

Environmental Impact Assessment for Establishment of an Integrated Water Management System in Sh. Fokaidhoo



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Proposed by: Ministry of Environment and Energy

Consultant: Development Advisory Services Pvt Ltd



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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 P19/11)

Signature: 

Executive Summary

This non-technical summary presents the finding of the Environmental Impact Assessment of the proposed Integrated Water Resource Management system development project at Foakaidhoo Island in Shaviyani 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 Foakaidhoo Island, Shaviyani Atoll. 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 total 132 amount 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.

* * * * *

دانشجویان سوادکوه به سرپرست خود، روحیه ای خستگی ناپذیر و بی‌سابقه در پیوند با دانشجویان و اساتید خود داشته‌اند. این دانشجویان با وجود اینکه در رشته‌های مختلف تحصیل می‌کنند، اما در زمینه‌های مختلف با هم همکاری و هم‌فکری می‌کنند. این دانشجویان با وجود اینکه در رشته‌های مختلف تحصیل می‌کنند، اما در زمینه‌های مختلف با هم همکاری و هم‌فکری می‌کنند. این دانشجویان با وجود اینکه در رشته‌های مختلف تحصیل می‌کنند، اما در زمینه‌های مختلف با هم همکاری و هم‌فکری می‌کنند.

در رشته‌های سوادکوه به سرپرست خود، روحیه ای خستگی ناپذیر و بی‌سابقه در پیوند با دانشجویان و اساتید خود داشته‌اند. این دانشجویان با وجود اینکه در رشته‌های مختلف تحصیل می‌کنند، اما در زمینه‌های مختلف با هم همکاری و هم‌فکری می‌کنند. این دانشجویان با وجود اینکه در رشته‌های مختلف تحصیل می‌کنند، اما در زمینه‌های مختلف با هم همکاری و هم‌فکری می‌کنند.

* * * * *

1. Introduction

1.1 The purpose of this EIA report

This EIA report is aimed to fulfil the statutory requirements under the Environmental Protection & Preservation Act of the Maldives (Law No. 4/93) and precisely the Environmental Impact Assessment (EIA) Regulation (2007) and First Amendment (2012) to the EIA regulation. These legal frameworks were utilized as a basis for preparation of this document.

This Environmental Impact Assessment report is an evaluation of the potential environmental impacts which will accompany with development of an integrated water resource management (IWRM) project in Sh.Foakaidhoo island. This report will provide background information on the project components of aforementioned project and their potential impacts on the natural and social environment of Sh.Foakaidhoo island. Mitigation measures to minimize the environmental impact will be proposed in this report. An Environmental Management Plan and monitoring program will be formulated to evaluate the effectiveness of the proposed mitigation measure. Alternatives for the project components included but not limited to locations, designs, environmental considerations will be suggested in this report. Overall, this report will contribute to minimization of the environmental impact due to project interventions of proposed IWRM project in Sh.Foakaidhoo island.

1.2 Project Title

The project is called Integrated Water Resource Management (IWRM) project in Sh.Foakaidhoo Island.

1.3 Project Proponent

The proponent of this project is Ministry of Environment and Energy (MEE). The Ministry of Environment and Energy is mandated with provision of safe water supply to the citizen of the Maldives. The project is funded by the Green Climate Fund (GCF). This project contributes to the aforementioned mandate. The following are the details of the proponent;

Ministry of Environment and Energy
Green Building, Handhuvaree Hingun,
Maafannu, Male' 20392, Maldives

1.4 Scope of the EIA and Terms of Reference

As per the approved terms of reference, the scope of this Environmental Impact Assessment is to generally assess, identify and predict the environmental and social impacts of the proposed IWRM project in Sh.Foakaidhoo Island. The main project components include installation of Reverse osmosis (RO) plants, establishment of a rainwater harvesting collection and conveyance system,

deployment of a groundwater infiltration galleries and construction of a piped water network with household connections. Importance was given to include all the project components and predict the environmental and social impacts which may arise due these project interventions. Furthermore, significance was given to ensure compliance with legal requirements of project of this nature.

This Environmental Impact Assessment study also include the existing natural and social environment of Sh.Foakaidhoo and predicts the environmental impacts which may arise due to project and how these impacts can be managed, mitigated and reduced.

The assessment more specifically adheres to the Terms of Reference (TOR) issued by Environmental Protection Agency. A copy of the TOR is attached in Appendix.

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 existing 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

1.5 EIA Methodology

The methodology adopted to predict identify, predict & assess impacts of the project intervention include the following;

- Assessment of the baseline of the environmental indicators within the project area prior to project work initiation. This assessment was conducted via field survey which was aimed to determine the environmental components as well as the social aspects required under the approved TOR.
- Prediction of impacts on various environmental indicators by the project interventions such as excavation for installment of a piped water network using environmental impact matrix.
- Ranking the predicted environmental impacts using significance analysis.

- Professional judgment, expert opinion and review of similar environmental impact assessment studies were used to for prediction and identification of environmental impacts and evaluation of these impacts.
- A specific section of this report discusses various methods used for collection of baseline environmental and social data.
- The impact assessment methodology (environmental impact matrix) and significance analysis will be discussed in the Environmental Impact & Mitigation Measures.

1.6 Literature review

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 in whole all the major components similar to the proposed IWRM project in Sh.Foakaidhoo. 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 extracting ground water.

1.7 Project Aims and Objectives

The aims and objectives of the IWRM project include the following;

Develop an integrated water resource management system in Sh.Foakaidhoo Island. The main components of this IWRM system include;

- Installation and operation of RO plants;
- Establishment of a rainwater harvesting collection and conveyance system;
- Deployment of a groundwater infiltration galleries;
- Construction of a piped water network with household connections.

2. Project Description

2.1 Project location and study area

The project location is at Miladhunmadulu Uthuruburi or Shaviyani (Sh.) atoll at the northern end of the atoll. The island Foakaidhoo is located at the north east edge of the atoll located with the geographic coordinates of $6^{\circ} 19' 35''$ N and $73^{\circ} 08' 57''$ E (see Figure 1). The island is situated in a reef system of its own. The closest inhabited islands to Foakaidhoo is Feevah to the north east which is about 6 km and Milandhoo which is about 11 km at the south east of the Foakaidhoo.

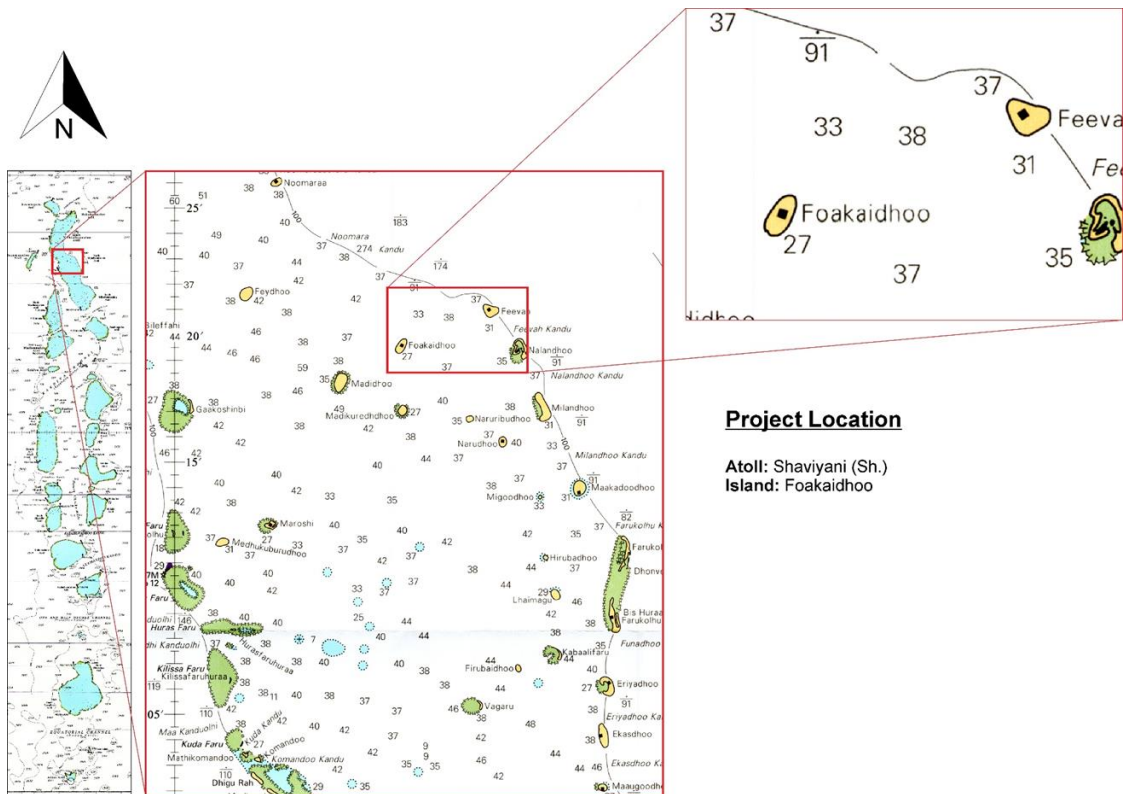


Figure 1: Project Location

Table 1: Key information about Sh.Foakaidhoo

Island Name	Sh.Foakaidhoo
Location	6° 19' 35" N and 73° 08' 57" E
Land area within vegetation	70.9 Ha
Length	1.05 km
Width (at the widest)	0.68 km
Distance to Male'	241 km
Nearest inhabited island and distance	Sh.Feevah which is 6 km to ENE

2.2 Justification for the project

The Government of the Maldives is devoted to ensure that all Maldivians have access to water supply services at an affordable price to the island communities. Water systems in the outer islands typically occurs with use of rainwater harvesting tanks at a public and private level along with tapping into the groundwater system. Water supply services are a major concern in many island communities. Increased groundwater salinization, demand by the community for higher levels of services, along with socioeconomic development, raised the need for immediate action to improve water supply services in the atolls.

Maldives is a country with a limited water resources. There is no surface fresh water resources in the Maldives, which make islands of the Maldives highly vulnerable for adverse impacts of climate change. Rainwater is the only available source of fresh water in these islands. Many islands suffer water shortage during the dry period. Due to small nature of the islands, storage capacity and catchment for rainwater harvesting is minimal. In addition, due to poor sanitation systems in the island, the groundwater has been polluted in many islands. Therefore, the government has been looking to provide a solution to provide safe drinking water to islands. The aim of provision of IWRM systems in these islands are twofold. Firstly to provide safe drinking water to islands and to create hubs in different regions to produce safe drinking water where these will act to provide drinking water to other islands during dry periods.

2.2.1 Current situation

Sh.Foakaidhoo is a small island where the land area accounts for only 22.60 hectare. Currently, the population of the island is 1,723. The main livelihood of the island is agriculture which requires fresh water to sustain. Due to this Sh.Foakaidhoo has a significant demand for clean water.

At present, every household has either one or two 2500 litre HDPE tanks to store rainwater. Water is collected in these storages without any prior treatment. Furthermore, the island has rainwater harvesting systems in community buildings to be used when the water is scarce. Existing community RWH system is at the following location:

- School
- Health center

- Island court
- Island office
- Mosque
- Sports building

Despite of these rainwater harvesting system operational in Sh.Foakaidhoo, the island has suffered water shortages during the dry period. According to National Disaster Management Center (NDMC), emergency water supplies has been provided for Foakaidhoo in the past. The Table 2 enlists the quantity of water emergency water supplied to Sh.Foakaidhoo between the year 2005 and 2016.

Table 2: Quantity of emergency water supplied to Sh.Foakaidhoo during the year 2005 - 2015 (Source: National Disaster Management Authority 2016)

Year	Quantity of emergency water supplied (Tons)
2005	30
2006	32
2007	20
2014	45
2015	45
2016¹	40

Based on this information, it can be inferred that Sh.Fokaidhoo is highly vulnerable for recurrent water shortage during the dry period and the island community is in need of a reliable drinking water sources.

There is no existing sanitation system in Sh. Foakaidhoo. Every household has a septic tank followed by soak pit for domestic waste water treatment and disposal. Sludge from the septic tank is disposed by the household to the site identified by the Island Council.

The following problems were identified during the preliminary design stage for the proposed IWRM project in Sh.Foakaidhoo;

1. The rainwater is collected in storage tanks without any treatment.
2. Storage capacity of the existing storage tanks are insufficient to meet the water demand of the island.
3. A large portion of the populations lacks access to safe drinking water.
4. There is no existing storm water drainage system in the island.
5. Public awareness is poor in terms of management during a water shortage.

2.2.2 Expected Benefits of the Project

The proposed IWRM project is aimed to address these problems and is expected to benefit the island community in Sh.Foakaidhoo in multiple ways. The proposed IWRM project will address

¹ Information provided by Island Council

the issue of water scarcity during the dry period. The proposed installation of the RO plants will increase the water security of the island. The rainwater harvesting, conveyance and storage systems will enhance the storage capacity of the island and contribute further for the water security of the island. The proposed commissioning of infiltration gallery would also enhance the water security and reduce reliance on one source of water.

2.3 The Project

2.3.1 The project outline and project site plan

The project mainly involves establishment of an Integrated Water Resource Management (IWRM) system in the island. The proposed project includes the following main components;

- Installation and operation of RO plants;
- Establishment of a rainwater harvesting collection and conveyance system;
- Deployment of a groundwater infiltration galleries;
- Construction of a piped water network with household connections.
- Storage tanks;
- Water distribution network.

The Figure 2 is a schematic diagram of the IWRM system proposed.

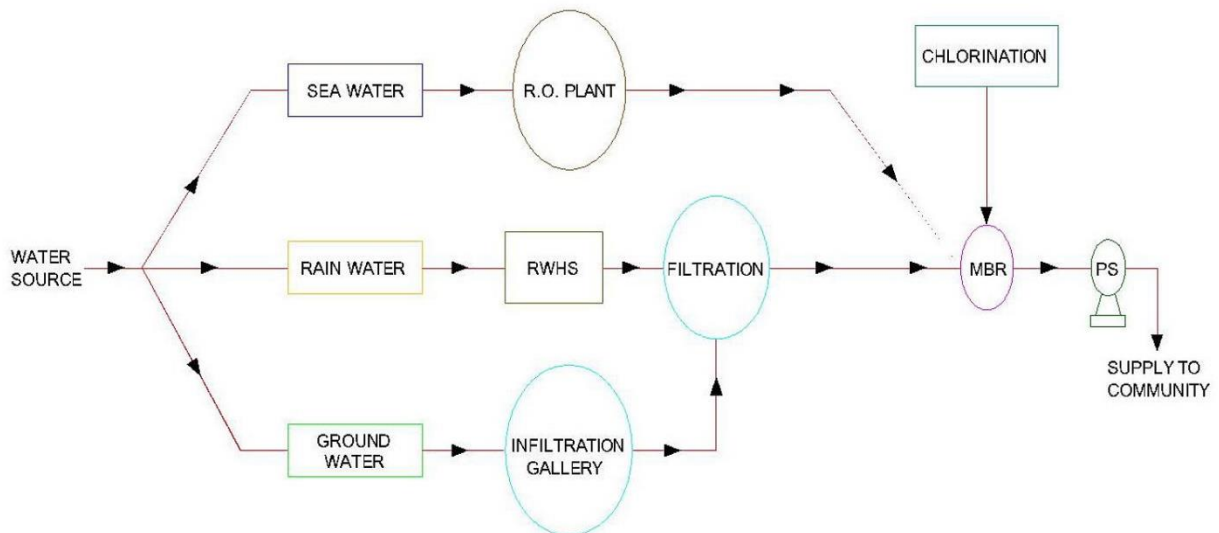


Figure 2: Schematic diagram for the IWRM system to be established in Sh.Foakaidhoo (Source: Ministry of Environment and Energy 2016)

2.4 Project boundary and impact zone

The project boundary is the whole of the island of with the lagoon area at the point of reject line. 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 at the reject line outlet which is shown in Figure 4.

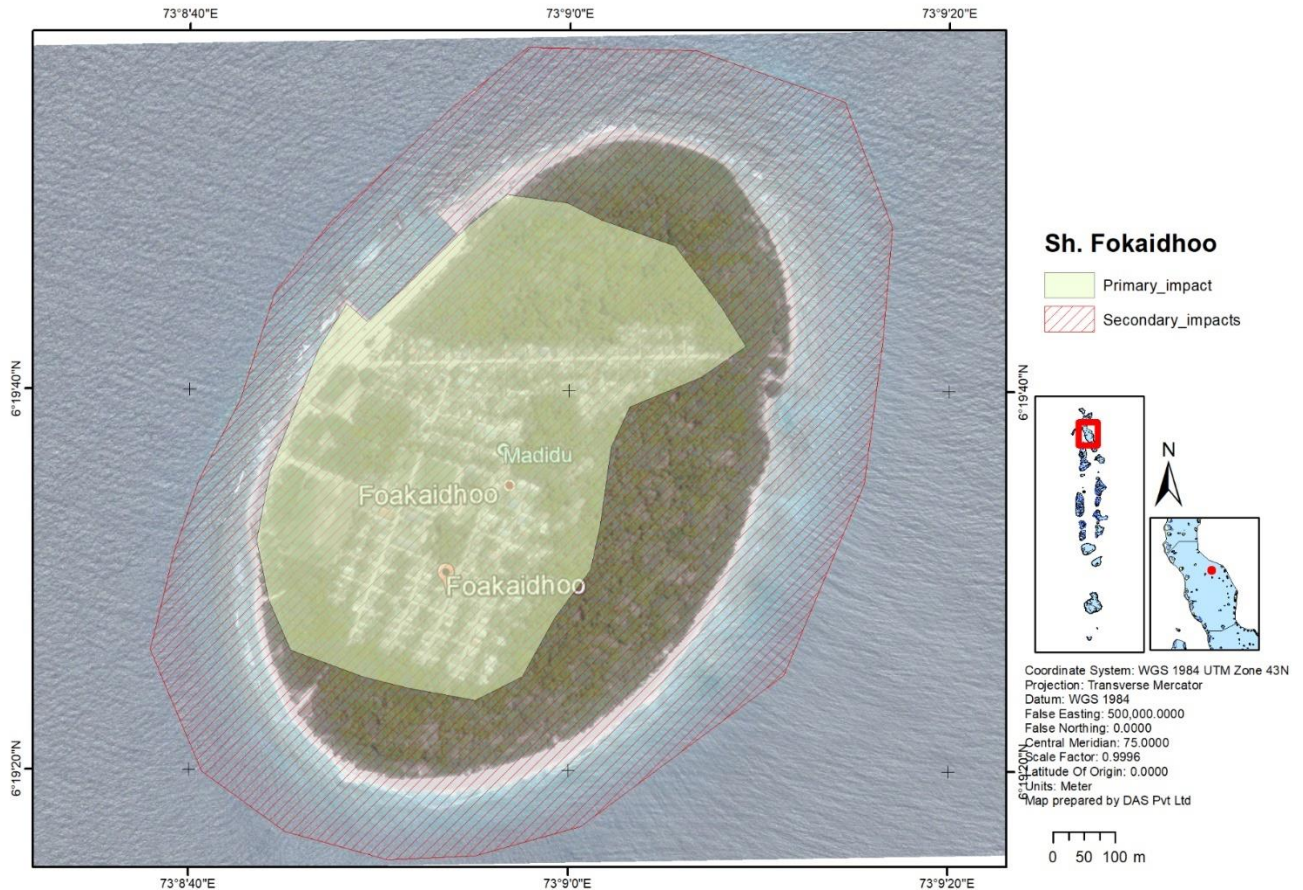


Figure 3: Project boundary with possible primary and secondary impact boundaries

2.5 Detailed Project Outline

2.5.1 Installation and operation of RO plant

The Reverse Osmosis desalination plant is the most appropriate technology for a project of this nature. Two RO plants are expected to be installed which will have the capacity to meet half of the maximum daily demand for the island. These RO plant will be utilized as a back-up water supply for the IWRM system.

The shortfall of the water demand will be met by utilizing the other components of the IWRM system including the community based rainwater harvesting system. The capacity of the RO plant is expected to be sufficient till the year 2045 for which the IWRM system has been designed. A new desalination plant of same capacity can be installed by 2045 if required. The capacity of the RO plant were planned and selected by taking into consideration the following;

- Rate of water supply for drinking and cooking purposes;
- Total quantity of water required per day (Ultimate stage - Year 2045);
- Maximum day demand factor;

- Maximum day demand (Ultimate stage) – Year 2045;
- Capacity of Each RO plant (Ultimate stage) – Year 2045;
- Total Capacity of RO plant (Intermediate stage).

RO plants will be assembled with all the necessary equipment and all the civil, electrical and mechanical works related to the same to ensure a fully functioning plant. Environmental Protection Agency (EPA) guidelines will be followed for installing desalination plant. All the regulatory permits for operation of the RO plant will be obtain from EPA. Table 3 provides the key features considered in choosing the RO plants.

Table 3: Key features considered for the RO plants

Rate of water supply for drinking and cooking purpose	20 Lpcd
Total quantity of water required per day (Ultimate stage) –Year 2045	0.071 ML/ Day
Maximum day demand factor	1.5
Maximum day demand (Ultimate stage) – Year 2045	0.108 ML/Day
Capacity of Each RO plant (Ultimate stage) – Year 2045	0.054 ML/Day
Total Capacity of RO plant (Immediate stage)	0.072 ML/Day
Provide two nos. of R.O. plant of capacity each (Immediate stage)	0.036 ML/Day

At the end of the project it has been decided the operation and maintenance of the system would be handled by FENAKA utility.

2.5.2 Feedwater for RO

Feedwater to the RO plant will be through two boreholes. One of these boreholes will be used as a backup. Borehole will be drilled by an experienced contractor using drilling equipment that can penetrate up to a depth of 30 to 40 m. This drilling will be done through sand and hard rock. Conductivity level will be monitored as the drilling is continued. Conductivity is used as an indicator to ensure fresh water is not damaged keeping conductivity level of 50 – 60 mS/cm.

2.5.3 Brine outfall of RO system

The Brine extracted during the desalination process will be discharged through a sea outfall. The location of the brine outfall will be constructed in the north-western side of the island (see Figure 4). This will be made of high density polyethylene (HDPE) of minimum class PN16. Diffuser will be installed at the termination point of the outfall.

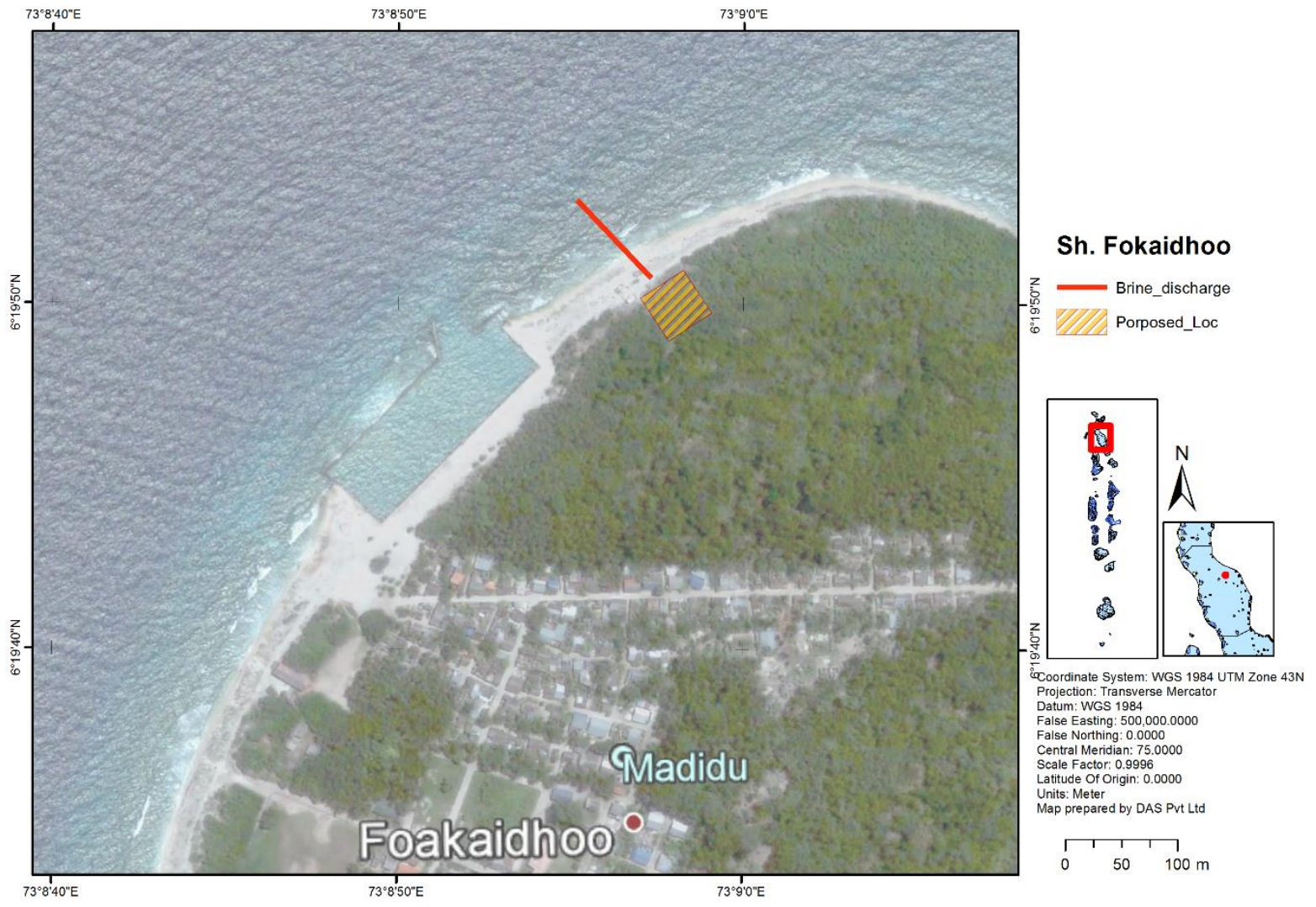


Figure 4: The proposed location for the brine reject outfall

2.5.4 Rainwater harvesting and conveyance system

The rainwater harvesting system is based on the following.

“Guidelines and Manual for Rain Water Harvesting in Maldives” published by Ministry of Housing Transport and Environment, Government of the Republic of Maldives Technical support, World Health Organization, Male, Maldives July, 2009.

Following parameters are considered in the design criteria:

- Rainfall data
- Runoff
- Roof catchment area
- Rainfall intensity

2.5.4.1 Catchment Area

The catchment area from the public buildings will be utilized for rainwater harvesting in the proposed IWRM system. The total catchment area to be utilized for rainwater harvesting is estimated to be 0.305 hectares. The Table 4 enlists the catchment area and their corresponding public buildings which will be utilized for the community rainwater harvesting system.

Table 4: The rainwater catchment area available for rainwater harvesting in public buildings of Sh.Foakaidhoo Island

Rooftop details	Area (Ha)
Adhalath Wing Office	0.011
Tauhid Masjid	0.011
Irnul Masjid	0.034
Pre School	0.021
Foakaidhoo school	0.103
Al Hidyaa Mosque	0.011
Council Office	0.016
Court	0.011
Health Centre	0.029
Guest House	0.012
Football Stadium	0.013
Sports Building	0.034

2.5.4.2 Runoff coefficient

The Runoff coefficient is the term used to measure the efficiency of a rainwater harvesting system. Runoff coefficient depends on the type of the roofing material used in the rainwater harvesting catchment. Rainwater can be collected on many surfaces. 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 5 shows the runoff coefficient of different types of roofing used in the Maldives.

Table 5: 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

2.5.4.3 Rainfall intensity

The rainfall data for Sh. Foakaidhoo Island is not available. Data from the Maldives Meteorological Service (MMS) recorded in Hanimaadhoo Station was used as a proxy. The rainfall data will be used to estimate the quantity of water available for rainwater harvesting. The Table 6 provides the average monthly rainfall for the year 2006 to 2015.

Table 6: The monthly rainfall data for the year 2006 to 2015

Month	Rainfall (mm)
January	26.1
February	31.9
March	49.8
April	50.3
May	214.2
June	216.0
July	237.7
August	228.9
September	179.3
October	203.4
November	142.2
December	147.8

The average monthly rainfall was found to be 144 mm. The yearly rainfall was found to be 1727 mm. From the aforementioned figures, it can be calculated that the potential rain water availability for Sh. Foakaidhoo is 4.477 ML per year.

2.5.4.4 Components of the Rainwater Harvesting System

Gutter and down take pipe

Common material used for gutters and take down pipes are either metal or plastic. Cement based product or bamboo or wood can be also used.

A leaf screen will be used to keep the leaves and debris from entering the rainwater system. This leaf screen will be made up of quarter inch wire mesh in a metal frame installed along the length of the gutter. The leaf screen can also be wire basket at the head of down spout. However, the gutter need to be cleaned at regular intervals.

First flush system

The first flush device will enable to flush away the first rainwater collected by the roof area. This will improve the quality of the rainwater since the roof area will be cleaned by the first rainwater.

For the proposed IWRM system, the first flush device is a manually operated bolt valve arrangement system.

Filter system

The runoff will enter the storage tank through a filter unit. The filter unit is a container or chamber filled with a medium such as coarse sand, charcoal, coconut fibers, pebbles and gravels. The chamber or container will have perforated bottom and the unit will be placed on the storage tank. Another simple way is to use a fine cloth as a filter media.

Slow sand filters are proposed for the IWRM project. Slow sand filters are an efficient method of producing good bacteriological and organic quality which requires marginal chlorination before distribution. The main advantages of slow sand filters include the following;

- Removes 99% of the bacteria and viruses in the water;
- Reduce color and odor;
- Oxidize ammonia and organic matter;
- Reduce turbidity of the water.

The slow sand filters work in two ways namely the deep sand bed and a surface coating filter which processes the water. The Figure 5, is a schematic diagram of the basic elements of a slow sand filter.

The Table 7 indicates the purification effect of the slow sand filters on different parameters of the water quality.

Table 7: Purification effect of the Slow Sand Filter on different parameters

Parameter of the water quality	Purification Effect of the Slow Sand Filter
Color	30% to 100% reduction
Turbidity	Less than 1 NTU
Fecal Coliform	99% to 100% reduction of the fecal coliform level
Viruses	Virtually complete removal
Organic Matter	60% to 75% reduction in COD
Iron & Manganese	Largely Removed
Heavy Metals	30% to 95% reduction

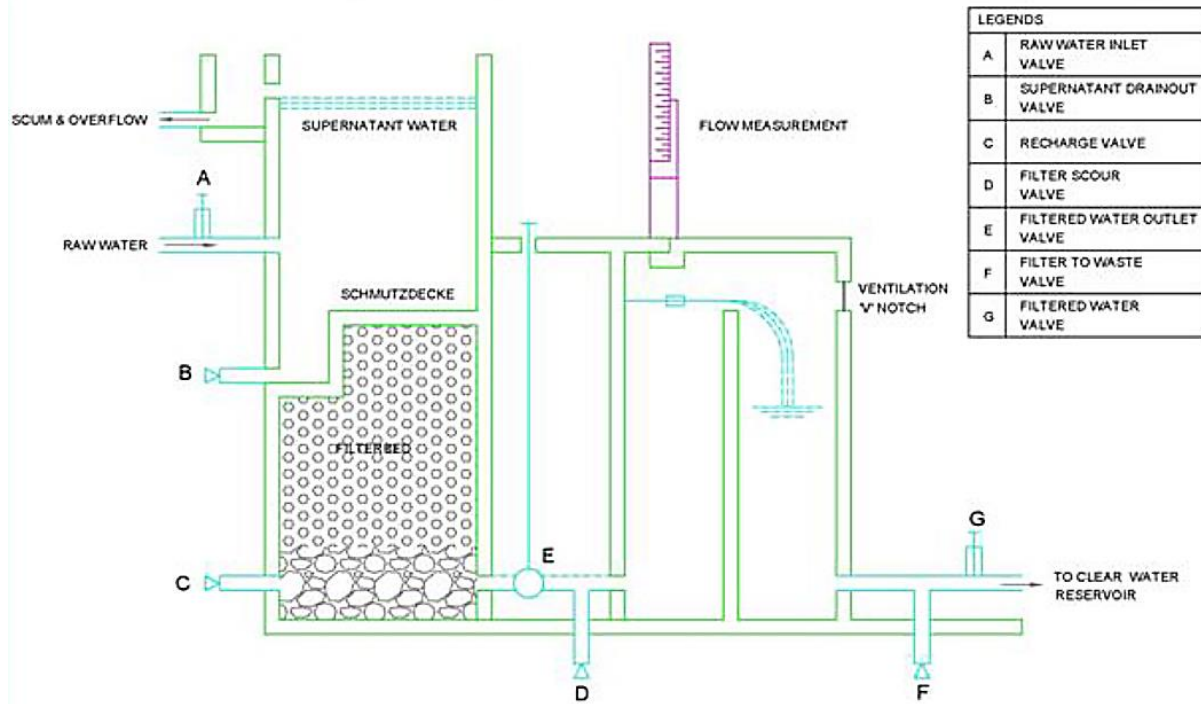


Figure 5: Schematic diagram of basic elements of a slow sand filter

2.5.5 Infiltration galleries and ground water

2.5.5.1 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 filter any large particles that might block the perforations.

Infiltration galleries will be used to collect or skim the surface water from the water table and laid just below the low groundwater 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 salinity meters 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 through the slow sand filter for further filtration and into a chlorination chamber for bacterial treatment before it is collected 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.

2.5.5.2 Design considerations of infiltration galleries

The length of the proposed infiltration system is 280m. Two infiltration galleries with a length of 140m 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 $0.25\text{m}^3/\text{day}/\text{m}$ of gallery and
- In the case of very fragile lenses; it should be less than $0.1\text{ m}^3/\text{day}/\text{m}$ 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 6 is an illustration of the arrangement of the proposed infiltration galleries and

Figure 7 is a cross-sectional diagram of the proposed infiltration gallery.

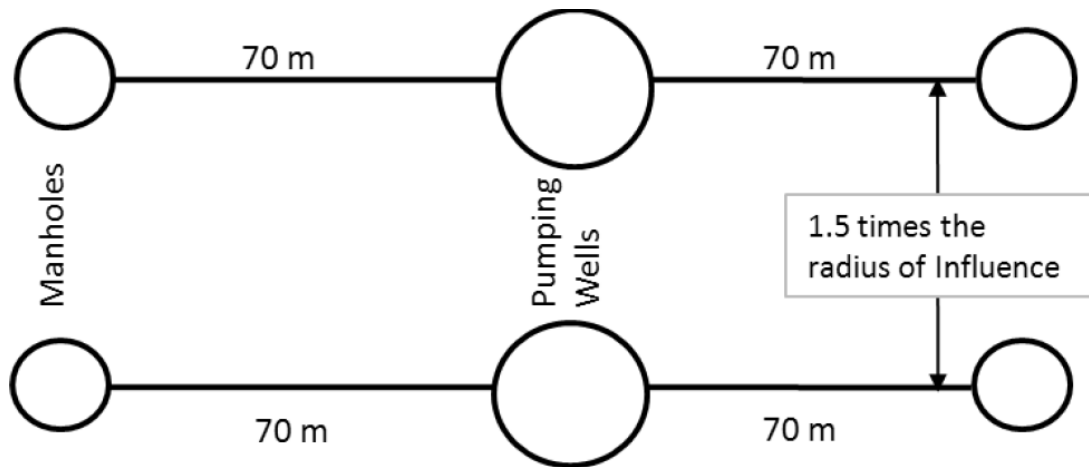


Figure 6: The proposed arrangement for the infiltration gallery including the manholes and the pumps

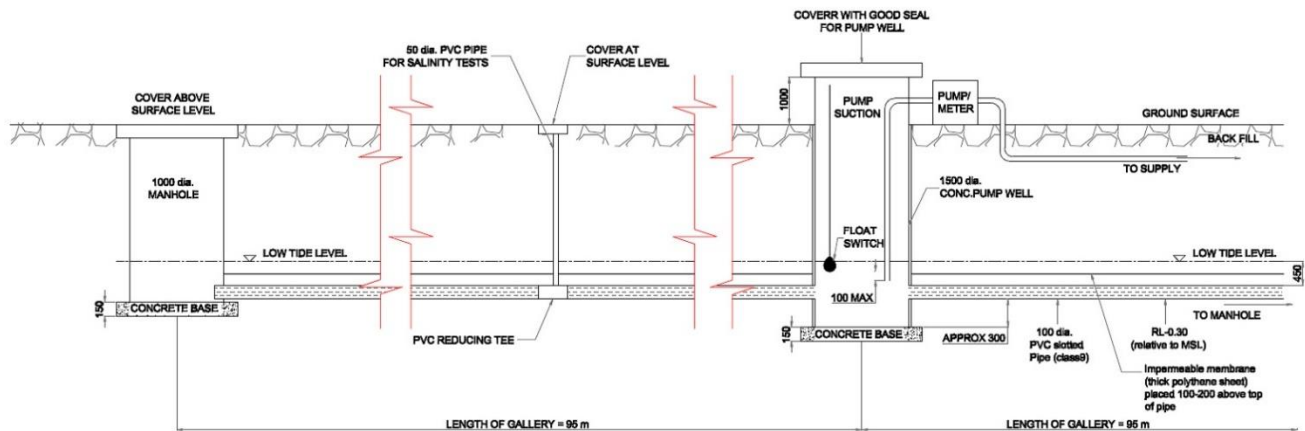


Figure 7: Cross-sectional diagram of the proposed infiltration gallery in Sh.Foakaidhoo

2.5.5.3 Engineering criteria's used in design

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

$$Q = k I A, \text{ where } k - \text{ permeability of soil}$$

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 / ($\pi \cdot D \cdot (H-h)$), 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.

2.5.6 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 x 70.9 ha = 31.905 ha

Assuming a recharge of 35%, and using the estimates above, a sustainable yield of approximately 61.19 m³/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.

2.5.7 Water storage and network system

2.5.7.1 Storage

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 25% 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 rainwater available can be calculated using the following equation;

$$= \text{Rainfall} \times \text{Roof area} \times \text{Collection efficiency} \times \text{Runoff coefficient}$$

Using the above equation, the water balance chart for Sh.Foakaidhoo was calculated. The Table 8 is the water balance chart for Sh.Foakaidhoo which includes water demand, average monthly rainfall, estimated rainfall collect and estimated surplus rainwater.

Table 8: Water balance chart for Sh.Foakaidhoo Island

Months	Water Demand (m ³ /month)	Average Monthly Rainfall (mm)	Rainfall Collected (m ³ /month)	Surplus (m ³ /month)
January	270.51	26.10	54.13	-216.38
February	270.51	31.90	66.16	-204.35
March	270.51	49.80	103.29	-167.23
April	270.51	50.30	104.32	-166.19
May	270.51	214.20	444.24	173.74
June	270.51	216.00	447.98	177.47
July	270.51	237.70	492.99	222.48
August	270.51	228.90	474.74	204.23
September	270.51	179.30	371.87	101.36
October	270.51	203.40	421.85	151.34
November	270.51	142.20	294.92	24.41
December	270.51	147.80	306.64	36.03

From the above water balance chart for the Sh.Foakaidhoo, the storage required for the Raw Water storage tank and the treated water storage tank can be calculated. The raw water storage tank was found to require a capacity of 800 KL and the capacity of the treated water storage tank was found to be 300 KL. This amount of storage is designed to ensure minimum 7 day storage.

2.5.7.2 Collection System Network

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.

A piped water network will be established to distribute the water from the community storage tank to the project site where it will be treated and stored in the treated water storage tank for distribution to households. Ground water from the galleries and desalinated water from the RO facilities will be connected via a different network to the storage facilities. The Figure 8 is a schematic diagram for the proposed collection system.

2.5.7.3 Water Distribution Network

The main purpose of a water distribution system is to transport treated water from the treatment facility to the consumers. The water distribution system was designed to meet the water supply needs of the Sh. Foakaidhoo Island in all the demand conditions. This includes both during emergency situations and dry period. In many islands of the Maldives where piped water networks have been established, water network are used for the secondary purpose of firefighting.

The drinking water demand is calculated based on a presumption that water required per capita for drinking purpose is 20 Litre per day. The total estimated water demand for Sh. Foakaidhoo was found to be 0.072 ML per day.

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 will be attached in the appendix A of this report.

2.5.8 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. The Figure 9 is the

schematic diagram for the project site. 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

2.5.8.1 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.

2.5.8.2 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.

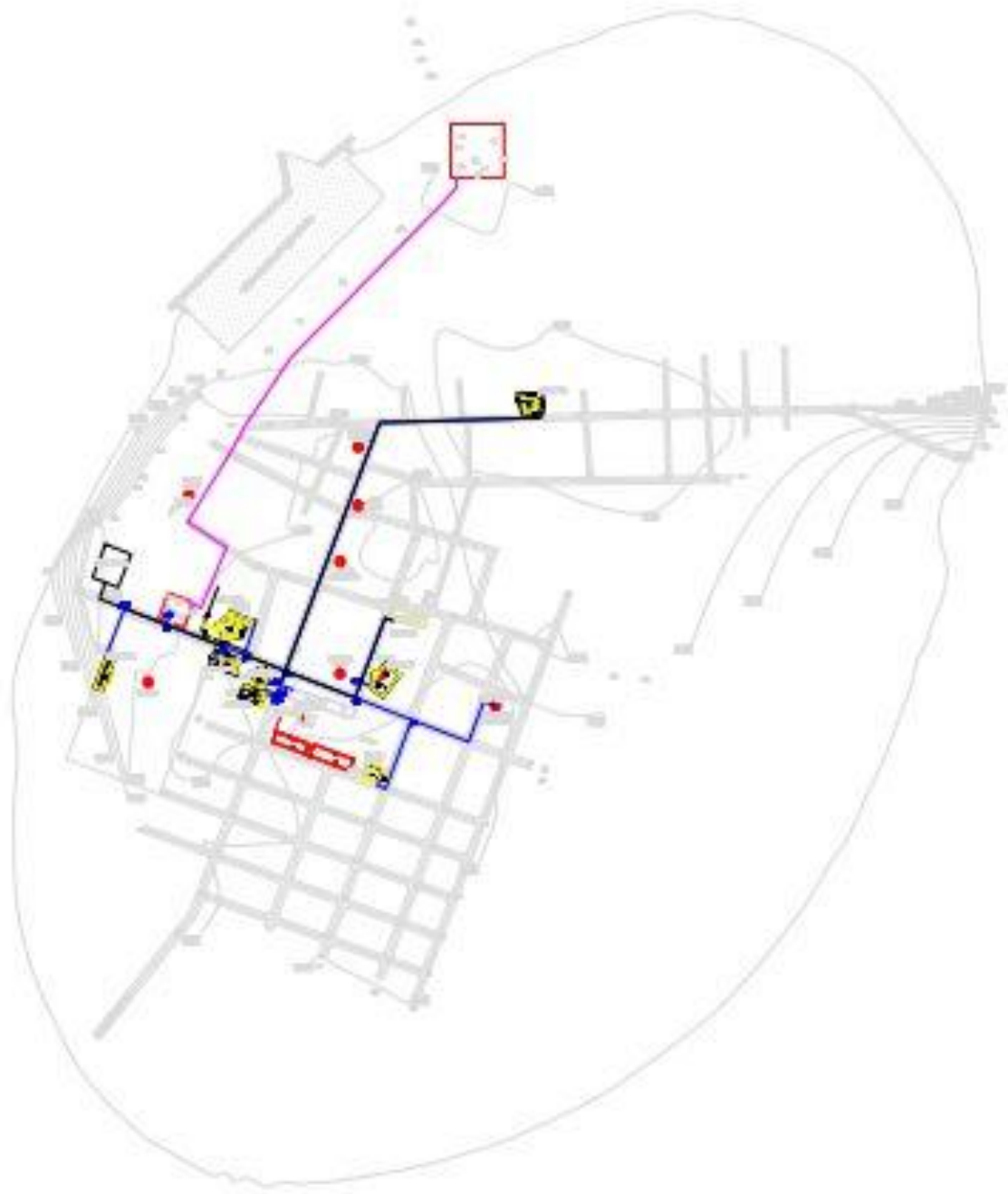


Figure 8: The proposed collection system for Sh.Foakaidhoo

2.5.9 Power Supply

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.

The diesel electricity generation is found to be the most cost effective way given the current petroleum prices. However, diesel power generation leads to emission of greenhouse gases (GHG) which contribute to global climate change. Furthermore, diesel generation leads to poor air quality due to exhaust fumes from fossil fuel burning.

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 m² 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 of Sh.Foakaidhoo lacks large public roofs or open areas and it is highly difficult to dedicate and area of 1500 m² 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.

2.5.10 Construction Phase Activities

The construction phase key activities include, site preparation for aforementioned project components, clearing of vegetation where the main buildings and desalination planned is proposed to be installed, land surveys for proper levelling, excavation for water network pipes, mobilization of materials and equipment, material transport, power generation facilities, construction of brine outfall and drilling of boreholes and staff mobilization.

2.5.10.1 Site Preparation

The preparation of the site is one of the most significant part of any infrastructure project. The site preparation includes fixing or dedication of a place (house) for construction and equipment storage, dedication of a secure place for administrative works, building of the operation building and material storage.

Furthermore, the following task will be completed prior to commencement of the project;

1. Identification of the exact locations for installation of RO plant, drilling of the bore holes, infiltration gallery, pump stations and storage tanks.
2. Conduct ground level surveys and build a level profiles for the piped water network.
3. Recruitment of the staff for site management and inventory the materials storage.
4. Clearance of the vegetation at the project site. The project site consists of an area of 2090 m². A detail description of the terrestrial environment for the project site will be provided in the existing environment section of this report.

2.5.10.2 Land clearance

The land plot allocated for the project site does have significant vegetation to be cleared. There are no mature trees or protected trees within the allocated space to be cleared. However, approximately 150 palm trees needs to be cleared from the site.

2.5.10.3 Mobilization of the Equipment and Materials

Mobilization of the equipment and materials involve transportation of the workforce, materials and the equipment required for the project to Sh.Foakaidhoo. The mode of transportation for all of the aforementioned item is via sea transport.

2.5.10.4 Workforce Management

Workforce management is one of the essential part for successful delivery of a project. For the proposed IWRM project at Sh.Foakaidhoo it is expected to recruit 20 staff including labourers, engineers and site supervisors. However, this number of staff can be subjected to change as currently the number of staff which will be recruited for the project is not known. As Sh.Foakaidhoo is a well populated island, the employees will be accommodated in the local houses or guest houses.

2.5.10.5 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 in Sh. Foakaidhoo is has thick vegetation, hence site clearance will generate certain 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.

2.5.11 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; and
- Certified chains and slings will be used at all times.

2.5.12 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 Sh.Foakaidhoo.

2.5.12.1 Brine Disposal

The reject brine concentrate from the desalination process of the seawater will be disposed to the north western site of the island outside the reef rim. 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 selected for brine outfall due to its potential to offer effective mixing during both monsoons. The current speeds of the proposed brine reject outfall has been discussed in the existing environment section of this report. This location offers the best conditions for mixing and hence will have the minimal impact of reject brine concentrate of the exiting marine environment.

2.5.12.2 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.

2.6 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.

2.7 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 be 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.

2.8 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 to 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.

2.9 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 be 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.

2.10 Risks associated with the project

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2.11 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.

2.12 Project Inputs and Outputs

The Table 9 provides a synthesis of major project inputs and outputs including how the resources will be sourced for the project. This synthesis is closely linked to identifying potential impacts of the project and recommendation of associated mitigation measures.

Table 9: The Major 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 system, RO plants, generator sets, waste management equipment, etc	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.
	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 in the Sh.Foakaidhoo
	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 ₂ eq/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 per day for the dry period of 90 days. 300 tonnes of water will be stored in treated water storage tank	Two 36 tonne RO plant will be installed.
	Brine	Two 36 tonne RO plant will produce 216 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	

The Table 10 is a matrix of the project output during the construction and operation of the project and their expected quantities and how waste will be managed.

Table 10: Main 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. Policy and Legislative Framework

3.1 Regulatory Consideration

Due to the multitude nature of activities that take place during the construction of IWRM system in Sh. Foakaidhoo, a number of laws, bi-laws and regulations that fall under the mandates of various government agencies come into play. This section highlights relevant national legislative framework applicable to the proposed project. The relevant national legislative framework provides guidance on several aspects related to planning, construction and operating a IWRM system in the Maldives. The legal frameworks pertaining to the proposed project are also aimed at sustainable development, impact mitigation and conservation of the country's natural resources. The main national legislative framework relevant to this proposed project and proposed compliance arrangements are summarized in the below;

3.1.1 Environmental Protection and Preservation Act (Law no. 4/93)

The Environmental Protection and Preservation Act is the main legal framework for environmental protection in the Maldives. This law is the main legal instrument requires all the development project which may have a significant impact on the environment undergo environmental impact assessment process. The EIA process is administered by Environmental protection Agency (EPA) on behalf of the Ministry of Environment and Energy.

Article 2 of the Environmental Protection and Preservation Act has given mandate for Ministry of Environment and Energy to formulate relevant policies and regulations to preserve and protect the environment of the Maldives. These regulations and policies which are relevant for the project has been discussed in this section.

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. As per the article the Ministry of Environment and Energy is responsible for developing relevant regulations responsible for administration of the EIA process in the Maldives. These include implementation of EIA process and quality assurance of the EIA system in the Maldives.

In order for compliance of this law, an EIA is carried out prior to the construction phase of this project.

3.1.2 Environmental Impact Assessment Regulation (2007), First Amendment (2012) and Second Amendment (2015)

The most significant regulation concerning the proposed IWRM project in Sh.Foakaidhoo is Environmental Impact Assessment Regulation (2007) under Environmental Protection and Preservation Act. This regulation includes all the regulatory guidelines for the EIA process in the Maldives.

The first amendment to the environmental impact assessment in 2012, outlined the prime EIA procedures to be conducted and the process which development projects which require EIA should follow. It also enlisted the project which will require an EIA study to be conducted prior to the commencement of the project.

The second amendment to the environmental impact assessment regulation in 2015, excluded tourism sector related EIAs as EIA process and procedures related to tourism sector development was included to the Tourism Act (Law no. 22/99). The second amendment to the environmental impact assessment regulation also included certain administrative changes to the EIA process in the Maldives.

However, since the proposed IWRM project in Sh.Foakaidhoo is a water and sanitation infrastructure project, an EIA study needs to be conducted in order to comply with this regulation.

3.1.3 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.

Desalination Regulation (2002) states that all sea water desalination plants installed and intended to supply water to 200 or more people or large scale agricultural needs or tourism related activity need to be registered prior to the operation of the plant. Therefore, it would be necessary to consider the impacts of desalination plant in this EIA so that registration can be done without further environmental scrutiny.

Desalination plant registration is required to be renewed every five years. Therefore, regular monitoring shall be ensured in order to carry out and efficient renewal process.

The Borehole Guideline, which came into effect in September 2011 is also of relevance to desalination projects. These guidelines provide the basis for installing boreholes in the Maldives.

A borehole will be drilled during the construction phase of the project and the aforementioned borehole guideline will be strictly followed during the construction and the operational phase of this project.

The proposed IWRM project will utilize two desalination plants hence the operators (currently unknown) will apply for operating license prior to operational phase of this project. Furthermore, the desalination plant will be registered in the EPA prior to operational phase of this project.

3.1.4 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 (Ministry of Environment and Energy) 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.

3.1.5 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.

3.1.6 Waste management policy

Ministry of Environment and Energy has developed a framework for a national waste management policy. The main components of this policy include safe disposal of solid waste, ensuring safe disposal of chemical industrial and hazardous waste.

Waste management of the proposed IWRM project in Sh.Foakaidhoo will be in line with the waste management policy.

3.1.7 Dewatering Regulation

The main objective of the Dewatering Regulation is to introduce and regulate measures to minimize the adverse effect on environment and ecosystem due to dewatering which may be carried out as an indispensable activity of construction works. The Dewatering Regulation states that any project which involves dewatering should be commenced upon approval of the EPA which is the implementing agency for this regulation in the Maldives. The regulation is not applicable for dewatering which may be required for the installation or cleaning of a groundwater well for personal use or groundwater utilized for agricultural purposes.

The proponent of such projects has to submit an application form to EPA with required documents prior to commencement of dewatering. It is mandatory for the proponent to inform relevant councils, any existing residential areas or agricultural land within 100 meters radius of the dewatering site. The regulation further provides guidance on what should be with the extracted water from the dewatering process and what actions should be taken if dewatering affects water resource users within a radius of 30 meters from the dewater site. Furthermore, the regulation

provides information on the fines applicable for proponents who does not comply with the dewatering regulation.

The proposed IWRM project will conform to the regulation, by first submitting an application to carry out dewatering within the project site. The proponent will also carry out all the additional measures necessary to obtain the approval for EPA and to abide by the regulation.

3.1.8 Regulation on cutting down, uprooting, digging out and export of trees and palms

The by-law on cutting down, uprooting, digging out and export of trees and palms states that the cutting down, uprooting, digging out and export of trees and palms from one island to another should only be done if there is an absolute necessity and no other alternative. It also states that for every tree removed two more trees should be planted in the island.

Removal of the following types of tree is totally prohibited under the by-law;

1. The coastal vegetation growing 15m from the shoreline and inwards toward the center of the island;
2. All the trees and palms growing in mangrove and wetlands spreading to 15 meters of land area;
3. All trees and palms that are growing in a designated protected area;
4. Trees which are protected by the government to protect animal species which lives in the tree;
5. Trees that are unusual in their structure.

The proposed IWRM project in the Sh.foakaidhoo will avoid removal of any tree protected under this by-law and will clear only few coconut palm trees which are in the proposed project site where the temporary construction site will be established.

3.2 International conventions, treaties and protocols

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

3.2.1 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”.

3.2.2 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.

3.2.3 United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC is the multilateral environmental agreement which deals with mitigation and adaptation for the climate change. Under the UNFCCC the main legal instrument was Kyoto Protocol which ended on 2015. A new climate agreement known as Paris Agreement was negotiated on the Conference of the Parties number 21 in Paris, France. Maldives has ratified the Paris Agreement and has a Nationally Determined Contribution (NDC) of reducing its business as Usual (BAU) by 10 percent by the year 2030.

The proposed IWRM project contributes to the emission of GHG due to fossil fuel burning. The potential for the Photovoltaics will be explored in order to contribute to the Government effort to fulfill the NDC outlined in the Paris Agreement.

3.3 Administrative Considerations

Due to the cross-cutting nature of the proposed IWRM project in Sh.Foakaidhoo and as can be seen from the governing legal framework of the developmental aspects water and sanitation infrastructure as described above, a number of governmental agencies have a stake in the Project. The most of important government stakeholders of the Project are the Ministry of Environment and Energy. The Ministry of Environment and Energy is given the prime mandate for development and regulation of water and sanitation facilities in the Maldives.

3.3.1 Ministry of Environment and Energy

The Ministry of Environment and Energy (MEE) is key Ministry in the government mandated with the protection of the environment. Environmental responsibilities assigned to MEE includes formulating environmental policies, coordinating, preservation and management of the environment throughout the country, and enforcing Environmental Protection and Preservation Act (EPPA) (04/93). Under Article 5(a) of EPPA, Environmental Impact Assessment (EIA) is mandatory for projects that may cause potential harm to the environment. The EIA report has to either submit to EPA and approval before commencement of a project. As per this legislation, any project that has any undesirable impact on the environment can be terminated without compensation by MEE.

Furthermore, MEE is mandated with development of water and sanitation facilities in the local islands in the Maldives.

3.3.2 Environmental Protection Agency (EPA)

EPA is the key regulatory body on environment, which is a semi-autonomous body formed under the umbrella of the MEE. It is mandated with implementing the EIA process in the Maldives, implementing the Environment Act and subsequent regulations on behalf of MEE, regulating water and sanitation, biodiversity conservation, waste management and coastal zone management. Also, it is responsible for developing environmental standards and guidelines in the country. EPA is also responsible for approving water and sewerage designs and registering RO plants.

3.3.3 Maldives Energy Authority (MEA)

The Maldives Energy Authority is an independent regulatory organization affiliated to the Ministry of Environment and Energy and operates under the guidance of a governing board. The mandates of MEA with regards to the proposed Project include setting the standards and operating the regulations for the administration and monitoring of this sector according to government policy on energy. It is also responsible for developing the regulatory code and standards on the production and use of energy in the Maldivian context, and developing and administering the regulation for provision of energy in the Maldives. MEA also issues permit to parties that wish to produce electricity for their own use, and monitoring such parties to ensure adherence to relevant regulations. Issuing permits to electric technicians and setting the standard for consultants and investigating issues between parties arising from non-compliance to the terms of agreements between providers and users of electricity are also among the mandate of MEA.

Since the proposed IWRM project involves operation of a diesel generator, any registration process will be done by the proponent prior to the operational phase of the project.

3.3.4 Island and Atoll Councils

The Shaiviyani Atoll Council was established under the Act on Decentralization of the Administrative Divisions of the Maldives (Law Number 7/2010). The Council has specific responsibilities with regards to the governing the projects and activities that fall within the jurisdiction of Shaviyani Atoll. Since the Council shall be accountable to the people of the Atoll, the Council has been involved in the preparation of the EIA report. A copy of the EIA report was submitted to the Atoll Council.

Sh.Foakaidhoo Island council is an important stakeholder of this proposed IWRM project. They are mandated with formulation of land use plans for their jurisdiction. They are also involved in the allocation of the land for different projects. The approval letters have been obtained from the island council for the project site and the letter has been attached in the appendix of this report.

4. Survey Methods

This section of the report will describe the survey methods used by the EIA consultant to collect and record the baseline environmental conditions associated with the IWRM project in Sh.Foakaidhoo. The following were 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

4.1 General Methodology of Data collection

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

4.2 Mapping and location Identification

The reef line, shoreline and vegetation line and existing infrastructure was mapped. Mapping was undertaken using standard DGPS and mapped on AutoCAD and ArcGIS. Figure 10 shows the locations of the terrestrial and marine samples were obtained

4.3 Marine Survey

4.3.1 Photo Quadrat Methodology

Photo Quadrat method was used to estimate the live coral coverage and the substrate composition at sample locations of the reef. CPCe software is used to assess the benthic substrate, which is one of the most widely used tools for marine assessments. 15 pictures were taken at each respective site from which 10 photos are chosen for analysis. CPCe used 25 points on each photograph to point out the substrate found at each point. The software calculates the percentage of each substrate for the 10 photographs. The method is repeated to take two transects at the outfall location. The locations of these transects are shown in the table and figure above.

4.3.1.1 Equipment

- 0.5 m² PVC quadrat
- 50 m transect tape
- Digital Camera

4.3.1.2 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. 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.

4.3.2 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)

4.3.3 Surface 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. The tracks are shown in Figure 10.

4.4 Terrestrial Survey

The flora at the project site was assessed using both qualitative and quantitative methods. The percentage cover of vegetation was determined using transect across the proposed project site. Visual assessments were also carried out.

4.5 Water Quality

The quality of the marine and ground water in the proposed development site was assessed by testing water samples at location in Figure 10. Samples were collected just below the water surface. Two ground water samples were taken from different areas of the island. 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. All water samples were into the water. Control sample was obtained from a location near the harbour. Water samples were tested from MWSC lab. The results are attached in the appendix.

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 Protection Agency with the involvement of the stakeholders. A focus group interview was conducted island community of Sh.Foakaidhoo. Public consultation and willingness to pay survey will be conducted prior to the operational phase of the project. A meeting was held in the Sh.Foakaidhoo council office regarding the proposed IWRM project. The findings of these consultations are described in a latter part of this report.

5. Existing Environment

5.1 General Settings

This section covers the existing environment of Sh.Foakaidhoo Island. The Island is situated in the northern shaiviyani atoll as shown in Figure 1. The island is approximately 1.05 km long and 0.68 km wide. The island has an area of approximately 70.9 hectares.

Foakaidhoo has a small reef system. The reef system is oriented in a NE-SW direction with the island also being oriented in a similar orientation. The island is enclosed by a small and shallow lagoon in all direction. The closest inhabited island is Feevah which is 6km in east north-east direction.

5.2 Locations of the survey

The following Table 11 is the geographical position of the surveyed locations. These coordinates were recorded so that they can be used during the monitoring surveys. The Figure 10 is a map showing different surveyed location enlisted in the Table 11.

Table 11: The geographical positions of the surveyed locations

Marine Transect		
	Latitude	Longitude
Marine transects		
M1	6.331596	73.148864
M2	6.331451	73.149258
Ground water		
G1	6.331596	73.148864
G2	6.331451	73.149258
Sea water		
S1	6.332038	73.149659

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 monsoons 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 12.

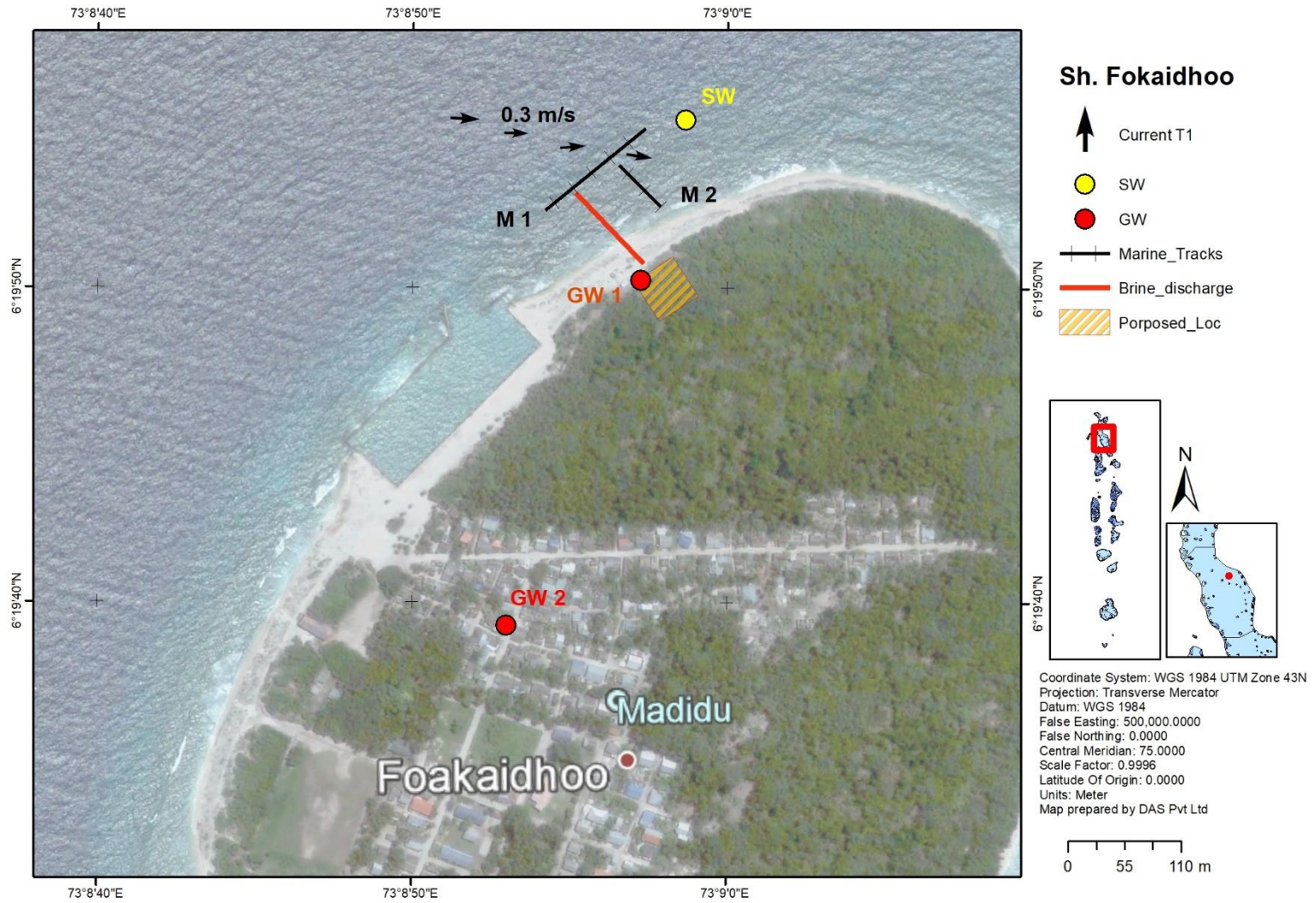


Figure 10: The surveyed locations for different environmental parameters

Table 12: Summary of the two monsoons

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

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 2003 to 2006. Figure below represents mean daily wind speeds and direction. It was determined that the winds from WSW to WNW is the dominant wind direction in the Southwest Monsoon, where wind from ENE and E was dominant during the North-East Monsoon. Wind determines the direction of the sediment movement and have an influence on the alongshore current patterns.

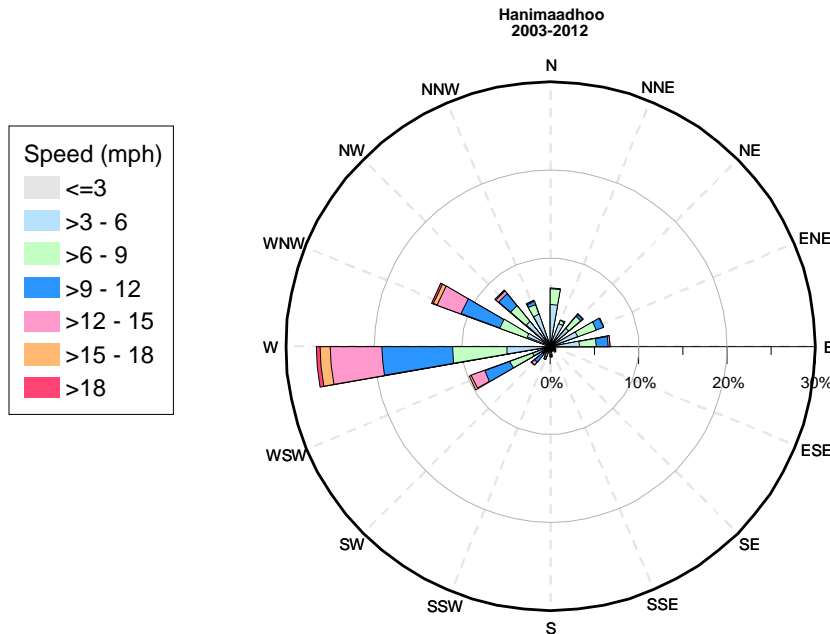


Figure 11: Wind speed and direction at Hanimaadhoo international airport

5.4 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 measured at the tide station in Hulhule was used to analyse the tide as in Figure 12. 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. The tide observed is mixed and dominantly diurnal in nature (Figure 12) according to the analysis which is a common characteristic of the tide observed in the Maldives.

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 on the sedimentation during the excavation process during laying of pipes.

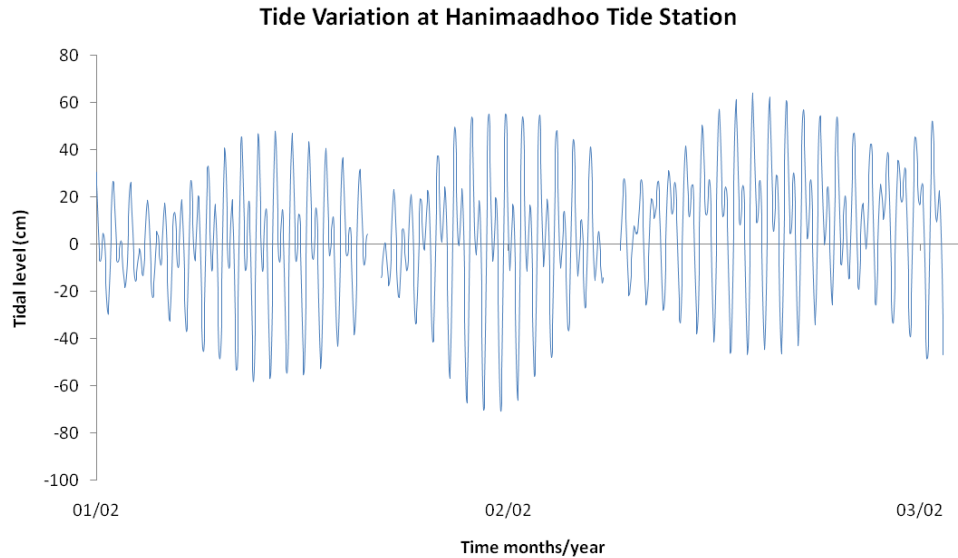


Figure 12: Typical tide at Hanimaadhoo tide station

5.5 Currents

Ocean currents play a significant role in sediment movement. Currents could be wind driven or tide driven. No site-specific currents were measured. 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 shown for the NE monsoon in Figure 13.

The long-term average current speeds during NE monsoon varies between $0.08\text{--}0.2\text{ ms}^{-1}$ which is typical current speeds around the island (Figure 13). However, it can attain speeds between 0.3 to 0.6 ms^{-1} in the SW monsoon. The current patterns at the time of the survey is shown in Figure 10.

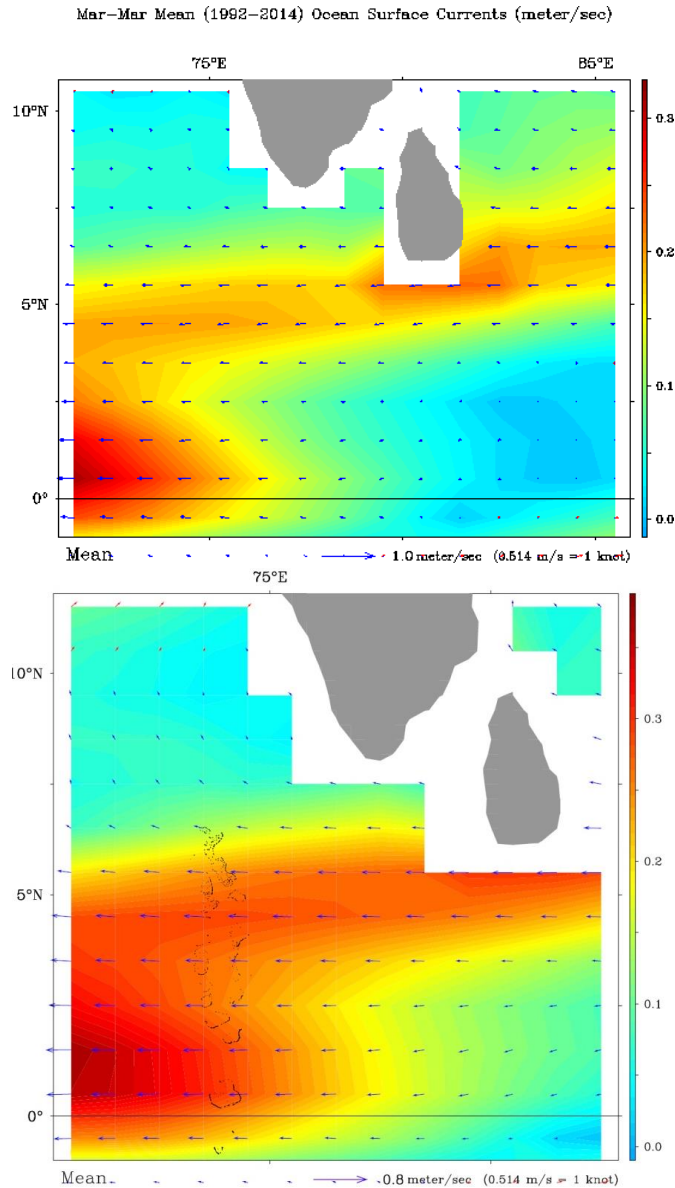


Figure 13: Average current regime around Maldives in NE monsoon (top) and SW monsoon (bottom).

5.6 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 (H_s) for the Male' region was 1.23m which a mean period (T_m) of 7.53s. Maximum H_s was 1.51 with a T_m of 7.74s.

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

5.7 Rainfall

During the South-West monsoon, from mid-May to December heavy rainfall is experienced to all atolls. The highest rainfall ever recorded during a 24 hour period was on 9th July 2002 at Kaadedhdhoo Meteorological office, which was 219.8 mm of rainfall.

Looking at rainfall data since 2000, heavy rainfall is experienced (between 200mm and 250mm of rainfall) from May to December. Lowest rainfall is between February and March, where rainfall is between 25mm and 80mm.

There is a considerable difference in the rainfall pattern between the North and the rest of Maldives during May to July and October to December. For North rainfall is higher during May to July which is at 250mm while for other areas 170mm of rainfall, during October to December rainfall for North declines from 225mm to 100mm while rainfall for other areas remains between 210mm and 240mm.

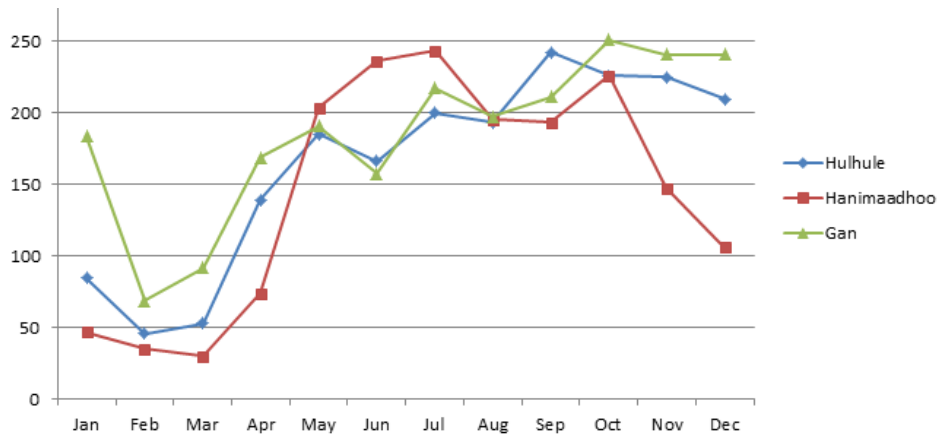


Figure 14: Rainfall (mm) data since 2000, adopted from the National Meteorological Centre

5.8 Temperature

As the Maldives consists of small islands surrounded by sea even hot days are tempered by cooling sea breezes and mild evening temperatures. Therefore thought the year there is little change in temperature. However the daily temperatures fluctuates between 31 °C in daytime and 23 °C at night. However there were rare temperature anomalies recorded; on 19th May 1991 the highest temperature ever recorded in Maldives was recorded at Kahdhoo Meteorological office - 36.8 °C and on 11th April 1978 the lowest temperature was recorded in National Meteorological Center- 17.2 °C.

Looking closely at the monthly maximum and minimum temperatures from four different meteorological centers, it becomes clear that there is a very small fluctuation in the maximum and

minimum temperatures throughout the year. However as expected there is a considerably huge variation in the maximum and minimum temperature for Hanimadhoo. From February to May, the minimum temperature for Hanimaadhoo rose from 24.5 °C to 26.5 °C.

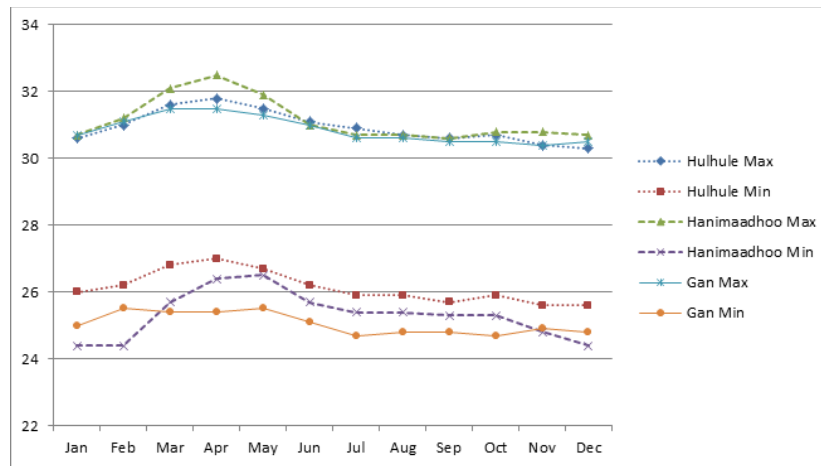


Figure 15: monthly maximum and minimum temperatures(°C) for Maldives throughout the year. Data since 2000, adopted from the National Meterological Centre.

5.9 Insolation

As the Maldives lie within the equator, receiving plentiful of sunlight everyday throughout the year. Highest insolation is received between February and April with a peak of 12 hours of daylight. For North, insolation is lower than for the other areas between May and July; 7 hours of insolation for North while for other areas the lowest sunshine was 8.5 hours. This will give plenty of sunlight for the operations of the solar PV.

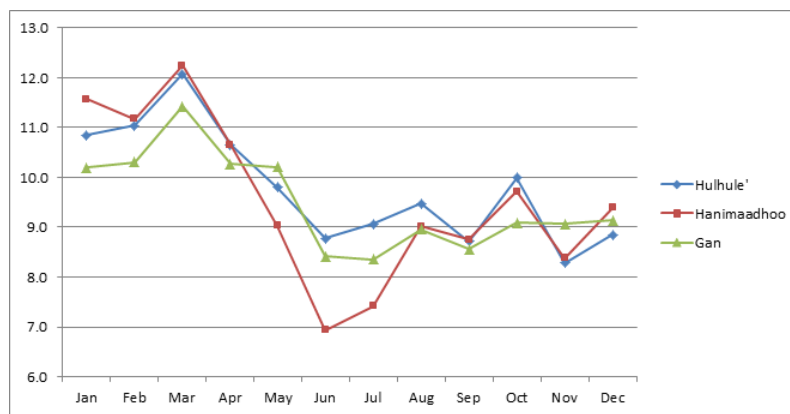


Figure 16: Average daily solar insolation (hours) for different areas

5.10 Marine Environment

Due to the nature of the project the marine environment which will be impacted due to project intervention will be described. The only project intervention which will impact the marine

environment is the proposed construction of a reject brine outfall. The survey locations of the marine transects can be found on the Table 11 and Figure 10.

5.10.1 Coral Cover

The surveyed location had a no live coral cover during the time of the survey. The coral cover has a some amount of dead coral with algae at the proposed brine reject outfall site. This may be due to eutrophication from the waste coming from the harbour area. The proposed brine reject outfall location (M2) had a macroalgae percentage of 8.89%. While location for proposed brine reject outfall pipe had a macroalgae percentage (M2) of 1.85%.

Sand/Pavement/Rubble (SPR) is the main composition of the coral cover in all the tree surveyed transects. The proposed brine reject outfall location (M1) had a SPR composition of 77% and the location for the proposed brine reject outfall pipe (M2) has a percentage of 94.8%.

The Figure 17 is a graphical illustration of the coral cover percentage at the three sampled transects. The apparent lack of life can be attributed to the recent development of harbour where the waste was use to reclaim part of land to make road for the area.

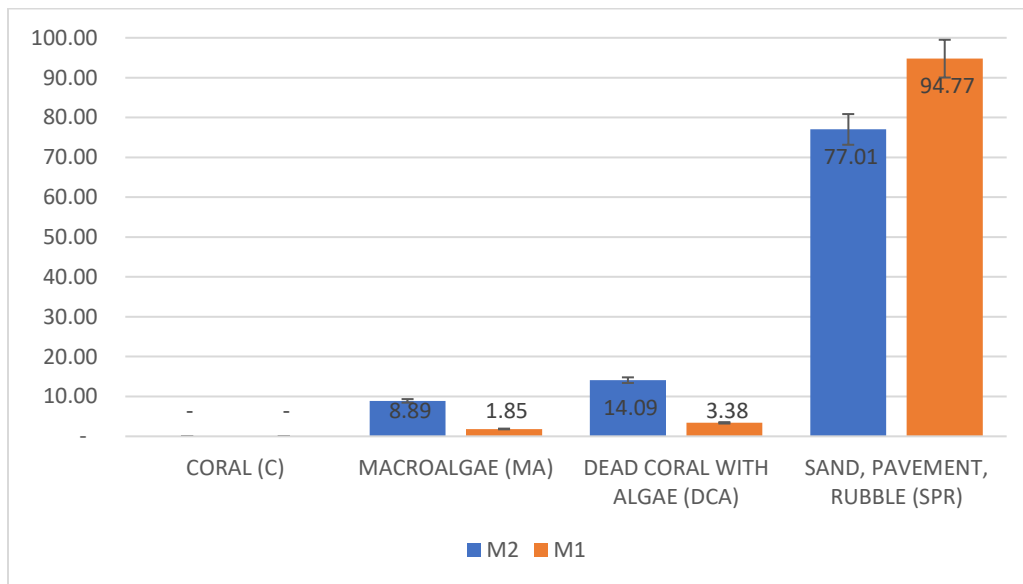


Figure 17: Coral Cover Percentage for the surveyed locations

5.10.2 Fish Population at the proposed brine reject outfall

The proposed location has very scarce fish population. The some species sited in the area includes *Acanthuridae* species and *Echeneidae Remora*. The Figure 18 is a picture taken during the marine survey at the proposed location for the brine reject outfall.



Figure 18: Coral cover and fish sitting at proposed brine reject outfall in Sh. Foakaidhoo

5.11 Terrestrial Environment of the project site

The proposed project site is in the north-western side of the island. This location is in close proximity with the solid waste disposal site on the northern side, the harbour in the western side and a wetland (also used as agricultural purposes) on the northern side. Due to close proximity to the wetland and the agricultural sites. The project site had large number of vegetation which may needs to be removed during the site preparation.



Figure 19: Sparely vegetated project site with few coconut palms

The main vegetation found during the, *Cocos nucifera* (Coconut Palm), with sparsely distributed mangroves ferns/shrubs (*Rhizophora* and *Bruguiera sp*) and few trees (less than 5) belonging to *Pandanus tectorius* (Boakashikeyo). The number of coconut palm which needs to be removed due to project interventions is approximately 132 coconut palms. According to Sh. Foakaidhoo Island Council, removal and transport process of the coconut palm can be arranged in coordination with a resort. All of the removed coconut palms will be used for landscaping purpose of a resort.

The Figure 19 are the pictures of flora found on the project site which needs to be cleared prior to the construction phase of the project.

5.12 Water Quality

Water samples were obtained from ground and locations from sea. The primary objective is to establish a baseline condition for the ground and 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 on the ground and marine water quality. All the test samples were tested at the MWSC laboratory. The results obtained from the MWSC laboratory were compared with Table 13 and Table 14 shows the ground water and marine water quality respectively. Original result sheets are attached in the appendix.

5.12.1 Ground water quality

The Table 13, is the parameters analyzed to determine the groundwater quality. Groundwater quality seems to be within the acceptable range for most of the parameters. Samples were obtained from the proposed project site where the borehole will be drilled and from the Harbour mosque in Sh.Foakaidhoo. A pH range from 7.82 – 8.31 was observed which is of typical ground water quality seen in Maldives as accepted by EPA. The electrical conductivity, TDS and hardness level is well above the the range which is acceptable by the Maldives EPA standards for drinking water.

Table 13: Parameter analyzed and the results for groundwater quality in Sh.Foakaidhoo

Parameter	Sample from Project (Proposed borehole location) – GW1	Well water from the main mosque – GW2	Maldives standards (adapted from RO plant registration form)
Physical Appearance	Clear with particles	Clear with particles	
Conductivity (µS/cm)	6350	4440	<1000
pH	8.31	7.82	6.5-8.5
Salinity (%)	3.46	2.36	
Temperature (°C)	21.2	21.1	25-30
Total Dissolved Solids (mg/L)	3180	2220	<500mg/l
Hardness, Calcium (mg/L)	405	300	
Hardness, Total (mg/L)	440	750	<150

Hardness in water is caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations (WHO 2017). According to WHO (2017), the taste threshold for the calcium ion is in the range of 100–300 mg/L, depending on the associated anion, and the taste threshold for magnesium is probably lower. The water sample taken from project site and well-water from main mosque was found to be 440 mg/L and 750 mg/L respectively which is well above the acceptable range of the Maldives EPA standards. The calcium hardness is at the upper range of WHO guideline for drinking water quality in the sample collected from the well in the main mosque. However, the calcium hardness is above the threshold level recommended by WHO guideline for drinking water quality in the sample obtained from the project site (proposed location of the borehole). The calcium hardness was 405 mg/L at the proposed location of the borehole. It was indicated by the island council that ground water situation in the island is less than desirable with ground water in most areas having a smell with some regions having a whitish colour to it during the dry season. Due to the salinity of ground water, rain water is used instead for irrigation and waste composting. They also highlighted that lack of proper sanitation system is a key source of pollution of ground water. The ground water is currently used for non-potable purposes like washing and flushing.

The groundwater quality at the project site would require significant improvement (particularly the hardness and salinity/conductivity) to use the proposed infiltration gallery. The use of IWRM however would improve the groundwater quality in medium to long term as it would lead to reduced extraction from groundwater, however. As for using groundwater as feed water, the untreated groundwater from the project site has fluctuated levels of hardness and pH, the reverse osmosis process and membrane filtration of the desalination process is expected to improve the quality of produced desalinated water. Furthermore, the water sample which was tested in the MWSC laboratory was obtained just 1 m below the ground level hence, the impacts of the contaminants is expected to be greater compared to water obtained from a borehole which will be around 30 m deep. The main expected reason for the higher hardness value is could be attributed to the construction waste being used to reclaim and make the road near the proposed project site. The proposed method of slow sand filter system is expected to improve the quality of the desalinated water and will be subjected to more scrutiny during the registration process of the desalination plant prior to operation.

5.12.2 Marine water quality

The Table 14 illustrates the results for parameters tested to determine the marine water quality. Marine parameters for the marine water sampled from the proposed brine reject outfall and alternative brine reject outfall location. A pH of 6.29 was found at the sampled locations at the proposed brine discharge location which is lower than EPA standard. Most of the parameters analyzed were within the acceptable range of the EPA standards. Only the temperature and the dissolved oxygen (DO) was out of the acceptable range. The values of the DO were found to be 7.88 mg/L. The acceptable values for DO according to EPA standards is 4 – 6 mg/L. The possible

lower value of pH and high value of DO may be due to high mixing resulting from disturbance of waves from the harbour and the wave surf zone in the proposed brine discharge location.

Table 14: The parameters analyzed for marine water quality near Sh.Foakaidhoo

Parameter	Proposed Brine discharge location	Maldives EPA standards (adapted from RO plant registration form)
Physical Appearance	Clear with particles	
Conductivity (µS/cm)	50700	35000 – 60000
pH	6.29	7.5-8.5
Salinity (%)	33.15	30-35%
Temperature (°C)	21.1	25-30
Total Dissolved Solid (TDS) (mg/L)	25300	15000-26000
Total Suspended Solid (TSS) (mg/L)	<5	
Turbidity (NTU)	0.317	
Total Alkalinity (mg/L)	109	
Dissolved Oxygen (DO) (mg/L)	7.88	4-6

5.13 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 within 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.

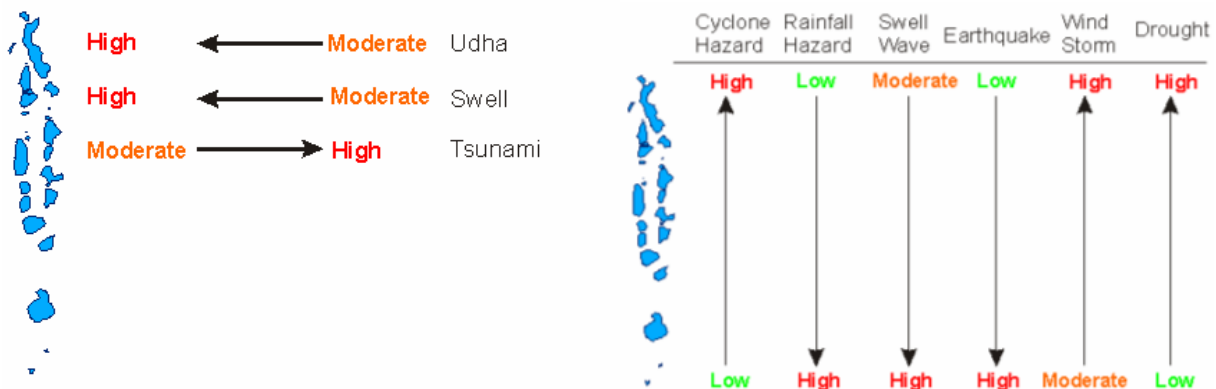


Figure 20: Latitudinal and longitudinal variations of major hazards across Maldives (Source: DIRAM 1, 2008)

However, according to the locals consulted and the council members there have been no reports of flooding in the island due to rain or even inundation during stormy weather. As the location of

the RO plant building is close to the coast there is risk of inundation due to storm surges. It was reported that there is severe erosion in different parts of the island.

5.14 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. Just adjacent to the project zone to the east, one of the ESAs do exist. This is an area of a semi-wetland with significant amount of vegetation. This is out of the demarcated boundaries of the land area given to the project. As the boundary is clearly marked, it is not envisaged that there would be any impact onto this area during construction and operation of the facility. There are no protected areas within close boundary to the project site.

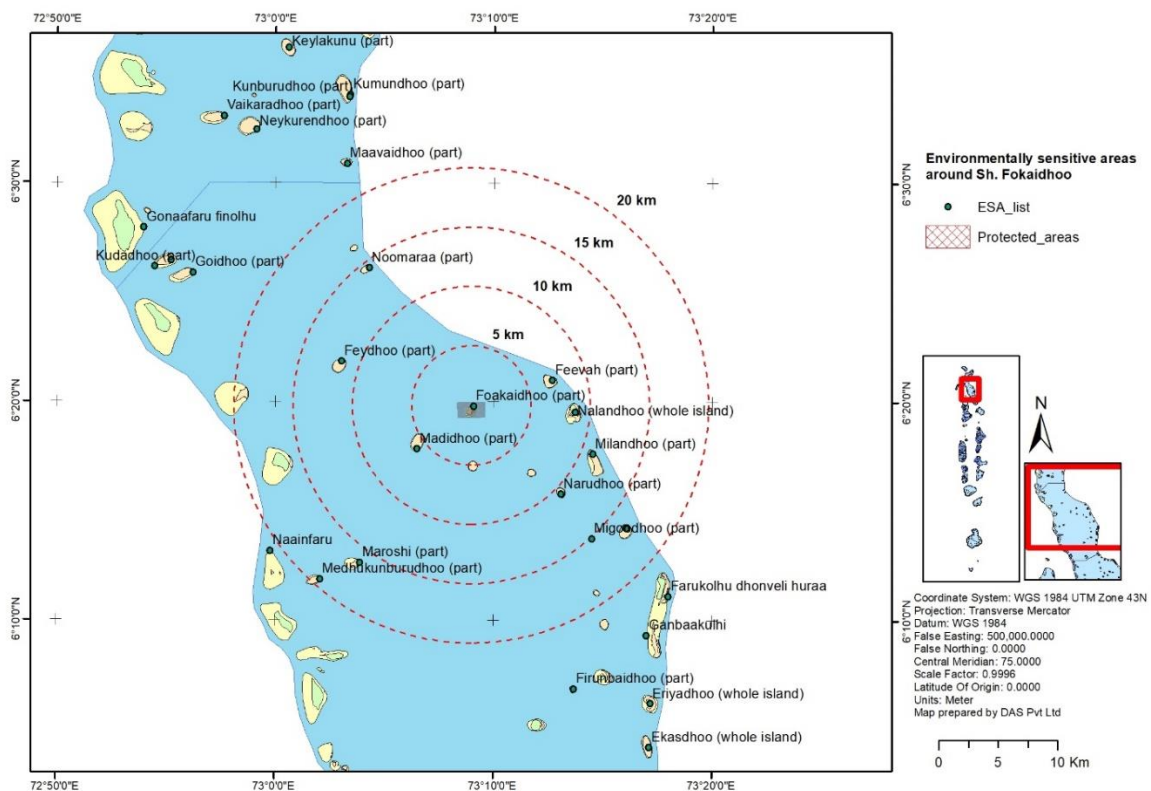


Figure 21: Environmentally Sensitive area near the project site (Sh.Foakaidhoo)

5.15 Socio-economic Environment

Sh.Foakaidhoo is a small island with a population of the 1723 and a small land area of 70.9 Hectares. The nearest airport island is located in HA. Hanimaadhoo which is 47km due north. In Shaviyani Atoll there are 52 Islands out of which 13 are inhabited. The capital of Shaviyani Atoll is Funadhoo. The population of the Atoll is 12636.

Sh.Foakaidhoo have some basic infrastructure such as solid waste management system, island council office, two schools including a pre-school, three mosque, magistrate court and health centre.

5.15.1 Population

According to the Sh.Foakaidhoo Island council, the residential population of the island was 1723 in the year 2016.

5.15.2 Employment

The major economic activities of the Sh.Foakaidhoo Community are fisheries, agriculture and construction works. A vast majority of the male population work in the Yellowfin Fisheries. Several people also work in fixed salary jobs in the civil service and resorts while some others make an earning thatch weaving.

5.15.3 Health

Sh.Foakaidhoo island has a health centre with primary health care facilities. Sh.Foakaidhoo health centre has the service of a doctor and a nurse. However, the basic facilities such as blood transfusion, E.C.G, laboratory services, ultra-sound scanning, x-ray is lacking. The quality and availability of services are still a concern for most of the people who visit the health centre. Regional Hospital is located in Sh. Funadhoo where most of the people travel for medical purpose. There is only one pharmacy operated in the Island by the State Trading Organization (STO).

5.15.4 Water and Sanitation



Figure 22: Public rainwater harvesting and distribution systems present at Sh.Foakaidhoo

There is no existing community water supply system in Sh.Foakaidhoo. The island community depends upon the rainwater harvesting as a mean of potable water. Many households in the island have one or two HDPE tank of 2500 Litres. The council do provide additional tanks on loans for those who requests every year. There are 16 community based rainwater storage tank which are

used to store rainwater collected from roof top catchment of public buildings in the island. The capacity of these storage tanks varies from 5000 litres to 10,000 litres.

There is no sewerage system in the Island. A septic tank system is currently been used in the household level and in public buildings.

5.15.5 Housing

The residential housing is mostly made up of cement bricks or coral and limestone. Most of the houses are single-story and few houses are two-story buildings.

5.15.6 Education

Sh.Foakaidhoo school is a government owned school in which students are taught to the Cambridge GCE O' level. Students can choose from the Commerce stream or the Science stream from the grade eight standards. Most of the teachers employed in the school are expatriate teachers either from India or Sri Lanka. There is shortage of qualified skilled local teachers.

5.15.7 Energy Generation and utilization

Sh.Foakaidhoo has a power station operated by FENAKA Corporation. Electricity is provided to all households and community buildings on monthly tariff basis. The power station has 3 generator sets (two 250kW generators and one 200kW generators). The powerhouse consumes approximately 349 kl of diesel to produce 973MWh annually. Almost all houses of the island use LPG for cooking. LPG is supplied by local traders.

5.15.8 Solid Waste Disposal

A plot has been allocated for the solid waste disposal in the northern side of the island although this plot is not currently used. It has to be noted that this plot allocated to the solid waste disposal is in close proximity with the proposed location for the project site.

5.15.9 Telecommunication

No land line telephone facility is available in the island except for schools, island council, magistrate court and health centre. However, the island has mobile telephone service is available via two mobile operators; Dhiraagu and Ooredoo Maldives on their respective 3G networks. Mobile credit recharging and prepaid cards are available in the shops. Televisions sets and radio sets are available in almost all the households of the island. Cable TV network facility is available in the island and most of the house hold subscribe this service. Internet facilities are available island-wide.

5.15.10 Transport

For land transport purpose, bicycles and motorbikes are widely used in the island. There are few other vehicles used in the island. These include car, pick-up trucks. These vehicles are used for carrying goods and construction material. There are no ambulances in the island. There are many sea vessels in the island, most of which are Yellowfin tuna fisheries.

The main access to the island is via the harbour. However, council indicated the island harbour is unusable during the wet-season due high wave action. Therefore, most of the time of year vessels are kept out of the harbour for safety.

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 15. Impacts are also described as associated, those that will occur, and potential, those that may occur;

Table 15: 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.
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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 16. Once an assessment is made of the magnitude and likelihood, the impact significance is rated through a matrix process as shown in Table 17. For ease of review, the significance rating is colour-coded in the text according to Table 18. Outlined in Table 19 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 16: 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.

	<p>Medium: where the affected environment is altered but natural functions and processes continue, albeit in a modified way.</p> <p>High: where natural functions or processes are altered to the extent that it will temporarily or permanently cease.</p>
	<p><i>SOCIO-ECONOMIC ENVIRONMENT</i>: Intensity can be considered in terms of the ability of project affected people/communities to adapt to changes brought about by the project.</p> <p>Negligible: There is no perceptible change to people’s way of life.</p> <p>Low: People/communities are able to adapt with relative ease and maintain pre-impact livelihoods.</p> <p>Medium: Able to adapt with some difficulty and maintain pre-impact livelihoods but only with a degree of support.</p> <p>High: Those affected will not be able to adapt to changes and continue to maintain pre-impact livelihoods.</p>
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 17: 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 18: Significance Color Scale

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

Table 19: 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 judgement 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 20 predicts the nature and types of environmental impacts based on the existing environmental condition of the islands and the surrounding environment.

Table 20: 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	No significant impact	Turbidity will increase in the lagoon hence deteriorating seawater quality	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	Divers and snorkelers maybe employed from the island for	No significant impact

	and increase in turbidity of the coastal environment		for a short period of time.	population in the vicinity		recreational swimmers in the lagoon.	brine 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 increase 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 workforce may be 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	No significant impacts	Increase of workers will contribute to air pollution and noise minimally.	The expatriate workers and 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.	The influx of expatriate and workers from other islands will contribute to congestion of the island	Expatriate workers and workers from other island will decrease the chance of employment for residents of the islands.	No significant impact
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 including	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.			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 location for the brine reject	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 current speeds. However, the proposed	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 generally used for reef fisheries	No significant impact	No significant impact	No significant impact

	outfall has a high velocity current which will enable adequate flushing of brine as well as low coral cover		location for the brine reject outfall has a high velocity current which will enable adequate flushing of brine.					
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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;

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

4. 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;

1. 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;
2. 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;

1. Accidental damage may occur to the corals from barges and other machineries;
2. Poor handling and management of diesel and other fuel often lead to contamination of the groundwater aquifer;
3. Accidental spillage of the fuel will degrade the sea water quality;
4. Localized noise pollution at the project site. However, this noise levels will be short term and only during the construction activities.
5. 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 increase 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;

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

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

1. Locals can be employed for land clearance purpose.
2. Compensation would need to be paid for the palms that is privately owned or used for economic activity.
3. 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 along with the current contamination from sewage and agricultural chemical used 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 impacts 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 21 is an impact analysis table. From the Table 21 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 21: 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 need to 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 unfavourable
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. Alternatives

This section includes some alternative 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.

8.1 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 inadequate 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.

8.2 Alternative Locations

8.2.1 Location of the project site

The Figure 23 shows the proposed and alternative location of the water treatment plant. Location was identified using island Land Use Plan and based on the community consultation. Alternative location of the treatment plant is close to the community which might have negative impact to inhabitants due to the noise and air pollution. In addition to that brine outfall location is far from the treatment plant. Additional cost would be added to the project. Hence this option is not recommended.

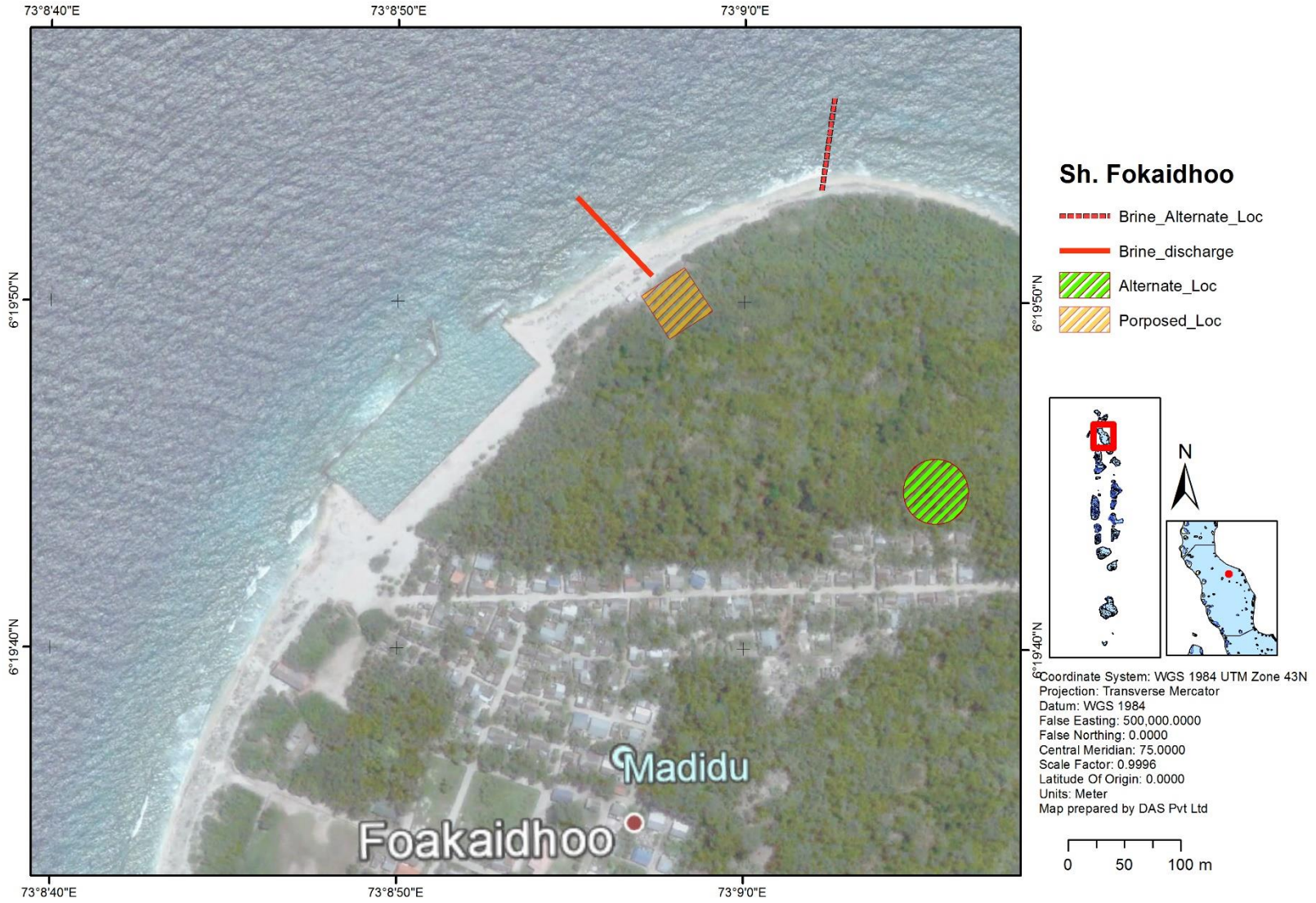


Figure 23: The proposed alternative locations for brine reject outfall and project site

8.2.2 Location of the brine reject outfall

The Figure 23 also shows the alternative brine discharge location. This location is far from the treatment plant and have high vegetation cover. Laying pipe line at this location need to clear large area of the thick vegetation. Hence puts high stress to the terrestrial ecosystem. 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 existing location.

Comparably short pipe line and less vegetation need to be cleared for the recommended location. At the discharge location no coral cover is observed at recommended location, discharge amount is comparably less and has good mixing ratio for both seasons, thus the impact is minimal.

8.3 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.

8.4 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.

8.5 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.

8.6 Alternative Water Treatment

8.6.1 Aeration

Aeration 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.

8.6.2 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.

9. Stakeholder Consultation

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

9.1 List of Stakeholder

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

- Sh.Foakaidhoo Island Council
- Shaiviyani Atoll Council
- Fenaka Corporation
- Project Proponent (MEE)
- Ministry of Housing and Infrastructure

9.2 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 Sh. Foakaidhoo Island Council, Fenaka Corporation, and informal communication Shaiviyani Atoll Council.

9.3 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 in Sh.Foakaidhoo.

9.3.1 Environmental Protection Agency

EPA is one of the key stakeholder of the project as they are the regulatory agency for the water and sanitation sector in the Maldives. As the regulator, EPA will be responsible for the approval of the detailed design. EPA is the administrator of the EIA process for development projects other than resort development. The scope of the EIA was determined in discussion and agreement with EPA.

9.3.2 Sh. Foakaidhoo Island Council

Sh.Foakaidhoo Island Council is a key stakeholder of the project. The island council was met during the field visit for data collection. The different aspects of the project were discussed with the island council. The report will be shared with the island once the report is completed for their comments and inputs.

9.3.3 Island Community of Sh. Foakaidhoo

The key beneficiary of the proposed IWRM project at Sh.Foakaidhoo is the island community. The key findings of the EIA study will be shared with the island community through island council and the representatives of the community groups. Arrangements will be made via island council to provide a copy of EIA report for any resident upon request.

9.3.4 Shaviyani atoll council

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

9.3.5 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.

9.3.6 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 starting 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.

9.3.7 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.

9.4 Summary of key outcomes

9.4.1 Foakaidhoo Council

Date: 19th March 2017

Time: 10:00 to 11:00 am

Type: Formal Meeting

- Water supply system is a key priority for the island along with sewerage system.
- In addition to water and sanitation issues, the island also faces following issues,
 - erosion problem with sea encroaching towards the farms,
 - harbor not being safe during wet (rough) season
- These needs are already shared with the relevant ministries.
- The island also experienced swell flooding early this year causing significant damage to agricultural produce.
- Indicated the importance of water source for healthy community and enhancing islands economic activities (fisheries and agriculture) on the island
- Island has faced shortage of water for the last three years (2014,2015,2016)
- Saltwater intrusion and sewage contamination from soak pits is a key issue faced by the groundwater aquifer in the island and expressed grave concern about the current situation of the aquifer.
- The island council approves the location for the proposed project site and brine reject outfall.
- The council highlighted their potential plan to transfer the palms to a nearby resort when the site is cleared to pay for the compensation to be paid.
- The council also indicated that public hasn't been formally informed on the details of the project, however there is a general understanding that there will be cost to the service and public generally are willing to pay a reasonable price.

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

Name	Designation	Contact
Mohamed Rasheed	Council President	9795353
Ahmed Asif	Deputy Councilor	9999689
Ahmed Hameed	Council member	7790805
Aishath Sizee	Economic Division officer	7888506
Ali Nizaar	Deputy Director	7884487



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 inconsistency 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 24.

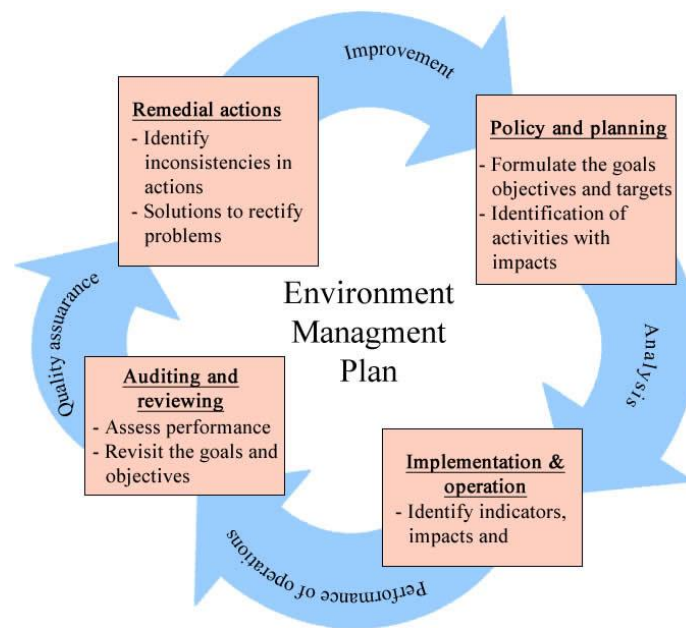


Figure 24: Schematics of the environmental management plan

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 FENAKA.

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 22: *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. Summary and Conclusion

Following are the summary and conclusions with regards to the proposed IWRM project in Sh.Foakaidhoo;

- The project has been proposed by Ministry of Environment and Energy to develop and operate an Integrated Water Resource Management (IWRM) water supply system in Foakaidhoo Island in Shaviyani atoll.
- The proposed project involves piped water network, installation of a RO desalination plant, deployment of a groundwater infiltration gallery and construction of a piped water network with household connections.
- As a result of the proposed project during the construction phase it is expected to have turbidity of lagoon and direct damage to coral due to installation of the brine reject outfall, excavation and pipe laying activities is expected to impact the groundwater for a short period of time.
- During the operational phase of the proposed project the main impacts predicted include the impact on the marine ecosystem due to brine disposal and impacts due to operation of pumps and RO plants.
- The proposed mitigation measures include carrying out the installation of brine reject outfall during the low tide, ensuring proper monitoring and supervision during the excavation and pipe laying work and installation of a diffuser system in the brine reject outfall to ensure that the reject brine concentrate will be effectively dispersed.
- Some alternative locations for the project site (including the site for desalination plant installation and drilling of borehole) and the location for the brine reject outfall have been proposed. Based on evaluation, it was found that the proposed project site and the location for the brine reject outfall is the preferred option.
- Environmental monitoring during both construction and operation stages has been given serious consideration in order to assess the degree and magnitude of environmental changes in the biophysical environment, through a follow-up monitoring of established baseline data.
- 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 out to see the possibility of using the technology.
- During construction, monitoring of construction will be undertaken once and during operation monitoring in every 6 months will be undertaken.
- Although there are some environmental impacts from the proposed project, most of these impacts can be reduced and mitigated by use of appropriate methodology and timing.
- The effectiveness of these methodologies can be documented by implementing a comprehensive monitoring programme. Also, with the need of the project to provide the population of Sh.Foakaidhoo with safe and secure water supply, it is concluded that the project should go ahead as proposed.

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Appendix A – Terms of Reference



No: 203-EIARES/438/2017/79

Terms of Reference for Environmental Impact Assessment for Establishment of an Integrated Water System in Sh. Fokaidhoo

The following is the Terms 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 **Sh. Fokaidhoo**. 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);

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvaareeHingun
Male, Rep. of Maldives, 20392

Tel: [+960] 333 5949 | [+960] 333 5951
Fax: [+960] 333 5953

1 of 6

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20392 ވަނގަވާއިދު ހޯއްދެވުމަށް
އިތުރު މަޢުލޫމާތު
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv



- 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 requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

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:

Environmental Protection Agency

Green Building, 3rd Floor, HandhuvaareeHingun

Male', Rep. of Maldives, 20392

Tel: [+960] 333 5949 [+960] 333 5951

Fax: [+960] 333 5953

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ދިވެހިރާއްޖޭގެ ބިޔަފުޅު ދަންނަވާ ޖަމިއްޔާއި ދިވެހިރާއްޖޭގެ ބިޔަފުޅު ދަންނަވާ ޖަމިއްޔާ

ދިވެހިރާއްޖޭގެ ބިޔަފުޅު ދަންނަވާ ޖަމިއްޔާއި ދިވެހިރާއްޖޭގެ ބިޔަފުޅު ދަންނަވާ ޖަމިއްޔާ

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Website: www.epa.gov.mv



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.



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 resources 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.

بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ



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Environmental Protection Agency EPA



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



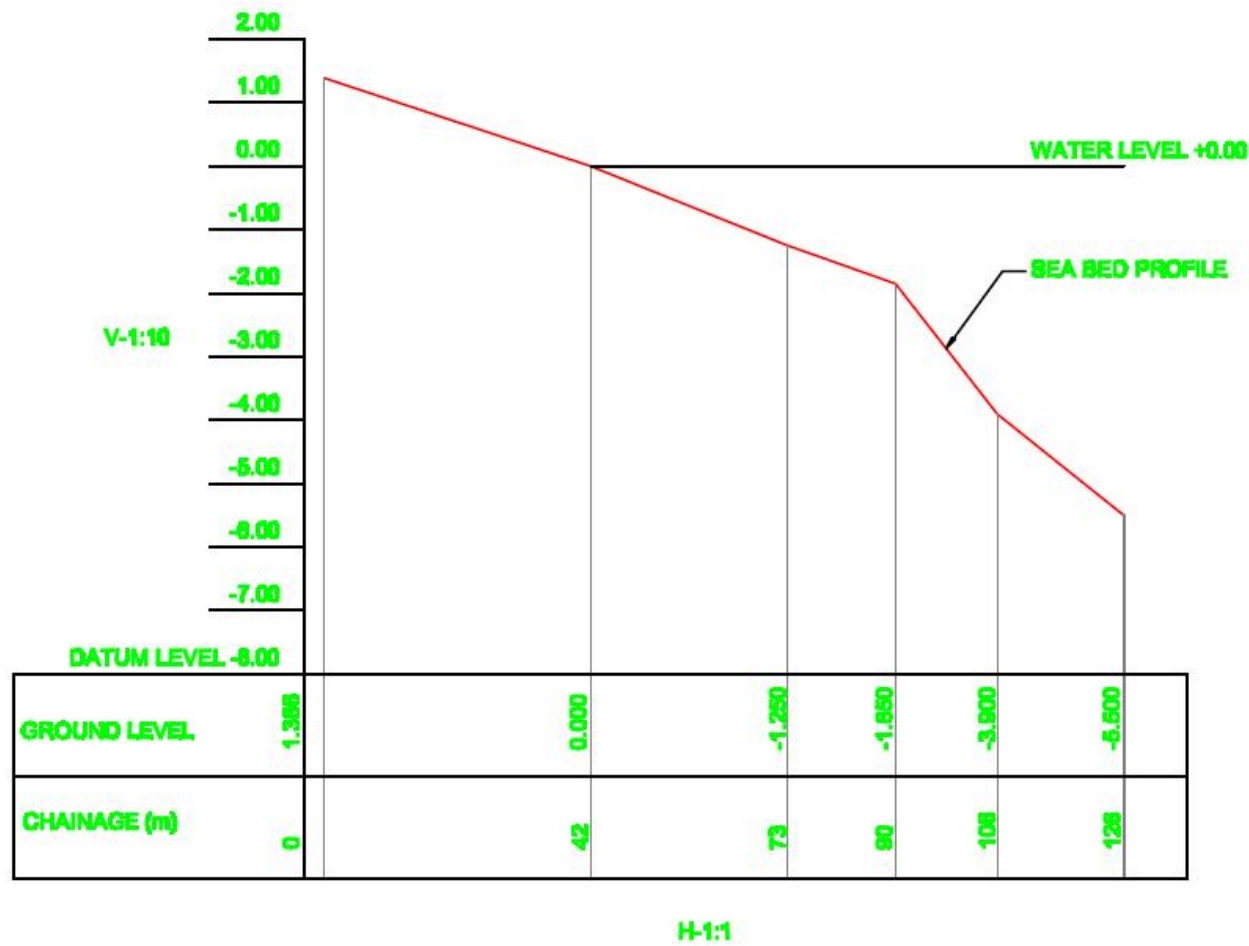
Environmental Protection Agency
Green Building, 3rd Floor, Handhuvaee Hingun
Male', Rep. of Maldives, 20392

Tel: [+960] 333 5949 [+960] 333 5951 ފޯން ނަންބަރު
Fax: [+960] 333 5953 ފެކްސް ނަންބަރު

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Website: www.epa.gov.mv ވެބްސައިޓް ލިންކް

Appendix B – Technical Layout Drawings



GRAPHIC SCALE :

CLIENT

MINISTRY OF ENVIRONMENT AND ENERGY
 ޤައުމީ ސަރުކާރުގެ ސަރުކާރު

PROJECT
 CONSULTANCY SERVICES FOR SURVEY, DESIGN OF SEAWALL FACILITIES
 IN THE ISLAND NAAYAKHOO, MALDIVES

TITLE
L- SECTION OF OUTFALL
FOAKAIDHO ISLAND

DESIGNER

BHAN TECHNICAL CONSULTANTS PVT. LTD., INDIA
 In Association With

DEVELOPMENT TECHNOLOGIES MALDIVES, MALDIVES

APPROVED:  DESIGNED:  CHECKED:  DRAWN: 

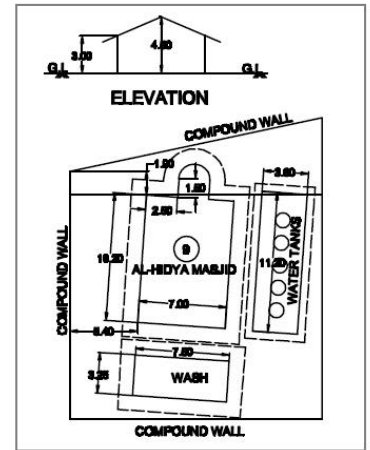
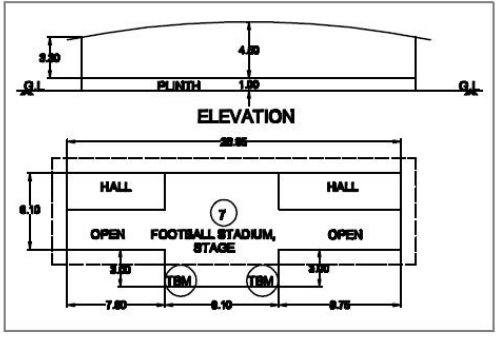
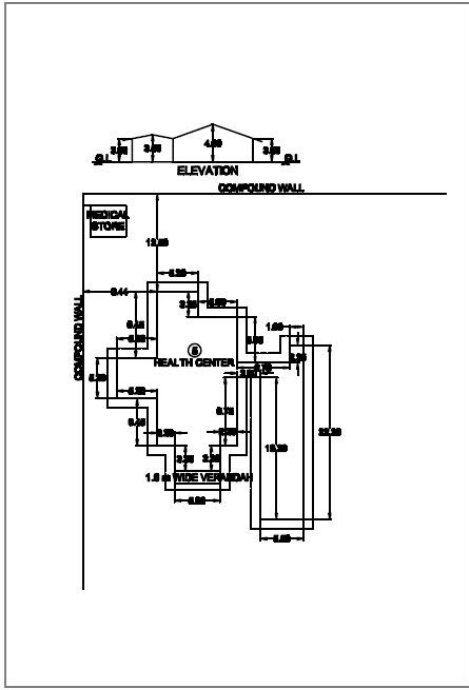
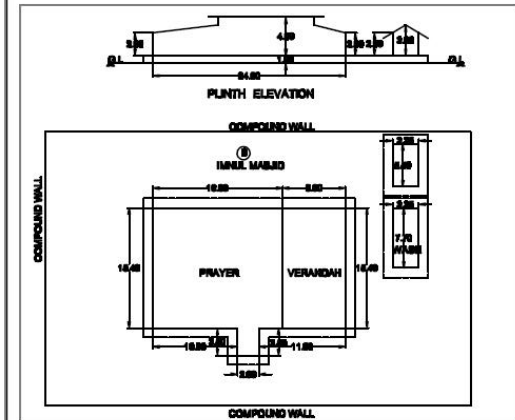
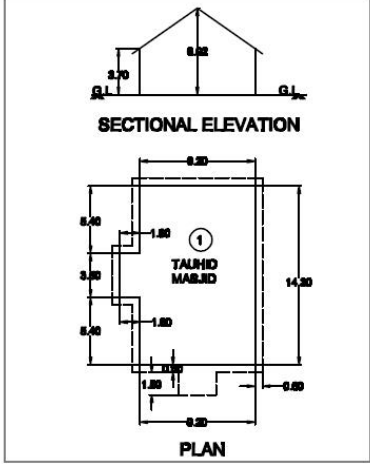
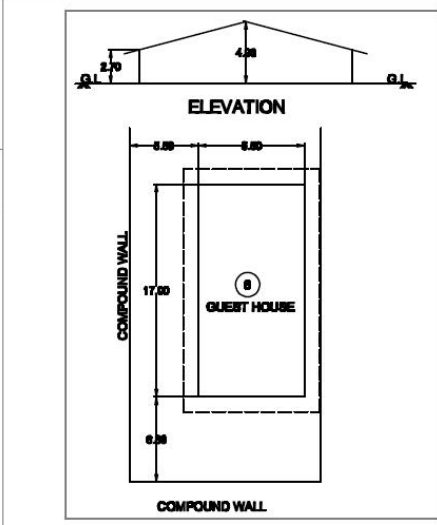
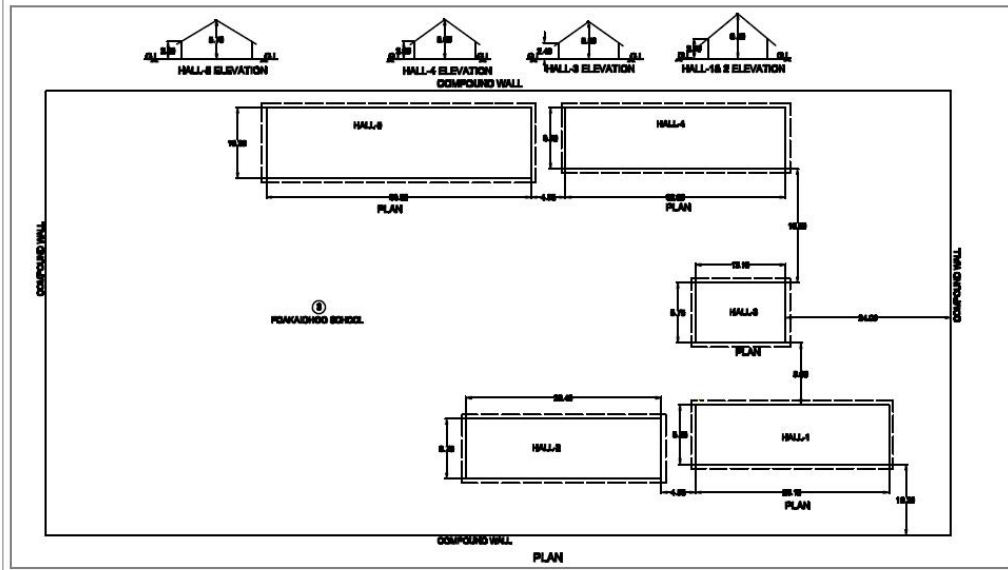
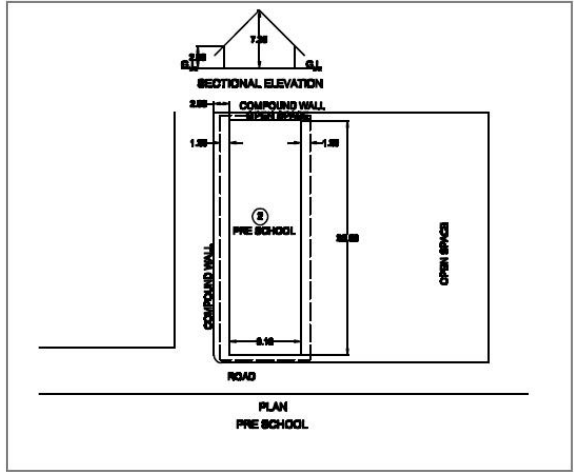
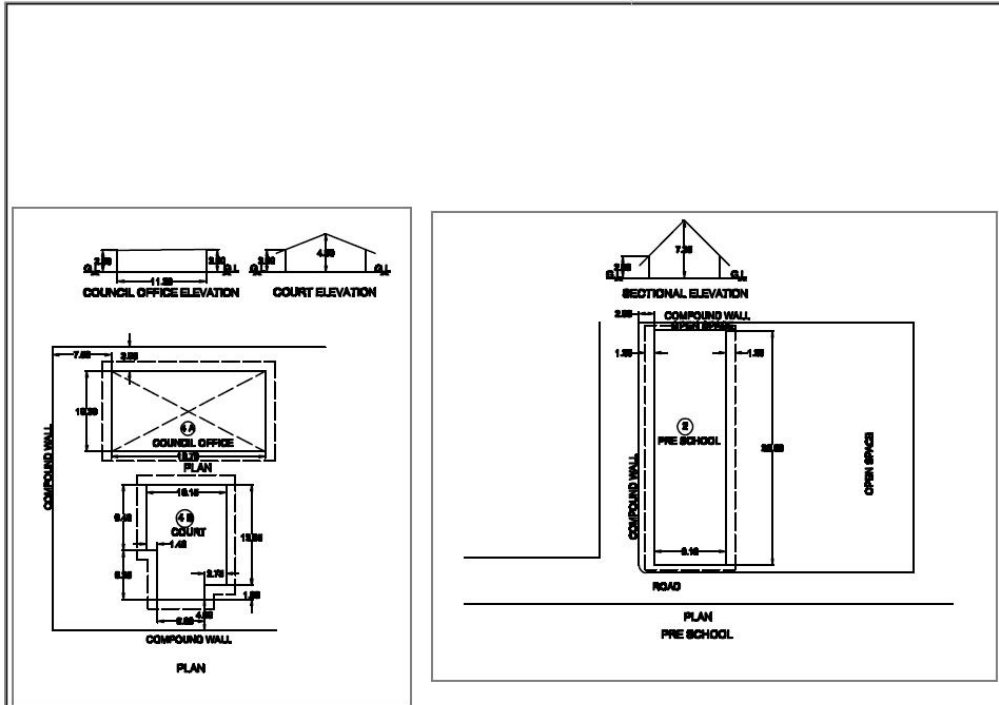
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AT-LANDSCAPE

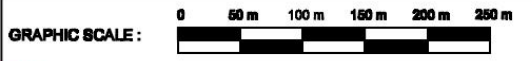
NOTES:

No.	DATE	DESCRIPTION	DRG. No.	DESCRIPTION
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REVISION REFERENCE DRAWINGS



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



CLIENT: **MINISTRY OF ENVIRONMENT AND ENERGY**
 MALDIVES REPUBLIC OF MALDIVES

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

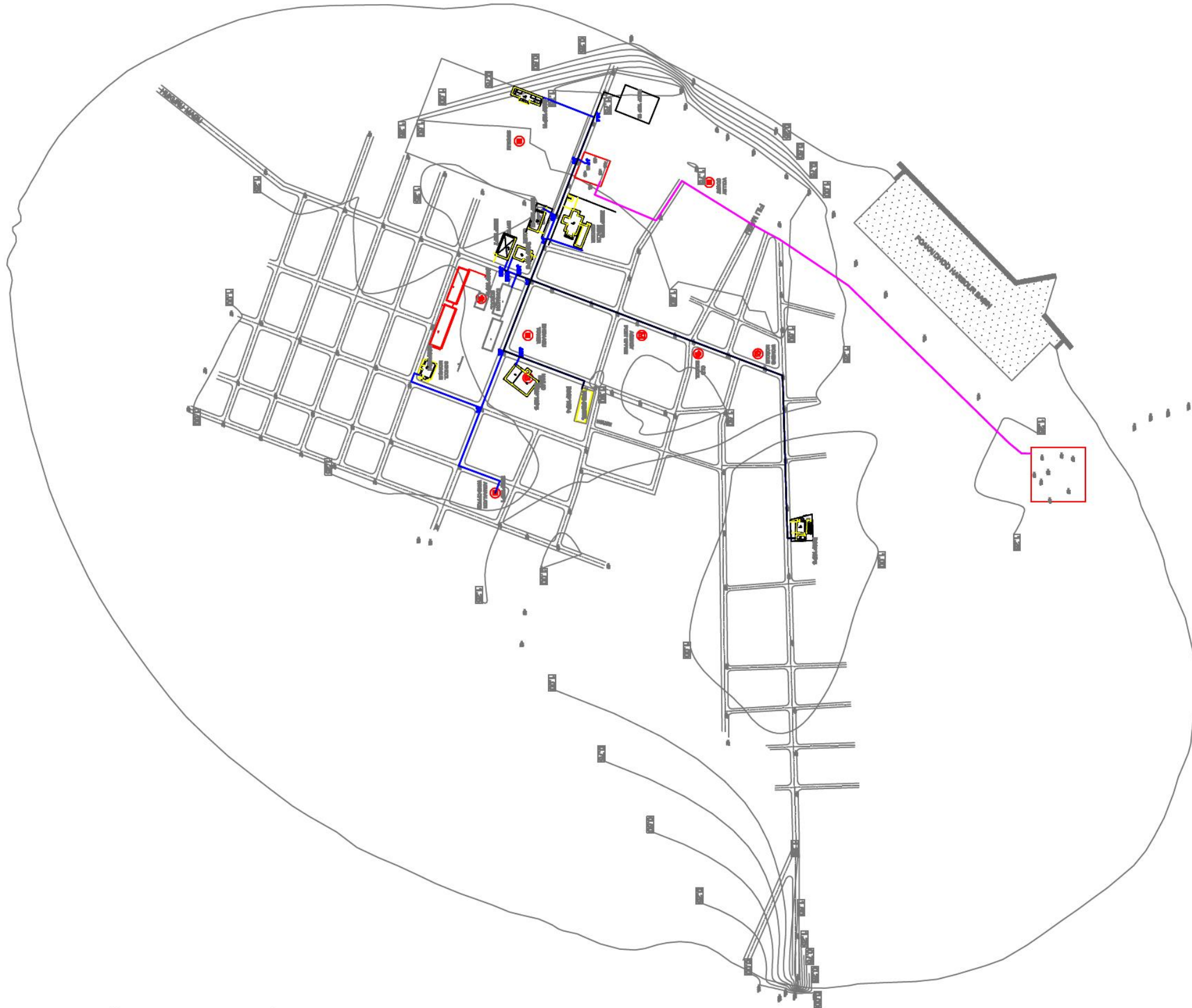
TITLE: **PLAN & CROSS SECTIONAL DETAILS OF EXISTING COMMUNITY CENTERS FOAKAIDHOO ISLAND**

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

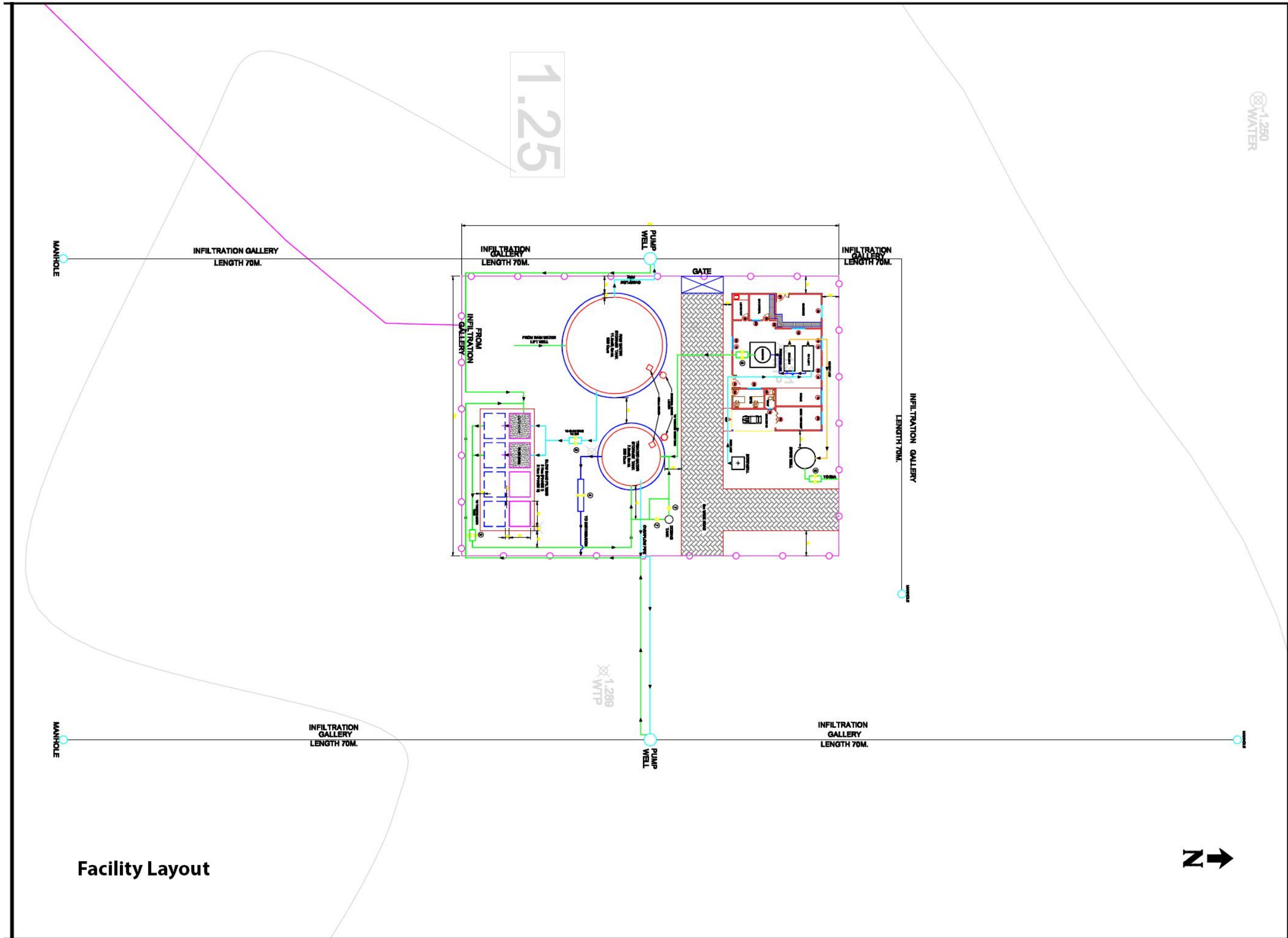
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		REVISION	REFERENCE DRAWINGS	

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NTS	JANUARY 2017	FIGURE 03	0

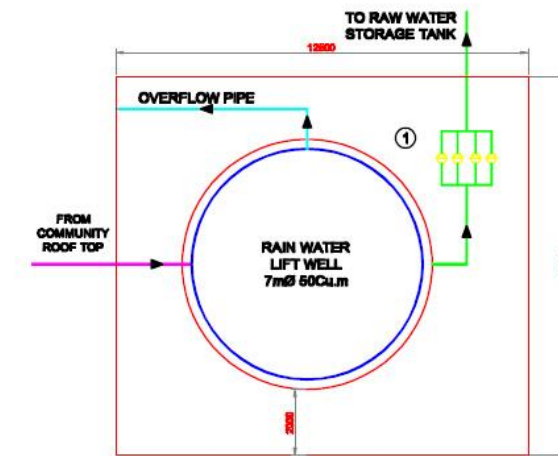
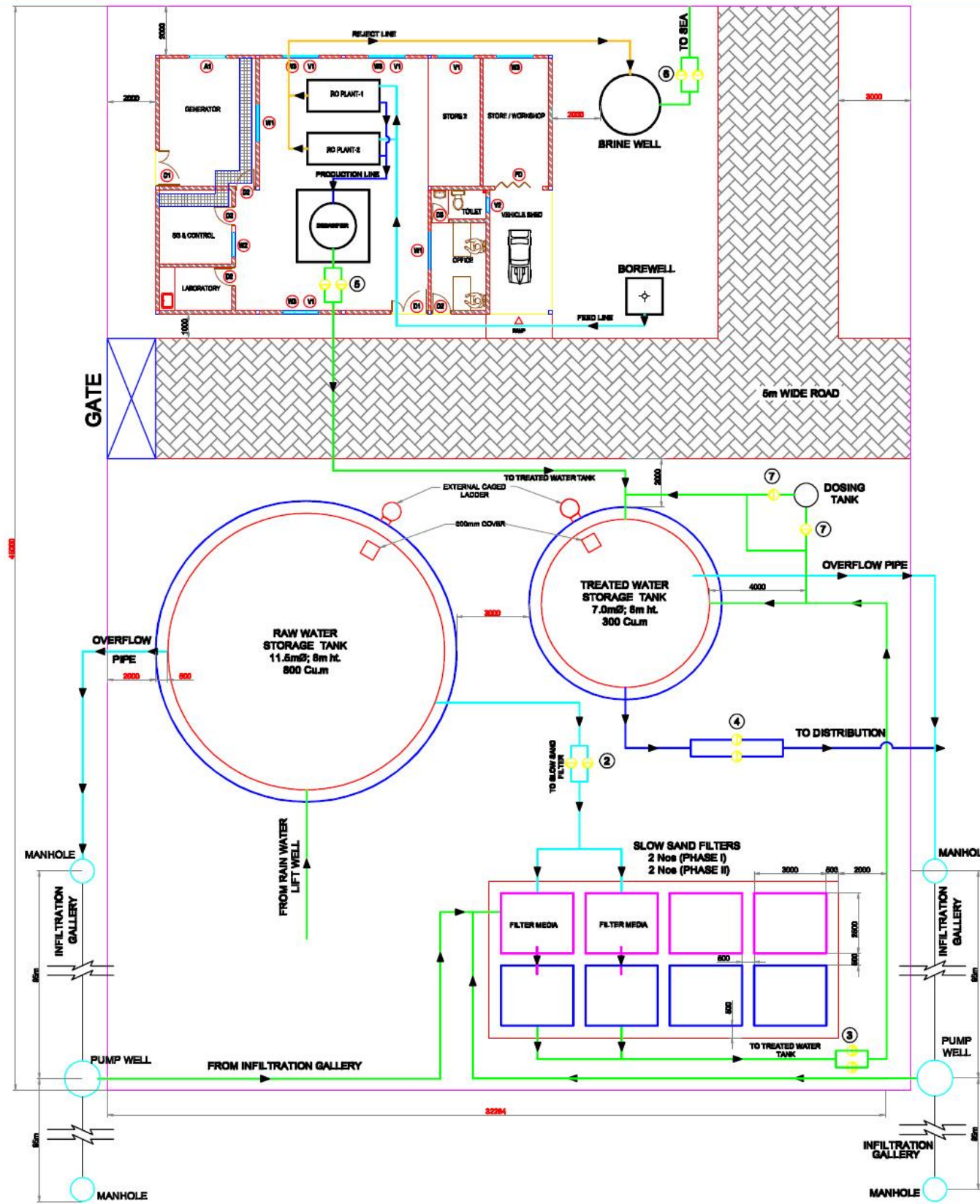
A1-LANDSCAPE



Conveyance system



Facility Layout



Treatment Facility Layout

Appendix C – Water Quality Reports

Male Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
 5th Floor, Mechatronics, Ametree Magu, Male', Maldives
 Tel: +9603326203, Fax: +9603326350, Email: wqa@mwsc.com.nv

Customer Information:
 Development Advisory Services Pvt Lt
 G, Heyli
 4C06 Lonuziyaaray Magu
 Male 'MALE'

WATER QUALITY TEST REPORT
 Report No: 500172344

Report date: 28/03/2017
 Test Requisition Form No: 500172353
 Sample(s) Received Date: 22/03/2017
 Date of Analysis: 22/03/2017 - 23/03/2017



Sample Description	Foakaidhoo GW Sample - Mosque	Sh Foakaidhoo Onsite GW	UNIT
Sample Type	Ground Water	Ground Water	
Sample No	83183414	83183415	
Sample Date	20/03/2017	20/03/2017	
PARAMETER ANALYSIS RESULT			
Physical Appearance	Clear with particles	Clear with particles	
Conductivity	4440	6350	µS/cm Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 21st edition)
pH	7.82	8.31	- Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 21st edition)
Salinity	2.36	3.46	% Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 21st edition)
Temperature	21.1	21.2	°C Electrometry
Total Dissolved Solids	2220	3180	mg/L HACH Method 8204
Hardness, Calcium	300	405	mg/L HACH Method 8213
Hardness, Total	750	440	mg/L HACH Method 8213

Key: µS/cm : Micro Selmeh per Centimeter, % : Parts Per Thousand, °C : Degree Celsius, mg/L : Milligram Per Liter

Checked by

 Nashath Ali
 Senior Laboratory Technician

Approved by

 Mohamed Eymen
 Assistant Manager, Quality

Notes: Sampling Authority: Sampling was not done by MWSC Laboratory
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 This test report is ONLY FOR THE SAMPLES TESTED.
 ~ Information provided by the customer

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




WATER QUALITY TEST REPORT
 Report No: 500172345


Customer Information:
 Development Advisory Services Pvt Lt
 G, Heyll
 4/G06 Lomziyaaraiy Magu
 Male' MALE'

Report date: 28/03/2017
 Test Requisition Form No: 900173293
 Sample(s) Received Date: 22/03/2017
 Date of Analysis: 22/03/2017 - 28/03/2017

Sample Description	Sample Type	Sample No	Sample Date	PARAMETER	TEST METHOD	UNIT
Foakaidhoo SW1	Saa Water	83183416	20/03/2017	ANALYSIS RESULT		
Physical Appearance				Clear with particles		
Conductivity				50700	Method 2510 B. (adapted from Standard methods for the examination of water and waste water, 21st edition)	µS/cm
pH				6.29	Method 4500-H+ B. (adapted from Standard methods for the examination of water and waste water, 21st edition)	-
Salinity				33.15	Method 2520 B. (adapted from Standard methods for the examination of water and waste water, 21st edition)	‰
Temperature				21.1	Electrometry	°C
Total Dissolved Solids				25300	Electrometry	mg/L
Total Suspended Solids				<5 (LOQ 5 mg/L)	Method 8006 (Adapted from HACH DR5000 Spectrophotometer procedure Manual)	mg/L
Turbidity				0.317	HACH Nephelometric Method (adapted from HACH 2100N Turbidimeter User Manual)	NTU
Total Alkalinity				109	HACH Method 8203	mg/L

Keys: µS/cm : Micro Saiman per Centimeter, % : Parts Per Thousand, °C : Degree Celsius, 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
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 ~ Information provided by the customer

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

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



WATER QUALITY TEST REPORT
 Report No: 500172346


Customer Information:
 Development Advisory Services P-V-L
 G.Heyli
 4G06 Lonzuyearay Magu
 Male' MALE'


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

Sample Description	Foakadhoo SW sample 2	UNIT
Sample Type	Sea Water	
Sample No	83183417	
Sampled Date	20/03/2017	
PARAMETER	ANALYSIS RESULT	
Physical Appearance	Clear with particles	
Dissolved Oxygen (DO)	7.88	mg/L

Keys: mg/L : Milligram Per Liter

Standard Methods 19th edition APHA

Checked by

 Nashedh Ali
 Senior Laboratory Technician

Approved by

 Mohamed Eymen
 Assistant Manager, Quality

Notes: Sampling Authority: Sampling was not done by MWSC Laboratory.
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 - Information provided by the customer

..... END OF REPORT

Appendix D – Letter of Commitment

EIA for the Proposed Water Supply System in Sh.Foakaidhoo

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 Sh.Foakaidhoo

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

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



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

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ދިވެހިސަރުކާރުގެ ގެޒެޓް އޮފީސް

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

1 ސަރުކާރުގެ ގެޒެޓް އޮފީސް 1



Green Building, Handhuvaree Hingun,
Maafannu, Male', 20392, Republic of Maldives.

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+ (960) 301 8301
www.environment.gov.mv

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secretariat@environment.gov.mv
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Ministry of Environment and Energy
Male', Republic of Maldives.

ދިވެހިސަރުކާރުގެ ގެޒެޓް ގައި ބަޔާންކުރި ގޮތުގައި
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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.
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Page 1 of 1
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بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ



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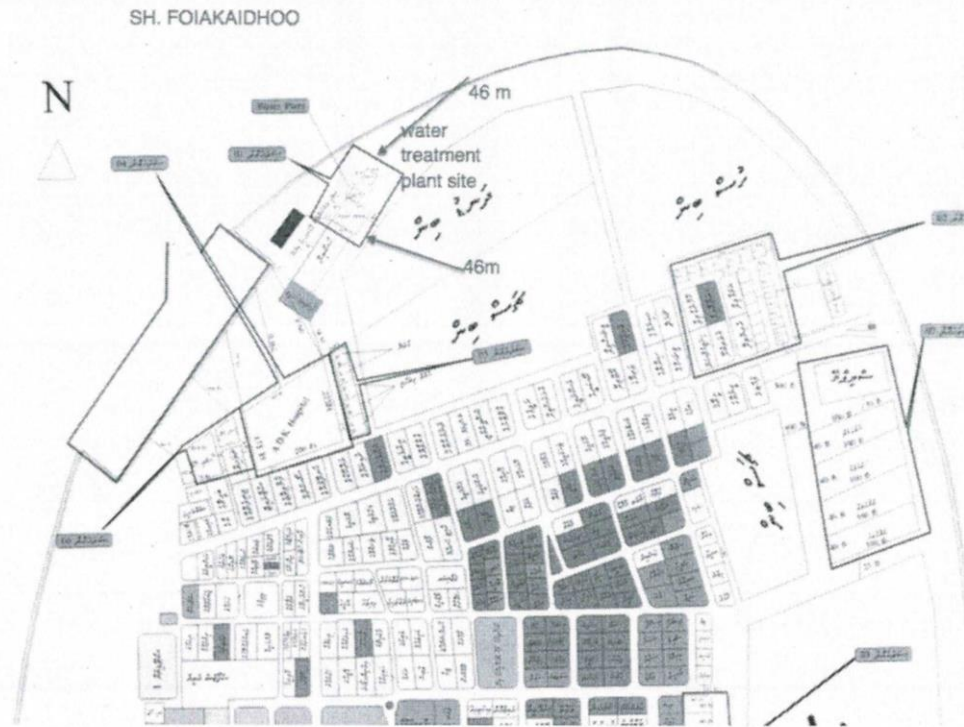
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FOAKAIDHOO



FOAKAIDHOO RAINWATER COLLECTION TANK SITE



بِسْمِ اللّٰهِ الرَّحْمٰنِ الرَّحِیْمِ



دائرة التعليم والتعليم
والتربية
مرفوعاً

سنة 2017/2 : 277/203

أشرفاً على العمل في
مرفوعاً

والتربية في
مرفوعاً

22 مرفوعاً 1438

14 مرفوعاً 2017

مرفوعاً

Ahmed






مرفوعاً

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أشرفاً على العمل في
مرفوعاً



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.	Sh.	R.	B.
	Nolhivaranfaru	Foakaidhoo	Maduvvaree	Dharavandhoo
Total population	4698	2592	2826	2292
Total household	587	324	353	286
(estimated)				
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.

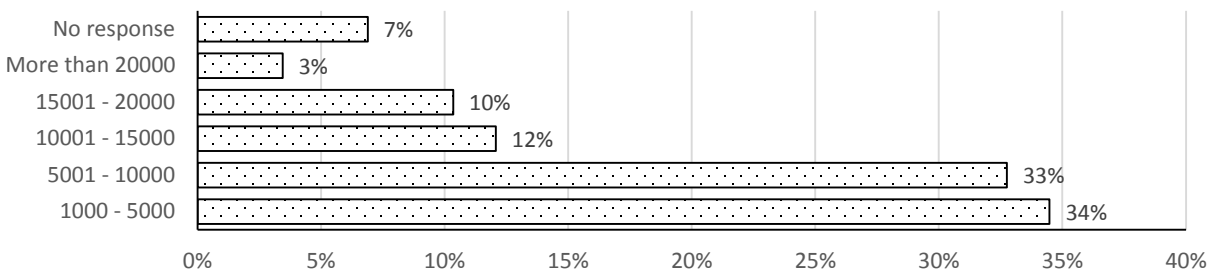


Figure 1: Household income per month for Sh. Foakaidhoo

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.

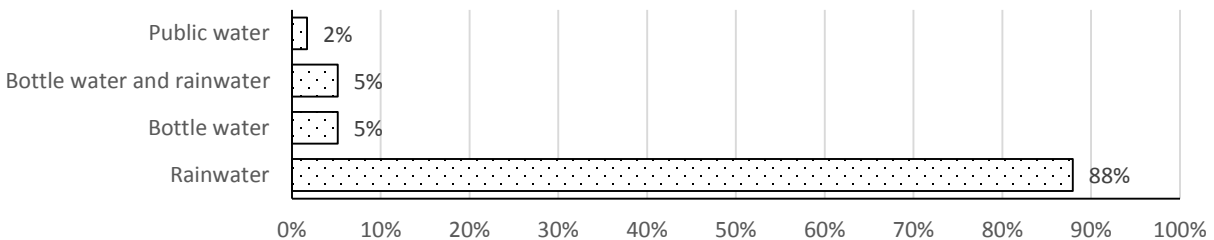


Figure 2: Source of drinking water for households in Sh. Foakaidhoo

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.

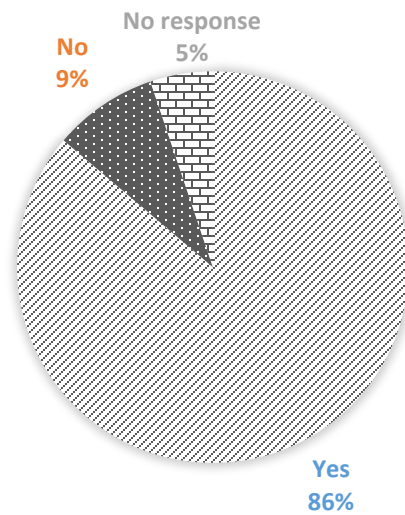


Figure 3: Willingness to pay for the IWRM system in Sh.Foakaidhoo

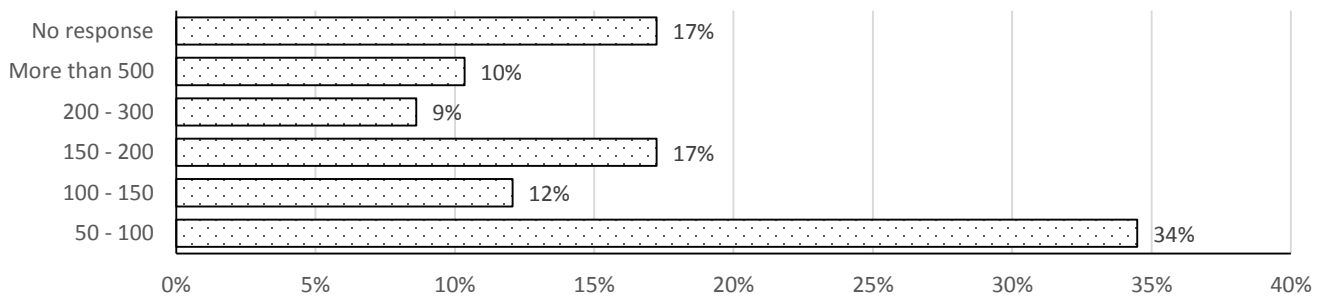


Figure 4: Amount Sh.Fokaidhoo household willing to pay for the services of IWRM

H.Dh. Nolvivanfaru

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.

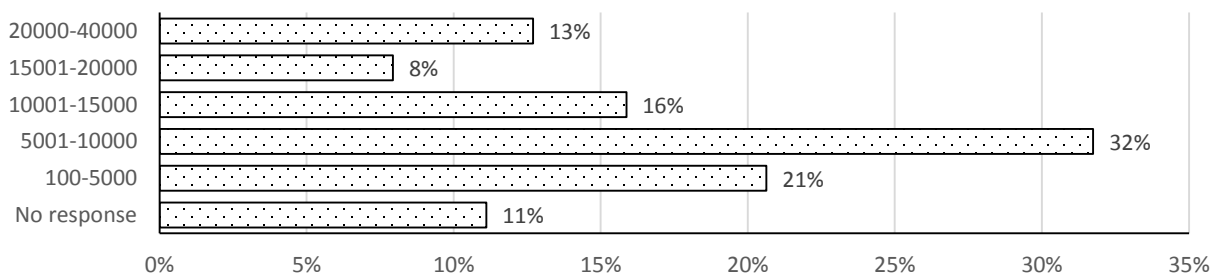


Figure 5: Household income per month for HDh.Nolvivanfaru

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.

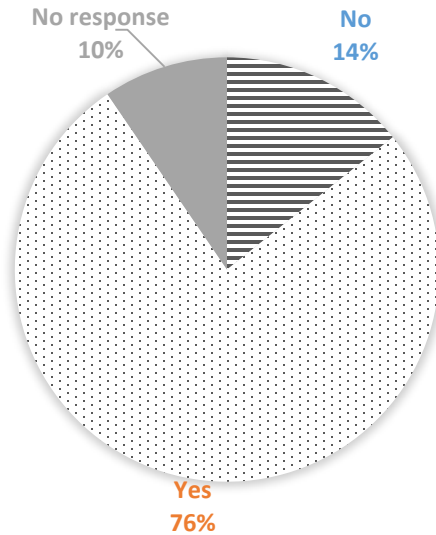


Figure 6: Willingness to pay for the IWRM system in HDh. Nolvivanfaru

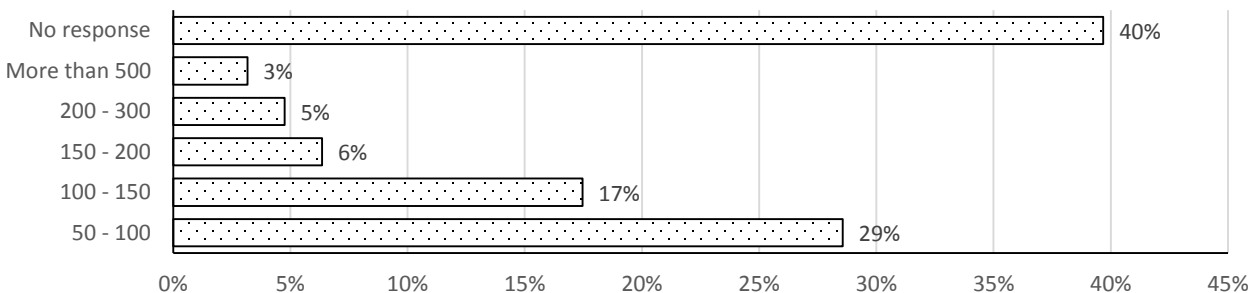


Figure 7: Amount HDh Nolvivanfaru household willing to pay for the services of IWRM

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.

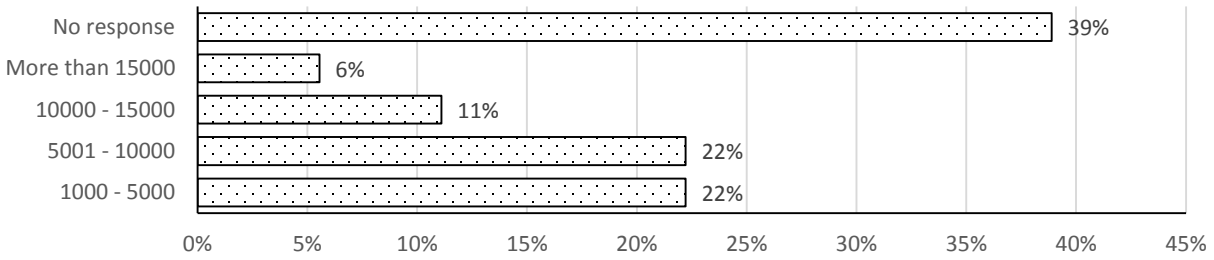


Figure 8: Household income per month for R. Maduvvaree

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 responding households (44%) get an income less than 10000 MVR per month, only (6%) gets an income more than 15000 MVR per month.

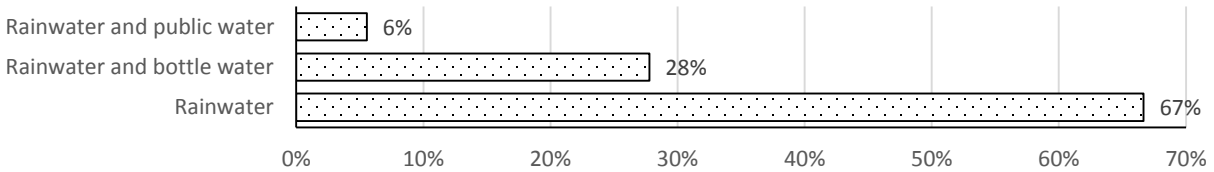


Figure 9: Source of drinking water for households in R. Maduvvaree

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.

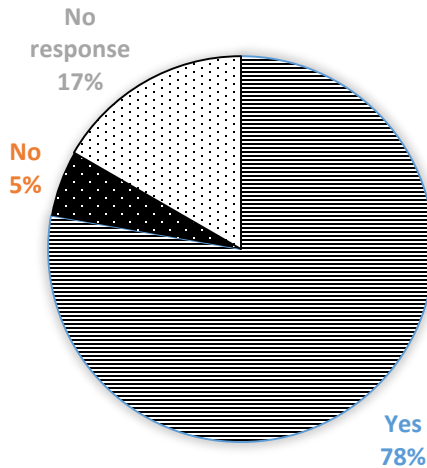


Figure 10: Willingness to pay for the IWRM system in R. Maduvvaree

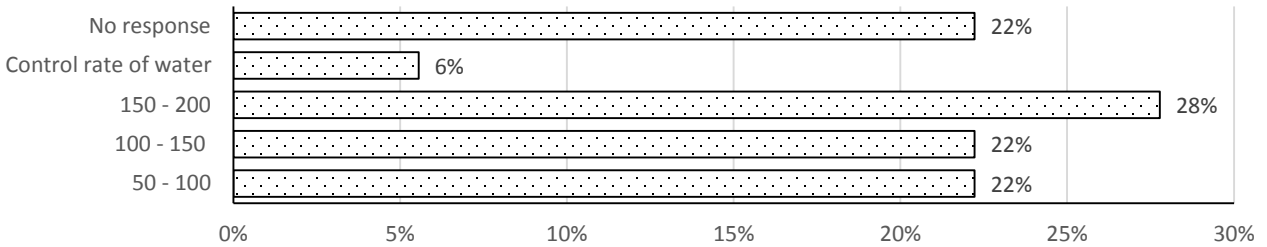


Figure 11: Amount R. Maduvvaree household willing to pay for the services of IWRM

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.

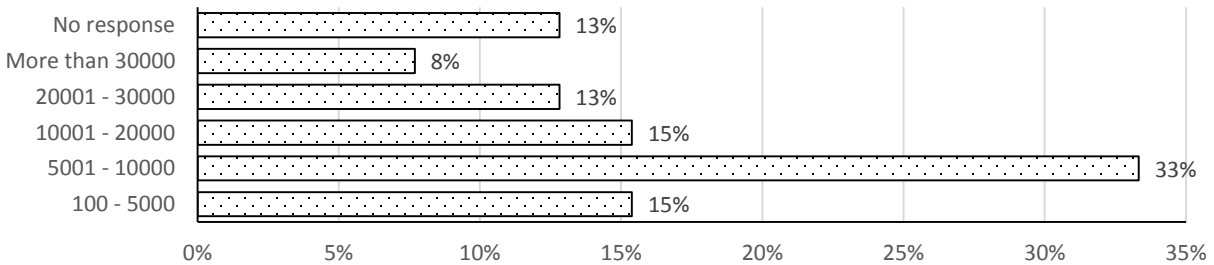


Figure 12: Household income per month for B. Dharavandhoo

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.

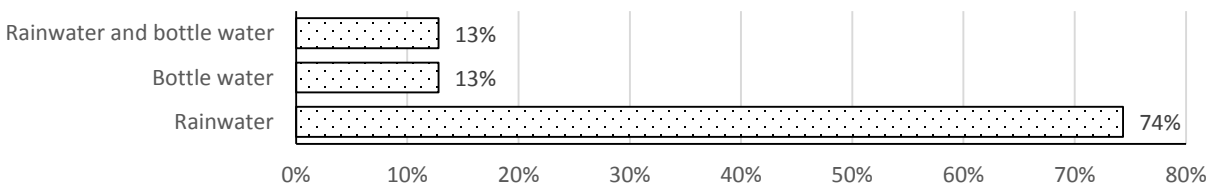


Figure 13: Source of drinking water for households in B. Dharavandhoo

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

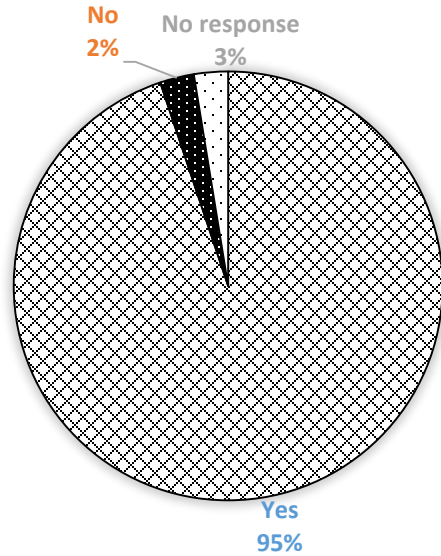


Figure 14: Willingness to pay for the IWRM system in B.Dharavandhoo

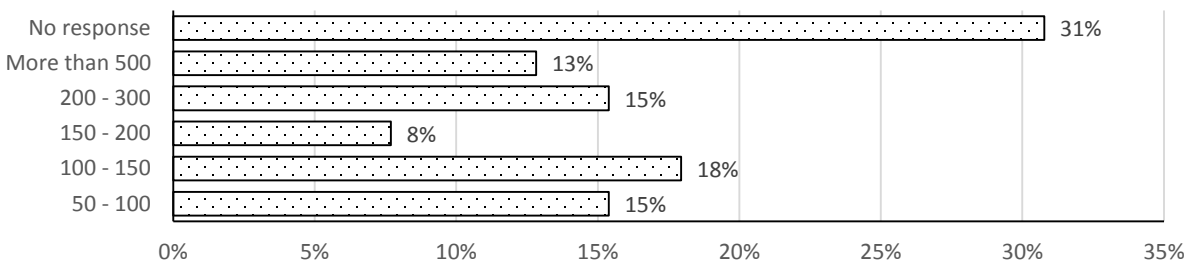


Figure 15: Amount B.Dharavandhoo household willing to pay for the services of IWRM

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	Ibrahim Fikuree
Project description	Ibrahim Fikuree Ali Shareef Zammath Khaleel
Policy and regulatory framework	Ibrahim Fikuree
Methodology	Ibrahim Fikuree
Existing environment	Ibrahim Fikuree Ali Shareef
Impacts and mitigation measures	Ibrahim Fikuree Ali Shareef Zammath Khaleel
Alternatives	Ibrahim Fikuree Ali Shareef Zammath Khaleel
Monitoring and management plans	Ibrahim Fikuree Ali Shareef
Stakeholder consultations	Ali Shareef Zammath Khaleel
Conclusions, executive summaries	Ibrahim Fikuree Ali Shareef Zammath Khaleel

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 (NZ AID, 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 @ Tehran, Iran. Faculty of Physics and Nuclear Sciences, Amirkabir University of Technology, Tehran, 127 @ 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

19 th Conference of the parties (COP 19) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parties to the Kyoto Protocol, Warsaw, Poland	3 Nov- 25 Nov 2013
36 th 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
18 th Conference of the parties (COP 18) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parties 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

17 th Conference of the parties (COP 17) to the United Nations Convention on Climate Change (UNFCCC) serving as the meeting of the Parties 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 ASSESSMENTS

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
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Ministry of Environment and Energy

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



Ali Shareef

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 mechanisms 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(Vientiane/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 Harbour Rehabilitation project – 2010
- Environmental Impact Assessment of B.Goidhoo Harbour 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

Maahaa

R. Inguraidhoo

Maldives

Phone: +960 9997816

Email: ibrahim.fikry@gmail.com**Ibrahim Fikree****Objective****Education****The Maldives National University**

- Bachelors of Science Jan 2012- Dec 2014
In Environmental Management
- Foundation Studies level 2 Jan 2011- Dec 2011
In Environmental Management

Baa. Atoll Education CentreJune 2004-June 2006

- GCSE A' Level

Raa. Atoll Education CentreJan 1995-Jan 2003

- CSE O' Level

Employment History / Work Experience

- **Ministry of Fisheries and Agriculture** Feb 2007 – Jun 2016
(Assistant Project Officer)

Responsibilities:

- HCFC phase out project (Fisheries component) works
- Fishery infrastructure development and providing infrastructure development related services
- Development of Fish Aggregating Device (FAD)
- Research on new technology regarding FADs
- Topographic surveying for the existing FADs and for the proposed FADs
- Maintaining and monitoring of the FAD web around Maldives

- **Foresight Surveyors Pvt. Ltd.** Jan 2015 – Present
(Environmental Consultant)

Responsibilities:

- Environmental consultation and land surveying.

- **The Maldives National University** Nov 2015 – May 2016
(Research Assistant and Coordinator)

Responsibilities:

- Research assistant and coordinating work of two Pilot project (1. Technical development and examination of live bait catch and holding for improvement their survival rate and 2. Technical development of tuna hand line on-board handling for quality improvement) under MASPLAN by the Japan International Cooperation Agency (JICA).

- **The Maldives National University** Jun 2016 – Present
(Assistant Director)

Responsibilities:

- Managing and Leading the Environment Section.
- Implementation of Environment regulation R-157/2015.
- Evaluation of EIA reports and documents.
- Coordinating the activities of biodiversity, conservation and other environment related activities with government agencies.
- Preparation of technical papers/standards and strategies in tourism sector in relation to environment.
- Preparation of action plans and budget.
- Implementation of work plan.

Training/Workshops attended

- Regional Workshop on Monitoring control and Surveillance on 16th -18th January 2008 Bangladesh. (BOBP)
- Regional training course on code of conduct for responsible fisheries held from 16th -27th June 2008 at Chennai and Mumbai, India. (BOBP)
- Training program on community based coastal zone management and information system-Project Selamat from 10th -12th March 2009 male'. (MoHE)
- Strengthening capacities for national SAICM implementation in the Maldives from 15th – 16th May 2013, Malé. (MoHE)
- Dolphing-watching Code of conduct workshop on 23rd June 2014 in Malé. (IUCN)
- Workshop on whale shark monitoring on 24th June 2014 in Malé. (IUCN)
- Group and regional focused training on policy support for sustainable regional fishery development through enhancement of fisher's organisation at National Fishery University (Japan) from March 30th, 2015 to June 9th, 2015. (JICA)

- Low carbon development conceptual workshop training held at Male' and B. Dharavandhoo, Maldives 09 -12 March 2015 (MoEE).

Skills

Computer

GOOD COMPUTER KNOWLEDGE

Experience in using MS office package, Coral Draw and Photoshop etc.

Personal

Have competitive attitude and can work under pressure to deliver the result to deadlines.

Can build and maintain strong relationships.

Confidential and able to work on own initiative.

Good communication skills.

Reference

➤ **Abdulla Jaufar**

Head Fisheries Infrastructure and development section

Ministry of Fisheries and Agriculture

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➤ **Ahmed Nuaim Aboobakuru**

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➤ **Dr. Shazlaa Mohamaed**

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The Maldives National University.

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-----Thank You-----