goal 6 of this Agenda focus on water and sanitation. The main objective of this goal is to ensure availability of sustainable water and sanitation to all. This goal has 7 targets which has elements related to the provision on IWRM as proposed under the project.

4. Survey Methods

4.1 Introduction

This chapter aims to discuss on methodology that was adopted during this EIA. Since site specific data or primary data is imperative in identification of the impacts associated with the proposed project the methods discussed in this chapter of the EIA is adopted.

The following where done in order to complete this impact study. The key components that were considered are, physical, social and economic environment. Following methods were used in the analysis.

- Assessment of existing environment to identify significant environmental components that would be impacted
- Public consultations to exchange information on the project and consider their concerns
- Literature review of similar projects

4.2 General Methodology of Data collection

The methodologies used for scientific analysis of the environment are standard and internationally accepted methods of environmental assessment. Terrestrial and marine environment was studied using the methods and parameters that is widely practiced.

4.3 Mapping and location Identification

The proposed location along with the alternative locations for the proposed locations are mapped. Mapping was undertaken using standard DGPS and mapped on AutoCAD and ArcGIS.

4.4 Marine Survey

4.4.1 Photo Quadrat Methodology

Photo Quadrat method was used to estimate the live coral coverage and the substrate composition at sample locations of the reef.

Equipment

- 0.5 m^2 PVC quadrat
- 50 m transect tape
- Digital Camera

Procedure

- Survey sites were selected, and at each site the start point was marked at a 2 m depth along the top reef.
- The transect tape was tightly stretched along the bottom of the 2 m depth contour, covering a length of 50 meters.
- The quadrat was then placed alongside the transect tape at every 5 meters.
- A digital photograph of each quadrat was taken from a fixed distance from the bottom.

- On completion of the survey, the digital photographs were processed using Coral Point Count with Excel extension 3.6[1]. For each quadrat image 20 random points were selected, and counted using the software.
- The mean count for each substrate type (e.g. Live Coral, Dead Coral with Algae (DCA), Sand/Rubble/Rock (SPR) etc.) was then calculated for the respective sites.

4.4.2 Fish Belt Transect Methodology

Fish belt transect method is used to count the abundance and estimate the composition of different fish species that occurs at a site.

Equipment

1. Slate with Pencil
2. 50 m transect tape

Procedure

- Fish belt transect surveys were carried out during day time hours
- Transect tapes laid for Photo Quadrat Survey were utilized for this survey

An observer swam slowly along the transect tape recording the fishes encountered in a 5 m belt. Abundance categories recorded: Single (**S** - 1 Fish), Few (**F** - 2-10 Fishes), Many (**M** - 11 – 100 Fishes), and Abundance (**A** - > 100 Fishes)

4.4.3 Currents

A purpose-built surface drifting drogue was used to measure the surface currents. The drogue was tracked using GPS. The drogue was released for a time window of 10 minutes to calculate the speed of the current.

4.5 Water Quality

Water samples were taken at the proposed brine outfall location and ground water at the specified locations shown in Figure 11. The quality of the marine and ground water in the proposed development site was assessed by testing water samples at location in Figure 11. At RO site water sample was collected directly from an open dug well by immersing the containers and the sampling bottle were rinsed 3 times with the sample water. The samples were tested at the MWSC laboratory. The parameter that was tested are conductivity, turbidity and pH and minerals tests.

4.6 Public consultation

The baseline socioeconomic condition of the island community was assessed using different methods of stakeholder consultations. A scoping meeting was held at Environmental

[1] Kohler, K.E. and S.M. Gill, 2006. Coral Point with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Computers and Geosciences, Vol. 32, No. 9, pp. 1259-1269, DOI: 10.1016/j-cageo.2005.11.009

Protection Agency with the involvement of the stakeholders. In addition, consultations were made with the locals of Nolhivaranfaru to gather information their views and concerns regarding the project to be carried. The island council of Nolhivaranfaru council was consulted in addition to consultations with EPA and MRC.

5. Existing Environment

5.1 Introduction

This section covers the existing environment of Nolhivaranfaru Island. The project location is at South Thiladhunmathi or Haa Dhaalu atoll. It is located on the northern east rim of the atoll. The island is geographic location of Hdh. Nolhifaranfaru is 6°41'49" N and 73°07'12" E. The island measures approximately 3.8 km in length and 0.9 km in width with a total area of 172.0 Ha. Similar to all the inhabited islands the island has many basic infrastructures including school, healthcare centre and mosques.

The island is situated in a reef system of its own. Nolhivaranfaru have a large reef system. The reef system is oriented in a NE-SW direction with the island also being oriented in North-South. The island is located on the eastern side of the reef system and this is the only island in this system. The island is enclosed by a shallow lagoon on the western side of the island. The island area is approximately, 30% of the reef system. The reef system spans a length of approximately 10 km with a length of 4 km with a width of 2 km at its widest point. The closest inhabited island is Nolhivaramu situated to the south west of the island. Nolhivranfaru is situated as shown in Figure 1.

There is a wider channel within the reef system which could have an influence on the island. This channel is located to the south west of the island and is approximately 300 m width. Given the wave influx is reflected along south west of the island, the island has thus adopted its much elongated shape. The island will be more exposed during the south west monsoon when there is strong influence of waves during that season.

Six quantitative marine surveys were carried at proposed brine outfall and two survey transects were done on where the RO plant and Water Treatment facility along with Storage tanks would be place. The locations of the survey are shown in Figure 11. Following Table 9 give the coordinates of the locations.

Table 9: Locations of the samples

Location	Longitude	Latitude
	Marine Samples	
SW 1	73.125911	6.699937
SW 2	73.126258	6.704557
	Ground water	
GW 1	73.123414	6.701141
GW 2	73.118821	6.702024

5.2 Locations of the surveys

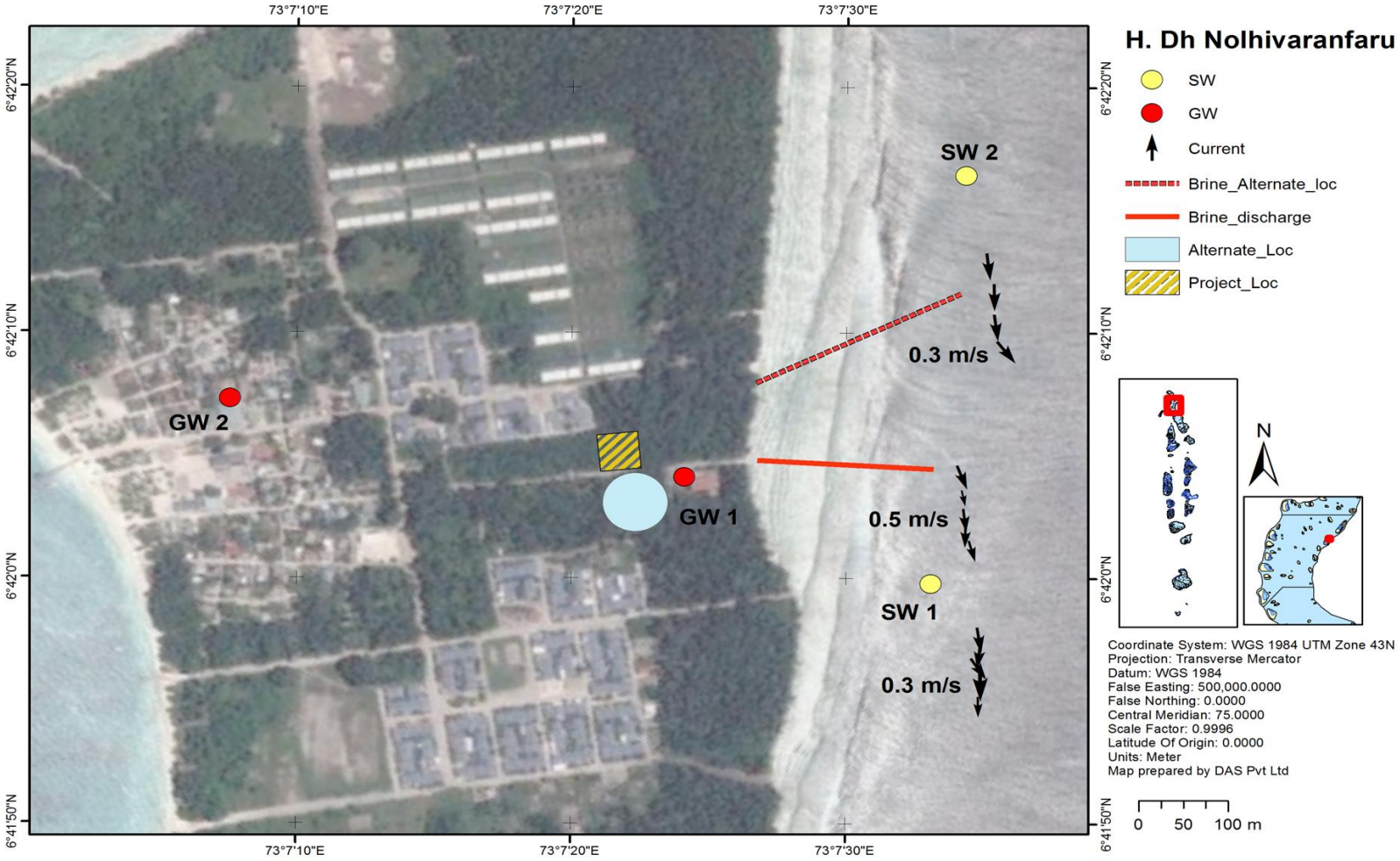

Figure 11: Survey location.

5.3 Climatology

The Indian Ocean Monsoons governs the climatology of the Maldives hence monsoonal reversal plays a significant role in weather patterns. Two very distinct monsoon are observed: the Northeast (*Iruvai*) and the Southwest (*Hulhangu*) monsoon. Monsoons can be best characterized by direction of wind and the amount of rainfall. The southwest (SW) monsoon is the rainy season which lasts from May to September and the northeast (NE) monsoon is the dry season that occurs from December to February. The transition period of SW monsoon occurs from March and April while that of NE monsoon occurs from October to November. The results are summarized in Table 10.

Table 10: Summary of the seasons.

Season	NE-Monsoon	Transition Period 1	SW-Monsoon	Transition Period 2
Month	Dec, Jan, Feb	Mar, Apr	May, Jun, Jul, Aug, Sep	Oct, Nov

5.3.1 Rainfall

Due to lack of data for the site, data from the closest metrological centre will be used. Figure 12 shows aggregated annual rate of the rainfall from 1992 to 2010. The results indicated that aggregated annual rainfall ranges between 1300 mm to 2200 mm. Over the years, there is slight increase in the amount of rain. The average rainfall around the year shows that increasing rainfall from May to July with a peak in July. On the other hand, the rainfall is low during dry season from January to April. Throughout the year, March experience lowest rainfall yield (see Figure 13).

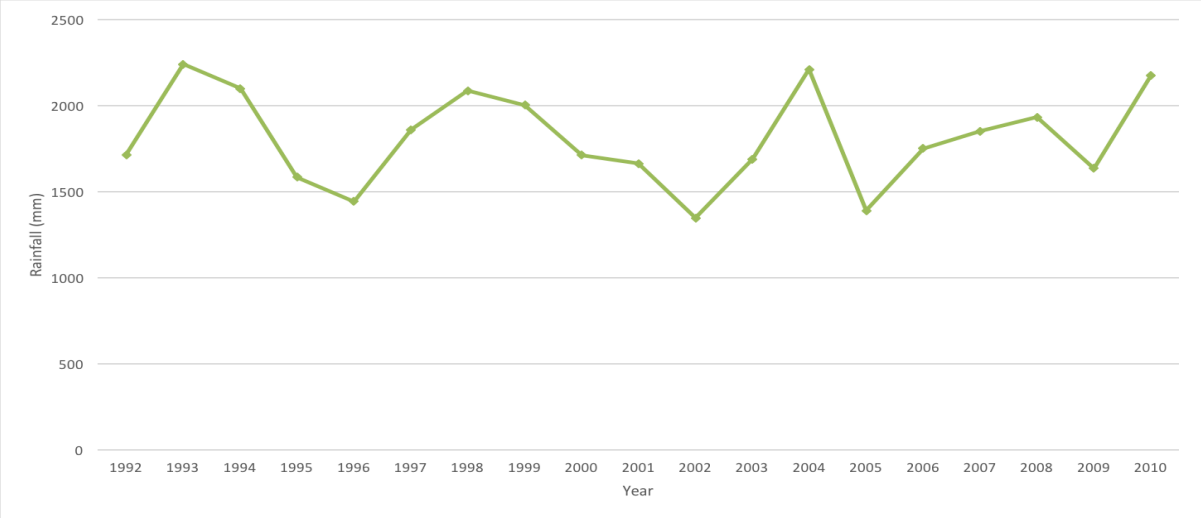

Figure 12 Aggregate rainfall from 1992 to 2010 (Data source from Maldives Meteorology Service)

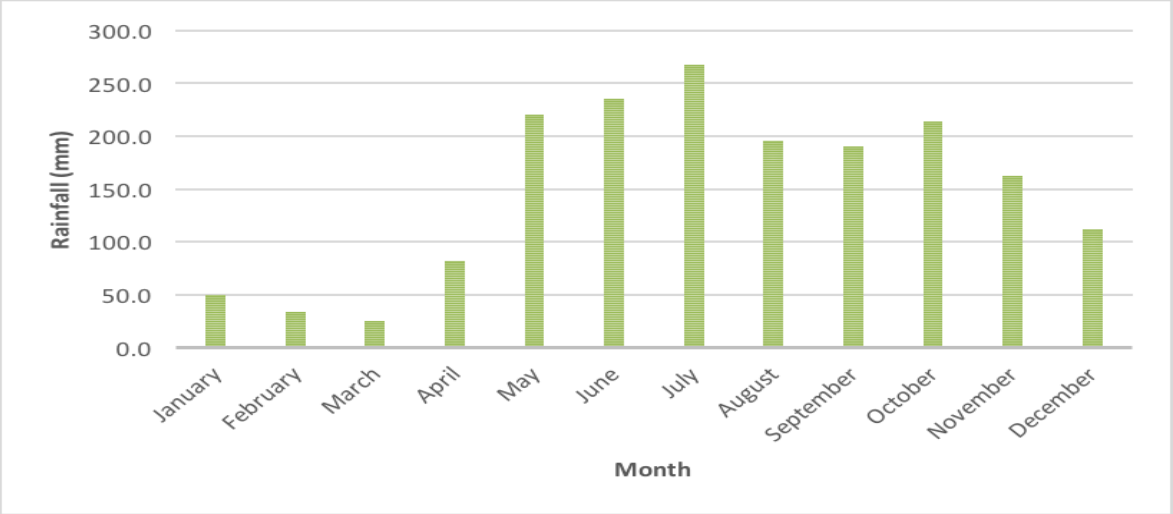

Figure 13 Average monthly rainfall from 1992 to 2010 (Data source from Maldives Meteorology Service)

5.3.2 Wind

Since there were no site specific wind data, wind regime around the island was assumed to be that similar to the closest meteorological stations. The closest station is the meteorological station at the Hanimaadhoo International Airport from 2002 to 2017. Figure 14 below represents mean daily wind speeds and direction for a year. It was determined that the winds from E to WNW is the dominant wind direction in the Southwest Monsoon, where wind from ENE and NNW was dominant during the North East Monsoon. Wind determines the direction of the sediment movement and have an influence on the alongshore current patterns.

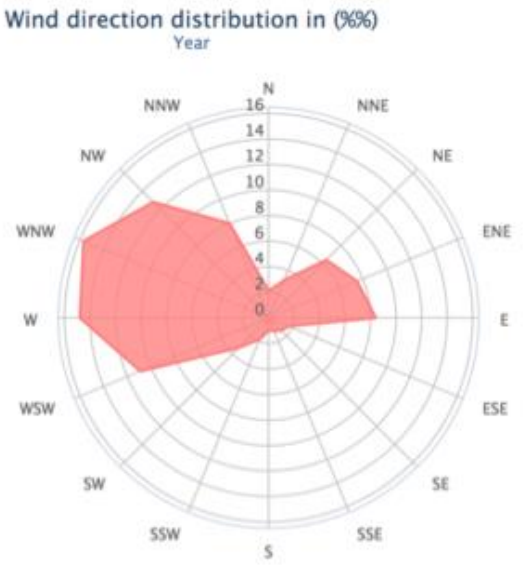

Figure 14: Wind speed and direction at Hanimaadhoo international airport (adapted from windfinder.com).

5.3.3 Tides and currents

Maldives experiences mixed semi-diurnal and diurnal tides with a strong diurnal inequality. There was no direct tide measured at the project site. Tide have an influence on the wave

conditions and the sediment movements in and out of the reef system. The hourly tide data from the University of Hawaii sea level archive for year 2011 is used in this analysis to cover the spring and neap tides. An approximate tidal range obtained at is 1.73 m (see Table 11).

Table 11: Water levels at Hulhule tide station

Water level from MSL (m)	Levels with respect to MSL (m)
Highest High water (HHW)	0.62
Mean Highest High water (MHHW)	0.34
Mean High water (MHW)	0.33
Mean Low water (MLW)	-0.36
Mean Lowest Low water (MLLW)	-0.37
Lowest Low water (LLW)	-0.72

Tides have significant influence on the formation, development, and sediment movement process (coastal processes) around the islands. Tides play an important role in the flushing of the water from lagoon. This has an influence of on the sedimentation during the excavation process.

5.3.4 Currents

Ocean currents play a significant role in sediment movement. Currents could be wind driven or tide driven. Available satellite information is used to draw information about the climatology of the currents around the Maldives region. This climatology is based on 23 years (1992-2014) data and the general pattern is show for the NE monsoon in Figure 15.

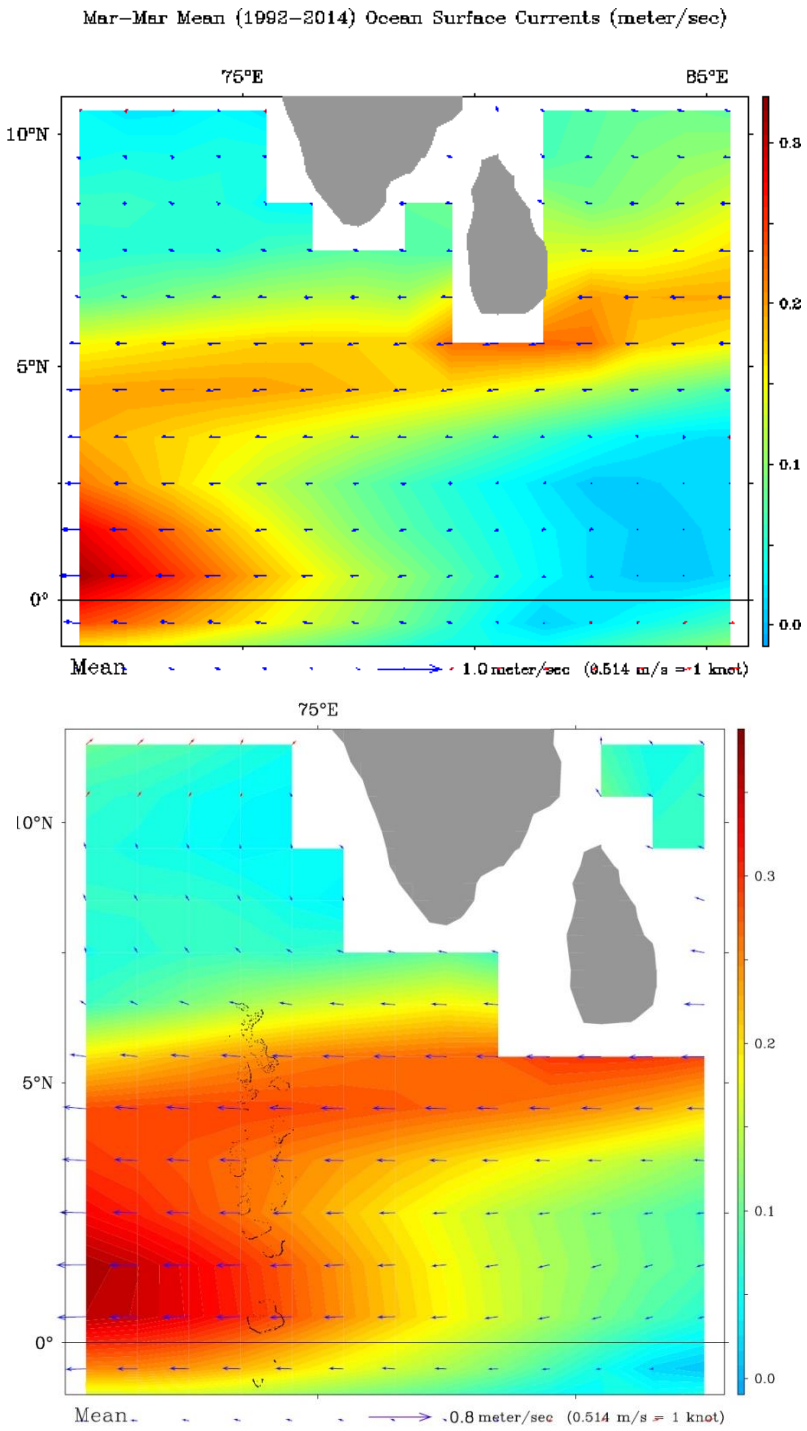

Figure 15: Average current regime around Maldives in NE monsoon (top) and SW monsoon (bottom).

The long-term average current speeds during NE monsoon varies between 0.08-0.2 ms^{-1} which is typical current speeds around the island (Figure 11). However it can attain speeds between 0.3 to 0.6 ms^{-1} in the SW monsoon.

Site specific current was measured near the proposed brine outfall and alternative location for the outfall. At alternative locations (NE) of the island the current flows from north to south with a speed of 0.3 ms^{-1}. Similarly, at proposed location (SE) of the island adopts same direction of current with speed reaching between 0.3 to 0.5 ms^{-1}.

5.3.5 Waves

The coastal dynamics such as accretion and erosion of islands depends on wave energy. Waves play a significant role in the modification of the beach environment and the surrounding. There are two major types of waves; wind generated waves and swell waves. Wind waves generated by the monsoon wind usually have a period of 3-8 seconds. Swell waves in Maldives are experienced by the swells generated by distance storms and have a period of 14-20 seconds (Kench et. al 2006, DHI 1999, Lanka Hydraulics 1988a and 1998b). Assessment done by Lanka Hydraulics shows that significant wave height (Hs) for the Male' region was 1.23m which a mean period (Tm) of 7.53s. Maximum Hs was 1.51 with a Tm of 7.74s.

Swell waves in Maldives are generally experienced by swells generated by distance swells generated due to storms. Occasional flooding has occurred in Maldives due to swells and distance storm generated swells were associated with these flooding's.

5.4 Terrestrial Environment

5.4.1 Soil Profile

The visual examination of island soil indicates that the island possesses similar kind of soil texture and types as of other Maldives islands. Due to the uniform characteristics of soil with other islands in the Republic, a site specific investigation was not undertaken. Hence, the details studies that was undertaken for Hdh. Kulhudhufushi will be used for the purpose of this EIA. Figure 16 shows the detailed results of the soil profiling which was undertaken in the island. The soil profile indicates that humus layer always caps on the sub soil level. The sub soil level starts with coral sand with pieces of coral rocks. Even though the length of each layers differ in both samples, there is no other difference in the samples. This is because different parts of the island have different compositional length of sub soil.

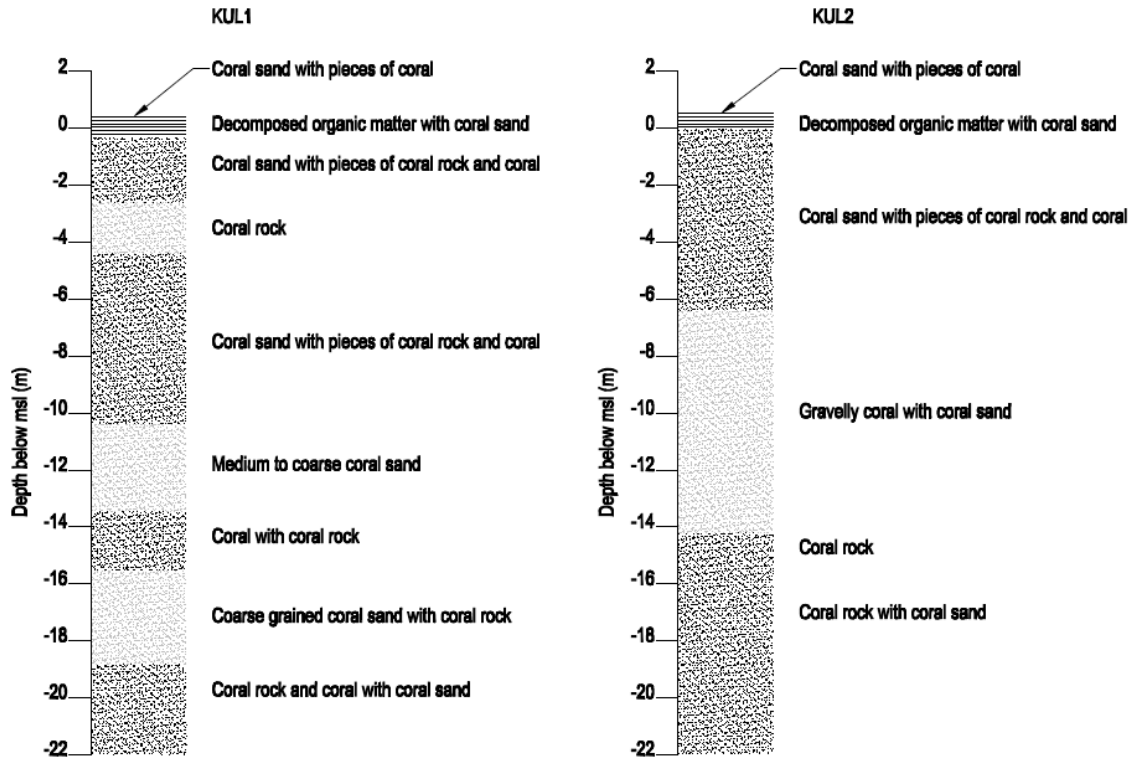

Figure 16 Soil Profile *of Hdh. Kulhudhufushi* (KUL 1: Sports Stadium) and (KUL 2: Jalaludheen School)

5.4.2 Flora and Fauna

5.4.2.1 Vegetation

A significant amount of land clearance has to been done at the proposed location since there is thick vegetation with approximately 50 coconut palm trees in the site. Two transects are taken at the proposed location. Figure 17 below shows transects. The transects shows that there is heavy vegetation which needs to removed completely for construction of RO plant facility. The vegetation ranges from small shrubs to large trees and palms.

Figure 17: Transect 1 (top) and Transect 2(bottom) shows vegetation at site location

The most commonly found type of trees are screw pine (*Pandanus tectoris*), Coconut Palm (*Cocos nucifera L*), Iron wood (*Pempis acidula*) and Sea hibiscus (*Hibiscus tilaceus*).

5.4.2.2 Fauna

During the field visit there was no sign of common fauna encountered at the island. However, common garden lizards were encountered in the area.

5.5 Water quality

5.5.1 Groundwater quality

Water samples were obtained from ground and locations from sea. The primary objective is to establish a baseline condition for the ground. This is established to be used in future monitoring of the environment as the environment is supposed to undergo significant changes and to see if there are any significant changes on the ground water quality. All the test samples were tested

at the MWSC laboratory. Table 12 shows the ground water. Original result sheets are attached in the appendix of this report.

Ground water quality seems to be within acceptable range for most of the parameters. A pH range from 7.38 – 7.57 was observed which is of typical ground water quality seen in Maldives as accepted by EPA. However the salinity levels are higher than what is usually found for fresh water.

Table 12 Groundwater Quality

Parameter	Near Mosque	Onsite
Physical Appearance	Clear with particles	Pale Yellow with particles
Conductivity (µS/cm)	733	4720
pH	7.57	7.38
Salinity (%)	0.36	2.52
Temperature (^{0}C)	20.9	20.9
Total Dissolved Solids (mg/L)	367	2360
Hardness, Calcium (mg/L)	51	390
Hardness, Total (mg/L)	59	735

5.5.2 Marine water quality

Water samples were obtained from sea. The primary objective is to establish a baseline condition for the marine water quality. This is established to be used in future monitoring of the environment as the environment is supposed to undergo significant changes and to see if there are any significant changes to the marine water quality. All the test samples were tested at the MWSC laboratory. Table 13 shows the ground water and marine water quality respectively. Original result sheets are attached in the appendix of this report. Marine parameters for the marine water seems to be within range.

Table 13: Sea water quality.

Parameter	Sea Water
Physical Appearance	Clear with particles
Conductivity (µS/cm)	5100
pH	6.63
Salinity (%)	33.41
Temperature (^{0}C)	20.9
Total Dissolved Solids (mg/L)	25500
Total Suspended Solids (mg/L)	<5 (LoQ 5 mg/L)
Turbidity (NTU)	0.553
Total Alkalinity	108
Dissolved Oxygen (mg/L)	6.16

5.6 Marine environment

5.6.1 Coral cover

The proposed brine outfall is to the southeast of the island. The marine environment at the location can be characterised as not healthy. Very few amount of fishes were observed during the timed swims. In addition, the bottom was largely dominated by rubbles and sand. Additionally, the living corals were also on the verge of dyeing as there is clear signs of bleaching in those. (Figure 18).

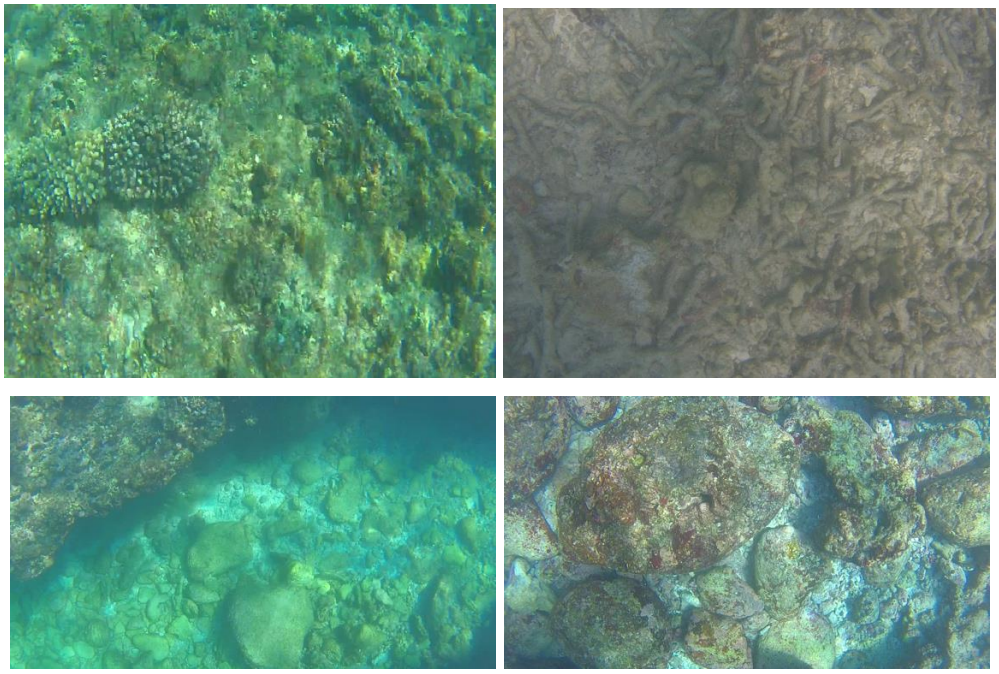

Figure 18 : Proposed brine outfall location

The following Figure 19 gives a quantitative measure of the type of benthic coverage. It is evident that percent of live coral is very few to none in this region and would be a good location for brine disposal.

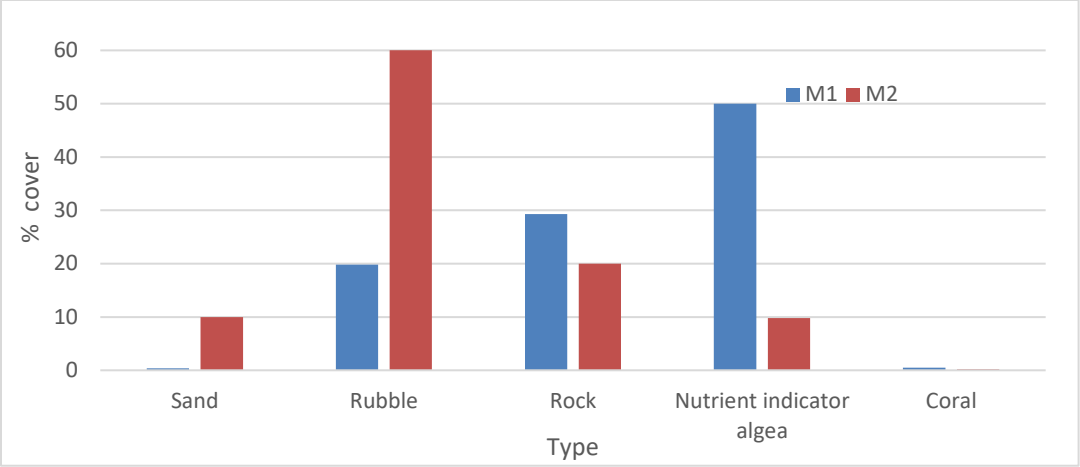

Figure 19: Type and coverage of benthic cover

5.7 Hazard vulnerability

An islands inherent vulnerability to environmental and climatic conditions lies in its geographic and geomorphic characteristics. Factors such as location of the island with in the atoll, its shape, formation and orientation, the degree of protection offered to the island by surrounding reefs and other islands, presence of mangroves and wetlands at the coast, its natural and manmade coastal protection structures, are all contributors to the resiliency of the island to withstand natural hazards.

Based on the outcomes of the DIRAM 1 report, the hazard exposure and vulnerability is medium as shown in Figure 20.

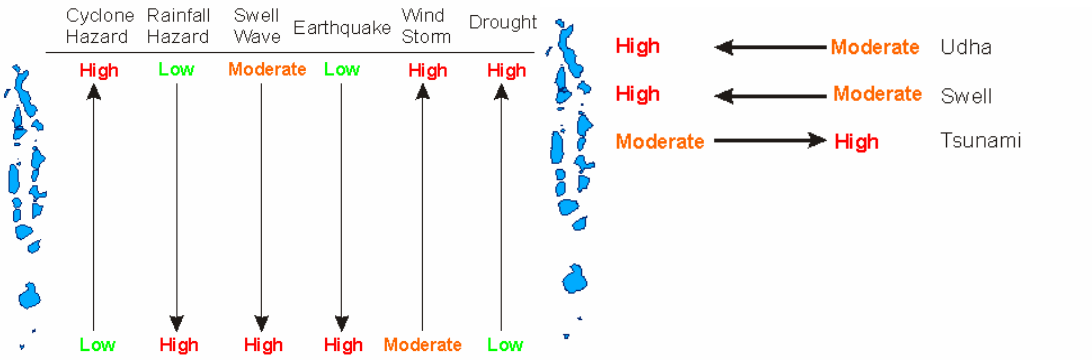

Figure 20: Latitudinal and longitudinal variations of major hazards across Maldives (Source: DIRAM 1, 2008)

5.8 Proximity to the Protected Areas and Environmentally Sensitive Areas

Figure 21 shows the locations of the environmentally sensitive areas (ESA), protected areas (PA) and the Marine Research Center (MRC) coral reef monitoring stations (CRMS) within the vicinity of the island. There are no PAs within the vicinity. However, there are ESAs near by the island within less than 2 km. One site is located to the very south of the island and the other is located

to the west of the island. These two locations are far from the project main impact zones. Moreover, since the IWRM involves use of less desalinated water and the dilution of brine in the marine environment, it is not envisaged that there would be any impact on the ESAs due to the project.

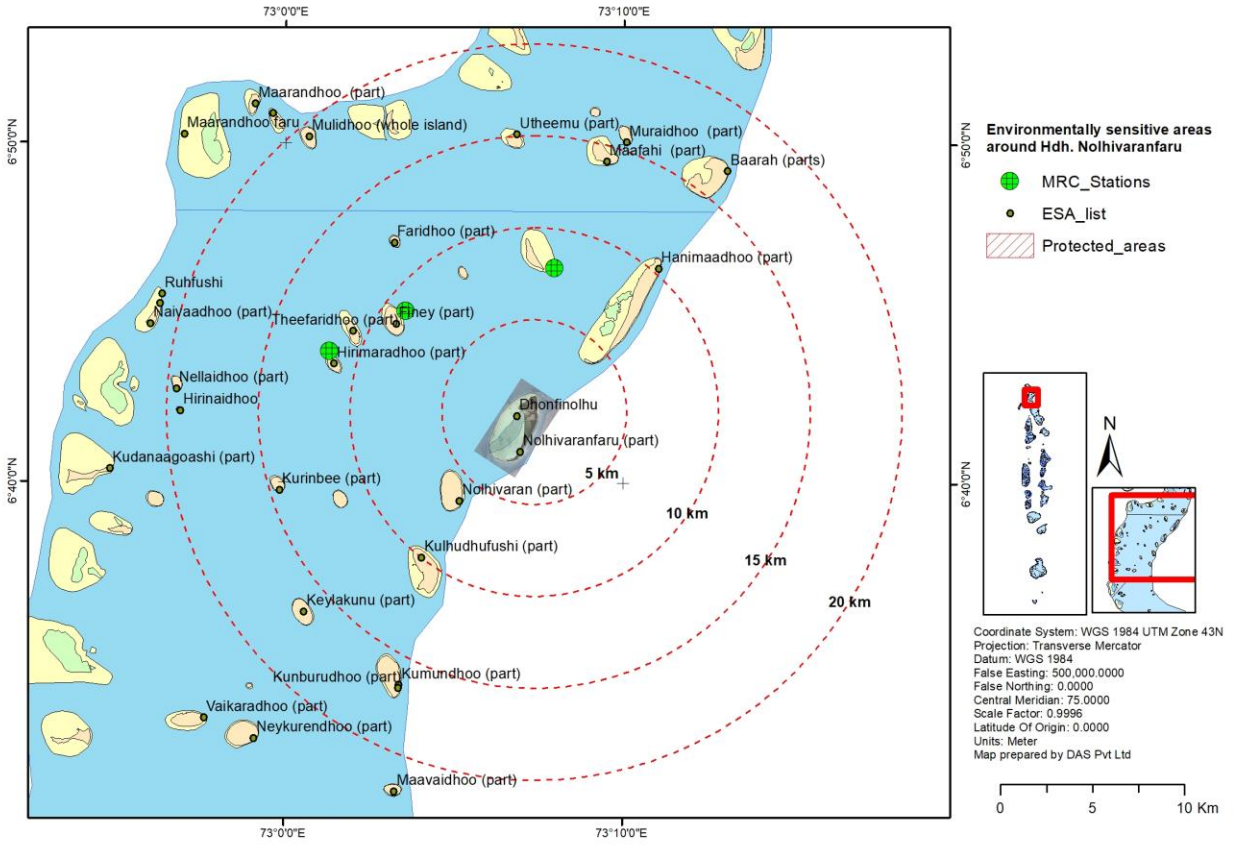

Figure 21: Proximity to environmentally sensitive and protected areas

5.9 Socio-economic environment

5.9.1 Introduction

This chapter aims to provide socio-economic situation of *Hdh. Nolhivaranfaru* and discuss stakeholder view on the proposed project.

5.9.2 Population and Demography

According to the census of 2014, the island has a registered population of 991 residents. However, as per the island council the current population of the island is 1870 in 2016. These difference in population may be due to the increased number of migration of residents from two islands of the atoll. The island is the third most populated island next to *Nolhivaramu*. Figure x shows population Hdh Atoll with respective to the *Nolhivranfaru*. The average population growth

of the atoll from 2006 to 2014 is estimated as 1.60. However, *Nolivaranfaru* had a population growth of 15.74 which is highest for the atoll. The growth of the island is more than both national and atoll level. Figure 23 shows the population trend of the island from 1985 to 2014 with projection for year 2052. Over all the island population is increasing with an increasing trend.

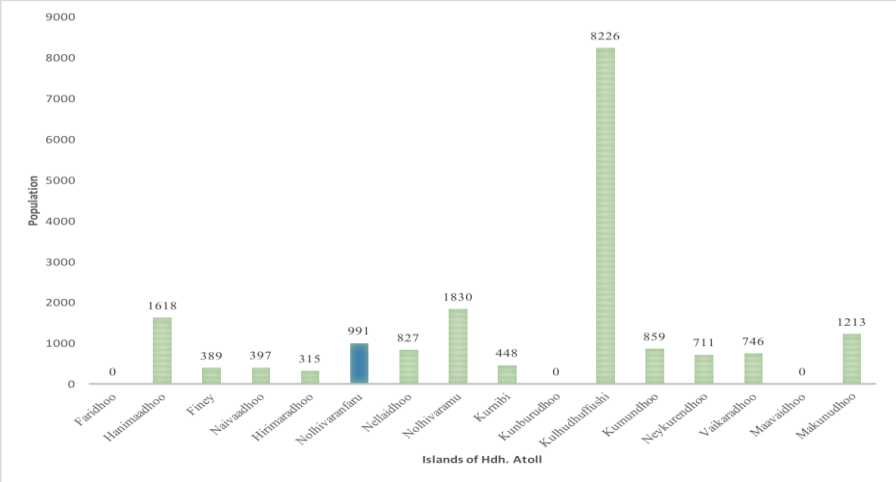

Figure 22 Population of Hdh. Atoll (Data from Bureau of Statistics)

5.9.3 Employment

The main economic activities of the island are construction works, agriculture. Fishing is not a main economic activity of the island. In addition to these economic activities, the atoll has the highest civil servant's employees in contrast to the other atoll of the republic.

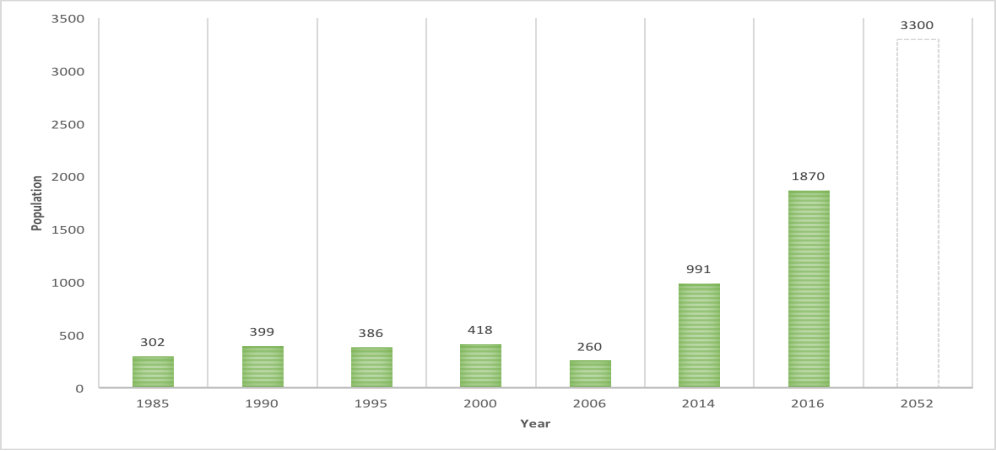

Figure 23 *Hdh. Nolhivaranfaru* Population trend from 1985 – 2016 (Data from Bureau of Statistics)

5.9.4 Heath and Education

The island has one health centre which diagnose common diseases. The island has one pre-school and one school. The Nolhivranfaru School teaches students to Ordinary Level.

5.9.5 Power sector

The island is 24 hours electrified by public or government own power station. Currently the power station is administered by FENEKA cooperation which is one of the main utility company of the nation. FENEKA Is 100 percent owned by the state. FENEKA have 319 customers from the island which is served by a 450 KWh generator sets.

5.9.6 Infrastructure

Island is equipped with basic infrastructure such as powerhouse, courts, mosques, health centres, schools, island office, police stations. Few other infrastructure is also planned and some infrastructure are constructed as we develop the EIA. These infrastructures are, island harbour, sewage system and waste management centre.

5.9.7 Water and Sanitation Facilities

The island utilises rain water is the primary fresh water for cooking and drinking. Groundwater is also used for other purpose such as washing, bathing and other purpose. Rainwater is currently harvested by individual household to meet with their consumption. All the household according to the council have total storage capacity of 5000 litres. In addition to this, there are few community water tanks located approximately 10 sites of the island. Despite this, the island faces water shortage problems over the last few years and particularly over the last 3 years. Approximately 5 tonnes of water are supplied to the island for period of 3 to 4 months in last 3 years by Maldives National Disaster Management Agency. Similar to water, the island adopts a very ad hoc technique for management of sewage. Individual households construct individual septic tanks with soak pit to drain effluent. Sludge is removed and disposed at the location designated by the island council. To address this issue government is currently planning for a sewage network for the island. The constructional work will be undertaken soon.

5.9.8 Coastal erosion

Erosion is not new to the island. The island is facing this environmental challenge over many years. However, with the increase in coastal infrastructure particularly recent harbour works have triggered significant erosion North of the island. Approximately 15 feet length is eroded.

5.9.9 Waste Management

Waste management is one of the biggest environmental challenge of the island. The island do not have adequate means to dispose waste. Mixed waste is dumped into area designated by the island council. When the area gets piled up with waste, the piles are either openly burned or buried. However, this solution is environmentally not sound hence the council is working with

the concerned government authorities to provide environmentally sound solutions in addressing waste management of the island.

5.9.10 Flooding

The island is very prone to storm water flooding, due to its topography. A shower of one to two hours will flood the island much. Communities faces bigger problems due to rainwater flooding in the island. Housing design in the island is also an additional factor which has elevated the problem. The houses are located below the road surface thus allowing storm water gushing into the households. National Disaster Management Agency provided with basic infrastructure to mitigate flooding however the facility is not used due to lack of capacity of the islanders to use the facility.

6. Environmental Impacts

6.1 Introduction

This section of the report provides a detailed description of the methodology used to identify, predict and assess the environmental impacts due to construction phase and the operation phase of the proposed IWRM project. First, the potential impact will be identified and then the identified impact will be evaluated to determine its level of significance. This section consists of the method used for impact assessment, the limitation and uncertainties, the justification for the method used for impact prediction and description of impacts during both construction and operation phase of the project.

6.2 Method Used for Impact Prediction

The impacts on the natural and social environment that may be caused due the project interventions are predicted and is distinguished from construction and operation phases of the project. A simple descriptive matrix has been utilized to predict the aforementioned impacts. The impact prediction was done using expert judgement and professional opinions of the EIA consultant and also the based on the information provided in the reviewed EIAs mentioned earlier in this report. Once the impacts have been predicted, a detailed description has been given for the purpose of understanding the nature and type of the impact.

An impact is any change to a resource or receptor brought about by the presence of a project component or by the execution of a project related activity. The evaluation of baseline data provides crucial information for the process of evaluating and describing how the project could affect the biophysical and socio-economic environment.

Impacts are described as a number of types as summarized in Table 14. Impacts are also described as associated, those that will occur, and potential, those that may occur;

Table 14: Types of Impacts (adapted from ERM 2008)

Nature or Type	Definition
Positive	An impact that is considered to represent an improvement on the baseline or introduces a positive change.
Negative	An impact that is considered to represent an adverse change from the baseline, or introduces a new undesirable factor.
Direct	Impacts that result from a direct interaction between a planned project activity and the receiving environment/receptors (e.g. between occupation of a site and the pre-existing habitats or between an effluent discharge and receiving water quality).
Indirect	Impacts that result from other activities that are encouraged to happen as a consequence of the project (e.g. in-migration for employment placing a demand on resources).

Cumulative	Impacts that act together with other impacts (including those from concurrent or planned future third party activities) to affect the same resources and/or receptors as the project.

6.3 Analysis of Significance of the predicted impacts

The analysis of environmental impacts is done in terms of their level of significance. According to Environmental Resource Management 2008, significance is a function of the magnitude of the impact and the likelihood of the impact occurring. Impact magnitude (sometimes termed severity) is a function of the extent, duration and intensity of the impact. The criteria used to determine significance are summarized in Table 15. Once an assessment is made of the magnitude and likelihood, the impact significance is rated through a matrix process as shown in Table 16. For ease of review, the significance rating is colour-coded in the text according to Table 17. Outlined in Table 18 are the various definitions for the significance of an impact.

Significance of an impact is qualified through a statement of the degree of confidence. Confidence in the prediction is a function of uncertainties, for example, where information is insufficient to assess the impact. Degree of confidence is expressed as low, medium or high.

Table 15: Criteria used to assign level of significance

Magnitude – the degree of change brought about in the environment	
Extent	On-site: impacts that are limited to the Site Area only. Local: impacts that affect an area in a radius of 20 km around the development area. Regional: impacts that affect regionally important environmental resources or are experienced at a regional scale as determined by administrative boundaries, habitat type/ecosystems. National: impacts that affect nationally important environmental resources or affect an area that is nationally important/ or have macro-economic consequences. Transboundary/International : impacts that affect internationally important resources such as areas protected by international conventions.
Duration	Temporary: impacts are predicted to be of short duration and intermittent/occasional. Short-term: impacts that are predicted to last only for the duration of the construction period. Long-term: impacts that will continue for the life of the project, but ceases when the project stops operating. Permanent: impacts that cause a permanent change in the affected receptor or resource (e.g. removal or destruction of ecological habitat) that endures substantially beyond the project lifetime.
Intensity	*BIOPHYSICAL ENVIRONMENT*: Intensity can be considered in terms of the sensitivity of the biodiversity receptor (E.g.: habitats, species or communities). Negligible: the impact on the environment is not detectable.

	Low: the impact affects the environment in such a way that natural functions and processes are not affected. Medium: where the affected environment is altered but natural functions and processes continue, albeit in a modified way. High: where natural functions or processes are altered to the extent that it will temporarily or permanently cease.
	SOCIO-ECONOMIC ENVIRONMENT: Intensity can be considered in terms of the ability of project affected people/communities to adapt to changes brought about by the project. Negligible: There is no perceptible change to people's way of life. Low: People/communities are able to adapt with relative ease and maintain pre-impact livelihoods. Medium: Able to adapt with some difficulty and maintain pre-impact livelihoods but only with a degree of support. High: Those affected will not be able to adapt to changes and continue to maintain pre-impact livelihoods.
Likelihood - the likelihood that an impact will occur	
Unlikely	The impact is unlikely to occur.
Likely	The impact is likely to occur under most conditions.
Definite	The impact will occur.

Table 16: Significance Rating Matrix

SIGNIFICANCE

		LIKELIHOOD		
		Unlikely	Likely	Definite
MAGNITUDE	Negligible	Negligible	Negligible	Minor
	Low	Negligible	Minor	Minor
	Medium	Minor	Moderate	Moderate
	High	Moderate	Major	Major

Table 17: Significance Colour Scale

Negative Ratings	Positive Ratings
Negligible	Negligible
Minor	Minor
Moderate	Moderate
Major	Major

Table 18: The definition of difference level of significance

Significance definitions	
Negligible significance	An impact of negligible significance is where a resource or receptor will not be affected in any way by a particular activity, or the predicted effect is deemed to be imperceptible or is indistinguishable from natural background levels.
Minor significance	An impact of minor significance is one where an effect will be experienced, but the impact magnitude is sufficiently small and well within accepted standards, and/or the receptor is of low sensitivity/value.
Moderate significance	An impact of moderate significance is one within accepted limits and standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that "moderate" impacts have to be reduced to "minor" impacts, but that medium impacts are being managed effectively and efficiently.
Major significance	An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the EIA process is to get to a position where the project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a development. It is then the function of regulators and stakeholders to weigh such negative factors against the positive factors, such as employment, in coming to a decision on the project.

6.4 Limitations and the uncertainties of the impact assessment methodology

The following aspects are considered as limitation and the uncertainties which may be involved in the impact assessment process;

- All the potential environmental aspects have been predicted and assumed for the proposed project development hence they may differ in the natural context such as site conditions and uncertainties in scales and magnitude.
- The baseline data for the existing environmental conditions were taken in a very short period of time hence may affect the accuracy in prediction of the environmental impacts.
- The aforementioned baseline data for the existing environmental condition were collected for one monsoonal season (*Iruvai* season) and inferred based on that seasonal data hence the predicted environmental impacts may vary on the other (*Hulhangu*) season.
- Expert judgment and professional opinion of the EIA consultant were enhanced using the existing EIA reports of similar nature, however due to the unique nature of coastal processes, lagoons and reef system in the Maldives each island is unique. Hence the predicted environmental impacts may vary from island to island.

6.5 Justification for the Methodology used

There are many various methodologies used for impact assessment in environmental context. One of the most commonly used methodologies include check lists and matrices such as Leopold Matrix (Lohani et al., 1997). The Leopold matrix was conceived by geologist Luna B. Leopold and his colleagues in 1971, as a response to the US Environmental Policy Act of 1969, which didn't give clear instructions to the Federal Government agencies for preparing an impact report or for examining the environmental effects of the projects that an agency plans. The Leopold matrix addressed this challenge by 'providing a system for the analysis and numerical weighting of probable impacts' (Josimovic et al., 2014).

According to the Leopold matrix method, EIA should consist of three basic elements:

1. a listing of the effects on the environment that the proposed development may induce, including the estimate of the magnitude of each of the effects;
2. an evaluation of the importance of each of listed effects (e.g., regional vs. local); and
3. a summary evaluation, which is a combination of magnitude and importance estimates.

The impact assessment method used in this report is a matrix which is derived from the Leopold Matrix however this method use a colour code to assign the significance level of each predicted impact. This method has been adapted from the Environmental Resource Management (2008).

Leopold Matrix is an effective impact assessment methodology which has been extensively used by EIA practitioners across the world. The colour coding enhance Leopold Matrix further. Since EIA is a technical report which are read by both technical experts of different field as well as the general public, the colour coding of the significance level will enhance the report easily comprehended by general public and people with no technical expertise in this field.

6.6 Impact Prediction

The environmental impacts of the proposed IWRM project at are predicted in this section of the report by using a simple descriptive matrix. The following matrix distinguishes the types of environmental impacts that may be associated with various project actions on key environmental components and distinguishes whether these are impacts during construction period or during post-construction and operations period. The following Table 19 predicts the nature and types of environmental impacts based on the existing environmental condition of the islands and the surrounding environment.

Table 19: Impact prediction table

Project Activities	Natural Environment				Social Environment			
	Reef and Coastal Environment	**Soil and groundwater**	**Lagoon and seawater**	**Air/Noise**	**Services and Infrastructure**	**Health and Safety**	**Employment**	**Costs to consumer/tax payer**
Construction Phase								
Excavation and pipe works on land	No significant impact	Excavation and pipe work laying will impact the groundwater for a short period of time due to dewatering and furthermore loosen sub layer of the soil.	No significant impact	Dust particles will be unsettled during the excavation and significant localized noise pollution is anticipated.	A temporary disruption to the services may occur due to accidents during excavation. The services, which are vulnerable for excavation accidents, include electricity, sewerage network, and internet and cable service.	Due to unsettling dust the community may be vulnerable to upper respiratory infections and asthma for a short period of time. There is a high probability of pedestrians and vehicles may face accidents during excavation.	Local contractors will be used for the excavation work hence employment opportunities will increase in the island.	No significant impact
Installation of brine reject outfall	Direct damage to corals to the limited corals found in the brine reject outfall location and increase in	No significant impact	Turbidity will increase in the lagoon hence deteriorating seawater quality for a short period of time.	Significant noise pollution and vibrations which may affect the sparse marine species	No significant impact	Turbidity of the lagoon will have some impacts on the seawater quality which may affect the recreational	Divers and snorkelers maybe employed from the island for brine	No significant impact

	turbidity of the coastal environment			population in the vicinity		swimmers in the lagoon.	reject outfall construction.	
Machinery and Equipment	Accidental damage may occur to the corals from barges and other machineries	Poor handling and management of diesel and other fuel often lead to contamination of the groundwater aquifer.	Accidental spillage of the fuel will degrade the sea water quality	Localized noise pollution at the project site. However, this noise levels will be short term and only during the construction activities. Emission of GHG and other air pollutants since the machinery will burn fossil fuels.	The fuel used for the machinery and equipment if obtained from the island will create a demand for fuel which may affect services and infrastructure.	The operation of machinery will increase sooty smoke which can decrease the air quality in the vicinity of the project site. Use of heavy machinery and equipment in close proximity to local community will increases chances of accidents involving small children and elderly.	No significant impact	No significant impact
Land Clearance	No significant impact	The ecosystem service provided by tree and shrubs such as prevention of soil erosion and water purification will be lost.	No significant impact	No significant impact	No significant impact	No significant impact	Locals can be employed for land clearance purpose.	Money need to be paid for the palms owned private parties
Impacts of workforce	Waste produced by the	Increased burden on groundwater	No significant impacts	Increase of workers will	The expatriate workers and	The influx of expatriate and	Expatriate workers	No significant impact

	workforce may be affect reefs if not properly disposed via existing solid waste disposal site.	resources since workforce will utilize groundwater for various purposes		contribute to air pollution and noise minimally.	workers from other islands will relay of the existing services and infrastructure to meet their basic needs hence extra burden of the existing services and infrastructure.	workers from other islands will contribute to congestion of the island	and workers from other island will decrease the chance of employment for residents of the islands.	
Drilling of a borehole	No significant impact	No significant impact	No significant impact	Noise pollution during the drilling in the vicinity of the project site.	No significant impact	No significant impact	No significant impact	No significant impact
Operational Phase								
Construction of the infiltration galleries	No significant impact	If uncontrolled amount of water is drawn, saline intrusion can happen	No significant impact	No significant impact	The use of infiltration gallery safely increases the water security and reduce recurrent costs of the IWRM system	A potential malfunction of the gallery or associated monitoring could lead to contamination of the IWRM system, leading to wide spread health and safety issues	No significant impact	Since groundwater infiltration is a part of the IWRM project hence maintenance of ground water infiltration galleries will be included in the water tariffs.

Operation of pumps and RO plants	No significant impact	Feedwater will be taken from a borehole which will have impact on the groundwater. The fuel used for pumps and RO plant if not properly handled may seep into ground and affect groundwater.	The brine reject concentrate which will be disposed to open ocean may affect the sea water quality if proper dispersion does not take place.	Operation on the pumps will produce GHG and other air pollutants which will affect the air quality especially in the vicinity of the project site.	No significant impact	Operation on the pumps will produce air pollutants which will affect the air quality especially in the vicinity of the project site.	Operation of pumps and RO plants will increase the employment opportunity especially for RO plant operator	The consumers need to pay the water tariff rates to obtain the services of desalinated water. However, since this project is IWRM the cost of desalination will be decreased since rainwater is harvested.
Water treatment / Disinfection	No significant impact	The chlorine used in the disinfection process may seep into groundwater if improperly handled.	The chlorine used in the water treatment may leach into the lagoon and affect the sea water quality and the marine population in the lagoon.	No significant impact	Improve the standard of the water quality available to the island community this improving the services such as agriculture, local gardening	Water treatment will prevent outbreaks of water-borne diseases such as typhoid, cholera and toxoplasmosis	No significant impact	No significant impact
Piped water network	No significant impact	Accidental damage to the piped network could lead to excavation and the similar impacts are anticipated as the pipe laying and	No significant impact	No significant impact	Improved drinking water delivered to doorstep via pipe will improve many services in the island	Availability of Improved drinking water will improve the health and well-being of the island community	No significant impact	The financial burden of paying for the service of piped water network is anticipated.

		excavation during the construction phase.			including restaurants, café and schools.			
Water testing chemicals (handling/storage)	If improperly disposed could reach the lagoon and open sea via the existing sewerage network and could affect the marine ecosystem. However, the likelihood of this impact is low as small quantities of chemicals will be used for water testing	If handled or stored improperly, the chemicals may seep into the ground and affect the groundwater. However, only small quantities of chemicals will be used and stored for a project of this nature.	If improperly disposed could reach the lagoon and open sea via the existing sewerage network and could affect the marine ecosystem. However, the likelihood of this impact is low as small quantities of chemicals will be used for water testing	No significant impact	No significant impact	The chemicals if seeped and contaminate the groundwater will have adverse health impacts, However, only small quantities of chemicals will be used and stored for a project of this nature.	No significant impact	No significant impact
Brine Disposal	The brine concentrate will have adverse effect on the reef ecosystem if not disposed into a mixing zone with great current speeds. However, the proposed	No significant impact	The brine concentrate will have adverse effect on the lagoon marine ecosystem and sea water quality if not disposed into a mixing zone with great	No significant impact	May impact the reef fisheries near the vicinity of the island as brine concentrate may impact the reef ecosystem. However the proposed location is not	No significant impact	No significant impact	No significant impact

	location for the brine reject outfall has a high velocity current which will enable adequate flushing of brine as well as low coral cover		current speeds. However, the proposed location for the brine reject outfall has a high velocity current which will enable adequate flushing of brine.		generally used for reef fisheries			

The above table illustrates project activities both during the construction and operational phase.

6.7 Description of the Impacts

6.7.1 Construction Phase

6.7.1.1 Excavation and pipe works on land

As discussed in the project description (See Section 2) the proposed IWRM project has two major pipe laying works on the land. This include laying of the piped water network from the project site where the treated water storage tank is kept to the individual households. The second network is the piped network which carry the rainwater harvested from the public buildings to the raw water storage tank in the project site.

The main predicted impacts on the natural environment include the following;

- Excavation and pipe work laying will impact the groundwater for a short period of time due to dewatering and furthermore loosen sub layer of the soil.
- Dust particles will be unsettled during the excavation and significant localized noise pollution is anticipated.

The main predicted impacts on the social environment include the following;

- A temporary disruption to the services may occur due to accidents during excavation. The services which are vulnerable for excavation accidents include electricity, internet and cable service.
- Due to unsettling dust the island community living in the near vicinity may be vulnerable to upper respiratory infections and asthma for a short period of time.
- There is a high probability of pedestrians and vehicles may face accidents during excavation if precautionary and safety measures are not taken.
- Local contractors will be used for the excavation work hence employment opportunities will increase in the island.

6.7.1.2 Installation of brine reject outfall

A brine reject outfall will be constructed in the north-western side of the island. This brine outfall will dispose the brine reject concentrate to the open ocean at a location where the mixing and dispersion of these brine concentrate will be maximum. The main treatment of this brine concentrate will be aerated to increase the dissolved oxygen in the brine concentrate.

The main predicted impacts on the natural environment include the following;

- Direct damage to the corals found in the brine reject outfall location.
- Increase in turbidity which may affect the coral reef and the marine community existing in the vicinity of the brine outfall location;
- Turbidity will increase in the lagoon hence deteriorating sea water quality for a short period of time;
- Significant noise pollution and vibrations which may affect the marine species population in the vicinity;

The main predicted impacts on the social environment include the following;

- Turbidity of the lagoon will have some impacts on the sea water quality which may affect the recreational swimmers in the lagoon if any is used in this area;
- Divers and snorkelers may be employed from the island for brine reject outfall construction which may be seen as a positive aspect as this will create temporary jobs.

6.7.1.3 Machinery and Equipment

The main heavy machinery and equipment to be utilized during the construction phase includes excavators, lorries, dumpers, concrete batching plants, cranes and barges. The impacts due to usage of these machinery are due to burning of fossil fuel for the operation of these machineries and potential accidents in utilization of these heavy machineries.

The main predicted impacts on the natural environment include the following;

- Accidental damage may occur to the corals from barges and other machineries;
- Poor handling and management of diesel and other fuel often lead to contamination of the groundwater aquifer;
- Accidental spillage of the fuel will degrade the sea water quality;
- Localized noise pollution at the project site. However, this noise levels will be short term and only during the construction activities.
- Emission of GHG and other air pollutants since the machinery will burn fossil fuels.

The main predicted impacts on the social environment include the following;

- The fuel used for the machinery and equipment if obtained from the island will create a demand for fuel which may affect services and infrastructure;
- The operation of machinery will increase sooty smoke which can decrease the air quality in the vicinity of the project site;
- Use of heavy machinery and equipment in close proximity to local community will increases chances of accidents involving small children and elderly.

6.7.1.4 Land Clearance

The main land clearance which is involved in the IWRM project is clearance of the proposed project area where the desalination plant will be installed. There are 132 palms of which most would need to be removed along with few mangroves and other few species of vegetation found in the project area.

The main predicted impacts on the natural environment include the following;

- The ecosystem service provided by palms, tree and shrubs such as prevention of soil erosion and water purification will be lost.
- Uprooting and removal of palm trees need to be handled carefully.

The main predicted impacts on the social environment include the following;

- Locals can be employed for land clearance purpose.
- Compensation would need to be paid for the palms that is privately owned or used for economic activity.

- It was mentioned by the island council that with the deployment of the machines for land clearance, other benefits such as road leveling are provided.

6.7.1.5 Impacts of workforce

It is anticipated to have an influx of semi-skilled workers to the island. These workers may be mostly expatriates and some workers from other islands. The main impacts on the environment will be that these workers will be utilizing the resources available in the island. However, most of the impacts is expected to be short term and mostly social impacts.

The main predicted impacts on the natural environment due to workforce include;

- Waste produced by the workforce may affect reefs if not properly disposed via existing solid waste disposal site;
- Increased burden on groundwater resources since workforce will utilize groundwater for various purposes;
- Workers residing in the island will cause an increase for demand for social and economic resources although minimal.

The main predicted impacts on the social environment due to workforce include;

- The expatriate workers and workers from other islands will rely on the existing services and infrastructure to meet their basic needs hence extra burden of the existing services and infrastructure;
- The influx of expatriate and workers from other islands will contribute to congestion of the island which already has a high population density;
- Expatriate workers and workers from other island will decrease the chance of employment for residents of the island.

6.7.1.6 Drilling of borehole

Borehole will be drilled at the proposed project site at a depth of 30 m to access brackish sea water from the ground water aquifer. Since the borehole is drilled into such a sheer depth the impact on the freshwater aquifer of the island is expected to be minimal. However, just like any other construction work some impacts on the natural and social environments are expected from drilling of a borehole. There are no infrastructure within 100 m from the proposed site.

The main predicted impact of drilling of a borehole includes the following;

- Noise pollution during the drilling in the vicinity of the project site.
- The bentonite clay used in drilling can cause environmental impacts if not properly disposed.

The main predicted impacts on the social environment drilling a borehole include the following;

- Vibrations due to drilling may affect the existing infrastructures in the island.

6.7.1.7 Generation of solid waste

It is envisaged that there will be considerable amount of solid waste would be generated during the construction phase. Plastic wrappings scraped metal, wood and plastics from PVC pipes would be produced during the process.

6.7.2 Operational Phase

6.7.2.1 Use of infiltration galleries

Infiltration galleries will be constructed as a pilot to use the ground water resource. The surface water will be skimmed and collected to be pumped out. However, some negative impacts are also anticipated from the infiltration galleries.

The main impacts predicted from utilization of infiltration galleries on the natural environment include the following;

- The extraction of groundwater using the proposed system would marginally decline the groundwater quality in the area especially considering the proximity to the shore. However, this may be compensated by reduced pumping of ground water from other parts of the island.
- The risk of overdrawing of fresh water compared to amount being recharged can cause salt water intrusion into the galleries.

The main impacts predicted from utilization of infiltration galleries on the social environment include;

- The use of groundwater would further reduce the cost of RO operations in the system;
- Since groundwater infiltration is a part of the IWRM project, maintenance cost of ground water infiltration galleries will be included in the water tariffs.

The risk involved with the infiltration gallery is related to the current state of the ground water on the island and the site. The high salinity and hardness within the vicinity of the site poses health and safety risks in using the groundwater. Although, it is expected the groundwater quality would improve overtime, the question remains whether the water quality would improve to yield groundwater for potable use quickly enough to justify the infiltration gallery. To address this, a thorough hydrogeological study of the island needs to be carried to ensure this. Taking into account, that this is an opportunity use, learn and adapt a technology which could prove to be very useful in ensuring water security in the future it is recommended to conduct a detail assessment of groundwater quality and its yield at the infiltration gallery site before including it in the detail design of the IWRM system.

6.7.2.2 Operation of pumps and RO plants

Pumps will be used for two different aspects of the proposed IWRM project. Pumps will be used to pump the water from the rainwater catchment in the public buildings to the raw water storage tank via the network. In addition, pumps will be used in the infiltration galleries to pump.

Two Reverse Osmosis desalination plants will be used for the project to produce water which meets the demand of a period of 90 days. The desalination plant will be powered by a dedicated diesel generator. Hence, most of the expected impacted are from burning of fossil fuel for desalination process.

The predicted impacts on the natural environment due to operation of pumps and RO plant include the following;

- Feedwater will be taken from a borehole which will have impact on the groundwater.
- The fuel used for pumps and RO plant if not properly handled may seep into ground and affect groundwater.
- Operation on the pumps will produce GHG and other air pollutants which will affect the air quality especially in the vicinity of the project site.

The main predicted impacts on the social environment include the following

- Operation on the pumps will produce air pollutants which will affect the air quality especially in the vicinity of the project site;
- Operation of pumps and RO plants will increase the employment opportunity especially for RO plant operators;
- The consumers need to pay the water tariff rates to obtain the services of desalinated water. However, since this project is IWRM the cost of desalination will be lower as harvested rainwater is utilized.

6.7.2.3 Water treatment / Disinfection

The main type of water treatment for the proposed IWRM project is slow sand filtration system and chlorination after the filtration process. Slow sand filtration is an effective process to remove both chemical and microbiological contaminants from water. The chlorine used for disinfection will assure that the final water produced for distribution is potable water which meets the EPA requirements.

The main predicted impacts for water treatment on the natural environment includes the following;

- The chlorine used in the disinfection process may seep into groundwater if improperly handled;
- The chlorine used in the water treatment may leach into the lagoon and affect the sea water quality and the marine population in the lagoon.

The main predicted impacts for water treatment on the social environment includes the following;

- Improve the standard of the water quality available to the island community this improving the services such as agriculture, local gardening;
- Water treatment will prevent outbreaks of water-borne diseases such as typhoid, cholera and toxoplasmosis.

6.7.2.4 Piped water network

Piped water network established in the proposed IWRM project include a network which involves house connections and the treated water from the treated water tank will be distributed. The second piped water network to be established under the IWRM project is the network which connects the public water storage tanks to the raw-water storage tank in the project site. These

networks are integral part of the IWRM system which will be operational after completion of the proposed project.

The main impacts on the natural environment from a piped water network include the following;

- Accidental damage to the piped network could lead to excavation and the similar impacts are anticipated as the pipe laying and excavation during the construction phase.

The main impacts on the social environment from a piped water network include the following;

- Improved drinking water delivered to doorstep will improve many services in the island including restaurants, café and schools;
- Availability of Improved drinking water will improve the health and well-being of the island community;
- The financial burden of paying for the service of piped water network is anticipated.

6.7.2.5 Water testing chemicals (handling/storage)

A laboratory will be established in the project site which will be used to perform water quality testing. The water quality testing will be done for the parameters such as pH, dissolved oxygen, mineral ions and microbiological parameters. A small stock of chemicals and other reagents required for water quality testing will be stored and handled in the laboratory. The main aim of the laboratory is to ensure that the water produced by the IWRM network meet the requirements of the EPA for drinking water quality.

The main impacts predicted on the natural environment from water testing chemicals include the following;

- If improperly disposed could reach the lagoon and open sea could affect the marine ecosystem. However, the likelihood of this impact is low as small quantities of chemicals will be used for water testing;
- If handled or stored improperly, the chemicals may seep into the ground and affect the groundwater. However, only small quantities of chemicals will be used and stored for a project of this nature;
- If improperly disposed could reach the lagoon and open sea could affect the marine ecosystem. However, the likelihood of this impact is low as small quantities of chemicals will be used for water testing.

The main impact predicted on the social environment from water testing chemicals includes the following;

- The chemicals if seeped and contaminate the groundwater will have adverse health impacts, However, only small quantities of chemicals will be used and stored for a project of this nature.

6.7.2.6 Brine Disposal

Brine reject concentrate will be treated in a brine well. The treatment includes aeration of the brine reject concentrate. The treated brine will be disposed via a brine reject outfall. The proposed location is expected to have strong ocean currents which will assist flushing and dispersion of the brine concentrate.

The following impacts on the natural environment due to brine disposal have been predicted;

- The brine concentrate will have adverse effect on the reef ecosystem if not disposed into a mixing zone with sufficient current speeds. However, the proposed location for the brine reject outfall has a high velocity current which will enable adequate flushing of brine.
- The brine concentrate will have adverse effect on the lagoon marine ecosystem and sea water quality if not disposed into a mixing zone with sufficient current speeds. However, the proposed location for the brine reject outfall has a high velocity current which will enable adequate flushing of brine.

The following impact has been predicted to cause by brine disposal;

- May impact the reef fisheries near the vicinity of the island as brine concentrate may impact the reef ecosystem. However, the proposed location is not normally used for reef fishery

6.7.3 Indirect Impacts

The most apparent indirect impact of the IWRM project is impact on the reef fisheries and bait fisheries due to the brine disposal. However, these impacts are expected to be extremely minimal. The currents at the proposed location for brine reject outfall is subjected to change seasonally and depending on the tidal fluctuations. However, there are uninhabited islands and shallow reefs which are used for reef fish fishery and bait fish extraction. It can be noted that no marine protected area or environmentally sensitive area will be affected by this indirect impact.

There are other envisaged indirect impacts such as over consumption of potable water for other residential and commercial purposes. This could lead to unsustainable management of water resources available in the island.

6.7.4 Cumulative Impacts

The only cumulative impact envisaged for this IWRM project is increase in capacity of the RO plant in the future to meet the demand of the increasing population. The capacity increase of the RO plant will be accompanied by more emission of GHG gas and also more brine reject concentrate disposed into the ocean.

Since the current system design cater the demand of current projected population for next 35 years growth the anticipated increase in capacity of the RO plant would likely be after 35 years.

6.7.5 Socio-economic impacts

The social and economic impacts of the proposed IWRM project will be mostly positive especially in terms of job opportunities and improvement of the health and wellbeing of the community. The health impacts are mainly due to availability of potable drinking water throughout the year without shortage in the dry period.

Even though, the epidemics of water borne diseases are rare, water safety and security is a key concern of the island community. Furthermore, economic burden on the taxpayer will be reduced as large sums of taxpayer money is utilized to provide desalinated water to island affected by water shortage during the dry period.

The negative impact would be that people will have to pay for the water. Although this may be the case, people indirectly pay for water even at the present time in that they would spend on pumps and energy the pumps consume as well as the disinfectants or energy for boiling water to render it safe. Therefore, this impact is considered a minor negative impact. It was mentioned during the community consultations; the public is willing to pay for the water services since they are already paying for other services such as TV and utility services. Through the consultations, it was found that the public is willing to pay for the water services too if reliable, clean and affordable service could be provided.

6.8 Impact Analysis and Evaluation

The following section will provide an analysis and evaluation of the previously described impacts on the natural and social environment in order to identify their significance.

The Table 20 is an impact analysis table. From the Table 20 it can be inferred that magnitude of the most of the negative impacts on the natural and social environment is moderate, minor or negligible. The most significant impact during the construction phase of the proposed IWRM project is installation of brine reject outfall.

For the operational phase of the proposed IWRM project, the infiltration galleries for use of groundwater and the piped water network are found to have moderate to high positive impacts as this will increase the amount of quality controlled fresh water resource available to the island. The most significant negative impacts are caused by operation of pumps and RO plants and brine disposal.

The indirect impact of this project was found to be negligible. However, the cumulative impact of this project was found to have a moderate negative impact. The overall, socio economic impact of the proposed IWRM project was found to be moderate and positive in nature.

Table 20: Impact Analysis Table

Project Activity/ Impact	Extent	Duration	Intensity	Likelihood	Magnitude	Color Scale
Construction Phase						
Excavation and pipe works on land	Local	Short-term	Low	Definite	Minor	
Installation of brine reject outfall	Local	Short-term	Medium	Definite	Moderate	
Machinery and Equipment	Onsite	Short-term	Low	Likely	Minor	
Impact of workforce	Local	Short-term	Negligible	Unlikely	Negligible	
Land Clearance	Onsite	Permanent	Medium	Unlikely	Minor	
Drilling of a borehole	Onsite	Short-term	Low	Likely	Negligible	
Operational Phase						
Infiltration galleries	Local	Long-term	Medium	Likely	Moderate	
Operation of pumps and RO plants	Local	Long-term	Medium	Definite	Moderate	
Water treatment / Disinfection	Onsite	Long-term	Low	Unlikely	Negligible	
Piped water network	Local	Long-term	Medium	Likely	Moderate	
Water testing chemicals (handling/storage)	Local	Long-term	Low	Unlikely	Negligible	
Brine Disposal	Onsite	Long-term	Medium	Likely	Minor	
Both Phases						
Indirect impacts	Regional	Long-term	Low	Unlikely	Negligible	
Cumulative impacts	Local	Long-term	Medium	Definite	Moderate	
Socio-economic impacts	Local	Long-term	Medium	Definite	Moderate	

7. Mitigation Measures

The main objective of the following section is to provide environmental management and mitigation measures that will be undertaken and monitored in order to minimize and offset previously described environmental impacts of the proposed IWRM project.

7.1 Justification for the proposed mitigation measures

The following factors were considered in order to evaluate the appropriateness of the proposed mitigation measures;

- costs;
- benefits;
- required manpower;
- equipment;
- expertise;
- timing and
- technology

The proposed mitigation measures will be the most cost-effective, have the maximum benefits and requires minimum utilization of manpower and equipment. Furthermore, the practicality of the proposed mitigation measures will be given a high priority. The technical aspects of the different project components were considered when evaluating the proposed mitigation measures.

7.2 Limitations of the proposed mitigation measures

The main limitation of the proposed mitigation measures is that these mitigation measures are proposed for an impact which is predicted. Since the impact has been predicted, there is an uncertainty regarding how the impact will affect the natural environment when the actual project is implemented. The nature of impacts even from similar project activities undertaken in a different location in the country could generate in a totally different manner.

7.3 Construction Phase

7.3.1 Excavation and pipe works on land

As described previously, major excavation will be done in the island in order to establish a piped water network in the island. These excavation is expected to be 1-2 meter below ground at may require dewatering.

The following measures will be taken during the excavation and pipe works on land;

- To ensure appropriate supervision and monitoring of the excavation and pipe laying work.
- Complete the work as soon as possible
- Keep workers informed with ways to minimize the impacts
- Wear safety and protection measures (personnel protection equipment)

- Keep appropriate signs for public safety

The following are key considerations for the most significant mitigation measure for reduction of impacts of excavation and pipe laying works.

Mitigation Measure	**Ensure appropriate supervision and monitoring**
Cost	Salary of the supervisors and engineers
Benefits	Appropriate care will be taken to minimize the impacts of dewatering, noise and dust impacts on the natural and social environment of the island.
Expertise	Supervisor, Management Skill and Engineering
Required Manpower	2 person
Responsibility	Contractor
Equipment and Technology	Not required
Timing	During the excavation and pipe lying works

7.3.2 Installation of brine reject outfall

As mentioned earlier, a brine reject outfall will be constructed in the south-eastern side of the island. This brine outfall will dispose the brine reject concentrate to the open ocean at a location where the mixing and dispersion of these brine concentrate will be maximum. Furthermore, these brine concentrate will be treated in brine well, constructed at the project site. The main treatment of this brine concentrate will be aeration to increase the dissolved oxygen in the brine concentrate.

The following mitigation measures will be taken during installation of the brine reject outfall;

To ensure appropriate supervision and monitoring

- Carry out the work at low tide;
- Complete the work as soon as possible;
- Use pre-fabricated concrete blocks;
- Avoid washing tools, equipment, etc. into lagoon.

The following are key considerations for the most significant mitigation measure for reduction of impacts of installation of brine reject outfall;

Mitigation Measure	**Carry out the work at low tide**
Cost	Zero
Benefits	At low tide the corals and other marine life will be visible hence the impacts on these marine organisms can be reduced. The impacts of sedimentation will be reduced.
Expertise	Local Knowledge
Required Manpower	Not applicable
Responsibility	Contractor
Equipment and Technology	Not required
Timing	Low tide period depending on the day of construction work.

7.3.3 Machinery and Equipment

The main heavy machinery and equipment to be utilized during the construction phase includes excavators, lorries, dumpers, concrete batching plants, cranes and barges. The impacts due to usage of these machinery are due to burning of fossil fuel for the operation of these machineries and potential accidents in utilization of these heavy machineries.

The following are the mitigation measures which will be undertaken during utilization of machinery and equipment;

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

The following are key considerations for the most significant mitigation measure for reduction of impacts of machinery and equipment;

Mitigation Measure	**Machines must be operated by experienced operators**
Cost	Salary of Experienced operators
Benefits	Accidental damage to reef and critical infrastructure such as sewerage network and cable TV internet can be avoided. The accidental spillage of fuel and lubricant oil can be avoided.
Expertise	Technical and Experience in operation of heavy machinery and vehicles
Required Manpower	Two to Three staff
Responsibility	Contractor
Equipment and Technology	Not required
Timing	Construction phase during the operation of heavy machineries

7.3.4 Impact of workforce

As discussed in the impact prediction section (see Section 6), it is anticipated to have an influx of semi-skilled workers to the island. These workers may be mostly expatriates and some workers from other islands. The main impacts on the environment will be that these workers will be utilizing the resources available in the island. However, most of the impacts is expected to be short term and mostly social impacts.

The following are the mitigation measure which will be undertaken in order to minimize the impacts of workforce;

- Educate and create awareness amongst the workers regarding potential environmental impacts;
- As much as possible, employ local residents from the island.

The following are key considerations for the most significant mitigation measure for reduction of impacts of workforce;

Mitigation Measure	**Employ local residents from the island**
Cost	Budget allocated for semi-skilled workers
Benefits	No additional burden on the resources of the island. No social problems will arise since employee will be from local island. These problems may arise if mostly expatriate workers are employed.
Expertise	Local connection with residents
Required Manpower	Existing human resource person of contractor
Responsibility	Contractor
Equipment and Technology	Not required
Timing	Construction phase

7.3.5 Land Clearance

The main land clearance, which is involved in the IWRM project, is clearance of the proposed project area where the desalination plant will be installed. There are 132 palms of which most would need to be removed along with few mangroves and other few species of vegetation found in the project area.

The following are the mitigation measure which will be undertaken in order to minimize the impacts of land clearance;

- Offset the environmental impacts removed trees removed from the project site by planting trees at another location.
- Careful considerations must be given while removing the palm trees and bigger trees not to damage the roots so that it could be planted elsewhere.
- Backfilling of the pits might not be necessary since the land would be excavated for the infrastructure to be built. However, should there be any backfilling needed, sediments from the excavation could be used to backfill the pits.
- It was also mentioned that, some of the excavated material would be used for leveling the roads.
- The necessary approvals from EPA for removal must be obtained before removal and transfer of the trees.

The following are key considerations for the most significant mitigation measure for reduction of impacts land clearance;

Mitigation Measure	**Planting trees to offset the plant removed from the project site**
Cost	Cost of the planted trees and deployment of machinery for removal
Benefits	The newly planted trees will provide the ecosystem services which the plants removed from the project site offered previously.
Expertise	Gardening and procurement
Required Manpower	2 staff
Responsibility	Contractor
Equipment and Technology	Removal machinery and Gardening tools
Timing	Construction phase or operational phase

7.3.6 Drilling of a borehole

A borehole will be drilled at the proposed project site at a depth of 30 m to access brackish sea water from the ground water aquifer. Since the borehole is drilled into such a sheer depth the impact on the freshwater aquifer of the island is expected to be minimal. However, just like any other construction work some impacts on the natural and social environments are expected from drilling of a borehole.

The following are the mitigation measure which will be undertaken in order to minimize the impacts of drilling of a borehole;

- The borehole drilling should be done by experienced contractors.
- It is recommended not to store any chemicals, oil or any other spillage materials near the borehole to protect the borehole from potential spills, although it is highly unlikely to cause any negative impacts.
- Careful consideration would be given not to spread the bentonite sealant and to collect it for disposal either in Thilafushi or Vandhoo site

The following are key considerations for the most significant mitigation measure for reduction of impacts of drilling a borehole;

Mitigation Measure	**The borehole drilling should be done by experienced contractors**
Cost	Sub-contract price
Benefits	The borehole will be drilled with minimum impact on the groundwater and the geomorphology of the island.
Expertise	Geotechnical Expertise
Required Manpower	3-5 staff
Responsibility	Contractor
Equipment and Technology	Borehole Drill, Casing and a bentonite sealant
Timing	Construction Phase

7.3.7 Construction and solid waste disposal

Following must be considered during construction and operation to mitigate the impacts due to waste generation and disposal

- Adhere to the waste management plans and procedures during the construction and operation of the facility
- Stock pile and store of waste in one area during construction
- Avoid any project work near the coastal area unless required
- Segregation of waste would be done at the waste management area
- Solid waste, oil and hazardous materials needs to be carefully handled and transported in sealed containers
- During operational phase, all the waste will be carried to an appropriate waste management center or designated place regularly.

7.4 Operational Phase

7.4.1 Use of infiltration galleries

Taking into account, that this is an opportunity use, learn and adapt a technology which could prove to be very useful in ensuring water security in the future it is recommended to conduct a detail assessment of groundwater quality and its yield at the infiltration gallery site before including it in the detail design of the IWRM system. The following mitigation measures will be taken prior and during the operationalization of the infiltration gallery;

- A hydrogeological study will be conducted prior to construction and operations in order to understand the quantity and quality of the groundwater.
- A mechanism or guidelines or regulations would be established not to withdraw ground water during the dry monsoon to avoid negative feedback of saltwater in to the water table.
- A routine check of the facilities of the galleries for cleaning would be established so as to ensure that no clogging of the galleries would happen. This could be carried either once a year or every two years.
- Conduct frequent tests on the quality of groundwater (particularly, salinity/conductivity and hardness) in the site to ensure the safety of water supplied.
- As the maintenance of gallery requires excavation, it is recommended that environmental impacts and mitigation measures mentioned for excavation is considered at each maintenance cycle.
- It is also recommended Fenaka is duly informed of the details (including maintenance requirements) of the gallery and develop capacity of Fenaka to carry out manage and maintain the system effectively to reduce risks of operational mishaps.
- Developing and installation of a proper sewerage system for the island to help improve the ground water quality.

The following are key considerations for the most significant mitigation measure for reduction of impacts of managing and maintaining;

Mitigation Measure	**Monitoring and supervision of the infiltration gallery operation and maintenance**
Cost	Salary of the plant operator
Benefits	Ensure proper maintenance and operation of infiltration gallery with reduced risk of any mishaps
Expertise	Water expertise
Required Manpower	1 supervisor
Responsibility	Utility company responsible for operation and maintenance of the water supply system.
Equipment and Technology	Not required
Timing	Operational Phase

7.4.2 Operation of pumps and RO plants

As previously discussed, pumps will be used for two different aspects of the proposed IWRM project. Pumps will be used to pump the water from the rainwater catchment in the public

buildings to the raw water storage tank via the network. In addition, pumps will be used in the infiltration galleries to pump.

Two Reverse Osmosis desalination plants will be used for the project to produce water which meets the demand of a period of 90 days. The desalination plant will be powered by a dedicated diesel generator. Hence, most of the expected impacted are from burning of fossil fuel for desalination process.

The following mitigation measures will be taken in order to minimize the impacts of operating a Pumps and RO plant;

- Utilize Solar PV as much as possible to meet the electricity demand of running pumps and RO plants;
- Monitoring and supervision of fuel handling and storage in order to avoid accidental spillage of fuel.
- Fuel should be stored in a secured location with concrete floor to avoid seepage into the ground.

The following are key considerations for the most significant mitigation measure for reduction of impacts of operating pumps and RO plants;

Mitigation Measure	**Monitoring and supervision of a fuel handling and storage**
Cost	Salary of the plant operator
Benefits	Proper handling and storage of fuel will be ensured. Contamination of groundwater due to fossil fuel spillage will be avoided.
Expertise	Fuel handling
Required Manpower	1 desalination plant operator
Responsibility	Utility company responsible for operation and maintenance of the water supply system.
Equipment and Technology	Not required
Timing	Operational Phase

7.4.3 Water treatment / Disinfection

The main type of water treatment for the proposed IWRM project is to use a slow sand filtration system and chlorination after the filtration process. Slow sand filtration is an effective process to remove both chemical and microbiological contaminants from water. The chlorine used for disinfection will assure that the final water produced for distribution is potable water which meets the EPA requirements.

The following mitigation measures will be taken in order to minimize the impacts of water treatment and disinfection;

- Train the staff involved in water treatment regarding handling and storage of chlorine.
- Train the staff involved in water treatment regarding the adequate quantities of chlorine to be used for disinfection.
- Residual Chlorine can be effectively removed by different chemicals, such as sodium bisulfite (Lattemann & Höpner 2008).

The following are key considerations for the most significant mitigation measure for reduction of impacts of water treatment and disinfection;

Mitigation Measure	**Train the staff involved in water treatment regarding the adequate quantities of chlorine to be used for disinfection.**
Cost	10,000 MVR per staff
Benefits	Adequate use of chlorine will effectively kill the microbiological contaminants and residual chlorine will not be present to affect the marine ecosystem.
Expertise	Water treatment expertise
Required Manpower	1 trainer
Responsibility	Utility company responsible for operation and maintenance of the water supply system.
Equipment and Technology	Not required
Timing	Operational Phase

7.4.4 Piped water network

Piped water network established in the proposed IWRM project include a network which involves house connections and the treated water from the treated water tank will be distributed. The second piped water network to be established under the IWRM project is the network which connects the public water storage tanks to the raw-water storage tank in the project site. These networks are integral part of the IWRM system which will be operational after completion of the proposed project.

The main impacts of the piped water network are positive hence no mitigation measure has been proposed. However, routine checks have to be done by the service provider to detect any faults in the network to rectify and provide a smooth service.

7.4.5 Water testing chemicals (handling/storage)

As described previously, a laboratory will be established in the project site which will be used to perform water quality testing. The water quality testing will be done for the parameters such as pH, dissolved oxygen, mineral ions and microbiological parameters. A small stock of chemicals and other reagents required for water quality testing will be stored and handled in the laboratory. The main aim of the laboratory is to ensure that the water produced by the IWRM network meet the requirements of the EPA for drinking water quality.

The following mitigation measures will be taken to reduce the impacts of water testing chemicals while handling and storage;

- Training of laboratory staff regarding the safety and precautions in handling and storage of chemicals.

The following are key considerations for the most significant mitigation measure for reduction of impacts of water testing chemicals;

Mitigation Measure	**Training of laboratory staff regarding the safety and precautions in handling and storage of chemicals.**
Cost	10,000 MVR per staff
Benefits	Adequate use of chlorine will effectively kill the microbiological contaminants and residual chlorine will not be present to affect the marine ecosystem.
Expertise	Laboratory expertise
Required Manpower	1 trainer
Responsibility	Utility company responsible for operation and maintenance of the water supply system.
Equipment and Technology	Not required
Timing	Operational Phase

7.4.6 Brine Disposal

Brine reject concentrate will be treated in a brine well. The treatment includes aeration of the brine reject concentrate. The treated brine will be disposed via a brine reject outfall. The proposed location is expected to have strong ocean currents which will assist flushing and dispersion of the brine concentrate.

The following mitigation measures will be taken to in order to reduce the impacts of brine disposal;

- Mixing and dispersal of the discharge plume can be enhanced by installing a diffuser system in the brine reject outfall which will be constructed.
- Treatment of the brine reject concentrate with chemicals like sodium bisulfite and Sulphur dioxide or hydrogen peroxide to remove the chemicals attained during reverse osmosis process.

The following are key considerations for the most significant mitigation measure for reduction of impacts of brine disposal;

Mitigation Measure	**Enhancement of mixing and dispersion by installation of a diffuser system in the brine reject outfall.**
Cost	Cost of purchasing a diffuser system and installation costs.
Benefits	The diffuser system will ensure adequate mixing and dispersion of the brine concentrate even when the current speeds at the outfall location is unfavorable
Expertise	Engineering and Procurement Expertise
Required Manpower	1 Engineer (Technical Expert), 1 Supervisor and 2 Divers
Responsibility	Proponent
Equipment and Technology	Diffuser system and tools required for installation
Timing	Construction Phase

8. Stakeholder Consultations

8.1 Stakeholder consultations

This section outlines the major findings of the consultations undertaken with regards to the proposed IWRM project.

8.2 List of Stakeholder

As per the approved Terms of Reference (TOR) for the EIA, the following key stakeholders have been identified;

- Nolhivaranfaru Island Council
- HDh Atoll Council
- Fenaka Corporation
- Project Proponent (MEE)
- Ministry of Housing and Infrastructure

8.3 Means of Stakeholder Consultation

There is no formal method for undertaking stakeholder consultation with regards to addressing concerns and issues relating to the project, hence a number of methods have been used to collect information from key stakeholders identified above. These include; formal communication with Island Council, Fenaka Corporation, and informal communication Atoll Council.

8.4 Communication channel among the stakeholders

The following section outlines mechanisms as requested in the TOR with regards to providing necessary information to key stakeholders that have been identified above. In this regard, the following mechanisms will be practiced throughout the process of the proposed development of IWRM project.

8.5 Summary of discussions

8.5.1 Island Council

The meeting was held with the island council on 19-03-2017 on *Nolhivaranfaru*. The following points summarises the discussion that took place between EIA consultant and the council with respective to the proposed project.

- The EIA consultant provided with project brief and purpose of the project. Consultant also linked the proposed project with the primary survey which was undertaken by Development Technology Maldives Pvt. Ltd. The EIA consultant framed the discussion into following areas and linked the proposed project with those areas.

- Consultant inquired on the **current situation of water and sewage** that is practiced in the island. The council explained the situation of water and sewage facility in the island. Council stated though there are two storage tank of 2500 litre capacity at individual household to harvest rainwater the island faces water shortage. The main reason council believes is community is not aware of how to efficiently use rainwater. Council indicated that the groundwater currently used for washing and bathing is not fit for its use due to heavy contamination. Furthermore, the no proper sewage system on the island makes heavy contamination of groundwater.
- When asked about the **acceptability of the proposed project**, council reported even though community consultations were not undertaken by the concerned authority, the community would welcome the project. Consultant raised the question about how would the community react to notion of pricing water. Council reported that in accordance to the briefing that was provided to the council during the initial survey the fee proposed (MRV 75 per household per month) would be an acceptable fee to the community.
- The proposed location for construction of RO facility comprises of many trees. The council explained the experience and method they have used in past on **compensation for uprooting trees at the project locations**. Council estimates about 50 palms at the site, which may be individual own and public owned. The ownership for the palms including big trees are announced and prices of those are determined by the council. Prior to clearance the council will either collect the amount from the contractor or project contractor will directly hand in money for individuals. The public trees will be auctioned.
- Council welcomed the project however, **the main concern of the council is that they are least informed about project in the islands**. Council having the overall responsibility of the management and provision of services to the community. Council believes that this responsibility is hindered as they are not involved in any phase of the project apart from consultations or arrangement of services to contractor. Council appealed to consultant to provide more update of the project to ensure that they could help more in implementing the proposed project in the island.

8.5.2 HDh atoll council

The EIA report will be shared with Atoll Council for information. They do not have a major role in the proposed development such as providing permits and inspections.

8.5.3 Fenaka Corporation

Fenaka Corporation is the main utility company responsible for operation and maintenance of water supply and sewerage system in the outer islands of the Maldives. It is expected that after completion of the construction phase the responsibility of operation and maintenance will be handed over to Fenaka Corporation. The proponent (Ministry of Environment and Energy) will decide whom the operation and maintenance will be handed over.

Fenaka Corporation will be made aware of the impacts during the operational phase of the project and the mitigation measures which needs to be taken.

8.5.4 Project Proponent

The proponent, Ministry of Environment and Energy, is responsible for preparing the EIA and all the contents including environmental monitoring and mitigation measures outlined in the EIA. They have formally communicated to relevant government agencies regarding the project. As the lead player in the government to provide safe drinking water to the public, MEE mentioned that use of IWRM technology is the current practice the government would want to implement as this will try to integrate the best available water resources to meet the water security of the communities. MEE is well aware of the risks involved in the various components and give the assurance that all the necessary measures will be taken to mitigate the risks.

It was also mentioned that this project would involve a pilot component of the infiltration galleries in Maldives, which has been proven to be successfully used in other small islands similar to the Maldives environment. All the necessary training, guidance manuals and maintenance manuals will be handed over to the FENAKA with the completion of the project. In addition, it was also mentioned that the personnel from the island would be trained from the very beginning of the project staring from the construction stages. These people would be employees from the FENAKA and would also be trained for the operation and maintenance of the system.

8.5.5 Ministry of Housing and Infrastructure

The ministry of Housing and Infrastructure mentioned that they have no issues regarding this project as there are no developments concerning them. However, they mentioned to share the as-built drawings with them as that will be used as information later should there be any infrastructure development projects related to them.

Following is a list of contacts from the stakeholder's consultations and photographic evidences.

Name	Designation	Contact
Ahmed Riyaz	Council President	9663332
Mohamed Hassan	Vise President	9739582
Hussain Abdulla	Asst. Director	9918238
Abdul Hakeem	Asst. Director	9711168
Mohamed Aslam	Station Manager FENAKA	7970696


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9. Alternatives

This section includes some alterative means to the project in terms of location of the project site, alternative location for the brine reject outfall, alternative groundwater recharging technologies and alternative methods for water treatment. Furthermore, the no project option was also explored in this section.

9.1 No development Option

It is envisaged that some environmental impacts will be generated from the proposed IWRM project to be carried out. If the project does not go ahead the existing environment will remain the same for the short-term future. However, the projected impacts of climate change namely salinization of groundwater due to sea-level rise and increased instances of high waves would deteriorate the existing environment without human intervention.

In addition, not having the proposed IWRM project implemented will have many unfavourable social impacts to the island community. The island faces recurrent shortage of drinking water during the dry period and emergency water supply has been provided to the island in the past. One of the main reasons is due to in adequate water storage. If the project does not happen, this additional storage will not be met.

Provision of water through 3 sources of water can address the water security of the project is to go on. However, this security threat would remain if the project does not happen.

Access to safe drinking water will improve the health aspects of the island as the cases of water borne diseases will be significantly reduced. Additionally, quality of food preparation services and health care service in the island is expected to improve due to availability of safe drinking water.

9.2 Alternative Locations

9.2.1 Location of the project site

The Figure 24 shows the proposed and alternative location of the water treatment plant. The alternative location shown is just on the opposite side of the road. The current existing environment of the proposed alternative location is the same as the proposed location. There is a significant amount of land to be cleared. Since the current proposed locations is chosen based on the existing land use plans and since there are no allocations made for the alternative location, it is not recommended to use the alternative location.

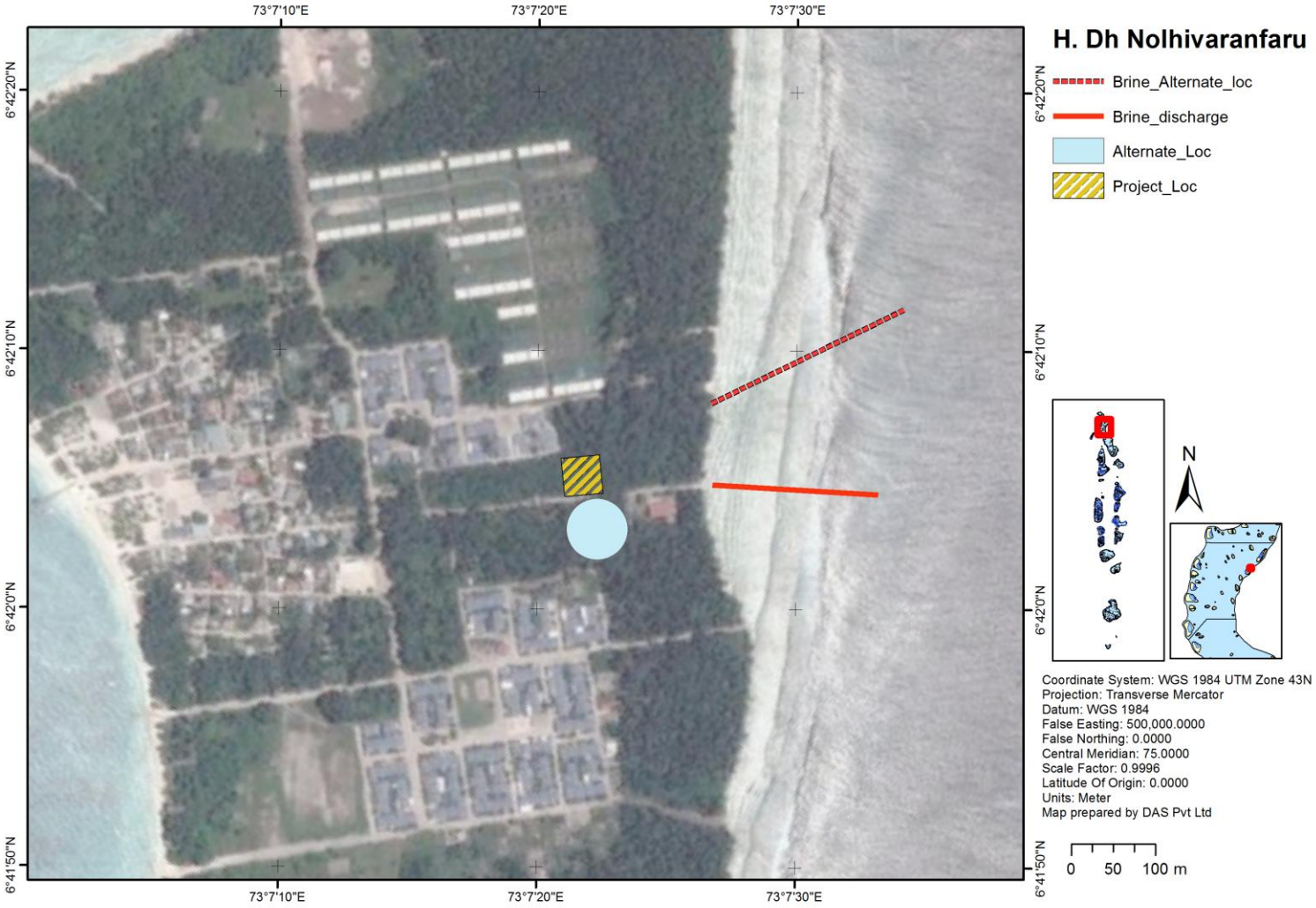

Figure 24: The proposed alternative locations for brine reject outfall and project site

9.2.2 Location of the brine reject outfall

The Figure 24 also shows the alternative brine discharge location. Alternative for brine outfall would be connecting the reject water from RO plant to sewage or other existing outfall. However, the island does not have any facility at the time of this project thus reject water can only be outflowed with an outfall. The proposed alternative discharge location is not further away from the proposed location. However, if it is to be slightly moved, this could increase the length in the pipe to be laid on the ground and along the reef, which could cause more damage than the way it is proposed. In addition to that laying brine discharge pipe line to this location adds additional cost to the project. Therefore, it is more preferred to use the proposed location.

9.3 Alternative to IWRM system

An alternative means to IWRM will be to use only a desalinated water with a network without harvesting rainwater. The proposed IWRM system utilizes a system of incorporating groundwater, rainwater and desalinated water. The cost of this system is cheaper. The energy requirement for a system which will only use desalinated water will be much higher thus more greenhouse gases emissions.

The proposed IWRM project will produced desalinated water for only 90 days. The remaining water supply will be from rainwater harvested from the public buildings of the island. Hence proposed IWRM system will have minor environmental impacts than a system which solely depend on desalination which will incur financial cost for operation and maintenance of the services since it would be used more often if it is to be used as a standalone system.

The other alternative is to use community water tank and household water tank to provide fresh water to the community by enhancing the storage capacity at that level. However, such a system lacks inter-connectivity and is vulnerable to climatic variations. In addition, the required additional land space at household level as well as community level would present further issues in its implementation. Therefore this option is not recommended.

9.4 Alternative to Infiltration Gallery

The infiltration gallery is the component used to extract and integrate groundwater to IWRM system. An alternative to the infiltration gallery would be to use pumps to extract groundwater from the freshest area on the island and be used in the system. However, due to the current fragility of the groundwater this alternative could have disastrously negative impacts on the environment and community.

Another alternative would be to remove groundwater extraction from IWRM. This would reduce the water security as well as increase cost of producing water using IWRM without the ground water. However, this would also remove the impacts and risks associated with infiltration gallery mentioned above. Taking into account, that this is an opportunity use, learn and adapt a technology which could prove to be very useful in ensuring water security in the

future it is recommended to conduct a detail assessment of groundwater quality and its yield at the infiltration gallery site before including it in the detail design of the IWRM system.

9.5 Alternative to borehole drilling

The proposed IWRM project will use a borehole as a source of feedwater. An alternative to borehole will be to use seawater from lagoon for desalination. However, this method will involve laying pipes beyond the reef edge and working on the reef areas including possible dredging or use of machinery. Hence, the environmental impacts of this method will be much higher than environmental impacts of drilling a borehole.

Furthermore, the feedwater water from the lagoon will have more contaminants than feedwater from a brackish water from borehole. This will significantly increase the energy consumed for the desalination process and membrane filtering process. Hence, the fuel costs and greenhouse gases emissions will be less when feedwater is taken from a borehole rather than from the lagoon. In addition, use of seawater will give a short lifetime for the membranes rather than using brackish water from the boreholes for filtering.

9.6 Alternative Water Treatment

9.6.1 Aeriation

Aeriation is a method of water treatment. This type of treatment is usually supplements to other types of treatment. The process involves exposing storage tank to the air. Exposing water to air will trigger chemical process known as oxidation of both Manganese and Iron in water This chemical reaction will remove some taste and order. This method even though of very low cost is risking given that through oxidation active pathogens are not filtered or removed. Therefore, a secondary process needs to be supplemented to remove pathogens.

9.6.2 Rapid Sand Filter

Rapid Sand Filters involve usage of coarse sand to filter the water which is flowed through the sand at higher rate. This process is very similar to the one proposed by the project. The cost implementation of this filter would be almost same as the Slow Sand Filter as suggested in this project. However, since water is passing at a very slow rate on a high coarse material, water would not be filtered to the level which would be directly distributed. It may need further treatment as most of the pathogens will not be removed.

10. Environmental Monitoring and Management

This chapter outlines the monitoring plan for the project. Adoption of appropriate mitigation measures can significantly reduce the environmental damage caused by a development project. However, occurrence of unforeseen impacts is still possible, even with proper implementation of mitigation measures. Moreover, some of the predicted impacts may turn out to be greater than predicted, necessitating different or more rigorous mitigation measures. Therefore, regular and frequent monitoring of the environment is vital, in order to avoid or reduce the chances of such events, and to minimize the impact and cost of unforeseen events by taking prompt remedial action if such events occur.

Since most environmental changes occur over long period of time, it is important to implement a specific long-term monitoring program for the marine and coastal environment. It is important to monitor the effects of development prior to, during and after project implementation. The proponent is fully committed to carry out environmental monitoring of the development and operation of the facility.

10.1 Aim of management and monitoring

The primary aim 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.

The objectives of this monitoring program are to detect and document the changes occurring to the environment and the surroundings due to the proposed project. The purpose will be to:

- Assess the magnitude of the impacts resulting from the various stages of the proposed work
- Undertake routine monitoring
- Undertake take mitigation measures to minimize the negative impacts.

10.2 Management plan

The management plan proposed for the project would comprise of a framework with four major components.

- **Policy planning and monitoring** which outlines the planning of actions and the frequency of monitoring of actions
- **Implementation and operation** which outlines the major indicators of the actions which should be monitored for maintenance of standard and quality assurance and the measures to mitigate the impacts.
- **Remedial actions** which specifies actions to address the inconsistence actions or problems identified during monitoring.
- **Auditing and reviewing** which is required to revisit the environmental management plan for better improvement of the plan as the project continues and change accordingly for quality of services.

A schematic of management plan is shown in Figure 25.

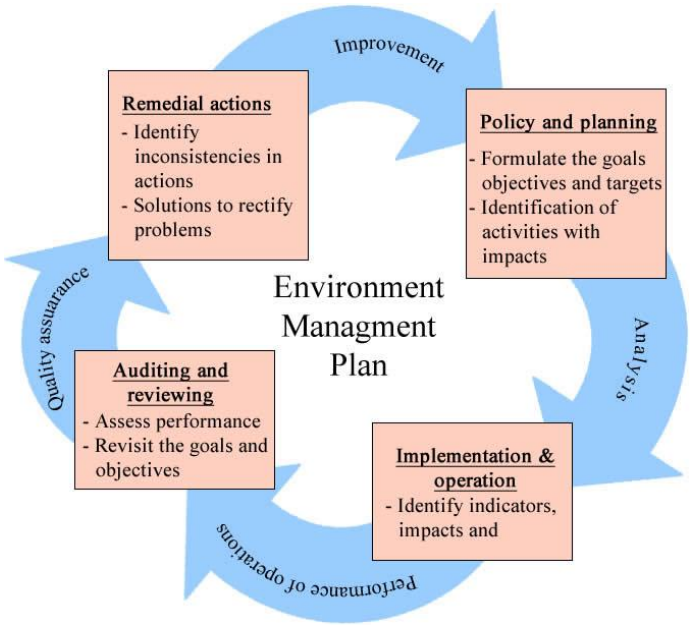

Figure 25: Schematics of the environmental management plan

10.3 Roles and responsibilities

Following key partners would be involved in the implementation of the management plan as described in the respective roles and responsibilities.

10.3.1 Proponent (Ministry of Environment and Energy/FENAKA)

Proponent would be responsible for all the project activities during the construction period of the project. The proponent has to be familiar with the rules and regulation relating to the project. In addition, the proponent will carry out the activities in the management plans and the monitoring. The necessary expertise would have to be sought to prepare the monitoring reports.

However, this function would be changed to whoever is undertaking the operation and maintenance of the facility once its complete and in operation. In this case, according to the proponent, it would be the public utility company FENAKA who will be taking over the operation of the facility. Therefore, the full implementation of the management plan during the operation would lie with FENAK.

MEE has mentioned that the necessary staff will be trained for the operations and maintenance of the system. The staff would be onboard from the time of construction and until the operations of the system. The necessary guidance materials and operations manuals will be provided to FENAKA.

10.3.2 Environmental experts

The environmental expert should do the necessary field and analysis. The expert should also compare with the baseline conditions and advice the proponent on the necessary changes. The expert would carry out environmental audits necessary for the enhancement of the management and monitoring plan.

10.3.3 Service provider

Proponent would be responsible for all the project activities during the operation period of the project. The proponent has to be familiar with the rules and regulation relating to the project. In addition, the service provider will carry out the activities in the management plans and the monitoring. The necessary expertise would have to be sought to prepare the monitoring reports.

10.4 Monitoring program

The following table outlines the major features of the monitoring program to be put in place during the construction period and during the operation period. The methods to be used in the

monitoring will be the same as the method which was used in the establishment of the baseline conditions. It also provides the frequency, the responsible partner and the estimated cost for the monitoring.

Some of the key components which should be given a special care in the monitoring program is the monitoring of the quality of the ground water and the quality of the water in the distribution tank. Special consideration should be given to the amount of water drawn from the infiltration galleries so that excess water is not drawn from the water table and to control the quality of the water. Care should also be taken on cleaning of the galleries to clean the sediment for better filtration through the galleries.

Table 21: Monitoring program

Parameters to monitor	Indicator & method	Frequency of monitoring	Responsible partner	Estimated cost (USD)
Ground water quality	pH, turbidity, conductivity, chemical tests	Once every month during construction, every six months during operation	Contractor during construction period Proponent during operation	300
Marine water quality	pH, turbidity, conductivity, chemical tests, BOD, COD,	Once every month during construction, every six months during operation	Contractor during construction period Proponent during operation	500
Water quality in the storage tanks	Conductivity, turbidity and hardness tests	Every fortnight during operations	Service provider	500
Quality and quantity of water from the galleries	Volume of water from the galleries, conductivity from the salinity meters in control wells	Salinity measured daily via logs during operations, volume measured daily when gallery used on demand	Service provider	200
Cleaning of galleries	Tied to the quality of the water from galleries	Could be carried twice a year, if not has to be based on the quality of the water from the galleries	Service provider	2000
Solid waste	Quantity and type of waste	Once every week during construction Once every six months during operation	Contractor during construction and service provider during operation	300
Terrestrial fauna	Number and type of species	Once before and after construction phase	Proponent and contractor	200
Marine water contamination	Oil spills and pollution on water	Every day during construction	Contractor during construction and Proponent during operation	100
Coral cover	Live coral coverage percentage	Once during construction and every 6 months during operations	Service provider	200
Desalinated water quality	Chemical tests, coliform tests, BOD, COD	monitoring to be done according to requirement of regulator	Service provider	300

10.5 Quality Control Measures

The same geographical locations of the sampled points which were used for different parameter during the determination of baseline environmental conditions shall be used during the monitoring periods. This will assure that any impacts of the project intervention will be identified via the proposed monitoring plan.

10.6 Monitoring Report

Based on the data collected, a mid-term monitoring report will be compiled and submitted to the relevant authorities for compliance. Following is a possible sample structure of the report.

- Introduction
- Background about the project
- Status of the baseline assessment
- Field assessment for monitoring
- Assessment methodology
- Assessment results and analysis
- Recommendations and conclusions
- Results compared to baselines status
- Recommendations for improvements

10.7 Commitment by the Proponent

The proponent is fully committed to undertaking the monitoring program outlined in this chapter (refer Appendix of this report) during construction and some of the key monitoring requirement during operation should be included in the facility handover obligations to the service provider.

11. Conclusions

This EIA report is written in accordance with the regulations and requirements to develop integrated water resource management facility at Hdh. Nolhivaranfaru. This project involves development key components of the IWRM via installation of proper rainwater harvesting techniques, infiltration gallery, desalination plant and water treatment facility. The EIA looked into the major impacts due to the proposed development. It assessed the possible impacts on the marine, terrestrial and social environment during the construction and operations stages of IWRM in the island. It also looked into the possible mitigation actions which could be undertaken to mitigate the impacts.

It was seen from the assessment that the most significant impact would be observed on the terrestrial and marine environment. This is due the major work to be carried on the terrestrial environment and construction of brine outfall for the rejected water. Excavation on the island in laying out pipes is considered as the major impact. With the mitigation actions proposed in the report, the impacts could be mitigated during the construction and operation of the resort. It is envisaged that this facility will bring some of the positive and negative social and economic benefits.

Alternative methodologies for construction methods and alternative locations for the infrastructure was considered during the design and assessment. The justifications for the chosen methodologies and locations were explained in the report. It is to be understood that all the alternative methods cannot be implemented which involves so many factors such as regulation and financial issues. However, if an alternative need to be chosen, it will be chosen wisely.

It is important that the actions in the management plan to be given a high consideration. Regular monitoring of the activities during the construction and operation of the resort be carried out to minimize the impacts and to take early action to rectify any issues. The proponent has committed that they will adhere to the mitigation measures and will implement those to minimize the impacts. Before the commencing of the installation, a thorough assessment of the water yield and hydrogeological survey of the area of the gallery to be constructed will need to be carried to see the possibility of using the technology.

The assessment showed that the positive socio-economic impact overwhelms the environmental impacts. Some of the environmental impacts would be inevitable but could be minimized with the proposed mitigations. Therefore, from a socio-economic perspective, the project is justified and it is recommended to carry on this project with the proposed mitigation measures, management plan and the monitoring plan.

Reference:

Leopold, L. B., F. E. Clarke, B. B. Hanshaw, and J. E. Balsley. 1971. A procedure for evaluating environmental impact. U.S. Geological Survey Circular 645, Washington, D.C.

DHI 1999, Physical modelling on wave disturbance and breakwater stability, Fuvahmulah Port Project. Denmark: Port Consultants.

Carpenter, C., J. Stubbs, and M. Overmars (ed.). 2002. Proceedings of the Pacific Regional Consultation on Water in Small Island Countries, Sigatoka, Fiji Islands. 29 July–3 Aug. 2002. Asian Development Bank and South Pacific Applied Geoscience Council, Suva, Fiji.

DHI 1999, Physical modelling on wave disturbance and breakwater stability, Fuvahmulah Port Project. Denmark: Port Consultants.

Falkland, A. (2001), Report on Integrated Water Resources Management and Sustainable Sanitation for 4 Islands, Maldives, Maldives Water and Sanitation Authority, Maldives

Falkand, 2000: Report on groundwater investigation, Addu Atoll Southern Development Region. Regional Development Project Phase 1. Asian Development Bank.

INSA Pvt 2016, Environment Impact Assessment on Proposed Water Production and Distribution Facility at Hoarafushi.

KENCH, P. S., BRANDER, R. W., PARNELL, K. E. & MCLEAN, R. F. 2006. Wave energy gradients across a Maldivian atoll: Implications for island geomorphology. Geomorphology, 81, 1-17.

KENCH, P. S. & BRANDER, R. W. 2006. Wave processes on coral reef flats: Implications for Geomorphology using Australian Case Studies. Journal of Coastal Research, 22, 209-223

SOPAC -Suva, FJ & UNEP International Environmental Technology Centre -Osaka/Shiga, JP, IETC, 1998. Source book of alternative technologies for freshwater augmentation in small island developing states, (Technical publication series / UNEP no. 8E) Osaka, Japan: UNEP International Environmental Technology Centre.

Sandcays 2012, Environment Impact Assessment on Adh. Mahibadhoo Integrated Water Resource Management project.

UNESCO [United Nations Education Scientific and Cultural organization] 1991. *Hydrology and Water Resources of Small Islands, A Practical Guide.* Studies and Reports on Hydrology No. 49, UNESCO, Paris.

Water Solutions 2014, Environment Impact Assessment on Dh. Bandhidhoo harbour rehalibitation project.

WWAP (United Nations World Water Assessment Programme). 2015. The United Nations World Water Development Report 2015: Water for a Sustainable World. Paris, UNESCO.

YOUNG, I. R. 1999. Seasonal variability of the global ocean wind and wave climate. International Journal of Climatology, 19, 931–950

Appendix A – Terms of Reference

بسم الله الرحمن الرحيم

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Environmental Protection Agency EPA

No: 203-EIARES/438/2017/80

Terms of Reference for Environmental Impact Assessment for Establishment of an Integrated Water System in Hdh. Nolhivaranfaru

The following is the Term s of Reference (ToR) following the scoping meeting held on ***15th June 2017*** for undertaking the EIA of the proposed integrated water resource management project at ***Hdh. Nolhivaranfaru.*** The proponent of the project is **Ministry of Environment and Energy.**

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 integrated water resource management schemes 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. Define the arrangements required for the environmental assessment including how work carried out under this project is linked and sequenced with other projects executed by other consultants, and how coordination between other consultants, contractors and government institutions will be carried out. List the donors and the institutions the consultant will be coordinating with and the methodologies used.

2. **Study area** – Submit a minimum A3 size scaled plan with indications of all the proposed infrastructures. 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 water schemes. 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):

Desalination plant and rainwater collection schemes

- Submit an A3 size plan with appropriate labels and scale;
- Describe technology for desalination (reverse osmosis, disinfection), distribution network and capacity (envisage population growth in the next 35 years);

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- Describe rain water collection scheme including sizing of storage tanks;
- Discuss water quality monitoring logistics;
- Specify materials, equipment, heavy machinery, staff estimate (quantity and period of time), key personnel positions, intermittent technical expertise required;
- Specify an emergency water supply plan if system fails;
- Project management: Include communication of construction details, progress, target dates and duration of works, construction/operation/closure of labor camps, access to site, safety, equipment and material storage, water supply, waste management from construction operations (mainly dredged materials), power and fuel supply;
- Specify an emergency water supply plan if system fails;
- Maximum ground water yield

Rainwater recharge scheme

- Submit an A3 size plan with appropriate labels and scale;
- Describe rain water recharge scheme including number size and location of recharge wells;
- Specify materials, equipment, heavy machinery, staff estimate (quantity and period of time), key personnel positions, intermittent technical expertise required;
- Project management: Include communication of construction details, progress, target dates and duration of works, construction/operation/closure of labour camps, access to site, safety, equipment and material storage, water supply, waste management from construction operations (mainly dredged materials), power and fuel supply

Brine outfall

- Justify brine outfall site selection depth and distance from shore using oceanographic and ecological information. Currents and waves ought to disperse the discharged water with minimum impacts on marine ecosystems and economic activities. The public and stakeholders should support the location of the brine outfall pipeline location;
- Describe equipment needed and construction methods for laying the offshore pipeline including handling transportation.

Water intake

- Location justification for the borehole;
- Depth of water intake including justification for the depth

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, studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirement s 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.

The baseline data will be collected before construction and from at least two benchmarks. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects and vegetation transects for posterior data comparison. information should be divided into the categories shown below:

Climate

- Rainfall data to calculate rainwater collection, and
- Risk of hurricanes and storm surges.

Geology and geomorphology at pipe location (localized maps)

- Offshore/coastal geology and geomorphology (use maps);
- Bathymetry (bottom morphology surrounding the island) (use maps);
- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction.
- Beach profile

Hydrography/hydrodynamics (localized maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Marine water quality at the brine discharge location and potential alternative location measuring these parameters: Temperature, pH, Salinity, E. Conductivity, TDS, Turbidity.
- Ground water quality with these parameter: Temperature, pH, Salinity, E. Conductivity, TDS, Turbidity

Terrestrial environment

- Type of vegetation, exact number and extent of vegetation to be cleared (if any).
- Terrestrial baseline monitoring surrounding all inland developments (See appendix 1 for monitoring guidelines). Include a description of all flora and fauna and any threatened or endangered species in the area.

Socio-economic environment

- Demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
- Economic activities of both men and women including seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities (an approved land use plan needs to be
- provided);
- Accessibility and (public) transport to other islands;
- Service quality and accessibility (water, waste/water disposal, energy, social services like health and education);
- Community needs;
- Sites with historical or cultural interest or sacred places (mosques, graveyard).

Hazard vulnerability

- Vulnerability of area to flooding and storm surge.

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
Tel: (+960) 333 5949 (+960) 333 595
Fax: (+960) 333 5953

ދާއިރާގައި ބަލައިގަތުމުގެ ކޮމިޝަން
ހަންދުވަރީ ހިންގުމުގެ، 3 ވަނަ ފަންގިފިލާ، ދަރުމަވީ ކަނޑާ
ދ. ކުޅުދުއްފުށި، 20392
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

*All water samples shall be taken at a depth of 1 m from the mean sea level or mid water depth for shallow areas. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

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. Show that the proponent has applied for all necessary permits. Specifically show how the proposed project meets the required legislative and regulatory requirements.

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, include all stages -The EIA report should identify all the impacts (direct, indirect and cumulative) and evaluate the magnitude and significance of each, both from the construction of the desalination facility and the installation of intake pipeline/borehole and brine outfall pipeline. This shall include:

Terrestrial impacts from construction

- Loss of vegetation and fauna from land clearance activities;
- Impacts on ground water quality;

Impact from installing the intake and brine outfall

- 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.
- Marine ecosystem impacts from changes in salinity at brine outfall site.

Social impacts:

- Noise impacts on local population during construction phase, if any;
- Aesthetics on-land and underwater impacts from intake and brine outfall pipelines affecting
- recreational use;
- Increased demands on natural resources and services (power supply, land availability);
- Land use displacement and economic opportunities.

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 "should be presented. 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 such as alternative location, tanks and plant capacity, intake and brine discharge arrangements, excess rain water recharge mechanisms, alternatives for disposal etc. The report should explore alternative designs for the project including the use of existing wells in the island. 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 resource s required to implement those measures should be specified. The confirmation of commitment of the Proponent/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 for brine water, product and intake water quality (See appendix for acceptable water quality ranges and suggestions on oceanographic monitoring required);
- Biological parameters such as terrestrial monitoring, coral reef and benthic monitoring, fish community census at brine outfall pipe locations to assess damages and recovery rates;
- Terrestrial monitoring in the surrounding areas of the desalination plant (see appendix to follow guidelines).
- Measures to prevent excess water uptake

Environmental monitoring reports shall be submitted to the EPA. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NCO 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. Major stakeholder consultation shall include relevant government agencies including Ministry of Environment and Energy, Ministry of Housing and infrastructure, engineers/designers, development managers, Island Council and members of the general public.

The report should include the results of willingness to pay survey and a statement from the Atoll Council indicating that they have received a copy of the final draft report. The report should include chronological evidence of consultation including contact details of those consulted and photographic evidence of consultation.

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
Tel: [+960] 333 5949 [+960] 333 5951
Fax: [+960] 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

بسم الله الرحمن الرحيم

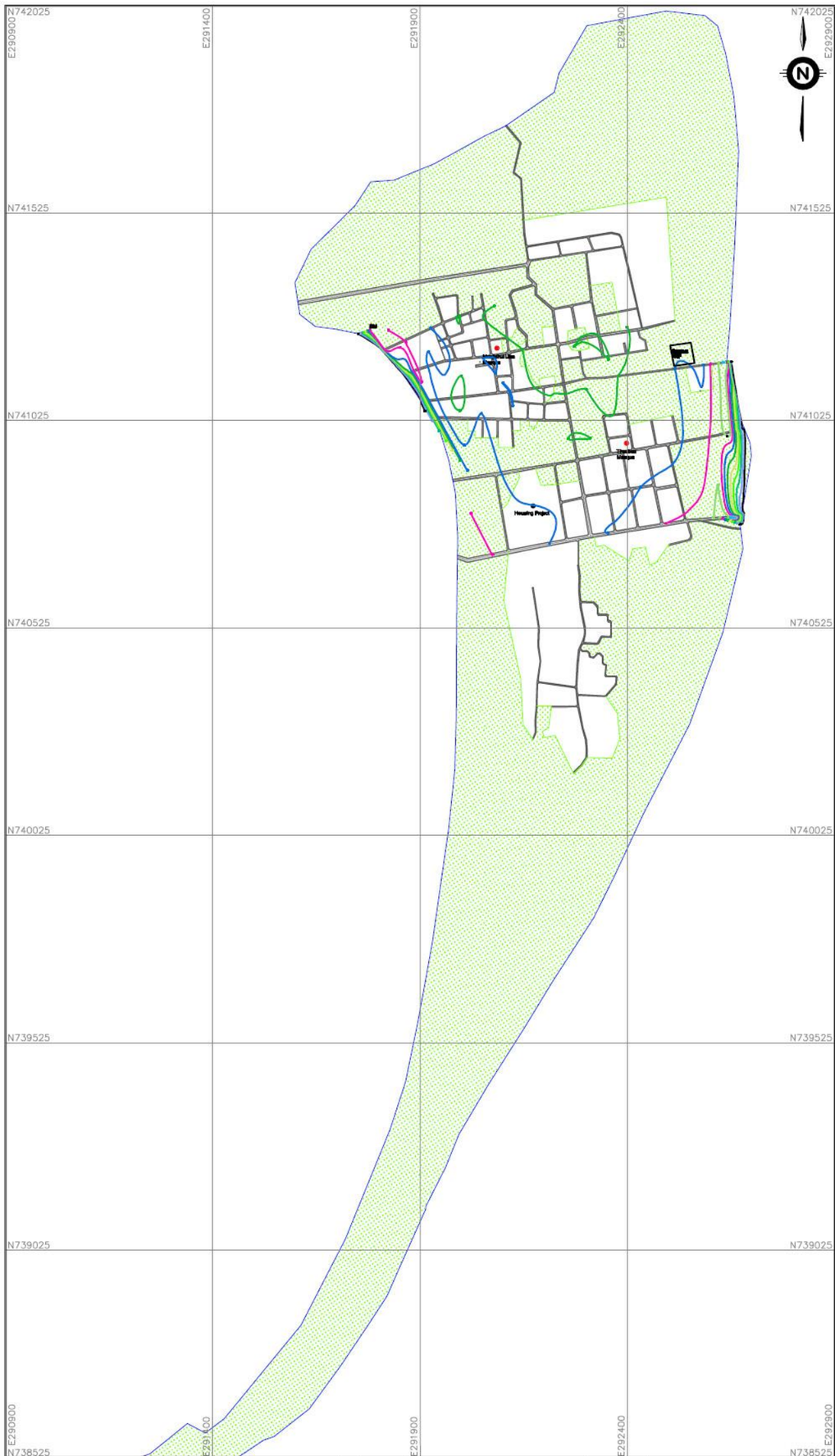
Presentation- *The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations of or any references 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 3 months from the date of this Term of Reference.*

Date: 18th June 2017

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
Tel: [+960] 333 5949 [+960] 333 5951
Fax: [+960] 333 5953
ދާއިރާތަކުގެ ރައްކާތެރިކަން ބަލަހައްޓާ ބަދަލު
ފ. ހަންވަރު ހިންގުން، 3 ވަނަ ފަންގިފިލާ، ކ.ދާދަ
ދާދ، 20392
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

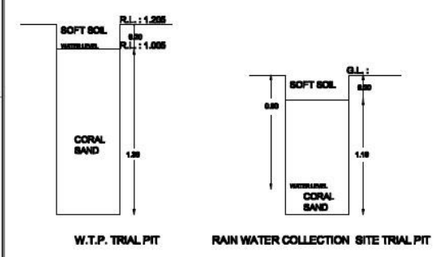
Appendix B – Technical Layout Drawings



NOTE:

GEOGRAPHICAL ATOLL - SOUTH THILADHUNMATHI ATOLL
ADMINISTRATIVE ATOLL - HAA DHAALU ATOLL

Name of Island	Area (ha)	Dimensions (km)	
		Length	Width
Hdh. Nolhivaranfaru	172.00	3.800	0.800
Road Length (Approximately) = 12.10 km			



W.T.P. TRIAL PIT — RAIN WATER COLLECTION SITE TRIAL PIT

NOTE:

ALL LEVELS ARE BASED ON THE BM AT SEA SHORE RL +1.480

NOTES:

1. ALL COORDINATES ARE BASED ON WGS 84 DATUM, UTM SYSTEM.
2. UTM ZONE - 43 N

No.	DATE	DESCRIPTION	DRG. No.	DESCRIPTION

REVISION — REFERENCE DRAWINGS

CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY
MALE' REPUBLIC OF MALDIVES

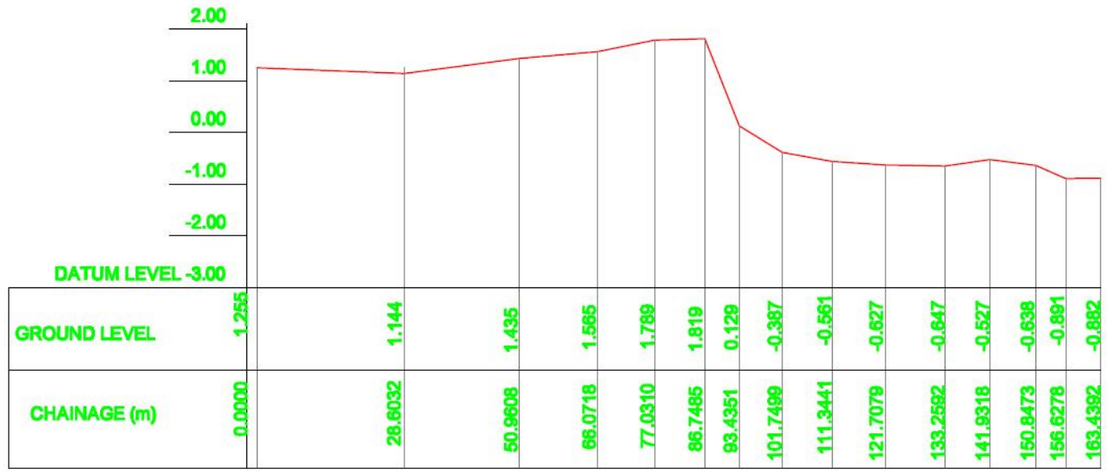
PROJECT: CONSULTANCY SERVICES FOR DESIGN AND SUPERVISION OF WATER SUPPLY FACILITIES IN THE ISLAND HDH. NOLHIVARANFARU, MALDIVES

TITLE: MAP SHOWING PROJECT AREA ISLAND
TOPOGRAPHICAL SURVEY - NOLHIVARANFARU

STC SHAH TECHNICAL CONSULTANTS PVT. LTD., INDIA
In Association With
DEVELOPMENT TECHNOLOGIES MALDIVES, MALDIVES

APPROVED	CHECKED	DESIGNED	DRAWN
SSS	SSS		SSN

SCALE	DATE	DRAWING No.	REVISION
1:5,000	JANUARY 2017	FIGURE 01	0



NOTES:

No.	DATE	DESCRIPTION	DRG. No.	DESCRIPTION

REVISION | REFERENCE DRAWINGS

GRAPHIC SCALE :

CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY
MALE' REPUBLIC OF MALDIVES

PROJECT: CONSULTANCY SERVICES FOR SURVEY, DESIGN OF SEWERAGE FACILITIES IN THE ISLAND NAAVAIDHOO, MALDIVES

TITLE: L-SECTION OF OUTFALL ALIGNMENT
NOLHIVARANFARU ISLAND

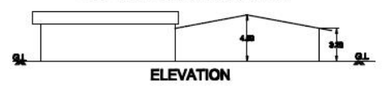
STC SHAH TECHNICAL CONSULTANTS PVT. LTD., INDIA
In Association With
DEVELOPMENT TECHNOLOGIES MALDIVES, MALDIVES

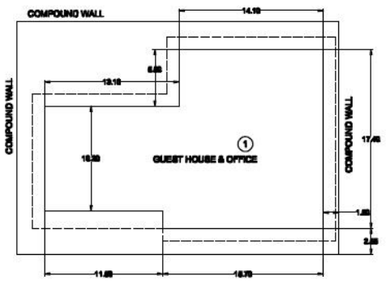
APPROVED	CHECKED	DESIGNED	DRAWN
SSS	SSS	SPP	SSN

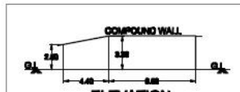
SCALE	DATE	DRAWING No.	REVISION
NTS	JAN 2017	FIGURE 02	0

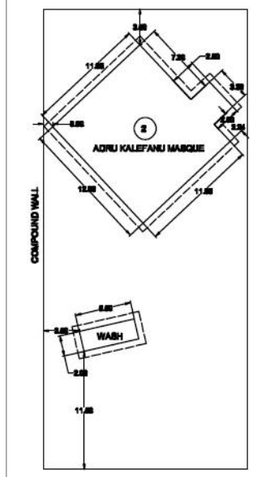
A1--LANDSCAPE

GUEST HOUSE & OFFICE

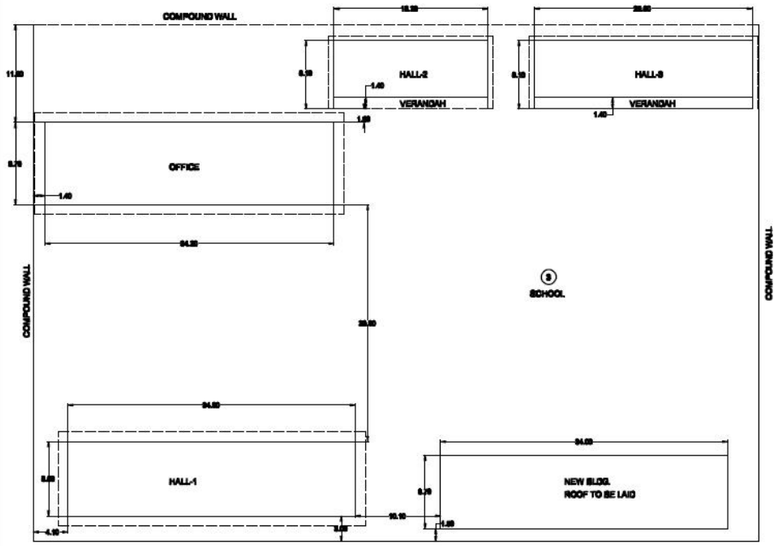




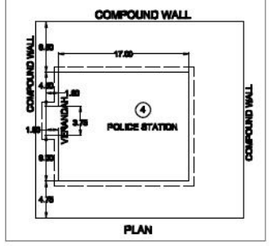




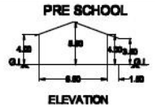
SCHOOL

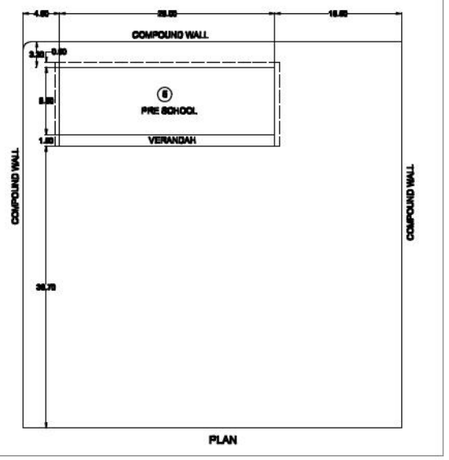


POLICE STATION

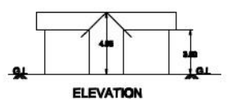


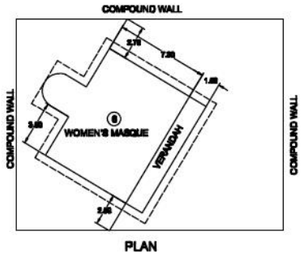
PRE SCHOOL



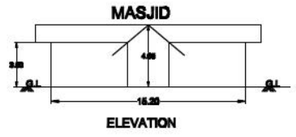


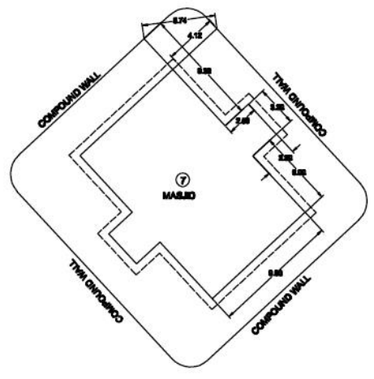
WOMEN'S MASQUE





MASJID





NOTES:

No.	DATE	DESCRIPTION	DRG. No.	DESCRIPTION

REVISION | REFERENCE DRAWINGS

GRAPHIC SCALE :

CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY
MALE' REPUBLIC OF MALDIVES

PROJECT: CONSULTANCY SERVICES FOR SURVEY, DESIGN OF WATER SUPPLY FACILITIES IN THE ISLAND HAA. KELAA, MALDIVES

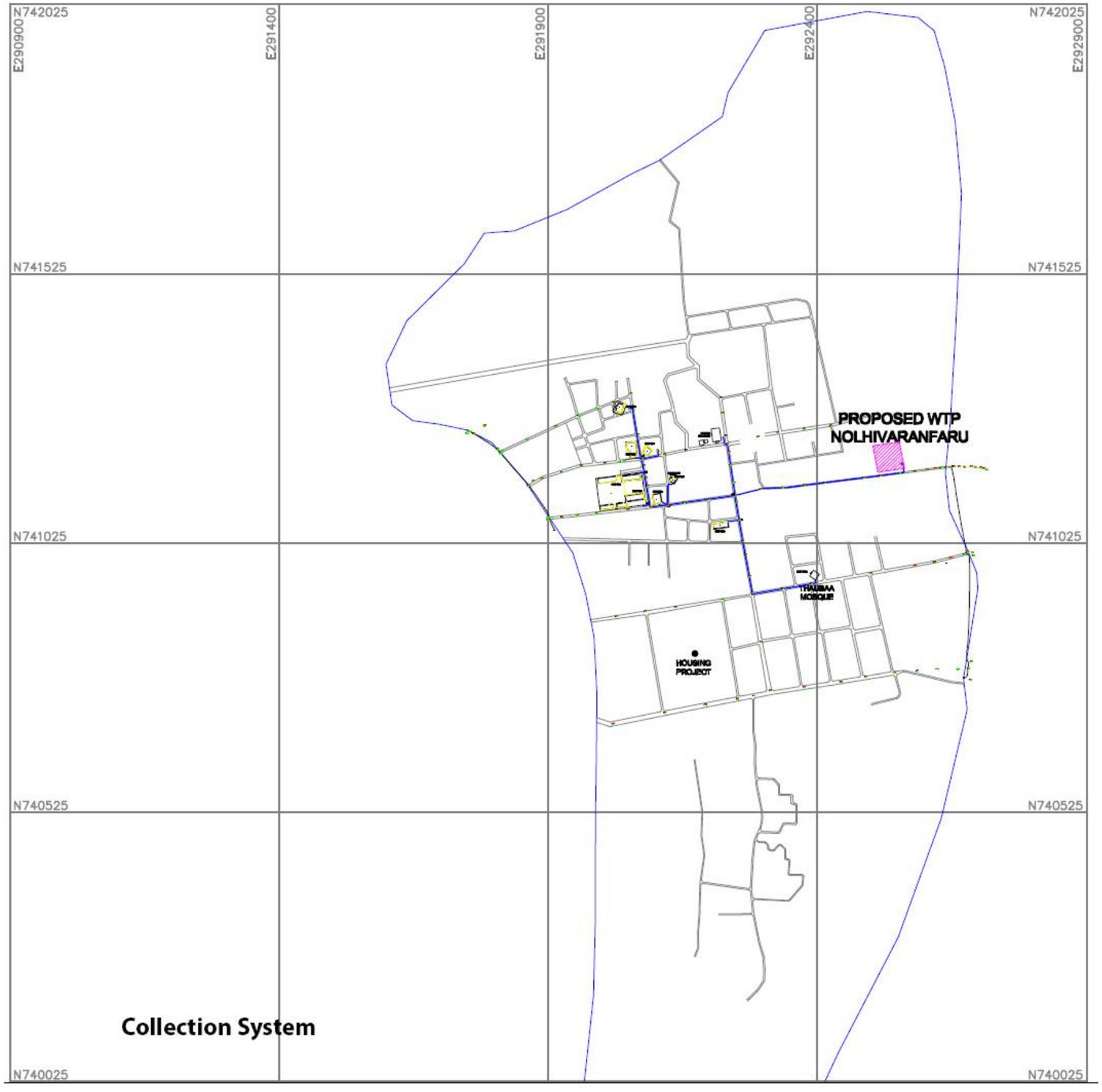
TITLE: PLAN & CROSS SECTIONAL DETAILS OF EXISTING COMMUNITY CENTERS NOLHIVARANFARU ISLAND

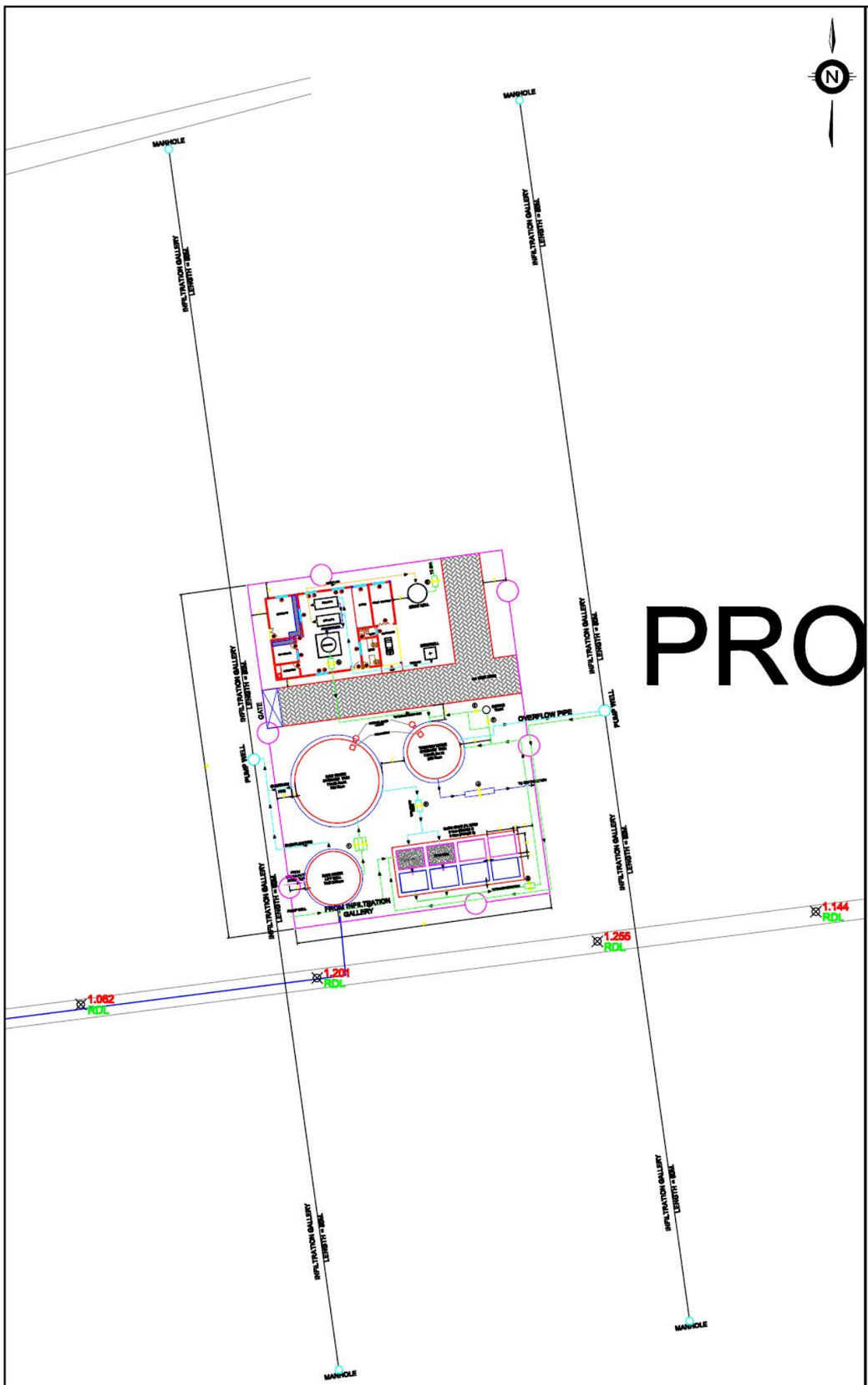
SHAH TECHNICAL CONSULTANTS PVT. LTD., INDIA
In Association With
DEVELOPMENT TECHNOLOGIES MALDIVES, MALDIVES

APPROVED	CHECKED	DESIGNED	DRAWN
SSS	SSS	—	SSN

SCALE	DATE	DRAWING No.	REVISION
NTS	JANUARY 2017	FIGURE 03	0

A1--LANDSCAPE


N742025
E290900
E291400
E291900
E292400
N742025
E292900
N741525
N741525
N741025
N741025
PROPOSED WTP
NOLHIVARANFARU
THAUBAA
MOSQUE
HOUSING
PROJECT
N740525
N740525
Collection System
N740025
N740025



NOTE:

GEOGRAPHICAL ATOLL - SOUTH THILADHUNMATHI ATOLL
ADMINISTRATIVE ATOLL - HAA DHAALU ATOLL

Name of Island	Area (ha)	Dimensions (km)	
		Length	Width
Hdh. Nolhivaranfaru	172.00	3.600	0.900
Road Length (Approximately) = 12.10 km			

Facility Layout

NOTES:
1. ALL COORDINATES ARE BASED ON WGS 84 DATUM, UTM SYSTEM.
2. UTM ZONE - 43 N

No.	DATE	DESCRIPTION	DRG. No.	DESCRIPTION

REVISION | REFERENCE DRAWINGS

CLIENT: MINISTRY OF ENVIRONMENT AND ENERGY
MALE' REPUBLIC OF MALDIVES

PROJECT: CONSULTANCY SERVICES FOR DESIGN AND SUPERVISION OF WATER SUPPLY FACILITIES IN THE ISLAND HDH. NOLHIVARANFARU, MALDIVES

TITLE: FIGURE 5.7: MAP SHOWING LOCATION OF INFILTRATION GALLERIES

STC SHAH TECHNICAL CONSULTANTS PVT. LTD., INDIA
In Association With
DTM DEVELOPMENT TECHNOLOGIES MALDIVES, MALDIVES

APPROVED	CHECKED	DESIGNED	DRAWN
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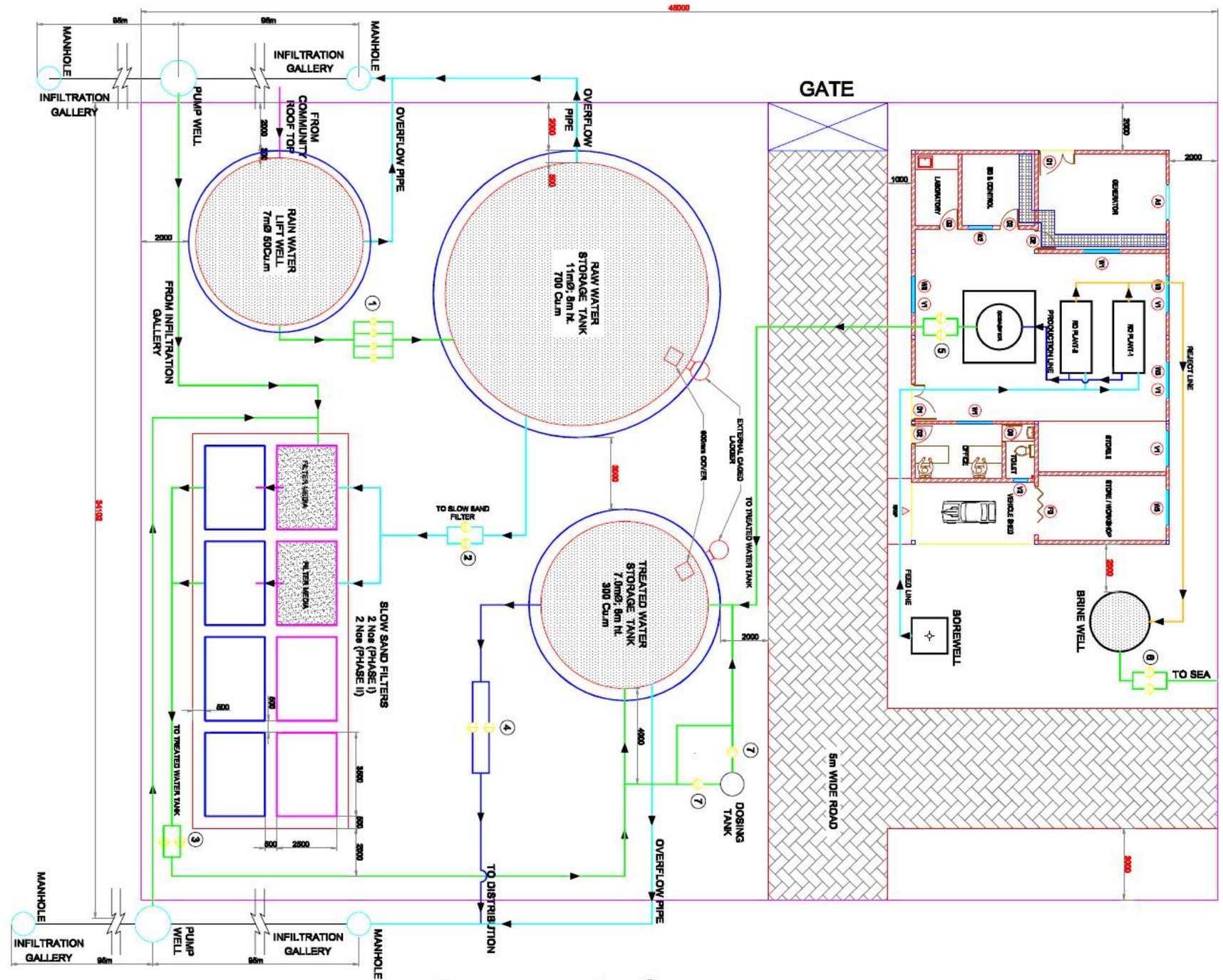
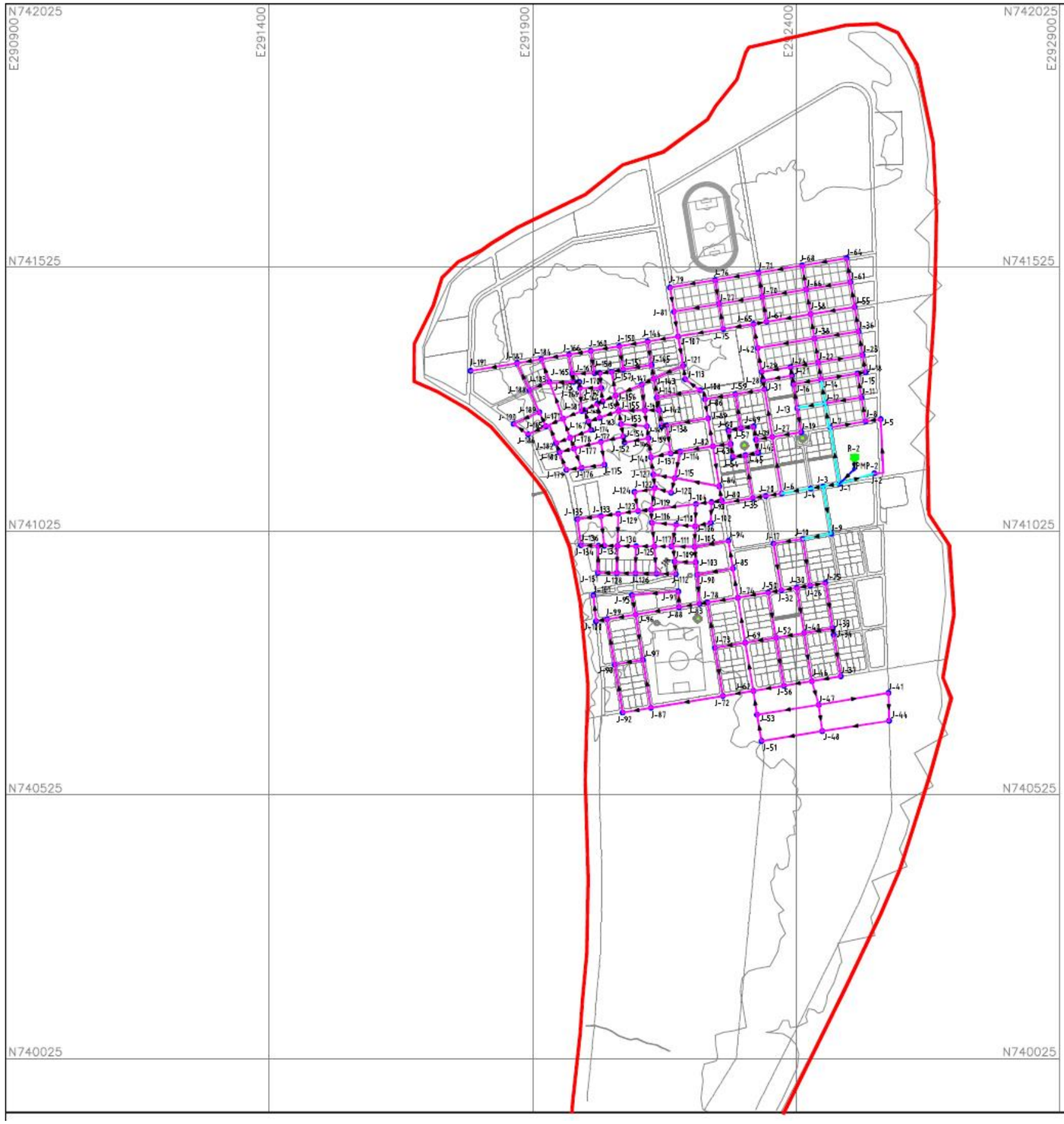
SCALE	DATE	DRAWING No.	REVISION
1:5,000	APRIL 2017		0



Treatment Facility



Pipe network layout

LEGENDS

WATER TREATMENT PLANT	
RESERVOIR	
WATER PUMPING STATION	
WATER PIPE LINE	
JUNCTION	
SLUICE VALVE	
SCOUR VALVE	

HDPE PIPE DIA (mm)	PIPE COLOUR
56_7	
99_3	
112_8	

NOTES :-

- WATER DISTRIBUTION NETWORK IS DESIGNED AS GRAVITY SYSTEM WITH RATE OF WATER SUPPLY SYSTEM AS 20 LPCD

Appendix C – Water Quality Reports

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangolhi, Ameenee Magu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

MWSC

WATER QUALITY TEST REPORT
Report No: 500172341

Report date: **28/03/2017**
Test Requisition Form No: **900173253**
Sample(s) Recieved Date: **22/03/2017**
Date of Analysis: **22/03/2017 - 23/03/2017**

Customer Information:
Development Advsory Services Pvt Lt
G.Heyfi
4G06 Lonuziyaaraiy Magu
Male' MALE'

Sample Description	Nolhivaranfaru Mosque GW	Nolhivaranfaru Onsite GW		
Sample Type	Ground Water	Ground Water		
Sample No	8318410	8318411		
Sampled Date	20/03/2017	20/03/2017		
PARAMETER	**ANALYSIS RESULT**		**TEST METHOD**	**UNIT**
Physical Appearance	Clear with particles	Pale yellow with particles		
Conductivity	733	4720	Method 2510 B. (adapted from Standard methods for the examinitation of water and waste water, 21st edition)	µS/cm
pH	7.57	7.38	Method 4500-H+ B. (adapted from Standard methods for the examinitation of water and waste water, 21st edition)	-
Salinity	0.36	2.52	Method 2520 B. (adapted from Standard methods for the examinitation of water and waste water, 21st edition)	‰
Temperature	20.9	20.9	Electrometry	°C
Total Dissolved Solids	367	2360	Electrometry	mg/L
Hardness, Calcium	51	390	HACH Method 8204	mg/L
Hardness, Total	59	735	HACH Method 8213	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter

Checked by

Nashath Ali
Senior Laboratory Technician

Approved by

Mohamed Eyman
Assistant Manager, Quality

Notes: Sampling Authority: Sampling was not done by MWSC Laboratory
This report shall not be reproduced except in full, without written approval of MWSC
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer

********** END OF REPORT **********

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameenee Magu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT

Report No: 500172342

Customer Information:
Development Advsory Services Pvt Lt
G.Heyli
4G06 Lonuziyaaraiy Magu
Male' MALE'

Report date: **28/03/2017**
Test Requisition Form No: **900173253**
Sample(s) Recieved Date: **22/03/2017**
Date of Analysis: **22/03/2017 - 26/03/2017**

Sample Description	Nolhivaranfaru SW Sample	**TEST METHOD**	**UNIT**
Sample Type	Sea Water		
Sample No	83183412		
Sampled Date	20/03/2017		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Conductivity	51000	Method 2510 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	µS/cm
pH	6.63	Method 4500-H+ B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	-
Salinity	33.41	Method 2520 B. (adapted from Standard methods for the examintation of water and waste water, 21st edition)	‰
Temperature	20.9	Electrometry	°C
Total Dissolved Solids	25500	Electrometry	mg/L
Total Suspended Solids	<5 (LoQ 5 mg/L)	Method 8006 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Turbidity	0.553	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Total Alkalinity	108	HACH Method 8203	mg/L

Keys: µS/cm : Micro Seimen per Centimeter, **‰** : Parts Per Thousand, **°C** : Degree Celcius, **mg/L** : Milligram Per Liter, **NTU** : Nephelometric Turbidity Unit

Checked by

Nashath Ali
Senior Laboratory Technician

Approved by

Mohamed Eyman
Assistant Manager, Quality

Notes: Sampling Authority: Sampling was not done by MWSC Laboratory
This report shall not be reproduced except in full, without written approval of MWSC
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer

********** END OF REPORT **********

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
FEN Building 5th Floor, Machangoalhi, Ameenee Magu, Male', Maldives
Tel: +9603323209, Fax: +9603324306, Email: wqa@mwsc.com.mv

WATER QUALITY TEST REPORT

Report No: 500172343

Customer Information:
Development Advsory Services Pvt Lt
G.Heyli
4G06 Lonuziyaaraiy Magu
Male' MALE'

Report date: **28/03/2017**
Test Requisition Form No: **900173253**
Sample(s) Recieved Date: **22/03/2017**
Date of Analysis: **22/03/2017 - 22/03/2017**

Sample Description	Nolhivaranfaru East-side SW Sample 01	**TEST METHOD**	**UNIT**
Sample Type	Sea Water		
Sample No	83183413		
Sampled Date	20/03/2017		
PARAMETER	**ANALYSIS RESULT**		
Physical Appearance	Clear with particles		
Dissolved Oxygen (DO)	6.16	Standard Methods 19th edition APHA	mg/L

Keys: mg/L : Milligram Per Liter

Checked by

Nashath Ali
Senior Laboratory Technician

Approved by

Mohamed Eyman
Assistant Manager, Quality

Notes: Sampling Authority: Sampling was not done by MWSC Laboratory
This report shall not be reproduced except in full, without written approval of MWSC
This test report is ONLY FOR THE SAMPLES TESTED.
~ Information provided by the customer

********** END OF REPORT **********

Appendix D – Letter of Commitment

Commitment letter

20th August 2017

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Ameenee Magu
Malé

Dear Sir,

EIA for the Proposed Water Supply System in Hdh.Nolhivaranfaru

This is in reference to the Environmental Impact Assessment (EIA) report for the Proposed Water Supply System in Hdh.Nolhivaranfaru.

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

Sincerely,

Ajwad Musthafa
Permanent Secretary

Appendix E – Approval letters

بسم الله الرحمن الرحيم

Ministry of Environment and Energy
Male', Republic of Maldives.

ފަރިތަކަމާއި ދާދި ތަރައްގީގެ ތަޅުދަނޑި
ދާދި، ދިވެހިރާއްޖެ.

Date: 25th April 2017

No: 438-WS/PRIV/2017/374

Gautam M. Shah
Managing Director
Shah Technical Consultants Private Limited
407, Raheja Centre, Plot No.214, Nariman Point
Mumbai-400 021, India

Dear Mr.Gautam

Project: Design and Supervision of Water Supply System in Hdh.Nolhivaranfaru, Sh.Foakaidhoo, B.Dharavandhoo and R.Maduvvaree.

Sub: Land Location Approval

With reference to the land location maps received for approval via email on 13th and 21st of February 2017.

We would like to inform you that the Ministry has approved the proposed location of Water Supply System in R.Maduvvaree, Sh.Foakaidhoo, Hdh.Nolhivaranfaru and B.Dharavandhoo in coordination with the Council. As such, herewith find attached the letter of approval from the respective councils conveying their approval for the identified locations in use of Water Supply System.

In this regard we kindly request you to submit the concept design for approval and simultaneously proceed with the detailed design preparations and Environment Impact Assessment (EIA) Works in accordance to EPA guidelines and regulations

Thank you for your cooperation.

Yours sincerely,

Afsal Hussain
Assistant Director

Green Building, Handhuvaree Hingun,
Maafannu, Male', 20392, Republic of Maldives.
+(960) 301 8300
+(960) 301 8301
www.environment.gov.mv
secretariat@environment.gov.mv
www.twitter.com/ENVgovMV
www.facebook.com/environment.gov.mv

بسم الله الرحمن الرحيم

Ministry of Environment and Energy
Male', Republic of Maldives.

ފަރުގަސްދާއި ތާވަލާއި ތަރައްގީގެ ވަޒާރާ
ދިވެހިރާއްޖެ.

Date: 27th April 2017

No: 438-WS/PRIV/2017/374

Gautam M. Shah
Managing Director
Shah Technical Consultants Private Limited
407, Raheja Centre, Plot No.214, Nariman Point
Mumbai-400 021, India

Dear Mr.Gautam

Project: Design and Supervision of Water Supply System in Hdh.Nolhivaranfaru, Sh.Foakaidhoo, B.Dharavandhoo and R.Maduvvaree.

Sub: Concept Design Approval

This is in reference to the revised concept design submitted by you on 05th April 2017 and the meeting held on 25th of April 2017 with regard to the Concept Design of 04 islands water network.

We conditionally give approval to the proposed Concept Design and move ahead with EIA and Detailed Design noting that the following matters should be considered in finalizing the Detailed Design.

1. Capital investment for including groundwater infiltration galleries within the system
2. System should be designed to incorporate buffer zones for areas with infiltration galleries
3. Risk mitigation measures should be proposed to the issues that might further contaminate the groundwater
4. Should have a proper mechanism to monitor groundwater quality

In this regard we kindly request you to complete and report Environmental Impact Assessment (EIA) and Detailed Design works in accordance to EPA guidelines and regulations.

Thank you for your cooperation.

Yours Sincerely,

Shaheeda Adam Ibrahim

Director General

Green Building, Handhuvaree Hingun,
Maafannu, Male', 20392, Republic of Maldives.
+(960) 301 8300
+(960) 301 8301
www.environment.gov.mv

ފަރުގަސްދާއި ތާވަލާއި ތަރައްގީގެ ވަޒާރާ،
ދާރުލްއަރާ، ދިވެހިރާއްޖެ، 20392
secretariat@environment.gov.mv
www.twitter.com/ENVgovMV
www.facebook.com/environment.gov.mv

بسم الله الرحمن الرحيم

[illegible]

މިލަދުންމަޑުލު ދެކުނުބުރީ ނޮޅިވަރަންފަރު ކައުންސިލްގެ އިދާރާ
ނޮޅިވަރަންފަރު،
ދިވެހިރާއްޖެ.

ފެކްސް މެސެޖް

ފޮނުވީ: މިލަދުންމަޑުލު ދެކުނުބުރީ ނޮޅިވަރަންފަރު ކައުންސިލްގެ އިދާރާ	ނަންބަރު: (MSG)262/438/2017/2
ލިބެނީ: މިނިސްޓްރީ އޮފް އެންވަޔަރަންމަންޓް އެންޑް އެނަރޖީ	ތާރީޚް: 20 އޭޕްރީލް 2017
ކޮޕީ:	ސަފުހާ:

އިޝާރާތް

ހދ.ނޮޅިވަރަންފަރުގައި ފެންގަނޑެއް ގާއިމްކުރުމަށް ބޭނުންވާ 150' x 150' ފޫޓުގެ
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އަޙްމަދު ރިޔާޝް
ނޮޅިވަރަންފަރު ކައުންސިލްގެ ރައީސް

ފޯން: 6520045 ފެކްސް: 6520045 އީމެއިލް : Nolhivaranfar262council@gmail·com

ތިލަދުންމަތީ ދެކުނުބުރީ ނޮޅިވަރަންފަރު ކައުންސިލް އިދާރާ
ހދ.ނޮޅިވަރަންފަރު ، ދިވެހިރާއްޖެ

Secretariat of the Nolhivaranfaru
Council ,
South Thiladhunmathi
Hdh.Nolhivaranfaru, Rep. of Maldives

ނަންބަރު: CB-/2017/02

ކައުންސިލް ޖަލްސާގެ ނިންމުން

(ނޮޅިވަރަންފަރު ކައުންސިލްގެ ދެވަނަ ދައުރުގެ 88 ވަނަ ޢާއްމު ބައްދަލުވުން)

- އެޖެންޑާ ކުރުމަށް ހުށަހެޅުއްވި ފަރާތް: ރިޔާސަތުން ހުށަހަޅުއްވާ
- އެޖެންޑާ 2.1 ނަންބަރަށްވާ މައުޟޫ: ހދ.ނޮޅިވަރަންފަރުގައި ފެނުގެ ނިޒާމު ޤާއިމުކުރުމަށް ބޭނުންވާ 150*150 ފޫޓުގެ ބިމެއް އިންޖީނުގެ އޮފީހަށް ކަނޑައެޅުމާއިމެދު ގޮތެއް ނިންމުން.
- ފާސްކުރެވުނު ގޮތް: ހދ.ނޮޅިވަރަންފަރުގައި ފެނުގެ ނިޒާމު ޤާއިމުކުރުމަށް ބޭނުންވާ 150*150 ފޫޓުގެ ބިމެއް އިންޖީނުގެ އޮފީހަށް ކަނޑައެޅުން.
- ފާސްކުރުމަށް ހުށަހެޅުއްވި ފަރާތް: ރިޔާސަތުން.
- ފާސްކުރުމަށް ހުށަހެޅުމަށް ތާއީދުކުރެއްވި ފަރާތްތައް: ކައުންސިލްގެ ނައިބުރައީސް މުޙައްމަދު ޙަސަން ، ކައުންސިލް މެމްބަރު އަދުރަހް ޖައުފަރު ، ކައުންސިލް މެމްބަރު ޙަސަން ތައުފީޤު.
- މެމްބަރުން ވޯޓު ދެއްވިގޮތް:

#	ނަން	މަޤާމު	ވޯޓު ދެއްވިގޮތް			ސޮއި
			ފެންނަ	ނުފެންނަ	ވަކިގޮތަކަށް	
1	މުޙައްމަދު ޙަސަން	ނައިބުރައީސް	✓	-	-	[signature]
2	އަދުރަހް ޖައުފަރު	މެމްބަރު	✓	-	-	[signature]
	ޙަސަން ތައުފީޤު	މެމްބަރު	✓	-	-	[signature]

މަތީގައި ބަޔާންކުރެވިފައިވާ ހުށަހެޅުން ، މެމްބަރުން ވޯޓު ދިނުމާއި ގޮތުގެމަތިން 12 އޮގަސްޓު 2017 ވީ ބުދަ ދުވަހު ހދ.ނޮޅިވަރަންފަރު ކައުންސިލް އިދާރާގައި ބޭއްވުނު ހދ.ނޮޅިވަރަންފަރު ކައުންސިލްގެ ދެވަނަ ދައުރުގެ 88 ވަނަ ޢާއްމު ބައްދަލުވުމުގައި ފާސްވެފައެވެ.

ދިވެހިރާއްޖެ ގޮތުގައިވާ ފަދަ ދާއިރާ:

5	ފުރަތަމަ ދަށަށްވުރެ
4	ދެ ސަތޭކަށްވުރެ ދަށަށް
3	ގޮތުގައި ބަދަލުތަކާ ދަށަށް
3	ފާސްކަނޑަށް ގޮތުގައިވާ ދަށަށް
-	ދުވާސްކަނޑަށް ގޮތުގައިވާ ދަށަށް
-	ވަކިވާގަނޑަށް ގޮތުގައިވާ ދަށަށް
3	ފާސްކުރުމަށް ބޭނުންވާ ގޮތަށް

ބަންދަރު ކިޔާނީ

ހިއްޕެވާ ކަންކަމުގެ ކޮމިޝަނަރ

2017 ފެބްރުވަރީ 16

Gmail

Ali Shareef <shareef.ali@gmail.com>

EIA report for council approval for water system installation

hdhnolhivaranfaru councilidharaa <nolhivaranfaru262council@gmail.com> Tue, Aug 22, 2017 at 12:17 PM
To: Ali Shareef <shareef.ali@gmail.com>

salam. dear ali, we have recieved Complied EIA report.

On Wed, Aug 2, 2017 at 9:48 PM, Ali Shareef <shareef.ali@gmail.com> wrote:

> Dear Secretariat,
>
> Please ignore the previous email as it had some mistakes and please find the rectified one. Please let me know if there are any issues to be addressed. If not please provide a letter that the council has recieved the report.
>
> Ali
>
> On Wed, Aug 2, 2017 at 4:32 AM, Ali Shareef <shareef.ali@gmail.com> wrote:
>
> > Dear Secretariat,
> >
> > Attached please find the EIA report which is ready to be submitted to EPA for final approval. Before this, I would need to get a letter from the Council mentioning that the Council and received this report.
> > I would appreciate if such a letter could be provided by the council after checking the EIA.
> >
> > Regards
> > Ali
> >
> > --
> > **"There are no unanswered prayers although sometimes the answer is NO"**
>
> --
> **"There are no unanswered prayers although sometimes the answer is NO"**

Appendix F - Work Schedule

Activity	Description	June	July	Aug	Sept	date of completion
1	EIA Scoping					1/7/2017
2	Consultation / Research & data collection					30/7/2017
3	Report Writing and Presentation					15/08/2017
4	EIA Approval					30/8/2017
5	Final Submission of Reports & Tender Documents					10/9/2017

SUMMARY FINDINGS OF THE WILLINGSNESS TO PAY SURVEY

H.DH. NOLHIVARANFARU, SH. FOAKAIDHOO, R. MADUVVAREE, B. DHARAVANDHOO

Target population

	H.Dh. Nolhivaranfaru	Sh. Foakaidhoo	R. Maduvvaree	B. Dharavandhoo
Total population	4698	2592	2826	2292
Total household (estimated)	587	324	353	286
Total sample taken	63	58	18	39

Instrumentation

A well-structured questionnaire was used to collect the data in this study. The questionnaire was developed based on research objectives and includes two main parts: household information, household water usage, condition of groundwater, water cleaning process in households, water storage information, water collection information, water storage issues, and affordability and willingness to pay. Household information includes socio-demographic and socio-economic characteristics of the study.

Data collection procedure and training

The research was conducted on December 17 in Foakaidhoo, December 18 in Nolhivaranfaru, December 19 in Maduvvaree and December 20 and 21 in Dharavandhoo with the help of three to four trained interviewers from each island. Volunteers were selected and trained in the standard survey methodology and data collection. The main purpose of the training was to inform the trainers about the procedure for approaching the households and to familiarize with the contents of the questionnaire. Face-to-face interviews were conducted to collect data for the research.

Focus group discussion

To obtain more information about the opinion and views focus group discussion were conducted with collaborate of island council in four islands. Focus group discussions were conducted because it is a standard method in the social sciences; in rural development they are also often applied for identifying development needs, project planning, or evaluating project impacts. Focus group represents cover all of the islands main groups like island council, NGOs, schools, women, students, construction and other private and public institutions. The objective of the focused group discussion is to share experiences and opinions on a topic, to identify and discuss potential measures for improving the situation and to monitor and evaluate the impact of development activities through the eyes of specific interest groups.

Ethical consideration

Before collecting the data, an informed consent was sought individually from all participants of the survey. Participants were assured that the information obtained through the survey will be maintained confidential and would be used for research purpose only and that they are capable to stop the survey or leave any question they don’t get comfortable to answer.

Data Analysis

The data was entered into Microsoft excel 2013 and categorized into groups. The data was analyzed using SPSS software version 20. All data was assessed for descriptive statistics and cross tabulations to check interdependency of the variables.

Findings

Sh. Foakaidhoo

Most of the participants were females (55%) and males (45%) but there is not much difference between them, like the other islands. Most of the participants who were interviewed were owners of the household 49%, 28% were owner's wife and 18% were owner's daughter.

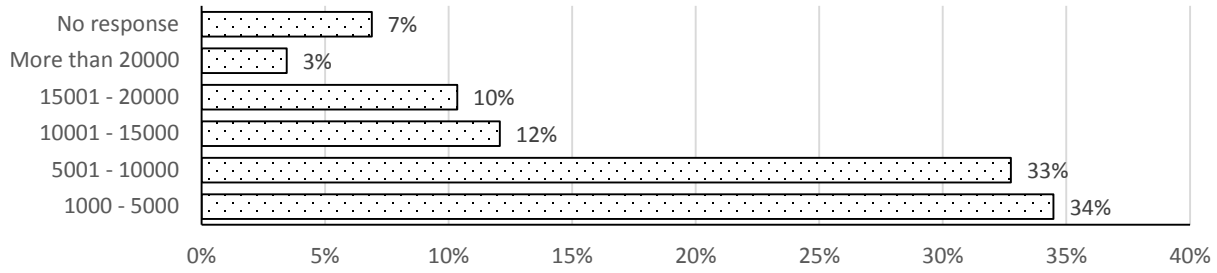

Figure 1: Household income per month for Sh.Foakaidhoo

The Figure 1 above shows income per household per month. About 34% of household said they get an income less than 5000 MVR per month, 33% of households gets an income between 5001 – 10000 MVR per month, and only 3% of households gets an income higher than 20000 MVR per month.

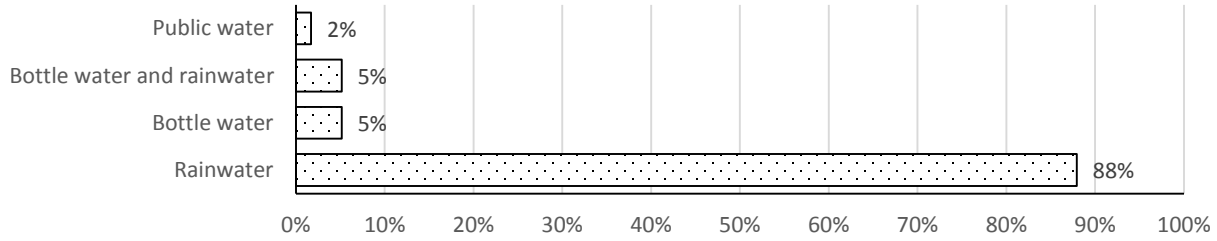

Figure 2: Source of drinking water for households in Sh.Foakaidhoo

The Figure 2 above shows that 88% of households use rainwater as their source of drinking, and 2% of households use public water. The remaining 10% uses a combination of rainwater and bottle water for drinking.

The Figure 3 shows the number of households who are willing to use and pay for the service, 86% of households said they are willing to pay for the service, 9% of households said that they are not willing to use the service and 5% of households didn't give any answer. The Figure 4 above shows the percentage of how much they are willing to pay for a month per household, 34% of households are willing to pay 50 – 100 MVR per month, 17% of households are willing to pay 150 – 200 MVR per month and 10% of households are willing to pay more than 500 MVR per month.

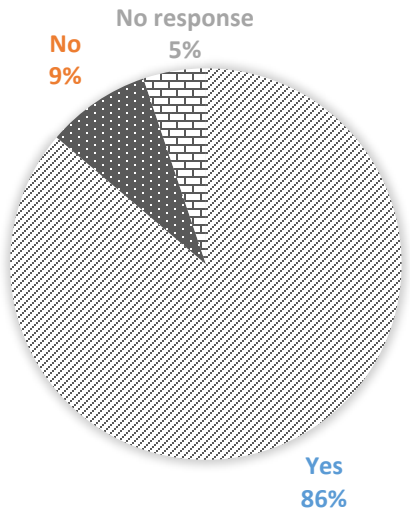

Figure 3: Willingness to pay for the IWRM system in Sh.Foakaidhoo

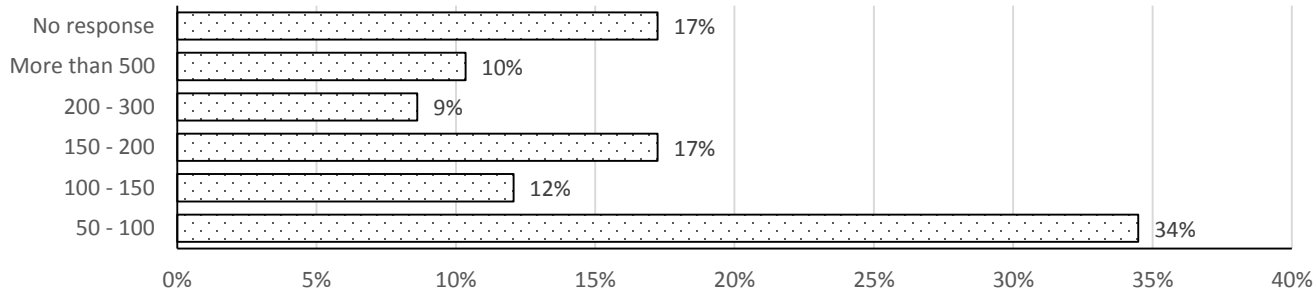

Figure 4: Amount Sh.Fokaidhoo household willing to pay for the services of IWRM

H.Dh. Nolhivaranfaru

Most of the participants who were interviewed were females (79%), only (21%) were males, this might be because most of the males might be working out of the island or they might not be present during the house visits. Among the interviewees 44% were household owners, 27% were house owner's daughters and 24% were owner's wife.

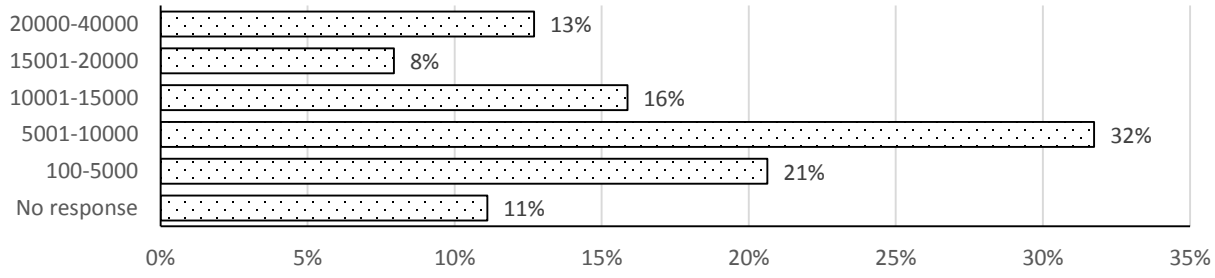

Figure 5:Household income per month for HDh.Nolhivaranfaru

Figure 5 above shows income per household per month. About 21% of household said they get an income less than 5000 MVR per month, 32% of households gets an income between 5001 to 10000 MVR per month, 13% of households gets an income higher than 20000 MVR per month and 11% of households did not respond for the question. Only 2 types of waters are used for drinking purposes, 94% of households use rainwater as their source of drinking and 6% of households use rainwater and bottle water.

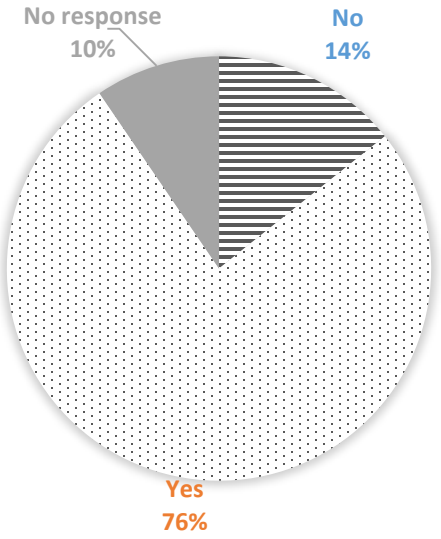

Figure 6:Willingness to pay for the IWRM system in HDh.Nolhivaranfaru

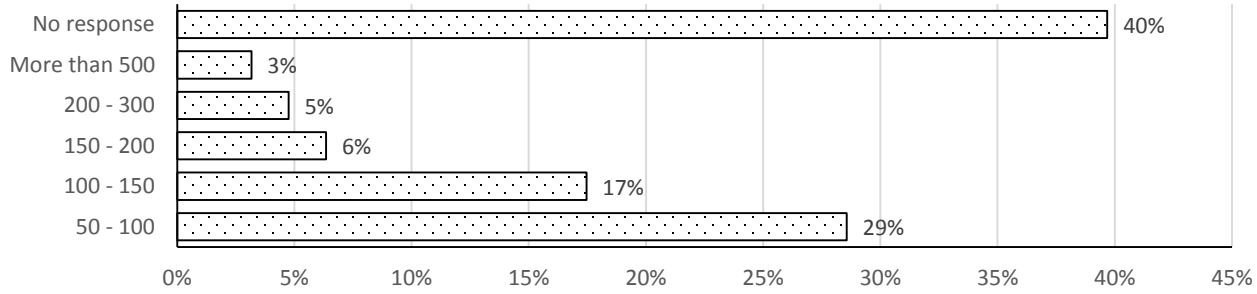

Figure 7: Amount HDh Nolhivaranfaru household willing to pay for the services of IWRM

Figure 6 above shows the number of households who are willing to use and pay for the service, 76% of households said they are willing to pay for the service, 14% of households said that they are not willing to use the service and 10% of households didn't give any answer. Figure 7 above shows the percentage of how much they are willing to pay for a month per household and 29% of households are willing to pay 50 – 100 MVR per month, 17% of households are willing to pay 100 – 150 MVR per month and 40% of households did not respond to the question.

R. Maduvvaree

Most of the participants who were interviewed were females (89%), only (11%) were males, this might be because most of the males might be working out of the island or they might not be present during the house visits. Among the interviewees 39% were house owner's wife, 33% were house owner's daughters and 17% were house owner.

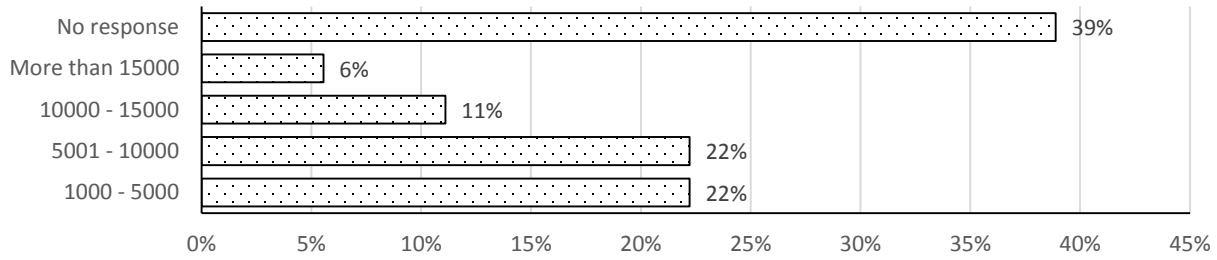

Figure 8: Household income per month for R.Maduvvaree

Most of the participants are not employed, it might be because most of the participants were females, and since most of the participants were married they want to stay home to take care of the family. According to participants they get income through husband or son, they were mostly involved in fishing activities, resort jobs and civil servants. As shown in the Figure 8 most of the responsing households (44%) get an income less than 10000 MVR per month, only (6%) gets an income more than 15000 MVR per month.

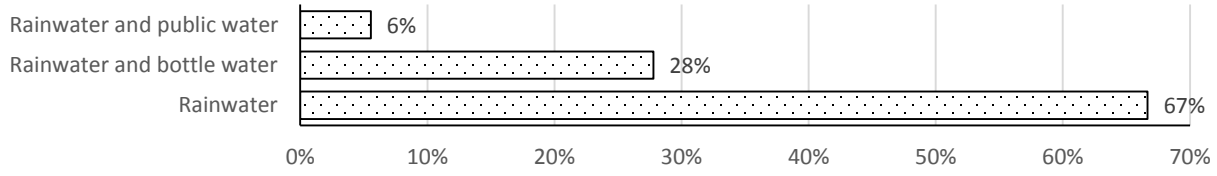

Figure 9: Source of drinking water for households in R.Maduvvaree

For drinking purposes most of the household use rainwater (67%) as shown in the Figure 9, 28% of the households use both rainwater and bottle water (mineral water) and only 5% of households use rainwater and public water.

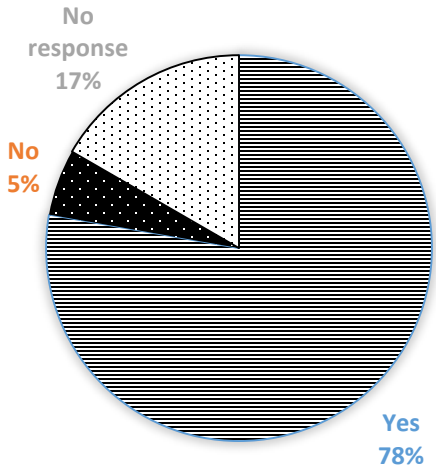

Figure 10: Willingness to pay for the IWRM system in R.Maduvvaree

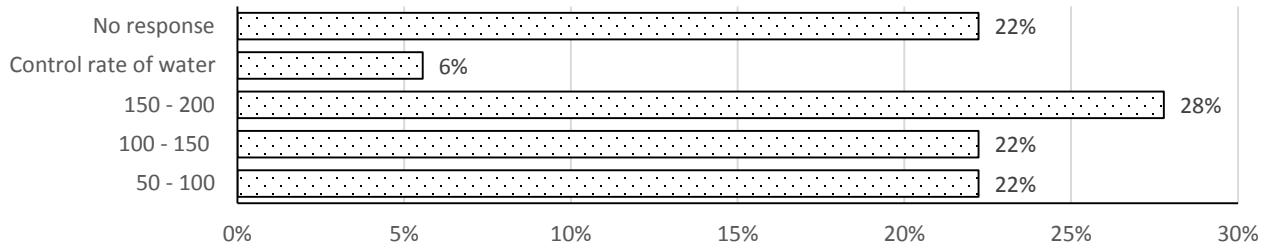

Figure 11: Amount R.Maduvvaree household willing to pay for the services of IWRM

Figure 10 above shows the percentage of participants who willing to pay for the service, most of the participants (78%) said the they are willing to pay for the service, only 4% of the participants mentioned that they are not willing to pay for the service. Figure 11 above shows the percentage of how much they are willing to pay for a month per household, 28% of participants are willing to pay 150 – 200 MVR per month per household.

B. Dharavandhoo

Most of the participants who were interviewed were females (77%), only (23%) were males, this might be because most of the males might be working out of the island or they might not be present during the house visits. Among the interviewees 77% were household owners, 16% were house owner's daughters and 5% were owner's wife.

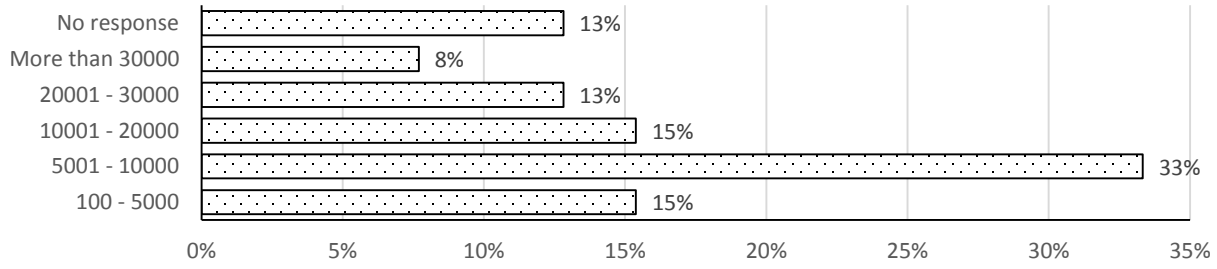

Figure 12: Household income per month for B.Dharavandhoo

Figure 12 above shows the income per month per household, as shown in the Figure (12) most of the households (36%) gets an income less than 10,000 MVR per month. Households with an income of 10000 – 20000 MVR is 15%, and only 8% of households gets an income higher than 30000 MVR.

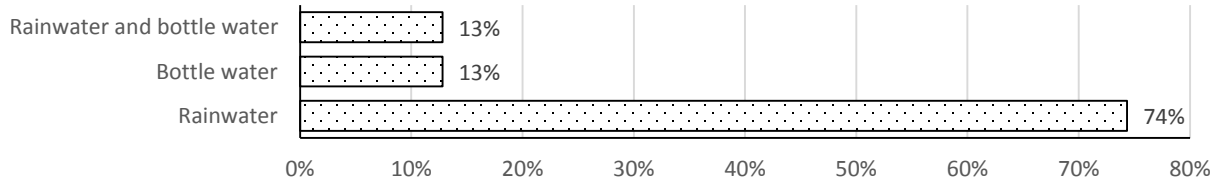

Figure 13: Source of drinking water for households in B.Dharavandhoo

Figure 13 above shows the types of waters used for drinking in households, only 2 types of waters are used for drinking purposes, 74% of households use only rainwater as their source of drinking, 13% of households only use bottle water as their source of drinking and 13% of households use both rainwater and bottle water

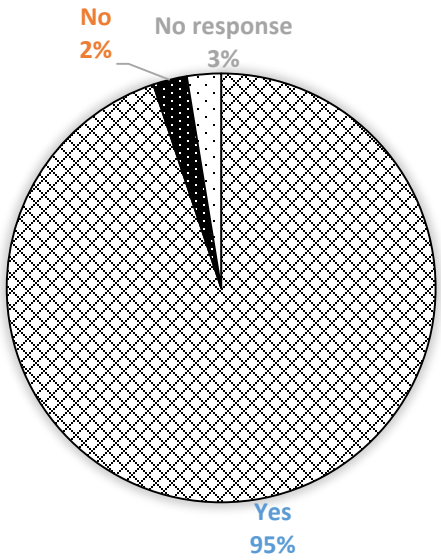

Figure 14: Willingness to pay for the IWRM system in B.Dharavandhoo

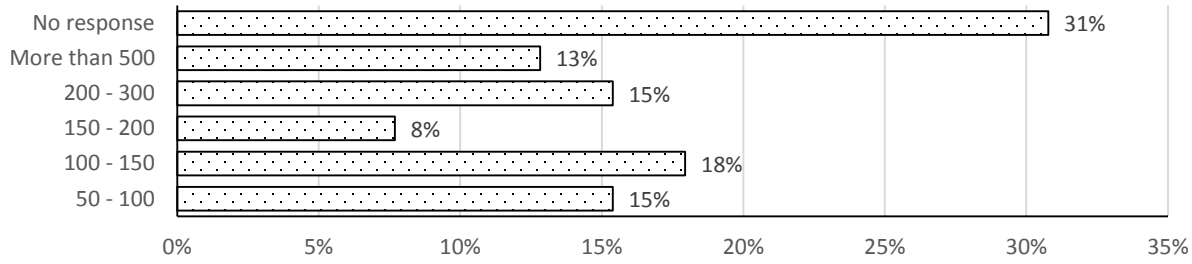

Figure 15: Amount B.Dharavandhoo household willing to pay for the services of IWRM

Figure 14 above shows the number of households who are willing to use and pay for the service, 86% of households said they are willing to pay for the service, 9% of households said that they are not willing to use the service and 5% of households didn't give any answer. Figure 15 above shows the percentage of how much they are willing to pay for a month per household, 15% of households are willing to pay 50 – 100 MVR per month, 18% of households are willing to pay 150 – 200 MVR per month, 13% of households are willing to pay more than 500 MVR per month and 31% of households did not respond to the question.

Chapter	**Consultant**
Introduction	Mareer Mohamed Husny
Project description	Mareer Mohamed Husny Ali Shareef Zammath Khaleel
Policy and regulatory framework	Mareer Mohamed Husny
Methodology	Mareer Mohamed Husny
Existing environment	Mareer Mohamed Husny Ali Shareef
Impacts and mitigation measures	Mareer Mohamed Husny Ali Shareef Zammath Khaleel
Alternatives	Mareer Mohamed Husny Ali Shareef Zammath Khaleel
Monitoring and management plans	Mareer Mohamed Husny Ali Shareef
Stakeholder consultations	Ali Shareef Zammath Khaleel
Conclusions, executive summaries	Mareer Mohamed Husny Ali Shareef Zammath Khaleel

Curriculum Vitae

Personal Information

Name: Zammath Khaleel
Gender: Male'
D.O.B: 26 October 1984
Marital Status: Single
Passport #: E0322096
Address: Muranga Villa 4th Floor, Muranga Magu
Maafannu, Male' 20340.
Mobile: (960)7990654
E-mail: xammat@gmail.com

Educational Background:

Level of Education	Institute/ University	Duration	Subjects
Bachelors Degree	Yuvarajas College/ University of Mysore	July 2006 – June 2009	Environmental Science Geology Chemistry
GCE Advance level	Center of Higher Secondary Education	June 2001 – June 2003	Physics Mathematics Biology

Language Proficiency

Language	Read	Write	Speak
Mother tongue: Dhivehi	Excellent	Good	Excellent
Second Language: English	Excellent	Good	Excellent

Work Experience

Designation: Environment Analyst
Duration: July 2009 to till date
Employer: Climate Change and Energy Department / Ministry of Housing and Environment
Responsibility: Job involves giving technical input in formulating projects related to climate change adaptation and mitigation. Job also involves representing the department and the country at various climate change and energy related forums. And to achieve nations carbon neutrality goal, we research potential technologies and emission reduction market mechanisms such as CDM and NAMA, develop project concepts involving the feasibility of those technologies and mechanism s to adapt these technologies and mechanism in Maldives. We also take part in sectoral development of concepts for investments and assist in the implementation of different projects. It also involves working closely with implementing agencies to develop possible action plan/ road maps for reducing emissions. The job also entails basic administrative work within the department, including setting up a proper structure for the department.

Designation: Electrician –trainee
Duration: April 2006 to July 2006
Employer: Energy Section / Ministry of Environment, Energy and Water
Responsibility: Administrative responsibilities of Outer Island Electrification project and liaising with the project consultants for the project implementation.

Designation: Administrative officer
Duration: June 2003 to April 2006
Employer: Fastcomms Maldives
Responsibility: Involves in writing quotation for IT and networking related bidding and subsequent paper work on successful bids. Assist on project implementation and involves going to field every now and then. Keeping track of all paper work and managing the filing system as well as the stock is also part of the job description.

Projects Experience:

Project: Maldives Green Facility - project
Capacity: Communication Focal Point, September 2011 till to date
Description: Project is a Danish funded project, to facilitate establishment of low carbon mechanisms such as CDM in the Maldives. The project also involves development of a Low Carbon Strategy covering all sectors of Maldives which is an important exercise for Carbon neutrality and economic sustainability. My work involve in liaising with the consultants, providing data, arranging stakeholder meetings, workshops and assisting them in implementation of the project.

Project: Renewable Energy Technology Development and Application Program
Capacity: Project Manager, July 2009 to January 2012
Description: Project is a GEF funded project designed to create and enabling environment for renewable energy technology investment. It involves some baseline studies like energy demand and supply studies, setting up basic technical structure and policy framework to move towards renewable. Since July 2009, major works included updating Energy demand and supply study for 2009, rewriting the policy to fit the current Governments priorities. The projects final evaluation was done in Q4 of 2011.

Project: Integrating Climate Change Risks in Resilient Island Planning
Capacity: Member of technical advisory committee, June 2010 to date
Description: This is a GEF LDCF funded project designed to build sustainable development and Climate change adaptation guidelines and demonstrate those guidelines in 4 islands. Purpose of the project is identifying means of combating the effects of climate change and preserve and improve the adaptive capacity of the fragile island community which faces climate change risks. Project started in 2010 and is a 3 year project involving adaptation baseline studies, training in the island on various adaptation options viable to the community, awareness and finally development of guidelines on adaptation and other projects for sustainable development. The technical committee would provide technical inputs in the required fields for the project activities.

Project: Outer Island Electrification Project
Capacity: Administrative officer, May 2006 to July 2006
Description: It is an ADB loan funded project for upgrading or developing power infrastructure in 40 islands. It was split into two batches of islands and my responsibility included maintaining the filing systems and arranging required stakeholder meetings.

Project: Wataniya Roll-Out Project
Capacity: Administrative officer, December 2004 to March 2006
Description: The Wataniya telecom Maldives started the project to start their services as the second telecom company in the Maldives. Fastcomms Maldives being the main contractor took charge of construction work of 20 islands, tower erections at all 96 sites and assist Wataniya in general in their roll out project. My responsibilities included handling most of the paper work, preparation of quotations and BOQs for additional activities required, and managing the work visa for the expatriate workers.

Other Professional Training & Experience:

- GHG Inventory Training Workshop for Asia Region (online) – 2012
- Represented Maldivian DNA for CDM in International DNA Forum (Durban/ South Africa) – 2011
- Represented Maldivian DNA for CDM in Regional DNA Forum (Kathmandu / Nepal) – 2011
- Part of Maldivian delegation in UNFCCC Climate Talks June session (Bonn / Germany) – 2011
- PADI open water diver - 2011
- Training course on Developing Policies and Strategies for Climate Change (Japan) – 2011
- Maldivian delegate for Tarawa Climate Change Conference(Kiribati) – 2010
- LDC workshop on Implementation of National Adaptation Plan of Action(Vientiene/Lao PDR) – 2010
- BOBLME and MFF Regional Training Course on Effective Communications(Bandos/ Maldives) – 2010
- Part of Secretariat to Cartagena Group Dialogue Meeting (Bandos/ Maldives) – 2010
- Expert group meeting on Identifying Impacts of Climate Change on Coastal Resources (Sri Lanka) – 2010
- South Asia Stakeholder Consultation, Asia Pacific Human Development Report on Climate Change (Kathmandu, Nepal) – 2010
- Executive Exchange Program to U.S. on Energy Efficiency (California/USA) – 2010
- Seminar of Clean Energy for Developing Countries(China) – 2009
- Maldivian Representative in SAARC Coastal Zone Management Center's 6th Governing Board Meeting (Paradise Island Resort / Maldives) – 2009
- Part of Secretariat team to Climate Vulnerable Forum (Bandos/ Maldives) – 2009
- National Workshop on Climate Change and Human Health (Bandos/ Maldives) - 2009

Contributed Documents:

- Environment Impact Assessment for proposed 80 Housing Units in Baa Goidhoo – 2011
- Environment Impact assessment for Proposed 11 storey building in Feyruvaadhee – 2011
- Environment Impact Assessment for Vandhoo Slipway Project – 2011
- Environment Audit for Ranveli Village Powerhouse and Desalination Plant Registration – 2011
- Environment Audit for Moofushi Island Resort Powerhouse and Desalination Plant Registration – 2010
- Contributor and reviewer of Maldives National Energy Policy and Strategies – 2010
- Expression of Interest from Maldives for Scaling up Renewable Energy Program – 2010
- Environmental Impact Assessment of Kaashidhoo Habour Rehabilitation project – 2010
- Environmental Impact Assessment of B.Goidhoo Habour Rehabilitation project – 2010
- Environment Audit for Police Powerhouse registration – 2010
- Environmental Impact Assessment of Dh. Meedhoo Sewage Outfall – 2009
- Environmental Impact Assessment of F.Nilandhoo Sewage Outfall – 2009
- Contributor to Maldives National Strategic Action Plan – 2009

Referees:

Name: Amjad Abdulla
Designation: Director General / Climate Change and Energy Department
Contact: amjad.abdulla@mhe.gov.mv, Abdulla.amjad@gmail.com

Name: Ajwad Musthafa
Designation: Deputy Director / Maldives Energy Authority
Contact: ajwad.musthafa@mea.gov.mv

Curriculum Vitae

Name: Ali Shareef
Date of Birth: 10 June 1978
Contact: Mob: +960 796 5626, Work: +960 301 8346
Email: shareef.ali@gmail.com ; ali.shareef@environment.gov.mv

EDUCATION

Masters of Science – Geography in Atmospheric Science and Numerical modelling (2009), Department of Geography, University of Canterbury, Christchurch, New Zealand. Thesis title: "*Numerical Analysis of Convective Storm Development over Maldives*".

Bachelor of Science (Honours) in Meteorology and Oceanography (2003), Flinders University of South Australia. Thesis title: "*Evaluation of Rainfall from satellite and rain gauge observations over selected islands in the Indian Ocean*".

General Certificate of Education Advanced Level (1997).

General Certificate of Education Ordinary Level (1995).

PROFESSIONAL MEMEBERSHIP

Licensed Environmental Impact Assessment consultant 2011 – Date

Member to the Least Developed Countries Expert Group (LEG) of the United Nations Framework Convention on Climate Change (UNFCCC) 2010

Least Developed Countries Expert Group (LEG) is a group of experts formed under a decision from the Conference of the Parties (COP) where members are nominated by the parties. The objective of the LEG is supporting the preparation and implementation strategy of National Adaptation Programs of Action (NAPAs) and support the national adaptation plans process within the UNFCCC. As a member my expertise was provided in the formulation of the guidelines for the development NAPAs for the UNFCCC and other several countries and reviewing several NAPAs submitted to the UNFCCC to ensure if they are within the NAPA guidelines.

SCHOLARSHIPS & AWARDS

Scholarship for postgraduate studies by New Zealand Development Aid (NZAID, open category).	2007
Golden Key Award, by the Golden Key International Honour Society (Flinders University of South Australia, Adelaide).	2001
Undergraduate Scholarship awarded under the Human Resource development project by WMO to the Maldives government.	2000

INFORMATION TECHNOLOGY AND DATA ANALYSIS	Level
Microsoft Windows and Office packages	Excellent
UNIX and LINUX operating systems (FEDORA, openSuSE, UBUNTU, SunOS)	Basic to intermediate
Experience with programming languages: FORTRAN, C, C++, JAVA, PHP	Basic to intermediate
Experience with Data analysis packages: MATLAB, SPSS, GrADS, Surfer, Grapher, ArcGIS, RBR	Basic to intermediate
Completed Intermediate course on Geographic Information Systems	Intermediate

EMPLOYMENT HISTORY

Assistant Director, Climatology, Climate Change and Energy Department, Ministry of Environment and Energy — 19 Jul 2009-current

Responsibilities: Formulation of climate change and energy strategies; Preparation and evaluation of project briefs and proposals for climate change adaptation and climate mitigation; Oversee and facilitate climate change adaptation and mitigation projects; Provide professional technical assistance to various stakeholders as to mainstream climate change; Advocate at local and international forums regarding the climate change status of Maldives and to secure finance to address the issues; Fulfil the requirements of the conventions on climate change such as UNFCCC and other bodies such as IPCC; Establishment of Clean Development Mechanism (CDM) unit under the guidance of UNEP RISO; Provision of professional expertise in climate change negotiation forums both local and international climate negotiations, participating several climate negotiations since 2009; Negotiate and liaise with various donors and funding agencies and other international partners; Lead the department in the absence of the superiors; Contribute to various other projects and office works.

Project Officer, Water and Sewerage Department, Ministry of Environment Energy and Water — 07 Jul 2007-25 Jan 2008

Responsibilities: Preparation of water and sanitation project briefs and proposals; Middle management of water and sanitation projects ensuring that the projects are delivered according to schedule and project implementation; Assist in provision of technical information regarding water and sanitation. Some of the key projects worked on was sanitation projects on Tha. Guraidhoo, AA. Rasdhoo, V. Felidhoo, HA. Dhidhoo, L. Isdhoo, Lh. Hinnavaru and Th. Thimarafushi.

Assistant Oceanographer, Department of Meteorology, National Meteorological Center — 17 Jan 2005-07 Jul 2007

Responsibilities: Collect information on daily weather status; Collect and analyses local and neighboring international weather data to prepare daily weather forecasts; Prepare daily, weekly and monthly weather reports; Research and analysis of meteorological and oceanographic data; Pioneering the use of numerical weather prediction in Maldives by use of meso-scale numerical weather forecasting models such as MM5 and WRF; Provision of training to the new recruit staffs on use of meteorological and oceanographic data and instruments.

Switching Technician, Dhivehi RaajjeygeGulhun (DHIRAAGU) Pvt Ltd — Jan 1998-Jan 2000

Responsibilities: Work at the mainframe telephone and mobile phone exchange units; Daily system checks of the mainframe units; Daily assistance in connections and disconnections of the telephones and mobile phones; Assist the telephone networks maintenance teams in trouble shooting and fixing of telephone, mobile phones and pagers; Routine checks of the local and international carrier trunks; Programing of mobile phones and pagers; Minor repair of mobile phones and pagers; Liaise with international partners ensuring smooth operation of the telephone and the mobile networks.

KEY PROJECT CONTRIBUTIONS

Coordinator of the Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), Vulnerability needs assessments coordinator. — Ongoing

In accordance with the principle of "common but differentiated responsibilities", parties to the UNFCCC have to report on the steps taken by the parties in implementing the convention. This report should include information about the vulnerability status, the impacts and the adaptive measures taken and planned to be taken by the party. It should also report on the Greenhouse Gas inventory and

the climate change mitigation measures undertaken and planned to mitigate the emission of greenhouse gases.

I was involved in coordination of vulnerability needs assessment where I have to assist the consultants who are working on the respective thematic areas in arranging the field trips, meetings, data analysis, results interpretation and compilation of the final report.

National Coordinator of Quantifying projected impacts under 2°C warming - IMPACT2C. Ongoing

United Nations Climate Change Conference in Cancun recognized that global warming beyond 2°C above pre-industrial levels will be a major threat to human welfare and to ecosystems and the goal to limit the global warming demands that discussions are informed by the best available science on projected impacts and possible benefits. IMPACT2C project enhances knowledge, quantifies climate change impacts, and adopts a clear and logical structure, with climate and impacts modelling, vulnerabilities, risks and economic costs, as well as potential responses, within a pan-European and in some of the world's most vulnerable regions. The project is a research collaboration among some of the countries within the European Union and some countries from the world's most vulnerable regions.

I was involved in coordinating with various stakeholders to collect the data via field expeditions and by other sources, coordination of the meetings, analysis and interpretation of results and contributing to the reports of the research findings.

Lead coordinator and co-Author of Maldives Energy Supply and Demand 2010-2012. 2014

Energy supply and demand is an accounting framework for the compilation and reconciliation of data on all energy entering, exiting and used within the national territory of a given country during a reference period.

I was involved in the data analysis needed for the compilation of the energy balance and was a co-author of the Energy supply and demand.

Lead coordinator and Lead Author of Baseline analysis of Adaptation Capacity and Climate Change Vulnerability Impacts in the Tourism Sector, Tourism Adaptation Project. 2013

To address the climate change issues, the Tourism Adaptation Project (TAP) facilitate and provide support to bring about the required amendments to the existing laws and regulations that govern the tourism sector, so as to incentivize private sector investments in climate change adaptation in the tourism sector. The baseline assessment carried out was to determine the existing vulnerabilities in resorts, tour operators, safari owners and the associated communities. It also assessed the impacts and the adaptive and mal-adaptive measures within the tourism sector. A social survey was carried out to determine this.

My role was to lead the entire project, involved in the field data collection surveys, results interpretation and compiling the final report as a lead author.

National Coordinator of the project on Mapping of the Maldives and Climate Change. 2011

The Mapping of the Maldives and Climate Change (MMCC) project with an overall objective of development of a large scale mapping of the Maldives. It included national capacity building in terms of information management and monitoring of climate change issues, acquiring and processing environmental data, research and development of monitoring methods for and actions to adjust to climate change, creation of a Maldives Environment and Climate Change GIS Geo-portal.

My role was to coordinate the various meetings with stakeholders and coordinate research field trips.

PUBLICATIONS AND CONTRIBUTIONS

Maldives Energy Supply and Demand 2010 – 2012, Ministry of Environment and Energy 2014.

Baseline Analysis : Adaptation Capacity and Climate Change Vulnerability Impacts in the Tourism Sector, Tourism Adaptation Project, 2013 participated as the lead author.

Scaling-up of Renewable Energy Program Investment Plan Maldives 2012, Ministry of Housing and Environment.

Co-Author of the project proposals for the European Union Climate Change Trust Fund on Climate Change Adaptation and Mitigation.

Contributed in formulation of Maldives National Energy Policy and Strategies 2010.

Numerical Analysis of Convective Storm Development over Maldives, 2009, Masters thesis.

KunioYoneyama, Yukio Masumoto, Yoshifumi Kuroda, Masaki Katsumata, Keisuke Mizuno, Yukari N. Takayabu, Masanori Yoshizaki, Ali Shareef, Yasushi Fujiyoshi, Michael J. McPhaden,V. S. N. Murty, RyuichiShirooka, Kazuaki Yasunaga, Hiroyuki Yamada, Naoki Sato, Tomoki Ushiyama, QoosakuMoteki, Ayako Seiki, Mikiko Fujita, Kentaro Ando, Hideaki Hase, Iwao Ueki, Takanori Horii, Chie Yokoyama, and Tomoki Miyakawa., 2008. *MISMO Field Experiment in the Equatorial Indian Ocean 2007*. Bull. Amer. Met. Soc

Introducing numerical weather forecasting in Maldives using MM5 meso-scale model. Rain O Shine 2007, Department of Meteorology, Maldives.

Overview of the Maldives Sea Level and the risk involved. Rain O Shine 2006, Department of Meteorology, Maldives.

Tomczak, M., A. Shareef, A. Henry-Edwards and J. Bennett (2004) *Determination of the fresh water flux at the air/sea interface for climate modelling*. Proceedings of the First International Conference on Physics (ICP) January 6-9, 2004 Ð Tehran, Iran. Faculty of Physics and Nuclear Sciences, Amirkabir University of Technology, Tehran, 127 Ð 136.

Evaluation of rainfall from satellite and rain gauge observations over selected islands in the Indian Ocean. 2003. Honours thesis.

WORKSHOPS AND TRAININGS

Economics of Climate Change Adaptation and Cost Benefit Analysis, Bangkok, Thailand.	11-14 Mar 2013
GIS and Remote Sensing, Male', Maldives.	6-17 Jan 2013
Intermediate course on use of GIS, Male', Maldives.	18-29 Nov 2012
Hands-on training workshop for the Asia-Pacific region on vulnerability and adaptation assessment, Vientiane, Lao Peoples Democratic Republic.	8-12 Oct 2012
Introduction to GIS and GIS tools, Male', Maldives.	26 Aug-6 Sep 2012
Regional workshop for Eastern European and Asia-Pacific regions to share experiences and lessons learned in the preparation and implementation of nationally appropriate mitigation actions (NAMAs), Yerevan, Armenia.	2-4 July 2012
Hands-on Training Workshop on Greenhouse Gas Inventory for the Asian Region, Colombo, Sri Lanka.	30 Jan-3 Feb 2012

Climate extreme analysis and Geo-Climate Information System – a visualization tool for displaying climate change scenarios for Maldives, Maldives.	22-26 Jan 2012
GIS basic training on use of the products from the Mapping of the Maldives and Climate Change, Male', Maldives.	22-26 May 2011
Workshop for Climate Risk Management Technical Assistance Support Project (CRM-TASP), Pondicherry, India.	5-7 Jul 2010
National Workshop of Climate Change and Human Health, Bandos Island Resort, Maldives.	5-7 Oct 2009
National Sustainable Development Strategy final workshop, Bangkok, Thailand.	10-12 Sep 2009
UNESCO-IOC Training Course on Tsunami Numerical Modelling Course II, Bangkok, Thailand.	29 Jun- 6 Jul 2007
Training workshop on seismology and Tsunami, Male, Maldives, organised by UNESCO International Oceanographic Commission (IOC), U.S Agency for International Development (USAID) and United States Geological Survey (USGS).	27- 31 Aug 2006
SAARC Training Workshop on MM-5 (Numerical Weather Prediction) Model held in New Delhi, India by the SAARC Meteorological Research Center (SMRC), Dahaka, Bangladesh and the Indian Meteorological Department (IMD), New Delhi, India.	27 Feb-10 Mar 2006
Workshop on Preparation and Interpretation of a Climate Risk Profile for the Maldives, Male', Maldives.	20-21 Feb 2006
IMO National OPRC Level 3 Training Course, Male', Maldives.	23-25 Jan 2005
Renewable energy technologies, Male', Maldives.	25-29 Dec 2005
Workshop on post-tsunami review, Male', Maldives.	24-29 May 2005
Science Demonstrators Training, staff development and training unit, Faculty of science and Engineering, Flinders University of South Australia.	25-26 Feb 2003

SEMINARS AND CONFERENCES

19th Conference of the parties (COP 19) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parities to the Kyoto Protocol, Warsaw, Poland	3 Nov- 25 Nov 2013
36th Session of the Intergovernmental Panel on Climate Change (IPCC), approval and acceptance of the report of the working group I.	23 Sep-26 Sep 2013
18th Conference of the parties (COP 18) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parities to the Kyoto Protocol, Doha, Qatar	28 Nov- 9 Dec 2012
Second General Assembly on Quantifying projected impacts under 2°C warming - IMPACT2C, Vienna, Austria	14-16 Nov 2012
Capacity Building Programme on the Economics of Climate Change Adaptation, Bangkok, Thailand	24- 26 Oct 2012
Cartegena Dialogue on Climate Change negotiations, Nairobi, Kenya	2-3 Apr 2012

17th Conference of the parties (COP 17) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parities to the Kyoto Protocol, Durban, South Africa	28 Nov-9 Dec 2011
Quantifying projected impacts under 2°C warming - IMPACT2C, Hamburg, Germany	4-5 Oct 2011
5th Preparatory Commission for International Renewable Energy Agency (IRENA) and the First Assembly of IRENA, Abu Dhabi, United Arab Emirates	3-5 Apr 2011
Sessions of the Intergovernmental Panel on Climate Change (IPCC), on various occasions.	
Sessions of the Intergovernmental Panel on Climate Change (IPCC) meeting of the Bureau, on various occasions	
Asia Pacific Climate Change Finance and Development Effectiveness Dialogue, Bangkok, Thailand	12-13 Sep 2011
East Asia Low Carbon Green Growth (LCGG) Roadmap Policy Forum , Busan, Republic of Korea	7-8 Jul 2011
Executive Exchange to the "European Wind Energy Conference and Exhibition", Brussels, Belgium	14-18 Mar2011
Carbon Forum Asia, Singapore	27-28 Oct 2010
18th meeting of the Least Developed Countries Expert Group (LEG) to the UNFCCC, Kathmandu, Nepal	12-15 Oct 2010
17th meeting of the Least Developed Countries Expert Group (LEG) to the UNFCCC, Bonn, Germany	12-14 Apr 2010
UN Climate Change Negotiations (AWG-LCA and KP) preparatory meetings (LDC, SIDS, G77China), Bonn, Germany	4-11 Apr 2010

ENVIRONMENT IMPACT ASSESMENTS

Environmental Impact Assessment for the proposed development of a Resort at Kuredhivaru 2014. Involved in, data analysis and compilation of the report on wave, tidal, meteorological, beach dynamics and satellite imagery data.

Environmental Impact Assessment for the proposed development of a Resort at Gdh. Havodda 2013. Involved in, data analysis and compilation of the report on wave, tidal and beach dynamics.

Environmental Impact Assessment for the proposed development of a Slipway at Raa. Innamaadhoo, 2013. Involved in field data collection, analysis and compilation of the entire EIA report.

Environmental Impact Assessment for the proposed development of a resort at Gdh. Havodda, 2013. Involved in data analysis and compilation of the waves, current and geomorphological changes to the island.

Environmental Impact Assessment for the proposed development of a Slipway at Thaa. Dhiyamigili, 2012. Involved in field data collection, analysis and compilation of the entire EIA report.

Initial Environment Examination for development of an 11 storey building at H. Feyruvaadhee, 2011. Involved in field data collection, analysis and compilation of the entire EIA report.

Environmental Impact Assessment construction of 80 housing units at Baa. Goidhoo, 2011. Responsible for compilation of entire EIA.

Environmental Impact Assessment for the proposed development of a Slipway at Raa. Vandhoo, 2011. Involved in data analysis on physical environment and compilation of entire EIA.

Environmental Impact Assessment for the proposed development of a Resort at K. Kudavillingili, 2011. Involved in data analysis on physical environment and compilation of final report.

Environmental Impact Assessment for the proposed development of Hospitality Institute and City Hotel at L. Gan and resort development at L. Gasfinolhu and L. Bodufinolhu, 2011. Involved in data analysis on physical environment and compilation of final report.

Initial Environment Evaluation for registration of power generation facility of 9 storey building at IskandarKoshi, Male, 2011. Responsible for field data collection and compilation of entire IEE.

EIA on proposed Harbour reconstruction project at B. Goidhoo, 2010. Involved in data analysis on physical environment and compilation of final report.

EIA on proposed Harbour reconstruction project at K. Kaashidhoo, 2010. Involved in data analysis on physical environment and compilation of final report.

EIA Report for proposed harbour construction at H.A Thuraakunu, Thuraakunu Island Development Committee, 2008. Involved in field data collection, analysis and compilation of the final report.

EIA on proposed resort development at H. A Berimadhoo, 2008. Involved in field data collection, analysis and compilation of the final report.

REFREES

Amjad Abdulla
Director General, Climate Change Department
+960 300 4300, abdulla.amjad@gmail.com
Ministry of Environment and Energy

Dr. Peyman-zawar Reza
Department of Geography
University of Canterbury Atmospheric Research unit
peyman.zawar-reza@canterbury.ac.nz
University of Canterbury, New Zealand

I hereby declare that the information given here is true to the best of my knowledge.

Ali Shareef

بسم الله الرحمن الرحيم

PERSONAL INFORMATION

• Name	**HUSNY, MAREER MOHAMED**
• Permanent Address	Fithuroanuge, Hithadhoo, Addu City, Republic of Maldives
• Present Address	401 E 34th Street, Apartment No. N15B, New York, NY, 10016
• Telephone	+1 (917) 432 9875
• E-mail	*mareermohamedhusny@gmail.com; mareer.husny@environment.gov.mv*
• Nationality	MALDIVIAN
• Date of Birth	05 November 1985

WORK EXPERIENCE

• Dates	February 2014 - Present
• Name of employer	Ministry of Environment and Energy | Climate Change Department
• Business type	Government of Maldives, Climate Change
• Position held	*Assistant Director, Climate Change*
• Main activities and responsibilities	Coordinate and implement adaptation plans in the Maldives under United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol Conduct research and prepare climate change vulnerability assessments Mainstream climate change policy in particular adaptation policy of the Maldives Active participation in the UNFCCC climate negotiations in the field of adaption Provide technical expertise in implementing climate change adaptation activities and project in the Maldives

• Dates	June 2015 - Present
• Name of employer	Ministry of Environment and Energy | Climate Change Department
• Business type	Government of Maldives, Climate Change
• Position held	*Climate Change Lead Negotiator of Alliance of Small Island Sates*
• Main activities and responsibilities	Develop and implement sessional and inter-sessional UNFCCC negotiation strategies Liaise with climate change thematic coordinators in preparation of negotiation strategies both in session and inter- sessionally to update on the Chief Negotiator. Develop and maintain relationships with negotiating partners; Oversee the work of the Technical Advisors; Speak to the media on behalf of AOSIS as instructed by the Chief Negotiator and its members; Attend bilateral meetings on climate change alongside the Chair and the Chief Negotiator; Coordinate drafting AOSIS statements, briefing documents, presentations and position papers; and Prepare reports of all meetings (UNFCCC, other and bilateral) for internal use, and update AOSIS plenary on meetings. Assume the chairing of sessions and bilateral in the absence of the Chief Negotiator Should report to Chief Negotiator and prepare briefing papers for Chief Negotiator.

• Dates	10 March 2010 – 10 January 2012
• Name of employer	CDE Consulting
• Business type	Private environmental consulting firm
• Position held	*Environmental Consultant*
• Main activities and responsibilities	Manage, author and prepare Environmental Impact Assessment and environmental related technical documents. Provide with best environmental solutions for clients to satisfy the needs of clients Conduct stakeholder discussion and such arrangement as per the task assigned

• Dates	19 July 2009 – 03 January 2012
• Name of employer	Ministry of Housing and Environment | Climate Change and Energy Department
• Business type	Government of Maldives
• Position held	Environmental Analyst
• Main activities and responsibilities	Provided technical assistance in implementing Integrating Climate Change Risk into Resilient Island Planning in the Maldives Provided technical assistance in implementing National Economic, Environmental and Development Studies Provided technical assistance in implementing Mapping of Maldives and Climate Change Provided technical assistance in implementing Institutional setting on Madanjeeth Climate Research Facility Provided technical assistance in implementing Multi donor Climate Change Trust Fund Provided technical assistance in implementing in Tourism Adaptation project Provided technical assistance in implementing Increasing resilience through integrated water resource management programme in the Maldives Implemented and oversee project development of Second National Communication of the Republic of Maldives to UNFCCC Provide technical expertise in climate change conferences and negotiations

• Dates	08 November 2005 – 30 July 2006
• Name of employer	Ministry of Environment Energy and Water | Environment Section
• Business type	Government of Maldives
• Position held	Environmental Officer (Trainee)
• Main activities and responsibilities	Provide administrative and technical support to Tsunami debris and waste management programme funded by the Australian and Canadian Red Cross Provide administrative and technical support to Tsunami hazardous waste collection programme by United Nations Environment Programme. Provide administrative and technical support to Sustainable livelihood waste management component implemented by the United Nations Development Programme Provide administrative and technical support to implementation of Maldives National Solid Waste Management Strategy Provide administrative and technical support to the waste management unit

EDUCATION AND TRAINING

• Dates	January 2012 to December 2013
• University	The University of Melbourne
• Principal subjects	Sustainability Policy and Management and Interdisciplinary and Environment
• Title of qualification awarded	**Master of Environment**
• Masters Thesis	The Threshold Framework of Human Development and Island Stability in the Maldive Islands (First Class Honors – H1).
• Dates	July 2006 – July 2009

• University	The University of Mysore, Yuvarajas College
• Principal subjects	Environmental Science, Chemistry and Geology.
• Title of qualification awarded	**Bachelor of Science (First Class with Distinction)**
• Dates	July 2006 – July 2009

MEETINGS AND SEMINARS ATTENDED

• 2006	Emission inventory preparation or scenarios or atmospheric transport modeling workshop under Malé Declaration.
• 2009	Regional Economics of Climate Change in South Asia: Part 1 Cleaner Technologies and options, Maldives National Experts Workshop
	Regional Workshop on the Implementation of Article 6 of UNFCCC for Asia and the Pacific
• 2010	International workshop on gender, technology and climate change adaptation and mitigation
	Five Year Regional Review of the Implementation of the Mauritius Strategy for Further Implementation of the Programme of Action for the Sustainable Development in SIDS (MSI +5)
• 2011	Workshop on Sea Level Rise and Ice Sheet Instability.
	South-South Exchange Programme on Renewable Energy.
	Fifth session for Preparatory Commission for IRENA.
	First General Assembly of IRENA.
	Lesson Learnt in, Climate Change Adaptation and Disaster Risk Reduction in SIDS.
	Final Symposium of Maldives Mapping and Climate Change.
• 2014	Fourth and Fifth Part of the Second Session of Ad-hoc Working Group on Durban Platform for Enhanced Action.
	40th Meeting of the Subsidiary Bodies of UNFCCC.
	Intergovernmental Panel on Climate Change (IPCC) Future Task Force Meeting.
	Bureau Meeting of IPCC.
	Endorsement of Summary for Policy Maker of Fifth Assessment Report of IPCC
• 2015	Eighth and Ninth Part of the Second Session of Ad-hoc Working Group on Durban Platform for Enhanced Action.
	42nd Meeting of the Subsidiary Bodies of UNFCCC

PERSONAL SKILLS AND COMPETENCIES

• **Awards and Membership**	Deputy School Captain (2004-2005) | Muhibbuddin School
	Government Scholarship for Undergraduate
	Australian Development Award for Masters Programme
	Member of the University of Melbourne Australia's Awardee's Club (June 2012 – June 2013)
	Temporary Environmental Impact Assessment Consultant, EIA License No: T03/14
• **Mother Tongue**	Dhivehi
• **Other Languages**	English
	Reading (*Excellent*), Writing (*Excellent*) and Verbal (*Excellent*).
• **Environmental Surveys**	Coral reef monitoring programme in Ari Atoll, 2011
	Desalination plant and powerhouse audit at *Olhuveli Beach and Spa Resort*, 2011
	Environmental Impact Assessment survey for development of picnic island at *K. Madivaru*, 2011
	Desalination plant audit and bathymetrical survey at *Helengili Island Resort*, 2011
	Environmental Baseline survey of *Thilafushi* (Marine component), 2011
	Desalination plant audit survey at *Meeru Island Resort*, 2011
	Environmental Impact Assessment survey for redevelopment of resort at *Giraavaru*

Island Resort, 2011

Waste Audit at *Vilamendhoo Island Resort and Spa*, 2014

• Academic Assignments focus on Maldives

The Threshold Framework of Human Development and Island Stability in the Maldive Islands, Masters Thesis (First Class Honors – H1) *The University of Melbourne*

Shifting of Climate Change Policy in the Maldives, *Climate Change Policy and Politics*, University of Melbourne

Critique to Water Policy in the Maldives, *Environmental Policy*, University of Melbourne

Critique to Social Impact Assessment prepared for Construction and Operation of Regional Waste Management Facility at R. Vandhoo, *Social Impact Assessment and Evaluation*, University of Melbourne

The Shifts in adaptive resilience after the 2004 Indian Ocean Tsunami: A Case of Maldives, (*Submitted to Maldives National University Journal*)

Environmental Impact Assessments and Reports

• 2010

Environmental Impact Assessment for reclamation of *Gulhifalhu Phase I*.

Environmental Impact Assessment Addendum for Beach Replenishment in *Vilamanedhoo Resort and Spa*.

Environmental Impact Assessment for the development of Picnic island facility in *Rahflahu Huraa*.

Environmental Impact Assessment for the development of picnic island at *K. Madivaru*.

• 2011

Environmental Impact Assessment for the construction of *Gulhifalhu Phase I*.

Environmental Impact Assessment for reclamation of *Gulhiflahu Phase II*.

Household Income Expenditure Survey for Foreign people residing in the Maldives

Registration of powerhouse and desalination plant in *Olhuveli Beach and Spa Resort*.

Registration of desalination plant and improvement to the existing football ground in *Kurehdhoo Island Resort and Spa*.

Environmental Baseline Assessment of *Thilafushi* for the construction of regional waste facility by International Finance Cooperation.

Desalination plant registration located in *Meeru Island Resort*.

Environmental Impact Assessment for the redevelopment of resort at Giraaavaru Islands.

Environment Impact Assessment of Reconstruction of Harbour for *Sh, Foakaidhoo*.

• 2012

Registration of desalination plant and construction of sea wall in *Helengili Island Resort*.

Cooperate Social Responsibility for *One and Only Reethi Rah of Maldives*.

Resort Environmental Safety and Management Action Plan for *Manafaru Island Resort and Spa*.

Resort Environmental Safety and Management Action Plan for Irufushi Island Resort and Spa.

Addu Land Use Master Plan 2012 – 2020.

• 2014

Vulnerability Needs Assessment for the Coastal Environment in Maldives (for Second National Communication to UNFCCC).

Persistent Organic Pollutants and Pesticide Inventory under the Stockholm Convention for the Maldives.

Environmental Impact Assessment for Upgrading of Sewerage System at *Fihalhohi Island Resort*.

REFEREES

• Name	Mr. Amjad **ABDULLA**
• Name of the organization	Ministry of Environment and Energy | Climate Change Department
• Business Type	Government of Maldives
• Position	Director General & Chief Negotiator of AOSIS
• Email	*abdulla.amjad@gmail.com*
• Mobile	(+960) 7775543

• Name	Dr. David M. **KENNEDY**
• Name of the organization	The University of Melbourne
• Business Type	Masters thesis supervisor
• Position	Academic, Lecturer
• Email	*davidmk@unimelb.edu.au*
• Phone	+61 83449168

• Name	Mr. Ali **SHAREEF**
• Name of the organization	Ministry of Environment and Energy | Climate Change Department
• Business Type	Government of Maldives
• Position	Director, Climatology
• Email	*ali.shareef@environment.gov.mv*
• Phone	(+960) 7965626

DECLARATION

I, **Mareer Mohamed HUSNY** here by certify that all the information given above is true and complete to my understanding

Mareer
09 August 2015