ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Small Scale Desalination and Water Bottling Plant
in Hullhudhoo, Addu City

Proponent: Abdullah Mutheeu

Consultants: Mohamed Musthafa and Hussein Zahir

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ފުޅިގައި ބަންދުކުރުމަށް ބޭނުންވާ މީރުފެން އުފެއްދުމަށް ބޭނުންވާ ލޮނުފެން ނަގާނީ ހަމަޖެހިފައިވާ ބިމުގެ ފެންފަރާތުގައި އަޅާނެ ފެންކޯރު ބޯރުހޮޅިއަކުން މިކަމަށް ހާއްސަކޮށް ތައްޔާރުކުރާ ޓޭންކަކުންނެވެ. މި ފެން ނަގައިގެން ފެންފަރުން މީރުފެން އުފައްދާ ޑީސެލިނޭޝަން (ފެން ފިލްޓަރކޮށް) ޑްރޮޕިލްޓަރ މީރުފެން އުފެއްދުމަށްފަހު ފުޅިގައި ބަންދުކުރުމަށް ބޭނުންކުރެވޭނެއެވެ. ލޮނުފެނުން މީރުފެން އުފެއްދުމުގައި އުފެދޭ އެކުލެވޭ ނުވަތަ ބަރުއިން ރިވަސް އޮސްމޯސިސް ޑްރޮޕިލްޓަރ ޑަރަން ބޭނުންކުރެވޭނެއެވެ. މިމަސައްކަތަށް ބޭނުންވާ ހަކަތަ ހޯދުމަށް ހަމަޖެހިފައިވަނީ ރަށުގައި މިހާރުވެސް ކަރަންޓުގެ ވިއުގައިންނެވެ. މިކަމަށް ވަރުގަދަ ޖަނަރޭޓަރެއް މި ޖިހާޒަކާ ކުރިމަތީ ކަރަންޓު ސަޕްލައި ކުރުމުގެ ޕަވަރ ހައުސްއާ ވާހަކަ ދައްކާފައިވާނެއެވެ. ކަރަންޓު ކަރަންޓުގެ ނިޒާމަށް ގުޅުވައިގެން މި ޕްލާންޓް ހިންގުމަށް ބޭނުންވާ ހަކަތަ ބޭނުންކުރާނީ މި ޕްލާންޓްއިއުލް ބަލައިލުމުން 200 ކޭ.ވީ.އޭ ސަބްސްޓޭޝަން ބައި ޖެނެރޭޓަރުގެ އެހީގައެވެ.

ޕްލާންޓް އޮޕަރޭޓް ކުރުމަށް ފަސޭހަކަމަށް ފެނުނުގޮތުން ދުވާލަކު 80 ފެން ކުދިކުދި ފުޅި ތައްޔާރުކުރެވޭނެ. ދުވާލުގެ މަސައްކަތް 20 މިލިލީޓަރުގެ 350 އާއި 400 އާއްމުކޮށް ބޭނުންކުރާ ފުޅިތަކުގައި މީރުފެން ގުއްޖާއިން 5 ލީޓަރު އަދި 1.5 ލީޓަރުގެ 300 އާއި 500 އާއްމުކޮށް ފެން ފުޅި އުފައްދައިން ވަނީ ފުޅިގައި ބަންދުކުރެވޭނެއެވެ. ހުޅުދޫ އަދި މީދޫގެ ރައްޔިތުންނަށް އަގުހެޔޮކޮށް ފެން އުފައްދާ މި ފެން ފުޅިގެ

ފިޔަވަޅުއެޅުން އަމާޒުކޮށް ރަށްރަށަށް އެހެން އަތޮޅުގެ އިތުރުވާނަމަ މީހުން ގެންނަ އުފެއްދުންތަކަށް
އިތުރުކުރުމަށްވެސް ވަނީ ރޭވިފައެވެ. މަޝްރޫޢުގެ މަސައްކަތް ހިންގުމުގައި އަދި މި ނިޒާމް
ހިނގަމުންދާއިރު ދިމާވެއްޖެނަމަ ލިބޭގެއްލުންތަކާމެދުގައި އަދި ލިބޭގެއްލުން ކުޑަކުރުމަށް އެޅިދާނެ
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ބެލުމަށް ޓެކްނިކަލް ކޮންސަލްޓަންޓެއް ތަޖުރިބާއެއް، މިކަމަށް ތައްޔާރުކުރެވުން ޓެކްނިކަލް އަދި ފައިނާން
ތަޖުރިބާކާރުންގެ މިފަދަ ދިރާސާތަކުގެ އެހީގައެވެ. މިގޮތުން، މިމަޝްރޫޢުގެ ސަރަޙައްދު އެންމެ ބޭރަށް
އަސަރުކުރާނެކަމަށް ބެލެވިފައިވާނީ އިމާރާތްކުރުމުގެ ބިމުގައި ހުރި ގަސްތަކާއި ނޭވާލުމަށް ފެން ޖެހޭނެތަން
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ފެހިކަރުދާސްފައިވާ ގެއްލުމަކުން ބާވައިރު އިމާރާތްކުރުމުގެ ސަރަޙައްދުގައި ހުރި ކުދިގަސް ކަނޑާލެވޭގޮތުގެ
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މަޝްރޫޢުގެ ކުޑަބޭނުމުން ބާވައިރު، ގެއްލުން ކުޑަކުރުމަށް އެޅޭ ފިޔަވަޅުތަކާއި ގުޅިގެން އަށް ބާވައިރު
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އެހެންކަމުން، މި މަޝްރޫޢަކީ ނިސްބަތުން ކުޑަ މަޝްރޫޢަކަށްވެފައި ޑިމާވެއްޖަށް ލިބޭގެއްލުންވެސް ކުޑަ
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މަޝްރޫޢު ރޮވިފައިވާގޮތަށް ކުރިއަށް ގެންދިއުމަށް ކޮންސަލްޓަންޓުންނަށް ފެނެއެވެ.

Executive Summary

The project has been proposed by a local entrepreneur (Mr. Abdulla Mutheeu, Nest Mead, S Hulhudhoo) to build and operate a small-scale water bottling plant in *Hulhudhoo* in Addu City. The proposed location of the facility is a leased land plot of 20000sq to the proponent from Addu City Council on the western side of Hulhudhoo. The land has been leased for a period of 10 years. The source water for desalination is to be drawn from a deep borehole drilled and installed within the site. The source water for the bottling will be purified desalinated water produced at site through desalination of deep groundwater (saline) through Reverse Osmosis (RO) process. The RO reject brine will be discharged into deeper lagoon in the west coast of Hulhudhoo. The electricity required for the operation will be obtained from the existing island power grid through FENAKA cooperation Hulhudhoo Meedhoo Branch which has been arranged. In emergencies electricity will be provided by the standby generator set of 200Kw to be installed along with the bottling plant.

The daily production capacity of desalination unit will be at 80m^3/day. The estimated daily production of bottled water will be at 350-400 bottles of 20L capacity (refillable) and 300 - 500 bottles of 5L and 1.5L capacity. The focused market is local communities in Hulhudhoo and Meedhoo. The client aims to expand the production and thus sell these products in other islands in the atoll based on the demand.

The potential environmental impacts during works implementation and during operation of the system are identified with appropriate mitigation measures. Positive and negative impacts, impact significance and impact severity from the proposed development have been primarily identified using checklist method along with consultations, expert opinions and professional judgements. Key impact zones identified are at vegetation clearance site and brine disposal location in marine water. Key impacts expected to be caused from the proposed project activities include loss of vegetation at building site due to vegetation clearance and suspension and increase of sedimentation at brine disposal site in marine water. These impacts are however low and insignificant due to the small scale of the project and appropriate mitigation measures and monitoring protocols have been proposed.

Given the small scale of the project with minor environmental impacts and the existing need for purified bottled water in these communities, the consultants feel the project is feasible to be implemented as proposed provided the given mitigation measures are taken and monitoring is carried out.

1 Introduction

A local entrepreneur has proposed to build and operate a small-scale water bottling plant in *Hulhudhoo* in Addu City. The proposed location of the facility is a land plot leased to the proponent from Addu City Council on the western side of Hulhudhoo. The source of water for the bottling plant is produced at site through desalination of deep groundwater (saline) through Reverse Osmosis (RO) process. The RO reject brine will be discharged into deeper lagoon in the west coast of Hulhudhoo

The client aims to produce refillable 20L bottles and 5L, 1.5L bottles. The focused market is local communities (Hulhudhoo and Meedhoo) and expands the production and thus sale in other islands in the atoll based the demand. The developer aims to maximize this production through cleaner technology.

This Environmental Impact Assessment (EIA) report has been prepared for obtaining required environmental clearance for the proposed project in accordance with the EIA Regulation No. 2012/R-27 enforced by Environmental Protection Agency (EPA). This report evaluates and analyses the existing environment, existing arrangement for implementing the project, its impact to environment and appropriate mitigation measures for adverse impacts.

The findings in this report are based mainly on available literature on project area, qualitative/quantitative assessments, professional judgements and field observations. Field visits were made to Hulhudhoo on 21-22 April 2016

1.1 EIA Team

This Environmental Impact Assessment report is prepared by Mr. Hussein Zahir and Mr. Mohamed Mustafa.

1.2 Aim and Objectives of the EIA

The aim of the EIA is to provide environmental clearance required by regulation for the implementation of the proposed project in Hulhudhoo in Addu City. It also aims to identify project impacts to environment and appropriate impact mitigation measures for minimizing or avoiding any negative impacts to environment, social and biophysical subsystems that mutually influence one another. Key objectives of this EIA are to

a. allow implementing the project through proper planning while ensuring efficient resource use, minimize or eliminate serious and irreversible damage to environment
b. identify potential impacts to environment and set appropriate impact mitigation measures
c. ensure environmentally sound decisions making and conditions settings

1.3 Scope of EIA

The EIA is prepared within a given Terms of Reference (TOR) approved by EPA on 16 February 2016. The TOR prepared by consultant was forwarded to EPA before the EIA scoping meeting held at EPA on 16th February 2016. Key stakeholders that included Addu City Council member, project client, project consultant and officials from EPA attended the scoping meeting. A copy of TOR is given in Appendix 1. Meeting attendance is given in Appendix 3

1.4 Project Client

The client of the project is Mr. Abdulla Mutheeu, Nest Mead, Hulhudhoo in Addu City. Mr. Mutheeu is a local businessman who has several years of experience in hotel, tourism, bottling water and soft drink production industries. Clients' declaration is given in Appendix 2

1.5 Project Justification

The project client being a businessman in Maldives, the primary aim of the proposed project is to invest and operate a water bottling facility with his vast experience in this business. The smallness of Maldives (limited to small islands) and due to its extremely limited natural freshwater resources, peoples are highly dependent on roof top harvested rainwater for drinking and cooking. The rainwater stored in household tanks is used without treatment and in most cases not safe for potable needs. The groundwater is also unfit for potable needs due to over exploitation and contaminations both are tied with population densities.

The source of water for *drinking* has been gradually replaced with desalinated bottled water. In Addu City, the major brands of bottled desalinated water available are *Life, Taza and Bonaqua* mainly produced and packed in Male atoll which is about 550km away from Addu City. These bottles produced mainly in Male' atoll is shipped to Addu City by domestic cargo ships with limited capacity operated in Addu City. In most cases the retailed shop owners in Hulhudhoo and Meedhoo travel to Feydhoo and Hithadhoo on passenger ferry for buying bottled water. The situation gets worse in rough season where the supply stops due to difficulties in travelling.

The proposed desalination and bottling facility in Hulhudhoo will provide a relief to common householders and retail shop owners in Hulhudhoo and Meedhoo from waiting for bottled water shipments from Male' or depend suppliers in Hithadhoo and Feydhoo.

The proposed production and distribution in Hulhudhoo will build confidence among the Hulhudhoo and Meedhoo community. The production will also benefit to environment as it involves refillable bottles, which will help to reduce the amount of empty water bottles that becomes large part of plastic waste, which has become a significant environmental issue.

The health benefits of having made improved drinking water available are broad in scope, ranging from reductions in diarrhoea/skin diseases and to enhanced social well-being/improved dignity.

1.6 Project Settings

The proposed project will take place in Addu City, Maldives in compliance with Maldives Environment Act 4/93, EIA Regulation 2012/R-27 and its subsequent amendment that include 2013/R-18 and 2015/R-174. All prescribed activities in Schedule D (*Jadhuvalu Raa*) of new amendment of EIA regulation 2012 requires detailed EIA to be carried out and obtained environmental clearance before commencing any physical work of the project. Installation of desalination plants is a prescribed activity under No. 34 of Schedule D of 2nd amendment of EIA Regulation 2012.

1.7 Scope of the Project

The project is implementation of small-scale desalination and water bottling facility in Hulhudhoo, Addu City. The daily production capacity of desalination unit will be at 80m^3/day. The estimated daily production of bottled water will be at 350-400 bottles of 20L capacity and 300 -500 bottles of 5L capacity.

2 Regulatory Framework

2.1 Environment Act 4/93

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management for development projects.

a. An EIA shall be submitted to EPA and obtained approvals by EPA before implementing any development project that may have a potential impact to the environment.

b. Any project that has any undesirable impact on the environment can be terminated without compensation.

c. Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.

d. The penalty for breaking the law and damaging the environment are specified in the Law.

e. The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

Key laws and regulation of relevance to the proposed project are tabulated as follows (Table 1).

Table 1 Key relevant regulations and their specific relevance to the project activities

Name of Regulations	Specific Articles/Sections and Clause No. Relevance to the project	Description	Enforced by
EIA Regulation No. 2012/R-27	Section 3, Clause 8 (c),	EIA clearance is required to be obtained for projects prescribed in Annex D	EPA
EIA Regulation 2nd Amendment No. 2015/R-174	Clause13 Annex D (34)	Annex D (34) under 2nd amendment of EIA regulation specifically says it requires EIA clearance before commencing any desalination plant of capacity 10,000L/day	EPA

		or above.	
Tree cutting, felling , uprooting and relocation regulation	Clause 5 (a)	This clause of the regulation says environmental clearance need to be obtained from Ministry of Environment for removal, felling, cutting or relocation or trees for development projects	EPA
Tree Felling, Cutting, Removal and Relocation Regulation, MEEW	Clause 5 (a)	It says EIA clearance is required for cutting or removing trees of large quantities for land clearance for any purpose	
1st Amendment to Tree felling, cutting, removal and relocation regulation No. 2014/R-7	Clause 3 (a)(1)	This amendment of Tree felling, removal, cutting and relocation regulation says removing, cutting and felling of trees within 15m from shoreline is illegal.	EPA
Dewatering Regulation No. 2013/R-1697	Clause 5 (a)(b)		EPA
Environmental Liability Regulation No. 2011/R-9	Clause 7	Fines and compensations on polluters	
Land Act 1/2002	Clause 4 (a)	Allocation of land for commercial needs	MHI
Waste Management Regulation 2013/R-58	Section 2, Clause 6 (7), Clause 10, 11 (b,c)	Waste disposal, extended producer responsibilities and management of hazardous wastes	EPA
Desalination Plant Regulation 2002	Clause 4 (a)	All desalination plants for industrial use are to be registered and an EIA need to be carried out before installed	EPA
Borehole Drilling Guideline 2011	Clause 4	EIA to be carried out for all deep boreholes for water projects	EPA

2.2 Environmental Permits required for the Project

2.2.1 EIA Decision Note

The environmental permit to commence the proposed project is the decision statement to be made by EPA. The decision statement will be given to the proponent after independent review of EIA report. The decision statement will on the degree/significance of impacts to environment from the proposed development. This EIA report will assist EPA making informed decision relevance to the proposed project.

2.2.2 RO plant registration

All desalination plants supplying water to the public has to be registered at Environmental protection agency of Maldives as water regulator. Plant can only be permitted to supply water to the public through plant registration. EIA decision Note is an essential component of the RO registration process.

3 Project Description

3.1 General Context of the Project

The project mainly is establishment of a small-scale desalination and water bottling facility in Hulhudhoo, Addu City. The daily production capacity of desalination unit will be at 80m^3/day. The estimated daily production of bottled water will be at 350-400 bottles of 20L capacity and 300 -500 bottles of 5L capacity.

3.2 Project Location

The proposed project islands Hulhudhoo located in the eastern edge of Addu City. The registered population of Hulhudhoo is 3666 (April 2015) and the number of houses in Hulhudhoo is at 541. The geographic location of Hulhumeedhoo is at 00°35′16″S 73°14′02″E as shown in Figure 1. The project site is located at western edge of Hulhudhoo as shown in **Error! Reference source not found.**. General location of the project site and ite layout outline drawings are shown in Appendix 5.

Figure 1 Addu City with six administrative towns

Figure 2 Project Site in Hulhudhoo

3.2.1 Land Approvals

Addu City Council through a lease agreement with the proponent has provided land with an area of 20000 square feet located on western shoreline of the island behind the futsal ground. This lease agreement is validated and approved by Ministry of Housing and Infrastructure under changes that have been brought to the governance and administration of land and other properties under local councils. The land approval letter is given in Appendix 6.

3.3 Project Components

The key components of the project that covers under this Environment Impact Assessment are as follows

1. Site clearance
2. Installation of reverse osmosis desalination unit of capacity 80m^3/day
3. Installation of brine discharge pipe installation

4. Installation of backup generator of capacity 200kW
5. Construction of fuel storage tank of capacity 600L
6. Construction of repair and maintenance workshop
7. Water quality testing laboratory
8. Construction and development of water bottling and packing house
9. Installation of bottling plant
10. Borehole drilling for source water

Various components of the project especially physical infrastructure components of the project are provided as drawings and other related documents in Appendix 3.

3.3.1 Site Clearance

The minimum vegetation clearance will be carried out for building. The area for the building will be sited with highest consideration to minimised impact on vegetation. Tree felling, cutting and trimming will be avoided where possible.

3.3.2 RO plant Design and Installation

Factory assembled RO plant of capacity 80cbm will be set up and mounted at the plant house by engineers from the manufacturer. The feed water for the RO plant will be extracted from a deep borehole to be installed within the site under the project. Disinfection is carried out using chlorine, which is later de-chlorinated before passed into RO membrane module by high pressure pumping. The product water is further treated with second pass followed by UV treatment before made it available for bottling. Figure 3 shows a generic flow diagram of seawater desalination process for the proposed system.

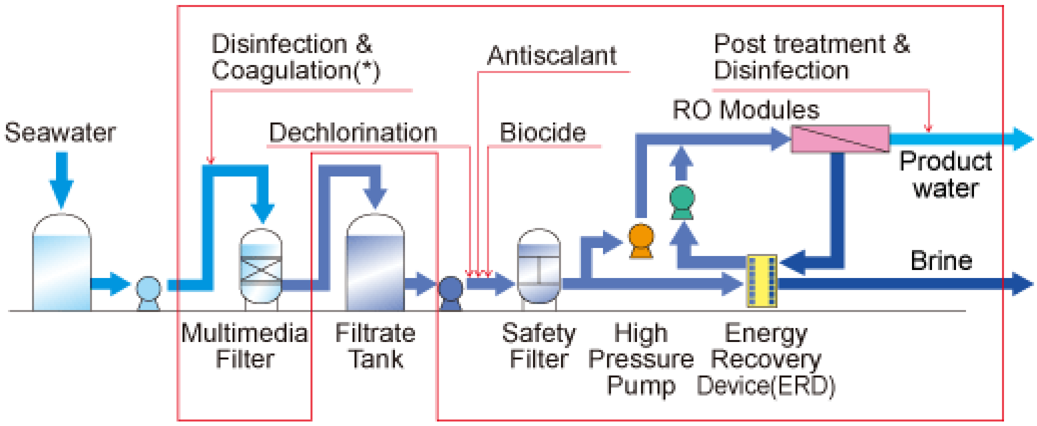

Figure 3 A generic flow diagram of sea water desalination

3.3.3 Installation of Brine Outfall

The brine or reject concentrate will be discharged into the deep water at west coast of Hulhudhoo at a distance of 930m from RO plant site.

3.3.4 Generator and Fuel Storage Tanks

A generator of 200kW will be installed to provide necessary electricity for the operation of RO plant, water bottling plant and lighting of the building. There will also be a fuel storage tank of capacity 600L

3.3.5 Water Quality Testing Laboratory

Water quality testing laboratory with equipment will be attached to the facility. The laboratory will be equipped to check both physical and biological parameters of both raw water and product water. The routine physical parameters that will be tested include pH, Electrical Conductivity, TDS, Salinity, Chloride, Turbidity and the biological parameters tested will be Faecal Coliforms and Total Coliforms

3.3.6 Water Bottling and Packing

Bottles of sizes 1.5L, 5L and 20L cans for filling are formed using preform blowing machines. Bottles formed in the process are then rinsed before filled with purified water and then passed on conveyance belt for light checking and visual inspection for any suspension in the water. A typical flow diagram of water bottling is shown in Figure 4

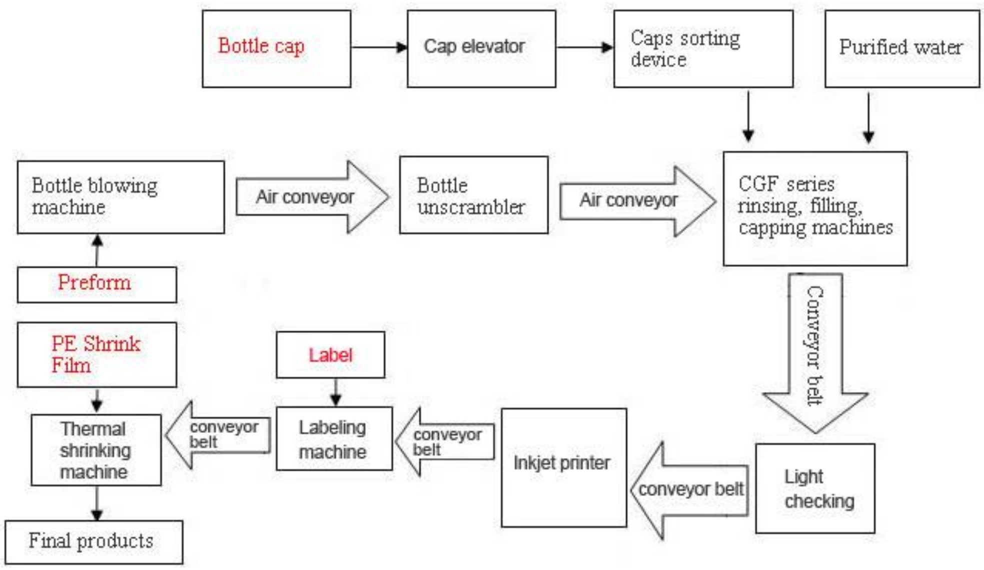

Figure 4 Typical flow diagram of water bottling plant

3.3.7 Borehole Drilling

One borehole will be drilled southwest corner of the plot. The borehole will be installed according to the *Borehole Drilling Guideline* of Environmental Protection Agency (EPA).

Borehole will be drilled using a borehole drilling machine or a rig as shown in Figure 5. The purpose drilling as known is to obtain a hole into the ground sufficient in size and depth, inside which well screen and casing pipes can be subsequently, placed. The borehole is made by cutting the formation material at the bottom and thereafter removing the disintegrated fragments to ground surface. The technique to be used for the proposed drilling will be with *rotary drilling* this is accomplished by the rotation of suitable tools to chip and grind the rock formation into small fragments. The disintegrated material will be removed continuously by means of a stream of water.

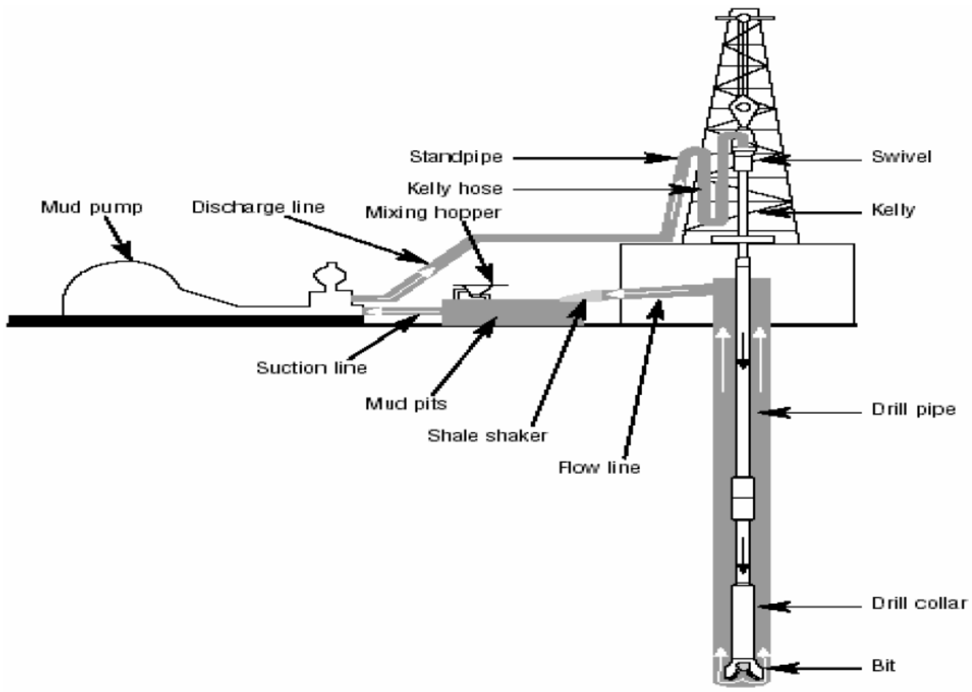

Figure 5 Typical Borehole drilling rig (machine) to be deployed for the drilling work

3.4 Construction Materials

Construction materials will include PVC pipes, cement, bricks, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, PVC conduits, diesel, petrol, tar, PVC adhesive, timber etc.

3.5 Implementation Schedule

The implementation of the proposed project is to be started in the 3rd quarter of 2016. The project is expected to be completed in 6 months as shown in the work schedule (Table 2).

Table 2 Project activity schedule

Key Project Tasks	Year 2016											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Project Planning	■											
Approvals (EIA)		■	■	■	■	■	■					
RO and Bottling plant Procurement				■	■	■	■					
Site Preparation								■				
Build Plant and Bottling Housing								■	■	■		
Borehole Drilling									■	■		
RO and Bottling plant Installation										■	■	
Installation of brine discharge line										■	■	
Installation of backup Gen Set										■	■	
Commissioning												■

3.6 Activities during Construction

Key activities in the construction phase include site preparation for RO plant and bottling facility building construction, mobilization of equipment, construction of plant building, borehole drilling, installation of RO plant, installation of bottling and filling unit, installation of generator set, setting of fuel storage tanks, construction of administrative and accommodation block and laying of brine outfall

3.6.1 Site Preparations

Site preparation considered to be one of the key elements of any such projects which include selective removal of vegetation for setting the main facility building and accommodation blocks

3.6.2 Mobilization of Equipment and Materials

Site mobilization involves mobilization of workforce, machineries/equipment and construction materials to project site to begin physical implementation work.

3.6.3 Workforce and Services

The proposed project requires appropriate management during the construction phase where 5 workers will be involved in the masonry and building construction, they include 1 engineer, 1 chief mason and 3 helpers. All required installation of RO plant, water bottling and filling stations; generator set, fuel storage tank and borehole will be installed by out sourced expert groups.

3.6.4 Material Transport

All materials that are required for the implementation of the proposed project need to be transported to the project islands. The transportation will mainly be on *land, sea and air*.

3.6.5 Waste Management

Solid waste generated during the development will be managed according to Maldives solid waste management Regulation No. 2013/R-58. Solid waste include vegetation removal, waste wood, concrete form work, waste steel bars from concrete reinforcement activities, material and equipment wrappings. Likely hazardous waste includes empty paint tin, thinner tin, wall colour tins, used wall colour rollers, used brushes, used oiled clothe pieces and empty tar cans.

3.6.6 Health and Safety

Workers health and safety is also an important aspect that needs attention during the implementation. Protection of employees from likely adverse effects will be one of the core duties of the proponent or contractor. All machineries and equipment must be operated by trained and experienced personals wearing necessary safety gears.

3.7 Operation Phase Activities

Key activity identified that may have direct impact to environment throughout the operation of the facility is found to be brine disposal. Other activities that may have secondary impact to the environment include water intake, greenhouse gas emissions from fossil fuel burning for electricity generation and generation of waste.

3.7.1 Brine Disposal

Brine disposal in any desalination is carefully considered and studied well when implementing desalination plant. The easiest way in disposing the brine is to discharge it in the sea via a brine outfall pipe as proposed in the project.

Brine concentration that varies from 50 to 75 g/L its concentration is denser than seawater and therefore tends to settle on the lagoon floor near the brine outfall outlet creating a very salty layer which can have negative impacts on the flora and the marine life. This effect will be avoided by releasing brine concentrate into a highly turbulent water body where there is current. Brine disposal has the potential to degrade the physical, chemical and biological characteristics of the receiving water body that however is highly dependent on the total volume of the brine being released, its characteristics, the dilution rate prior to discharge, and the characteristics of the receiving waters. The volume of brine concentrate from the proposed development is very small and will have highly insignificant impact to the marine environment.

3.7.2 Project Inputs and Outputs

The main output of the project is sea water desalination plant and drinking water bottling facility in Hulhudhoo, Addu City. The inputs and outputs are summarised in Table 3 and Table 4

Table 3 Project Inputs

Input resource(s)	*How to obtain/responsible by*
a. Construction workers	Client
b. Materials for works implementation: PVC pipes, HDPE, pipes, timber, cement, electrical cables, circuit boards, main circuit boards, reinforcing steel bars, river sand, aggregates, diesel, petrol, tar etc	Import and purchased by client

c. Water (during construction)	Rainwater or skimmed fresh groundwater by client
d. Electricity (during construction)	Client
e. Machinery and equipment for excavation. Machineries and equipment include 1. Excavator 2. Submersible pumps 3. Pickups 4. Wheel burrow 5. Mini diesel generators 6. Sea going vessels	Client
f. Cement	Imported or locally purchased by Client
g. Fuel (e.g. diesel, petrol)	Locally purchased by Client
h. PVC Adhesives i. Electric pumps j. Lights	Imported or purchased locally

Table 4 Project Major outputs

Products and waste materials	Anticipated quantities	Method of disposal
a. Waste oils from machinery during works implementation. ***b. Cleared green waste***	Minor Minor	Re-used to other applications Natural decompose
c. Brine Concentrate	Moderate	Disposed into sea where dilution and dispersion happens
d. Timber, cardboard, gunny bags and scrap metals (site	Minor	Recovered, reused , recycled

waste)		
e. Used oil (waste oil), grease	Minor	Reused
f. Solid waste (kitchen waste, waste from accommodation blocks)	Minor	Taken for disposal through island SW system

3.8 Hazard Vulnerability and Accidents

There could be many risks (hazards) and accidents to consider associated with many possible scenarios that could unfold depending on time, magnitude and location it occurs. These are important elements that need properly identified, assessed and analysed for what could happen if a hazard or accident occurs during development and in operation. First and foremost are the significant injuries to workers. Accidental fire outbreak is also an important aspect to be thought and prepared with properly designed fire extinguishing setup. The potential hazards include fire, explosions natural hazards (eg. flooding from heavy rain or wave, wind storms etc), hazardous materials (spills or release), workplace violence, mechanical breakdown and supplier failure. Those at risks are the workers in this case.

3.8.1 Risk Mitigations

The most common natural hazards flooding from heavy rain storm surges, strong winds etc. in Maldives are unavoidable. These natural hazards cannot be prevented or avoided, but have the opportunities for minimizing the damage and reduce the potential impacts on life, property, operation and the surrounding environment. The proposed facility under the captioned project located in the western edge of Hulhudhoo in Addu City will be subjected to strong wind and flooding from heavy rainfall during south west monsoon. Hence mitigation plans have been included to provide thick vegetation buffer at western edge of the site. Additionally, fire safety and emergency planes will also be in place accessible to workers and operators.

3.8.2 Emergency Plans

In sea water desalination and bottling facility such as the one proposed in Hulhudhoo the success and failure will depend on the quality and durability of machineries, quality of implementation work, system operation, maintenance and management. In a desalination system, a fault may occur at feed water intake borehole, a high pressure pump and pretreatment filtration system etc. In order to fix any of these faults spare materials, tools, pumps will be made available on site.

4 Methodology

Established standard methods have been applied in preparing this EIA report. The key steps include impact identification, base line study, alternative means for achieving the same goals, prediction, and evaluation of environmental impacts followed by recommendation of possible mitigation measures. Impact identification and analysis have been carried out using checklists and Leopold Matrix respectively.

4.1 `Impact Identification

Impact identification and evaluation has been carried out using checklist and Leopold matrix as described in Chapter 9. These are two standard methods that have been widely used in identifying and assessing impacts for a given project to a given site.

4.2 Data Collection

Site survey and data collection has been carried out using standard scientific methods in particular of focusing to establish baseline data. Field surveys and spot environmental checks were also undertaken for assessing the existing environment of the site and surrounding for understanding of the likely cumulative environmental changes and impact management. The key components of the existing environment assessed include; terrestrial flora/fauna, groundwater quality, coastal shoreline, seawater quality and marine life forms specific to study area.

4.3 Terrestrial Environment Assessment

4.3.1 Flora and Fauna

Floral and faunal survey has been focused to define faunal and floral species types to understand the types and species at the project site for its conservation and future environmental monitoring. The key element focused in undertaking the survey was direct counting for measuring relative abundance of vegetation, vegetation types, vertebrates and invertebrates in the project sites where vegetation removal has been proposed for the development

4.3.2 Groundwater Quality

Groundwater quality was measured in situ using *Hatch* potable water quality testing hand held meters. Parameters tested in situ include, Electrical Conductivity (µs/cm), Salinity (%) and Total dissolved solids (mg/l)

4.4 Marine Environment Assessment

4.4.1 Seawater Quality

Marine water quality has been tested in situ by using HATCH water quality logger. Parameters tested are pH, electrical conductivity (salinity and TDS), turbidity and TSS. Locations where water quality tested are indicated WQ1, WQ2 and WQ3.

4.4.2 Surface Currents

Lagoon current was measured by conducting drogue tests where brine outfall has been proposed. Drogue tests were carried out using purposely built drogue to understand the general current pattern within the proposed brine discharge zone.

4.4.3 Marine Ecology

The ecology and marine habitat survey of location where brine is to be disposed has been briefly assessed qualitatively followed by underwater photographs

4.5 Impact Assessment Methodology

Impact assessment has been carried out using standard impact identification approaches such as purposed built checklist and Leopold matrix coupled with field surveys consultants experience on similar projects in Maldives. Please refer Chapter 9 for further details.

5 Project Alternatives

5.1 Alternatives

This section looks at alternative ways of undertaking the proposed project or project components. The basic options are (1) No project option (leave the problem as it is), or (2) Undertake the proposed project.

5.2 No project option

The **"no project"** option has been considered as the baseline against which to evaluate the project option. The main advantages and disadvantages of the no-project option are given in Table 5.

Table 5 Advantages and disadvantages of no project option

Strategy	Advantages	Disadvantages
Keep the existing situation as it is	• No environmental change to the specific project site • No discharge of brine to marine environment • No felling of trees and vegetation clearance	• The opportunity to expand the business of client will not come to a reality • Private sector participation in water business not promoted in Maldives • Price of bottled water will remain unchanged • Hulhudhoo community will face short supply of bottled water during bad weather • New job opportunities will not be created • Empty water bottles keep increasing in the main waste stream

5.3 Alternative Locations

5.3.1 Alternative Site 1

One alternative location for the facility can be at the new harbour *(Sarahadhdhee Bandharu)* that has been built between Hulhudhoo and Meedhoo, which is also considered future commercial harbour. However the disadvantage for the client is that it is not able to secure land for this type of light industry and it is unlikely to get land from that area. The alternative site 1 is shown in Figure 6.

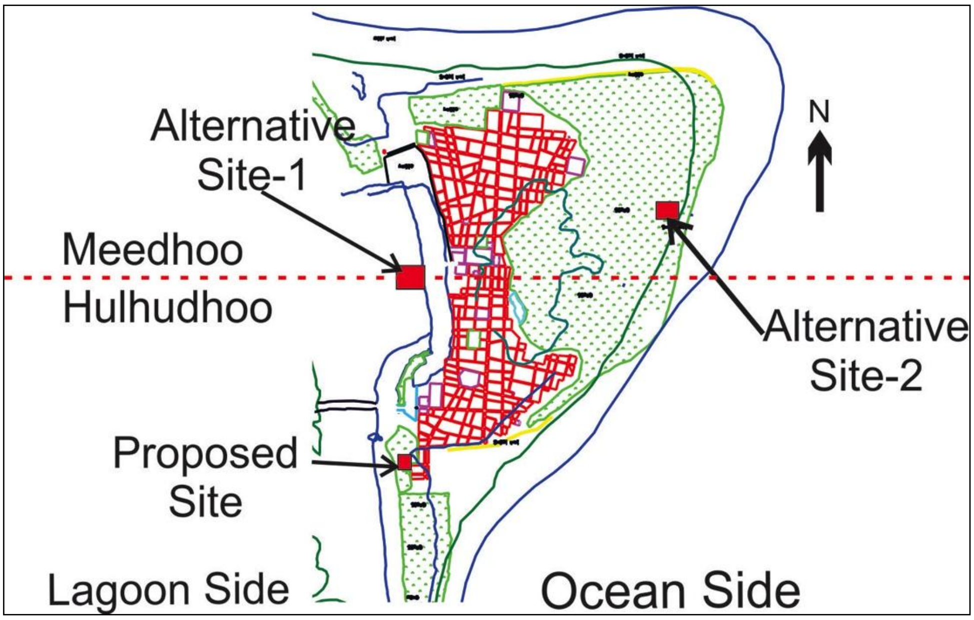

Figure 6 Alternative Locations

5.3.2 Alternative Site 2

Second alternative site is to build the proposed facility at eastern side of the island close to existing municipal RO plant as indicated in Figure 6. The following table (Table 6) compares the proposed and alternative site.

Table 6: Comparison of proposed and alternative project sites

Proposed Site	Alternative Site 1	Alternative Site 2
Land already secured and approved	Not able to secure land and no hope	Not able to secure a land in near future and no hope

Location is close to clients home	Location is very far from clients home	Location is very far from clients home
No cost of travelling to site by the client	Cost of travelling to site by the client is high	Cost of travelling to site by the client is high
Overall operational cost is expected to be low	Overall operational cost is high	Overall operational cost is very high

5.4 Alternative Brine Disposal

5.4.1 Brine Disposal into Sewer

The common practice of disposing brine is to discharge it directly into most appropriate marine water body where brine get diluted and dispersed with minimal impact to the marine sink. The alternative way of disposing brine concentrate is to mix it with sewage effluent via marine outfall. In order to set up this option the client has to obtain permit from sewerage service provider to comply regulation.

5.4.2 Brine Disposal into Existing Brine Discharge Pipe

The other alternative approach is to use existing brine discharge line that has been installed under the existing municipal RO facility in Hulhudhoo. With the permission of service provider this option can only be used if *alternative site 2* is used for the facility.

5.5 Preferred option

With due considerations to the alternative options discussed above, it is not viable to either acquire the alternative location for the facility or disposed the reject water through existing sewer system or brine disposal system of the public RO plant. These are additional costs to the project and these additional will significantly add to the overall project cost. Given the small scale of the project and considerations on environmental issues related to the project the proposed design and construction options are preferred.

6 Existing Environment

6.1 General Setting

The Maldives archipelago consists of a double chain of coral atolls, 80 – 120km wide stretching 860km from latitude 7° 6’ 30” N to 0° 41’ 48” S and longitude 72° 32’ 30 E to 73° 45’ 54” E (Ministry of Construction and Public Works, 1999). The double chain of the Maldivian atolls lies on the parallel submarine ridges in the central part of Indian Ocean known as Lacadive-Chagos ridge. The archipelago comprises 25 natural atolls (Naseer, 2004) grouped into 20 administrative units (Figure 7). The atolls are separated by east west running deeper channels. The atolls vary in shape from circular and oval to elliptical. The atolls contain 1190 islands, of which only 198 are inhabited. The total reef area of Maldives is 4,493.85km^2 while the total land area is 227.45km^2 (Naseer, 2004). Approximately 80% of Maldivian land area is less than 1m above mean sea level.

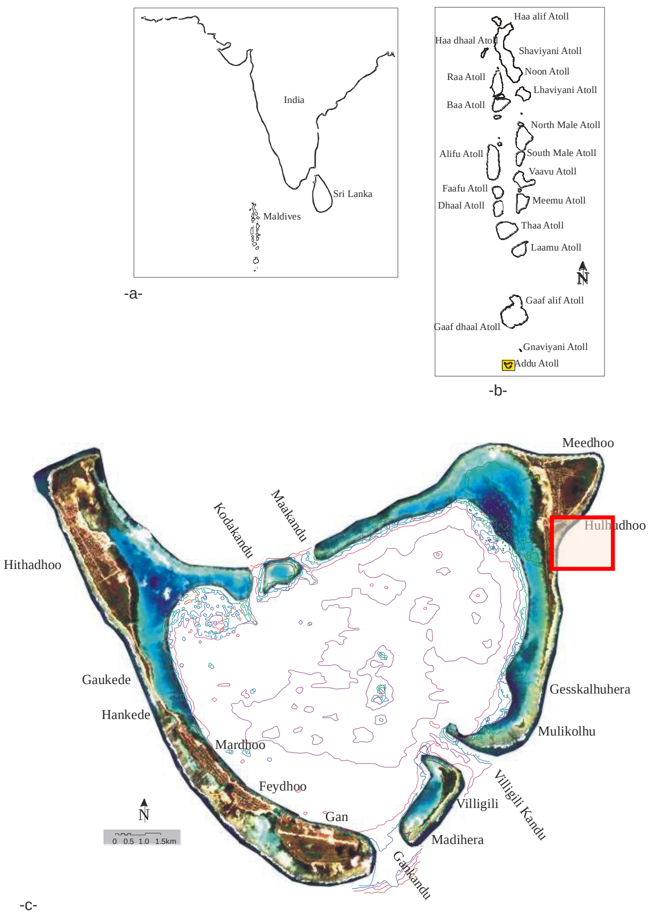

Figure 7 Geographic location of project site (within red square) in Hulhumeedhoo

The characteristics of reefs and coral islands of the Maldives vary considerably from north to south. The atolls to the north are broad banks discontinuously fringed by reefs with small coral islands and with numerous patch reefs and faros (the word faros is derived from the Maldivian word "*faru*") in the lagoon. To the south the depth of atoll lagoon increases, faros and patch reefs are rare in the lagoon, the continuity of the atoll rim is greater and a large proportion of the perimeter of the atolls is occupied by islands (Woodroffe, 1992). The islands have shallow reef flats on their seaward side, some with shingle ramparts at the seaward limit of the reef flat. The islands and the shingle ramparts owe their origin to the deposition of shingle or coral debris during storms. A number of islands can be found on a single reef. These islands may be separated by shallow passages that run across the reef flat. The width of some of these passages could be less 100m while some passages are over a few hundred meters wide.

Addu atoll located at 0° 38'S', 73°10'E is a relatively small atoll (159 km^2) compared to most other atolls in the Maldives. The average area of the Maldivian atolls was calculated to be approximately 855km^2 (Naseer and Hatcher, 2004). Addu atoll has a triangular shape that is dissected by four deep channels Gan Kandu, Viligili Kandu, Maakanda, and Kodakanda and comprises 16 islands, all of which are formed on the atoll peripheral reef (Table 2 & Figure 7). The atoll lagoon has depths between 30 and 80m. The atoll reef system has two major segments; the reef on the southwestern side of the atoll (Gan – Hithadhoo reef) and the reef that accommodates Hulhudhoo-Meedhoo on the north to the northeastern side of the atoll. The Hulhumeedhoo reef section represents about 11% of the total perimeter of the atoll. The total area covered by the atoll peripheral reef flats, including the islands is approximately 44km^2. The length of the atoll periphery reef is 60km (Table 7).

Table 7 Geomorphic features of Addu Atoll

Description of the physical attribute	Dimension		
Atoll area	159 km^2		
Atoll peripheral reef length	60 km		
Area of the reef flat (excluding the reef top islands)	30 km^2		
Area of the islands	14 km^2		
Length of Hulhudhoo-Meedhoo reef stretch	22.3 km		
Length of Gan-Hithadhoo reef stretch	29.1 km		
Deep channels	***Width***	***Max depth***	
Gankadu	961 m	17 m	
Viligili kandu	851 m	55 m	
Maakadu	571 m	30 m	
Kodakadu	397 m	30 m	
Width of shallow passage along Gan-Hithadhoo reef stretch prior to 1960's			
Gan-Feydhoo	400 m		
Feydhoo-Maradhoo	168 m		
Maradhoo-Hankede	100 m		
Hankede-Gaukede	336 m		

The island of Hulhumeedhoo lies at the northeastern side of Addu atoll on the Hulhumeedhoo reef complex, measuring 2.3 km in length and around 1.7 km in width (at maximum), the island covers an area of 283 hectares.

The land plot allocated for the project is located adjacent to the sport complex at the southern side of Hulhudhoo harbour basin. The location of the plot is given in Appendix 5

6.2 Climate and Oceanography

6.2.1 Rainfall

The Maldives generally has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) and relative humidity ranging from 73% to 85%. While Maldives receives an annual average rainfall 1900mm, the average rainfall in northeast monsoon also known as the dry season is recorded at 50-75 mm.

The average annual precipitation ranges in Maldives increase from north to south with between 1500 mm and 2000 mm. Figure 8 and 9 shows mean annual rainfall pattern from north to south and comparison of April 2016 rainfall with long term average of S.Gan

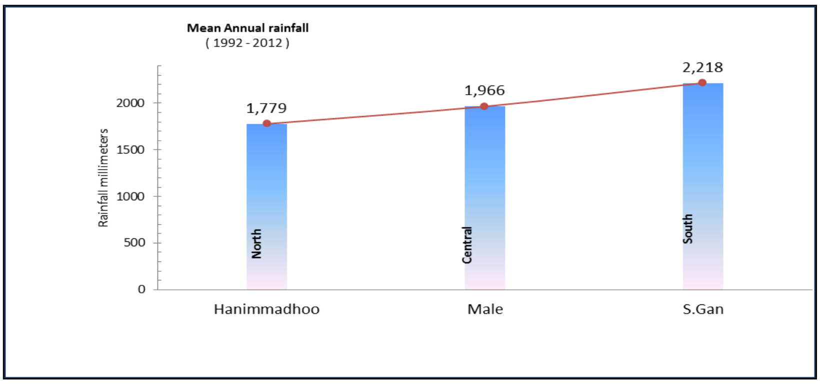

Figure 8 Mean Annual Rainfall 1992 -2012 (Source: MMS, 2015)

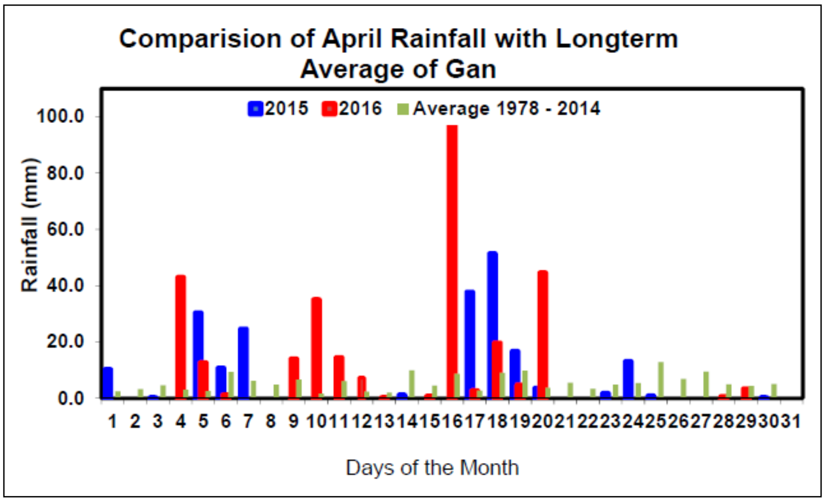

Figure 9 Comparison of April 2016 rainfall with long term average S. Gan (Source: MMS, 2016

6.2.2 Wind

Wind climate in the Maldives is dominated by the Indian monsoon climate South West (SW) monsoon and North East (NE) monsoon. The Indian monsoon system is one of the major climate systems of the world, impacting large portions of both Africa and Asia (Overpeck et, al., 1996). The monsoon climate is driven by the atmospheric pressure differences that arise as a result of rapid warming or cooling of the Tibetan Plateau relative to the Indian Ocean (Hastenrath 1991; Fein and Stephens 1987). During the summer of northern hemisphere the Tibetan Plateau warms rapidly relative to the Indian Ocean which results in an atmospheric pressure gradient (Low pressure over Asia and high pressure over the Indian Ocean) between the Asian landmass and the Indian ocean, which drives the prevailing wind from south to westerly directions. The period during which prevailing winds are from south to westerly direction is known as the SW monsoon. In the winter of northern hemisphere the continent cools relative to the ocean. This reverses the pressure gradient (low pressure over the Indian Ocean high pressure over the Asian landmass) and the prevailing winds become northeasterly. The period during which prevailing winds are from northeasterly directions is known as NE monsoon. The transitions from NE to SW monsoon and vice versa are distinctly different from SW or NE monsoon. During these transition periods the wind becomes more variable.

The SW monsoon lasts between May and September while the NE monsoon lasts between December and February. The period between March and April is the transition period from the NE monsoon to SW monsoon known locally as the Hulhangu Halha, while the transition period from SW monsoon to NE monsoon is known as Iruvai Halha. Iruvaihalha lasts from October to November (Table 8). The SW monsoon is generally rough and wetter than the NE monsoon. Storms and gales are infrequent in this part of the world and cyclones do not reach as far south as the Maldivian archipelago (Ministry of Construction and Public Works, 1999).

Table 8 The four seasons experienced in the Maldives

Season	**Month**
NE-Monsoon	December January February
Transition Period 1	March April
SW-Monsoon	May June July August September
Transition Period 2	October November

SW monsoon is characterized by strong Westerly winds and is considered to be the wetter period of the year. The seas are generally rough in this period. In contrary, NE Monsoon is characterized milder wind from NE quadrant. This period is in general much lighter and dryer than other seasons. Gale and storm winds in this region are infrequent and cyclones do not reach deep into the central region of Maldives.

The wind speed recorded to be fairly uniform through the year in Addu atoll, except heavy winds that occur during south west monsoon. The direction of wind also changes predominantly from north east in the northeast monsoon to west and south west in the southwest monsoon. Wind gusts of 35 mph to 45 mph were occasionally recorded. The highest wind recorded in Addu Atoll is at 103.5 Miles from SW in 1991 (Dept. Meteorology, 2015). In September 2015 the maximum wind speed from west was recorded at 40mph. The maximum wind speed in the atoll in September in 2014 was recorded at 51mph from south west (Maldives Department of Meteorological Service, 2015). Figure 11 shows S. Gan wind rose diagram in April 2016

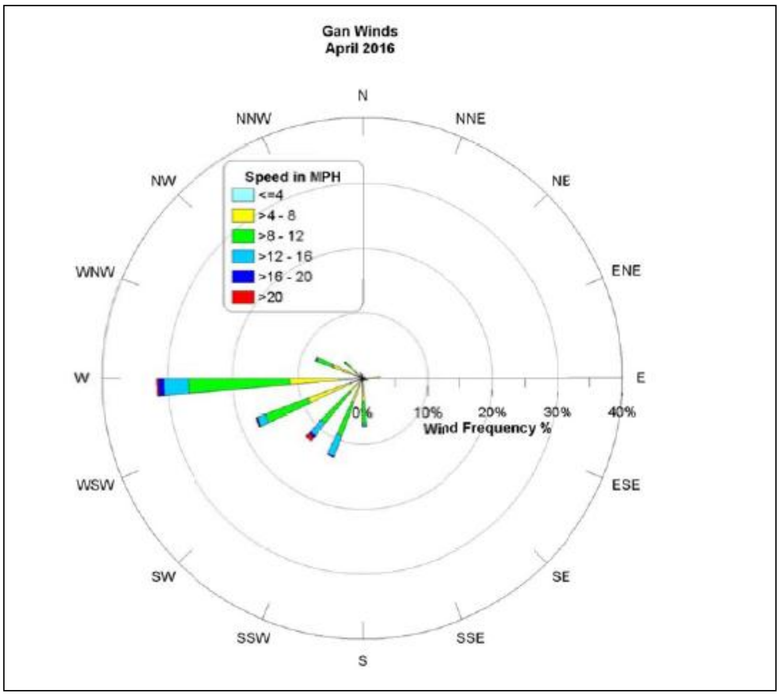

Figure 10 Wind rose diagram for Addu City (Source MMS, 2016)

6.2.3 Waves

General offshore wave conditions in the southern regions of Maldives for a project by Danish Hydraulic Institute reported that during NE monsoon the oceanic swells that approach the southern atolls of Maldives are generally from east – south (DHI, 1999). The longer period waves of the wave spectrum are from south – southwest directions while the shorter period waves are mainly from east – northeast directions. During the SW monsoon the waves are mainly from south. The longer period waves of the wave spectrum are from south – southwest while the shorter period waves are from southeast – south. It is therefore evident that the incident waves in the southern atolls of Maldives are predominantly from a southerly direction.

The local wind generated waves that are directly related to the wind climate in the region varies with the seasonal changes in the wind velocity. DHI (1999) reported that during the NE monsoon the wind is predominantly from NW – NE and the high-speed winds are from west (Table 9). During *Hulhangu Halha* (Transition Period 1) the wind varies to all directions but the high winds during this period are from west. Southwest monsoon is marked by winds from SE – SW and strong winds from west. *Iruvai Halha* (Transition Period 2) also experiences westerly winds. DHI (1999) reported that the high wind in the southern atolls of Maldives throughout the year is from west.

Table 9 Seasonal wind and wave climate around southern atolls of Maldives

	Month	Wind	Waves		
			Total	**Long period**	**Short period**
NE-Monsoon	December January February	Predominantly from NW-NE. High speeds from W	Predominantly from E-S. High waves from W	From S-SW	Mainly E-NE. High waves from W
Transition Period 1	March April	From all directions. Mainly W. High speeds from W	Mainly from SE-S	From S-SW	Mainly from NE-SE
SW-Monsoon	May June July August September	Mainly from SE-SW High speeds from W	From SE-SW. Mainly S. High waves also from W	From S-SW	Mainly from SE-S. High waves from W
Transition Period 2	October November	Predominantly from W High speeds from W	As SW-monsoon	From S-SW	From SE-W. Higher waves from W

Wave data reported shows that the highest waves reaching the southern Atolls of Maldives archipelago are from west direction (DHI, 1999). Waves of Hs 2.75m with wave periods [Tp] of 8s and 9s have been recorded from west direction. Swell waves with wave periods greater than 9s prevails from South and Southwest directions. Over 80% of the waves from south and southwest directions are long period swell waves.

6.2.4 Tides

Tides originate from the gravitational forces of the sun and moon acting on the rotating earth. As the earth rotates on its axis, spatially varying gravitational forces from the moon and the sun causes the elevated body of water (tidal wave) to follow the relative motion of the sun and the moon. The lunar calendar, which is based on the appearance, size and disappearance of moon, can be used to estimate the tidal changes. Due to the variation of tide levels, a reference mark needs to be established for tide level measuring. In Maldives, mean sea level (msl) is used as the reference mark to measure tidal levels. The commonest scientific method of analyzing the water level elevation caused by the tides at any given location is by harmonic analysis of tide data collected from that site.

Davies et. al, (1971) reported that the tide floods into Addu Atoll lagoon through Villigili Kandu on the southeastern periphery of the atoll and Koda Kandu on the north periphery of the atoll only; the flow at this time through Gan Kandu on the southern tip of the atoll and Maa Kandu on the north periphery of the atoll is out from the atoll lagoon. The tide ebbs from the atoll lagoon through all four channels. The tidal regime in the Maldives in general experiences both 12 hour and 24 cycles. Thus indicating a mixed, dominantly diurnal tide. The approximate lowest low water level for Addu Atoll was calculated to be -0.54m (MSL). The approximated tidal range from low to high in Addu Atoll is 1.09m. This can be true to the site given the insignificant variation in tide levels in Maldives

6.2.5 Currents

The near-shore environments of Maldivian islands are composed of coralline and other bioclastic skeletal material derived from the reef. The sediments in this environment are predominantly coral fragments, calcareous algae (Halimeda) and foraminiferans. The major forces, which produce sediment on the reef, are storm waves and waves driven by monsoon winds and erosion of reef substrate through biological erosion. Tidal and wave driven currents play a significant role in the transport of sediment.

Sediment transport within the reef complex is based on the hydrodynamic factors such as long shore currents, currents across the reef flat etc. Due to the continuous land except a break in the south end of reef it is likely that long shore currents would aid the sediment transport. Sediment production is in general through physical and biogenic processes within the reef system.

Current measurements were taken specific to the project site with respect to the location of the brine (RO plant reject water disposal location). Three close by location where current measurements were taken showed a slight current with velocities of 0.08, 0.11 and .09m/s on average with a southerly direction. The currents are of mainly wind driven at the time of measure and the wind speed is estimated 15mile per hour. The depth of the area where currents were measures is about 1m below MSL.

6.3 Marine Environment

The marine environment in the Maldives is predominantly coral reef ecosystem based with atolls and associated atoll reefs, which vary in shape, size and morphology. In addition to coral reefs there are other coral reef associated habitats such as sea grass beds and mangroves. These associated habitats are always within the atoll-based reefs mainly associated with near shore environment.

The dominant near-shore habitat is sea grass habitat surrounding near-shore environment where the proposed project would be located (Figure 11). The shoreline is already significantly modified with some excavation as drainage to relieve recent rain flush flooding. The water flow near-shore is somewhat restricted

Sea grass surrounds the larger part of the environment where the proposed facility would be constructed. Sea grass habitat is composed of shallow lagoon with shallow and deep areas (depth ranging from -1m to -5m MSL within the larger lagoonal area. There are few coral formations within the lagoon.

Figure 11 Relevant coastal and marine habitats at proposed facility.

These include shallow reef flats; isolated coral patches which vary in size, coral biomes as single of few corals growing as columns from the seabed and large areas of fine sediments referred as lagoons.

The sea grass beds dominate near-shore habitat in the vicinity of the harbor basin somewhat blanketing the entire shoreline. This area is sediment laden due to the semi enclosed nature of the environment as a result of the existing harbor projecting outwards from the natural shoreline. It is noteworthy to say that the entire shoreline in the vicinity of the two existing harbors has been modified in the process of their construction several years back. It is difficult to make a judgment on the nature of the shoreline before the modification. Sea grass beds are part of the near-shore environment in Hulhudhoo and Meedhoo even before the harbor construction. Changes to the sea grass due to these changes are difficult to estimate due to unavailability of data.

Coastal vegetation of the island is predominantly coconut palms mixed with magoo, halaveli and kuredhi.

6.3.1 Sea grass

Sea grass surround as dominant benthic marine ecosystem where the proposed RO plant reject water would be disposed. Dominant species are *Thallassia hemprichii* and *Syringodium filiformis*. This species does not naturally occur in the Maldives.

The density of sea grass was greatest in the mid part of the sea grass meadow with almost 100% cover dominated by *Thalassia hemprichii*. Among other important flora associated with sea grass is Halimeda sp. This is a calcareous sea grass common in reef environment significantly contributing to reef sediments where they grow abundantly. Many other epiphytes such as several species of algae were found in association with the sea grass meadow. Figure 12 shows images of the characteristics of the sea grass meadow in the vicinity of the proposed brine outfall pipe.

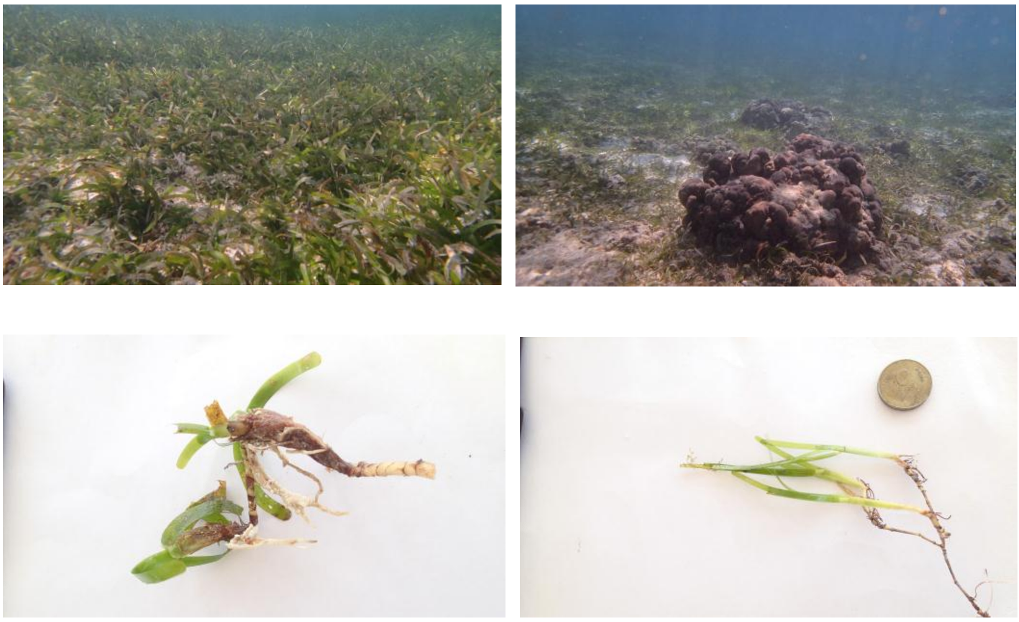

Figure 12 Sea grass community at brine outfall site with two dominant species

6.3.2 Seawater Quality

Marine water quality has been tested at four different locations at project development area including control as shown in Figure 13. Water quality results are shown in Table 10. Water quality has been tested using potable water quality equipment. TDS, EC and Salinity have been measured using Hatch water quality instrument (Series Hatch SensION5). Turbidity has been measured using Hanna Instruments HI 93703 Portable Logging Turbidity Meter. Total Suspended Solid (TSS) has been determined using the general linear logarithmic correlation equation (ln(TSS) = 0.979ln (Turbidity)+0.574) (William R. et al, 2011).

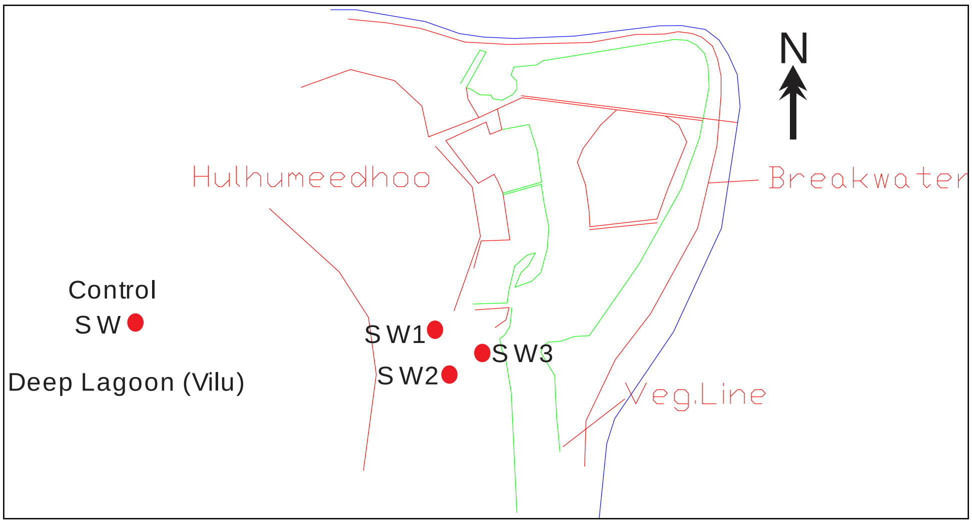

Figure 13 Seawater Quality Testing Locations

Table 10: Marine Water Quality

Hulhudhoo					Average	Maximum	Minimum
GPS Locations	**0°35'51.13"S, 73°13'1.44"E**	**0°35'55.33"S, 73°13'16.34"E**	**0°35'57.09"S, 73°13'18.23"E**	**0°35'56.23"S, 73°13'20.61"E**			
SW Q Test Locations	**SW Controll**	**SW1**	**SW2**	**SW3**			
E.Conductivity (µS/cm)	56500	55500	56000	55600	**55900**	**56500**	**55500**
TDS (mg/l)	28800	27800	28500	27900	**28250**	**28800**	**27800**
Salinity (ppt)	32	34	33	34	**33**	**34**	**32**
Temperature (◦C)	29.2	29.3	29.8	29.7	**30**	**29.8**	**29.2**
Turbidity (NTU)	1.3	1.32	1.28	1.1	1.25	**1.32**	**1.1**
TSS (mg/l)	2.3	2.33	2.26	1.94	**2**	**2.33**	**1.94**

6.4 Terrestrial Environment

The terrestrial environment of the project site is similar to other inhabited islands across Maldives with common vegetation

6.4.1 Terrestrial Flora and Fauna

The floras of Hulhudhoo have no difference from the terrestrial floras found in other inhabited islands in Maldives. The common trees found in Hulhudhoo include *Ambugas, Dhonkeyu, Feyru, Hirundhu, Dhiggaa and Dhivehi Ruh etc*

Tree count recorded at the proposed project site in Hulhumeedhoo is as shown in Table 11. The dominant trees found at this site include young *Sea Lettuce* (Gera or Magoo) and coconut palms (not mature). Others include *Dhiggaa* (Beach Hibiscus).

Table 11 Tree counts

Local Name	Common Name	Scientific Name	Nos
Dhigga	Beach Hibiscus	*Hibiscus tiliaceus*	16
Gera (young)	Sea Lettuce	*Scaevala Taccada*	55
Dhivehi Ruh (young)	Coconut Palm	Cocos nucifera	6
Dhivehi Ruh (Not mature)	Coconut Palm	Cocos nucifera	15

6.4.2 Coastal Vegetation

The composition of marine and coastal fauna and flora is also similar to that of other islands across Maldives. Common coastal vegetation types found includes *Kuredhi, Magoo, Kaani, Hirundhu and Boakashikeu etc.* Figure 15 shows coastal vegetation type in Hulhudhoo

Figure 14: Common Coastal Vegetation Types

6.5 Geological Settings and Hydrogeology

In general the islands in Maldives are small, low lying and flat with common type of vegetation generally formed with the enclosed house reef system and a lagoon. The fresh groundwater aquifers generally are formed as freshwater lenses floating on salt water, which depends on island width, recharge rate and the ease of transmission of freshwater through soil (Falkland *et al*, 2007). Typical illustration of a freshwater lens in small coral islands is shown in Figure 16.

6.5.1 Groundwater lens

Key factors which are considered in measuring the size of the groundwater aquifers in small islands are; size of the island, width of the island, rainfall pattern and extraction of groundwater. The average freshwater lens area estimated by Falkland (2000) Hulhumeedhoo is at 300ha. The expected groundwater to be discharged daily into ocean through toilet flushing is at 1.78million litters assuming per capita total water demand at 90L/ day. The groundwater hydrological assessment undertaken in Addu by Toney Falkland in 2000 it is estimated the freshwater lens area in Hulhumeedhoo to be at 175ha and the freshwater volume is estimated to be at 4200ML. The sustainable yield is estimated at 2012KL/day

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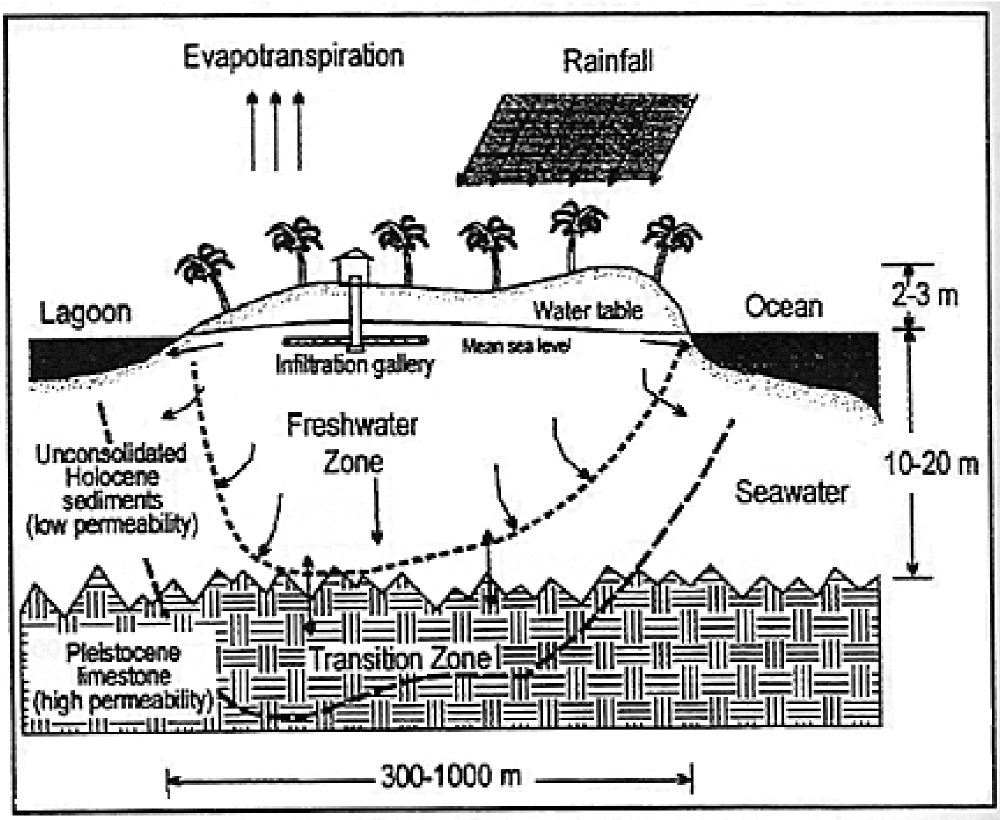

Figure 15 Illustration of typical freshwater lens in small islands (Source: Falkland, 2007)

6.5.2 Groundwater Quality

The quality of aquifer depends on several factors including both natural, human intervention and its geological formation. The quality of groundwater at project site has been tested for its salinity, electrical conductivity, total dissolved solids, pH, and temperature (Table 12).

Table 12: Groundwater Quality at Project Site

	Hulhudhoo				Average	Maximum	Minimum
GPS Locations	0◦ 3'55.91"S, 73°13'24.98"E	0°40'21.73"S, 73° 7'33.73"E	0°35'55.12"SS, 73°13'23.92"E	0°35'55.19"S, 73°13'23.79"E			
GWQ Test Locations	GWQ 1	GWQ 2	GWQ 3	GWQ 4			
E.Conductivity (µS/cm)	516	1926	517	965	**981.00**	**1926**	**516**
TDS (mg/l)	250	967	261	473	**487.75**	**967**	**250**
Salinity (ppt)	0.3	1	0.2	0.5	**0.50**	**1**	**0.2**
Temperature (◦C)	30.2	30.2	30	29.8	**30.05**	**30.2**	**29.8**
Water Depth (m)	0.3	0.3	0.3	0.3	**0.30**	**0.3**	**0.3**

6.6 Socio Economic Environment

6.6.1 Demography

The current living population in Addu City is 19787 (Census, 2014). The total land area is recorded at 15000 hectares with a total registered population of more than 31000 people (ISWMP, 2013).The total registered population in Hulhudhoo is at 3666 (April 2015, Addu City Council). The average growth according to Census 2014 results rate in Hulhudhoo is at -0.52.

In terms of marine resources all communities in the atoll are facing problems with continued impact to their marine resources such as loss of bait fisheries, reef fishing due to reclamation, sand mining for home building and over fishing etc. in the atoll. Hulhudhoo community is heavily impacted due to restriction imposed on them for local reef fisheries due to Herathera Resort.

6.6.2 Economic Activities and Income

The income sources in general similar to other islands in Maldives is mainly based on fisheries, tourism, public administration, agriculture, whole sale and retail trade and transport. Among these income categories more than 25% of share from those engaged in public administration. The per capita income in the atoll is at RF2126 and the per capita expenditure is RF1956 (HIES, 2012)

6.6.3 Accessibility and Public Transport

Although the atoll is small there are challenges in meeting the public transport within the atoll. Hulhumeedhoo community is connected to the capital Hithadhoo by a public sea ferry that keeps operating in Meedhee. Hulhumeedhoo community heavily depends on this ferry for getting access to regional Hospital in Hithadhoo for medical treatments and trade. If the weather is rough ferry stops its operation and people in Hulhumeedhoo face difficulties in travelling.

6.6.4 Utility Services

In Hulhudhoo people have access to 24hr electricity. The service is provided by FENAKA cooperation. Water supply network was being laid by FENAKA cooperation at the time this EIA survey was carried out.

6.6.5 Health and Education

There is one referral hospital in Hithadhoo, Addu City known as Hithadhoo Regional Hospital that provides 24hr services. Apart from this, there are health centres, private clinics and private hospitals. F&C Medicare in Maradhoofeydhoo, F&C Medi Care and Scan Centre in Maradhoofeydhoo, Aims Diagnostic Centre in Feydhoo and Dr. Didi Dental Clinic in Hulhumeedhoo are examples.

There are 18 schools in Addu City. Among these schools 10 schools are government and public schools. In 2014 total number of students enrolled in schools in Addu City was at 5670. Among these 2832 are males and 2838 are females (MoE, 2014)

7 Stakeholder Consultations

The key stakeholders involved in the project include Environment Protection Agency, Addu City Council, Hulhumeedhoo Council, Maldives Food and Drug Authority and FNAKA Cooperation.

7.1 Scoping and Stakeholder Consultation

The scoping has been held at EPA on 16 February 2016. The meeting was attended by Consultant, Addu City Council and Environmental Protection Agency (EPA)

7.1.1 Consultation with Hulhudhoo Council

A consultation meeting was held with Hulhudhoo Council member and senior officials at Hulhudhoo office on 21 April 2016. The meeting was at Hulhudhoo Council Office. Table 13 provides people represented in the meeting with local council.

Table 13 List of members attended to consultation meeting held in Hulhudhoo, Addu City

Name	Title	Representing office
Ali Mohamed	Councillor	Hulhumeedhoo Council, Addu City
Ali Anwar	Asst. Director	Hulhudhoo Town Office, Addu City
Mohamed Mustafa	Asst. Director	Hulhudhoo Town Office, Addu City
Mohamed Mustafa	EIA Consultant	NA
Hussain Zahir	EIA Consultant	NA

7.2 Community Consultation

Community consultation session was held at Kandooelhe Café in Hulhudhoo on 22 April 2016 at 4pm. The meeting was attended by several key members from the community (list is given in Appendix 4). Information shared, discussed and opinion explored with individual community members.

a. An overview of proposed desalination and bottling plant to be implemented in Hulhudhoo
b. Brief description of the project including key project components
c. Brine disposal and how the disposal line get installed
d. The opinion of the community towards the proposed project by the business man born and live in Hulhudhoo
e. Post development impacts to project development site
f. The importance of EIA for the project

7.2.1 Community Opinion

The community in general welcome the project and they have no issue or concern in implementing it in Hulhudhoo. The community in fact need more such job opportunity oriented projects to be implemented in their soil which they believe will have direct and indirect benefit to the community. Some of the questions and clarifications made by some of the members in the meeting include

1. The continued likely contamination and impact to marine environment from brine disposal. EIA consultants clarified to the community that the impact from brine to marine environment will be insignificant and negligible. The location where proposed brine disposal is highly dynamic and has high dilution potential. In terms of installation of brine disposal line, the line will be installed or laid at low tide as at low tide the entire lagoon bed get exposed to air.

2. Also expressed their concerns regarding the likely elevation of groundwater salinity level due to pumping of water from boreholes. EIA consultant explained that it is unlikely that the groundwater get affected by tapping water from deep boreholes. Water from boreholes is drawn far below the freshwater lens at 30m depth.

8 Environmental Impacts and Mitigation Measures

8.1 Environmental Impacts

This section covers potential environmental impacts identified and measures to mitigate these impacts due to the proposed project in Hulhudhoo. The potential environmental impacts during works implementation and during operation of the system are identified with appropriate mitigation measures and outlined in the following sections.

8.1.1 Impact Identification

Positive and negative impacts, impact significance and impact severity from the proposed development have been primarily identified using checklist method as shown in Table 14 along with consultations, expert opinions and professional judgements. Checklist method for identifying impacts in EIA studies have been widely used which usually consist of environmental factors that may be affected by project activities. It gives guidance on the scaling and weighting of impacts.

8.1.2 Impact Zones

Impact zone in this EIA is mainly focused at brine outfall locations in coastal water. The impact of brine effluent on the receiving water quality of the coastal environment mainly depends on volume of the discharge, the chemical composition and concentrations in the effluent. Dominant processes that lead to a large-scale reduction of pollutant concentrations are buoyant spreading, ambient advection and dispersion by the action of coastal currents and turbulence, and finally pollutant transformation and decay.

8.1.3 Uncertainties in Impact Prediction

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. There is also no long term data and information regarding the particular site under consideration, which makes it difficult to predict impacts. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring as described in the monitoring programme given in the EIA report.

Table 14: Impact Identification checklist

		PHYSICAL						BIOLOGICAL				SOCIO ECONOMIC							
	Activities	Soil	Topography	Coastal Water Quality	Air Quality	Ground Water Quality	Beach	Reef system	Coastal and Reef Fishery	Vegetation	Animals (eg. Birds)	Employment	Landuse	Noise	Natural Resource	Energy	Human Health	Land Traffic	Marine Trafic
Construction Phase	Vegtation clearence	(-)	(- -)		(-)					(--)	(-)				(-)	(--)			
	Installation of Boreholes	(--)	(-)		(-)	(--)				(-)		(++)		(--)		(--)	(-)	(--)	
	Installation of Brine discharge line	(--)	(-)	(-)			(-)			(-)		(++)				(--)		(-)	
	Installation of RO plant and Bottling factory	(--)	(--)		(-)					(--)	(-)	(++)	(-)	(-)	(-)	(--)		(-)	
	Installation of Generator set		(-)		(-)					(-)	(-)	(++)		(-)	(-)		(-)	(-)	
	Handling and transportation of goods	(-)	(-)		(-)		(-)			(-)		(++)	(-)	(-)		(--)		(-)	
Operational Phase	Operation of Boreholes			(--)	(-)							(+)		(-)		(--)			
	Brine discharge into lagoon			(--)					(-)										
	Operation of admin Building											(++)				(--)			
	Bottling factory				(-)														
	Desalinated water production				(-)														
	Operation of Gen set (Stand by)				(--)									(--)		(--)	(-)		
	Operation of vehicles				(-)							(+)		(-)		(--)			
	Repair and maintenanace of machineries and vehicles	(-)			(-)	(-)						(++)		(-)		(-)	(-)		

Scoring System: (=) - Negetive Impact, (-) - Negetive Impact Possible, ☐ - No Effect, (++) - Possitive Impact, (+) - Possitive Impact Possible, (?) - Unknown Effect
(-/+) - May have Positive or Negetive Impact

8.1.4 Identifying Mitigation Measures

Impact mitigation measures are identified and discussed for those impacts that practically can be mitigated. Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project through:

1. Eliminating or avoiding adverse effects, where reasonably achievable, OR
2. Reducing adverse effects to the lowest reasonably achievable level OR
3. Regulating adverse effects to an acceptable level/acceptable time period OR
4. Creating other beneficial effects to partially or fully substitute for, or counter-balance, adverse effects.

8.1.5 Mitigation Options

Possible mitigation options in general include – alter designs, alter working method, provide environmental protection, change to good management practices, changes operational procedures and carry out environmental monitoring during implementation and at operational phase

8.1.6 Impacts from Implementation

Implementation phase will have the major, direct short-term impacts and some secondary long-term impacts on the environment. The proposed project mainly will involve drilling of borehole, installation of brine discharge line and vegetation clearance for building.

8.1.7 Mobilization Impacts

The mobilization impact that may cause from the proposed project include during transportation of material and machinery to work site usually that include:

a. Accidental spillage of construction materials (e.g cement).
b. Accidental spill of oils and other chemical.
c. Accidental grounding of large vessels that carry materials and machineries
d. Propellers' wake can break fragile corals.
e. Anchor damage from the vessels.
f. Hazards of transport of material and machinery to site including overtopping of barges.

8.1.8 Impacts from Machinery Operations

In addition to accidental damage caused to corals from barges and other machinery these machines run on diesel fuel, which will have fuel handling issues in addition to carbon emissions. Poor handling of diesel and other fuel as in many islands, often lead to contamination of the soil, groundwater and marine water.

8.1.9 Impacts from Materials

Materials such as cement and fuel for machineries have the potential to damage the marine and terrestrial environment. Both terrestrial and coastal activities can pollute the environment including soil, aquifer and coastal water due to accidental spill of oil and chemicals. Sometimes these materials are thrown into the environment due to absence of appropriate supervision at work sites.

8.1.10 Impacts from Laying Brine Outfall

The key impacts of brine outfall may cause degradation of marine water quality due to sedimentation and discharge of brine concentrate may damage the immediate aquatic marine habitat. During construction and mobilization of equipment would cause re-suspension of bottom sediments at deeper portion along the outfall. Implementing the brine pipe laying work at low tide however will significantly reduce the impact from sedimentation. In addition to this 80% of the entire pipe length will be exposed to air.

8.1.11 Impacts to Workers

The impact to workers is both positive and negative. The positive impacts include that workers are getting paid from the project which is an added income to the workers considered a positive socio economic impact. The likely negative impacts could be health and safety issues during the construction and in operational phase. The operation of heavy machinery and equipment such as borehole drilling machine usually cause impacts to workers at varying degrees. Some of these impacts include falls and accidents due to carelessness both during implementation.

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

8.1.12 Operational Impacts

In the operational phase no significant negative impact is anticipated apart from brine discharge into marine environment. There will be significant positive impact to the community.

8.1.13 Impacts from Brine Disposal

The short term major negative impact from the proposed project is insignificant. The determination of long term major indirect impacts is difficult to quantify due to the lack of past baseline data at project site. However, based on the information, data available and consultant's professional experience in Maldives on similar settings elsewhere in Maldives, the impact to environment both marine and terrestrial is expected to be moderate. Key impacts associated from brine disposal to marine environment is noted to be as follows

a. The effects on marine Water Quality due to potential chemical pollution and turbidity because of the presence highly concentrated saline effluent.
b. The impacts on plankton by causing a drop in osmotic pressure and hence causing negative effects in primary production at the zone of discharge. The impact however is minor and insignificant due to the small volume anticipated in the production
c. The impacts on fish faunal community are likely. However many fish can swim far away from the site of disposal where the turbidity and salinity level expected to be slightly elevated. Again the impact is minor and insignificant due to the small volume of brine anticipated from the production.
d. The impacts on coral reefs, which are very sensitive to changes in environmental conditions such as chemical pollution, hydrodynamic alterations, temperature, salinity etc. The proposed brine discharge location do not have corals
e. May impact on sea grasses due to the presence of the high concentrated saline brine effluent, depending on the sensitivity of the species.

8.1.14 Transport Related Impacts

The use of diesel as well as petrol in vehicular engines and operation of machines cause emissions of carbon dioxide, sulphur dioxide and nitrogen oxides with fine particular matter. However the impact to environment from the GHG emission is relatively small due to small fraction of GHG emitted during the operation of the system.

8.1.15 Impact from Noise

Impact from noise will cause both during implementation and operation. During implementation and installation machineries will make noise that may cause impact to workers. The ambient noise level measured at the proposed location is 55dB (A) which is considered low since the surrounding environment is currently with out major development. The nearest residential area to the site is currently 150m from the sites. Ambient noise at street level near the residential area is 60-65 (dB). At the time of noise level measure some road construction works were on going with light machinery.

8.1.16 Socio-Economic Impacts

The socio-economic impacts from the proposed bottling and desalination plant will be both positive and negative. Creation of job opportunities is a positive impact to the community and also it will increase public satisfaction.

During construction period it will mainly be positive impact as a whole to the communities and to local contractors. It will create jobs, sales, and services during the project implementation and operational phase.

8.2 Mitigation Measures

There are actions that can be taken to minimize the identified impacts. Those that are explored below emerged out of the discussions and consultations during this EIA and from the past experience of the consultants. Mitigation measures are selected to reduce the severity of predicted environmental effects and improve the overall environmental performance and acceptability of the project.

Mitigation measures are discussed for the construction and operational stage of the project. During the construction stage it is important to take measures to minimize impacts on the project site and surrounding natural environment. A construction method that has least impact on terrestrial or marine environment has to be utilized. Similar is proposed for operational aspects of the project. Table 15 shows environmental impacts and impact significance

Table 15 Summaries of Environmental Impacts, Impact Significance

Activity	Causal Factors	Impact	Direct Impacts	Cumulative Impacts	Indirect Impact	Short Term Effects	Long term Effects	Impact Significance
CLEARING OF VEGETATION)	Reduced number of mature trees on the island	a. Loss of vegetation	✓				Contributed global warming	Moderate
		b. Loss of habitats for birds and domestic animals	✓			Short term		Low
		c. Elevated atmospheric CO_2			✓	Short term		Low
INSTALLATION OF BOREHOLE	Atmospheric emissions from fuel burning and discharge chemicals in drilling mud	a. Alters groundwater and marine water quality	✓			Short term		Moderate
		b. Affects soil	✓			Short term		Low
		c. Atmospheric pollution	✓	✓		Short term		Low

Activity	Causal Factors	Impact	Direct Impacts	Cumulative Impacts	Indirect Impact	Short Term Effects	Long term Effects	Impact Significance
MARINE OUTFALL FOR BRINE DISCHARGE	Release of brine concentrate into marine water	Increase sedimentation	✓			✓		Low
INSTALLATION OF RO PLANT AND BOTTLING PLANT	Site clearance by cutting vegetation for RO plant and Bottling plant housing Generation of waste	Loss of vegetation Added waste into main waste stream	✓		✓		Contributed global warming	Low Low Low
	Production of bottled water	Positive impact	✓	✓			The public satisfaction and happiness increased	High
MACHINERY & EQUIPMENT	Heavy machinery operation and construction	Local noise and air pollution			✓	Temporary disturbance to particularly habitats/people	None	Low
	Accidental damage from operation.	Local damage soil	✓					Low
HANDLING AND	Loading/unloading	Air and noise			✓		Disturbance	Low

Activity	Causal Factors	Impact	Direct Impacts	Cumulative Impacts	Indirect Impact	Short Term Effects	Long term Effects	Impact Significance
TRANSPORT OF GOODS AND MATERIALS	noise Dust and air emissions	pollution					to terrestrial and marine ecological systems	
	Transport including road transport	Increased risk of accidents Increased pollution			✓ ✓	Increased air and noise pollution	Increased air and noise pollution	Low

9 Monitoring and reporting

Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental variables associated with the development projects. Monitoring is required to;

- Compare predicted with actual impacts
- Assess efficiency of mitigation measures proposed for the project
- Identify responses of receptors to impacts
- Enforce conditions and standards associated with approvals
- Prevent environmental problems with uncertain predictions
- Minimize errors in future assessments and impact predictions
- Make future assessments more efficient
- Provide ongoing management information
- Improve EIA and monitoring process

Impact and mitigation monitoring is carried out to compare predicted and actual impacts occurring from project activities to determine the efficiency of the mitigation measures. This type of monitoring is targeted at assessing human impacts on the natural environment. Impact monitoring is supported by an expectation that at some level anthropogenic impacts become unacceptable and action will be taken to either prevent further impacts or re-mediate affected systems. Mitigation monitoring aims to compare and predicted actual (residual) impacts so that effectiveness of mitigation measures can be determine.

The environmental monitoring proposed here is to determine the effectiveness of the mitigation measures and long term change to the natural environment (especially shallow lagoon habitat dominated by sea grass). The survey and sites established during the field surveys for EIA report preparation will be used for the monitoring program. All monitoring activities will be carried out under the supervision of an environmental monitoring and management consultant. In addition photographic documentation of the site during the construction works shall be carried out. Commitment to carry out the monitoring program from proponent as the client (proponent) for all construction related works is provided in Proponent’s Declaration. The following table (Table 16) outlines environmental impact mitigation measures what may further reduce potential environmental impacts associated with the proposed activities of the project. Table 17 provide environmental monitoring requirement to reduce and further minimise environmental impacts associated with the project that include costs and responsible people to follow the monitoring required.

Table 16 Impact Mitigation Measures

	Activity	Potential Impacts	Mitigation Measures	Responsible Institute	Cost (MVR)
Design and Planning Phase	a. Identify the site for RO plant and Bottling housing b. Identify the location for brine disposal c. Identify and mark the location for borehole drilling	NA	NA	NA	0
Construction phase	a. Excavation and laying of brine discharge pipe b. Borehole drilling c. Mobilization of materials, machineries and equipment d. Site preparation through vegetation clearance e. Machineries and equipment operation	a. Soil loosening b. Suspension of sedimentation c. Pollution from drilling fluid (Eg. Bentonite mix) d. Emission of greenhouse gas e. Loss of vegetation f. Groundwater pollution	a. Selection of appropriate development windows by executing the work in low tide b. Collect the drilling fluid in a containment tank for safe disposal c. Monitor suspended solids in water flowing out and spreading during installation of brine outfall d. Completion of work as soon as possible but by avoiding working at night e. Minimize clearing of vegetation f. Monitor groundwater quality g. Avoid any spilling into the	Contractor Proponent	25000

			ground that can contaminate soil and groundwater h. Plan for the use of appropriate equipment. i. Provide appropriate working windows j. Ensure proper monitoring of construction activities k. Establish strict regulations and safety measures for machinery operation l. Locate storage area on the island m. Provide effective management of fuel handling area and other dangerous substances n. Design for appropriate solid waste disposal such as provision of disposal facilities and collection procedures o. Establish appropriate mechanism for waste management employed with trained and informed personals p. Construction waste must be disposed appropriately		

			q. Construction debris shall not be disposed in the marine environment r. Produce and enforce strict regulations for liquid and solid waste disposal s. Ensure emergency procedures in case of spill out of dangerous substances are in place t. Appropriate solid waste collection facilities shall be placed u. Produce and enforce hazardous material handling and storage procedures v. Ensure emergency procedures in case of spill out of dangerous substances are in place. w. Identify clear responsibilities and enforce health and safety procedures at all work sites		
Operation phase	a. Discharge of brine effluent into marine environment b. Production waste generation	a. Migration of hyper saline sensitive fish from the site of brine disposal b. Sedimentation at site of brine disposal	a. Monitor coastal water quality at site of brine disposal b. Monitor fish abundance c. Monitor sea-grass bed	Client	50000

		c. Suffocation of sea-grass bed at the site of disposal d. Alteration of marine water quality at site of brine disposal e. Added waste into main waste stream	d. Monitor waste generation		

Table 17 Environmental Monitoring Plan

Proposed mitigation measures in Phase A, B & C	**Parameters to be Monitored**	**Locations**	**Measurements (including equipment's and tools)**	**Frequency of Measurements**	**Responsible**	**Cost (RF) (Including equipment and personals)**
A. Design and Planning Phase	NA	NA	NA	NA	NA	NA
B. Construction phase	a. Groundwater quality for E. Conductivity (µS/cm), Salinity (ppt), TDS (mg/l)	All groundwater tested locations shown in the site map	*Hatch* or *Horiba* water quality testing potable equipment	Monthly	Consultant, Contractor and the Proponent	25000
	b. Vegetation removal	At construction site for the building	Monitor if vegetation is removed from approved sites and specified type of vegetation	During construction	Contractor and Proponent	
	c. Oil leakage at machinery operations	At machinery operation sites	Visual Visual and testing	Daily during installation and at work	Contractor and Proponent	20000

	d. Sedimentation	At drilling mud disposal site		Daily during work	Contractor and Client	
C. Operation phase	a. Seawater quality for E. Conductivity (µS/cm), Salinity (ppt) and TDS (mg/l), b. Sea grass cover c. Fish abundance d. Waste generation	All seawater tested locations shown in At brine disposal site Brine disposal site At production facility	*Hatch* or *Horiba* water quality testing potable equipment Sampling bottles for faecal coliforms Photographic surveys Photographic surveys Monitoring	1st two years: Monthly From 3rd year onward: every six months for 5 years. 1st two years: Monthly From 3rd year onward: every six months for 5 years. 1st two years: Monthly From 3rd year onward: every six months for 5 years.	Operator and Proponent Proponent Proponent	20000 (monthly) 10000 (b +c monthly) Nil

	at production			Daily	Client	

9.1 Monitoring Report

A detailed environmental monitoring report will be compiled and submitted to the Environment Protection Agency using the given format. The report will present the data to be collected for monitoring the parameters included in the monitoring programme given in this report.

Environment Monitoring Reporting Format

Project Name:

Name of the Island:

Monitoring Date:

Period Covered:

Prepared by:

Contributions:

A. **Introduction**
   Give a brief introduction about the project and the monitoring carried out
B. **Methodology**
   Brief detail of the methodology applied for undertaking the monitoring assessment

C. **Environmental Monitoring**
   a. **Groundwater quality**
      Parameters given in the monitoring plan need to be assessed
   b. **Marine water quality**
      Parameters given in the monitoring plan need to be assessed
   c. **Marine reef assessment at outfall locations**
      Reef areas assessed in the baseline surveys need to be assessed for coral cover and its health

D. **Risks and Mitigations**
Please indicate any critical unresolved risks that affect the course of the system operation, analyse the cause, assessing the potential impacts on the environment providing the proposed mitigation strategy

E. **Problems Encountered**
Indicate any problem areas encountered and any corrective measures that will have to be taken.

F. **Recommendations**
If specific recommendation is noted during the monitoring phase, specify it in the report

G. **Conclusions**

Reference
Appendix

10 Conclusions and Recommendations

In conclusions the proposed small scale seawater desalination and desalinated water bottling facility in Hulhudhoo in Addu City is going to be an establishment that will have great benefit to Hulhudhoo and Meedhoo communities. The system is a simple RO desalination system attached with a bottling plant. The associated elements in the development of the system are site clearance for plant house, installation of boreholes for source water extraction, laying a brine disposal marine pipe line, installation of standby generator set installation. The key activities that may cause negative impact to environment are identified to be site clearance with vegetation removal, borehole drilling, brine disposal, installation of brine disposal line and operation of machineries and vehicles. With appropriate mitigations measures negative impacts to environment can be either eliminated or minimized. Brine effluent discharge outfall has been appropriately located based on oceanographic features at proposed sites. Vegetation clearance also will be removed only those that falls at the building foot print. The vegetation removal has been minimized through careful planning and designing during site allocation.

Groundwater quality and marine water quality have been tested for physical parameters. No significant pollution has been noted form the test results. The net positive impact of the proposed project is significant due to the strong attachment and need of such a facility in that community. It creates job opportunities and it will be an added source of income to Hulhudhoo. Therefore, the proposed small scale desalination and bottling facility in Hulhudhoo is highly recommended to implement.

These recommendations includes

a. Avoid laying brine outfall during high tide.
b. Avoid discharge of drilling mud into marine water.
c. Put in place a proper monitoring program, check quality of groundwater and marine coastal water
d. Properly supervise the civil work to ensure quality work is carried out
e. Maintain a good housekeeping during development during operation

11 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2007, issued by the Ministry of Environment, Energy. We certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of our knowledge and abilities.

Hussain Zahir (EIA reg. no. 04/07)

Signature

Date: 22 June 2016

Mohamed Mustafa (T02/15)

Signature

Date: 22 June 2016

12 Reference

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13 Appendices:

Appendix 1: TOR

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203-EIARES/INDIV/2016/25

Terms of Reference for Environmental Impact Assessment for the Proposed Installation of Small-scale Desalination and Water Bottling Facilities in Hulhudhoo, Addu City

The following is the draft Terms of Reference (ToR) following the scoping meeting held on **16 February 2016** for undertaking the EIA of the proposed project at S.Hulhumeedhoo. The proponent of the project is Mr.Abdullah Mutheeu/ Nest Meed, S.Hulhudhoo. 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 and background of the project. Clearly identify the rationale and objectives to enable the formulation of alternatives, if required. Define the arrangements required for the environmental assessment including how work will be carried.

2. **Study area** – Submit a minimum A3 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 desalination plant. 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 and construction 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 design

- Submit a scaled plan with appropriate labels and scale;
- Describe the technology (reverse osmosis, disinfection) and capacity
- 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 labor camps, access to site, safety, equipment and material storage, waste management from construction operations (mainly dredged materials), power and fuel supply;

Brine outfall pipeline

- 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;

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

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

Intake pipeline

- Location of borehole, type and size. Justification for selecting this method of raw water; installation details

Bottling Unit

- Describe the bottling unit, its capacity, daily production, production line

Power

- Describe power, and how electricity is taken, if backup gen set is proposed give details

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

The baseline data must 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, vegetation transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

Climate

- Temperature, rainfall, wind, sunshine, wave patterns, currents etc.

Geology and geomorphology (localized maps)

- Bathymetry (bottom morphology surrounding the island) (use maps);
- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction.
- Shoreline.

Hydrography/hydrodynamics (localized maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Sea water quality measuring these parameters: temperature, pH, salinity, turbidity and TSS.

Biological environment:

- Marine and terrestrial environmental conditions of the impacted area.
- Present a detailed description of the flora and fauna (marine and terrestrial) of the area. Generally, species dependence, habitats/niche specificity, community structure and diversity ought to be considered including

Marine

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

- A quantitative and qualitative assessment of coral reef environment (the benthic coral fauna and fish fauna cover) at the proposed brine concentrate discharge area, intake area and alternative locations

Terrestrial

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

a) *Socio-cultural environment:*

Present and projected population; present and proposed, land use, planned development activities, community structure, economic base/employment, distribution of income, goods and services; utilities; recreation; public health and safety; cultural peculiarities, aspirations and attitudes should be explored. The historical importance (if any) of the project area should also be examined. While this analysis is being conducted, it is expected that an assessment of public perception of the proposed development be conducted. This assessment may vary with community structure and may take multiple forms such as public meetings or questionnaires.

b) Hazard vulnerability and Accidents

- Vulnerability of area to flooding and storm surge.
- Project prone accidents and risks

* The overall outcome of collecting this data is to find the optimum site selection for the brine discharge pipeline.

**All survey locations shall be referenced with Geographic Positioning System (GPS) including sampling points, sediment sampling sites. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project.The EIA report should clearly identify the different applicable clauses and articles of the legislative and regulatory requirements. Show that the proponent has applied for all necessary permits.

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

Terrestrial impacts from construction

- Loss of vegetation and fauna from land clearance activities (deployment and dewatering, if any);
- Ground water quality;

Operational phase impacts from borehole and brine outfall pipelines

- Potential impact of boreholes on groundwater lens, if any;
- Marine ecosystem impacts from changes in salinity at brine outfall site.

Social impacts:

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

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

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

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

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 dispersion and water intake quality;
- Biological parameters such as terrestrial monitoring, coral reef and benthic monitoring, fish community census at intake and brine outfall pipe locations to assess damages and recovery rates;
- Terrestrial monitoring in the surrounding areas to the desalination plant ;

Ecological monitoring must be submitted to the EPA to evaluate the damages during construction, after project completion and every three months thereafter, up to one year and then on a yearly basis for five years after. 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.

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

- Addu City Council
- Maldives Food and Drug Authority
- Relevant government ministries and agencies
- Members of the general public.

Presentation - The environmental impact assessment report need to be presented in digital format, shall be concise and focus on significant environmental issues. It shall contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data.

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

16 February 2016

Appendix 2: Proponents Declaration and Commitment

Proponents Declaration and Commitment Letter

Nest Mead
Hulhudhoo Town
Addu City
15 June 2016

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Government of Maldives

Dear Sir

Sub: Small Scale Desalination and Water Bottling Plant in Hulhudhoo, Addu City

As the developer of the captioned project I confirm that I have read the EIA report thoroughly and hereby confirm my commitment to carry out and bear the costs of environmental monitoring and mitigation measures outlined in this EIA report.

Thanking you

Yours Sincerely

Abdulla Mutheeu
Project Proponent

Appendix 3: Scoping Meeting Attendance

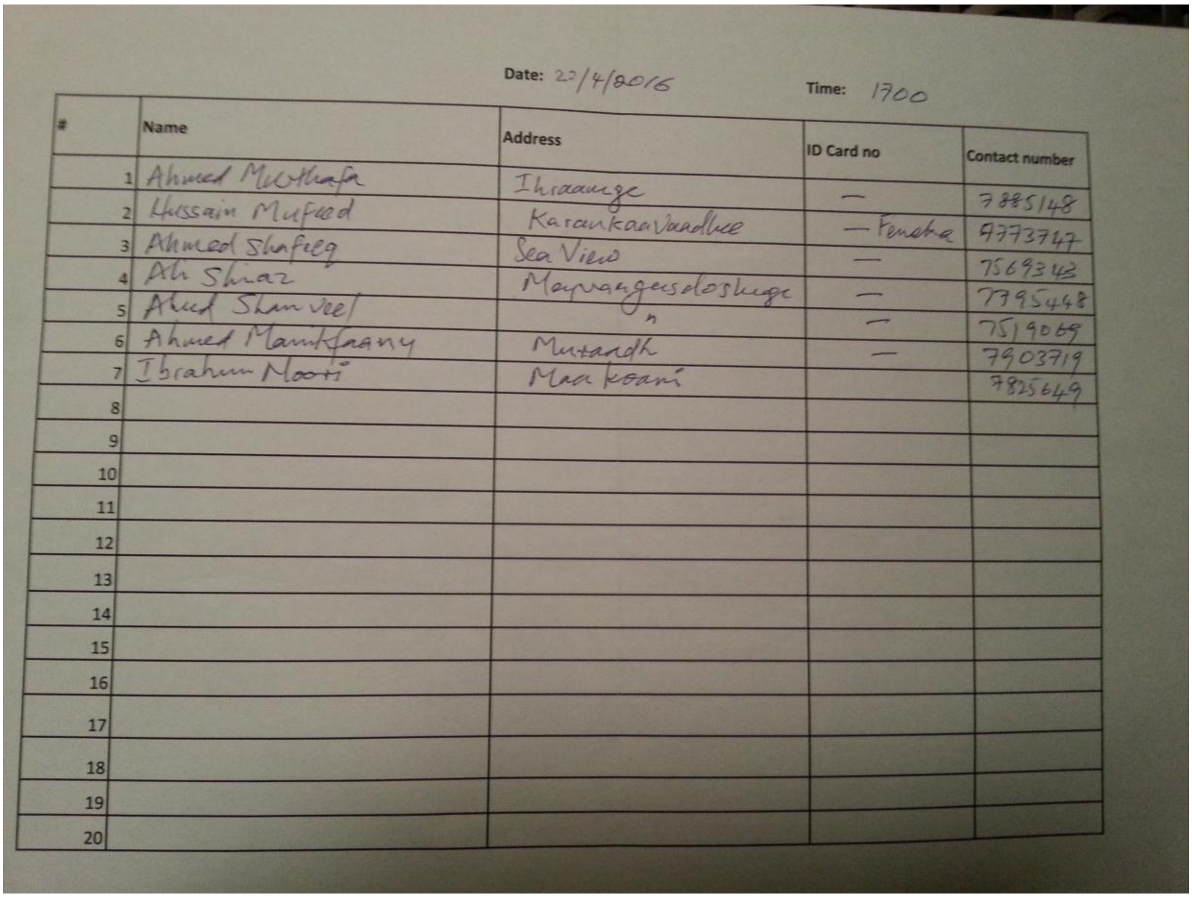
Environmental Protection Agency
Male', Rep of Maldives

Meeting: Scoping meeting for the proposed installation of small scale desalination & water bottling facilities @ S.Hulhudhoo.
Date: 16/02/16
Time: 10:00 am.

MEETING ATTENDANCE

	Name	Designation	Office	Email	Phone No.	Signature
01	Ahmed Anwar	Asst. Director	MEE			
02	Mohamed Mustafa	Consultant	—		7782393	
03	MOHAMED YASRIF	CITY COUNCILOR	ADDU CITY COUNCIL	yasrif@adducity.gov.mv	7781342	
04	Mutheeu	OWNER	—	—	7771512	
05	Safa Ahmed	Asst. Director	EPA/ECA	safa.ahmed@epa.gov.mv	9645680	
06	Aminath Mohamed	Env. Analyst	EPA/waste	aminath.m@epa.gov.mv	7504494	
07	ALI MISHAL	Engineer	EPA	ali.mishal@epa.gov.mv	7766659	
08						
09						
10						

Appendix 4: Community Consultation Attendance



Date: 22/4/2016 Time: 1700

#	Name	Address	ID Card no	Contact number
1	Ahmed Musthafa	Ihraamge	—	7885148
2	Hussain Mufeed	Karankaavaadhee	— Fenaka	9773747
3	Ahmed Shafeeq	Sea View	—	7569343
4	Ali Shiaz	Mayvaangeesdoshuge	—	7795448
5	Ahmed Shanveel	"	—	7519069
6	Ahmed Manikfaany	Mutandh	—	7903719
7	Ibrahim Moosa	Maa koani		7825649
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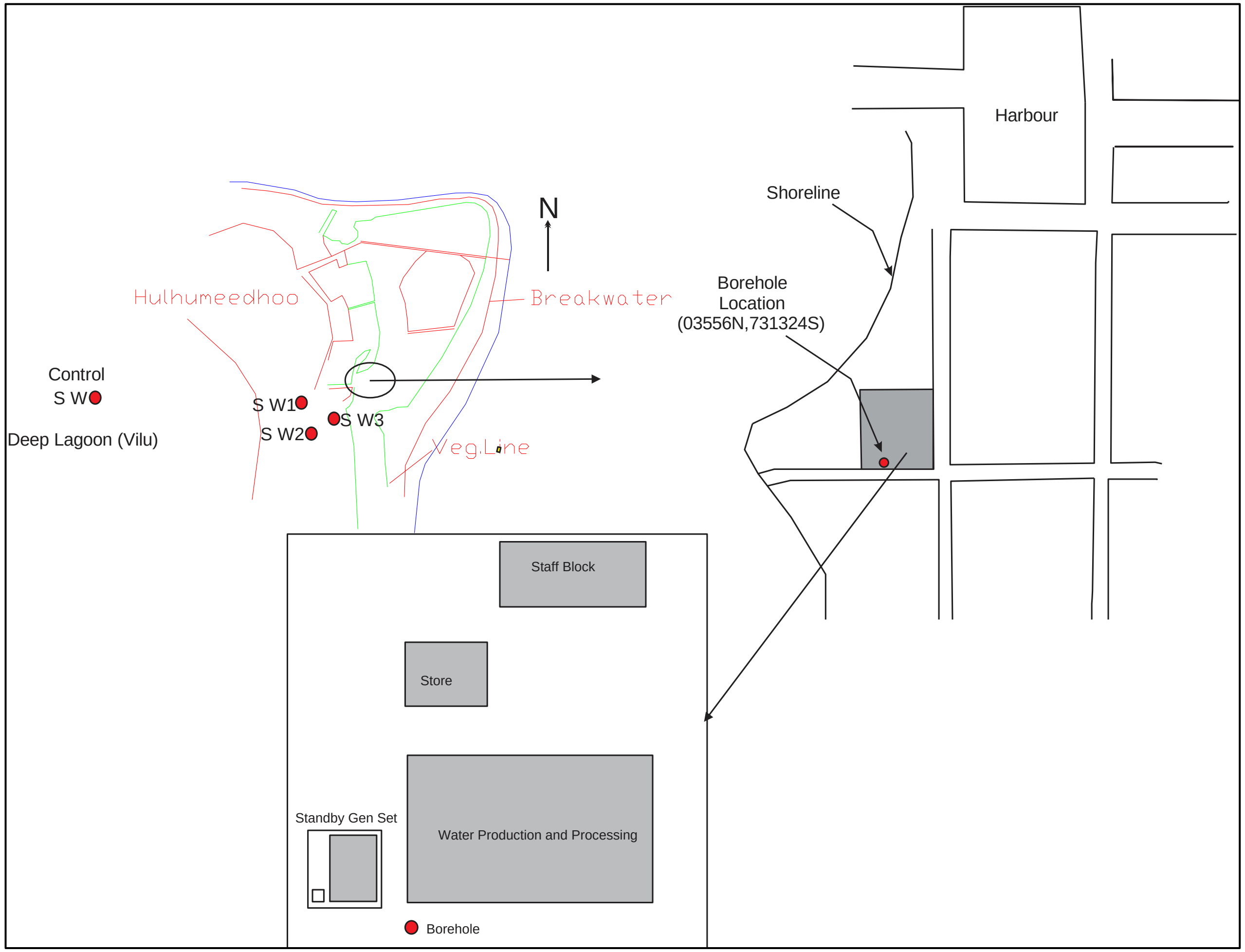
Appendix 5: Site Plan



Appendix 6: Land approval letter

Land, Building and Municipal Services Department
Hulhumeedhoo Section, Addu City
Ministry of Housing and Infrastructure

[illegible] (OTHR)138-LS/INDIV/2016/67

[illegible]

[illegible] (A058595 [illegible]) [illegible] (AGR)138-LS/INDIV/2016/2 (07 [illegible] 2016) [illegible] 20,000 [illegible] 07 [illegible] 2016 [illegible] 06 [illegible] 2026 [illegible] 10 [illegible]

08 [illegible] 2016

[illegible]

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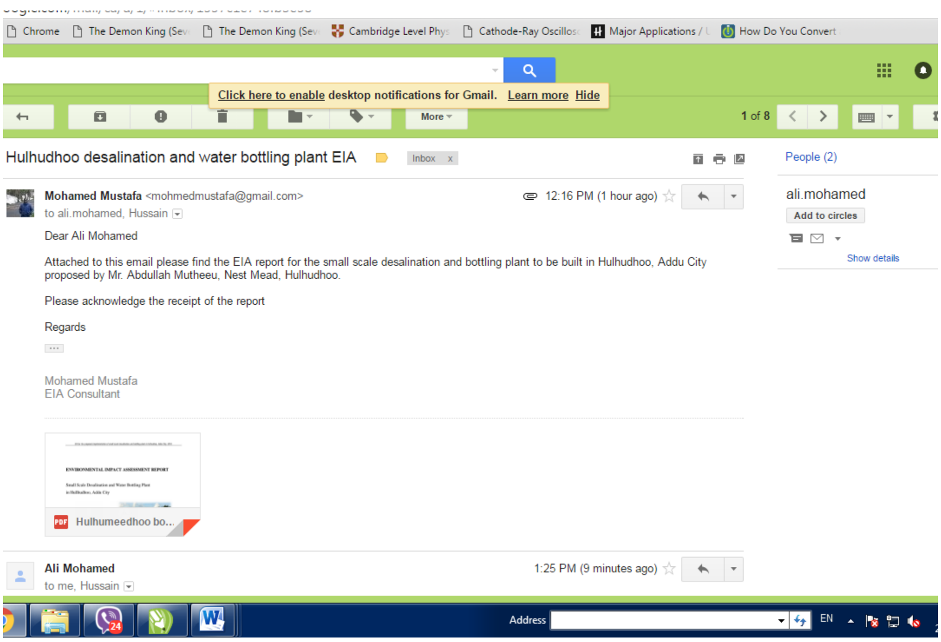
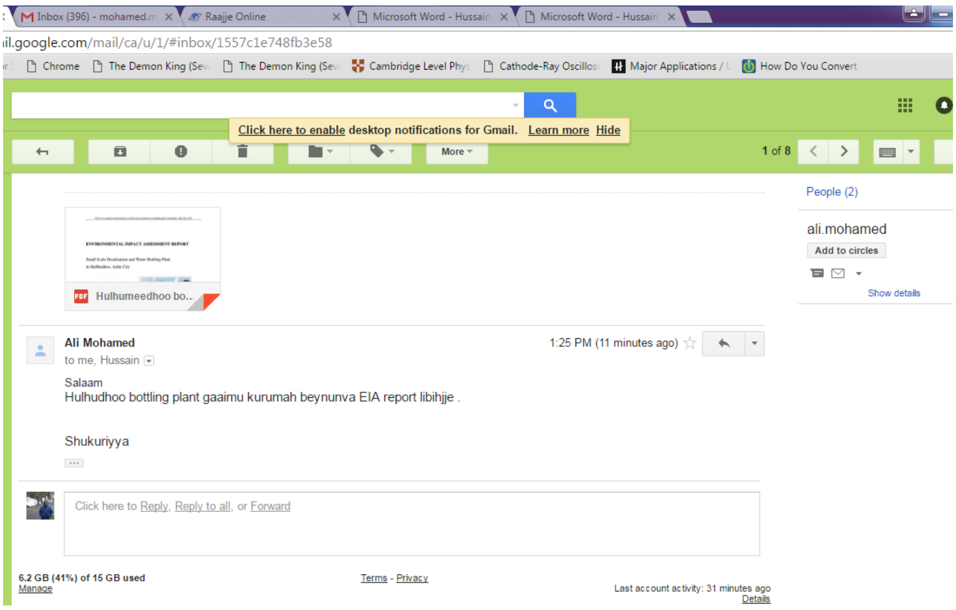
Appendix 7: Evidence of EIA submission to Council





Appendix 8: Consultants CV